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Information technology, the organization of production, and regional development

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Abstract. Information technology (IT) was conventionally viewed as a process that affects the spatial organization of production significantly yet has little impact on technical and managerial structures. Specifically, IT was said to encourage decentralization and centralization in space because the new infrastructure, 'the electronic superhighway', both compresses space and reduces turnover time. Regional policymakers were then advised to design measures to enhance the decentralizing effect of IT. Only recently has attention been directed toward the impact of IT on industrial processes. However, such contributions remain limited because of their view of IT as a process phenomenon. We argue that IT is better viewed as a process *and* as a productive force and that from this perspective its impact is not limited to spatial organization of industries as it also alters production methods. Beginning with this understanding of IT, we have identified and presented two emerging technospatial tendencies, namely, integration and disintegration. Whereas decentralization disengages production stages from a centralized hub of productive activity, disintegration actually alters a centralized production hub into new fragments, each of which incorporates every necessary production stage to create a comprehensive and self-sufficient structure. Likewise, whereas centralization simply collects production stages together, integration restructures groups of production stages into a new whole and leads to comprehensive resource-sharing among diverse industries. The implications of this new formulation for regional development policy are far-reaching. There are also ramifications for the existing theory of new international division of labor, a subject that is not treated in this paper. Regional planners will need to restructure 'innovation techniques' specifically to accommodate disintegrated firms and to design policies that correlate with the industrial objective of competitive advantage. The most significant ingredients in this process are the establishment of an intelligent network, high-quality labor training, and support of productivity strategies designed to meet the needs of firms in the 1990s. Policymakers must also introduce regulations to promote universal access to IT and prevent integrated firms from becoming oligopolies, including the creation of countervailing local forces.

1 Introduction

The emergence of information technology (IT) as the 'new infrastructure' or 'electronic superhighway', as depicted in some planning literature, has generated great interest among academics regarding its impact on industrial organization and spatial change. Specifically, popularly defined as the collective utilization of electronics, telecommunications, software, decentralized computer workstations, and integrated media, this superhighway is believed to have a strong impact on global spatial organization and the production system (Frisk, 1988). The comparison of IT with a highway infrastructure is made because of their two common functions: connecting distant places and accelerating production processes. Significantly, as different types of transportation infrastructure have uniquely impacted industrial organization and location in the past, the new infrastructure has the potential to inspire a complete paradigm shift in current thinking on locational decisions and industrial production technology.

Existing planning literature widely supports the contention that two conflicting industrial location forces, namely centralization and decentralization of production, may increase in influence because of the growth of IT as the new infrastructure.

Production, by definition, consists of every aspect of the production process, including the stages of conception, development, manufacturing, advertising, and marketing (Random House, 1952). Decentralization of production, then, often entails a disengagement of *some* production stages from a centralized hub of productive activity and a physical relocation to a distant place, such as the movement of manufacturing to branch plants. Likewise, centralization is a trend that collects *some* production stages together and is represented as their conglomeration in one physical location. Obviously, these definitions are limited to the spatial aspect of each tendency and exclude control and ownership aspects, as these are not the focus of this paper. The general argument holds that, as functions of IT advance, a perfect stage is set for the simultaneous centralization and decentralization of production. For example, owing to the capability of IT to connect distant places, the new infrastructure is conducive to the decentralization trend. A case in point is the high quality of job training programs offered via telecommunications to workers in remote locations. In comparison, the capability of IT to speed up production processes is said to catalyze the centralization trend. This occurs in order to increase a firm's productivity by using IT, especially during the stages of idea conception and design; proximity of workers to a concentrated hub of information, as well as to suppliers, customers, and one another, is considered vital (Camagni, 1988). Furthermore, according to Malecki (1991), large firms centralize in urban centers in order to maximize information-intensive contacts.

Of primary significance is the fact that theorists agree that both centralization and decentralization have a great impact on regional economic development. For example, decentralization of production is often viewed as a beneficial consequence of new information infrastructure, as it may offer peripheral regions economic development opportunities. IT is said to help diffuse new ideas or innovations to outlaying areas and reinforce 'trickle-down' and 'spread effects' of development elsewhere, resulting in spatial convergence. Centralization of production, however, is generally portrayed as a threat to regional development, in that most economic opportunities will be directed to already developed regions and will exclude those areas located in the periphery. IT, in this case, is said to work in the direction of reinforcing 'backwash effects' and leads to 'cumulative causation', thus exacerbating spatially uneven development. This latter tendency is said to be particularly strong in developing countries.

Although the relevant literature is accurate in recognizing the existence of both centralization and decentralization as simultaneous, conflicting location trends, it appears as if a second, more severe, set of technospatial tendencies is better able to measure the impact of the new information revolution. Indeed, disintegration and integration of production may result in addition to decentralization and centralization of production as economic entities recompose themselves spatially and organizationally in the age of global restructuring. Disintegration and integration are also different from decentralization and centralization because they are largely functional and not necessarily spatially dependent, and they emphasize human capital development more than cost minimization as a central organizational imperative. Disintegration alters a centralized production hub into new fragments, each of which incorporates every necessary production stage to create a comprehensive and self-sufficient functional structure. Integration, on the other hand, restructures groups of production stages into a new whole and leads to comprehensive resource-sharing among diverse economic activities.

A primary reason why centralization and decentralization theories exist relates to the way IT is conceptualized. Specifically, the decentralization and centralization literature concentrates on IT solely as a *process* (or infrastructure) that tends either to connect distant places instantaneously or to speed up production. For example, 'reverse engineering' is a cost-effective process which depends on IT to speed up production. In this procedure, those firms which make a quality product cheaper by processing it faster can take the product away from the inventor (Thurow, 1992). Swiss industries, for instance, invented and monopolized the digital watch market. Within years, manufacturers in Japan used IT to reduce the cost of the watch to about 3% of the cost to its competitors and to sell more reliable products. The market for Swiss watches was badly affected, forcing the Swiss to compete mostly on other characteristics such as fashion, as reflected in the innovation of Swatch™ (Yates and Benjamin, 1991). Significantly, in order to capture the market successfully, the Japanese industry centralized interactions between technology and labor resources to speed up the process of production effectively and establish quality control.

In contrast, in the disintegration and integration hypotheses we define IT as both a process and a productive force. Viewed in this way, IT not only overcomes the spatial friction or shortens turnover time, but also operates as a means of production, and as such it engages various aspects of production and alters the organizational arrangements of that production. The concept of IT as a productive force does not refer to the final product of a specific information–communication industry, such as a telephone from AT&T. Rather, it is a means of production that different levels of skilled workers can review, analyze, manipulate, or deploy in real time during the processing stages in many industries. Specifically, we argue that IT allows a complex recomposition of economic entities that supersedes traditional arguments concerning centralization, decentralization, and the new international division of labor. These trends involve the disaggregation or aggregation of the firm, with various functions located in different places or agglomerated in one location to either minimize costs or maximize market access. We maintain, however, that IT allows new forms of aggregation and disaggregation, not only spatially in industrial districts but also organizationally in terms of functions. Thus we have two processes going on at once, one spatial and one organizational, with the organizational process having spatial implications as well.

For example, StereoLithography, patented by 3D Systems of Valencia, CA, is a technology by which computer aided design drawings of three-dimensional objects are automatically translated into solid, prototype models. Automobile and computer industries use the prototypes developed through StereoLithography to benefit from the product suggestions offered by colleagues and preliminary consumer test markets in creating a more refined product in a shorter time (Padwick, 1990, page 29). Medical professionals use the rapid prototyping system to develop prosthetic bones and joints for further testing. IT in the form of StereoLithography becomes more than a process tool; it represents a productive force, comparable more to a human hand than to a highway. Recognition of this viewpoint, along with the unique characteristics of IT, enables the technology to serve a critical, new place along the traditional production cycle for some industries in certain locations.

Not only does IT, considered as a productive force *and* as a process, demand a new position in the production cycle, it also facilitates functional integration among the sequential stages of production (Camagni, 1988). For instance, once a prototype created in StereoLithography is accepted, the design can be saved on the computer and immediately used for manufacturing and marketing processes (Padwick, 1990). In this respect, the traditional production stages of science, invention, innovation, manufacturing, marketing, distribution, and consumption become less functional on their own terms and more efficient in combination. In light of the observation that IT produces linkages which may interweave the conception and execution components of production, traditional theories of centralization and decentralization need further elaboration. Clearly, selection of workplace sites still takes place either in a central or peripheral location, decentralization continues as firms move out of central cities to suburban areas, edge cities, or low-cost regions, and centralization is still a major force in advanced services and financial sectors and in certain industrial districts. Nevertheless, there exists sufficient evidence to suggest that these spatial tendencies are complicated by new organizational or functional trends. For example, there are movements away from the isolated firm and toward joint venture, and away from single-function branch plant or service agency toward more functionally integrated ones.

It is the primary purpose of this paper to contribute new ideas regarding the role of IT in new production and its space. It is our view that many authors, particularly in the regional studies field, have categorized IT singularly as a process infrastructure and consequently have failed to account for the full impact of the new technology. In comparison, we argue that IT must also be considered for its ability to formulate a product, that is, as a productive force. From the perspective of IT as both process and product, the impact of the information revolution goes beyond the traditional theories of centralization and decentralization. It also alters the production cycle and thus motivates the trends of integration and disintegration. Although several experts in sociology and economics fields, such as Castells (1989), Hepworth (1990), Zuboff (1988), and Mansell (1993), have recognized the product characteristic of IT and its impact on labor processes, our position is unique in the way we relate this very characteristic to the organization of production and spatial change.

