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PhD thesis

THE IMPLICATIONS OF ADVANCED-TELECOMMUNICATIONS ON THE SPATIAL STRUCTURE OF THE URBAN SYSTEM

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Introduction

It has long since been hypothesized that a change in the ability to interact across space, be it in a tangible (i.e. railroad) or intangible (i.e. telephone) manner, has and will continue to have spatial implications on the urban landscape. However, a considerable component of the existing research can be categorized more in the realm of journalism than academia. While such notions are not entirely useless, in that they contribute to public awareness, they are overall misleading, but are also in such abundance that they can simply not be ignored (an unfortunate by-product of pursuing a research agenda in the realm of advanced-telecommunications). One possible explanation for the rise of such content has been the neglect of urban studies.

More creditable research in the realm of advanced-telecommunications does exist, but it still tends to be limited in scope and scale. It would seem that these theories treat cities as uniform entities, or fail to acknowledge that tangible elements, such as manufacturing goods may also continue to influence the structure of the economy. The missing element in such studies is the consideration of the urban system from the perspective where it may be deemed as a implicit spatial account of the culmination of economic activity in space, offering the necessary framework for considering how a change in the ability to interact across space. Telecommunications introduced a new way for cities and the activities located within them to interrelate with one another, while advanced-telecommunications with its (a) *increased capacity with which to interact across space* and (b) introduction of the *Internet* has extended this potential even further. However, while interurban communications may be facilitated by telecommunications, it is not the only method in which cities and activities interrelate.

The state of the argument

Much of the speculation surrounding the increasing use of advanced-telecommunications in society is hype and half-truths. While such theories arguably make for interesting reading, they are on the whole vague and ambiguous. They tend to be extremely simplistic, relying on assumed or unjustified assumptions and not based on any particular understanding of the city, how cities interrelate, or a systematic methodology. These theories can be divided into two broad categories: utopians (or futurologists) and dystopians (or anti-utopians) (see Kitchin, 1998, chapter 1). The utopians herald telecommunications as the 'quick fix' solution to the social, environmental, or political ills of industrial society. The dystopians, on the other hand, paint a portrait of an increasingly polarized and depressing urban era dominated by global corporations who will shape advanced-telecommunications and the urban realm in their own image. Such theories are extreme in nature and could perhaps qualify as technological propaganda.

Warren (1989) suggests that the immaturity and disregard of urban telecommunications studies has induced what he refers to as the 'candy store effect', in that a lack of relevant hypothesis have allowed for an approach to the subject which makes no attempt at justifying the theory or methodologies adopted. Such neglect has led Graham and Marvin to suggest 'that urban telecommunications studies remains perhaps the most underdeveloped field of urban studies' (Graham and Marvin, 1996. p. 6).

In attempting to offer an explanation as to why this general neglect has persisted, it has been hypothesized that a major deterrent for urban studies towards the study of telecommunications and urban change can be attributed to the 'invisibility' of the subject matter, literally and with respect to causation, which are by no means mutually exclusive. The fundamentally hidden nature of telecommunications distinguishes it from virtually all other aspects of urban development. Batty (1990) suggests that much of telecommunications-based change has a degree of invisibility, which does not characterize traditional economic and social activity. Telecommunications development in cities tends to be intangible and abstract, which partially explains why it is dominated by esoteric terminology and concepts. Arguably, it could be offered that conventional urban studies is inclined towards a preoccupation with the visible, tangible and perceivable aspects of urban life, such as housing, or transportation. Students of urban studies have been led to believe that technological innovations, like that of the railroad or steamboat, induce a series of tangible and direct developments on the urban landscape, which would further suggest why the development and application of telecommunication tends to escape the attention of all but the specialist.

While a component of the literature is unrealistic, more creditable research in the field of telecommunications and the urban realm does exist. However, while slightly more balanced, it is still somewhat narrow in its approach. Advanced-telecommunications is increasingly referred to as a 'shock', 'wave' or 'revolution', impacting on, or about to influence urban centers. Cities, on the other hand, are referred to as 'informational' (Castells, 1989), 'invisible' (Batty, 1990), electronic spaces' (Robins and Hepworth, 1988), to name a few. This perspective is limited because it is assuming that technological change will occur in a simple, homogenous, linear cause and effect manner. For example, *'the advanced-telecommunications 'revolution' will turn cities into 'electronic space'.* Goklap (1988) refers to these theories as 'grand metaphors'. He suggests that since the implications are complex and not entirely understood, researchers implement grandiose images to explain what they cannot.

The difficulty with accepting these so called 'grand metaphors' comes from their treatment of cities as homogeneous entities, as well as their lack of consideration of the presence and value of tangible goods and services (tangible type services represents a type of service that as a general rule can not be facilitated via advanced-telecommunications; this will be subject to further stipulated in chapter 3) or their production and distribution. As will be further conveyed in chapters 1 and 2, urban systems are characterized by aggregations and disaggregations, which implies some degree of dominance and dependence within the system. This further suggests that cities partly interact in terms of an absolute advantage, as exemplified by certain aspects in regional growth theory (Richardson, 1973), and are thus by no means uniform.

In suggesting that cities will evolve into entities wholly occupied by 'information' or that they may in fact become 'invisible', a number of assumptions are made that are simply unrealistic. The first, and considerably more abstract, is that benefits offered by advanced-telecommunications will be greater than the benefits offered by the pre-existing infrastructure in urban centers, plus any transfer costs that might be incurred in shifting to these so called 'invisible' cities (of course, in the long run, such transfer costs would be nominal or a non-consideration). The second assumption is the total lack of need for tangible goods and services, as well as their production and distribution. While there is no doubt advanced-telecommunications has and will continue to influence the manner in which manufactured goods, or tangible services, are produced (Schoenberger, 1987) and delivered (Hepworth, 1990), it seems ridiculous to suggest that it will totally eliminate society's need to consume or produce them. This hypothesis could, in fact, be referring to the production of tangible goods in less advanced economies of the world, but the aspect of distribution will always continue to be a reality. Although services have been observed as being the fastest expanding sector in modern economies (Daniels, 1993), the manufacturing sector remains as a fundamental component. Furthermore, it has been suggested that the service sector is a by-product of a surplus (Castells, 1989), which is predominantly organized to facilitate the production and distribution of commodities (Scott, 1988); further question the conceptual foundation of such 'grand metaphors'.

Arguably, one of the more valuable contributions to the discussion on advanced-telecommunications and its potential influence on the urban system is the treatment of advanced-telecommunications as having a spatially bi-directional influence, in that it induces both a centralization as well as decentralization of economic activity (Wise, 1971; Nicol, 1985; Downs, 1985; Manderville, 1983; Kellerman, 1984, 1993; Pool, 1990; Graham and Marvin, 1996, 2001), which is a function of the continued structural and occupational shifts that are clearly assisted by advanced-telecommunications (Castells, 1989; Hepworth, 1990). It should, however, be noted that this hypothesis was not conceived with advanced-telecommunications in mind, but rather the basic telephone system. In relation to the increased capacity with which to interact across space, the theory's assertions are potentially every bit as relevant now as they were at the time of the basic telephone system. However, in relation to the Internet, of which increased capacity is a prerequisite, the theory makes no such reference.

The spatial centralization and decentralization takes place in two possible contexts, inter- and intraurban. At the interurban level a decentralization of economic activities may occur, primarily in routine manufacturing and intangible services (intangible services refers to service type activities that as a general rule can be facilitated via advanced-telecommunications; this will be further stipulated in chapter 3), having moved from large metropolitan areas to smaller cities and towns, or a decentralization of such activities will occur in large metropolitan areas. From an intraurban perspective, dispersion refers to the potential decentralization of economic activities as well as residences within urban areas (i.e. suburbanization). Furthermore, the inter- and intraurban dispersion processes could in fact be related to one another, in that processes of interurban dispersion may induce the intraurban decentralization resulting from developments in telecommunications. The industrial dispersion of industrial production from large cities to peripheral areas, aided by telecommunications means, amounted to their increased control, which could potentially be centralized in larger metropolitan centers. As metropolitan areas grow in size it has become more economically efficient to shift certain routine activities, which were once found in the CBD (central business district), to a more decentralized location, so as to obtain relatively cheaper input costs, but still maintain the required contact with the CBD. However, while such research has made an invaluable contribution to the development of a greater understanding of how advanced-telecommunications has affected economic activity, the majority of such efforts has been primarily descriptive in nature and have failed to offer a positive analysis. With specific reference to interurban behavior, the perspective of this study, no attempt has been made to relate the increased ability with which to interact across space to the wider urban system.

In relation to the Internet, or the dynamic consolidation of information in non-space as it will be treated throughout the course of the research effort, studies as to how the location of economic activity in space and thus the spatial structure of the urban system are limited. The fact of the matter being, the World Wide Web (WWW), as it has come to be known, was initiated in 1991. BITNET and NSFNET, which linked research institutions, universities and military establishments together was conceived in the early 1980s, and has been designated as the origins of the Internet, because they were the first network to link individual institutions together (Zakon, 2002), however, it was somewhat limited in its accessibility.

Variations of the Internet, of considerably smaller scale and scope, had previously been available, but were unsuccessful. In Prato, Italy, for example, an Internet like system called SPRINT was also established in the early 1980s as an online link between local authorities, trade associations, firms and chambers of commerce, in which information could be exchanged between. However, according to Capello and Gillespie, SPRINT failed because the traditional cooperation of local entrepreneurs was already embedded into the local social structure as well as the lack of a previously developed advanced-telecommunications culture (Capello and Gillespie, 1993).

Obviously, more recent studies of the Internet have been carried out. However, apart from being considered as an extension of the abstract discussion on 'space and place' (Kellerman, 2002 see chapter 1), most studies focus on its affects on the price of goods (see for example Lee, 1998; Lee et al, 2000) and cost of production, more specifically transaction costs (see for example Bakos, 1998; Berthon et al, 2002), which has led to an increased the role of the market over that of production hierarchies (Malone et al, 1987). In a spatial capacity, research on the Internet has not transcended beyond that of observing points of production (see for example Moses and Townsend, 1997, 1998; Zook, 2000).

Thus, in considering how advanced-telecommunications, including that of the Internet, stands to influence the spatial structure of the urban system, it becomes apparent that substantial deficiencies are present. There is a need to clarify growing misconceptions of the manner in which advanced-telecommunications will potentially influence the location of economic activity in space and thus the cities with which activities locate. Prior assertions are extreme in their treatment of advanced-telecommunications, and overly simplistic in their treatment of cities. Cities are not uniform entities and therefore a reaction to a change in the manner in which they interrelate should not be either. The missing link is the consideration or application of the urban system. The inherent acknowledgement that different activities exist throughout the urban system and, more importantly, that a logic, to a certain degree can be formulated. This fact is further exemplified by Henderson (1988), in which he suggests cities that specialize in similar activities also tend to be of a similar size.

Advanced-telecommunications as a force of change: A technical and economic/evidence based perspective

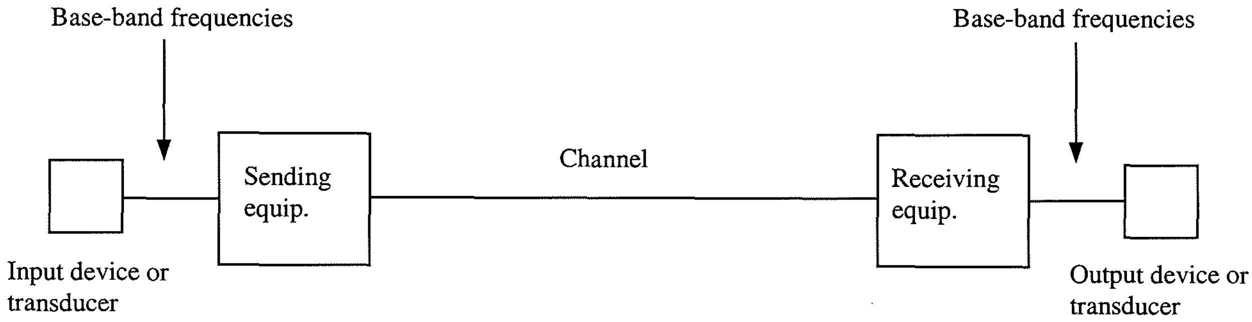
There is no reason as to why the trend conveyed through the bi-directional hypothesis, or some variation of that trend, should not continue. As suggested by the initial feature, the increased ability with which to interact across space, the capabilities of advanced-telecommunications have evolved drastically in the last two decades. The relatively recent advancement of digitalized information in the 1970s led Pool to suggest that it was a 'revolution as profound as the invention of printing' (Pool, 1990, p. 7).

