Technological Change and Cities

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Abstract

The United States is in the midst of a technological revolution, driven in large part by rapid advances in microelectronics. There has been much speculation about the impacts of the "information superhighway" on society as a whole, but surprisingly little is known about the potential effects of this technology revolution on the spatial distribution of jobs and people either broadly or in urban conditions specifically. This paper reviews the literature and research assessing the impact of technology on both intra- and intermetropolitan change. Based in part on the review of the literature and the findings from the Office of Technology Assessment report, The Technological Reshaping of Metropolitan America, *the final section speculates how this technology revolution will affect cities and metropolitan areas.*

The United States is in the midst of a technological revolution, driven in large part by rapid advances in microelectronics. Digital electronic technologies permit information in a myriad of forms to be generated, routed, and transmitted anywhere cheaply, nearly instantaneously, and at high volumes. Although urban scholars speculate about the impacts of the "information superhighway," "digital society," and emerging "cyberspace" on society as a whole, surprisingly little is known about the potentially broad effects of this revolution on the spatial distribution of jobs and people or on urban conditions specifically.

This revolution is important to cities because many scholars have argued that it is comparable in scope to the revolution in transportation technology that dramatically influenced settlement patterns in the early part of this century. Today, economic activities are increasingly shaped by continuous and real-time interactions facilitated by information technologies (computing and telecommunications technology). Because these interactions differ so markedly from past interactions, which were more burdened by space and time constraints, their impact on industries and jobs has the potential to significantly reshape America's metropolitan areas, leading to growth for some places and decline for others. However, views differ about which places will benefit and which will lose.

Some students of economic geography suggest that the basic postulate of the information age is that information technology (IT) is eliminating the effects of distance, and that this, in turn, will have profound implications on the spatial organization of society. As a result, they argue that this new technology system will create an even more spatially dispersed and footloose economy, which in turn will cause metropolitan areas to be larger, more dispersed, and less densely populated. In contrast, other scholars argue that technological change is reinforcing the position of cities as "nodes" on the information superhighway. According to this view, the increased importance of innovation and information processing in late-20th-century advanced industrial economies is leading to a parallel increase in the importance of agglomeration economies and the advantages that cities possess.

In either view, technological change does not suggest that other socioeconomic and public policy factors have not played—or will not continue to play—important roles. Crime, single-parent families, teenage pregnancies, welfare dependency, and drug abuse all contribute to urban problems and, by extension, to economic and residential spatial patterns. Similarly, public policy interventions that create advantages for homeownership, such as building the interstate highway system, the location of public housing, and taxation, have also influenced the present patterns of urbanization. Nevertheless, technology plays an important enabling role in shaping cities and metropolitan areas.

Yet, in spite of the importance of technological influence, surprisingly little is known about its role. Seamus Grimes (1995) notes that "analysis of the role of IT in restructuring of economic activity has been particularly speculative to date, mainly due to the paucity of empirical research, but also due to the futuristic nature of the processes involved in this early stage of IT diffusion." While it may be too strong to say that, "nobody knows how information and communication technologies will influence the way people and firms use space," much of the scholarly and popular work on the topic has relied more on theory, anecdote, and speculation and less on careful empirical analysis (DeMichelis, 1996). The current and future spatial distribution of business and residents is a key factor in formulating national urban policy. The trends and factors that determine this distribution will, in large part, determine the context in which urban policy is made and which central challenges to urban areas are faced. Because technology has the potential to affect the future spatial distribution of people and jobs, understanding its impact is critical to developing appropriate urban policies. Technology also affects labor markets and skills in urban areas. If technology changes the types of skills needed by urban residents, it also influences economic opportunities.

This article reviews the literature and research assessing the impact of technology on both intra- and inter-metropolitan change. Based in part on the review of the literature and the findings from the U.S. Congress Office of Technology Assessment report, *The Technological Reshaping of Metropolitan America*, the final section predicts how this technology revolution will affect cities and metropolitan areas.

Background and the New Technology System

A metropolitan region (metro) is a complex techno-politico-socio-economic system with attributes resulting from ongoing decisions by individuals, governmental bodies, and business firms. These decisions are shaped by the technological possibilities of the time. Urbanization has been driven by technology transitions that redefine urban hierarchies and bring new types of specialization to the urban economic base. As a result, many urbanists argue that the pattern of urbanization has not been a smooth evolution—it has been marked by major transformations from one form of city to another (Borchert, 1967; Barras, 1987; and Berry, 1995).

Indeed, technology has always shaped U.S. cities. For example, in the first part of this century the wave of new technologies included:

- Transportation technologies of automobiles and airplanes.
- Infrastructure technologies, including widespread diffusion of electricity, highways, and water systems.
- Mass production manufacturing technologies.
- Agricultural mechanization.

These new technologies drove the emergence of more dispersed cities and spurred growth in less developed regions. Air travel, long-distance communications, and truck transport began to recast regional relationships, allowing large-scale urban development to spread farther south and west. Arterial highways followed limited access parkways, and subsequent interstate highways tied metropolitan regions and finally the entire Nation together. Widespread electrification allowed industry much greater locational freedom, stimulating much of southern and western industrialization. The development of air conditioning made living and working in hot southern and western climates more tolerable. Agricultural mechanization led to significant decreases in agricultural labor with concomitant migration from rural to urban areas.

Within metropolitan areas, cities were reshaped by the automobile. Streetcars created initial extensions from urban cores, but increased automobile use caused radical shifting of residential locations further from urban cores, leading to patterns of “bedroom suburbanization.” Steel-girded buildings, electric elevators, and telephone communications facilitated the construction of skyscraper office towers, intensifying use of central business districts.

The New Information Technology System

As new technologies emerged in the 1960s (for example, prototype facsimile or fax machines and mainframe computers), urban scholars began to speculate about the possible effects IT would have on cities. For example, Richard Meier (1962) postulated that the city is a mechanism for communications. He defined cities as those parcels of land in which intense communication processes take place. In his view enhanced communication through telecommunications threatened the viability of cities. Ten years later P.C. Goldmark (1972) reported about a pilot project that allowed workers living in satellite cities 50 miles from a dense urban central business district to work in the “telecommuting center.” Of course, limitations of technology at the time precluded such efforts from succeeding. Early IT applications improved internal operations—from mainframe to desktop computing—and often created “islands of automation” with little interconnection between components. As a result, their impact on the location of activities was limited.

In fact, predicting the effect of telecommunications (telecom) and IT on cities in the 1970s and even in the 1980s was somewhat similar to trying to predict the effect of autos on cities in 1900 at the introduction of electric trolleys. The technology revolution of the last 10 years was not even imagined by most people in the 1970s and 1980s. However, within the last 10 years discussion of the impact of telecommunications and information technology on urban form and the location of people and jobs has increased. Before discussing this more recent generation of research, however, it is important to examine the key technologies that underpin this new technology era.

Only recently have technologies facilitating linkages and communication between operations begun to be widely adopted. These technologies are falling in price while increasing in performance and, as a result, will continue to be adopted throughout the economy. What makes these technologies revolutionary is their ability to capture, store, and transmit information in digital form, which makes electronic, instantaneous transmission possible. Rapid adoption of these technologies is being driven by the significant increases in productivity they make possible (Horan, Chinitz, and Hackler, 1996). Information technologies perform three main functions: transmission, conversion of information into digital form, and distribution and routing.

Transmitting Electronic Information

Technology to transmit digital data between places is advancing rapidly. Radio-frequency-based wireless technologies, including telephones, computers, faxes, and other electronic devices, are becoming widespread. Low earth-orbit satellite systems now in development would use switching and satellite broadcast, expanding mobility for wireless communications to remote areas of the world. The terrestrial-based telecommunications infrastructure is evolving as both the delivery systems and applications advance. In the last decade, there has been widespread deployment of high-speed, high-capacity fiber-optic cable. Moreover, prices of telecommunications have fallen dramatically in inflation-adjusted dollars. For example, from 1972 to 1986 ordinary telephone service rates fell between 36 and 44 percent when adjusted for inflation (Johnson, 1991). Within most major metropolitan areas, advanced telecommunications technologies, including fiber-optic lines, are available to most moderate and large users. Advanced packet switching, integrated services digital network (ISDN),[1] and other services allow transmission of digital signals. Broadband services to the home will enable near instant access to remote computers. For example, cable companies are installing fiber-optic transmissions systems in most metropolitan areas, allowing the use of broadband cable to transmit data to and from the home (Moschella, 1997). Telecommunications companies are beginning to roll out asymmetric digital subscriber line (ADSL) service that significantly increases data transmission speeds of regular telephone lines.

Transforming Information into Electronic Form

In terms of impact on business and residential location, the ability to transmit large quantities of digital information at high speeds is not enough. Information must be in digital form initially and must be able to be read and processed. Many technologies do this.

Laser-based CD-ROMs and CDs with read and write capabilities make data storage even cheaper and faster than magnetic hard-drive technology. These technologies allow users to obtain information without handling paper records. Optical character recognition (OCR) technology converts images of text into digital code that can then be processed by computers. For example, new check encoding machines recognize some check amounts and automatically magnetically encode them. Electronic folder management, an offshoot of imaging and database applications, consists of whole files of documents that are stored and retrieved electronically. Combined with distributed computing that links personal computers into a system, users are able to access the same information.

Despite its early invention in the 1930s and the accolades it received at the 1964 New York World's Fair as the wave of the future, video telephony has been slow to be adopted. However, new systems utilizing video modems are less expensive and more portable. Some telecom experts expect desktop video conferencing to become commonplace for many users with access to advanced telecommunications.

Advances in speed, storage capacity, and ease of use have increased the utility of personal computers. Graphical user interface software (such as Microsoft Windows) makes computing easier for nontechnical personnel by allowing more functions to be installed on computers. Development of even faster microprocessors—Intel recently announced production of a 300 megahertz processor—will enable computers to process real-time graphics. Portable computing has become less expensive and more powerful, better enabling the distribution of work.

Financial institutions are readying themselves for another step in the continuing convergence of information and finance—the expanded use of smart cards to perform a variety of financial functions. Smart cards differ from conventional credit or automatic teller machine cards in that they can carry large amounts of information using an embedded microchip. A smart card could be used, for example, to download funds from the cardholder's bank account directly onto the card itself.

Other technologies include fax machines; computers, including portable and laptop models; bar code readers; knowledge-based software systems; database software systems; and voice recognition. In general, electronic data storage capacity and access speed have increased while costs have decreased. Moreover, database software has become more sophisticated. As a result, large amounts of information are now stored and accessed electronically.

Distributing Electronic Information

Distribution technologies allow electronic information to be switched and routed to particular places or uses. For example, electronic data interchange (EDI) protocols allow documents, forms, and other data to be transmitted among users. Development of new software and hardware applications in telecommunications has created a number of new uses for telephones, enabling more distributed work. For example, digital call distribution systems and distributed computing make it possible to disperse telephone service functions that previously had to be in more central locations. Conversely, call routing technologies allow calls from a wide geographic area to be routed to available offices, enabling companies to centralize service facilities and better manage the flow of calls. Remotely accessed voice mail and call forwarding better enables remote work. In recent years, innovations such as digital call distribution systems, telephone keypads, and screen phones have made it possible for banks, brokerage firms, and mutual funds to broaden the range of services that clients can access by phone. Rapid growth in toll-free (800) service has meant that more companies can inexpensively serve customers throughout the country or even the world (Moschella, 1997).[2] In 1995, so many companies had 800 numbers there was a shortage of available new numbers.

The rise of groupware systems allows distributed work teams to cooperate electronically. Most importantly the Internet is exploding as a data-exchange tool. The numbers of Internet subscribers are growing rapidly, and the range of information and services on the Internet is vast.

Summary

The IT revolution is rapid and sustained. Costs are falling, applications broadening, and diffusion deepening. In fact, it is not unrealistic to expect that much of the world will, in fact, be digital within the next 10 to 20 years (Gates, 1995; Negroponte, 1995).

Changes are rapid and evolving. Only a few years ago the focus was on ISDN circuits because they allowed nine times more information to be transmitted than regular modems. However, newly available cable modems transmit 30 times more information than ISDN, and advanced cable modems can be even 10 times faster, whereas fiber-optic transmission is 20 times faster. The Internet is growing at an explosive rate. Development of high-definition flat-panel displays offers the promise of larger television and computer screens with much higher resolutions. IT is becoming cheaper and more user friendly. Hardware is smaller (e.g., witness the recent rise of palmtop computers), and software is available in an ever-widening range of applications. A large share of financial transactions will be conducted digitally as paper transactions (e.g., cash, forms, files) slowly disappear, and the ability to process, store, and transmit large amounts of data, voice, and images cheaply will continue to grow. In short, information of all kinds will be digitized with universal translation, reading, and transmission.

These technologies are important because they represent the opportunity to conduct many more economic transactions at a distance—from an employee at home to a central office, from a consumer to a store, from one company to another. When most information was in paper form and transactions were between people in face-to-face mode, IT had little effect on the spatial distribution of the economy. However, with a growing share of the economy in digital form, the tyranny of distance and time can be removed or, at least, radically reduced. As a result the need for people and industry to agglomerate in high-cost cities may be reduced. In fact, some have even suggested that cities emerged to facilitate movement of people, goods, or paper (atoms) from one place to another and that the new information economy is about moving bits (electrons) across space with no time constraints and little cost. With the rise of a postindustrial information economy where information consists of an ever-increasing share of the GNP, such speculations seem ever closer to reality.

Recent Literature and Research

In the last 10 years scholars have attempted to understand the relationship between technological change and the spatial location of jobs and people. While this work is diverse, it can be categorized into five main areas:

- The geography of high-technology.
- Localization and clusters.
- Telecom and global cities.
- Urban futures.
- Sector-based analysis of the impact of technology on industry and residential location.