This paper is organized into six further parts. In the next section we briefly document the history of modern IT. A complete review of the literature on decentralization and centralization is provided in sections 3 and 4 to outline the debate regarding the process aspect of the new infrastructure and its spatial impact. We also discuss the theories which explain the initial causes of decentralization and centralization of production. We then take up the disintegration and integration hypotheses and explain each term in some detail, justifying them as emerging IT-induced tendencies. Finally, we apply the disintegration and integration of production concepts to long-term regional development efforts for a measure of impact and a discussion of policy design.

2 'New' information technology

Historically, the introduction of the telegraph over 150 years ago was probably the most dramatic step in creating time-space compression and stimulating production efficiency. It reduced the transit time of information across the oceans from weeks (even months) to minutes. In the 1870s, the telephone was invented and, as few as 10 years later, this communications device was already a major component of business functions throughout the world. Yet the telegraph and telephone were initially only point-to-point technologies. During an attempt in the 1860s to create a 'wireless' telegraph to target multipoints, broadcast technology was accidentally discovered. By the 1920s, radio receivers were available in most developed countries, and demonstrations of broadcast television were beginning to appear (Williams, 1991). Two technical factors contributed most to the advancement of IT during the decades following the invention of the telephone: the introduction of switching systems and the development of increased-bandwidth transmission (Mansell, 1993).

Switching systems were necessary to open and close telecommunications lines quickly as the number of telephone users increased exponentially and the number of possible point-to-point linkages were filled. The earliest switch systems were analog circuit switches, where a link established between two sites remained completely dedicated for the duration of the communication. Even though circuit switching was limited, as it was most appropriate for voice communication, its impact greatly expanded the telephone system. As early as the 1960s transmission of computerized information over the public switched telephone network represented the start of computer networking. Modems were used to convert digital signals from the computer to analog form for transmission along telephone wires. Packet switching, first developed in 1964, further increased the usage of data transmission, especially in local area networks, by splitting data files into packets to enable the sharing of paths in a network. As a result, "large public and private organizations developed their own computer networks to link decentralized branches or departments with their centralized information hub, or mainframe", a development that coincided with the rise of the service sector (Newton, 1991, page 122). 'Fast' packet-switching technology currently available enables integrated voice, text, data, and video information at very high speeds.

Transmission capacity relates to the physical limits on bandwidth and constraints on speed. Recent transmission advancements, therefore, include larger-bandwidth technology, such as fiber optics, to send and receive a large amount of diverse information simultaneously, such as voice, video, text, and data. IT introduced since the telephone, such as the fax, satellite systems, and computer networks, have successfully focused on increasing the bandwidth of information that can be transmitted in an instant, thus furthering time–space compression and the efficiency of production (Yates and Benjamin, 1991). Also, transmission advancements have improved the speed of computer networks, which is especially vital for connecting remote facilities, by transforming signals from analog to digital form. Where analog signals express information in discrete numeric values, digital signals represent information as discrete pulses coded in the binary format understood by computers.

IT, in general, has grown at an exponential rate in almost every industry. In 1981, for example, there were about 5.8 million workstations (personal computers and on-line terminals) in US offices. By 1986, the figure for workstations had risen to 26 million, and in 1988 the Institute for the Future predicted that by 1995 there would be 60 million workstations (Yates and Benjamin, 1991), a figure that seems a bit too high given the size of the labor force. Furthermore, in Australia, "the size of the labor force involved in information-related activity is currently in excess of forty percent" (Newton, 1991, page 96). The past decade has witnessed rapid technological change in the local authority sector of Britain's economy as well. Investment in IT was expected to climb beyond £1 billion in 1993 in England and Wales (Hepworth, 1990).

'New', or modern, IT can best be explained as an 'intelligent network' (Mansell, 1993; Williams, 1991). These networks combine the power advantage of computers developed in the 1980s with client–server technology in an incredibly fast computing environment. The intelligent network specifies a way in which computerized databases and complex software can be used to expand even further the capabilities of a telecommunications network, whether public or proprietary. In the 1980s, intelligent networks developed throughout the United States, Japan, and Europe. In fact, Mansell (1993) states that in 1993 intelligent networks were being implemented in more than thirty countries. This network system is described as 'intelligent' after a recent advanced switching characteristic: digital switching.

The advanced services offered as a result of these intelligent networks include information-processing capabilities far beyond those needed for voice transactions. Significantly, the breakthrough of digital switches, combined with digital signals, enables the integration of many types of transmission technologies into one network, allows different kinds of computer systems to talk to one another, and grants one the ability to transmit multiple messages simultaneously on a single communications circuit. In particular, these networks support simultaneous transmission of voice, video, and data signals, such as videoconferences from desktop to desktop which involve both a previously designed multimedia presentation and a real-time video exchange of participants. One very recent trend focuses on 'artificial intelligence' and 'expert systems', which in many ways simulate the human brain and nerve system. Some of the new intelligent networks can not only 'think' but can also 'see' (*New York Times* 1994).

Furthermore, intelligent networks make use of the powerful, but inexpensive, personal computers that are readily available to many businesses. In order to reap fully the advantages of the personal computer, many corporations are moving away from mainframe technology with connected terminals. Instead, a more recent network configuration, termed client-server architecture, is becoming the standard. In client-server architecture, most of the client functions (processing power and interfacing) are provided from a desktop computer, with storage of certain application software and data being concentrated in a networked 'server'. This new type of architecture enhances the role of integrated networks, compared with centralized IT, because, instead of individual workstations being dependent on a single source of IT, workstations have enough computational power to be independent.

The development of IT through the years, up until this point, has been focused on business applications which are transactional in nature. For example, the telephone enabled voice transactions, and the fax provided image-based transactions for the purpose of sharing information within and between businesses. Businesses require a transaction technology in order to connect distant places and speed up production. In fact, digital signals were initially developed to relieve overcrowded circuits for the purpose of increasing the transaction speed (Mansell, 1993). Yet this emphasis and advertisement of IT as a transaction-based service, such as "reach out and touch" someone, has established a universal perception of the technology as process-oriented, concealing its function as a productive force.

Intelligent networks, designed with digital signals and switches, complex software, and large-bandwidth transmission media promote IT as a productive force. Intelligent networks are more integrated and flexible than was previous IT, as they combine the previously isolated technical functions of storage, communications, and computational processing and translation into one seamless technology. In so doing, intelligent networks encourage new information that otherwise would not exist, such as a virtual reality session where the interior of the human brain is graphically dissected by a medical student in a dorm. Virtual reality, a branch of IT still in its infancy, is a simulation system which enables humans to create and interact with multidimensional worlds. According to Zuboff (1988), after IT automates an industrial process, there is a step which 'informates', that is, which produces information which previously did not exist [for an overview of emerging intelligent networks and their special applications, see the special issue of *Business Week* (1994), on "The information revolution: how digital technology is changing the way we work and live"].

3 Information technology and the decentralization thesis

Decentralization may be defined as the movement of certain production stages away from a previously centralized hub of productive activity. Perhaps one of the most documented consequences of IT is the trend of decentralization, as reflected by teleworking, teleproducing, teleconferencing, teleshopping, and telebanking (*Fortune* 1993b). In this paper, however, we deal specifically with the decentralization of production, and focus on debates that view IT as a process which encourages teleproducing. For example, fiber-optic telecommunications combined with computer technology enable employees to communicate and share information across many miles, whereas automation technology may allow a firm to relocate to a peripheral region where labor is not readily available. According to Williams (1991, page 27),

> "Telecommunications makes it much easier to coordinate the components of decentralized businesses, branch stores, or intensive supplier links. Management decentralization networks and methods allow a company to locate its sales outlets near lucrative markets, manufacturing near labor and suppliers and headquarters in financial and design centers."

It is important to recognize, though, that the existing theories supporting decentralization do not necessarily promote IT as the causal factor which motivates the trend; rather, the technology is consistently highlighted as a *facilitator* of decentralization. As Kellerman (1985) suggested, telecommunications is perceived as a powerful device that may assist industries to achieve goals that are determined independently of communications considerations.

Historically, theorists have disagreed as to the likely causes surrounding the decentralization of production. One group of theorists views the trend as a product of labor-capital conflicts rather than as a result of technological change or consumer preference (Gordon, 1978, page 25; Hepworth, 1990, page 151). Accordingly, decentralization was used as a strategy to reduce the power of organized labor whose militancy was partly rooted in urban concentration. Another group of theorists explains industrial decentralization as part of a general suburbanization process that began in the mid-19th century in response to decaying conditions in central cities and to government incentive policies (Ashton, 1984). Advocates of location-determinants theory argue that decentralization of production occurs primarily when certain factors, such as cheaper land, labor, or transportation costs, become available in a specific location (Ullman, 1954). Another related powerful explanation considers proximity to market as a major motivating force for decentralization (Hoover, 1975).

Technological change has also promoted decentralization. In the post-1945 period, for example, London has witnessed the emergence of production decentralization for the first time, as its spatial scale widened to include peripheral areas of Britain and eventually the developing world (Goddard, 1991). The cause of this shift was a movement toward more Fordist techniques in order to develop economies of scale in manufacturing industries. The transition to Fordism involved "employing lower-paid and less-skilled workers which were only available outside the city of London" (Goddard, 1991, page 195). Proponents of the product-cycle theory, including Vernon (1979), stress that decentralization of production is most likely to occur during the 'mature' period of the product cycle, or when production involves long runs of mass production. This is so because of the high quantity and low skills required of the workers involved in mass production. Markusen (1985, pages 40-45) argues that decentralization of production is accelerated during the 'market-saturation' stage of the product profit-cycle. At this stage, higher skilled labor must pool resources to design the next product, and at the same time the lower skilled workers must mass produce the current product. However, others have argued that it is capitalism which tends to create a geographical hierarchy of labor in which lower skilled workers are pushed toward the peripheral areas (Castells, 1985).