The technical perspective

The Internet (feature 2) can be attributed to two major scientific advancements: the personal computer (PC) and the advanced-telecommunications network (ATN). An improvement in the POTS (feature 1), is in fact embodied in the onset of the ATN, further implying that feature 1 is a necessary precondition of feature 2. As with all contemporary scientific developments, numerous and equally relevant advancements have preceded the conception of both the PC and ATN. These advancements, which manifest themselves in either the development of the PC and/or the ATN, are factors that define the characteristics as well as capabilities of the PC and ATN, and thus the Internet itself.

Due to the highly diverse types of communication, and the techniques employed, it is important to first sectionalize the essential components of the process; only then can an understanding of the contribution of the pertinent advancements be identified and developed. Brown and Glazier (1966) state that the communication process involves five basic components (see figure A).

Figure A - A generalized telecommunications system



1. The input device or transducer
2. Sending equipment
3. The channel proper
4. Receiving equipment
5. The output device or transducer

The *input device or transducer* is the entity with which information that is intended for transmission is applied. It effectively converts some physical quantity such as air pressure, displacement, light, etc., into a corresponding electrical signal, which is regarded as the base-band frequency. For example, in a telephone the transducer is the microphone, which converts sound waves into electrical signals, or generally speaking, base-band frequency. In the case of picture transmission, the transducer is the photo-electric-cell or electric tube, which converts light into an electrical signal, also a base-band frequency.

The *sending equipment* receives the base-band frequency from the input device and converts it into a form suitable for transmission over the channel. A great variety of possibilities for this exist. A simple example is a direct analogue telephone line where the sending equipment is simply a telephone circuit that connects the microphone to the line. A more complex system might involve the use of digital transmissions, which in the case of the telephone would necessitate the presence of an entity that could transform the base-band frequency into digital form. The *channel proper* is the portion of the system that propagates the signal by electromagnetic means.

The *receiving equipment* effectively performs the inverse of the sending equipment. In other words, it receives the electromagnetic energy from the channel proper and converts it back to the base-band signal. Although the receiving and sending process involves different procedures it is not uncommon for the same unit (i.e. a telephone) to sometimes facilitate both. And finally, the *output device or transducer* is responsible for converting the base-band signal into a form suitable for the user to comprehend. Such examples include the earpiece of a telephone or the monitor of a PC.

The improved ability to communicate across space (feature 1) as well as the subsequent conception and development of the Internet (feature 2) involves the improved capacity of the previously regarded five basic components of the communication system. As previously noted, the Internet can be attributed to two major scientific advances, the PC and ATN, while the improved ability to communicate across space is personified through the ATN. Of the technical advancements that have preceded both the PC and ATN, five general advancements have been identified which are not only responsible for the Internet's conception, but also for the improvement of the basic components of the telecommunications system. They are the introduction and development of binary code, network switching, network protocols, and the development of the processor and carrying capacity. With the exception of network protocol, the aforementioned advancements generally embody the key technological developments responsible for the development of the ATN and thus feature 1.

'*Carrying capacity*' refers to the increased capacity of the third component, the channel proper, while the '*processor*' is representative of the four remaining components. Clearly, the notion of the 'processor' is a general one in that it refers to an increased ability to handle relatively larger amounts of information for the purpose of transmission in relatively less time. Such a phenomenon is largely due to the advent of *binary code*, which can be regarded as the standardization of all forms of information and thus the potential manipulation by that of *microprocessors*, the capacity of which has, and will continue to, increase. *Network protocol*, which as previously noted refers specifically to the Internet's development, is the procedure that enables multiple PCs to communicate with one another in the context regarded as the Internet. This, however, is not without the basic feature of *switching technology*, which allows networks to establish a higher capacity of communication paths among its users with fewer links and thus at a lower per-user cost (see Appendix A for a more in depth description of the previously noted five technological advancements).

An economic/evidence based perspective

In relation to communicating across space via telecommunications, approximately 50 years after Bell had invented the telephone (1876) the number of domestic telephone calls in the US had exceeded the number of letters (Kellerman, 1993). Thus, for three-quarters of the 20th century, the telephone has been the primary method for interacting between physically and economically inaccessible points in space (assuming a telephone is present at both locations).[1]

Telecommunication rates in real terms have been in general decline since their conception, which can be attributed to the increased efficiency of the relevant technology, as noted above. Furthermore, while rates had previously been subject to distance, such improvements have also led to the uniformity of rates regardless of place. This has led Castells' (2001) to note that the cost of communicating within and between economies has become less a factor of distance a more a factor of infrastructure.

The increased ability to interact across space (feature 1), in conjunction with a number of other technological advancements, has led to methods of producing goods and services becoming even more complex and their method of production increasingly integrated (Vernon, 1957; Gillespie and Williams, 1988; Daniels and Bryson, 2002). This trend is towards one of capital intensity, which as already noted, has led to occupational and structural changes. Other such indications would be the increasing proportion of trade attributed to multi-national corporations (Daniels, 1993). Multi-nationals depend greatly on the enhancement of managerial capacities as well as division of labor between tasks of conception and execution of production. The managerial tasks could be further characterized by high-level office activities locating in large cities where they would engage in complex business transactions drawing on a variety of equally complex producer services. On the other hand, production oriented tasks, depending on the labor process, could either locate where

[1] It should be noted that while the global production of radio and television programming has been estimated to lie between 66 and 112 petabytes (1000 terabytes equal one petabyte), several times the 7.2 petabytes that has been estimated for telephone calls (Lyman and Varian, 2000), radio and television are clearly not an interaction, but rather unilateral communication.

specific externalities existed (e.g. a valued resource), if such benefits were indeed required, or a peripheral location where labor was abundant, wages low, and possibly where traditions of worker resistance to managerial initiatives were weak or nonexistent.

As a tool for general consumption, The United Nations, for example, established their web site in 1993, while the United States government followed two years later (Zakon, 2002). Thus, considering that such major government and inter-governmental institutions have been 'online' for less than a decade, the relative youthfulness of the Internet is abundantly apparent.

The Internet, which was only made available to the public in the early 1990s (see Kitchin, 1998 chapter 2 for a comprehensive account of the Internet's conception and development), as noted previously, is growing in both terms of user ship and volume at a fantastic rate. Worldwide user ship in 2002 has been estimated at 560 million, with an increase in 2003 of almost 50% (Global Reach, 2002), which has also led to the increasing role of electronic commerce within the market place. Furthermore, it has been estimated that the World Wide Web (WWW), or 'publicly indexable' Web (what is available to all potential users), is growing by an estimated 7.3 million pages a day (Lyman and Varian, 2000), while the 'deep' or 'invisible web', which consists of specialized databases (i.e. e-mail accounts or password protected information) available to specific users is approximately 400-500 times larger (Lawerence and Giles, 1999). Clearly, Internet user ship tends to favor developed economies (Graham and Marvin, 2001; NUA, 2001; Grubesic and Murray, 2002), which in 2001 were observed to have penetration rates of approximately 50% and above (NUA, 2001).

As user ship increases, as has the amount of commerce facilitated through the Internet. In the US, online retail sales increased by 26%, to $ 55 billion (The Economist, 2004a), while in the UK, sales rose by 36% to almost £ 5 billion (The Economist, 2004b). Furthermore, while these figures include the fees earned by Internet auction sites they do not include the value of goods sold, which accounted for $24 billion-worth of trade via eBay alone, the biggest online auctioneer, in 2003 in the US (The Economist, 2004a). In relation to services, certain industries have encouraged the increased use of the Internet with which to facilitate their transactions. For example, in Europe, 99% of low-cost bookings are made through the Internet, compared to that of 75% in the US (The Economist, 2004d). It has been hypothesized that 'within a decade, most travel bookings are likely to move online' (Economist, 2004c).

However, while the previously noted figures provide an indication of the trade that is occurring between businesses to consumers (B2C), or in the case of eBay, consumers to consumers[2], it fails to account for transactions between businesses, commonly regarded as B2B (business to business). One such example of a B2B is MetalSite, http://www.metalsite.com, which was initiated by the steel producers LTV Steel, Steel Dynamics, and Weirton Steel Corp. It functions as a neutral market for the metal industry, serving as an electronic outlet for products and services of participating suppliers. Initially, it was used for hard-to-sell secondary and excess products like that of flat-roll construction steel and cans, but has begun to encompass premium and made-to-order products as well as other metals apart from steel like copper, aluminum and zinc. Another such example is Superfr8,

[2] The notion of consumer to consumer is laymen's for the more technical term of person to person (P2P).

http://www.superfr8.com, which is also a neutral market, but for the trucking industry. Superfr8 acts as an electronic bulletin board, where it provides truckers and shippers the opportunity to match truckers' excess cargo space with shippers' yet to be dispatched cargo. In terms of the potential market of B2B transactions, in 2001, the Gartner Group estimated that global transactions in 2003 could potentially reach approximately 6 trillion dollars, while the Forrester Research estimated a global e-commerce figure of 6.8 trillion dollars in 2004, of which 90 percent would be B2B (Business Week, 2001).

Superfr8, and websites like it, have effectively replaced a previously established function that had once been responsible for matching cargo space to yet to be dispatched cargo. Due to the once relatively unconsolidated and undynamic nature of information it had been economically unfeasible for truckers and shippers to expend time towards, essentially, finding one another, and thus a broker was effectively employed. With the aid of the increased capacity of advanced-telecommunications and the utilization of previously standardized information (i.e. volume, weight, destination), such Internet sites consolidate the necessary information, processes it and provide the applicable aspects of that information to anyone who desires it regardless of space. More importantly, however, is that while Superfr8 deals exclusively with truckers and shippers, online commerce, regardless of whether it is B2C, P2P or B2B, functions under the same principles.

Outline and methodology of the impending study

As noted in the previous subsection, the missing component in studies that have attempted to assess the affects of advanced-telecommunications on urban form, and/or the location of economic activity in space, is the consideration and application of the urban system. Thus, in an attempt to justify the urban system as a framework for analysis as well as establish the context of the study, chapter 1 identifies the general characteristics of the urban system from the regional and spatial economic perspective. While the increased ability with which to interact across space and the Internet have and will no doubt continue to have wide ranging implications in, for example, a social and political context, the perspective of this study is purely a spatial economic one.

Chapter 2 goes on to review the structure and logic of the urban system. Its purpose is to identify the underlying mechanisms that govern the locational decisions of economic activities and their contribution to the system's general structure. This involves the consideration of classic industrial location theory and market area theory and their relationship to central place theory as originally conceived by Lösch (1944/1954) and Christaller (1933/1966), as well as the adaptations to central place theory that have followed which have improved the theory's empirical significance and thus applicability. However, as alluded to in classic location theory as well as market area theory, certain activities do not adhere entirely to the laws of centrality, but rather, given the character of the activity in question, locate according to the availability (or lack there of) of unique features. This can be further explained in terms of agglomeration economies, which are not only offered as a compliment to the framework that governs an activity's optimal location, but also implicitly provides the structures of production with which activities exist and thus interact. The amalgamation of central place theory and agglomeration economies will serve as the framework of the analysis.

Chapter 2 also serves as the theoretical basis of chapter 3, which goes on to consider the manner in which activities relocate as a result of shifts in technology and how such changes influence the urban system's spatial structure. Two types of change are identified, which are both caused by an improvement in the ability to interact across space or a reduction in the cost of production. The first is a uniform shift, which is analogous to the diffusion of a process or activity, while the second is the relocation of an activity, which is not unlike the decentralization of a unique activity. The types of change, in conjunction with the highly popular bi-directional hypothesis, will serve as a valuable point of departure in attempting to derive a positive explanation of the central research question.

The analysis will consist of three general components. The initial component of the examination (chapter 4) will attempt to evaluate the implications of feature 1 on the spatial structure of the urban system, as manifested through an ability to transmit information at zero marginal cost. In practical terms, this can be expressed as a function of both 'the processor' and 'carrying capacity'.[3] As already noted, improvements in both entities would technically allow for a larger amount of information to be transmitted in a given interval of time. Assuming the complexity of a transmission is related to its volume, and the cost of the interaction, or transaction cost, is positively related to the amount of time involved transmitting the information in question, then a superior 'processor' and 'carrying capacity' would indicate relatively lower marginal costs. This notion can be further exemplified through the relative marginal cost of transmitting identical information via a telegraph compared

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[3] Clearly, the status of switching technology and binary code, or lack there of, would influence the ability and thus cost of communicating across space, in that a unique line would have to be established for each of the points communication was desired. However, since the character of switching technology or binary code has not been the subject of major developments it will thus be assumed present or not.

to that of electronic mail. A telegraph functions in terms of single transmissions of individual articles collected by an operator who would then recompose the sum of the transmissions into a comprehensible format. Electronic mail, on the other hand, is transmitted and received in its entirety instantly. The time, not to mention potential labor costs (for example, the involvement of an operator processing the transmissions in question), and thus relative transaction costs would obviously be considerably greater for that of the telegraph; more so when considering the absence of multiplexing technology and thus the monopolization of the transmission facilities.