Geography of High-Technology

In the last two decades employment in innovation and research-and-development (R&D)-based manufacturing and services (e.g., software) has been growing faster than less technology-intensive manufacturing. Increased employment in areas such as software development, telecommunications equipment, semiconductors, aircraft, computer hardware and other electronic equipment, and biomedical technology comprises a growing share of many regional and urban economies.

As a result, many researchers have focused on understanding the locational patterns of industries producing high-tech products (Oh and Masser, 1995). For example, researchers have studied the determinants of growth in technology-based regions such as Silicon Valley (Saxenian, 1993), Boston’s Route 128 (Todtling, 1994), Los Angeles

(Scott, 1988), New York (Willoughby, 1995), and North Carolina's Research Triangle Park (Luger and Goldstein, 1992). Others have studied the locational preferences and patterns of different high-technology industries such as biotechnology (Haug and Ness, 1993; Hall et al., 1987), software (Egan, 1994), and computer equipment (Park and Lewis, 1991). Other work has focused on the extent to which high-technology locates in rural versus metropolitan areas (Glasmeier, 1991). Still other work has studied technopoles, technology-based concentrations around the world, particularly where some kind of government policy intervention has occurred (Castells and Hall, 1994).

Location factors for high-technology are different from industry in general. A well-educated work force—including a high number of technical workers and engineers—a good quality of life, proximity to research universities, and an existing agglomeration of other technology-based firms are key factors in explaining regional high-technology growth.

Studies of the location of high-technology manufacturing suggest that it is more concentrated in metropolitan areas than less technology-intensive industries. In 1982, 88.6 percent of high-technology employment was located in metropolitan areas (Barkley, 1988). David L. Barkley found that high-technology manufacturing grew faster from 1975 to 1982 in metropolitan than in nonmetro areas and, within metros, suburban counties grew the fastest. However, high-technology employment does not necessarily stay fixed in these locations. Mark Schneider and Duckjoon Kim (1996) found that high-technology employment was becoming more geographically dispersed between 1977 and 1987. As high-technology employment grew, spatial distribution occurred—at least among the 184 metro counties in their sample. In other words, a smaller share of the industry's employment was in a fixed number of metro areas. And, high-technology manufacturing showed greater spatial mobility than other kinds of manufacturing, or economic activities in general. This may be a natural reflection of spatial change that reflects product cycle activities (Rees and Norton, 1979). As high-technology production matures, its prevalence is more likely to be found in lower cost areas, where the need for spatially proximate suppliers and collaborative linkages is less important (Todtling, 1994). Or its locations may reflect the fact that output of high-technology manufacturing has grown more rapidly than other manufacturing and that it has expanded by moving to new locations.

However, in contrast to manufacturing as a whole, most of the variation in growth occurred within, rather than across, the nine census regions. Schneider and Kim (1996) speculated that high-technology firms were redistributing employment to satellite cities. Studying Missouri for high-technology employment change, they found that high-technology firms were more likely to locate and grow in wealthy suburbs with higher housing costs, higher wages, and stronger tax bases. Also, distance from the central city correlated positively with growth. Schneider and Kim concluded that, because high-technology is attracted to affluent communities and contributes to their economic health, this portends a widening gap between wealthy suburbs and poorer suburbs or central cities. This is consistent with other research that suggests that within large metropolitan areas, high-technology industries appear to be more suburbanized than low-technology industries (Office of Technology Assessment, 1995).

Urban core areas possess some advantages with regard to high-technology employment. For example, much biomedical employment is related to spin-offs from universities and research hospitals, many of which, such as Johns Hopkins, the Cleveland Clinic, and Boston's hospitals, are located in central cities. The Office of Technology Assessment (OTA) argued that in general healthcare is becoming a more important economic driver of urban core economies (Office of Technology Assessment, 1995). Thus the future health of research and teaching hospitals will influence the economic health of urban core areas. Other new technologies may spin off corporate and advanced service functions already located in urban cores. For example, the new media industry such as Internet media has grown significantly in Manhattan and Brooklyn.

However, high-technology employment is largely a metropolitan-suburban phenomena. The creation of technologically based manufacturing production complexes is driven in part by their need to interact closely with suppliers, customers, competitors, and other institutions, including universities and research institutes (Castells and Hall, 1994). This need for agglomeration economies means that most jobs are in metropolitan areas. Among regions, high technology is drawn to sunbelt and western metros, but within regions, it is drawn to suburban locations. Older industrial regions, urban cores, and inner-suburban locations will fare less well in attracting and growing high-technology employment.

Localization and Clusters

A considerable volume of longstanding literature points to the external benefits to industries of a large pool of workers with the necessary range of skills, the availability of nontradable specialized inputs, and a regional milieu in which information about technological possibilities and market trends and options is readily available. Michael Porter (1990) has popularized the idea that spatially proximate clusters of particular kinds of business activities increase industry competitiveness. Porter, however, was not the first to advance this idea. The notion of competitive advantage offered by localization economies has a long tradition in urban economics, dating back to the work of Schumpeter, Marshall, and Hoover in the first half of the century (Czamanski and Czamanski, 1977). However, Porter stressed the role of clustering in fostering industry innovation. At the organizational level, innovation involves interaction between the user (innovator) and the supplier (producer). Rivalry between spatially proximate producers speeds up innovation, as does local spin-offs and related diversification. Research on flexible specialization has led many regional scientists to speculate that intraregional clusters of similar firms are becoming more important to generating competitive advantage (Christopherson and Storper, 1989; Amin and Thrift, 1992).

However, while much of the literature has focused on the rise of clusters, the actual experience of places suggests a more complex reality. Ann Markusen (1996) has shown that regional agglomerations take many different forms. For example, she discusses the hub-and-spoke model of corporate linkages between a lead company and local suppliers, such as Seattle (Boeing, Microsoft), central New Jersey (pharmaceuticals), and Detroit (autos), in which the districts are dominated by one or more large, vertically integrated firms in one or more sectors, surrounded by smaller suppliers. The satellite platform, another model, is a congregation of branch facilities of externally based multiplant firms. These normally have little interaction with the local region but, instead, communicate with parent companies, particularly using IT. Satellite platforms can be based on research (Research Triangle Park), manufacturing (auto plants in Tennessee and Kentucky), or services (back offices in Phoenix). Indeed, the economy of most of these regions is based on manufacturing, but increased use of IT has led to the rise of remote “service factories.” For example, John Goddard (1991) states that widespread use of IT is “facilitating the growth of the so-called tradable information sector in the economy.” Markusen (1996) identifies a third variant, government-anchored districts. In fact, as Markusen notes that “although the presence of Marshallian industrial districts … can be confirmed in a number of American instances, the claims made for the paradigmatic ascendancy of this form of new industrial space do not square with the experience of most rapidly growing agglomerations in industrialized or industrializing countries. Moreover, most metro areas exhibit elements of all four models."

Jean Pollard and Michael Storper (1996) came to a similar conclusion in a study that classified industries into three different types (innovation based, intellectual capital, and variety based) and tracked employment change in 12 major metropolitan areas. They found that while some metros specialized in one or two industry types, others, such as Atlanta and Minneapolis, were not specialized. They did, however, find a strong link between specialization in innovation-based employment—industries with high R&D—and overall regional employment growth.

Thus, although technology is increasing the importance of agglomeration for only some kinds of economic activity, it is more important in some places than others. Moreover, it is not clear whether the most important component of agglomeration is localization or urbanization. That is, does industrial specialization (localization) bring advantages with respect to innovation, or is innovation generated by the broader advantages of being in larger metropolitan areas (urbanization)?

B. O'Huallachain and M. Satterthwaite (1992), in a study of sectoral growth patterns in metro areas, found that urbanization and localization economies were both important in explaining manufacturing and services growth. However, in a study examining the influence of location and agglomeration on innovation in metal-working firms, Bennett Harrison, Maryellen Kelley, and Jon Gant (1996) found that while localization economies—the presence of a larger number of metal-working firms in an area—were important in determining the adoption of new production technology, urbanization economies were more important. In fact, they found that after controlling for plant and firm-specific variables, metal-working firms in counties adjacent to core counties—outer suburbs or exurbs—of both large and small metros were the most innovative. Firms in rural counties were least likely to adapt, followed by firms in core counties of large metros. Moreover, in contrast to the literature that stresses the importance of large metros to innovation, Harrison and his colleagues found that firms in small metros were more innovative than firms in large metros. However, it is possible that selection bias is involved and that suburban locations house more innovative firms as opposed to any aspect of the suburban environment being more innovative. In either case, their study suggests that more innovative metal-working firms are located in the suburbs.

Notwithstanding a growing literature on clusters and industrial districts, debate continues on a number of issues, such as whether innovation is stimulated by local rivalry or collaboration, or whether the most important knowledge transfers come from within or outside a core industry. In addition, there is little agreement on whether spatial advantages are becoming less important with the rise in IT. Because of the increased importance of innovation and information processing, many argue that the new industrial economy increasingly favors cities. For example, Goddard (1991) argues that "the city is—and always has been—the focus for information processing and exchange functions; as information becomes more important in both production and distribution, so the pivotal role of certain cities is reinforced." He states that IT will enhance the role of cities with regard to the development of new services and relationships. And with the rise of a postindustrial information economy, where information consists of an ever-increasing share of the GNP, such speculations seem ever closer to reality.

Yet, these arguments often presume that cities and metros are exactly alike. While it may be true that cities used to be the central focus for information exchange, if metros in general can do this job just as well if not better, implications for core cities are very different than if they cannot. Moreover, if much of the information industry involves processing rather than generating information, localization is not as important. In fact, OTA concluded that IT is reducing the importance of localization economies as activities can easily communicate across space (Goldberg, 1997). For example, in designing its new 777, Boeing relied on a worldwide network of engineering and design all linked together electronically in a virtual design team (Pollard and Storper, 1996).

It is possible that information-based industries simply have a low propensity to agglomerate and that IT linkages enable dispersed locations without any adverse competitiveness impact. For example, Pollard and Storper (1996) found that all 12 metros had growth in information-based employment but only one-half had location quotients above one. They suggest several possible reasons for this lack of specialization, including the emergence of new specializations. But they also suggest a "more daring hypothesis" that "the telecommunications revolution is making possible a less agglomerated growth pattern." However, they acknowledge that more research is needed.

Telecom and Global Cities

A third area of research has focused on the role of telecommunications technology in fostering a global division of labor and the consequent strengthening and restructuring of so-called global cities. These researchers postulate that global telecommunications systems allow a select group of cities to emerge as global command and control centers linked by telecom to production facilities worldwide (Castells, 1989). For example, S. Sassen (1989) argues that it "is precisely because of the territorial dispersal facilitated by telecommunications that agglomeration of certain centralizing activities has sharply increased." These activities are generally higher level corporate command and control services, including global banking, financial services, and corporate headquarters. Within these higher order services, "improved technology broadens the hinterland which the existing centers can serve" (Simmons, 1994). For example, Barney Warf (1995) documents the rise of global telecom systems as driving the growth of global cities and dispersal of back offices around the world.

According to this line of thinking, telecommunications has accelerated a global division of labor, allowing corporations in industrial nations to move routine production to developing nations and, increasingly, to specialize in advanced corporate command and control functions (Moss 1987a, 1987b; Hepworth, 1990; Kellerman, 1993). The rise of global cities such as Boston, Chicago, Los Angeles, New York, and San Francisco are offered as evidence.

Much of this research focuses on the advanced telecommunications infrastructure in global cities as evidence that they possess a unique competitive advantage. Some researchers point to statistics showing the large share of telephone traffic that originates in global cities. For example, more than 40 percent of all telephone traffic in Canada is from or to Toronto. Peter Hall (1995) states that "within the urban hierarchy, a few key locations are emerging as global sites for data and communication networks." P.G.W. Keen argues that an advanced telecommunications infrastructure will be a key determinant of whether cities and regions attract or lose business. K.A. Duncan and J.R. Ayers (1987) point to "teleports" as futuristic analogs to maritime ports and facilitating economic activity in concentrated areas.[3]

Although these arguments may have been valid in the 1980s, today the evidence for differential telecom infrastructure, at least among metropolitan areas, is weak. For example, with respect to teleports, technological advance has largely bypassed teleports for anything other than transmission of television and other video media. Fiber-optic cables across the oceans now permit information to be routed anywhere in the world, expanding access dramatically to any place in North America with access to fiber-optics. Because fiber now extends across the country and within most metro areas, it is truly a dispersed infrastructure. Office of Technology Assessment (1995) found that the ability to transmit and receive large amounts of information rapidly will be critical in the competition for jobs and industry. However, the report also noted that "just as the spatial distribution of the electrical power infrastructure helped shape urban development, so too does the spatial distribution of the telecommunications infrastructure shape development today. Moreover, like electrical power networks, advanced telecom infrastructure is rapidly diffusing across the country, minimizing competitive differences based on infrastructure alone."

In short, global cities appear to have few or no advantages with respect to advanced telecommunications when compared with other metropolitan areas, particularly large and medium-size metros. Thus it is not the technology itself that has allowed a concentration of advanced command and control functions in a few cities. Rather than the advanced telecom infrastructure attracting and retaining global firms, it is more likely that global cities have strong telecom systems and a large share of calls because they have more intensive telecom users.

Given that the technology is relatively uniform, and that it may increase locational freedom of companies (as discussed below), what does this mean for the future of global cities? Some globalists argue that technology is not likely to change cities because many people and companies like locating in them. Rather, technology will reinforce the dominance of global cities (Salomon, 1996). By extension they argues that the technology revolution will have very little affect on large cities generally and will not change their competitive position. For example, Salomon argues that "cities … are immense systems, not likely to change radically in response to some new economic activity or technology."

However, this argument has several limitations. First, global command and control functions are a relatively small part of the economy and, as such, are affecting development in only a few major cities. As Alex Schwartz (1993) notes:

> It is unclear how many jobs within corporate service firms actually involve direct contacts with client companies, jobs that are usually rooted to central city agglomeration economies. Many other jobs within these service firms can be, and are, relocated outside the city…. Corporate services, therefore, are not critical to the economies of many U.S. cities.