3.1 Information technology and decentralization

Industries, on an international level, may respond differently to each of these causal factors underlying decentralization. However, in each case, the role of IT could be vital, as it is a widely recognized facilitator of the decentralization trend because of its ability to connect distant places. Although the term 'intelligent network' is a dynamic concept, there have been many applications of this modern network both in large and in small firms, which serve to demonstrate decentralization. Large businesses are especially able to coordinate their many departments and locations, making it increasingly possible to manage an organization whose spatial dispersion reaches global proportions (Williams, 1991). For example, Labatt Breweries, which employs over 4000 individuals, connected microcomputers in decentralized, regional offices to a computer center in its London headquarters (Hepworth, 1990). Each of the regional offices used the network for applications such as production scheduling, inventory control, accounts payable and receivable, and payroll. Impacts of the network for Labatt Breweries, according to Hepworth, included lower inventory costs, lower administration costs, and enhanced market knowledge and sales forecasting among regional office employees. Because of these beneficial impacts, the intelligent network eventually catalyzed the decentralization trend by supporting transnational data links to new regional offices in the United States (Hepworth, 1990).

Wal-Mart Stores Inc. is a discount retailer which gained national recognition in the United States for becoming the country's most profitable retailer in 1990, only twenty-seven years after it began operation in the midwest (Williams, 1991). One component of Wal-Mart's success story is its private telecommunications network. Although the corporation was the first to use the Universal Product Code scanning system to speed up the checkout time and to track merchandise, the most unique component of the company's technology base is its Very Small Aperture Terminal (VSAT) satellite network. In 1990, Wal-Mart's VSAT network supported two-way data and voice communications between its headquarters in Arkansas and 1600 decentralized stores in twenty-five states (Williams, 1991, page 61). The application is very cost-effective because it is not distance sensitive and costs are fixed and not affected by the volume and length of phone calls. Wal-Mart estimates that it saves two thirds on its long-distance telephone costs. These savings in costs enable the company to expand freely to other parts of the country.

To give another example, General Motors operates a global computer network which supports manufacturing orders, personnel and financial records, new design information, troubleshooting, and training between all branch plants and headquarters. According to a plant manager, "it doesn't matter if the plant is in Detroit, Singapore or Matamoros because the network makes the distance irrelevant" (Williams, 1991, page 53). Smaller manufacturers are also decentralizing production, including international operations. Modern communications enabled Maverick Arms, a subsidiary of O F Mossberg, a major gunmaking firm located in Connecticut, to split up production to plants in Texas, Connecticut, and Mexico. Recent advances in high-speed digital networks which employ fast packet switching, such as digital fiber-optic networks, are currently being made available to firms internationally. Although the proliferation of these digital networks among industries still remains insignificant, future networks may indeed further the decentralization trend as the function of connecting distant places extends far beyond voice and text capabilities.

3.2 Regional development and decentralization

Regional interest in the connection between IT and decentralization began in the 1970s and continued through the mid-1980s with the 'diffusionist theorists', such as Bell (1973), Deken (1983), and Toffler (1980). They predicted a crucial role for IT in the social and economic arena of future societies. Bell (1973), for example, envisioned the informational society of the future as an intense, but evenly developed, social formation centered around communication technology and mobile information. According to Bell, an economically and spatially decentralized society would emerge as a result of IT. Deken (1983) expanded Bell's initial proposal by introducing the idea of telework, a means of doing business or schoolwork from home. Toffler (1980) argued that new automation systems would develop on the basis of innovative IT and would greatly reduce manual work within manufacturing industries.

Although the ideas of the diffusionists may be a little too futuristic for the current time, they do offer insight into the capabilities of IT to alter traditional location theory. Generally, the impact of these three authors is significant in that their concept of a balanced, informationalized society penetrated regional thought. In the 1980s, for example, regional developers marveled at the fact that the organizational and spatial forms of production were becoming less determined by physical locational factors, such as land quality, and more by regions' socioeconomic structure, available labor and space, and ability to attract increasingly mobile capital and technology. It was argued that capital had overcome spatial friction and that time and space were shrinking as labor processes had intensified and large corporations had become increasingly footloose (Harvey, 1988; Lapple and Hoogstraten, 1980). The time–space compression was seen as a revolutionary trend that would eventually sweep away current forms of production systems and their spatial location.

During the 1980s, the promotion of high-technology industries across the world encouraged many regions to begin changing their economic development priorities from growth techniques to innovation techniques in order to gain access to high-technology industrial development (Janssen and van Hoogstraten, 1989; Storper and Scott, 1988). Innovation techniques which attract decentralized, high-technology industries include development of a desirable physical environment and a highly trained pool of local labor (Amirahmadi and Saff, 1993). Underdeveloped regions also pursued high-technology strategies of economic development because, according to Thompson (1989), high-technology industries are much less dependent on natural conditions than are traditional manufacturing industries. Moreover, they produce goods that are often informational in nature or have higher value-to-weight ratios, making transportation costs less of a consideration, and thus enabling decentralization of production stages in areas of *either* conception *or* execution.

In direct response to the ideals set forth by the diffusionists, and along with the proliferation of IT and the high-technology industries, regional experts in the 1980s viewed decentralization of production, facilitated by IT, as a key to discovering economic advantages. Indeed, in the United States, Japan, Europe, and the newly industrializing countries, technological innovation and industry-driven research has emerged as the centerpiece of state and local government strategies to foster regional growth (Mody and Dahlman, 1992). Science parks, for example, are technology centers which have been promoted by many countries in the spirit of this emphasis on high-technology industrial development and regional growth (Amirahmadi and Saff, 1993).

Most recently, however, theorists have challenged the earlier futurologists' ideas regarding decentralization of production. For example, one group of theorists, including Castells and Malecki, argue that IT-aided decentralization of production will not necessarily cause an equitable distribution of resources. Castells (1985, page 13) contends that IT will rapidly increase the current uneven development under modern capitalism. In fact, he concludes that "there will remain switched-off, wireless communities, still real people in real places, yet transformed into urban shadows doomed to haunt the ultimate dream of the new technocracy". Similarly, Malecki (1991) observes that, although decentralization exists among high-technology firms, it is almost always the branch plant which is separated. Last, Hepworth (1990), Massey (1984), and Mansell (1993) maintain that a new, public, digital telecommunications infrastructure may not support open access to all, but instead will respond only to the needs of multinational firms. In Britain, for instance, 60% of all data communications traffic is generated by 300 large companies (Hepworth, 1990, page 65). Equity-related issues are currently being debated in national arenas as developed countries, including Britain, the United States, Germany, and France, prepare to create public digital telecommunications infrastructures.

These arguments notwithstanding, most theorists maintain that decentralization is connected to IT and that it has enabled industries to overcome spatial restrictions. For example, Harvey (1988) states that communications technology allows firms to overcome geographical distance, take advantage of time compression, and restructure business relationships. Hepworth (1990) explains that multilocational firms are able to achieve high levels of locational flexibility, including decentralization, as a result of greater economies of scale and scope brought about by computer networking. The contentions of these and other authors have helped the development of the superhighway concept.

4 Information technology and the centralization thesis

Centralization of production refers to the drawing of distinct production stages toward a center. The concept, like its counterpart decentralization, is widely documented throughout existing literature on IT and regional development. Many authors, in fact, analyze the two locational trends in the same piece of work, as they argue that decentralization and centralization occur simultaneously and are two sides of the same process. Ironically, the literature generally reveals that IT facilitates centralization of production in the same way that it facilitates decentralization of production. Specifically, whereas IT is said to reduce spatial friction and facilitate decentralization, the technology helps speed up production and as a result fosters centralization. For example, firms wishing to speed up product design need to use IT, a requirement that pulls them towards centers of highly-skilled labor, advanced services, suppliers, and customers. This requirement, in turn, facilitates production centralization. However, as IT is not necessarily the initial cause of centralization, it is important to examine other theories for a better understanding of causal factors.

Historically, causes for centralization have varied greatly. Notable arguments include cost minimization and resource-sharing advantages that businesses draw from agglomeration economies, uneven development of modern capitalism, and greater international access. For example, Vernon's (1979) product-cycle theory explains that centralization of production occurs in the early stage of production, or the stage of conception, as firms pursue agglomeration economies. This is so because the early stage is basically concerned with a new product undergoing constant refinement. Therefore, efficient production is best maximized when located near centers where firms can take advantage of the intensity of information interchange and access to capital sources, new markets, highly skilled and specialized labor, and support services. Likewise, Malecki (1991) and Premus (1988) argue that research and development (R&D) facilities require a centralized environment: close to business contacts, universities, and top management.

In another example, the Joint Economic Committee's survey of high-technology companies in the United States identified a need for daily interaction with other high-technology companies, suppliers, and customers as the primary reason why high-technology firms prefer to locate centrally in urban environments (Premus, 1985). Scott (1988a) argues that this high-technology agglomeration is motivated mainly by a need to reduce transaction costs. Camagni (1988) and Schoenberger (1987) argue that the decentralization of industry to rural areas is no longer a viable alternative. Instead, production is increasingly being pulled back to the central places where R&D, engineering, and interaction with suppliers and customers can be accomplished.