In attempting to further assess the implications of feature 1 on the spatial structure of the urban system, a series of comparative-static (before and after a technological shift) pseudo-central place models will be derived. As noted in the previous sub-section, the models implemented integrate the two components that determine the location of economic activities (central place theory and agglomeration economies) and thus the spatial structure of the urban system as highlighted in chapter 2. The models are similar to the central place model in that they utilize the previously established understanding of how urban centers are distributed throughout space as a function of the interactions/relationships between them.

However, as will be further stipulated in chapters 1 and 2, urban centers within a given system are by no means uniform, be it in terms of size and character of the activities contained at a given point. In central place models, specifically the 'successive inclusive hierarchy' (see chapter 2) this is simply expressed through the relatively ambiguous assertion of a *relative number* of activities being contained within a center in a given order. The models implemented in the impending analysis differ from the central place model in that the types of activities, albeit generalized, i.e. routine manufacturing, will be assumed as present (or absent) at certain point(s). The purpose of instituting a series of activities is to exemplify and further assess the manner in which different activities respond to certain technological changes. In relation to this particular study, generally speaking, the improved ability to interact across space will have different spatial implications for an activity whose inputs and outputs consist of information, i.e. a call center, relative to those activities that utilize and produce tangible goods, i.e. steel. A relative assessment is deemed more appropriate due to the unfeasible prospect of determining absolute values for advantages or disadvantages for an activity at a given point in space as well as potential transaction and interaction costs.

Equally important, and also an adaptation to the central place model, is the application of a specific production structure (i.e. vertical production structure) on those activities that have been assumed to be present, as conveyed through the types of agglomeration economies. Each production structure is effectively the configuration of the involved components and thus the number of interactions between components. Furthermore, the character of the activity further determines the manner in which the components interact. Like that of previous adaptation to the central place model, or the imposition of standardized activities, the application of production structures provides the opportunity to exhibit how different structures respond to a certain technological change in different ways. For example, an activity that has X number of interactions of a certain type may be subject to different locational requirements, so as to minimize production costs while maximizing profits, than an activity that has X-Y (X > Y) interactions of the same type.

It is important to further note that for the purpose of studying the implication of advanced-telecommunications on the spatial structure of the urban system and/or location of economic activity in space the impending study integrates two facets of economic analysis. Transaction costs, in the context of the institutional structure of production as conveyed by Coase in his now famous article, 'The nature of the firm' (1937) and location theory as further embodied by central place theory and agglomeration economies. However, the two components used to describe the location of economic activity, and thus the spatial structure of the urban system, contain elements that might be considered in conflict with one another. The application of production structures as derived from agglomeration economies are effectively bound together by interactions. In the analysis, such interactions are assumed as taking the form of transportation and/or transaction costs. While transportation costs are an essential component of the central place model, as will be further observed in chapter 2, no such mention of transaction costs is made. This is, however, not unexpected as central place theory spans from a neo-classical viewpoint, which tends to assume transaction costs away.

Without further stipulation this discrepancy could potentially contradict the analytical framework in two ways. The first is the generally dubious nature of such an assumption in that the absence of transaction costs tends to contradict the existence of agglomeration economies, clearly a fundamental component of the analytical framework, not to mention location analysis. The second is more practical in that the functions of those activities that stand to be replaced through the advent of the Internet are in existence because of the presence of transaction costs within certain markets.

In relation to the first conflict, as will be further stipulated in chapter 2, transaction costs represent a major impediment for trade and in many instances the formation of markets. Thus, market failure can potentially occur as a result of high transaction costs (Nicol, 1985). Conversely, where the costs of operating competitive markets are zero there would be no economic justification for the vertical, horizontal or lateral integration of activities, in other words, certain agglomeration economies. Therefore, the removal of transaction costs is a somewhat dubious assumption considering their role in the determination of an activity's location with regards to agglomeration economies.

With regards to the second conflict, as previously noted, certain functions and thus activities have come to bear as a result of relatively high transaction costs. One such activity is the consolidation of information for the purpose of matching buyers and sellers of certain goods and services, i.e. financial brokers. As noted in the previous sub-section, consolidated information lends itself well to the nature of the Internet, which effectively offers the opportunity to access consolidated information at any point in space. In a neo-classical model, however, perfect information is typically assumed to be present further suggesting that those activities that managed information would not exist. Thus, any analytical framework implemented for the purpose of assessing the spatial implications of the Internet would have to make allowances for transaction costs for the simply reason that the existence of the subject matter depends on it.

The second component of the analysis (chapter 5), utilizes the framework established in the first component to consider the implications of the Internet, or more specifically, the ability to access consolidated information, from any point in space on the spatial structure of the urban system. Clearly, the ability to access information from any point in space requires the improved ability with which to interact across space, thus the ordering of components. Similarly, as conveyed through the prior sub-sections, advanced-telecommunications is not simply limited to the improved ability with which to transmit information across space, but rather the ability with which benefit from the efforts of remotely located PCs.

The introduction of binary code provided the basis with which PCs could communicate with one another, provided the appropriate infrastructure is also present, which enable PCs to have the ability to connect to the telecommunications network. PCs are relatively powerful processors in and of themselves and their amalgamation with the telecommunications network has provided their users with the ability with which to extend their processing abilities beyond the confines of their previously designated location. Processed information can be transmitted, and thus accepted, between PCs remotely located from one another, further suggesting that a user of a PC is capable of benefiting from a remotely located PC's efforts. It is, however, important to specify, as suggested by feature 1 and further illustrated through the relative capabilities of digital and analog signals, the relative volume that was potentially transmittable in a given interval of time has considerably increased and will most likely continue to do so. Switching technology, applied in the identical manner as it was before PCs were integrated into the telecommunications network allows PCs to interact with one another as so long as they were connected to the network. Thus, a single PC located at a unique point in space is capable of accepting transmissions from multiple PCs which may also be located at a unique point in space, or in essence benefiting from the efforts of multiple remotely located PCs. Assuming the collected information is similar in character, the PC that has collected the information from multiple sources could integrate or possibly process the information in question as required. Conversely, a single PC is able to transmit information to any number of PCs. The application of network protocol, as previously noted, simply expedites the interactive process that could potentially occur between PCs. Information can simply be made available at a given PC and accessed according to any potential users needs, or single or multiple users could deposit (consolidate) information at a unique point.

The ability to benefit from remotely located PCs is indicative of how activities involved in information processing and/or consolidation can be remotely located. However, the re-evaluation of an activities' optimal location as a result of a change in the manner of interaction is not the sole subject of consideration. The increased efficiency of the processor dictates that their operating costs relative to their capabilities was less constrained by its need for economies, and thus able to operate in relatively smaller markets. As will be exemplified in the second component of the impending examination, a relatively smaller required market size, in conjunction with the ability to transmit more extensive amounts of information in a given interval, will potentially lead to not just an activity's potential re-evaluation of their optimal location, but a reconsideration of the structure, and thus location, of the firm with which the activity serves.

While the analytical components in chapter 4 and 5 consider the relative locational flexibility of individual activities, and could thus be deemed micro in its perspective, the final component of the analysis (chapter 6) is distinctly more macro. Drawing upon Duranton and Puga's (2000) examination of diversified and specialized cities, the analysis in chapter 6 utilizes the previously established standardized activities along with the assumptions relating to an activities' ability to interact within and across space to develop a series of comparative-static urban systems. Although the examination considers an urban system in its entirety, the variables and assumptions are almost identical, which allows for the locational framework developed in chapter 4 to be adopted. Each urban center will be characterized by its internal geography character, which will be applied to empirically observed regularities for the purpose of developing an understanding of how the improved ability with which to interact across space has affected and will continue to affect the spatial structure of the urban system.

1 Definitions and Perceptions

It is important to clarify from the outset that the essence of both 'the spatial structure of the urban system' and 'the location of economic activity in space' are very much of the same ilk. Not only did an understanding of the latter undoubtedly precede the former, but more specifically, our current understanding of the spatial structure of the urban system was derived from the development of location theory (Smith, 1971; Norcliffe, 1975). In regards to the impending analysis, the former will serve as the format for the consideration of change(s) in the ability to interact across space (advanced-telecommunications to be exact) on the latter. Thus, it could be offered that the notion of the urban system ultimately serves as a conduit with which to examine the implications of advanced-telecommunications on the location of economic activity in space. This, of course, in no way suggests that a consideration as to how advanced-telecommunications stands to influence the spatial structure of the urban system is not a valid inquiry unto itself. Rather, as will be further considered in this current chapter, (a) the urban system is potentially an elusive term and thus referring to it in context to 'the location of economic activity in space' places it in the appropriate context, while in the following chapter, (b) an understanding and appreciation for the theoretical underpinnings of the particular context is essential for justification of the method and the analysis in the second part.

The theoretical application of technological change on the spatial structure of the urban system can be attributed to our understanding of what an urban system is and how it is understood as functioning within a given context. Thus, before a functional understanding of the urban system can be conveyed it is imperative that the relevant definition and perspective of the urban system is established. As a research topic, the concept of the urban system has been considered in numerous dimensions, and as will be conveyed further, the regional scientist is forced to explicitly outline from the outset the perspective that is relevant to the study in question.

Thus, the primary objective of this current chapter is to provide a general understanding of the urban system from the *regional and/or spatial economic perspective*, and in doing so, contribute to the justification of its application of an analytical structure. However, as will become apparent, due to the nature of the subject matter, the generally accepted definition tends to create just as much ambiguity as it clarifies. Such a phenomenon may be attributed to the fact that while certain generalizations have been categorically observed, variations, be it in a cross-sectional context or over time, exist and thus any definition offered has to be relatively broad so as to be inclusive and thus worthwhile.

The stipulation of existing variations in an attempt to further characterize the relevant attributes of the urban system is unfortunately not a viable option. Such an exercise would not only be too extensive, but also misleading, in that it would imply that each urban system is one of the variations specified. Rather, the more effective option is the identification of the common attributes found in most developed urban systems. Although depending on the perspective key attributes may be subject to variation, the previously noted perspective (regional and/or spatial economic) clearly defines the pertinent attributes. Six fundamental attributes have been identified and will be illustrated accordingly. Drawing upon the general characteristics of the urban system, the pertinent conceptual attributes of the urban system will then be considered. This will not only contribute to the development of the methodology, but also help justify the use of the urban system as a conduit for analysis.

1.1 What is an urban system?

There has no doubt been considerable progress in understanding the character of modern urban systems and the processes that have created and changed these systems. Like that of a typical scientific endeavor, two distinct features characterize the growth of knowledge of urban systems. In the spirit of the reductionist, the first has been the creation of a series of separate, yet related bodies of literature, focusing on different facets of the concept regarded as the urban system, for example, urban aggregation, functional complexity, nodality and interaction, etc (see Berry and Horton, 1970). This, of course, is a simple by-product of the scientific need to limit the size and scope of a given field of research so that it may be comprehensively analyzed within a single study. The second is the rejection or extension of established ideas or principles in a given sub-field(s) of research, ultimately resulting in the development of the sub-field(s) and thus subject matter as a whole.

The intention of this chapter, as previously suggested, is to define the urban system as well as further stipulate the applicable sub-fields that are applicable to the present consideration. As already noted, the fundamental notion of the urban system can be construed as containing certain ambiguities making it notoriously difficult, if not impossible, to specify. However, this exercise is not one of precision, but rather one of identifying a number of fundamental criteria and descriptive components that comprehensively capture the general character of the notion. In doing so, additional aspects of the urban system that are of direct as well as indirect importance to the format and understanding of the impending analysis will also be emphasized. It is important to also note that the method of consideration in this section is almost entirely a conceptual one and in attempting to draw out the necessary generalities no quantitative limits are offered.

1.1.1 A definition

In its most general sense, the notion of the urban system can be defined as, 'the collectivity of urban centers within a defined territory (e.g. a region or a nation) and the interrelationships among these centers' (Parr, 2002). Such a perspective is a relatively new one, as it has emerged between the two world wars (see chapter 2). Previously, the focus was usually on the individual city or on cities in a cross-sectional sense, for example how certain economic and social phenomena varied with city size. As will be further stipulated throughout the course of this chapter, the perspective of the urban system provides a more complete view of the urban realm and is more functional than the previous two.

1.1.2 Urban center?

The key terms of the definition are, obviously, 'urban centers' and 'interrelationships', both of which contain elements of ambiguity that require further clarification. In regards to the former, scholars have been at odds to provide a comprehensible definition of the urban phenomenon. Numerous definitions over the years have been brought to bear, both by academics seeking to identify those fundamental characteristics of 'urban' through a series of concepts or attributes, and by census authorities and data collection institutions seeking to rigorously define urban places by quantitative criteria. Initially, it would seem that these conflicting sentiments would induce more confusion than clarity, but like that of the definition offered for urban systems, a number of fundamental criteria or descriptive components can be identified, which appear to comprehensively summarize the general character of urban settlements.

