Telecommunication and the tyranny of space

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AND
THE TYRANNY OF SPACE

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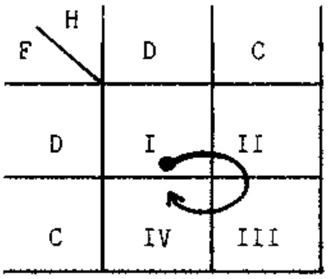
1. The Tyranny of Space

Spatial patterns of economic activity have never been static, but always in a state of flux. Both external driving forces and internal behavioural reactions of economic actors have led to a permanently changing land use and location pattern from the side of both households (H) and firms (F). Their location patterns have varied between dispersion (D) and concentration (C) in different periods of the history. The resulting combinations of spatial patterns of H and F can be illustrated by means of the following 2 × 2 cross-tabular representation.



Cell I (dispersed locational pattern of both households and firms) relates to a primitive society based on small-scale handicraft and a self-supporting economy. Cell II describes a society which is facing the first signs of urbanization (the medieval society, e.g.), while most economic activities (agriculture, extractive activities, e.g.) are still dispersed (the Von Thunen economy). Then cell III refers to the period of the industrial revolution marked by a concentrated pattern of both households and firms (the Weber economy). Finally, cell IV concerns the post-war period in which a large-scale suburbanisation and desurbanisation takes place, leading to a rise in commuting radius. These four different phases in the history of locational developments are represented by means of the arrow in the abovementioned figure. It is of course an intriguing question whether the circle will be closed, in other words, whether a circular movement of locational patterns will emerge.

It is sometimes hypothesized that the current information society with its emphasis on telecommunication may lead to a liberation of the tyranny of space, so that more deconcentrated and even dispersed patterns of location may become plausible. Therefore, it may be interesting to focus attention on the information sector and its potential geographical implications.

2. The Information Sector

The modern informatics sector plays an important role in the framework of both entrepreneurial decision-making and public decision-making and planning (at both a national and a regional or local level). In general, information is not only power, but even ammunition. Consequently, effective and efficient decision-making in a modern society is strongly oriented toward the use of modern communication and information technology.

In contrast to the conventional industrial technology (mechanization, energy transmission, electronics), it is noteworthy that the informatics sector has a highly regulating and controlling potential which makes information and telecommunication extremely appropriate instruments in a policy-making context. This new development has three major features, viz. (a) high speed and reliability, (b) flexibility and adaptive potential, and (c) organizational and communicative power. Consequently, informatics will not become a substitute for private or public decision-making, but it will enhance its quality by providing complementary tools (cf. Wegener, 1985). In this respect one may assume that the 'wealth of nations' (Adam Smith) will in the future be determined by the 'wealth of information'. The distribution and use of modern information and telecommunication technology will also exert a decisive impact on the distribution of welfare among regions (see also Fritsch and Ewers, 1985). Free access to information and knowledge networks is therefore of paramount importance for a balanced development of a country or a global economy. Monopoly tendencies on the other hand will no doubt aggravate distributional and spatial inequalities (see Nijkamp, 1987).

Given the increasing importance of information for management and decision-making, it is no surprise that the information sector has grown dramatically. For instance, Naisbitt (1982) claims that approximately 60 percent of total employment in the USA is information-oriented. Despite this growth, it is interesting to report on some disenchanting observations, made by Jonscher (1983), who claims that the contribution of the information sector to final (consumer) expenditures is relatively low (approx. 7 percent), and that it is more its turnover and substitution rate within the quaternary sector which is higher, than its absolute total growth. On the other hand, the indirect productivity increases caused by the information sector may be very significant. In general, the employment generating effects of the information sector appear to be fairly modest, while the assessment of these effects is fraught with various difficulties and uncertainties. For instance, the information technology market is highly segmented and mainly composed of 3 different segments (see Hills, 1984), viz. computers (mainframes, micros, software, etc.), telecommunications (transmission via satellites, microwaves, fibre optic, cable, videotex, etc.), and microelectronics (chips, microprocessors, etc.).