Smith (1984) and Soja (1989) have argued that uneven development is basically the systematic geographical expression of the contradictions inherent in the constitution and structure of capital. In this sense, production stages associated with decisionmaking may be centralized within a firm to support an effective vertical hierarchy of power (Fox-Przeworski, 1991). Myrdal (1959) proposed the cumulative causation hypothesis to explain spatial inequality which occurs anytime the backwash effect of an activity in a core area toward a less-developed place is stronger than the spread effect. Other authors have argued that centralization is necessary for international business relations, where hub centers are the only existing human contact stations. According to Moss (1986), Warf (1989), Sassen (1991), and Fainstein (1994), it is the large urban areas, the world cities, particularly New York, London, and Tokyo, which serve as office headquarters and financial capitals. Last, Goddard (1991) explains that fundamental changes in the regulation of the British economy during the postwar period have promoted centralization. Specifically, the "national state's actions of public purchasing, support for research and development, and initiation of grants and loans, facilitated centralized private sector development to the City of London" (page 195). Increases in collective wage bargaining through national sector-based unions further caused centralization (page 195). Similarly, in the United States the financing of high-risk ideas and new technologies through venture capital funds is geographically concentrated in major cities (OECD, 1985).

4.1 Information technology and centralization

These different causes of centralization have undoubtedly been evident, to varying degrees, in many industries. Their contribution notwithstanding, the trend is facilitated by the ability of IT to speed up production. The same intelligent networks which are currently playing a strong hand in facilitating the decentralization trend have also simultaneously motivated the centralization of production trend. Whether the networks used by firms for international communictions are public or private, IT facilitates centralization of production as well as control and deal-making. Several major themes within existing literature directly correlate new IT, or intelligent networks, with the trend of production centralization. One such theme, based on the efficiency of management, explains that, through IT, an ideal stage is set which is conducive both to faster decisionmaking and to the more efficient control of operations. According to Williams (1991, page 27), "Most managers and planning personnel have more information at their fingertips and thus have the opportunity to improve the speed and quality of decision-making. This can range from the information that engineers use in design operations, to gathering of real-time information over a network that monitors information from the firm's production processes in remote locations."

In Hepworth's (1990) case study of the intelligent network designed for Labatt Breweries, the mainframe information hub located in London was found to have enabled centralized applications such as business planning, financial control, market research, and advertising. The reported impacts of this centralized capability were "higher labor productivity in management and administrative occupations; more effective research and product applications; and more enhanced control of regional operations" (page 102). These impacts suggest that utilization of an intelligent network for supporting a centralized environment can be highly beneficial to a multilocational firm. Furthermore, although intelligent networks may function to support spatial decentralization in productive or technical operations, their simultaneous use as "control innovations suggests that the traditional, centralized decision-making power within organizations could remain unchanged or even exacerbated" (page 102). Another aspect of the efficiency of management is an overall improvement in administrative quality. Williams (1991) suggests that, as a result of IT, individual managers are potentially responsible for more people and more operations, and, in essence, this may actually reduce the need for middle-management positions.

A second argument, based on the facilitation of personal interaction brought about by IT, claims that the intelligent network allows for the greatest maximization of agglomeration economies. Firm-to-firm interaction is facilitated when the intensity of telephone calls and fax transmissions is increased and when computer networks potentially overlap. Both of these developments are more likely to happen where firms are localized. For example, different firms located in New York's financial market are able to access one centralized information source which is updated by the minute. Access to a resource such as this is vital for meeting the needs of clients in a competitive environment. In this sense, Malecki (1991) emphasizes that many firms try to maximize information-intensive contacts by centralizing in urban areas.

Another reason why IT facilitates the centralization trend is its presence in places where economic acivities are concentrated. Although there are numerous theories surrounding the initial development of cities and their continued growth, according to Fox-Przeworski (1991) urban centers have developed in close relationship with development of telecommunications and other intelligent networks. This occurs because it is in the cities that IT has often been most prevalent. Intelligent networks help facilitate the many disparate functions that large urban centers perform. Firms seeking to maximize IT in order to speed up production are often limited either to developing a private network, which is an expensive option, or to using the public telecommunications network for access. Essentially, the latter is disproportionately available in centralized areas (Mansell, 1993). In a sense, firms make locational decisions in anticipation that centralization will facilitate the emergence of technological trends. According to Goddard (1991, page 209), in the peripheral regions surrounding London advanced telecommunications services are being produced only where demand is justified; in very small centers where there are too few users to justify such advanced services intelligent networks are not very developed.

Historically, telegraph technology and the introduction of railroads surfaced in developed countries during the same time period (Newton, 1991). Indeed, telegraph lines often followed railroad lines, and telegraph operating stations often developed within railroad stations, generally located in populated geographic areas such as major cities and towns. Once new and advanced IT replaced the telegraph, public telecommunications systems continued to centralize in large cities. Therefore, this centralization pull relates not only to the physical placement of lines, mainframes, and networks, but also to the level of market demand for such resources. Given the expanding demand in large cities, new IT will most likely continue to concentrate in these areas where a certain amount of compatible infrastructure and support services exist (Goddard and Gillespie, 1988). Urban areas usually maximize demand for information because they possess a higher proportion of knowledge-based workers, an assembly of universities and research agencies, more options for job mobility, and a diversity of amenities. These same qualities make cities natural seedbeds of innovation and a place where new industries are easily fostered. These developments, in turn, perpetuate the continued growth of public telecommunications networks in centralized areas.

One example of the demand for advanced public IT services in large urban areas is the introduction of the teleport. Teleports provide integrated facilities that link a multitude of satellite and cable services via telephone, fiber-optic, or microwave installations to many customers in a region. The concept, which originated in the United States, has not necessarily had much success to date (Williams, 1991). Although teleports could essentially be placed anywhere, they are being installed in the largest cities, because of the need for intricate and compatible computer architecture in the service area. Moreover, should problems arise, immediate servicing of the technology is more accessible in large cities. For example, of the forty operating teleports in the United States in 1987, twenty-seven were located in the seventeen largest metropolitan areas (Fox-Przeworski, 1991). This relationship between centralized places and IT presents many new challenges for regional development planners.

4.2 Regional development and centralization

Areas that are 'information-rich' are becoming the nerve system for the international economic system. In essence, telecommunications infrastructure in the 'postindustrial' era is analogous to the ship or rail terminal of the industrial era. Acknowledgement of this trend has led regional developers to fear that peripheral areas may not be able to attract the industries they need in order to survive or grow. According to Moss (1986), firms situated in the major business districts of the United States will have the benefit of competition in selecting fiber-optic local carriers in the near future, whereas in remote areas copper cable is unlikely to be replaced by fiber optics. In the United Kingdom, large parts of the country are excluded from the existing or planned network, and the availability of service is further restricted depending on the distance from a distribution node (Goddard, 1991). Universal access, however, contains two vital components: access to a telecommunications infrastructure, and access to all services at affordable rates.

Likewise, based on the characteristic of intelligent networks to facilitate centralization and help maintain vertical hierarchies of power among large corporations, regional development experts assert that IT is technically capable of excluding selected locations from all decisionmaking functions. According to Hagerstrand (1967), the spread of information follows a hierarchical form and occurs through a limited number of channels. Generally, the flow is from large centers, or developed places, to smaller areas, or peripheries, reflecting the concentration of socioeconomic or political decisionmaking. This pattern of flow increases the vulnerability of disadvantaged localities whose access to information is controlled. Now, if IT were actually to foster centralization or to increase control of the 'informating' channels by large firms or centers, then regional planners would have every reason to become concerned. This is so because access to information is an increasingly important determinant of regional economic development and adaptation to change. For example, a small firm in an isolated area may not become informed of new ideas developing in large metropolitan centers. Castells (1985) also contends that IT may help perpetuate a society of economic and social dualism, even though the direct cause is not the rise in the new technology but, instead, the failure of modern capitalism to diffuse it evenly over geographies.

Throughout history, economic development advocates, on an international level, have been active in lobbying for legislation that would force public telecommunications networks to provide universal access to all areas. For example, in 1948 the United States established the Rural Electrification Act to create a Rural Electrification Administration. The Administration has enabled rural regions to access the telephone service by making low-cost loans to rural telecommunications companies to build and expand local networks (Williams, 1991). The future of intelligent networks with regard to the universal access issue is currently being debated. Mansell (1993) explains that two camps exist to explain the future potential of intelligent networks: idealists, who believe in automatic, universal access; and strategists, who argue that policy actions must be constructed for universal access to become possible.

5 Information technology and the disintegration thesis

'Disintegration' is not a completely new term, although the many contexts and definitions attached to it clearly do vary. For the purpose of this paper, disintegration is discussed in relation to production and therefore is defined as the fragmentation of a centralized production hub into several restructured units, each of which incorporates every necessary production stage to create a comprehensive and self-sufficient structure. Different from the mere movement of certain production stages in space, such as manufacturing to branch plants, associated with decentralization, disintegration strategy represents the functional alteration of the traditional production stages. For example, when the United States government forced AT&T to dismantle its monopoly, the firm disintegrated into new production facilities across the country. Significantly, each new facility not only included a few production stages, but also incorporated all production stages into a new, comprehensive, and self-sufficient functional structure. Ironically, the federal intervention became the cause for a major industry initiative.

Although industries have in the past disintegrated for a multitude of reasons, including deregulation of a major monopoly, the tendency for firms to disintegrate functionally as they approach the 21st century is based on several causal criteria, or what we have termed 'base premises': (a) production stages will function better together than in isolation; (b) flexible production will be more efficient than Fordism; (c) different levels of labor will be more productive when combined in teams than otherwise; and (d) development of competitive advantage will be vital to a firm's survival. These premises are viewed in the context of current global trends, including those which affect interproduction relations, such as globalization. In particular, the new challenges presented by globalization are likely to reinforce industrial disintegration. Globalization may be referred to as "a process whereby certain megatrends are made universal to the human condition, although they are differently experienced by diverse cultures and activities and at various territorial scales" (Amirahmadi, 1993, page 537).