An urban center in its broadest sense has been defined as 'any nucleated human settlement whose inhabitants are supported chiefly by non-agricultural pursuits' (Marshall, 1989). Conceptually speaking, such a definition embodies the consideration of both *form* and *function.* In a research capacity, however, certain practical adaptations have to be applied to the definition, because the objective is to acquire a quantitative value the result is dependent on the validity of the method employed and efficiency with which the data is collected. Much has been written on the inconsistencies that exist between urban values produced by census bureaus and other such institutions responsible for the collection and provision of data (Hornby and Jones, 1980). Inconsistencies in the concept and measurements be it through changes of classifications over time or simply a different classification between institutions, within or between nations, are only to common, resulting in conflicts between nations and potentially distorting historical and cross-sectional perceptions.

In an attempt to draw points of commonality between the vast array of practical definitions Simmons and Bourne (1978) offered three common elements: 1) a minimum population threshold for an inclusion as an urban area; 2) a geographic scale large enough to encompass the built-up urban area and small enough to maintain a minimum level of population density; and 3) an area from which workers are drawn to the urban central core, effectively the urban labor market. Like that of Marshall's previously stated highly theoretical definition, the common elements found in practical definitions also inherently exhibit both form and function.

The difference between the practical and the theoretical is the requirement of a subjective specification that due to its very nature will inherently be open to errors and inconsistencies. In regards to Simmons and Bourne's first element, the establishment of a lower limit, a researcher has to bear in mind that a specification could be due as much to practical considerations, e.g. survey collection costs, than any relevant theoretical consideration. The presence of a geographic scale both large and small, of which it could be said the third element, a spatially restrained labor force, could be employed as one of the guiding factors, is intended to capture the concept of the 'geographic city' or 'urban agglomeration' or in regards to Marshall's (1989) definition, 'nucleated settlement'. However, there is a potential margin for error between that of a natural agglomeration and the imposed legal boundaries of a city (Hartshorn et al, 1980). For example, researchers have frequently attempted to compare urban population densities for different cities, using simply the population of a municipality divided by it geographic area (Plane and Rogerson, 1994). Such a measure is so sensitive to the slightest boundary change – the inclusion of another suburb, or water area, or a large park – as to be potentially worthless. On the other hand, in a theoretical context, the notion of a 'nucleated settlement' as stated in Marshall's definition is simply implicit, while the suggestion of 'non-agriculture pursuits' is equally uncomplicated.

Thus, due to the sheer impracticality of measuring urban centers through time or between nations, it is difficult, if not impossible, to establish an exact definition of the term in a quantitative context. Rather, the nature of the term requires certain generalizations, so that the term remains flexible enough to be useful. Clearly a conceptualization of the term provides a less-ambiguous understanding, which can be applied in a theoretical context with the help of a reasonable assertion(s).

1.1.3 Interrelationships?

While the notion of geographic and logistical boundaries are a familiar problem in the consideration and analysis of urban centers, the second fundamental concept identified in the definition of urban systems, 'interrelationships', highlights another crucial aspect that also requires clarification. Assuming the definition of 'urban' has been accepted, 'interrelationships' is intended to convey the notion that in a developed region an urban center is by no means an independent or isolated entity, but rather interdependent beyond that of its immediate spatial agglomeration that accounts for its as a 'nucleated settlement'. Clearly, any one urban center's size, economic characteristics, and prospects for growth are affected by the nature and strength of its interconnections with other towns or cities (Dziewonski and Jerczynyski, 1976).

In comparing the nature and character of different urban systems, it has been noted, for example, that highly industrialized urban regions may interact with one another in a manner unlike systems found in less industrialized regions (Bourne and Simmons, 1978). This would further suggest that urban systems are in fact as unique as the factors or culture that exists within them (Pred, 1977). Furthermore, in considering an interrelationship in a specific context, it is entirely possible that certain factors blatantly contradict one another. For example, are cities considered more or less linked together through complimentary economic specializations or through linkages apparent through the existing transportation network? Thus, the notion of 'interrelationship' can potentially take on several meanings that conceptually oppose one another, forcing the regional scientist to explicitly outline at the outset which interdependencies within the system are important to the particular study and which are not.

1.2 Broad Dimensions

Although a definition, along with a degree of specification has already offered, due to the previously noted ambiguities, it could be said that only a vague notion of the urban system has been conveyed. This, of course, is in accordance with the general nature of the concept in that it needs to be broad so that it may capture the multitude of variations that exist between both regions and time. Additional generalizations beyond that of simply 'urban centers' and 'interrelationships' have been identified, and their stipulation at this time will help to provide additional clarity to the pertinent characteristics of the urban system. In regards to the urban system's conceptual attributes, as will be conveyed in the following sub-section, broad dimensions will provide further theoretical grounding and thus additional justification for the application of the urban system.

Reiner and Parr (1980) asserted that regardless of the regional or national context, any urban system is capable of being viewed in terms of six basic characteristics. It is important, however, to highlight that these characteristics, much like that of the previously considered terms 'urban center' and 'interrelationships', are complex and are not completely without their uncertainties. Furthermore, like that of the previously noted terms, these characteristics are not static, but rather vary between countries and regions in both structure and content over time. The six dimensions are as follows:

1. The aggregate size of urban centers and their size distribution.
2. The location of urban centers in space.
3. The functional and structural nature of each urban center.

4. Linkages and interaction between urban centers (or the constituent units/activities within each center) and the character of such interactions.
5. The area which is served by an urban center, specific to the function under consideration, or conversely, the urban center to which each area is dependent on for certain functions.
6. The area which supports or supplies a particular urban center, specific to the function under consideration, and complementarily, the dependent urban center to which a given area sends the bulk of its output.

It is important to further note that Simmons and Bourne (1978) offered a similar set of criteria in the underlying framework of a collection of articles in their book, *Systems of Cities*. Davies (1989) also established a criterion similar to that of Reiner and Parr, but instead of six offered seven basic characteristics of the urban system, which are as follows:

1. Degree of aggregation
2. Functional Complexity
3. Linkages
4. Social heterogeneity
5. Identity
6. Permanence
7. Location

Obviously, Davies replaced Reiner and Parr's third characteristic, 'the functional and structural nature of each urban center, with 'Social Heterogeneity' and 'Functional Complexity', while adding the characteristics of 'Permanence' and 'Identity'. Clearly Davies attempted to transcend the regional and spatial economic perspective by trying to integrate perspectives from several other disciplines to encompass a wider relevance. The adoption of Reiner and Parr's criteria in this particular instance should not, however, be interpreted as a commentary that those aspects of the urban system that involve culture and identity are unimportant and should thus be disregarded. Perhaps in some contexts Davies' criteria is more effective, but this current analysis is less concerned with social aspects and more concerned with the tangible or quantifiable aspects of national settlement patterns.

In a logistical capacity, it is important to further note that each of the six dimensions stated represent a substantial body of literature unto themselves, and the provision of an extensive review for each dimension would be superfluous. The intension here is not so much to explain 'why', but rather to convey 'what is'. In doing so insight into the character of each dimension will be provided, while at the same time highlighting the relevant aspects of the dimension that might be of particular significance to the current examination. It should also be noted that each of the previously noted dimensions are highly interrelated to the point where they clearly influence the status of one another, an aspect which will also be highlighted when appropriate.

1.2.1 Size of center (and size distribution)

Clearly, urban centers vary in size within a given region. While size is usually assumed to be a reference to population, the notion can qualify as any number of characteristics, i.e. active labor force, number of households, or geographic area, to name but a few. The fact that population is the most commonly used indicator is because it is highly related to a wide variety of ratios – crime rates, ethnic composition, voting behavior, etc (Hoch, 1972; Stone, 1974). As noted in the previous sub-section, when attempting to measure urban centers, certain practical considerations are forced upon the researcher that may produce additional complications when attempting to draw cross-sectional comparisons or simply comparisons over time. Similarly, the implementation of thresholds, unintentionally as well as unjustifiably deem what is 'urban'.

In regards to the statistical distribution of such centers, investigations into the possibility of patterns within a given region has led to the identification of several, as opposed to just one, statistically noteworthy pattern of size distributions. Arguably the most popular as well as most commonly observed pattern is the rank-size distribution, also known as Zipf's law (1949). The rank-size distribution refers to the frequency of urban centers of an approximate size in a given urban system as being inversely related. Consequently, there should be few large centers, a greater number of medium centers, and then an even greater number of relatively smaller sized centers. Another commonly regarded pattern is the lognormal distribution (Aitchison and Brown, 1975). This pattern states that centers in successively smaller size classes are found to have increasingly greater frequencies initially, but then increasingly smaller frequencies. In other words, there are fewer large centers, a larger number of medium centers, and then relatively fewer smaller centers.

To a certain degree, the relationship of size and frequency and thus pattern observed, has generated some possible assertions as to possible relationships between certain socio-economic factors and size distribution patterns. It has been suggested that newly industrialized regions tend to exhibit different patterns, than urban systems found in more developed regions (Beckmann, 1958; Berry, 1961).

In addition to statistically significant size distribution patterns, other characteristics identifiable through the aspect of size may also be emphasized. Primacy, or the notion that a center within a given region overtly dominates in size, which can be logically related to a multitude of additional attributes like that of activities, productive capabilities, innovative capacity and so on (Jefferson, 1939, Balchin et al, 2000). The suggestion of a primary center is potentially reaffirmed in the previously noted rank-size distribution and lognormal distribution. However, primacy, as in a single dominant center, is, of course, by no means a definitive assertion, as two or even three cities of approximately equal size have been observed as dominating a region's urban landscape (Balchin et al, 2000).

The suggestion of primacy in conjunction with the rank-size distribution pattern highlights another important size related element, synonymously found within the urban system; the presence of a hierarchy. A hierarchical system is one of levels, also commonly referred to as 'orders', where centers of a given order would have approximately equal populations. However, the notion of the hierarchy not only entails a size distribution similar, but by no means identical to that of a rank-size distribution,[4] but also implies a certain dependency or dominance (Griffith, 1979; Bourne, 1999), depending on the perspective of the center within an urban system. This is in contrast to the pure form of a rank-size distribution, as a hierarchical system suggests cities within a given region being of the same size, or 'order', while the rank-size distribution, or lognormal distribution for that matter, implies a situation where no centers are of equal size. It is important to highlight that the notion of a hierarchy will be the focus of considerably more attention as not only one of the conceptual attributes that have contributed to the development of the methodology, but in also a central component in the derivation of the central place theory.

1.2.2 Location

Another important consideration of settlement patterns is the spatial setting of each urban center. This not only refers to the exact location of a given settlement, but equally, if not more important, is the relative location of settlements to one another. On the one hand, an urban centers' surroundings, in conjunction with the level of technology available, will most likely have an influence on the function and form of those activities located in a given urban system, an aspect which will be further explored in the following dimensions. However, on the other hand, and as previously implied, an urban center rarely functions as an independent entity and as will also be further explored in the next dimension, 'linkages', requires interaction with other centers, further suggesting that relative location is an essential consideration for the purpose of limiting the cost of such interactions (see chapter 2).

Thus, in a theoretical context, the notion of interrelationships between dimensions is further demonstrated, while in a practical context, it can be deemed that certain observable patterns, like that of a cluster or uniform distribution may relate to certain endogenous factors like that of the level of technology available. Various geographic statistical methods have been developed to examine possible the relationship between spatial patterns and certain attributes (Clarck and Hoshing, 1986; Shan and Wheeler, 1994). However, assessing spatial patterns encompasses similar complications like that of attempts to measure or define the size of urban centers.

Measurements can be classified into two main categories, geographic and economic. The former is meant to represent the real distance between the points in

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[4] Both Beckmann (1958) and Berry and Garrison (1958) argue for the compatibility of Christaller and Losch type hierarchies (both type of hierarchies will be the subject of further consideration in the

question, like that of the definition of a line, 'the shortest distance between two points'. In regards to relative location and urban centers relative location, Reily's law (1931), which has been observed as having, 'apparent predictive success' (Berry and Parr, 1988), suggests that the larger the urban center in question the further its location from an urban center of comparable size. The latter, the economic perspective, is more concerned with the cost involved in interacting. This aspect implies that activities locate at particular points in space, in particular, urban centers, to minimize necessary interactions. Considering the central research question in conjunction with the previously established notion of economic costs, as will be further considered in the following dimension, 'linkages', the potentially significant relationship between an activities' location and its method of interaction and improvements in such methods may cause an activity to reevaluate its point of location. This, of course, is not to say that activities function purely on their ability to interact across space, as will also be the source of further consideration in the following chapter; interactive capabilities is just one locational consideration of several. Other less quantifiable barriers, but by no means less important, potentially contribute to the cost of interacting across space. Cultural, or more specifically, language, barriers might exist; or perhaps political barriers such as the Berlin wall during the cold war, for example.