Moreover, many other business services, such as engineering, R&D, data processing, and personnel supply, are not tied to central cities. Also, restructuring and reengineering of corporate offices to downsize management functions run counter to the claim of centralization (Wilson, 1994).

Second, because of the high costs of global cities, it is not clear that they have a sustainable advantage or that they will be able to sustain a large enough share of specialized information jobs to maintain growth, especially as routine service and production jobs shift to lower cost regions (Pollard and Storper, 1996). Third, most urbanists use the terms city and metro area synonymously. Even if command and control functions locate in large metros or global cities, they may not necessarily locate in urban core areas. Rather, as the recent decision by Swiss Bank to locate in the Connecticut suburbs of New York City indicates, companies may choose suburban locations.

Finally, many urbanists use misleading analogies from the physical world. Some suggest that cities are becoming nodes of the network-based economy, the way airports and Internet hosts are nodes in the travel and cyber worlds, respectively. Yet, such analogies are at best only partly valid. Indeed, one of the aspects of information technology on the World Wide Web is that the action does not take place at the nodes, which are passive switching stations. Instead, the action occurs at the extremities among dispersed users. In other words, in the new dispersed telecommunications environment, nodes have little meaning. They are largely an invisible aspect of a seamless system connecting users in one place to users in another.

Urban Futures

A fourth area of research speculates about the widespread application of information technology, particularly telecommunications and the Internet, in the future of cities. Within the last 5 years, a flowering of research has speculated about the effects of the IT revolution on society in general and cities in particular (Qvortrup, 1994). This research is distinguished from others in that it is rooted not in location theory or other geographic and economic disciplines but rather in sociology, architecture, political science, and other disciplines. As a result, with respect to the impact of IT on cities, this work is often speculative and general. As Stephen Graham and Simon Marvin (1996) note, "Debates on cyberspace (and cities) tend to be simplistic, taking either a utopian or dystopian form. Cyberspace is seen as totally liberating and good or totally dangerous and all bad." Many use IT-generated metaphors to describe the new city, such as: wired city (Dutton, Blumler, and Kraemer, 1987), city of bits (Mitchell, 1996), intelligent city (Laterasse, 1992), telecity (Fathay, 1991), informational city (Castells, 1989), network city (Batten, 1995), and invisible city (Batty, 1990).

Many of these writers view cyberspace as embedded in and affecting all aspects of society in a revolutionary way. The dystopian view envisions IT as leading to new sweat shops conducted in global cottages at low wages; to the rise of impersonal telecommunication-mediated contact that destroys community; and to an increasingly divided society where IT leads to loss of work, leaving whole sections of the population behind and to vastly uneven development among places (Roque, 1996). Utopians see IT's liberating possibilities that allow people to work and live anywhere, reducing urban congestion, linking people to global like-minded communities, and significantly increasing productivity ("City vs. County," 1994). Both views see the IT revolution as radically reshaping society, and by extension, cities. For example, architect Michael Pittas (Marshall, 1996) has said that telecommuting will turn central business districts (CBDs) into "dinosaurs" with the "extinction of the modern office building as we know it." Yet, without careful analysis of the affect of IT on industry and residential location patterns, such generalized speculations may provide misleading conclusions that overestimate the effects of IT on cities.

Impact of Technology on Industry and Residential Location

Because the form of cities and metropolitan areas is largely shaped by patterns of commerce and industry, it is important to examine the likely impact of the IT revolution on the location of employment. The location of jobs can change as technology, product mix, and industrial organization change. Technology can be particularly important to this process since it can alter the nature and mix of inputs, including type and quantity of needed labor, materials, energy, land, information, and buildings. As these change, optimal locations also change. As Thomas Horan, Benjamin Chinitz, and Darrene Hackler (1996) note, "cities are greatly shaped by business and household location decisions, and urban form can be seen as an aggregate consequence of these locational preferences.…

If information technology alters locational decisions to some extent, the resultant urban form may also change." Conventional location theory assumes that the organization has one production function and that the organization seeks to optimize its location by trading off factors such as access to resources, markets, labor, and other production costs. However, the IT revolution is increasingly allowing the disintegration of companies through the physical separation or outsourcing of functions (Ewers, 1995). As a result, what used to be one location decision, now becomes a multiplicity of decisions, each corresponding to the particular function (Horan et al., 1996).

Relying on location theory and studies of actual industries, companies, and households offer the most promising approach to understanding the impact of technological change on cities. And yet while most promising, this approach is also least studied. These phenomena need to be studied at the level of the sector, the firm, and the household.

Some work has been done. In assessing the impact of technology on cities and metros, OTA conducted detailed sector studies of a number of industries, including freight transportation (O'Neill, 1995a), wholesale trade (Glasmeier and Kibler, 1995), finance and banking (O'Neill, 1995b), and telecommunications. Amy Glasmeier and Marie Howland (1995) studied a number of industries, including banking; Patricia M. Mokhtarian, Susan H. Handy, and Ian Salomon (1995) studied telecommuting patterns; and John Bodenman (1995) studied the securities industry. In a study of the data processing industry, Howland (1993) described the technologies used currently and those expected to emerge, the different production processes, and the different types of processes in urban, rural, and overseas locations.

Only this kind of firm and sectoral analysis will allow accurate predictions. More work at this level would add to the understanding of technology's impact on cities. The following section summarizes the expected impacts of technology on cities and metros based on the literature reviewed above.

The Impact of Technology on Location

New technology can change the spatial distribution of industry and people in several ways. First, the widespread distribution of new types of physical infrastructure makes new locations accessible and cheaper. For example, the building of the interstate highway system allowed manufacturers that were traditionally dependent upon rail and water to locate in other areas. Today, widely deployed advanced telecommunications infrastructure may allow some information-processing firms to locate in more peripheral areas.

Second, industries or demographic cohorts with different locational patterns grow or decline at different rates. For example, increases in agricultural productivity, largely a result of mechanization and application of biochemical and biological processes, reduced farm employment, leading to the migration of 24 million people from rural to metropolitan areas between 1922 and 1954. More recently, the increase in central city employment in the late 1970s and 1980s was due, in large part, to the absolute and relative employment growth in sectors such as legal services, banking, and other producer services (Noyelle and Stanback, 1984; Beyers, 1989). For example, the doubling of legal service jobs from 1977 to 1987, an industry heavily concentrated in urban downtowns, contributed to the turnaround of the decline of many central cities (Warf and Wije, 1991). These new legal jobs required an estimated 120 million square feet of new office space—equivalent to three Chicago central business districts (Office of Technology Assessment, 1995).

The importance of differential sectoral growth patterns should not be underestimated. Different industries and occupations/functions within industries have different locational patterns. For example, OTA found that some industries, such as law and securities trading, tend to locate in urban core areas. Others, such as data processing and insurance, tend to locate in suburbs. B. O'Huallachain and N. Reid (1992) found that many service industries (including personal services, computer programming, engineering, and R&D) do not appear to require close informational linkages with other firms that characterize central business districts. In contrast, other services, such as advertising, accounting, and legal, have been more bound to central cities. Therefore, if technology forces urban-based industries to grow more quickly, their "mix" effect will be positive, leading to increased urban growth.

In fact, quick growth has been happening. Employment in producer services has grown in central cities because the sector has grown nationally. However, the rate of growth of producer services in core counties of larger metros is slower than in the suburbs or midsize metros. Between 1974 and 1985, core counties of the largest 40 metros gained 2.5 million producer services jobs, but they would have had to gain an additional 1 million to keep pace with growth in the rest of the Nation (Glasmeier and Howland, 1995). The fastest growth in producer services has been in the suburbs (Howland, 1991). In other words, while central cities had a favorable industry mix, they were losing their share of these jobs to other places.

There are two technological drivers of differential growth—productivity and new products. Productivity in goods production has outpaced services significantly over the last 40 years, leading to a relative increase in service employment. Productivity in more routine services appears to be growing more quickly than in more complex, higher order services, leading to higher employment growth in the latter. Similarly, new ITs may lead to increases in employment in the telecom and media industries. Continuation of these trends suggests that metropolitan areas will continue to have advantages.

Third, technologies can influence where people live, in turn, influencing where firms locate, particularly firms that serve local markets. For example, the development of air conditioning made large sections of the south and west attractive to millions of people. Advances in medical technology enabled a larger share of the population to live longer after retirement, allowing the retirement population of States such as Florida, Texas, California, and Arizona to expand significantly.

Finally, and the focus of most research, the location of jobs can also change as technology, product mix, and industrial organization change. The rest of this article will focus on this aspect of technology change.

Technology Allows More of the Economy To Be Operated at a Distance

Historically, cities rose and grew as centers of transactions and commerce, largely because of the need for physical proximity among firms, suppliers, and customers. Agglomerations of people, infrastructure, and industry allowed for efficient production, transport, and distribution of goods and services. By allowing activity to be physically farther apart, yet functionally still close, advances in technology, particularly new transportation modes (e.g., train, electric trolley, cars, and trucks), helped shape the first industrial city and the mass-production metropolis. Today, new information technologies are creating closer connections among economic activities, enabling them to be physically farther apart (Johnson, 1991).

Three factors determine the extent to which widespread diffusion of these advanced technologies will alter the location of industry and employment:

- The degree to which functions can be cost-effectively transformed into electronic flows facilitated by telecommunications.
- The degree to which these new activities still require spatial proximity to suppliers, customers, competitors, and other units in the firm.
- The degree to which other urban advantages remain important.

Information technology is allowing information functions to be conducted through telecom. Thirty years ago information was generated on paper and transferred physically, requiring filing clerks, messengers, and sometimes pneumatic tube operators, to transport it in large offices. Today, a small but growing number of offices are moving to computer-based systems for practically all information. For example, in a growing number of insurance companies, centralized customer information files containing the history of customer interactions with the company allow a customer service representative to see the customer's entire history with the company. On the whole, IT appears to be leading to a shift from transactions and learning based on face-to-face communication and the shipment of goods to one based on less expensive electronic forms of communication.

The effect of greater numbers of electronic transactions appears to be a loosening of spatial linkages between firms and their suppliers, customers, competitors, and other units within the firm. Industries performing routine functions—but located in urban areas because of the need to transport or display physical goods (for example, back office operations of some wholesale banks)—are increasingly freed from the need for proximity through application of IT. Similarly, industries requiring frequent face-to-face contact—for example, architects in design teams—might now be able both to communicate using electronic means such as e-mail, shared computer-aided design, and video telephones, and to locate in suburban locations.

How technological change will spatially reorder economic activity will depend to a great extent on the type of function involved. Because the nature of linkages differ depending on what is being done—moving goods versus moving information, face-to-face contact versus electronic contact—the next sections examine those functions: routine front office (customer interaction), routine back office (no direct customer interaction), goods production and distribution, complex back office, and telework. The functions that can be farthest apart spatially are generally those that are the most routine and most information-based (as opposed to involving the physical transfer of goods or paper).

Routine Front Office Functions

Historically, the location of most service employment was dictated by local demand. Branch banks, retail stores, customer service centers, and other consumer functions were widely distributed to serve local customers. However, mail order catalogues allowed customers in remote locations to buy goods. Developments in computing technologies, database access, and telecommunications have increased the share of services that can be sold without physical proximity to the customer, although functions involving some transmission or manipulation of physical goods are likely to be bound by the location of their customers.

These customer access technologies have allowed a number of functions to be moved from neighborhood sites to central processing facilities. For example, many banks have moved loan-processing and other functions from local branches to centralized customer service centers where face-to-face contact with the customer is nonexistent.[4] Telephone technologies have also made it increasingly possible to locate telemarketing and other phone functions in distant locations. For example, Omaha and San Antonio are centers for a large number of telemarketing firms ("Business Services," 1995). Similarly, when residents of London call to inquire about processing city parking-ticket fines, the calls are processed in a small city in northern England.

Many of these remote functions will now be accessed by consumers directly, often from home. Thus major banks, software companies, and information service companies are all gearing up for what they expect to be a major new market in distribution of financial services using the information superhighway. The transition away from traditional local retail structures toward direct customer access seems likely to continue as customers grow more comfortable handling a wider range of transactions without face-to-face contact.

For example, online shopping is expected to increase from $518 million in 1996 to $6.6 billion in 2000, with the largest increases in computer products, travel, and entertainment (Sandberg, 1996). Companies such as Amazon.Com (books), CDnow (compact disks), E*Trade Securities (stocks), and Security First Network Bank (banking) sell only through the Internet. Widespread diffusion of greater bandwidth to the home, widespread adoption of Internet access, greater security measures, and Internet commerce links that allow consumers to order directly from the manufacturer and receive the attendant discounts create the potential to significantly increase electronic commerce. For example, airlines offer discounts for Internet ticket sales, passing on savings formerly paid as commissions to travel agents (Sandberg, 1996). Most Internet shopping is now between customers and retail outlets. When it moves to the wholesaler and manufacturer, the consumer may realize large cost savings generated because the retailer has been bypassed. For example, electronic grocery shopping is expected to bypass grocery stores altogether, shipping instead from regional warehouses and distribution centers (Richards, 1996). Because of savings in real estate and labor costs, some economists estimate that it may be possible to serve customers in the home for the same price as grocery store shopping. Home banking is also likely to take off within the next few years. For example, 10 major banks have teamed with IBM to offer complete home banking services (Weber, 1996).

In summary, a significant share of activities such as banking, travel reservations, and shopping that occur in neighborhood shops could be replaced by electronic interactions. This would lead to the development benefits shifting from dispersed face-to-face businesses in neighborhoods and malls to concentrate in a few back office and warehouse locations where such services are administered. These are likely to locate in lower cost regions and lower cost areas of the metro, usually outer suburbs or exurbs.

Routine Back Office Functions

Back office work, or routine work not directly dealing with customers, is increasingly mobile because of IT. Historically, large-scale back office functions were behind the front office, usually in the CBD. The back office was like an assembly line where paper was processed and information added at certain places (Moss, 1990).