Despite many uncertainties, it is clear that the information sector has grown in importance over the past decades. For instance, the telecommunications industry absorbs already one per cent of the GNP in the OECD countries annually (see Ergas and Okayama, 1984). This importance is also illustrated by Figure 1, based on Business Week (June 30, 1980, p. 140) The same journal also states:

> 'The old industrial society that generated wealth in the form of capital goods and manufactured products is giving way to a new society valued in terms of intangible assets, such as knowledge and information processing. In fact, for 15 years more people have been working at processing information than any other type of job.' (June 30, 1980, p. 102)

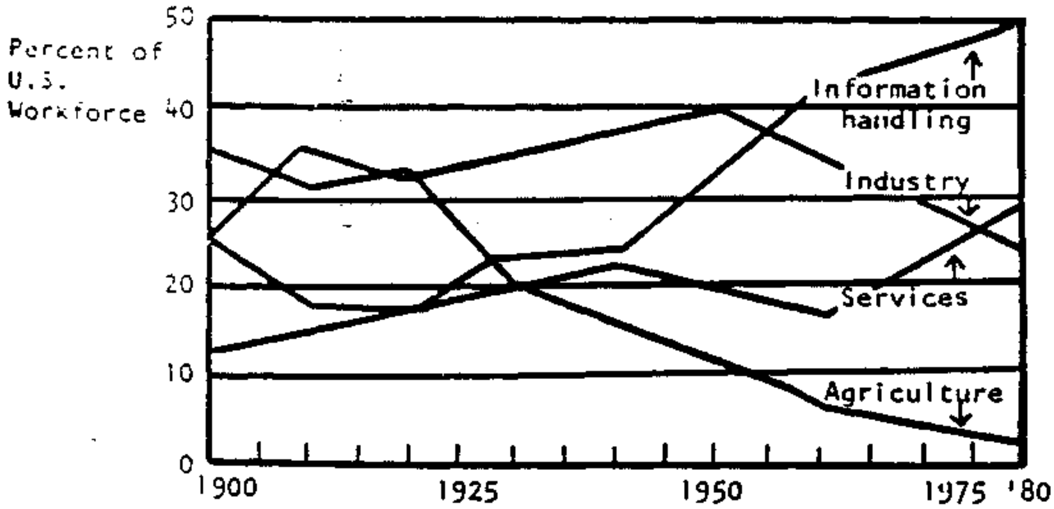


Fig. 1: Employment Trends in Four US Sectors (1900-1980)

An interesting contribution to the discussion on the importance of the information technology for corporate strategy has been made by Goldhar and Jelinek (1983), who emphasize the economies of scope - in contrast with the economies of scale - offered by this technology. This means that the information technology allows an integration of all economic, organizational and technological functions (such as engineering and marketing) in one organization, so that the process predictability, timely delivery, quality and efficiency can be improved without losing flexibility and variety. The capabilities of such information-based systems for manufacturing processes are:

Extreme flexibility in product design and product mix, which allows for an almost unlimited variety of specific designs within a reasonable family of options, including alternative materials.

Rapid response to changes in market demand, product design and mix, output rates, and equipment scheduling.

Greater control, accuracy, and repeatability of processes, all of which lead to better quality products and more reliabe manufacturing operations.

Reduced waste, lower training and changeover costs, and more predictable maintenance costs.

Greater predictability in all phases of manufacturing operations and more information, both of which make possible more intensive management and control of the system.

Faster throughput due to better use of all machines, less in-process inventory, fewer stopping for missing parts or materials, or machine breakdowns. Higher speeds are now made possible and economically feasible by the sensory and control capabilities of the 'smart' machines and the information management abilities of the CAM (Computer Aided Manufacture) software.

Distributed processing capability make possible and economical the encoding of process information in easily replicable software.