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following chapter) and rank size distributions.

1.2.3 Linkages

As suggested previously, an urban center is rarely observed as functioning as an entity unto itself, but rather interacts with other centers. As implied by the increasingly prominent status of globalization, which is clearly a result of a general decline in transportation and communication costs (Castells, 1996), interactions between points in space are increasing. However, it is important to note that these interrelationships, which are also commonly regarded as linkages, are considered the most complex of all the dimensions. Interaction between urban centers come in various forms, and like that the previously established dimensions, are highly dependent on one another as well as other such attributes like that of technology.

The content of linkages can be generalized into three main categories. The first being the migration of the population, while the second and third are tangible and intangible goods and services respectively. Additionally, it is important to stipulate that as implied by the analogous term, 'interrelationship', the concept of a linkage is intended to represent the presence of some sort of association between the urban centers in question, characterized by the bi-directional or completely biased flow of labor, goods, services, all three, or any combination.

Two such types of flows can be identified, circulation and structural modifications, which are very much representative of the notion of time. In regards to circulation, population migration could be exemplified by commuting. Similarly, an example of a linkage characterized by a tangible good and intangible service, could be the shipment of a commodity good or a financial transaction, respectively.

On the other hand, a structural modification refers to the systematic reallocation of economic activity within the system. The two types of flows are by no means irrespective of one another, and over time, the first may ultimately lead to a manifestation of the second. Inducing one of the main themes of the central research question, and as previously implied in the previous dimension, it can be asserted that a change in the manner of interaction (like that of advanced-telecommunications) which facilitates circulatory flows, may in fact induce a structural change rather than simply an adjustment in the rate of the flow itself.

It is important to also note that the aggregate value of linkages to a given center may potentially relate to that urban center's potential growth, regression (Thompson, 1965), a notion similar to that of a trade surplus or deficit. Furthermore, as already stated, an urban center does not exist independently and thus a positive or negative sum of linkages could also potentially have an influence on those urban centers it may also share interactions with. Although linkages occur between centers that do not share a common region, as will be explored in the following chapter, urban system behavior suggests that centers largely interact with centers within a certain locality or region. Thus, rather than considering linkages in terms of individual centers it is perhaps more common to attribute a sum of linkages to a region. The collective relationship between centers within and given region to those centers beyond the regional boundary is of primary concern to the process of regional growth and development (Perloff et al, 1960).

As previously noted, the flow of linkages between two centers can be bi-directional, but it may also be biased. This aspect highlights an essential characteristic of the urban system, which is the potential dominance of an urban center over one or several urban centers, or conversely, the dependence of an urban center on one or several urban centers. Such behavior can be further ascribed as characteristic of the previously noted hierarchy. The presence of a hierarchical structure is an essential consideration of urban system behavior. As will be the subject of further stipulation in the following section, 'Conceptual Attributes' (1.3), it embodies several basic characteristics of the urban system and helps to define the nature of their behavior; its acknowledgement and utilization in regards to the methodology is essential.

1.2.4 Function and structure

The function and structure is essentially the description of the settlement pattern. Arguably, it is the most extensively studied dimension of all those in question (see Berry and Pred, 1964). While such studies exist in both qualitative and quantitative form, the general intention of both is to identify spatial regularities in the distribution and structure of urban functions. Based on the assumption that the occupational or industrial structure of a town's labor force reflects those economic, political, and social activities in which residents of the town engage, industry employment or occupational data has been manipulated in various ways to establish groups of towns with similar functional specializations. Specialization, in this particular context, refers to the amount or proportion of the labor force in a given industry category which exceeds a certain margin of some predetermined minimum level. Furthermore, it has been asserted that a predominant pattern within an urban system is where relatively larger urban centers can usually be characterized by containing a diverse set of functions, while relatively smaller centers are observed has having a more specialized set of functions (Black and Henderson, 1998).

Technology not only facilitates interaction, as noted in the previous sub-section 'linkages', but helps to determine the level of productivity of each activity in relation to size, further influencing the level and type of labor found in each center. For example, Berry and Horton (1970) suggested that the high incidence of machinery and metal manufacturing in American cities of 10,000 to 100,000 and 1000,000 to 500,000 was in contrast to the locational distribution of such industries in India because U.S. cities of that size had achieved an adequate base of labor skills, while Indian cities had not. Thus economic activities, or functions, in a given center, in conjunction with the level and type of technology available, further define the manner in which the activities manifest themselves within a given center. It is, however, important to also highlight that functions within an urban center do not entirely consist of income generating activities. Such activities like that of administration, religious and military institutions, for example, while exhibit less of an observable pattern are no less important when considering the potential influence functions may have on the future structure of an urban center.

The composition of the labor market in a given center is, of course, just one perspective of the population structure. Other important variations, which are no doubt highly related to one another, is the age distribution, especially when considering future growth patterns, which has further implications on the infrastructure requirements in both provisional as well as occupational terms.

The subject of further consideration in the third chapter, where the changing nature of the urban systems will be examined, are the less tangible aspects of activities in a given center, like those of as decision makers as well as developers and innovators of new ideas and technology. Naturally, new technologies not only create functions, but also potentially adjust the form of existing functions of which both may modify the previously established urban structure. Similarly, certain activities within the urban system facilitate a disproportionate amount of the decision making process. This notion has become more prominent with the introduction and rise of multinational corporations (Pred, 1977). Head offices, which tend to be found in higher order centers (Balchin et al, 2000) facilitate activities located in other centers, of which adjustments to their behavior may further influence the structure of the center with which they are located.

1.2.5 Service areas

Every function in an urban center has an area in which its activities provide goods and/or services to. Within this area, consumers, be it in the form of individuals, establishments or institutions utilize functions within a given center rather than those of another center that contains identical or comparable functions. As previously noted, an urban center is essentially the co-location of activities, however, while activities may tend to share a location, the size of their respective service areas may differ. As will be the source of further consideration in the following chapters, the multi-layered nature of service areas for a given urban center is an important characteristic of the previously noted urban hierarchy, and more importantly, provides the theoretical underpinnings for virtually every central place model.

However, as will be observed in the following chapter, the boundaries between areas in a theoretical context are clearly marked, as if defined by an invisible line (see for example Hyson and Hyson, 1950). Reality is, of course, less consistent.

In some cases, markets overlap (Hoover, 1971) and consequently the conflicted area is being served by more than one center. Conversely, an area for a given function may not even be serviced.

Furthermore, while some functions within the urban system have a well-defined and uncontested service area, and thus genuinely fulfill a part of the 'central place' criteria, other activities have poorly defined service areas in which they may not only compete for consumers, but the their consumer-base may also be dispersed beyond that of a well-defined area. Such activities are commonly regarded as 'specialized-functions' and as will be further acknowledged in the following chapters, improvements in the ability to interact across space along with advancements in production capabilities have made it such activities an increasingly important factor of the modern urban system. Thus, it can be asserted that two types of service area configurations have come to define the settlement pattern of developed urban system: a central place pattern and those of specialized-functions.

1.2.6 Supply areas

While the service area represents the area with which functions in a given urban center provide goods and services, the supply area is the well-defined area in which an urban center is dependent on for support. Like that of a service area, which is potential multi-layered and thus certain hinterlands provide a range of goods and services, certain supply areas may also potentially offer a range of products within a well-defined area. The products in question might include supplies for households (i.e. foodstuffs) or production inputs (i.e. raw materials or manufactured goods) to industrial activities located at the urban center. For centers involved in the processing of agricultural produce or the processing of raw materials supply areas tend to be well defined. At the same time, supply areas can be fragmented or discontinuous. Centers that specialize in fabricative manufacturing industries might draw inputs from numerous, spatially dispersed sources, a phenomenon not unlike that of supply areas of 'specialized activities' noted in the previous sub-section. Thus, the dual forces acting upon the service area configuration (a central place pattern and those of specialized-functions) that have come to define the settlement pattern of developed urban systems, are equally present in the designation of supply areas.

1.3 Conceptual attributes

Although certain manifestations of 'interrelationships' can potentially conflict, in addition to the presence of previously noted ambiguities that may be attributed to the notion of 'urban centers', the two concepts, in accordance with one another, highlight a number of fundamental conceptual attributes of the urban system that are of particular value to the following examination. Three such attributes reaffirm the use of the urban system as a method of analysis for the consideration of the central research question. One such attribute is the implicit consideration of all urban centers in a given region. The second is the inherent consideration of space, while the third, as conveyed through dominant or submissive interaction between centers, is the urban system's hierarchical structure.

An urban system by definition is not an urban system if all of the urban centers in given region are not included. Thus, the sheer suggestion of an urban system implicitly considers all centers. Additionally, as this current examination is a consideration of the implications of advanced-telecommunications on the location of economic activity in space, it could be further asserted that in considering all the urban centers in a given region, there is also an implicit consideration of the existing range of activities within those centers as well. The provision of a range of activities is essential, because different activities will naturally have a unique reaction to changes in technology. A given range of activities also provides the opportunity with which to evaluate such changes in a relative capacity. Similarly, as such changes are considered within the urban system and not in, for example, a cross-sectional context, changes, regardless of how extreme, are still contained and thus observable.

The inherent consideration of space, which is, of course, an essential component of the central research question, is the simple recognition that urban centers within a given region do not collectively exist at a single point, but are distributed across a region. Thus, in conjunction with the notion of 'interrelationships', simple logic can further assert that urban centers subsequently interact across space. While this will be dealt with in greater depth in the following components, the relative distribution of centers within systems has been related in both a theoretical (see Richardson, 1973) as well as empirical context (Preston, 1971).

This leads to the previously noted third fundamental attribute, the notion of the hierarchy, which will also be dealt with in greater depth in the following components. It can, however, be briefly offered, that this aspect is related to the character of the interrelationships between urban centers across space. Urban centers obviously range in different sizes, which are directly correlated with the area with which it provides goods and services. Centers can be grouped, or placed in distinct 'orders' according to their size and to the particular set of goods and services they provide to the surrounding areas (Brown and Holmes, 1971). Naturally, some centers will serve other centers, while conversely; some centers will be served. This general interaction between centers and the area with which centers serve is a simplified appraisal of a structure that is hierarchical in nature manifesting itself in the urban system.

2 The theoretical underpinnings of the urban system

The previous chapter defined as well as offered a general overview of the notion of the urban system through the identification of broad attributes commonly found in most developed systems. This current chapter, which contains the second and third of the four components that make up the functional understanding of the urban system will provide the theoretical perspective. In reviewing existing theories and their interrelationship, not only will the concept of the urban system as a format for analysis be further verified, but the fundamental mechanisms that govern the structure will be identified, thus providing the framework with which to further consider its changing nature; the subject of the following chapter.

Thus, the chapter will begin with a derivation of classic urban system theory (the second of the four overall components). This will involve Weber's (1909/1929) location theory and include the likes of Lösch (1944/1954) and Christaller's (1933/1966) path breaking works and conceptual foundation of central place theory. The intention of the progression is to exhibit how the basic principles of the location of economic activity, as suggested by classic location theory, make up the building blocks of central place theory, while at the same time, demonstrating the close association between the two previously noted entities, 'the spatial structure of the urban system' and 'the location of economic activity in space' (see chapter 1). More importantly, however, are the actual concepts expressed through the theories themselves and their contribution to an understanding of the form and function of the wider urban system. Such notions will not only help to further justify the use of the urban system as an appropriate context for the method of analysis, but also contribute to the development of the general format for the method implemented in the analysis.

However, as valuable as the work of Christaller and Lösch was and continues to be, there is good reason to deem both works unsatisfactory as general theories for explaining the spatial structure of the urban system. This leads to the second component presented in this chapter (the third of the four components), which will be an attempt to define those elements, which are not contained in the previously noted theories of the second component, but clearly exert an influence on the location of economic activity in space and thus the wider urban system. Such notions include agglomeration economies, and like that of the motivations for the provision of central place theory, agglomeration economies are presented to not only to explain the locational behavior of certain activities, but as a supplement to the general framework which will further evaluate the relative changes in the behavior of activities. Furthermore, agglomeration economies are evaluated in terms of overall benefit (positive or negative) and thus potentially involve an array of coexisting factors. However, unlike the central place theory, which attempts to explain the system as a 'whole', these distinct forces are more activity specific, and as noted in the previous chapter (see '1.2.4 Function and Structure') are commonly regarded as, 'specialized function activities', as opposed to 'central place activities', and are thus deemed more concerned with individual 'parts' of the system. Thus, the second section of this chapter, will review those locational determinants that are substantial, but have little or no consistency in regards to the observable form of the wider urban system.