Because linkages between routine back office functions and customers' firms are relatively limited, these functions have been more footloose than front office or managerial and professional back office work. Moreover, the routine nature of the work has meant that information technologies were applied early, facilitating spatial decentralization. The growing share of easily transmitted digital information, along with effective intrafirm communications, has meant that many back office functions can be easily physically separated from front office and complex back office work with small losses in overall efficiency. In addition, IT is a factor in the growth of average firm and establishment size in the service sector, making it easier for companies to split off routine functions from more complex functions to put each in its optimal location (Office of Technology Assessment, 1995).

IT is enabling a larger share of back office work to be separated physically from the place where paper is processed or people interact. For example, the U.S. Postal Service is using optical character readers (OCRs) to read addresses on mail, which is then bar coded and automatically sorted to its appropriate substation. Addresses not recognized by the reader are digitally photographed and transmitted to a computer screen where an employee manually types the address into a terminal (McAllister, 1994). Although OCR sorting takes place in Washington, D.C., at the central mail facility, the manual address entry is done in Greensboro, North Carolina, where wage rates are lower. This system is being implemented nationwide.[5]

In summary, back offices are becoming more locationally footloose with IT (Richardson and Gillespie, 1996). The increased locational freedom afforded by IT to service functions, particularly less complex and less innovation-based functions, suggests that cities and metros that have depended on back offices may not be able to do so in the future. As Graham and Marvin (1996) note, "the routine service employment that offered hope for resuscitating urban economies in the wake of the collapse of manufacturing seems increasingly under threat." Another study concluded that "information and communication technologies are increasing location options, allowing industry and commerce to seek lower factor costs and, in the case of knowledge-intensive industries, high amenity, as jobs follow people into suburban or fringe locations" (Brotchie, Anderson, and McNamara, 1995).

Goods Production and Distribution

Processing goods involves four main components: production, transportation, distribution, and sales. Within production, it is worthwhile to distinguish between technologically advanced, complex production and more routine production. The development of mass-production technologies has allowed decentralization, both in this country and overseas, of a considerable share of routine production. Many manufacturing firms have spun off low-skill assembly and warehousing functions to low-cost regions, in part because telecom facilitates communication between physically distant headquarters and these branch facilities (Scott, 1988).

However, for nonroutine production, cities and large metros have more advantage. As discussed above, high-technology industries are more likely to locate in metropolitan areas. As manufacturers shift to more flexible production and to goods with shorter product life cycles, agglomeration economies become more important, favoring core locations closer to markets, suppliers, and a skilled, adaptable work force (Markusen, 1994; Barkely and Hinschberger, 1992).

Within wholesale trade and distribution, telecom and new IT practices such as EDI and bar coding allow products to be delivered to the customer more quickly than before. Moreover, the declining real cost, increased reliability, and increased speed of many forms of transportation—particularly integrated, all-air cargo operations—mean that distributors do not need to be close to the final customer, allowing in turn a consolidation of distribution facilities. These larger distribution facilities tend to locate outside the core of large metropolitan areas, with lower land and labor costs. Similarly, technological change allows freight transportation functions to consolidate and serve wider markets from fewer areas. During the past two decades, most of the growth in warehousing and distribution has occurred on the periphery of America's metropolitan areas. This trend is likely to continue, driven by new technologies and operational practices, combined with increasing consolidation (Glasmeier and Kibler, 1995).

Complex Back Office Functions

Even though information technology builds linkages in cyberspace that weaken, if not substitute for, physical space, not all functions are amenable to such less tangible linkages. Many functions, though supplemented by IT linkages, still depend on face-to-face proximity. These are more complex functions that are nonroutine in nature and usually undertaken by managers, professionals, and executives in industries such as accounting, law, consulting, and R&D and offices in corporate and regional headquarters. In addition, innovation and development of new products and services is a nonroutine, predominantly metropolitan function—in many cases, an urban core function. IT appears to be bringing about an increase in the share of more complex functions and employment by changing labor requirements, product and service offerings, the product and service cycle, and the innovation process (National Academy of Sciences, 1994).

Face-to-face interactions are still critical in many industries and functions. In some industries, such as accounting and consulting, professionals usually meet in the offices of their clients. In contrast, in industries such as banking and legal services, which still tend to be concentrated in urban cores, clients usually meet in the service provider firms (Beyers and Lindahl, 1994). Traditional localization economies—clusters of firms in similar industries—continue to be important for innovative functions. Although IT is increasingly used in these activities, it does not substitute for close physical proximity or face-to-face contact but—due to the complex and highly varied nature of the interactions and information being transferred—supplements it.

Yet, a number of new technologies at least conceptually have the potential to reduce the importance of spatial proximity in communication. For example, the portable computer and telephone, e-mail and Internet connection, facsimile (fax) machines, and videophone all make distance communication easier. Ubiquitous computing, high-definition displays, and high-speed communications will accelerate this trend. While these innovations make it easier and cheaper to communicate over distance, there are at least two reasons why they may not substitute for a large share of face-to-face needs.

First, the extent to which technology can replicate face-to-face communication is not clear. Such communication not only has richness and contextual advantages, but also includes informal, "water-cooler" conversations and meetings over lunch. Technology developers are working on devices to overcome these limitations, such as videophone systems that randomly call other group members for informal, spontaneous chats, and ways to allow users to enter "hallways" for e-mail conversation. As work groups gain more comfort with these systems, they may be willing to use them over a distance. However, to date, the ability of these systems to foster productive relationships at a distance has not been proved. In addition, relatively little is known about how organizational learning occurs. As more functions and sectors in the economy adopt flexible production modes and continuous innovation strategies, organizational learning becomes increasingly important. The extent to which this can occur in scattered settings is not clear.

Second, some industries and functions within other industries may be more willing to use these systems to decentralize than others, probably depending on the extent, nature, and importance of communications and the extent of cost competition in the industry. Professionals, such as doctors, lawyers, architects, engineers, and scientists, who depend upon face-to-face communications, may be especially resistant. For example, one study found that coworkers need to be less than 70 feet apart to share information casually (Goldberg, 1997). One anecdote illustrates that proximity may continue to be important. An attorney in a mid-size Washington, D.C., law firm recently moved to a more spacious and plush office at the other side of the building, requiring a short walk to the rest of her colleagues. After about 2 weeks of feeling isolated the attorney asked to return to an office next to her colleagues. It is not likely that any kind of technology advance, at least in the next decade, will overcome the need for proximity in these situations.

These technologies do appear to facilitate communications among groups located in different central locations. For example, Xerox is using an e-mail and video-conferencing system to facilitate cooperative R&D efforts among groups of scientists and engineers around the world. Similarly, consulting firms such as Arthur Andersen use Lotus Notes to communicate and work cooperatively with its offices worldwide. In both cases, the employees involved are in central locations (for example, Palo Alto and New York).

Telework

Telework—the partial or complete substitution of an employee's normal working hours in a traditional office or other workplace for the home or alternative workplace such as a neighborhood telework center—is a growing component of all types of work. Telecommuting reduces commuting time and is accomplished through IT. The terms *telework*, *telecommuting*, and *distributed work*, refer to the substitution of transportation for the use of telecommunications and other IT (Nilles, 1975).

Telework includes people who telecommute, self-employed people who work at home, and mobile workers who use IT and telecom to do their jobs. A teleworker may use a laptop and modem at the customer's site to conduct business; a telephone, fax, computer, and/or modem to work out of a permanent office located in the home; or a cellular telephone to conduct business while in a vehicle.

Three kinds of tasks are amenable to telework: routine information-handling tasks, mobile activities, and professional and other knowledge-related tasks (Office of Technology Assessment, 1995).

- **Routine information-handling tasks.** Employees in these positions perform well-defined tasks using telephones, fax machines, or computers with modems in such a way that they are not tied to a physical location. Thus a customer service representative who uses a computer to answer telephone queries or input information into a computer from toll-free telephone calls may be a candidate for telework. Directory assistance, dispatching, and data entry may also be suited for telework. Conversely, if specific paper or other resources tied to a central location, such as a library, are necessary to complete the tasks, telework is not appropriate.
- **Mobile activities.** Field service representatives, delivery personnel, and field salespeople are examples of employees who perform their duties at the customers' or vendors' sites. They may not require an office environment except for occasional meetings or to use shared resources. Many employers use telework arrangements for such workers to encourage more direct contact with customers and to save the cost

of unoccupied offices while the workers are offsite—a concept called *hoteling*. For example, American Express' travel-related services, the division that services commercial accounts accepting their credit cards, had representatives report to 50 field offices throughout the United States. Now, through the use of laptop computers, e-mail, and cellular telephones, agents spend little time in offices that have subsequently been downsized. Hoteling saves office costs but requires special workspace arrangements, as well as sophisticated telephone and networking tools.

- **Professional and other knowledge-related tasks.** "Knowledge workers" manipulate, analyze, or otherwise process information in a nonroutine manner and may spend many hours with telephone, fax, computer equipment, and/or paper documents. Thus consultants, translators, marketing personnel, authors and editors, software engineers, executives, and others may telework from home or while traveling. This set of tasks may overlap with the other categories. For example, a consultant may work at home or at a customer site, performing both knowledge- and mobile-worker activities.

One estimate suggests that 40 percent of the workers in the United States have jobs suitable for telework at least some of the time, but many of these workers may not prefer or be suited for telework or their managers may not encourage telework. The U.S. Department of Transportation (DOT) estimated a total of 2 million telecommuters (1.6 percent of the labor force) in 1992, telecommuting an average of 1 to 2 days per week, working mainly out of homes (99 percent) (U.S. Department of Transportation, 1993). DOT forecasts that the number of telecommuters would increase to 7.5 to 15 million by 2002, telecommuting an average 3 to 4 days per week, with about one-half working from telework centers. This amounts to 5 to 10 percent of the forecast labor force. A 1991 forecast estimated that the number of U.S. telecommuters would grow to 12 to 25 million by 2002 (Nilles, 1991a). The estimate is generally seen to be optimistic, assuming that all factors favorable to telecommuting come to fruition.

However, these optimistic forecasts are unlikely to come to pass. First, claims about the importance of hoteling, telework, and virtual offices "rest on a handful of cases which are constantly repeated, thus creating a telework mythology." (Richardson, Gillespie, and Comford, 1995.) Second, as OTA notes, many employees and managers do not want full-time work at home. Some kinds of physical interactions, including water cooler conversations, are still important to many kinds of work and organizations (Office of Technology Assessment, 1995).

The optimistic forecasts of hoteling are also not likely to come true. Hoteling is successful in many applications where field service technicians, sales representatives, or consultants are in the field most of the day. Through hoteling, the accounting firm of Ernst & Young reduced its office space needs in Chicago's Sears Tower by 10 percent.[6] However, other kinds of employees require dedicated space and equipment to perform their work, even if they are not in their offices for the entire workday. If only a few employees in an office can practice hoteling, management may not perceive sufficient savings to implement it because real estate cost savings would be marginal. However, both telecommuting and hoteling are likely to grow because of IT, although probably by less than proponents claim. Both practices mean more locational freedom for people and jobs.

Impacts of New Technology on Rural, Urban, and Suburban Economies

It is difficult to anticipate what may occur in the future. New, powerful information and telecommunication technologies continue to be developed, and their impacts on industrial and residential location are still evolving. However, it is possible to see how advanced technologies are changing the locational patterns of individuals and industries, and, on the basis of this, to predict how these changes are likely to affect metropolitan economies in the United States over the next 10 to 20 years.

Urban/Rural Growth

IT and telecom are making the location decisions of an increasing share of the economy less dependent on face-to-face contact and close proximity with customers, suppliers, and competitors. This reduced dependence and concomitant rise in a company's ability to be footloose invites speculation about the radical decentralization of jobs from metropolitan areas to smaller cities and rural areas. Indeed, many back office and consolidated front office functions have been located overseas. Several U.S. insurance companies have followed New York Life's lead by establishing life insurance-processing operations in Ireland. They benefit from relatively low wages for well-educated workers with mathematical and computer skills and a lower employee turnover rate (McGahey et al., 1990).

Some economists argue that higher skill functions will also be increasingly conducted electronically from overseas locations (Wolman and Colamosca, 1997). Yet so far these relocations appear confined to a few specific functions, particularly computer programming. Motorola has established computer programming and design centers in India, China, Singapore, Hong Kong, Taiwan, and Australia (Bradsher, 1995). Similarly, the number of computer programmers in India working for companies located in the United States has grown. This is consistent with locational patterns in programming, which has been done off site for many industries. However, as discussed below this does not signal the beginning of an overseas migration of skilled U.S. jobs.

Among companies that locate functions in smaller towns of the United States, Rosenbluth Travel, one of the largest travel agencies in the Nation and headquartered in Philadelphia, moved its 200-employee reservations center from downtown Philadelphia to Linton, a small town in North Dakota, to save on labor costs. Rosenbluth also had voiced concerns about labor quality. Functions that require relatively low skills and a high percentage of clerical workers are more likely to be located in smaller places (Richardson, 1996). Examples include telemarketing, where operating costs must be kept to a minimum and travel and services needs are limited.

Rural areas have grown in the 1990s. According to Kenneth M. Johnson and Calvin L. Beale (1995), the U.S. rural population grew by 1.2 million between 1992 to 1994, almost equal to the 1.3 million growth in the decade of the 1980s. But, much of this growth is in retirement counties or in areas adjacent to metros where residents commute to edge cities. Beale and Johnson attribute the causes to a general trend toward deconcentration, made possible by technology and precipitated by urban diseconomies, such as crime and traffic. But this is not locational freedom to go anywhere—only 45 percent of rural remote counties gained residents between 1992 and 1994. Most of the nonmetro growth was in counties near metropolitan counties.