The same authors also claim that the differences between traditional technology and Computer-Integrated Manufacturing in factories and organizations can be indicated as follows (see Goldhar and Jelinek, 1985):

Traditional technology	Computer-Integrated Manufacturing
Centralization	Decentralization
Large plants	Disaggregated capacity
Balanced lines	Flexibility
Smooth flows	Inexpensive surge and turnaround ability
Standard product design	Many custom products
Low rate of change and high stability	Innovation and responsiveness
Inventory used as a buffer	Production tied to demand
'Focused factory' as an organizing concept	Functional range of repeated reorganization
Job enrichment and enlargement	Responsibility tied to reward
Batch systems	Flow systems

Such new technologies, especially in the field of the information and telecommunication sector, may have a far reaching impact on the locational pattern of firms and hence on regional development. The modern technology offers also a large growth potential for traditional rural areas, provided these areas are connected with an information and knowledge network. Thus, the adoptive capability of a region for this new technology will be decisive for its future economic position.

Clearly, the new information technology (NIT) may also exert an impact on mobility behaviour of people (tele-shopping, teleconferencing, e.g.). The use of modern telecommunication facilities enables technically the substitution of physical commuting by telecommuting, so that more jobs may cease to require physical travel. However, the degree to which this will take place is still very much subject to speculation. This issue will be further discussed in subsequent sections.

3. Telecommunication: Design and Adoption

Popular views suggest that telecommunication is a friction reducing technology, so that it may induce geographical dispersion of economic activities. Consequently, any increase in the use of telecommunications would make many activities more footloose, so that future locational patterns would become more dispersed. It is however doubtful whether this simple hypothesis can be supported from empirical facts, as the relationship between telecommunications and spatial deconcentration is rather complex (see Goddard, 1980). In order to study the spatial impact of new technologies like the telecommunications sector, we may make a useful and systematic distinction between three phases of implementing such new technologies (see Stoneman, 1983):

(i) design and generation. This phase concerns mainly the invention of a new product, production process, production system, institutional system or management system, and leads eventually to the emergence of a new technological 'regime' (see Nelson and Winter, 1982).

(ii) diffusion and adoption. Diffusion processes of new phenomena have both a temporal and a geographical dimension (see Hagerstrand, 1967, as well as Davies, 1979, Dosi, 1984, Kamien and Schwartz, 1982, and Rogers, 1983). The recent literature on this issue exhibits a wide variety of diffusion paths, depending on the parameters of the diffusion model, the initial conditions, the feedback structure of the evolutionary model, and the resistance factors from the side of potential adopters. The conventional deterministic epidemic disease model is increasingly loosing its relevance, whilst it is being substituted for more behaviourally-oriented models incorporating decision uncertainty, systemic resilience and environmental complexity (see for example the self-organisation model advocated by Prigogine, 1976).

(iii) effects. These effects are usually multidimensional in nature, and may relate to employment effects, locational effects, environmental effects, land use effects, effects on industrial structure etc. at different geographical scales.

In conclusion, forecasting of new technologies is characterized by many uncertainties emerging inter alia from the attributes of the technology at hand (e.g., the competitive structure of the industry at hand), the intervening opportunities offered by related technologies, and the information supply regarding the potential of such new technologies. Consequently, forecasts of impacts of such technologies are in general highly stochastic in nature (see also Jimenez Montano and Ebeling, 1980).

The evolutionary behaviour of new technologies like NIT has led to the emergence of various dynamic models aiming at portraying and forecasting the time trajectory of such a new technological regime. Instead of conventional cost-disease (or unbalanced growth) models for the evolutionary path of new technologies, we observe nowadays more complicated nonlinear dynamic models, based inter alia on a competitive exclusion of new technologies, or on a predator-prey approach adopted from population biology. Especially the latter type of model has recently become very popular in dynamic economic analysis, mainly due to the appealing analytical properties of the underlying Volterra-Lotka dynamics (which is mainly based on the principle of primacy of major activities).

The information sector (including telecommunications) may be one of such primate activities. In this respect, it is often claimed that the productivity rise caused by the information sector is formidable. For example, the transmission of live performances from theatres to television broadcasting represents one of the largest leaps in productivity that have ever taken place, as approximately the same amount of efforts is able to offer services to millions of people watching television instead of to a couple of thousands of people visiting a theatre (see Baumol and Wolff, 1984).