However, before presenting the theoretical foundations of the urban system, it is important to reaffirm that it is a potentially complex and at times elusive idea. As will be stipulated in greater depth, the fact remains that while the concept of the urban system holds considerable merit for numerous reasons, a well-developed urban system has simply too many variables to derive an exact understanding. Lösch, before presenting his central place theory, acknowledged this very point (Lösch, 1954, 8):

> If we wish to be precise and to consider the influence of the selection of a particular location on all other locations... then we enter upon the general theory of location. The repercussions, strictly speaking, are transformed into mutual relations, and its ceases to be meaningful to pick out one location and examine its relation to its neighbors in isolation. We are faced with the interdependence of all locations. Equilibrium of the location system can therefore no longer be charted, but can be represented only by a system of equations that are insoluble in practice.

Because of these countless variables, as will be observed in the initial component of this chapter, it is understandable why central place theory does not conform exactly to every urban system found in developed nations and/or regions. Although, it is important to underline the fact that with the appropriate adjustments the theory applies itself in realistic situations impressively well. Thus, it is important to bear in mind that the theory does hold a certain explanatory value even if it is not a precise one and irrespective of the exact details, it is impossible to disregard.

2.1 Weber's Conception

The birth of modern location theory is generally dated at 1909 when the German economist Alfred Weber published his book *Uber den Standort der Industrien.* However, Weber was by no means the first to consider industrial location, rather by the end of the 19^{th} century a number of Germans had attempted to write on the subject. Most notable was Wilhelm Laundhardt (1885), who attempted to show how the optimum location could be found in a simple situation with two sources of material employing a triangle of which the material and market represented the corners. However, regardless of the degree of the contribution made by Laundhardt and others, Weber's theory is commonly regarded as fuller and more rigorous than anything previously.

Although Weber limited his inquiry to the location of manufacturing it is worth noting that Isard (1956) suggested that his last chapter could be deemed the first attempt at constructing a general theory of the location of economic activity. Weber's approach was entirely deductive. His intention was to derive a basic set of rules for explaining the location of economic activity. Three basic assumptions were applied in order to eliminate certain complexities that could potentially exist in reality. The first is in regards to the location and abundance of resources, (e.g. fuel, raw materials, etc...) which were assumed to be given. The second is that the size and nature of consumption, in other words, *what* and *how much*, is also given as are the places they are meant to occur, further implying that not only do numerous points exist, but their location as well. The third assumption refers to the availability of labor, which like markets, is located at several points, and is also deemed immobile and unlimited at a given wage rate. Other assumptions and simplifications were made as they were needed, such as the acknowledgement of perfect competition; the disregard of certain institutional factors like that of interest rates, insurance and levels of taxation; a uniformity of culture and political systems; as well as firms exercise profit maximization behavior and as a consequence minimize costs.

Given the aforementioned set of assumptions, the key determinants of location of a given activity are transportation costs and relative cost of inputs, i.e. labor and capital. Using the same framework as Launhardt, often regarded as the Weber location-production triangle (see figure 2.0), Weber demonstrates how such determinants, in conjunction with a firm's desire to minimize costs, help to determine an activity's location. The notation for triangle is as follows:

> L – the location of the firm.
> w_1, w_2 – weight of material of input goods 1 and 2 consumed by the firm.
> w_3 – weight of output produced by the firm.
> p_1, p_2 – price per unit of weight of the input goods 1 and 2 at their point of production.
> p_3 – price per unit of weight of output at the market location.
> t_1, t_2 – transport rate for unit of weight per unit of distance (i.e. per ton-kilometer) for input goods 1 and 2.
> t_3 – transport rate for unit of weight per unit of distance (i.e. per ton-kilometer) for output of firm.
> P_1,P_2 – location of production for input goods 1 and 2
> M – location of market for output of the firm.

In order for the firm to produce good 3 it has been assumed that a firm requires two inputs, good 1 and 2. Furthermore, the proportion and quantities with which both good 1 and 2 are employed to make a unit of good 3 are fixed. Thus, the production function takes the form:

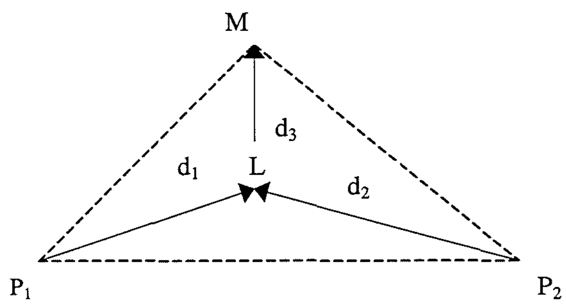
$$m_3 = f(p_1 w_1, p_2 w_2). \qquad (2.1)$$

For simplistic purposes q_1 and q_2 will be assumed at a value of 1. Therefore, the production function can be rewritten as follows:

$$m_3 = f(w_1, w_2). \tag{2.2}$$

As stated by Weber's assumptions and further observed in figure 2.0, the location for the production of goods 1 and 2 (P_1, P_2) are given along with the location of the market (M), at which the good produced by the firm is sold. Thus, given that all the prices for inputs and outputs are exogenously set, and the prices of production factors are invariant with respect to space, the only factor that modifies relative profitability is the potential location. The reason for this being that different locations

Figure 2.0 The Weberian location triangle



incur different costs for the transportation of goods 1 and 2 to the location of the firm (L), and subsequently the firms output to the market. The optimal location, considering the cost constraints facing the firm, is thus the point at which transportation costs for both the delivery of goods 1 and 2, as well as the cost of delivering the firm's output to market. This is regarded as Weber optimum location and can be expressed as the following:

$$TC = Min \sum_{i=1}^{3} w_i t_i d_i \tag{2.3}$$

TC represents total cost, while '*d*' is the distance that potentially exists between the firm's location, points of production for goods 1 and 2 and the market. The subscript *i*, refers to possible weights, transport rates and distances over which both the inputs and the output are shipped.

The cost condition (formula 2.3) indicates a unique relationship between the factors involved and how their relative values may influence the optimal location of the firm in question. The cost condition not only suggests that the cost of transporting inputs may influence the location of a firm, but the cost of delivering the firm's output to the market as well. Furthermore, a difference in the relative value of inputs (w_1/w_2), or a difference in the proportions required for production (p_1/p_2) may also influence the location of production. Similarly, a difference in transportation costs for the inputs or outputs could potentially alter the optimal location in favor of one point more than another.

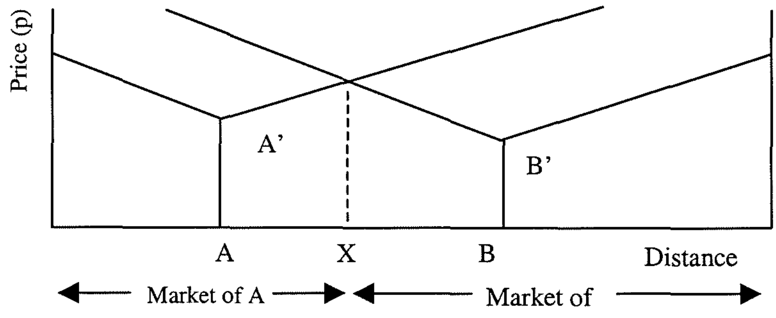
While Weberian location theory supports the previously stated notion that a change in the ability to interact across space can potential lead to a reconsideration of an activity's given location, the theory itself has been the subject of much criticism. The model is highly abstract, which is clearly a by-product of its extremely general assumptions. However, as will be observed in the following sections, Weber's theory was the beginning of a theorization and understanding of how activities behave in space, for which their location can be determined, not the end.

2.2 Market Areas

The next major contribution to an understanding of how and why activities organize themselves in space came from Swedish economist Tord Palander, whose thesis, *Beitrage zur Standortsheorie* was published in 1935. Palander was concerned with how conventional general equilibrium theory, which suggests everything happens at a point in space, was inadequate in providing an explanation for industrial location. In an attempt to offer a theoretical approach to industrial location he offered two fundamental questions. The first was identical to that of Weber's, in that given the price and location of materials and the position of the market, where will production occur? The second, given the place of production, certain competitive conditions, costs of production and transportation, how does the price affect the area with which certain producers sell their goods? Considering the notion of market areas, in conjunction with the place of production, Palander effectively offers some of the initial insights into locational interdependence of activities in space.

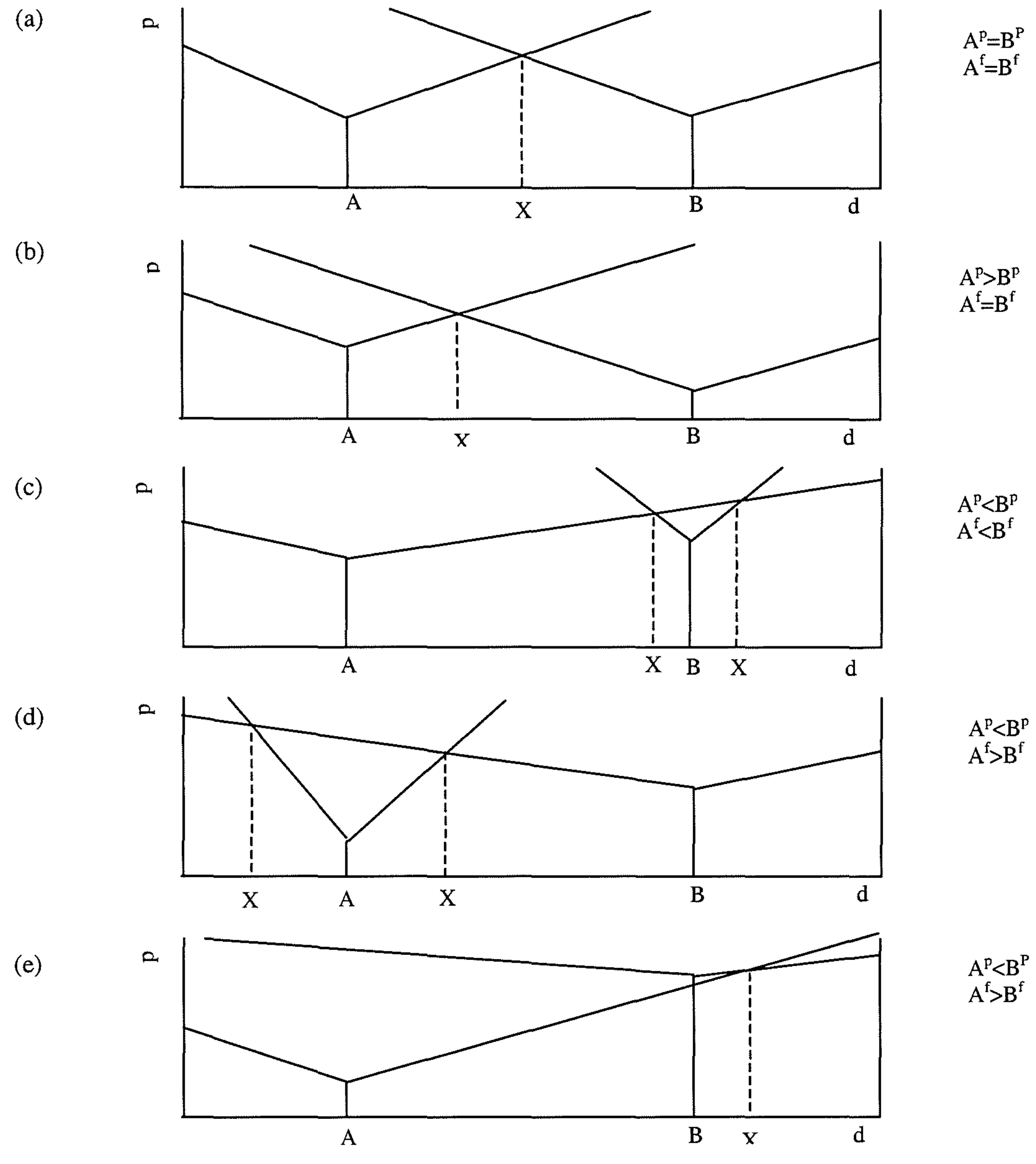
Palander induces a simple situation where two firms are involved in making the same product for a linear market. In doing so, he demonstrates how a combination of production and freight costs cause the creation of two markets. As observed in figure 2.1, firm *A* and *B* are serving a uniform market distributed across the horizontal axis. Plant costs are represented by the vertical lines, *AA'* for firm *A*, while *BB'* for firm *B*. Like that of Weber's triangle, where transportation costs are positively correlated with distance, the further away a customer from the point of production the greater the price of the good, as indicated by the lines rising in either direction from *A'* and *B'*. Thus, at any point, the price charged includes a fixed plant cost and a variable cost of transportation. The boundary, signified by *X*, is where the delivered price from both producers is equal and at that point in space customers will be indifferent as to which firm they buy from.