For several reasons, technological change is not likely to lead to a widespread export of jobs overseas or to a rural renaissance like that of the 1970s (Martin and McKeown, 1993). First, much exported work is relatively routine, low-skilled, and most amenable to elimination by automation (Howland, 1991; Wilson, 1994). For example, much of the manual processing of grocery store coupons is conducted in Mexico, but new technologies and bar coding on coupons that allow them to be scanned and the information sent electronically to the manufacturer for reimbursement will eliminate these manual data-entry jobs. Similarly, in 1981 American Airlines moved its ticket-processing center from

Tulsa to Barbados. However, as ticketless travel becomes more widespread, many of these jobs are likely to be eliminated.

Second, firms may not want to lose control of operations or raise concerns about security of operations. This is especially true in banking and credit card operations. Realistically, the range of functions that can be transferred overseas is probably limited. For example, to send domestic payment transactions overseas simply to reduce labor costs would not make sense.

Third, customer service is becoming more important. For example, most insurance companies want to colocate claims processing and customer service (Moran et al., 1994). As a result, firms are hesitant to place these functions overseas because there may be problems with language, accents, cultural attitudes, and skills—all of which would make it harder to establish a rapport with customers.

Even though information technology is making it easier for work to be done at a distance, at least in the near future, many operations will locate in metropolitan areas, albeit usually suburbs and mid-size metros, for five important reasons.

Technology allows many service functions to gain greater economies of scale. Many companies are establishing central utility offices to carry out specific functions. Similarly, new technologies are allowing freight transportation and distribution functions to consolidate in smaller numbers of sites. In addition, as firms reduce middle managers, remaining managers exercise a broader span of control and are responsible for more operations. Dispersing these operations spatially would make it more difficult to manage them.

These consolidated centers are usually located in metropolitan areas. For example, when Aetna Insurance consolidated its 55 claims adjustment centers to 22, virtually all of the closed offices were located in smaller cities while those remaining open were in larger metropolitan areas. Similarly, a major bank that currently processes loans from 92 local branches plans to establish two central loan-processing centers, both in large metropolitan areas. A credit card company is considering consolidating eight locations for credit card processing, including credit analysis and marketing, into one center in a major metropolitan area.

As a rule, larger offices and facilities are in larger cities, whereas smaller cities house smaller offices.[7] When deciding which branch facilities to close in a consolidation, firms are often hesitant to close larger branches because it would require laying off large numbers of employees and hiring and training others in the smaller, expanding office. As a result, the more common pattern is to close smaller offices in smaller cities and towns and build up larger offices in metropolitan areas. In addition, because of downsizing, many firms have excess space in metropolitan areas that can be filled through consolidation. For example, an east coast insurance company located its new data center in a midwestern city because the largest of the several data-processing facilities it planned to consolidate was already located in this city (Office of Technology Assessment, 1995).

Metropolitan economies have larger, more diverse, and more skilled labor pools. This large market gives firms access to a sufficient number of qualified personnel.[8] Many firms attach as much importance to the availability of qualified personnel as they do to cost, for both nonroutine and routine functions. Indeed, one leading relocation consultant says, “Workforce availability is the number one factor in locating back offices. Cost is number two” (Office of Technology Assessment, 1995). However, these factors do not remain fixed over time. Because of the rapid growth in back office jobs in Wilmington, Delaware, by the late 1980s, banks that had built new back office facilities were expressing concern about their ability to find qualified personnel (Gang, 1993). In addition, as technology restructures work and automates many routine jobs, other jobs are requiring more skills (Noyelle, 1987). In fact, managerial and professional employment grew from 22 percent of total employment in 1972 to 30 percent in 1994. As a result, the increasing share of services with information-based employment means that metropolitan locations are important.

Metropolitan areas may also be more attractive sites for workers. For example, Gulliano has argued that the increasingly flexible work force and shortened job tenures, coupled with the increase in two-earner families, mean that location in large and mid-size metro areas increases the possibility for successful job matches (Horan, Chinitz, and Hackler, 1996). Other advantages for individuals include high-quality medical care and cultural and educational institutions.

Many firms are reluctant to locate back office operations in places with poor access. In an analysis of northern Scotland, Ranald Richardson and Andrew Gillespie (1996) found that the provision of advanced telecom alone does little to enhance the development potential of peripheral regions. As one U.S. bank executive noted, companies want to keep operations within a 2- or 3-hour drive because they want to be able to drive out and back in a day to “kick the tires” (Office of Technology Assessment, 1995). This is part of the reason for the rise of back offices in such cities as Albany and Wilmington, and small cities close to large metros, such as New York and Philadelphia. Access is also a factor leading to the location of many back office functions in places with good air travel. Sales staff, in particular, need to travel to customers whereas corporate managers need to be able to fly into areas to inspect facilities. Because corporate decisionmakers fly so frequently, air access is often important in location decisions. Metros have an advantage because they are usually served by more and less expensive flights and by more jets and fewer propeller airplanes. For example, from 130 to 132 cities are reachable by nonstop flights from Chicago and New York, respectively, compared with 31 from San Diego and 38 from Cleveland. Many firms have limited their search for a headquarters to metropolitan areas in which major airlines offer direct, point-to-point jet service. Airline deregulation appears to have strengthened air transportation from large metro areas hosting hub airports. Similarly, freight transportation and distribution relies on infrastructure (that is, ports, intermodal facilities, and air express) usually located in metropolitan areas.

Metropolitan areas offer an environment conducive to innovation and learning. As technology increases the importance of continuous product and service development, a metro location is an advantage to more firms. Innovation is also more likely to occur in communities or regions marked by vigorous competition among a multiplicity of local firms and in places where large numbers of sophisticated, demanding buyers are concentrated than in places where one or just a few firms are dominant. Moreover, rapidly changing technologies and markets mean that inter-firm cooperation is increasingly important, and this cooperation is enhanced by locating in large and mid-size metro areas. This situation is just as true of the financial community in Wall Street as it is of the microelectronics industry in Silicon Valley. Such competitive conditions have long been characteristic of major financial centers like New York and Chicago. The concentration of wholesale and investment banking firms in New York City, for example, has helped make it the leading center of innovation in global finance.

Teleworking. Some studies suggest that widespread adoption of telework would lead to more decentralized land-use patterns, as residents choose to live farther from dense metro centers in exchange for lower real estate costs, lower property taxes, and more rural settings (Kumar, 1990). The degree of decentralization depends on whether telecommuting continues to be part time for most participants or becomes predominantly full time. In the former case, residents of more remote metropolitan areas would still have to live within commuting distance of metro centers, although this distance could be considerable. In the latter case, participants could live almost anywhere, leading to a much wider decentralization of activities and a much greater impact on residential location (Nilles, 1991b). Those who think of telecommuters living in idyllic, remote locations are generally thinking of the full-time telecommuter. For example, Christopher B. Leinberger (1994) has coined the term *flexecutives* to identify self-employed consultants and executives who reside in resort towns and, with the aid of jets and telecommunications, commute to work worldwide.

Most experts expect that full-time telework will remain a small fraction of overall telework, suggesting that it is unlikely to result in a widespread shift of households to rural locations. For example, Mitchell Moss and John Carey (1994) argue that telecommuting will not displace offices, because most telecommuters do not telecommute exclusively, but that it may "allow the further dispersion of work to remote locations, by allowing workers to have greater residential choice and longer, but fewer commutes to work."

Intermetropolitan Differences

Consistent with historical patterns, new information and telecom technologies are making more economic functions footloose—at least with respect to the choice of metropolitan areas in which to locate. These technologies are making it easier to locate many operations in any region of the country, which is likely to lead to increasing factor-price equalization among regions. Historically, some regions had advantages stemming from agglomeration economies, location near natural resources, accessible transportation, and most recently an advanced telecommunications infrastructure. However, as information technology allows more distance transactions or consolidated functions, these competitive advantages are likely to lessen. As a result, lower cost regions, providing they have sufficient external economies—air travel, transportation, and labor force—are likely to grow. Moreover, widespread diffusion of an advanced telecommunications infrastructure, at least to the top 50 to 100 metros, further reduces the inherent advantages of the largest places. Advantages once held by some higher cost metropolitan areas are likely to decline and lead to concentrated dispersal to a larger number of metropolitan areas.

Once technology enables more freedom of location, the search by firms for lower cost locations is likely to continue to reshape regional employment patterns, in part leading to higher rates of growth for many lower cost smaller and mid-size metros. For example, wages are almost one-third (32 percent) higher in cities of more than 500,000 inhabitants than in smaller places (Glaeser and Mare, 1994). Office rental costs range from $14 a square foot in Denver and Tampa to $28 in Chicago and $31 in New York ("It's San Francisco," 1995).

According to one study in 1991, locating a 300,000-square-foot facility that employs 1,000 clerical and operating personnel in Phoenix, instead of San Francisco, would save $6.35 million annually—just in property and payroll costs. Between New York City and Tampa, the differential is even greater—$11.25 million a year (Office of Technology Assessment, 1995). Such cost differences were a significant factor in Salomon's choice of Tampa as a site for its new back office complex. The average annual salary of Salomon's back office staff in New York was $39,000, compared with $23,600 in Tampa (Columbia Business School, 1994). Consistent with these patterns, some Sunbelt areas that have grown rapidly during the past decade, such as Phoenix and Dallas, have seen their cost advantage begin to lessen.

Some economists have argued that one effect of IT will be to reduce the hierarchy of cities, where the position of cities is not merely determined by population size (Graham and Marvin, 1996). This means that many operations will not locate in historically high-cost metros such as New York, Boston, Los Angeles, San Francisco, or Washington, D.C., but instead in less expensive metros, many in the central regions of the country. In fact, geographic centrality aids operations by reducing average air travel distance to U.S. cities. Moreover, central or mountain time zones allow companies longer daily access to customers in all regions of the country. Geographic wage and other cost differentials will continue to encourage business relocation to low-cost regions until an equilibrium is approached.

Similarly, those places that have not managed a transition to the postindustrial metropolis may suffer. Places whose economic base remains in declining activities, particularly older manufacturing and traditional services, are likely to continue to experience relatively poor economic performance. Places with low quality of life, high crime, and poor environmental conditions are likely to decline or grow more slowly than other places without these conditions. Low-quality-of-life locations risk a continuing cycle of decline as reduced advantages (both public and private) lead to reduced economic growth, which in turn reduces advantages even more. In contrast, high-quality-of-life places—those with a skilled, moderately priced labor force; a good educational system; an attractive natural environment; low diseconomies, such as crime, congestion, and environmental pollution; and an economic base of advanced innovative companies—will continue to do well. The disparity among places in terms of attractiveness may be growing. In short, this dispersal is highly selective and uneven, and not all places will do well.

Central City Prospects

Many core city economies have grown in the last 15 years, but some have either stagnated or lost jobs. Much of the revival of central cities in the 1980s was due to dramatic growth in producer services and increased foreign immigration. Yet, the perception has grown that American cities, particularly the urban cores of many large metropolitan regions, are in trouble and may not be sustainable over the long term, drifting in downward spirals of joblessness, business failure, revenue shortfalls and declining services, crime, racial strife, and ungovernability, with middle-income families leaving while the wealthy wall themselves inside protected enclaves. For example, Edward W. Hill and Harold L. Wolman (1997) documented the gap in real mean per-capita income between suburbs of large metro areas and their central cities, which almost doubled from 1980 to 1990 ($821 to $1,603).

Technological change is likely to continue to impact urban cores. Letting more of the economy be operated at a distance threatens the economic well-being of many central and inner cities and the inner, older suburbs of metropolitan areas. The historic dominance of the central city has given way to a much more dispersed pattern of growth in which economic activity is spread throughout the metropolitan areas in other nodes and centers—what some term *edge cities*. Yet, this growth is uneven in most places. Some parts of metros, usually a select group of outer suburbs and even exurban locations, are growing quickly and becoming home to fast-growing companies, whereas other parts, particularly those of the central city and inner suburbs, are suffering from job loss, disinvestment, and poverty. A number of important changes are facilitated by technology.

The Metropolitanwide Economy

A look at urban settlement patterns in the late 20th century clearly indicates that the model of the core city as home to most of the productive capacity in the metropolitan area is no longer valid. Today, as industry has become spread throughout the metro region in large agglomerations, the metropolitan area as a whole is the functioning economy.

One cause and result of the rise of metropolitanwide economies is that technology is enhancing the locational freedom of firms within metropolitan areas. At one time, most core cities had historic advantages stemming from agglomeration and reduction of travel that compensated for their high costs. However, technological change and other factors are reducing the privileged position of the core, in some sense making it one of several edge cities within the metropolis (Kutay, 1986). By making the spatial location decisions of firms less relevant, technology has accentuated the tendency of many industries for jobs to follow people (Howland, 1991). Quality of life and cost become more important factors. As a result, the traditional monopoly of center cities as the location for many firms is likely to end. Increasingly, central cities will have to find competitive advantage from other factors, including cost, niche markets such as tourism, and amenities.

Weakened Central City and Inner-Suburb Economies

Several technological factors will put economies of central cities—particularly areas outside the central business district—and inner suburbs at risk. First, as discussed above, technology is reducing the importance of distance for many functions, particularly those that are routine. As a result, firms have the freedom of locating on cheaper land with lower cost buildings and labor. These locations are often outer suburbs or exurbs or in mid-size and small metros. Moreover, such locations provide firms an opportunity to avoid the diseconomies of crime, traffic congestion, and air pollution that are endemic to many urban core areas. In addition, because technology leads to consolidation in larger facilities—and in some cases requires new and larger facilities—many routine goods and services industries are locating in the outer suburbs or exurban and satellite areas at the edge of metros where larger and cheaper parcels of land are available.

Technology also enables a greater share of nontraded or resident functions to be centralized and moved. As a result, many of the jobs on which cities and inner suburbs rely because of local spending (e.g., branch banks, local phone service centers, insurance agents) could disappear, having been centralized and located either in other regions or in outer suburban jurisdictions. In large part, this is caused by the shift from local service delivery to regional or even national distribution service centers, a practice that favors lower cost locations outside older urban areas. Places that cannot capture these or other new functions will be at risk of decline.