One current global megatrend is worldwide competition, and, because of this, industry leaders of today are required to create novel approaches to enhance productivity (Morton, 1991). Two very crucial enhancement approaches to productivity have been identified (Rockart and Short, 1991). The first is to respond quickly and effectively to market forces for the purpose of increasing productive capacity, and the second is to improve the quality of conformance to customer requirements. In many cases, in order to accomplish these enhancements the development of human capital, rather than cost-minimization techniques, is critical. Thurow (1992, page 45) contemplates:

> "Consider what are commonly believed to be the seven key industries of the next few decades—microelectronics, biotechnology, the materials industries, civilian aviation, telecommunications, robots plus machine tools, and computers plus software. All are brainpower industries. Each could be located anywhere on the face of the globe. Where they will be located depends upon who can organize the brainpower to capture them. In the century ahead comparative advantage will be man-made."

The old concept of comparative advantage based on natural-resource endowment is no longer a functional theory for many industries. Instead, what determines industrial success in the current global arena is the application of knowledge and technology to create 'competitive advantage' (Porter, 1990). Resourceful *places* are being replaced by locations with resourceful *people* who use technology to maximize productive skills. This new form of advantage is competitive, instead of comparative, because it is based largely on a survival strategy rather than on resource endowment. On an international level, countries lacking the ability to use intelligent networks effectively to achieve competitive advantage could risk increasing their chance of being left out of international trade and investment flows.

A firm's ability to improve productivity is vital if it is to remain competitive in a globalized economy. Productivity enhancements, as a means of gaining competitive advantage, maximize human capacity in a variety of ways. It may involve better coordination of manufacturing and purchasing tasks so as to maximize economies of scale, and linking the purchasing and warehousing components and/or hastening the time it takes to bring a product to market (Morton, 1991). The phrase 'time to market' has become a catchword in business, referring to a firm's ability to design, produce, and bring to market new products quickly, or to manage the existing product lines better. For example, the Black & Decker Corporation now brings products to market in half the time it took before 1985 by using IT networks to meld workers from different departments toward one common goal (Madnick, 1991).

Functional integration, the first premise which underlies the disintegration thesis, is one method of improving productivity, and, therefore, of maintaining competitive advantage. In recent years, many firms have been organized as a group of loose minicorporations, decentralized in groups according to type of production or function. Although this may simplify the management structure, it has been found to incur various inefficiencies. For example, according to Madnick (1991), a firm's designers are often removed from the concerns and needs of the manufacturing and purchasing groups. This approach has led some organizations, such as Xerox, to develop task forces that consist of members from design, manufacturing, and purchasing departments working together on new products. Similarly, Camagni's (1988) research on Italian manufacturing firms demonstrates that competitive pressure to develop higher rates of product innovation effectively motivated functional integration, basically by "interweaving product *conception* tasks *with* product *execution* tasks" (page 54, our emphasis).

Another method of achieving enhanced productivity, and competitive advantage, is flexible production. This method, often used by disintegrated facilities, enables an increase in the responsiveness to market trends and the requirements of customers and is intended to result in sales volume and a reduced level of energy waste (Madnick, 1991). The new mode of flexible accumulation challenges the ideas inherent in Fordist production systems. Fordism is commonly characterized by large-scale routine mass production (assembly lines) and vertical integration of the stages of production within large firms. Flexible specialization, on the other hand, is often smaller in scale and focuses on market niches, allows for more diversity in working hours and time schedules, supports multitasking, and incorporates mechanized robots. Because individuals are not separated from the preliminary stages of the innovation process, flexible production is often believed to be more efficient than Fordism in maximizing human capital and stimulating innovation (Mair, 1993).

Meanwhile, productivity enhancements are especially a challenge to firms in the 1990s because of the present 'volatile environment' resulting from social, legal, and governmental conflicts (Morton, 1991). This environment and the increasing competitive pressure require even large firms to ensure responsiveness and quality to customers, much like a small firm (Madnick, 1991). No wonder large firms tend to move away from Fordism and adopt 'just-in-time' mechanisms, where frequent deliveries of small amounts of high-quality parts at the last minute enable firms to adjust their inventory flexibly to customer demands (Mair, 1993, page 209).

In addition to flexible production, productivity enhancements, which maximize human capital, necessitate a job design that is integrated both vertically and horizontally. Work, therefore, requires the use of multiskills and promotes the use of teams, often on a project basis (Scarbrough and Corbett, 1992, page 39). The Ford Motor Company, for example, has claimed that the 'Team Taurus' approach shaved more than a year off the time needed to develop, build, and bring to market the Taurus–Sable line (Rockart and Short, 1991). Ken Olson, Chairman of Digital Equipment Corporation, believes that the ability to bring teams together is one of the most important features of the company's capabilities. In the future, according to Drucker (1973), many tasks will be accomplished primarily in teams. The move toward teams also supports functional integration, as effective teams require the input of workers representing different production stages. On the basis of a research study accomplished by a task force from the Massachusetts Institute of Technology, Morton (1991, page 13) states:

> "Xerox, among others, connected design, engineering, and manufacturing personnel within its intelligent network and created a team focused on one product. Such teams have accomplished tasks in shorter time with greater creativity and higher morale than with their previous tools and organizational structures. There is no part of the organization, in principle, which is excluded from the team concept."

Because of the concept of competitive advantage, many firms are moving toward the utilization of productivity-enhancement mechanisms which maximize human capital. This movement, in turn, is stimulating the disintegration trend as evidenced by an increase in subsidiary and spin-off creation. "In this age of divesture, it is not uncommon to find a large corporation spinning-off various smaller divisions, to operate as autonomous corporations" (Madnick, 1991, page 33). Decentralized branch plants which may have effectively serviced customers in the production stage of manufacturing for many years, for example, may fail to compete with flexibly producing disintegrated firms in the era of sophisticated demand functions and intelligent networks. The decentralized branch plant in the global economy of today requires more dependency on the other production stages in order to satisfy customer demands and remain competitive. Instead, disintegrated branch plants may arise as 'intelligent plants'; although still responsive to a central facility, these plants will be more capable of making decisions by reacting flexibly and efficiently both to customer demands and to other market pressures.

5.1 Information technology and disintegration

The intelligent characteristic of new IT supports several typologies of a disintegrated firm, although each type of disintegration maintains the base premises. First, disintegration of production may be evident on a project-based level within one building, such as the establishment of a new and comprehensive department whose sole task is to bring a laptop computer product to market. Second, disintegration of production may exist on a networked level throughout many different branches of a firm, so that a new disintegrated entity is created alongside a traditional corporate structure, such as a multiregional task force created to bring an old product to market more quickly and with improved features. For instance, Xerox Corporation has made product-design changes and manufacturing improvements in its copier division to increase market share. In this example, compressing the time to market required increased functional integration among distant departments, such as design, engineering, manufacturing, purchasing, distribution, and servicing (Morton, 1991).

Last, a whole, new disintegrated firm, acting like a subsidiary or a spin-off, may be created (Madnick, 1991). Completely disintegrated firms provide that all stages of the traditional production cycle will collapse into one (Massey, 1984). This type of disintegration is evidenced by large corporations which locate in foreign countries to expand, and, because of local consumer requirements, must develop new products and a new facility which meet local demands. Modern intelligent networks will enable whole, disintegrated facilities to exist independently from the rest of the associated firm in terms of production, and this is in spite of their embeddedness. In this respect, therefore, a disintegrated facility is different from the old decentralized subsidiary.

New IT is extremely conducive to each of the above topologies which support production disintegration. The primary reason for IT being conducive to disintegration is related to its product and process combination. Basically, the *process* aspect of an intelligent network provides the interface conducive to the creation of a single, transparent, production stage, and the *product* aspect of the intelligent network continuously fosters new information which would previously have been unvailable. This newly created information, such as the prototype from StereoLithography discussed in section 1, is available for manipulation and review by different teams of workers, resulting in increased speed of production and productivity. For example, the new information helps workers to develop higher-quality products and respond rapidly to consumer demand by utilizing consumer feedback in the entire production process, from design to distribution. Usage of intelligent networks by workers to *create*, rather than simply to organize and coordinate, spurns decisionmaking at every level of production, from low-level to high-level employment. Decentralization, on the other hand, fails to support this sharing of 'new' information and therefore workers are often not even made aware of the comprehensive goals of the centralized decisionmaking body, let alone allowed to aid product development.

Intelligent networks have a profound impact on the ability of firms to act in the manner defined by the base premises. In order to react quickly to the needs of customers, for instance, firms utilize the networks to become more flexible, to track their inventory, and to meet demand. The role of IT on flexible production and on quality enhancement is very evident in an example from Benjamin Moore Paint

Company. In addition to inventory tracking, all of the Benjamin Moore outlets have, as part of its intelligent network, 'smart' paint blenders that analyze paint chips brought in by a customer and calculate the proper mix proportions to match them (Rockart and Short, 1991). IT is highly conducive to teams in that it enables mature group-interactions. Current intelligent networks, for instance, are supporting an increasingly large amount of 'groupware', that is, software which is specifically designed to motivate efficient teamwork and group 'brainstorming'.

Future applications of intelligent networks are likely to encourage even more human-capital maximization. This is in spite of the generally accepted notion that technology tends to displace human resources. For instance, 'neural networks' are currently gaining ground among engineers internationally as the hottest emerging computer technology. Computer engineers construct neural networks imitating, in software or silicon, the structure of brain cells and the three-dimensional lattice of connections among them (*Fortune* 1993a). The primary differences between this technology and other types of computer 'expert systems' is that in neural networks the computer learns by experience, not by obeying programmed instructions. Once intelligent networks are able to learn by past experience, the role of workers in molding these experiences will become vital.