The growth of the information sector (as a whole) is in most developed countries no doubt impressive, no matter how the information sector is defined precisely (see Jonscher, 1984). In this context, various models have been described to analyze the evolutionary pattern of this sector (e.g., the stochastic process control model, the disaggregate market signaling model etc.). Whatever the contents and shape of the models aiming at portraying an uncertain future may be, it is in any case clear that a further growth in information-processing resources will have a direct impact on the growth path of telecommunications in the future. In this framework, an interesting econometric exploration based on a growth model for the relationship between R&D capital in communication, output and governement expenditures in this sector has been developed by Terleckyj (1984).

In order to design a systematic analysis framework for assessing the spatial impacts of the telecommunications sector, we will use Figure 2.

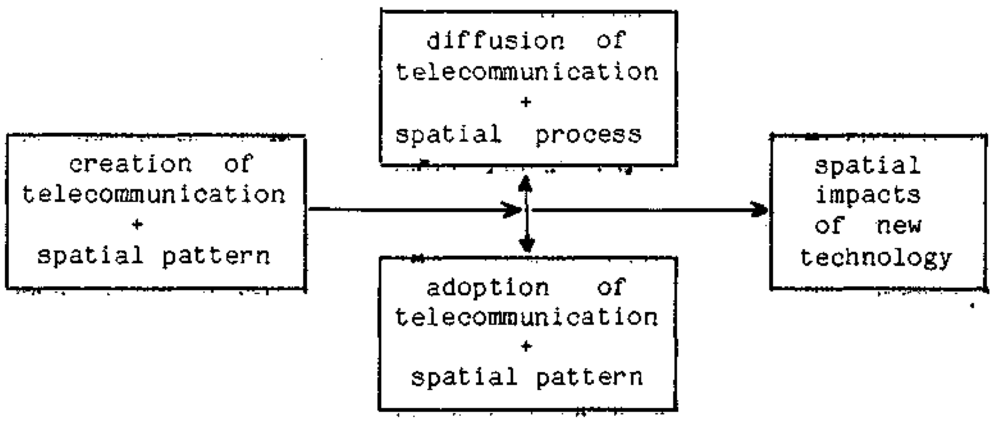


Figure 2. Phases in spatial impact analysis of telecommunication

The <u>offspring</u> of new technologies like telecommunications can be explained from various angles (see Nijkamp, 1986). Examples are the <u>demand pull</u> hypothesis, the <u>depression trigger</u> hypothesis, and the <u>technology push</u> hypothesis.

Clearly, in all three cases a distinction has to be made between the adjustment of old technologies, the introduction of new technologies, and new applications of existing technologies. In this respect the telecommunications secto. is multi-faceted and heterogeneous, so that some caution is needed if general statements are to be made regarding its evolution and impacts. Attributes to be considered in this respect are: speed of infomation transmission, quality and bandwidth of information, reliability and security, the modularity and flexibility of information transferred and the versatility of the telecommunications system concerned.

In most countries, there appears to be an increasing need for information and hence - as a derived demand - for telecommunications services (Manski and Salomon, 1985). This information need is codetermined by the rise in complexity of intertwined socio-economic, spatial and environmental processes (see also Nijkamp and Rietveld, 1984). In addition, statistical and mathematical tools, as well as suitable computer hardware and software stimulate a further increase in demand for information and hence for telecommunication services.

From a geographical viewpoint, it has to be added that the current organization of socio-economic life in Western countries is based on ever increasing interpersonal interactions (face-to-face contacts, business linkages etc.), because our economies exhibit increasingly a complicated network structure. This exponential rise in the demand for interactions is hampered by the physical ability of man to fully interact at an (inter-)personal level, with many people involved.