These technological and economic trends suggest that the noncentral business district portions of many central cities and their inner suburbs will continue to be the weakest part of metropolitan economies for at least the next two decades and that their relative competitive position will get worse without economic development policies.

Core Specialization: Innovative and Complex Service Functions

In addition to weakening many core economies, technological change and other factors contribute to a restructuring of urban core economies, particularly in the central business district, as places containing more specialized functions employ people with higher skill and education levels. As routine work moves out of central cities, the economic base is increasingly shaped by more complex, high-end office work, including managerial and professional functions (Stanback, 1995). For example, Schwartz found that providers of services to large corporate headquarters are predominately located in the largest 10 to 20 cities in the United States (Stanback, 1995). Because 90 percent of investment banking advice to large corporations is conducted in the 10 largest U.S. cities, the importance of producer services to the economic viability of the central city has grown. In 1984, the core counties of the 24 largest metros housed 66 percent of all law offices with more than 50 employees, 75 percent of all investment and securities offices with more than 50 employees, and 39 percent of all jobs in information-intensive industries (Office of Technology Assessment, 1995). In nine major metros,[9] white-collar services constituted from 20 to 40 percent of central city economies in 1970 but as much as 40 to 60 percent of these same economies in 1990 (Kasarda, 1995). There are several reasons for this increase.

First, while technology makes work routine and movable, it also supports, especially in the services, the continuous creation of new products. In the late 1970s, U.S. financial institutions began to move beyond the automation of routine processes to using computer technology to create new products and services—a process that continues today. This is important because if product cycle theory applies to services, it suggests that innovative functions tend to be conducted where they were developed. Innovative activities in established centers usually have greater access to the specialized skills, detailed market knowledge and support services needed for the development and introduction of new products and services. Many innovative firms continue to need the kind of stimulating and supportive environment in which they first arose. In addition, established service centers may also provide the best location from which to access potential customers for new services.

Second, the rise of globalization in both manufacturing and services has meant that a larger share of the U.S. economy is devoted to command and control functions, including headquarters of multinational companies as well as large producer service firms—that is, legal service, consulting, engineering—with clients across the globe. These high-level functions are naturally attracted to a small number of global cities, including New York, San Francisco, and Los Angeles.

Finally, even though managerial and professional offices continue to disperse throughout the metropolitan area, many are still concentrated in central cities because these locations facilitate face-to-face communications. As Meier (1962) wrote, “The need for face-to-face contact offers perhaps the best explanation for the strong attraction retained by the urban center.” For example, functions such as law, corporate banking, securities trading, and professional services, such as accounting and advertising, are more concentrated in central areas of large metropolitan areas than other firms. These operations employ a high percentage of managers and professionals and require the support of large banks, law firms, accounting, advertising, and courier and postal services on a regular basis (Black, 1990).

Despite the importance attached to face-to-face contacts for binding offices to the central business district, little empirical work has been done. One 15-year-old study of firms in downtown Toronto sheds some light on differences in contact between sectors (Gad, 1979). The sectors with the greatest number of face-to-face linkages were corporate banking and legal services. In contrast, life insurance had a very low level. These data are consistent with locational patterns of these industries in the last 20 years. Overall, when tasks are complicated and instructions can be easily misunderstood, face-to-face communications are more important (Gasper and Glaeser, 1996). The rise of IT suggests that routine activities in services will continue to be able to move out of high-cost central business districts and that core cities will increasingly specialize in more complex functions.

What Is the Future for Urban Manufacturing?

In the 1960s, Chinitz (1964) pointed to the increase in efficiency of manufacturing as reducing dependence on raw materials and increasing the importance of linkages with suppliers, as a countervailing force to the continued decentralization of manufacturing. Although this might have slowed the dispersal trends, advances in transportation and communications technology have continued them. In general, manufacturing has dispersed from urban core and inner suburban areas to outer suburbs and exurban areas. There are several reasons why some manufacturing remains in urban areas (Poole and Samuels, 1994).

The first reason is inertia. Many small and medium-size manufacturers in cores stay because moving is too expensive or bothersome. However, sooner or later, the private owners of inert businesses retire or die, close their plants, and disperse their employees.

Second, some manufacturers, such as printers, food processors, construction material producers, and makers of arts/entertainment equipment, are located in cities to serve local markets (Nicholson, Brinkley, and Evans, 1981). Similarly, recycling firms increasingly locate in urban areas to be near waste supplies.

Third, some technological trends create specialized niche functions, which may give urban core areas an edge or at least help them compensate for their disadvantages. Many of these niche functions are related to innovation, flexibility, speed of delivery and response, and other factors—often described as flexible specialization. For example, as Moss (1997) points out, technological change has lowered optimal establishment size and allowed manufacturers to reach economies of scale at smaller sizes. In particular, the introduction of computer numerically controlled machine tools means that smaller manufacturers can be more competitive. The post-World War II mass-assembly factory that required a lot of space put cities at a competitive advantage because they could assemble large tracts at competitive prices. Smaller optimal plant size—coupled with the fact that new production technologies, such as reduced inventory and cellular manufacturing, use less space—has meant that small factories are more viable. The average manufacturing establishment declined from approximately 50 employees in 1977, to 42 in 1992 (Office of Technology Assessment, 1995), reducing land and building costs and pressure to migrate to areas with lower land costs. Thus locating within the confines of urban factories and warehouses becomes more feasible.

Fourth, the need to respond to rapid changes in consumer preference has made geographic proximity for some sectors an asset. Manufacturing dependent upon rapidly changing designs or proximity to upscale customers may do well. For example, textile manufacturing in Los Angeles was spawned by design requirements. Los Angeles garment manufacturers required two things: high-quality, well-designed textiles and just-in-time production to satisfy the demand for seasonal clothing changes and sophisticated fashion. These manufacturers created a local market for textile specialists from around the world—Iran, Korea, western and eastern Europe, and the eastern United States—all of whom converged in Los Angeles in the mid-1970s. Yet, even when these opportunities become economically and technologically feasible, they are likely to remain a niche function, targeting specific markets.

Finally, cities provide a pool of workers, often immigrants, willing to work at low-wage manufacturing jobs such as apparel and leather goods. Cities are home to low-wage but often skilled immigrant labor.

New York City exemplifies many elements that support the persistence of urban manufacturing. New York has a number of firms that remain because of inertia. For example, Farberware is a cookware manufacturer that has been in the same building in the South Bronx for more than 50 years. New York City's density also provides an internal market for customized food and commercial bakery products. Its role as a center for the arts and design activities spawns customized manufacturing that relies heavily on the design component, that can adapt to cyclical changes in fashion and that produces for niche markets. This helps to explain why industries such as fashion apparel, leather goods, fabricated metals, specialized and upscale furniture, cosmetics, crafts, entertainment, and specialized textiles are doing well there. New York's strong service sector likewise stimulates certain kinds of manufacturing, such as commercial printing, paper-related products, construction materials, office furnishings, and arts and entertainment equipment and supplies.

Overall, however, urban manufacturing cannot be expected to grow. Productivity growth is expected to reduce manufacturing employment nationally. And as described above, the fastest growing high-tech manufacturing sectors are generally located in suburbs. Finally, the deconcentration forces in manufacturing are at least as great as the concentration forces. However, with the appropriate policies—for example, increasing the National Institute of Standards and Technology's Manufacturing Extension Partnership resources devoted to urban manufacturing—it may be possible to stabilize urban manufacturing.

Urban Economies and Skills

Technology will likely continue to lead routine and goods-related work to disperse from the core and, conversely, concentrate highly skilled professional and managerial jobs there. In addition, technology is creating many more skilled jobs in all locations. As a result, there is a growing mismatch between the location of the new skilled economy and the large and rapidly growing population of lower skilled and often minority residents in urban cores.

In many industries future jobs will require more skills. For example, as the insurance industry uses more technology and less labor, the skill requirements of its labor force increase. Not only are organizations leaner, they must respond faster and complete tasks correctly the first time. In organizations with flatter management structures, there is no place to refer difficult questions, catch errors, or develop successors through on-the-job training. Employers expect technical proficiency in operational aspects of the business. Moreover, in many service sectors, lower skill office jobs are disappearing to be replaced by more complex customer service and back office jobs. Increasingly, customer service employees are required to have a congenial personality and pleasant voice to respond to customers, be able to solve problems on the spot, and have significant product knowledge. In addition, differences in perceived or actual work ethics can play a role in hiring.

Business responses echo this change. A bank executive from a large midwestern city noted that "we are thinking about moving more routine work out of the city since labor costs are high, and getting good-quality labor is hard. The graduates of the public schools are very bad, and as a result, we need to retrain people who can read, write, and communicate" (Office of Technology Assessment, 1995). In a 1991 survey of financial services chief executive officers conducted for the New York City Partnership, 82 percent of respondents said that the quality of entry-level workers was either "extremely important" or "somewhat important" in their choice of location for their operations, and 71 percent said they believed the quality of entry-level workers in New York City was worse in 1991 than it had been 5 years earlier (Price Waterhouse, 1991). As a result, cities face the challenge of bridging a growing gap between the skills required for employment in advanced services concentrated in urban cores and the limited skills that many entry-level big-city residents bring to the job market.

Urban Infrastructure and Buildings

Because new technologies are changing the organization of work and the nature of production processes, the potential for a mismatch between infrastructure developed for the mass-production metropolis and the infrastructure needs of the postindustrial metropolis is significant (Barras, 1987). Several urban redevelopment efforts undertaken by core cities in the 1980s adapted urban infrastructure and buildings designed for industrial and goods-handling functions to fit the needs of an information-based services economy. However, the need for adaptation is likely to continue for two reasons. First, because technological change threatens to reduce economic activity in some urban cores, there is likely to be increased vacancy and underutilization of the built environment, including infrastructure and buildings. In part, this is driven by the fact that fast-growing industries in both manufacturing and services are increasingly located in the suburbs.

Second, the changing nature of demand for infrastructure is also likely to lead to underutilization. One reason for the high rates of business suburbanization is that facilities in the suburbs are usually more readily adapted to current technology. In some service sectors, buildings that can easily be reconfigured, especially to accommodate fiber-optics and other wiring, are increasingly important. In many older buildings it is difficult to wire for computers and telephones or to change wiring. Similarly, old retail downtown stores with narrow fronts and deep backs make less sense with today's greatly reduced inventories. Just-in-time delivery allows for different store shapes. Many new back office transaction factories in the service industries require large floor areas in large horizontally laid-out buildings, in contrast to the highrise office complexes in the core. Freight transportation and distribution facilities increasingly require larger facilities, which are more available in the suburbs. Also, the move to a flow system in wholesale trade through practices like cross-docking requires new configurations of buildings quite different from older, smaller, multilevel, urban warehouses (Glasmeier and Kibler, 1995). Transportation infrastructure also sometimes does not accommodate new technology. For example, the trend toward larger trucks will further erode the already tenuous position of many older cities as regional or national distribution centers. In many cases bridges, tunnels, and arterial highways in these cities were not designed to accommodate trailers as large as those used today. Similarly, the move to double-stack railroad cars can put urban areas with low bridge clearances at a disadvantage.

Outer Suburban and Exurban Prospects

Over the next two decades many outer suburbs will continue to be the healthiest part of the metropolitan economy and the strongest parts of the national economy. Job growth is likely to continue, driven by relocations out of the central city and inner suburbs and by faster rates of expansion. In general, suburban jurisdictions housing this growth will enjoy fiscal health. However, they may be hard pressed to find the resources to pay for expansion, especially if they do not require new development to pay its share of the associated public costs, such as roads and schools. These places will need little or no assistance from State or Federal governments to promote development. Residential development is likely to continue to expand at the peripheries of most metropolitan areas, leading to increased urban sprawl and lower density developments. These trends are likely to exacerbate a number of problems, including outer suburban traffic congestion, consumption of open space, and increased gasoline consumption.

In fact, Roger R. Stough and Jean Paelinck (1996) argue that IT is leading not just to development of edge cities in metros, but to the rise of satellite cities far beyond the existing development fringe. Thus, within metros, technological change will continue to exacerbate metropolitan sprawl. “Other things such as current land-use and zoning practices at the local jurisdiction remaining as they are today, sprawl will be the continuing paradigm of metropolitan development.” But they argue that technology allows a spatial leapfrogging pattern with significant growth occurring in existing (satellite) centers as much as 50 to 75 miles from the urban fringe. They claim that these exurban centers—often with fewer than 20,000 inhabitants today—will be the primary growth nodes of metro areas over the next two decades. Existing edge cities will have to be “far more innovative and competitive to hold the jobs and firms that form their economic base” (Stough and Paelinck, 1996).

Prognosis

The IT revolution is by no means fully upon us. In fact, in terms of likely impacts on the ability of business functions to be conducted at a distance, the next 10 to 20 years will provide more impact than the last 10 or 20 (Moschella, 1997). As a result, IT is likely to continue to diminish locational constraints (Horan, Chinitz, and Hackler, 1996). Given this increased choice of location, what will become of core cities and older, industrial era metros? The most optimistic view of core cities and larger, older metros over the next 20 years includes the following:

- Cities will continue to lose their share of jobs and population, but in absolute numbers they will not decline.
- Welfare reform will lead to an increased share of urban core residents working, stimulating second-order economic activity in cities and also reducing crime and other social disorders.
- Environmental pressures, such as demands for clean air, will encourage concentrated patterns of development that reduce auto transport, leading to increased pressures for development at the core.
- Because of differential productivity growth and an increasing global division of labor, complex activities will grow faster than routine activities, leading to increased concentration of economic activities in cities and large metros.
- Technology’s ability to substitute for face-to-face contacts will be minimal.
- People will be increasingly attracted to the advantages of more concentrated urban living, such as walkable cities, particularly if relative quality of life declines in suburbs and if the quality of K–12 schools improve.
- Urbanization economies of diverse job market, labor market, supplier base, and air transport will support location in large metros.