Figure 2.1 The derivation of a boundary between the market areas of two competing firms with equal transport costs



Changing the relative values of plant price (*p*) and freight charges (*f*), Palander illustrates potential variations, as depicted in figure 2.2a – e. In case a the two firms have equal plant price as well as the same freight costs per unit of distance, and so the market boundary is midway between firm *A* and *B*. Case b shows firm *B* as having relatively lower plant costs, while freight costs remain equal. Due to firm *B*'s comparative advantage, it is able to capture a larger share of the market. In case *c*, firm *B* has both higher production costs, as well as being subject to higher freight rates per unit of distance. While firm *B* is able to control a relatively smaller share of the market, firm A not only captures the majority, but its market totally surrounds *B*'s. In case d, although firm *A*'s production costs are considerably lower than those of *B* its freight costs are higher causing a similar situation to that of case *c*. Finally, case *e* exhibits a relatively similar situation to that of case *d*, although freight costs for firm *A* are relatively less expensive off setting firm *B*'s market away from its point of production. Thus, similar to that of Weber's cost condition where not only relative adjustments in the rate of transportation and cost of inputs influence the optimal location of a firm, it has been observed that adjustments in freight rates and production costs have implications on the size of a firm's market.

Figure 2.2a-e The derivation of market area boundaries in different situations



Removing the assumption of a linear market provides the opportunity to observe the previously noted situations in a three dimensional context (see for example Hyson and Hyson, 1950 and Parr, 1995).

Additionally, it is important to highlight the positive relationship between the size of the market controlled by a firm and potential profits. As conveyed in the above scenarios, production and transport costs are given, which in conjunction with the fact that the market is uniform across space, further suggests that total profits are a function of the distance from the plant. Therefore, it can be concluded that a firm will locate accordingly in order to obtain the largest market share possible. In the case of more than one firm, profit-maximizing behavior further suggests that firms will locate relative to one another so as to acquire the largest market possible.

Drawing upon Hotelling (1929), in a scenario like that of Palander's two firm linear market, firms providing identical goods end up sharing a single central location. The logic behind Hotelling's conclusions is that assuming production costs are the same everywhere as with the freight rate per unit of distance, the two firms will inevitably gravitate towards the center because as observed in figures 2.3a – b[5] at any other point one firm will command a greater share than another.

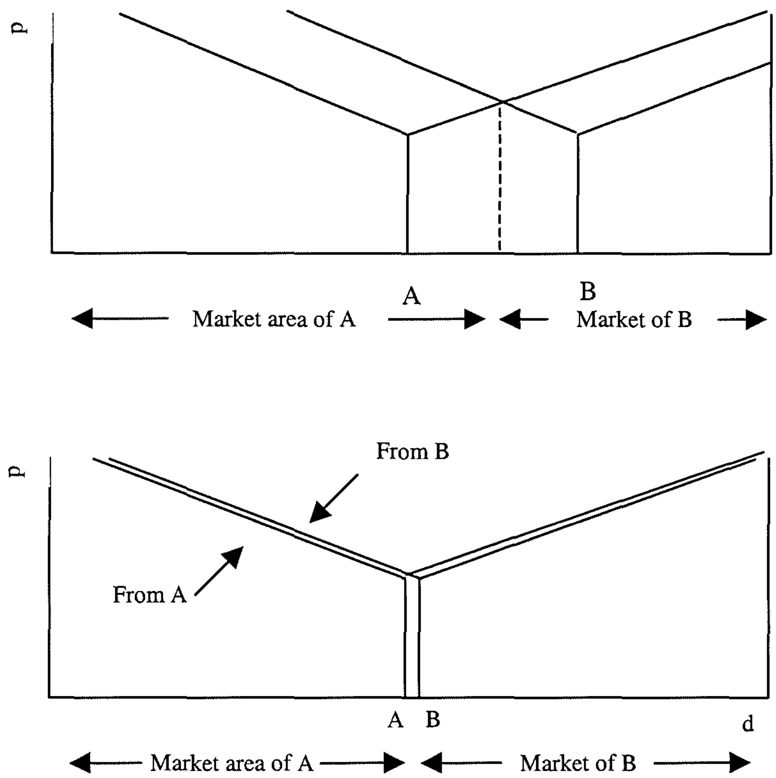
Figure 2.4a represents the initial locations of both firm *A* and *B*, of which due to firm *A*'s relative location to that of firm *B*, clearly controls a greater portion of the market. Figure 2.3b, represents the most optimal location for firm B relative to firm *A*, in that firm *B* acquires not only some of the market it was deprived of in 2.3a, but given the equal level of production and freight costs, an equal share of the available market. Thus, the optimal location of firm *A* and *B*, assuming both are attempting to maximize profits, is one where the two firms share the central location. It is worth noting that Hotelling's model is not without its criticisms (Lösch, 1944/1954; Chamberlin, 1962). Under Hotelling's own assumptions, duopolists do not have to

[5] It should be noted that the assumption of a linear market is made simply for ease of graphical presentation.

occupy the central location to share the market, as so long as they are located symmetrically with respect to the center. However, such a notion implies certain welfare considerations as well as the absence of short-term first mover advantages.

Figure 2.3a-b The location of duopolists competing for a linear market a la Hotelling.

(a)



Criticism directed towards both Hotelling and Palander is that in reality individual firms usually charge the same delivered price for a given product at all locations. Thus, it could be asserted that spatial markets are not divided up according to delivered prices, which according to both models vary with location. However, if delivered price is indeed invariable with respect to distance within a given market area this would imply that marginal profitability of each delivery will be different according to the customer because transportation costs are being absorbed by the firm. Thus, net marginal profits are still a function of distance, further suggesting that for any given spatial distribution of markets, the location of a firm will still determine the overall profitability of a firm.

Thus, while Hotelling and Palander applied a similar method of analysis, from which they obtained different outcomes, their general conclusions were very similar. Both examinations highlighted the importance of locational interdependence as a dimension to classic location theory based on the search for the least-cost location. Hotelling demonstrated how, and to a certain degree why, spatial industrial clustering occurs naturally. This being, where price competition is unimportant, spatial competition for markets may encourage such firms to locate in relative proximity to one another; a notion that is of particular importance in the realm of retailing. It is, however, important to note, and as will be further considered in the following sub-sections, that the motivations for the co-location of activities is not purely for the purpose maximizing market area. On the other hand, Palander highlights the importance of a firm's relative location to that of another firm that has similar produce, when attempting to maximize their market area given a certain level of production and transportation costs. As will be exhibited in the following section, the maximization of market area, relative to similar type firms is a fundamental component in the theoretical derivation of the urban system structure.

2.3 Lösch

Although a number of earlier explorations into central place theory as well as the structure of the urban systems had been offered they tended to associate the location of urbanization with that of a particular local feature, i.e. a mineral deposit, a crossing point of a river, or a center of a particular skill (see for example Berry and Horton, 1970 chapter 1). However, as indicated by the work of Palander (1935) as well as Hoover (1937), attention began to be directed towards the locational implications of competition between firms. Similarly, another criticism of early location theory was its neglect of demand. As observed in Laundhardt (1885) and Weber's (1909/1929) work, location is regarded as a product of spatial cost differences, with variations between places' sales potential virtually ignored; a component which also eluded Hoover, in that his analysis was confined to exhibiting what market area a given location would serve. It was left to German economist, August Lösch (1944/1954) to produce the first systematic analysis of location with demand as a major spatial variable.

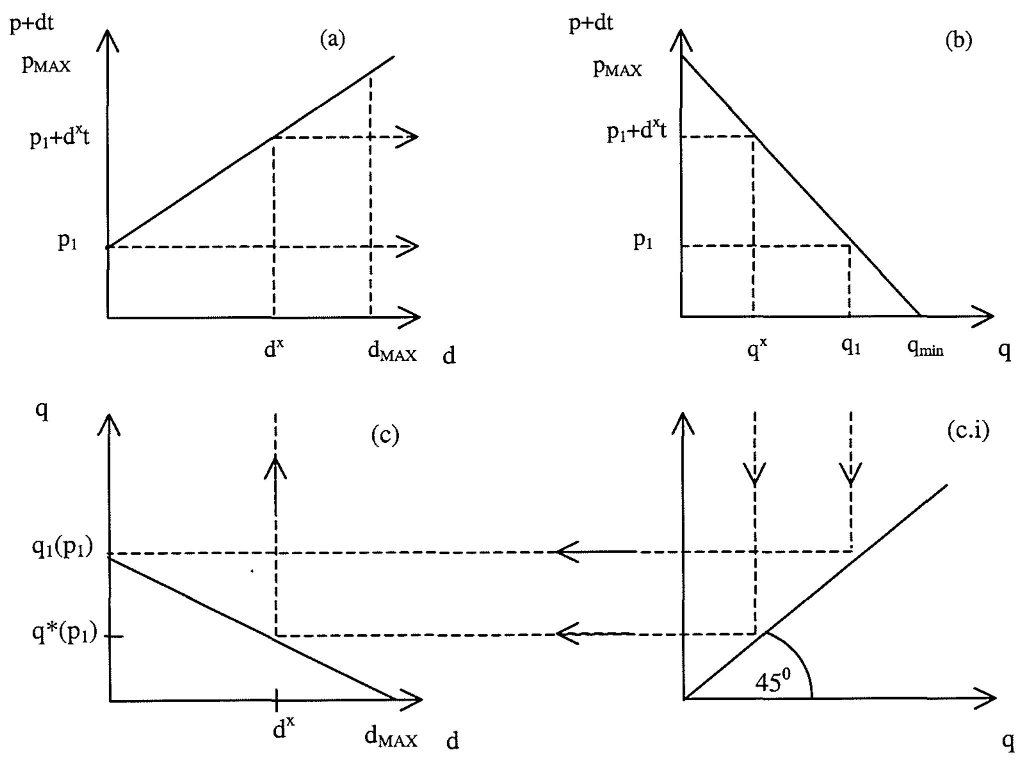
Lösch's *Die raumliche Ordnung der Wirtschaft* has arguably aroused more interest than perhaps any other contribution to the theory of location. This is most likely attributed to the fact that it was not only the first description of general spatial relations expressed through a set of simple equations (Richardson, 1969), but it portrayed what Stopler, in his introduction to the translation, regarded as 'a full general equilibrium system describing in abstract the interrelationship of all locations.' Thus, drawing upon prior understandings of market area and earlier location theory, as will be further conveyed throughout the course of this sub-section, Lösch offered the first comprehensive understanding as to how the system functions as a whole.

Lösch's examination was effectively a controlled experiment. Unlike those before him, his purpose was not to explain the location of economic activity in the real world, but rather to explore a more general explanation. As stated in the introduction, '[t]he real duty of the economist is not to explain our sorry reality, but to improve it. The question of the best location is far more dignified than determination of the actual one.' (Lösch, 1944/1954, p. 4).

The circumstances in question, conveyed through a series of assumptions, involved not only a controlled environment and manner of interaction, but also the uniform distribution of local particulars. The first assumption was that all activities were to exist on a homogenous plain in which raw materials were evenly distributed. Second, the population was also deemed evenly distributed. Third, all individuals have identical preferences and regardless of their location on the plain have an identical demand curve. Fourth, all goods are subject to f.o.b. (free on board) pricing further suggesting that the consumer is responsible for the cost of transporting goods from the point of production to the point of consumption. Fifth, there existed free entry into production, with no social or institutional impediments to entry, furthermore, entry would occur until only normal profits remained. Finally, sixth, it is assumed that rationality existed, in that producers would attempt to maximize profits, while consumers would attempt to minimize costs, or in other words, as the fourth assumption would dictate, purchase goods from the nearest producer. Lösch suggested that if under the previously regarded assumptions, or 'general conditions of equilibrium' (1944/1954, pp. 94 – 97), the concentration of economic activity still occurred, than it could be concluded that additional forces, beyond that of local particulars, were also responsible for concentration.

Lösch's point of departure was the derivation of the spatial demand and cost conditions facing a single producer. As suggested by the fourth assumption, the price of a good is positively correlated with the distance (*d*) between its point of production to its point of consumption. This can be expressed in terms of the simple formula, p_I+dt, and graphically observed in figure 2.4a, where p_I represents the price of the good before delivery or 'real price', while t is the rate of transportation per unit of weight per unit of distance. Subject to the consumer's preferences, the end of the line, or p_{MAX}, is the highest price the good in question can assume, which corresponds to the d_{MAX}, the furthest possible distance the good in question would be consumed. Figure 2.4b depicts the conventional demand curve, which as suggested by the dotted lines between figure 2.4a and 2.4b, are inversely correlated with one another; quantity

Figure 2.4a-c.i Spatial demand for consumers



demanded (q) is a function of price for the consumer, which in this case is increasing with distance. Thus, for those consumers located at the point of production, the price facing them is p_1, or the 'real price', which corresponds to a given level of quantity demanded (q_1), while the quantity demanded for all other consumers' decreases, due to the relatively higher prices facing them as a result of increasing distance between them and the point of supply increases.