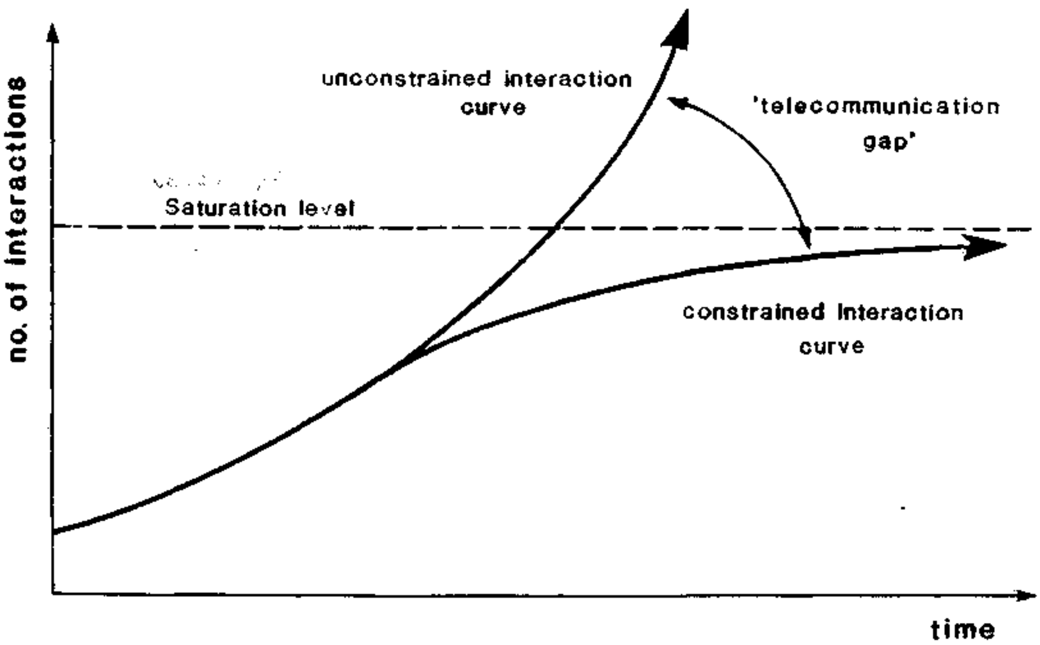


Figure 3. The 'Telecommunications Gap'

Therefore, telecommunication services are, to some extent, necessary in order to compensate for an exponential growth pattern in interactions. This also implies that - given a certain physical saturation level for direct human interactions - the use of telecommunications services is likely to exhibit a rapid growth in the near future (see also Figure 3). The 'telecommunications gap' reflects here essentially the increase in the use of telecommunications services caused by physical constraints of persons who have a potentially exponential growth curve for human interactions.

It is obviously an interesting question <u>where</u> these new technologies are likely to be generated. The telecommunications sector is a specific high-tech sector which is strongly oriented towards the presence of a high skilled labor force (engineers, technicians etc.) in a given area. Thus a region may exert an incubator or 'seedbed' function, if its specific labor market configuration acts as a birthplace for such new activities (see also Malecki, 1980, Nijkamp, 1985). Usually, the presence of a university and advanced R&D centers is regarded as a necessary condition for such new telecommunication technologies to emerge. Thus, the geographical pattern of the telecommunications sector is not randomly distributed, but exhibits usually a strong orientation toward academic information and knowledge centers.

The <u>diffusion pattern</u> of telecommunications services is often assumed to follow a logistic growth curve over time and a distance decay curve in space. It is worth mentioning, however, that constraining factors may impede such a regular trajectory. A major reason is that - in contrast with conventional thinking - telecommunications technology is not mainly supply-driven: the introduction of a specific technology in this area is very much determined by constraints and by user needs and preferences. If the demand side is decisive for the introduction and acceptance of a new technology, a forecast of the temporal and spatial penetration of specific telecommunications technologies should take into account underlying behavioural factors.

Thus the supply of telecommunications diffusion may be hampered by various types of inertia and limitations of suppliers and demanders. Consequently, a conventional S-shaped growth curve and a downward bending spatial friction curve are not by definition appropriate analytical forecasting tools. Much consideration has to be given to behavioural aspects of all actors involved, thus increasing the level of uncertainty of forecasts of the use and impact of telecommunications technology.