The most pessimistic view of core cities and large metros over the next 20 years includes the following:

- People’s desire for large lots, more rural living, and escape from urban problems will precipitate even more of an exodus from urban core and inner-suburban areas.
- Industry will increasingly locate in lower cost, higher amenity areas, leading to absolute loss of jobs in large high-cost and low-quality-of-life metros and urban core areas.

- Technology will increase people's ability to telecommute and business' ability to locate in outer suburbs and exurbs, leading to significantly increased metropolitan sprawl.
- Technology will permit more connectedness among economic activities than expected—for example, video telephony will prove to be a substitute for some face-to-face activities.
- Social problems, such as crime and poor schools, in cities will either remain the same or increase.
- Cities will be caught in a downward spiral of cumulative causation—reduced revenues, reduced services, higher taxes, and reduced middle-income residents.
- Technology will increase the skills mismatch between the increasingly prevalent higher end jobs in cities and the lower skill labor force living there.

Most likely, trends over the next 20 years will lie somewhere between the pessimistic and optimistic forecasts. In particular, the current wave of technological change is likely to continue to cause metropolitan areas to grow. The United States will not undergo a radical deconcentration of employment and population shift to small towns and rural areas. Nevertheless, the relative advantages of some higher cost, and usually the largest, metropolitan areas, such as New York, Boston, Los Angeles, and San Francisco, could weaken, with lower cost, high amenity, mid-size metros seeing the fastest growth rates.

Within metropolitan areas, the national redistribution of economic activities due to sectoral and residential change will also have a dramatic effect on the location of jobs and residences. Technological change and other factors will reduce the privileged position of the core, in some sense making it one of several edge cities within the metropolis.

By widening the potential number of sites available for business location, technology has accentuated the tendency for jobs to follow people to the suburbs, reducing investment and jobs in many urban cores. Moreover, urban core economies, particularly the central business district, increasingly contain more specialized functions, employing skilled and educated people. In contrast, lower skill work—particularly in goods production, transportation, and distribution—is increasingly migrating away from the core to the suburbs. These changes will likely increase the spatial and skills mismatch between urban jobs and low- and moderate-income urban residents. The changes will also lead to reduced investment and an increasing underutilization of the built environment, with resultant fiscal problems for many urban core governments.

The most likely prognosis is that in the new information economy, some places will have trouble adapting and will face disinvestment, job loss, and fiscal difficulties. The economies of many older, higher cost metropolitan areas, as well as central cities and older inner suburbs of many metros, are likely to face increasing job loss and disinvestment, leading to underutilization of the built environment; potentially reduced central city agglomeration benefits for industry; increased poverty and ghettoization for residents, particularly minorities; and fiscal problems for local governments. Moreover, the mismatch between the location of the new economy—in the suburbs and in postindustrial metros—and the skills it demands and the large and rapidly growing population of lower skilled and often minority residents in urban cores is likely to exacerbate current economic and social problems in the urban core.

Conclusion

In the 1960s, Edgar M. Hoover (1964) studied how the Pittsburgh economy had failed to adapt to changes in technology and the economy. He stated that, "Rapid technological change means rapid obsolescence of physical facilities and skills alike. By that token it poses particularly serious adjustment problems to areas like the Pittsburgh region which have especially large proportions of their physical and human resources committed in terms of earlier technical conditions."

Today, adaptation is the central challenge facing urban core—central city and inner suburbs—and older industrial metros. Thomas Stanback (1995) argues that the future of core city economies will depend on "whether or not that economy is able to strengthen or renew those activities in which it enjoys a fundamental comparative advantage." Improving the transportation system; making the city safer, cleaner, and more attractive; and providing better housing, and dramatically reforming and improving education are important to cities for retaining their advantage. Reforming and reinventing many urban governments to reduce tax burdens and increase the efficiency and quality of services is equally as important. Here, IT can play a role by helping local government cut costs by delivering services electronically.

The close relationship between cities and technology, including transportation, infrastructure, telecommunications, process technology, and industrial and work organization, leads to mismatches and conflicts. Productive systems, especially in market-based economies, are characterized by their fluidity and openness to change, particularly stemming from the introduction of new technology systems. Enterprises are born and die, expand and contract, move and reorganize, and develop new products and adopt new process technologies. Likewise, although at a slower pace, the population's income, demographic characteristics, skills, and lifestyles also change and evolve, leading to new preferences of regions, cities, and neighborhoods.

In contrast, cities and their institutions adapt even more slowly. Without adaptation, buildings can be abandoned or underutilized and land can become vacant. Institutions can become rigid and poorly suited to new challenges. Urban political leaders can become unwilling to work for needed change, especially when it requires challenging entrenched special interests. Work-force skills and capacities can diverge from new workplace needs. Moreover, for some segments of the population, especially lower income groups, adapting to economic change is difficult, resulting in mismatches between skills, attitudes, and opportunity. Because these population groups are more heavily concentrated in certain regions and parts of metros, these places have felt the effects more profoundly.

Technology itself can also play a role in improving urban conditions. An interagency study on urban communications published in 1971 was an early predecessor to today's National Information Infrastructure Initiative.[10] The study suggested pilot applications, such as telemedicine, distance education, intelligent transportation systems, electronic delivery of public services, and video surveillance for public safety. These applications are still relevant, even though the specific technologies used to implement them have changed (National Academy of Engineering, 1971). Today, there is speculation that the IT revolution is bypassing America's disadvantaged communities, but that with the appropriate policies, it can be used to help revitalize urban core communities (Anderson and Melchior, 1995).

Some cities have been well positioned or able to adapt more easily than others because their locations, infrastructures, businesses, or populations are more suited to the new economy. In addition, because adaptation is first and fundamentally a manmade process of investment and disinvestment, some cities will simply be organized to do better than others. Thus the history of U.S. cities is in one sense a story of cities growing and prospering during certain technological epochs and then either adapting to the next phase, or not, making the transition, or declining or stagnating in real or relative terms.

Author

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Notes

1. Commonly called ISDN, integrated services digital network is an emerging technology that combines voice and digital network services in a single medium, making it possible to offer customers digital data services as well as voice connections through a single telephone wire.

2. In the late 1980s, AT&T posted about 60,000 numbers in its nationwide 800-service public listings directory.

3. Teleports are usually satellite-based facilities to uplink or downlink large quantities of information.

4. In the 1970s, many banks sorted and sent checks to their customers. Now this function is done in centralized check-processing centers.

5. These facilities can also be located in distressed urban areas if the costs of living are low enough and if, in some cases, incentives are provided. For example, the city of Gary, Indiana, is using HUD funding to construct a 20,000-square-foot building to be leased to the Postal Service for use as such a remote encoding facility.

6. Interview with officials at Ernst & Young, October 1994, quoted in Office of Technology Assessment (1995). See also Michael Bagley, J. Mannering, and P. Mokhtarian, University of California at Davis, Institute of Transportation Studies, “Telecommuting Centers and Related Concepts,” research report UCD-ITS-RR-94-4, prepared for the U.S. Federal Highway Administration and the California Department of Transportation, March 1994. According to the U.C. Davis study, Ernst & Young expects eventually to shrink its office space nationwide by 2 million square feet, for a savings of $40 million a year.

7. The larger the metropolitan area, the larger the size of the producer service firm. See Andrew J. Kremenec and Roger Cohn, “Business Services Within a System of Cities,” paper presented at the 22nd annual meeting of the Mid-Continent Regional Science Association, Chicago, May 31, 1991, cited in William Testa, “Producer Services: Trends and Prospects for the Seventh District,” *Economic Perspectives, Federal Reserve Bank of Chicago,* Vol. XVI, No. 3, May/June 1992.

8. Many corporations have moved their information services departments from expensive central city or large metropolitan locations to mid-size metros. A major reason for not moving to smaller or rural areas is the difficulty of attracting highly skilled IT employees. See Jim Daly, 1995, "How To Staff IT," *Forbes ASAP*, pp. 26–29.

9. The metros include New York, Philadelphia, Boston, Baltimore, St. Louis, Atlanta, Dallas, Denver, and San Francisco.

10. The National Information Infrastructure Initiative is a center that informs foundations and nonprofits about Federal funding to develop planning and demonstration projects to leverage philanthropic investment in areas such as education, healthcare, public safety, and citizen action.

References

Amin, A., and N. Thrift. 1992. "Neo-Marshallian Nodes in Global Networks," *International Journal of Urban and Regional Research* 16:571–587.

Anderson, Teresa, and Alan Melchior. 1995. "Assessing Telecommunications Technology as a Tool for Urban Community Building," *Journal of Urban Technology,* Fall, 3(1):29–44.

Barkley, David L. 1988."The Decentralization of High-Technology Manufacturing to Nonmetropolitan Areas," *Growth and Change* 19(Winter).

Barkley, David L., and Sylvia Hinschberger. 1992. "Industrial Restructuring: Implications for the Decentralization of Manufacturing to Nonmetropolitan Areas," *Economic Development Quarterly* 6(1).

Barras, Richard. 1987. "Technical Change and the Urban Development Cycle," *Urban Studies* 24:5–30.

Batten, D. 1995. "Network Cities: Creative Urban Agglomerations for the 21st Century," *Urban Studies* 32(2):313–327.

Batty, Michael. 1990. "Invisible Cities," *Environment and Planning B* 17(1):127–130.

Berry, Brian. 1995. "Classification Systems for U.S. Cities." Contractor report prepared for the Office of Technology Assessment.

Beyers, William. 1989. *The Producer Services and Economic Development in the United States.* Final Report to the U.S. Department of Commerce. Washington, DC: Economic Development Administration.

Beyers, William B., and David P. Lindahl. 1994. *Competitive Advantage and Information Technologies in the Producer Services.* Paper presented at the American Association of Geographers meeting, San Francisco, CA.

Black, Thomas. 1990. *The Changing Office Workplace.* Washington, DC: Urban Land Institute.

Bodenman, John E. March 17, 1995. *Dispersal of the Institutional Investment Advisory Industry in the United States, 1983–1993.* Paper presented to the American Association of Geographers annual meeting, Chicago, IL.

Borchert, John. 1967. “American Metropolitan Evolution,” *Geographical Review* 57: 301–332.

Bradsher, Keith. 1995. “Skilled Workers Watch Their Jobs Migrate Overseas,” *New York Times*, August 28, p. A–1.

Brotchie, J.F., M. Anderson, and C. McNamara. 1995. “Changing Metropolitan Commuting Patterns,” in *Cities in Competition*, J. Brotchie, M. Batty, E. Blakely, and P. Hall, eds. New York: Transatlantic Publications, Inc.

“Business Services,” 1995. *Business Facilities*, February, pp. 18–22.

Castells, Manuel. 1989. *The Informational City*. Oxford, England: Blackwells.

Castells, Manual, and Peter Hall. 1994. *Technopoles of the World.* New York: Routledge.

Chinitz, Benjamin. 1964. “Introduction,” in *Cities and Suburbs*. Englewood Cliffs, NJ: Prentice Hall.

Christopherson, Susan, and Michael Storper. 1989. “The Effects of Flexible Specialization on Industrial Politics and the Labor Market: The Motion Picture Industry,” *Industrial and Labor Relations Review,* April, 42(3):331–347.

“City vs. Country.” 1995. Tom Peters and George Gilder Debate the Impact of Technology on Location.” *Forbes ASAP* January.

Columbia Business School. 1994. *Salomon Brothers.* Unpublished case.

Czamanski, D.Z., and S. Czamanski. 1977. “Industrial Complexes,” *Papers of the Regional Science Association* 38:93–111.

DeMichelis, Nicola. 1995–1996. “Cities on the Information Highway,” *The OECD Observer* 197(December/January):12.

Duncan, K.A., and J.R. Ayers. 1987. *Teleports and Regional Economic Development.* New York: North Holland.

Dutton, W., J. Blumler, and K. Kraemer, eds. 1987. *Wired Cities: Shaping the Future of Communications.* Washington, DC: G.K. Hall.

Egan, Edmund. 1994. *Spatial Concentration and Networking in the U.S. Computer Software Industry.* Paper presented at the Association of Collegiate Schools of Planning Conference, Tempe, AZ.

Ewers, Hans-Jurgan. 1995. “The Locational Impact of Declining Costs of Transportation and Communication,” in *Urban Agglomeration and Economic Growth*, Herbert Giersch, ed. Heidelberg/Berlin: Springer-Verlag.

Fathay, T. 1991. *Telecity: Information Technology and Its Impact on City Form.* London: Praeger.

Friedman, David. 1992. “Getting Industry to Stick: Enhancing High Value-Added Production in California.” Unpublished manuscript, p. 7, May.

Gad, G. 1979. “Face-to-Face Linkages and Office Decentralization Potentials: A Study of Toronto,” in *Spatial Patterns of Office Growth and Location,* P.W. Daniels, ed. New York: John Wiley.

Gang, Gi-Yong. Fall 1993. *Corporate Restructuring and Urban Economic Development Policy: Delaware Back Office Strategy in the Wilmington Metropolitan Area*. Unpublished doctoral dissertation University of Delaware, Wilmington.

Gaspar, Jess, and Edward L. Glaeser. 1996. *Information Technology and the Future of Cities.* Working paper 5562. Cambridge, MA: National Bureau of Economic Research.

Gates, Bill. 1995. *The Road Ahead.* New York: Viking Penguin.

Glaeser, Edward, and David C. Mare. 1994. “Cities and Skills.” Unpublished manuscript. Cambridge, MA: Harvard University.

Glasmeier, Amy K. 1991. *The High-tech Potential: Economic Development in Rural America.* New Brunswick, NJ: Center for Urban Policy Research, Rutgers University.

Glasmeier, Amy, and Marie Howland. 1995. *From Combines to Computers.* Albany: State University of New York.

Glasmeier, Amy, and Jeff Kibler. July 1995. “Turning Stocks into Flows: The Effects of Technological Change and Transportation Deregulation on the Location of Wholesale Employment in the U.S.” Report prepared for the Office of Technology Assessment on Wholesale Trade and Distribution. University Park: Pennsylvania State University.