5.2 Regional planning and disintegration

Whether disintegrated flexible firms tend to decentralize or agglomerate is debated in the literature on new industrial spaces (see Amin and Robins, 1990; Amin and Thrift, 1992; Henry, 1992; Lovering, 1990; Scott, 1988a; 1988b). Scott (1988a) has claimed that, because flexibly specialized firms are based on the social division of labor, the formation of external economies, and the dissolution of labor-market rigidities, they tend to agglomerate, form new types of 'industrial districts', and lead to a resurgence of federated self-contained regional economies on a pervasive scale. The tendency to agglomerate is also said to emanate from the need for extensive technical cooperation between sellers and buyers (best achieved through 'person contacts') in flexible firms which produce customer-specific products. As opposed to this localization thesis in which high-tech industrialization and territorial development are seen as simultaneous processes, Lovering (1990), among others, has argued that such a concentrated outcome can hardly be expected of the new firms (which, incidently, may not even be flexible) given the globalization of production and the extensive network that transnational and national firms have created. In particular, globalization tends to create embeddedness and, as such, to negate local territorial integrity. This leads to a more diffused pattern of location and regional development.

But, as Amin and Thrift (1992, pages 575-577) have attempted to show, industrial districts and local complexes may be seen as the outgrowths of a world economy that is dominated by global corporate networks and powers. Drawing on Marshall's work on 'industrial atmosphere', they have also, and correctly, argued that we are witnessing the growth of "increasingly integrated global production filieres orchestrated and coordinated by large corporations. But, because these filieres are more decentralized and less hierarchically governed, there are in fact a number of very considerable problems of integration and coordination". They then list the problems as representation (basically, generating and disseminating firm-favorable discourses), social interaction, and the tracking of innovation. Exactly because of these problems, Amin and Thrift have argued that, although "the world economy may have become more decentralized, it is not necessarily becoming decentered". They state that centers are still needed and that these have to be geographical centers in which an industrial atmosphere needs to be created to nurture knowledge, communication, and innovation in order for firms to retain their competitive advantage.

Although basically sound, Amin and Thrift's argument could have informed the new trend even more fully had it been placed within a conceptual framework that viewed the role of IT both as a process and as a productive force. Specifically, viewing the technology as an infrastructure, they remain captive to the charm of decentralization and centralization trends, yet in reality they should have extended their argument to indicate that firms are indeed disintegrating from centers that remain large and show a tendency for integration. As they have noted, a decentralized firm is no longer merely a branch or single-function unit. Rather, disintegrated firms are in themselves complete facilities that, although appearing isolated, integrate every necessary aspect of production, often from conception to marketing, and continue to remain connected to certain centers. However, the centers may not be geographical centers, a fact that is also implicitly acknowledged by Amin and Thrift, who remain agnostic concerning the future of their proposed geographical centers. The industrial atmosphere which is created to nurture knowledge, communication, and innovation in a disintegrated firm is evidenced most over the intelligent network which acts as an umbilical cord stretching between a new life and a guiding-parent 'strategic node'.

It is precisely because IT has become a productive force that new, more numerous typologies of disintegrated firms are developing and are connected to sophisticated strategic nodes, instead of only to geographical centers. Significantly, decisionmaking individuals define these strategic nodes, not their physical locations. A strategic node, or 'cloud' describes the control and strategy aspects of a firm, yet is spatial in that the key individuals may be distributed throughout an intelligent network. However, intelligent networks connected to functional strategic nodes, such as the larger centers with more global functions, do nurture knowledge, communication, and innovation in order to retain competitive advantage.

In terms of location, disintegration is more flexible than decentralization in that competitive advantage is a strategy which utilizes intelligent networks and strategic nodes, instead of specific geographical sites. In the century ahead, resources, capital, and new product technologies are going to move rapidly around the world as a result of such networks (Thurow, 1992). Implications of such an international flow will more often be based on the ability to transfer information than on transportation or locational considerations. In other words, disintegration can occur in a firm over a network among already decentralized branches, or it can be instilled, in a spin-off fashion, in a centralized environment. Spatial tendencies of disintegration will depend on the type of production enhancements instilled within the firm and on the firm-specific causes of disintegration. However, each of the productivity enhancements emphasize human capital. Therefore, regions around the world which put priority on IT to help generate human-capital enhancements may be in the best position to attract disintegrated firms and boast a competitive advantage in the 21st century. For instance, as even lower skilled laborers in the future will require some proficiency in high-technology processing, regions may respond to the disintegration trend by providing firms with a diverse pool of workers skilled in using IT and by offering training programs.

One significant problem with disintegrated firms is that use of an intelligent network is often one of proprietary design in order to control interfirm security and to promote interfirm growth. But proprietary networks developed to support disintegrated firms may not support standard network architecture and, in effect, may completely limit access to those outside the network. Regional developers must remain aware of the limiting impacts which are controlled by the disintegrating firm's strategic node. Interestingly, the same firms which may devise proprietary intelligent networks to enable disintegration may simultaneously demand access to a public intelligent network for the purpose of integrating with other firms.

6 Information technology and the integration thesis

Integration, in general, is not an unfamiliar term to experts of many academic disciplines. In fact, integration is a current topic of interest in education, sociology, and geography. However, it is a specific type of integration, one which is connected to production, that is our concern in this discussion. Although centralization is a physically close conglomeration of competing or complementary industries, usually, though not always, representing monoproduction stages such as R&D or corporate control, integration of production is defined as bringing together diverse industries, or previously disunited production stages, into a new comprehensive resource-sharing relationship, either geographically distributed or centralized. Although input–output tables reveal that industries are truly dependent on one another, there is no empirical claim that individual industries are completely and consistently integrated in terms of production processes. Therefore, integration has not been highly visible in the past on a global scale. One possible analogy might be the integration of US military production techniques into the private sector. For example, the end of the Cold War motivated the US government, through the National Aeronautics and Space Administration, to open technology transfer centers for use by all high-technology industries. These centers function as state-of-the-art facilities for rapid information-sharing. All industries have the same opportunity to review the previously unavailable materials and to access high-technology training material (NTTC, 1992). Ideally, any private-sector firm which utilizes the nationwide centers will increase the efficiency of its production as a result of the new knowledge gained.

Integration of production, viewed in the context defined above, is beginning to occur as a result of one of the very same concepts which enabled disintegration to develop: globalization. In terms of integration, globalization has been described by Soete (1991):

> "the process in which the internationalization of science and technology has gone hand in hand with an increase in transnational networks and strategic alliances between enterprises as a means to competitive advantage in global markets, increasingly through the joint development of access to technology. It raises major questions about the role of government policies, and their relationship to the strategies of such enterprises" (cited in Mansell, 1993, page 200).

The concept of competitive advantage, discussed in the previous section of this paper, is a strategy of firm survival which focuses on productivity enhancement as the key to industrial success. Therefore, firms may simultaneously disintegrate and integrate in order to maximize 'advantage' and to minimize 'competition'. Where firms improve the quality and efficiency of production by disintegrating, firms may also expand production and quality, gain access to technology, and reduce competition by integrating with other firms. In this sense, the base premises which support integration are as follows: (1) resource-sharing among firms will bring benefits to every participating firm in a 'win–win' situation; (2) links between firms and their suppliers are vital for maintaining competitive advantage; and (3) intrafirm production will minimize industrial competition. These base premises emphasize the importance of human capital, more than cost-minimization, as integration promotes sharing intrafirm talent through the use of teams, utilization of just-in-time production, and quality improvements.

In the case of disintegration, industries gain competitive advantage by collapsing the traditional product cycle and fragmenting into a group of completely restructured production facilities. Integration, however, does not follow a collapse in the traditional production cycle; rather, it requires that different industries and firms form partnerships with each other to gain maximum capacity. The integration process begins with the separate stages of the production cycle, from creation to sales. Selected production stages of one firm become *informationally and functionally integrated* with various production stages from other firms. Furthermore, this trend occurs across many diverse industries and government agencies (Morton, 1991).

An example of this type of integration exists in the 'virtual corporation', as well as in partnerships and strategic alliances. The virtual corporation concept, introduced by Nagel at Lehigh University, consists of a group of firms which share different production functions on a temporary basis, such as for the lifetime of a certain product (*Business Week* 1993). Each firm in the virtual corporation, each often a leader in a specific production stage, is united by a common intelligent network. The virtual corporation acts as a comprehensive industrial unit committed to efficient production by means of continuous information-sharing in a real-time network. Benefits of the virtual corporation include access to talents of other corporations and the ability to incorporate all phases of production successfully. Larger firms benefit because, alone, they cannot react fast enough to compete effectively with the increasingly shorter product-to-market times. Smaller firms benefit by gaining the talent 'muscle' to bring a conceptualized product to market (*Business Week* 1993). Furthermore, firms engaged in virtual corporations are able to reduce competition in a product line by collaborating with rival firms to develop a joint endeavor.

Early examples of virtual corporations stem from large-scale military projects, such as the development of the B-1 Bomber. In this case, divisions of groups from as many as two thousand corporations worked together essentially as departments within a virtual industrial environment to accomplish the design and manufacture of the required product (Madnick, 1991, page 32). In a 1991 negotiation, Apple Computer Inc. turned to the Sony Corporation to manufacture a less-expensive version of the PowerBook laptop: "It was an obvious pairing, melding Apple's easy-to-use software with Sony's manufacturing skills in miniaturization" (*Business Week* 1993, page 100). The agreement between the two firms lasted only one year; however, both firms have moved on to participate in new virtual relationships with other firms.