The <u>adoption pattern</u> of telecommunication technologies reflects the demand behaviour of (potential and/or actual) users. The degree of adoption of NIT and related services depends on various factors, such as:

- the nature of the information that can be transmitted through the system. This is exemplified by the tendency of organizations (or some of their functions) involved in negotiation-type interactions which are not amenable to telecommunications, to prefer agglomeration economies over benefits of decentralization (see e.g., the study of Goddard and Morris, 1976, on office decentralization in the Greater London Area).
- the reliability of the system, both in terms of technical performance and in terms of the security of the information.
- the relative costs of obtaining a desired level of information via alternative communication media for including face-to-face interaction (i.e., physical travel).
- the socio-demographic characteristics or organizational attributes of the adopters. In the case of households, it is generally assumed that age composition, education, income, and employment configuration are relevant explanatory factors. In the case of organizations, the structure, the geographical pattern and the relative shares of intra- and inter-organizational information flows are among the relevant factors. The decision to adopt a new technology is not always determined by measurable (economic) criteria but is often influenced by perceived costs and benefits, including prestige as one specific benefit (see Gold, 1979, Charles, 1981).

Clearly, the adoption of telecommunication services has a geographical component, not only in terms of the spatial location pattern of adopters, but also in terms of a judgement of real physical distance versus socio-psychological distance between senders and receivers of information. Perception of distance and the importance of direct face-to-face contacts are major factors in adopting a certain telecommunications technology (see Meyerowitz, 1985; Korzenny, 1978; Salomon, 1986). Furthermore, urban agglomerations and geographical concentrations of activities may provide more stimuli for a rapid adoption of new telecommunications technologies in the household sector due to imitative behaviour caused by the 'keeping up with the Joneses' effect. Thus, the geography of adoptive behaviour has no doubt an impact on the spatial dispersion of telecommunications technologies.

The next section will be devoted to a more thorough discussion of the spatial effects of the telecommunications technology.

4. Geographical Impacts of Telecommunications

The most publicised spatial effect of telecommunications is decentralization. It is based on the assumptions that i) telecommunications will provide a uniform distribution of information over space, and ii) that the technologies and their applications will be adopted by significant shares of a growing information-dependent market. The uniform validity of these arguments is however questionable. Presently such impacts can only be identified in well-defined particular contexts for specific technology applications. Only one plausible generalization can be made, viz. that individuals and firms may enjoy greater flexibility in their locational decisions, the reason being that - given the principle of minimization of transport costs in many location decision models - the major impact of telecommunications technologies is that it produces a different cost-distance distribution than that solely based on physical movements. While telecommunications rates are significantly less distance-sensitive than travel costs, they do exhibit greater sensitivity to the duration of communication. Hence, both perceived and actual cost 'maps' are altered by the availability and use of telecommunications systems. There are numerous moderating variables which affect the spatial patterns of NIT-induced phenomena. Some major variables in this context are the scale effect, the prior geographical distribution, the demand for information, the organizational structure and the logistics. These factors will successively be discussed.

The Scale Effect

The first moderating effect can be attributed to scale. The spatial impacts of telecommunications range from the micro-scale of a single building or complex (e.g. 'smart buildings'), through local, metropolitan and regional scales to the national and international scales (e.g. location of multi-nationals at the proximity of telecommunications facilities). While a certain effect is observed at, say the metropolitan scale, it need not be repeated at other spatial scales. For example, the decentralization of back-office activities from major metropolitan centers like New York city (Moss, 1985) does not imply that one should expect a general decentralization of back-offices at local or regional scales.

The Prior Geographical Distribution of Activities and Resources

The impacts of telecommunications on the spatial distribution of activities is likely to depend on the distribution prevailing prior to the introduction of the new technology. Forces of both centralization and decentralization are here always at work, while inertia (or costs of transaction) and the current distribution of costs of communications and resources create a quasi-equilibrium in the locational patterns. However, a change in the costs of traversing distance for particular (information-intensive) activities relaxes some of the constraints on location or may change the relative weights of location factors (see Baki, 1981; Brotchie, 1984). For instance, existing firms can - as a result of the availability of telecommunications - change their pattern of activities. This would mean that they can then enter markets which were too remote prior to the change, or they can increase their interactions with other firms so as to generate new products or services.