Goddard, John. 1991. “New Technology: The Geography of the Information Economy,” in *Cities in the 21st Century, New Technologies and Spatial Systems,* John Brotchie et al. eds., New York: John Wiley.

Goldberg, Carey. 1997. “Real-Space Meetings Fill in the Cyberspace Gaps,” *New York Times,* February 25, p. A–12.

Goldmark, P.C. 1972. “Communication and Community,” *Scientific American* 227: 143–150.

Graham, Stephen. August 1995. “Cyberspace and the City,” *Town and Country Planning* 64(8):199–201.

Graham, Stephen, and Simon Marvin. 1996. *Telecommunications and City: Electronic Spaces, Urban Places.* New York: Routledge.

Grimes, Seamus. April 1995. “Regional Development Aspects of Information Technology.” Paper presented at Telecom Tectonics Conference. East Lansing: Michigan State University.

Hall, Peter. 1995. “Moving Information: A Tale of Four Technologies,” in *Cities in Competition*, J. Brotchie, M. Batty, E. Blakely, and P. Hall, eds. New York: Transatlantic Publications, Inc.

Hall, Peter, Melvin M. Webber, and Reed Grier. 1987. “Where Biotechnology Locates,” *Built Environment* 13(4):152–156.

Harrison, Bennett, Maryellen R. Kelley, and Jon Gant. 1996. "Innovative Firm Behavior and Local Milieu: Exploring the Intersection of Agglomeration, Firm Effects, and Technological Change," *Economic Geography*, July, 72(3):233–258.

Haug, Peter, and Philip Ness. November 1993. "Industrial Location Decisions of Biotechnology Organizations," *Economic Development Quarterly* 7(4):390–402.

Hepworth, Mark E. 1990. *Geography of the Information Economy.* New York: The Guilford Press.

Hill, Edward W., and Harold L. Wolman. March 1997. "City-Suburban Income Disparities and Metropolitan Area Employment: Can Tightening Labor Markets Reduce the Gaps?" *Urban Affairs Review* 32(4):558–582.

Hoover, Edgar M. 1964. "Pittsburgh Takes Stock of Itself," in *City and Suburb: The Economics of Metropolitan Growth*, Benjamin Chinitz, ed. Englewood Cliffs, NJ: Prentice Hall.

Horan, Thomas A., Benjamin Chinitz, and Darrene Hackler. 1996. *Stalking the Invisible Revolution: The Impact of Information Technology on Human Settlement Patterns.* Claremont, CA: The Claremont Graduate School, November.

Howland, Marie. 1993. "Technological Change and the Spatial Restructuring of Data Entry and Processing Services," *Technological Forecasting and Social Change* 43(3):185–196.

Howland, Marie. 1991. "Producer Services," *Economic Development Commentary*, Fall, 15(3):7.

"It's San Francisco." 1995. *Fortune*, November 13.

Johnson, Kenneth M., and Calvin L. Beale. July 1995. "The Rural Rebound Revisited." *American Demographics* 17(7):46–54.

Johnson, Leland L. 1991. "Advances in Telecommunications Technologies That May Affect the Location of Business Activities;" Rand Note N–3350–SF, RAND Corporation.

Kasarda, John D. 1995. "Industrial Restructuring and the Changing Location of Jobs," in *State of the Union*, Reynolds Farley, ed. New York: Russell Sage Foundation.

Keen, P.G.W. 1991. *Shaping the Future.* Cambridge, MA: Harvard Business School Press.

Kellerman, Aharon. 1993. *Telecommunications and Geography.* New York: Halsted Press.

Kumar, Ajay. 1990. "Impact of Technological Developments of Urban Form and Travel Behavior," *Regional Studies* 24(2):137–148.

Kutay, Aydan. 1986. "Effects of Telecommunications Technology on Office Location," *Urban Geography* 7(3):243–257.

Laterasse, J. 1992. "The Intelligent City," in *Telecom, Companies, Territories*, F. Rowe and P. Veltz, eds. Paris: Presses de L'ENPC.

Leinberger, Christopher B. 1994. "Flexecutives: Redefining the American Dream," *Urban Land*, August 1, 53(8):51.

Luger, M., and H. Goldstein. 1992. *Technology in the Garden: Research Parks and Regional Economic Development.* Chapel Hill: University of North Carolina Press.

Markusen, Ann. July 1996. "Sticky Places in Slippery Space: A Typology of Industrial Districts," *Economic Geography* 7(3):293–312.

Markusen, Ann. September 1994. "Sticky Places in Slippery Space: The Political Economy of Postwar Fast Growth Regions." Paper presented at the Harold Innis Centenary Conference on the Spatial Constitution of Economic Activity. Toronto: University of Toronto.

Marshall, Alex. March 1996. "Technology Transforms the Places We Live," in *Metropolis*, p. 21.

Martin, William J., and Sean F. McKeown. April 1993. "The Potential of Information Technologies for Rural Development," *The Information Society* 9(2):145–156.

McAllister, Bill. 1994. "Automated Sorter Wins Letter Carriers' Praise," *Washington Post*, April 17, p. D1.

McGahey, Richard, Mary Malloy, Katherine Kazanas, and Michael Jacobs. 1990. *Financial Services, Financial Centers: Public Policy and the Competition for Markets, Firms and Jobs.* Boulder, CO: Westview Press.

Meier, Richard L. 1962. *A Communications Theory of Urban Growth.* Cambridge, MA: MIT Press.

Mitchell, William J. 1996. *City of Bits.* Cambridge, MA: MIT Press.

Mokhtarian, Patricia, Susan Handy, and Ian Salomon. 1995. "Methodological Issues in the Estimation of the Travel, Energy, and Air Quality Impacts of Telecommuting," *Transportation Research A* 29A(4):283–302.

Moran, Stahl, and Boyer. 1994. "Trends in Insurance Company Location—and Relocation." New York.

Moschella, David C. 1997. *Waves of Power.* New York: American Management Association.

Moss, Mitchell. 1997. "Technological Trends Affecting the Manufacturing Sector of New York City," *FRBNY Economic Policy Review*, February, 3(1):87–89.

Moss, Mitchell L. 1990. *The Information City in the Global Economy.* Paper presented at the Third International Workshop on Innovation, Technological Change and Spatial Impacts, Cambridge, England.

Moss, Mitchell L. 1987a. "Telecommunications: Shaping the Future," in *America's New Market Geography*, George Sternlieb and James W. Hughes, eds. New Brunswick, NJ: CUPR Press, Rutgers.

Moss, Mitchell L. December 1987b. "Telecommunications, World Cities, and Urban Policy," *Urban Studies* 24(6):534–546.

Moss, Mitchell, and John Carey. 1994. "Telecommuting for Individuals and Organizations," *Journal of Urban Technology* 2(1).

National Academy of Engineering. 1971. *Communications Technology for Urban Improvement.* Report to the U.S. Department of Housing and Urban Development. Washington, DC: National Academy of Engineering, June.

National Academy of Sciences. 1994. *Information Technology in the Service Sector.* Washington, DC: National Academy Press.

Negroponte, N. 1995. *Being Digital.* New York: Alfred A. Knopf.

"Neither Rain, Nor Snow, But Bad Info?" 1994. *Washington Post,* July 22.

Nicholson, B.M., Ian Brinkley, and Alan W. Evans. 1981. "The Role of the Inner City in the Development of Manufacturing Industry," *Urban Studies* 18(3):57–71.

Nilles, Jack M. October 1975. "Telecommunications and Organizational Decentralization," *IEEE Transactions on Communications* COM–23(10):1142–1147.

Nilles, Jack. 1991a. *Telecommuting Forecasts.* Los Angeles, CA: JALA International, Inc.

Nilles, Jack M. 1991b. "Telecommuting and Urban Sprawl: Mitigator or Inciter?" *Transportation* 18(2):411–432.

Noyelle, Thierry. 1987. *Beyond Industrial Dualism: Market and Job Segmentation in the New Economy.* Boulder, CO: Westview Press.

Noyelle, Thierry J., and Thomas Stanback, Jr. 1984. *The Economic Transformation of American Cities.* New York: Rowman and Allenheld.

Office of Technology Assessment. 1995. *The Technological Reshaping of Metropolitan America.* OTA–ETI–643. Washington, DC: U.S. Government Printing Office.

Oh, D., and I. Masser. 1995. "High-tech Centres and Regional Innovation," in *Technological Change, Economic Development, and Space,* C.S. Bertugila, M.M. Fischer, and G. Preto, eds. Heidelberg/Berlin: Springer-Verlag.

O'Hullachain, B., and N. Reid. 1992. "The Intrametropolitan Location of Services in the United States," *Urban Geography* 13(4):334–354.

O'Hullachain, B., and M. Satterthwaite. 1992. "Sectoral Growth Patterns at the Metropolitan Level: An Evaluation of Economic Development Incentives," *Journal of Urban Economics* 31(1):25–58.

O'Neill, Hugh. July 1995a. "The Impact of Technological Change on the Location of the Freight Transportation Industry." Report prepared for the Office of Technology Assessment on freight transportation. New York: Appleseed.

O'Neill, Hugh. March 1995b. *Real Places and Virtual Money.* Report prepared for the Office of Technology Assessment on banking and financial services. New York: Appleseed.

Park, Siyoung, and Lawrence T. Lewis. 1991. "Developments in the Location of Selected Computer-Related Industries in the United States," *Growth and Change* 22(2):17–35.

Pollard, Jane, and Michael Storper. 1996. "A Tale of 12 Cities: Metropolitan Employment Change in Dynamic Industries in the 1980s," *Economic Geography* 72(1):1–22.

Poole, Kenneth E., and Caroline Samuels. 1994. "Manufacturing Trends in America's Larger Cities," in *Urban Manufacturing: Dilemma or Opportunity?* Washington, DC: National Council for Urban Economic Development.

Porter, Michael. 1990. *The Competitive Advantage of Nations.* New York: McMilliam Free Press.

Price Waterhouse. December 1991. *Survey of New York City Executives in Six Industry Sectors.* New York: New York City Partnership, Growth Strategies Project.

Qvortrup, Lars. 1994. "Telematics and Regional Development: A Research Literature Review," *Prometheus* 12(2):152–167.

Rees, John, and R. D. Norton. 1979. "The Product Cycle and the Spatial Decentralization of Manufacturing," *Regional Studies* 13(2):141–151.

Richards, Bill. 1996. "How Big a Bite," *Wall Street Journal,* June 17, p. R10.

Richardson, Ranald, and Andrew Gillespie. 1996. "Advanced Communications and Employment Creation in Rural and Peripheral Regions: A Case Study of the Highlands and Islands of Scotland," *The Annals of Regional Science* 30(2):91–110.

Richardson, Ranald, Andrew Gillespie, and James Cornford. March 1995. "Telework and Rural Development," *Town and Country Planning* 64(3):82–84.

Roque, Julie A. 1996. "The Social Dimensions of Technological Change: Reshaping Cities and Urban Life," in *Preparing for the Urban Future: Global Pressures and Local Forces,* Michael A. Cohen et al. Washington, DC: Woodrow Wilson Center for Scholars.

Salomon, Ian. 1996. "Telecommunications, Cities and Technological Opportunism," *The Annals of Regional Science* 30(1):75–89.

Sandberg, Jarad. 1996. "Making the Sale." *Wall Street Journal,* June 17: p. R6.

Sassen, S. 1989. *Global Cities: New York, London, Tokyo.* Princeton, NJ: Princeton University Press.

Saxenian, Annalee. 1993. *Regional Advantage.* Cambridge, MA: Harvard University Press.

Schneider, Mark, and Duckjoon Kim. November 1996. "The Effects of Local Conditions on Economic Growth, 1977–90: The Changing Location of High-Technology Activities," *Urban Affairs Review* 32(2):131–156.

Schwartz, Alex. June 1993. "Cities and Suburbs as Corporate Service Centers." Final report to the U.S. Economic Development Administration.

Scott, Allan J. 1988. *Metropolis: From the Division of Labor to Urban Form.* Berkeley: University of California Press.

Simmons, T. 1994. "Telecoms Contribute to Cities' World Status," *Municipal Review,* January/February, 65(688):210.

Stanback, Thomas. 1995. "Putting City-Suburb Competition in Perspective," in *Cities in Competition,* Brotchie et al., eds. Melbourne: Longman Australia.

Stough, Roger R., and Jean Paelinck. 1996. *Substitution and Complementary Effects of Information on Regional Travel and Location Behavior.* Paper prepared for presentation at the Regional Science International Association World Congress. Tokyo, May 1–5.

Todtling, Franz. 1994. "Regional Networks of High-Technology Firms—The Case of the Greater Boston Region," *Technovation* 14(5):323–343.

"Trends in Insurance Company Location—and Relocation." 1994. New York: Moran, Stahl, and Boyer.

U.S. Department of Transportation. 1993. *Transportation Implications of Telecommuting.* Washington, DC: U.S. Department of Transportation, April.

Warf, Barney. March 1995. "Telecommunications and the Changing Geographies of Knowledge Transmission in the Late 20th Century," *Urban Studies* 32(2):361–378.

Warf, Barney, and Chand Wije. Fall 1991. "The Spatial Structure of Large U.S. Law Firms," *Growth and Change* 22(4):157–174.

Weber, Thomas E. 1996. "Banking on the Future ... Again." *Wall Street Journal*, June 17, p. R12.

Willoughby, Kelvin W. 1995. "The Local Milieux of Knowledge-Based Industries: What Can We Learn from a Regional Analysis of Commercial Biotechnology?" in *Cities in Competition,* Brotchie et al., eds. Melbourne: Longman Australia.

Wilson, Mark I. 1994. *Telephone Tectonics: Communications and the Restructuring of Global Services Production.* Unpublished paper. East Lansing: Michigan State University.

Wolman, William, and Anne Colamosca. 1997. *The Judas Economy: The Triumph of Capital and the Betrayal of Work.* Reading, MA: Addison-Wesley.