A second example of integration is currently evident in the retail industry. In this case, firms which have the best inventory-control systems survive. Retail stores may be directly linked to suppliers to minimize the time lags between the customer's purchase of some particular item and the restocking of that item. In effect, a seamless web is created where merchandise is manufactured only shortly before it is delivered and sold. The just-in-time technique is another example of the integration thesis. The technique is described as a production system which allows a buyer and a supplier to coordinate the production and shipment of an input to another production process, reducing the buyer's inventory of supplies to almost nothing (Yates and Benjamin, 1991). These techniques, practised first in Japan where automakers ordered raw materials only when needed (Dohse et al, 1985; Malecki, 1991), are increasingly being implemented by firms as a productivity enhancement to achieve competitive advantage. Seamless inventory linkages, supported by an intrafirm intelligent network, enable firms to establish quality control and reduce competition by reacting more quickly than competitors to changes in the market. For instance, Applied Materials Inc. which makes equipment to manufacture semiconductors, has an intelligent network based on a collaborative web of suppliers and customers. Each integrated firm specializes in doing a part of the production well, so that Allied does not need to do everything well (*Business. Week* 1993). In essence, integrated firms are composed of the best of everything.

6.1 Information technology and integration

Intelligent networks are highly supportive of integration. Specifically, it is IT as a productive force which facilitates the trend by making it easy for firms to share resources and link with suppliers. The characteristic of intelligent networks to generate 'new' information, or to 'informate', creates productivity enhancements when firms link resources together. A case in point is the shared vision of American Airlines and United Airlines to extend their reservation systems, originally built for their own agents, to systems that include flights of other airlines. After the original, dual airline database was implemented, 'new' information was produced and the value of the IT was realized. The decision to expand the database enabled the two corporations to lock in a large number of travel agencies, and, therefore, benefit from the revenues obtained from forming an electronic market. As American Hospital Supply Corporation has shown, one single database can serve as the sellers' order entry system and the buyers' purchasing system, connected by terminals and data links in an intelligent network (Yates and Benjamin, 1991, page 82).

Supplier linkages, as in just-in-time production, require more than a transaction-based perception. Intelligent networks are vital to create a medium for 'informating' (Zuboff, 1988) the necessary step toward maximum worker decisionmaking. In this example of integration, the IT product (the output from the inventory-control system) is reviewed, monitored, and manipulated by workers employed by both the supplier and the distributor. The supplier and the buyer are also informationally linked by an intelligent network to other industries, such as financial services and advertising, which further the integration process. According to David Nadler, founder of Delta Consulting Group, the greater level of collaboration among competitors, suppliers, and customers will "create so much overlap that it will be tough to determine where any one company ends and another begins" (*Business Week* 1993, page 100). The role of intelligent networks is so central to the integration process, that even the legal negotiations of corporate partnership may be reduced to electronic contracts.

There are several typologies of integration. First, a firm may integrate its production stages with another firm's production stages (or a government agency), on a temporary, project basis. For instance, in order to develop the Power PC microchip, several major high-technology corporations developed a team of employees who were dedicated to idea collaboration and resource sharing in order to create this specific product. Second, a firm may establish a continual link with another, preestablished, group of firms. This is the case during just-in-time production, where a supplier, distributor, and manufacturer may be informationally linked in a long-term agreement. The third, and most extreme, type occurs when one, 'open', intelligent network supports complete and continual integration between any firm or group of firms. In this case, the input-output table would show consistent, high rates of dependency in the intraindustry categories.

With respect to the first type, many firms are currently employing integration in order to realize the benefits of collaborative development. In support of this contention, corporate data networks throughout the world have joined the Internet, a network of networks where computers can communicate with one another as a result of the establishment of a standard protocol, called Transmission Control Protocol/Internet Protocol. The Internet allows individuals all over the world to 'talk', transfer files, and search for information via a desktop computer. Use of the Internet is specifically targeted as an international communications tool for businesses, education and library institutions, research centers, and government. According to Cronin (1994, page 155),

> "Almost every discipline and every major corporate research laboratory can provide numerous examples of the Internet's impact in facilitating cooperation and advancing the pace of research. In even the most competitive of businesses, the walls between companies have been penetrated by the power of high-speed networks."

The goal of the Internet in industrial communications is to enhance the quality and efficiency of production on a macroeconomic scale by the acquisition of new knowledge. For example, Intel's computer-aided design groups often collaborate with universities on the development of algorithms and software; and most of this work takes place on the Internet (Cronin, 1993, page 161).

The concept of integration is not without its critics. Virtual corporations, for example, carry many risks as one firm may not meet the demands of others in the integrated corporation. Also, others have coined the term 'hollow corporation' because most such virtual firms seek to allocate only the manufacturing component of production to another firm (*Business Week* 1993). The Internet is also often described as an unorganized system which is difficult to use and lacking in useful information. Yet, the intelligent network is a technology still in its infancy. The network of the future, which will utilize digital signals, digital switches, and high-powered computers, has even more potential to motivate integration. For instance, artificial intelligence systems, neural networks, and sensing devices may soon connect engineers directly to the production line. Recent enhancements to the Internet include video, audio, and multimedia as well as data functions.

6.2 Regional development and integration

Firms in the 21st century will have the option to disintegrate or integrate, decentralize or centralize. Owing to the importance of competitive advantage in a globalizing economy, we argue that firms are more likely to utilize the disintegration and integration trends simultaneously to enhance productivity. Although the integration of firms may induce positive productivity benefits, such as resource sharing across industries, there are potential negative sides to integration in terms of impact on space. In fact, it is often argued that integration of production may actually further restore a vertical labor hierarchy. As shown earlier, analysts of centralization theories, such as Castells (1985), state that intelligent networks may only benefit the areas which have supporting infrastructure such as the established larger and more powerful 'world cities'. It is also possible that the formation of agglomerations or networked industrial districts will be encouraged. Integration of production, then, may be even more conducive to the characteristic of modern capitalism to create uneven development as extreme integration among few, major firms and industries may cause oligopoly formation and, consequently, lead to an oligopoly of power.

Firms which disintegrate may develop a proprietary, intelligent network to reach productivity goals and maintain security. Integrating firms, however, require access to a common telecommunications architecture, such as an intelligent network, in order to collaborate effectively. Because these networks are currently forming in many developed nations, firms which have recognized the benefits of integration are able to influence the standards and policies of the intelligent network. Multinationals, for instance, are very heavy users of the public intelligent network and could inevitably create an 'elite' network, which would become too expensive for the rest of the world's firms to afford. According to Mansell (1993), many regionalists' greater fear is the 'networked firm'. Furthermore, individual oligopolies could locate anywhere in the world that is primarily strategic to their goals, because integration is not necessarily spatial. Integration among firms in underdeveloped regions, such as collaboration on the Internet, could occur to balance the oligopoly but significant and powerful relationships would always be controlled by the moves of corporate leaders. Policy measures to control a situation such as this would include antitrust laws, 'universal access' regulations, and labor-related measures. To implement these, however, the South needs cooperation from the North.

In essence, integration of production without public policy regulation could lead, and has led, to the formation of huge, networked supermultinational corporations. Additionally, as different firms integrate with others across industries to share information, firms seeking common goals might integrate together, permanently, to form a global competitive power. In fact, integration of production in this sense could be analogous to the term 'economic integration', described as "cooperation among and unification of the economies of different nations; the elimination of the barriers to trade among these nations; the bringing together of the markets in each of the separate economies to form one large market" (McConnell, 1987, page 848). Significantly, as the European Economic Community benefits from lower costs and more efficient production by integrating economies via policies, supermultinationals may benefit from lower costs and higher quality production by integrating productive capabilities via IT. Indeed, the recent increases in the number of multinational firms seem to support these claims, as well as the notion that intelligent telecommunications networks are being developed to support the specific interests of these firms (Mansell, 1993).

Although integration is not spatially restrictive, as is centralization, regions do not necessarily benefit economically from ignoring integrated facilities. For one reason, labor hierarchy is more likely to occur in a large proportion in supermultinationals than in centralized regions where a horizontal grouping of firms is the norm. This may cost undeveloped regions the benefits of high-skilled labor opportunities. Furthermore, integration poses a threat to those industries not part of a conglomeration, just as the European Common Market is an economic threat to countries outside of the European Communities. Regions, in this respect, need to contribute to the integration trend by motivating local industries and firms to lobby for universal access to the public intelligent network. Without the development of IT as a regional policy, the birth of supermultinationals could cause a large reduction in the number of regional industries and exacerbate uneven development, especially in common markets.

7 Implications for regional development

Throughout history, authors of planning literature have debated the appropriate role of decentralization in spatial development. Although the authors disagree as to the initial cause of decentralization or its exact impact, they generally believe the trend offers a catalyst for regional economic development. The literature also implies that IT, because it connects distant places, has a strong impact on regional development as it facilitates the decentralization trend. Yet we have argued in this paper that the product characteristic of IT, in combination with the process attribute, tends to stimulate an even more sophisticated and perhaps useful trend, namely, disintegration.

Specifically, by defining IT as a process and a product, it is our position that disintegration of production is the functional and locational trend of the future. Currently, industries are disintegrating for a variety of reasons, including globalization and the importance of maintaining competitive advantage. IT as a productive force is conducive to disintegration because it effectively facilitates functional integration, the use of teams, and flexible production techniques. In fact, the power of a disintegrated facility lies in its ability to enhance and increase productivity as a required factor in the current globalized and volatile environment. In contrast, decentralized production stages that maintain their traditional functional organization, or decentralize in search of natural advantages, do not utilize IT to its fullest potential, that is, to 'informate'. This is because they tend to lack the more sophisticated human-capital component which is necessary to realize such potential in order to secure competitive advantage.