Current trends like the decrease in environmental quality in large cities, the increase in congestion and the resulting demand for rural life styles evident in many developed countries are also affecting the probability of decentralization of activities into non-urban regions. Yet, the desired amenities (e.g., cultural) available in cities can only partially be transmitted through NIT. In particular, the spatial distribution of labour resources illustrates this point.

The combination of the growing share of service and information activities with the availability of telecommunications may provide for a new spatial pattern of employment. On the one hand, individuals who did not participate in the labour force due to physical or social mobility constraints can now - given the option of telecommuting - engage in information related work. This opens new pools of labour for employers, e.g., housewives in the suburbs. On the other hand, it may provide also new alternatives for individuals who prefer the amenities of rural environments without being removed from the 'urban' white-collar labour market. In that sense, the prior distribution of attractive environments can now be exploited more efficiently. Yet, it is worth mentioning that urban amenities exert a centralizing force in attracting people to remain in urban areas and this may be in line with Holland's (1976) claim about the importance of social factors in the location of economic activities.

However, the 'flexiplace' work location, a popular concept introduced as a result of telecommunications availability, does not seem to have major impacts in terms of changing the geography of employment. Social and psychological impediment to working at home (Salomon and Salomon, 1984; Shamir and Salomon, 1985) along with management reluctance (Olson, 1983) indicate that in the near future the 'work-at-home' application of remote work is not expected to be widely adopted. So, while 'electronic cottages' are likely to appear in many remote areas, the magnitude of the phenomenon may be expected to be limited.

The Demand for Information

As the demand for telecommunications is derived from the demand for information, firms and individuals with different demand patterns are likely to exhibit variations in their location decisions. A communications analysis can reveal the extent to which the reliance on telecommunications-based interactions is economically feasible to a firm, taking into account not only the perceived travel-cost savings but also such 'softer' long-term effects as changes in productivity of managers deprived from their (enjoyable) business trips (see Gold, 1979).

Given the development that can be expected in the next decade or so, it is plausible that for firms having a demand for information which is largely not suitable for telecommunications transmissions, the costs of 'maintaining contact' (Pye, 1977) will result in only very few relocation decisions to remote areas. The city's role as a 'transaction centre' (Gottmann, 1983) will likely continue to attract economic, political and social activities.

The Organizational Structure

The suitability of various telecommunications technologies to accommodate for different categories of information can result in spatial behaviour varying as a reaction of the organizational structure. Intra-organizational communications, given its nature and the probability of acquaintance between parties, are more amenable to electronic communications than inter-organizational communications. Consequently, multi-plant corporations or large ones which can fragment into corporate plants, are more likely to adopt telecommunications in order to accommodate for locational dispersion than single plant or small firms. Hence, the market composition will affect the extent of decentralization attributable to telecommunications.

Logistics

Even highly information-based - and more so high-tech-oriented - industries involved in production rather than R&D have a certain need for physical goods movements. The influence of this need is twofold. First, in considering the location decision, the costs of goods movement need also be considered. Second, as a second-order spatial effect, the possibility of decentralization of activities implies an increase in total vehicle movement to remote locations. This enhanced traffic can in itself create spatial impacts such as service centres, requirements for road improvements (to be paid by the public sector), etc.

Concluding Remarks

At present, there is very little empirical evidence that supports either the dispersion or the concentration hypothesis attributed to telecommunications. Hence, most forecasts are, at best, only educated speculations. Webber (1963), Mandeville (1983) and Kellerman (1984) have, in different ways suggested that these technologies are neutral and may, depending on specific contextual facotrs, accommodate either of the directions of change. We therefore refrain from attempting any generalization as to the spatial impacts of NIT. Instead, forecasts should aim to identify the factors (some of which are discussed above) which affect the location decisions of particular agents, i.e., individuals' residential and workplace choices, and firms' decisions, distinguishing between different organizational structures and information dependency. Also, governments' intervention in the telecommunications sector, through direct investment, subsidies or regulation are to be accounted for as sometimes dominant factors in shaping the spatial impacts of these technologies.