Developments influencing the traditional decentralization trend present a problem to underdeveloped regions where planners have attempted to attract decentralized facilities to stimulate regional economy. Traditionally, many regions have developed the environment thought to be conducive to decentralization by providing physical amenities, cheaper land and labor, and, often, an information infrastructure. The birth of high-technology industries has given regions an even greater motivation to develop diverse innovation techniques for the purpose of achieving rich, economic benefits. Innovation techniques described in the relevant literature vary greatly, but it often includes ability to attract high-tech industries both to other high-tech firms and to universities. Not surprisingly, regional planners found IT especially valuable because of its perceived capability of facilitating high-technology decentralization.

Yet if we are correct and the traditional, spatial decentralization trend does, in fact, weaken in potential as intelligent networks develop, then regional economic development techniques based on spatial decentralization will fail to benefit lagging areas. Regions, in this case, would need to restructure innovation techniques specifically to accommodate disintegrated firms instead of decentralized firms. In particular, if disintegration does occur in addition to decentralization, regional planners must adjust their economic development techniques to correlate with flexible production trends, team work, just-in-time techniques, multiple labor skills, and other productivity enhancements. One significant means of promoting these enhancements is to introduce an intelligent network in an attempt to create new information for utilization by firms.

Regions have not traditionally prepared for the event of disintegration; yet it is important that regional planners research and analyze the diverse consequences of the trend. The first question that must be answered is whether regions should attract disintegrated firms, as they did in the case of decentralized branches. We suggest that a disintegrated facility would be a highly successful component of regional development because a large and diverse labor pool would be employed, causing direct and indirect economic benefits. Yet disintegrated firms are not necessarily spatially dependent. The three typologies explained in this paper, for instance, represent network configurations more than locational change. A region which exists as a node on a proprietary network may benefit most from disintegration in that a previously single-function branch plant in the region may become a disintegrated facility for a remote firm.

The second question for regional planners and policymakers to consider is how to obtain new disintegrated facilities. Generally, disintegrated facilities are more flexible than decentralized facilities locationally because they are not natural-resource-oriented and IT is much more mobile than most other factors of production. This implies that disintegrated firms could exist over a network, for example, in different countries. Yet, whereas traditional innovation techniques or attraction strategies were mostly place-based and incentive-based, in terms of disintegrated industries, regional techniques must include three other important types of incentives: that is, the provision of high-technology training for *diverse* groups of labor; an understanding of productivity-enhancement methods such as flexible production, team work, and functional integration; and access to a healthy intelligent network.

As technology is more mobile than other factors of production, people move slower than IT, causing disintegrated facilities to require large pools of higher skilled labor. Furthermore, because disintegrated facilities, by definition, include a diversity of labor skills, it is desirable to target innovation techniques at comprehensive training programs designed for many types and levels of labor skills. For example, although disintegrated facilities require large pools of highly skilled labor, it is the middle skilled and lower skilled labor groups which actually use the technology designed for production. Training for these diverse skills may be implemented in regional areas via a postsecondary high-technology vocational training system, perhaps similar to the successful vocational system in Germany. Although vocational education in the United States has been changing its emphasis from plumbing and carpentry to computer-system maintenance and computer-aided design, a more regional attempt to offer such technical training to lower skilled workers would be vital to be successful in attracting disintegrated firms. Of course, higher skilled labor would benefit academically and professionally from graduate-level and continuing education opportunities at the university level. Because of the prevalence of distance-learning courses, regions which are not located near a major university could easily access college courses via satellite or other networked systems. However, it is an important policy measure to ensure that regions have the technology available locally for employees to utilize.

Accordingly, it is vital for regionalists to demand legislation which promotes affordable, universal access. Without such legislation, remote regions with low population may not be guaranteed fair service compared with populated areas. Specifically, it should be a policy of central governments to provide financial support to qualified regions for designing and building a local intelligent network. It is vital that regions be able to support the proprietary networks designed by large firms. In particular, lagging regions will require IT networks that are competitive with the networks located in more developed areas. Additionally, promotion of legislation which would force the creation of international telecommunications standards may curtail development of many of the private networks, and government regulation would prevent high costs from limiting regional access to these networks.

Centralization of production has traditionally been analyzed as the locational trend which occurs simultaneously with decentralization. Although the many perceived causes of centralization vary among different authors, it is shown in this paper that IT facilitates centralization and this occurs as a result of the characteristic of IT to speed up production, which encourages industries to locate near an information center and close to one another. However, this characteristic reflects the ability of IT to act as a process. When IT is viewed as a product and as a process, as we have done in this paper, then its impact extends beyond the spatial decentralization trend and includes a functional integration trend that in itself may not be as adverse to lagging regions as the traditional centralization trend has been.

Specifically, it is argued in the centralization literature that IT will not diffuse equally across the globe at one time and that centralized 'hub' areas containing many industries may maintain their initial comparative advantage over remote locations, perpetuating uneven spatial development. Therefore, regions may never gain new economic stimuli in the form of industry and may lose local labor to the employment opportunities in nearby centralized areas. As much as regionalists hail IT for its ability to facilitate decentralization, it can create what Castells (1985) has identified as completely isolated communities, 'turned off' from the rest of society. As our definition of intelligent networks introduces integration as another, more functional, trend that is being propagated by IT, regional planners are encouraged to undertake further research, exploring and comparing the consequences of centralization and integration trends.

Integration can be summarized as an industrial trend which provides comprehensive resource-sharing among many, diverse industries. The virtual corporation is an example of integration where different firms combine resources for the duration of a product or some other temporary time period. Resource sharing between two firms may reduce the time it takes to bring a new product to market. Integration between suppliers, customers, and manufacturers may also lead to quality improvements and increased productivity. As these enhancements have become critical for firms to maintain competitive advantage, integration strategy has increasingly become an inevitable undertaking which in turn requires utilization of intelligent networks. The strategic body within each firm carries the entire responsibility of understanding and introducing each of the productivity-enhancement techniques discussed in this paper. However, the role of public policy is also important. The goal for public policy should be to support the firm by instituting labor-training programs for low-level and high-level employees in order to create a regional talent pool and by developing information resources and training programs to educate firms about just-in-time production, quality control, and resource-sharing benefits.

Integration may present one additional, crucial, policy challenge. The growing industrial reliance on today's infant, intelligent networks for the purposes of integration, such as usage of the Internet, implies that a universal, telecommunications architecture must be developed. Yet evidence is revealing that the growing number of multinational firms may have the best opportunities, because of their size and international power, to influence the developing public intelligent networks. For instance, integration practices currently occur mostly between large firms. Without proper policy protection on national levels, indeed, integration may actually lead to a worse consequence than centralization for greater imbalanced regional economic development. Access to intelligent networks could very easily become too expensive or not possible at all for peripheral regions, simply because of low population or distance from multinational firms. Therefore, from the regional development perspective the integration trend has two policy implications: the need for universal access to a physical, intelligent network and the need for universal access to opportunities for integration.

Universal access requires that an advanced intelligent network should be developed to be accessible to all individuals and firms and at an affordable rate. Although many national intelligent networks and policies are still forming, it is vital that regional innovation techniques begin concentrating on working with policymakers to provide universal access. Without the medium for affordable access, it will be impossible for existing regional firms to become involved in the integration process. Consequently, local labor forces may migrate to areas of increasing viability, such as the areas surrounding integrated activity. However, a national infrastructure-based incentive program complete with technical training would allow integration to act as a resource-sharing system equally accessible to all areas—both central and at the periphery—with information infrastructure. In this case, the fear of inequity is diminished as all industries have the same access to primary information sources and to one another. Needless to say, different countries, and many different telecommunications providers, are each responding differently to the plea for universal access, and no international agency exists to monitor national policies and demand universal access. Perhaps such an international agency will be established in the future as the world becomes increasingly globalized. In any case, policy actions toward national, universal access include lobbying efforts for regional funding, and negotiations between national governments and telecommunications providers. Of course, many issues surface, such as how to regulate an internationally integrated industry and how to handle the high cost of information for regional usage. Only further research into the potential for the actualization of the integration trend and its overall impacts on regions can provide answers to these and other similar concerns.

Public policy initiatives may also be necessary to expand integration opportunities to remote regions and inner cities. Specifically, the trend of integration may motivate excess corporate control and directly cause supermultinational firms to develop further. In other words, unregulated resource-sharing among major corporations could create international oligopolies. Policy measures should therefore consist of regulations for integrated firms, such as the implementation of antitrust laws to prevent national oligopolies, and local incentive-based techniques, such as job training, to enable the existing regional work force and businesses to compete with and become a part of integrated environments. For example, the state of Texas has designed a program for qualified small businesses that guarantees complete access to the Internet for a very small fee. If an antitrust law is implemented, regions are likely to benefit, as national oligopolistic movements would be regulated to a point of minimal impact.

In sum, we have argued in this paper that IT is better viewed as a process *and* as a productive force and that from this perspective its impact is not limited to spatial organization of industries as it also alters production methods. Beginning with this understanding of IT, we have identified and presented two emerging technospatial tendencies, namely, integration and disintegration. We have also explained the implications of this new formulation for a more effective regional development policy. There are also ramifications for the existing theory of the new international division of labor, a subject that is not treated in this paper. Specifically, IT allows new forms of aggregation and disaggregation, not only spatially in industrial districts but also organizationally in terms of functions. Thus we have two simultaneous processes, one spatial and one organizational, with the organizational process having spatial implications as well. Future research may include a study of the impact of IT on the emerging second new international division of labor.

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