5. A New Spatial Organization of our Society?

Telecommunications will undoubtedly have certain spatial impacts resulting from the spatial variation in the generation, diffusion and adoption of new technologies. However, forecasting these impacts for policy-making or private sector decision-making is complicated by the above mentioned factors.

In recent years, the results of telecommunications have become spectacular due to the emergence of video transmission, telefax, teleshopping etc. Information and communication have become key elements in industrial organization and location. A new 'paperless' or 'wired' society is likely to emanate, so that the printing technology which has had a superior position for many centuries may loose ground. Talking and communication machines as well as artificial intelligence may be a next step, although one has to realize that - despite the technological potential - the human mind has in general only a limited capacity for adopting revolutionary innovations. In this framework, Naisbitt (1982) argues that any 'high tech' development evokes a countervailing ' high touch' development, as the alienation caused by technology forces people to compensate by increasing personal and social face-to-face contacts.

As said before, the development of informatics may potentially have an impact on the spatial patterns of economic activities of our societies. For instance, peripheral areas might get a direct access to the information centres of the world or of the country concerned. On the other hand, traditional centres might perhaps reinforce their position as a 'spider' in a network, so that the role of nodal points in such a network becomes even more important. The net result of all such developments is hard to forecast, so that at best one can try to identify some prevailing trends in the field of informatics and regional development.

A special case is here the transportation sector, as the impacts of so-called telematics on the transportation system are becoming more evident. Various studies have been undertaken in the meantime to analyze the viability of tele-commuting, tele-shopping and tele-recreation, and so forth (cf. Fritsch and Ewers, 1985). Although conventional wisdom suggests that telematics may lead to a reduction of physical movements as it compensates for distance friction costs ('the tyranny of space'), empirical evidence suggests so far only a very modest impact (see also Nijkamp and Salomon, 1986). In the goods production, however, it is clear that telematics no doubt will have a substantial impact, witness the great influence of modern logistics on storage management and automated routing systems, including JIT (just-in-time) technologies. It turns out that in this field the use of telematics favours both geographical concentration and decondentration, so that a dual spatial development is likely to emerge.

It is plausible that, although telecommunications will be adopted and applied in remote regions - inducing in turn some new activities in such areas - the overall pattern of activities will not be significantly different from that known today. We expect that telecommunications will never create a uniform distribution of information over space and therefore firms at remote locations are likely to be disadvantaged as compared with more centrally located facilities. Temporary departures from this general pattern may be observed in newly emerging branches which exhibit high revenues until competition arrives. The high revenues can then only temporarily off-set other locational disadvantages.

Economic activities are increasingly dependent on the availability and use of reliable and up-to-date information systems. In general, the best access to such information systems can be found in nodes of a network. Consequently, there will be a tendency to a geographical orientation of firms toward nodes in a communication network. Such a multi-nodal geographical configuration is - to some extent - already present in the current spatial patterns of our societies (Pred, 1977). Apart from specific cases, a dramatic spatial dispersion of activities is hence not likely to take place. A related point is that in nodes of a network a wide variety of polyvalent information may come together, so that firms seeking for risk minimization in terms of information gathering and availability will be tempted to seek for risk-minimizing and strategic (i.e., usually central) positions in a multi-nodal network.

Moreover, corporate organizations and multi-plant firms are of course facing a situation of information management among different branches, and here also the principle of centrality and multi-nodality applies. Despite the technical possibility for decentralization of firms, we still observe a strong centrality or multi-nodality tendency, especially at the levels of management and decision-making.

The polyvalence of information flows also evokes the problem of a structured access to telecommunications systems and a systematic use of such information. In this framework, decision support systems (DSS) and artificial intelligence (AI) may set the stage for new interactive forms of decision-making, in which centralized and decentralized information is linked in a coherent manner.

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