Given the relationship between figure 2.4a and 2.4b, it is possible to establish the more direct inverse relationship between quantity demanded at a given price and distance, as observed in figure 2.4c; figure 2.4c.i is simply a reflecting line to further verify the direct relationship between the two. With this association it is possible to derive the Löschian demand function, which specifies the firm's market area, and its total market revenue. The relationship between quantity demanded at a given price and distance, as conveyed in figure 2.4c, can be construed as existing in a single dimension. Regardless, the total market sales of the firm are given by the sum of all the individual demands at each location, and can be written as

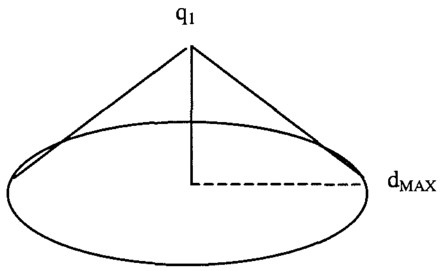
$$Q = \int_0^{D_{MAX}} f(p + td)dd \tag{2.4}$$

Calculating the above relationship in a two-dimensional context requires the relationship in figure 2.4c to be rotated 360° about the 0q-axis.

$$Q = \int_0^{2\pi} \left[\int_0^{D_{MAX}} f(p + td)dd \right] d\vartheta \tag{2.5}$$

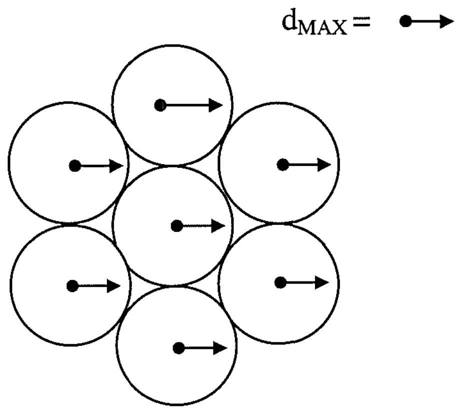
Figure 2.5 is the graphical representation of the above formula and is what Lösch termed the 'demand cone'. It is important to note that the size of the market and thus total market revenue is directly related to the level of the f.o.b. price and transportation costs. The higher both factors, the smaller the demand cone.

Figure 2.5 Spatial demand cone



Since firms exercise profit-maximizing behavior (assumption six) and since the initial producer in the market is naturally uncontested, assuming production is viable, the above relationship between quantity demanded and price can be deemed as yielding profits beyond that of 'normal profits'. As basic classical economic theory would suggest, and clearly stipulated through assumption five, the existence of profits indicates to would-be producers that entry into the market to supply the product in question would be profitable. The location chosen by the next producer entering the market could very well be the location of the original producer; however, the revenue generated at that specific location would have to be large enough to support two firms. Assuming this is not the case, the new firm would choose to locate at a point where their market area would not encroach on the original firm's. As additional producers enter the plain applying a similar rational to that of the second producer, the plain begins to fill up until each market area is tangentially surrounded by six other market areas, as exhibited in figure 2.6.

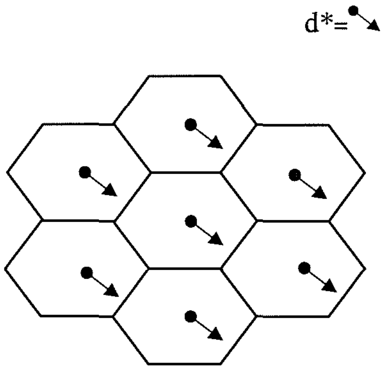
Figure 2.6 The market area structure for the initial supplier and those following suppliers in the absence of effective competition.



As long as profits remain beyond that of 'normal profits', would-be producers will continue to enter the plain. Eventually excess profits disappear and are replaced by 'normal profits', and assuming demand and cost conditions have not changed, the loss of such profits are only realized through the firms' market area. It can therefore be further asserted that the edges of a firms' market area will be encroached upon until no firm on the plain collects profits. Once 'excess profits' have disappeared spatial equilibrium has been achieved.

The spatial organization of this final equilibrium obviously differs from the one represented by figure 2.6, or when profits were present. This new equilibrium is illustrated in figure 2.7, where each firm is situated within the center of their own hexagonal market area, with a radius of d^*, which is naturally shorter than d_{MAX}. The rational for hexagonal market areas is that it allows firms to arrange themselves in a triangular pattern with respect to one another. This ensures that the distance from any point of production to a market boundary is minimized. Thus, the average delivered price of goods is minimized over space, as there are a maximum number of competing suppliers in the spatial economy. It can be further asserted that the Loshian spatial pattern represents the ideal landscape for a single industry.

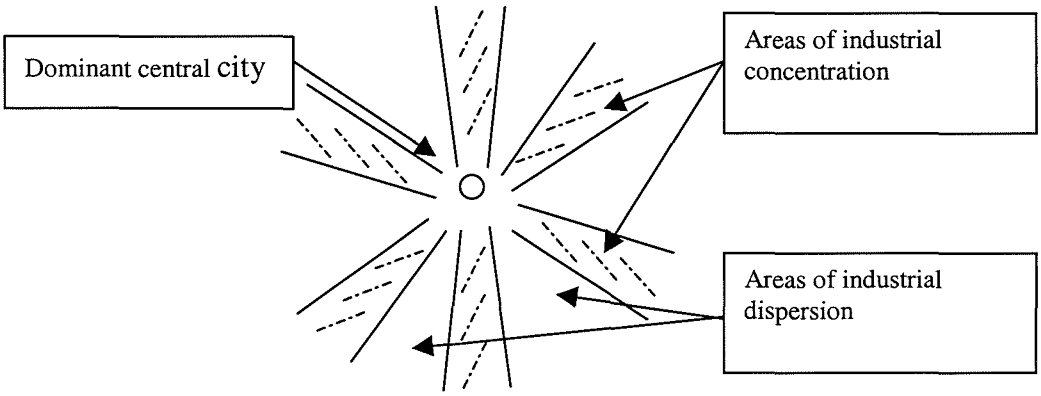
Figure 2.7 The market area structure for suppliers at equilibrium.



Thus, Lösch's 'general conditions for equilibrium' elicits a pattern of production observed as occurring at a limited number of well-defined locations. This pattern, as previously noted, clearly defines the urban system as a whole. The character of the pattern, or relative frequency of points, is defined by two factors. As previously noted, the level from which the f.o.b. price begins, which could be a question of increasing economies of scale; the greater the economies of scale the fewer the number of points. Secondly, transport costs; the higher the rate, the greater number of points on the plain. Undoubtedly, under the given circumstances, both factors induce a system that is defined by the locational interdependence of activities.

Considering an economy with *n* number of goods, each good would be subject to an individual demand and cost condition. Assuming the conditions for each good are unique, which would, of course, be more realistic, Losch suggested that the spatial economy would naturally exhibit a variety of hexagonal market areas due to variations in the level from which f.o.b. pricing begins as well as differing transport rates. In an attempt to exhibit how the production of different goods in an economic system would give rise to a unique spatial economy, or urban system, Lösch superimposed all the individual systems of market areas upon one another, with one primary production center in common. It was found that a pattern in accordance with the original equilibrium conditions would form in which there were six sectors with many production sites coinciding, and six sectors intervening in which there were fewer sites, as exhibited in figure 2.8. Lösch's argument was that the most efficient economic landscape would be one where the maximum number of firms located at the same point, giving rise to agglomeration economies, which will take place between each of the sets of firms located at the same place.

Figure 2.8 The ideal Loschian landscape



Whether or not Lösch's conclusions were justified has been the source of much debate (Beavon, 1977). It is true that empirical evidence was provided to support the previously noted city-rich and city-poor spatial arrangement (Lösch, 1944/1954, p. 125), however numerous individuals have identified inconsistencies within the structure that makes it difficult to accept (Isard, 1956; von Boventer, 1962). Regardless, as noted at the beginning of this section, it was never Lösch's intention to explain reality. The strength of the theory, as suggested by Parr (2002), is that it showed that concentration or urbanization could arise independently of local features. Furthermore, and perhaps of more importance to this particular research effort, is that Lösch rejected a chaotic interpretation of the spatial economy, regardless of how much the real world differed from his theory. He states, '[n]o doubt the spatial economic pattern about us contains enough illogical, irregular lawless features. But I refuse to put the whole emphasis on this lack of order (Lösch, 1944/1954, p. 124). Like that of Christaller in the sub-section to follow, Lösch's theory provides a template of the whole urban system with which to consider complimentary principles, like those of agglomeration economies in the following section after next, or to compare and contrast against reality. In understanding the underlying logic in the function and structure of the given theories, assertions can be extracted as to why reality does not conform to the hypothesized structures, furthering an understanding of the urban system itself.

2.4 Christaller's Hierarchy and Beyond...

The first comprehensive theory of the urban hierarchy is also regarded as the first general discussion of the urban system, in that it predates Lösch's central place theory. This was offered by Walter Christaller (1933/1966), and while Lösch's effort was deductive, Christaller's was inductive, in that it was based more on the careful observation of reality (the spatial distribution of towns and cities in Southern Germany) than on a derivation based on first principles. However, as will be further acknowledged, the works of both men are complementary to a certain extent.

While Lösch's derivation of the urban system's theoretical structure provided insight into the locational distribution of economic activities on the urban landscape under particular circumstances, it failed to offer a functional understanding into one of the previously noted conceptual attributes, the urban hierarchy. The urban hierarchy, while a fundamental dimension of the urban system (see '1.2 Broad Dimensions'), in relation to this particular research effort, is also an important component of the framework with which to evaluate changes in the urban system. As will also be conveyed in this current section, the structure of the urban hierarchy implies certain general structural characteristics, like those noted in the previous chapter' sub-section 'function and structure; this further indicates types of behavior for those activities located throughout the hierarchy. In regards to validating its use, Christaller's system and adaptations of his initial theory has been observed in certain central place systems in reality, further supporting its employability.

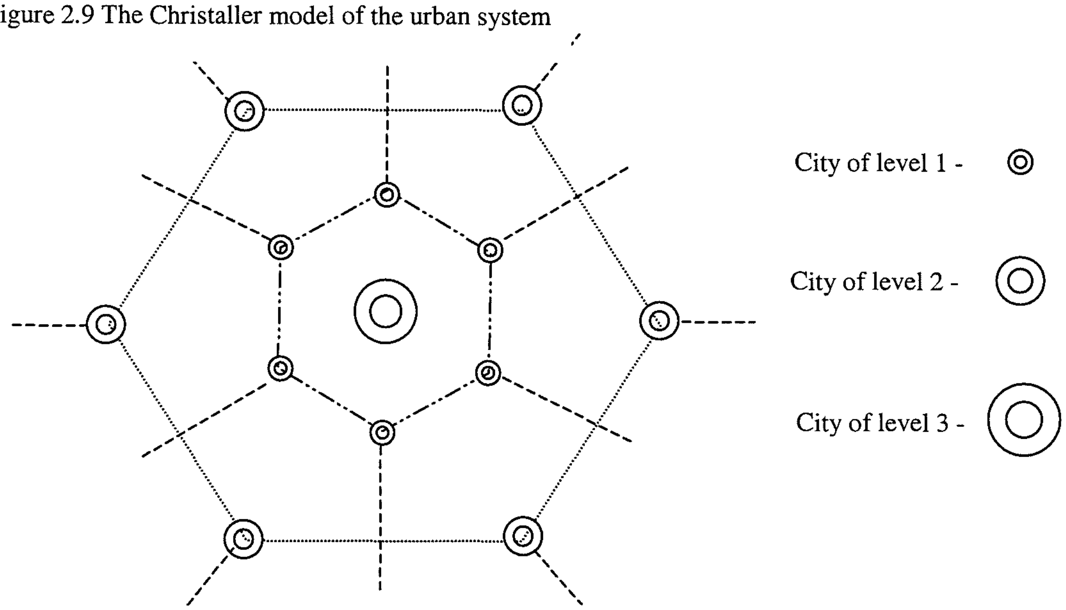
2.4.1 The Derivation of the Christaller system

The Christaller system is effectively a representation of potential spatial forms multiple supply functions can take when orientated towards the market. Considering similar mechanisms to that of Lösch (specifically economies of scale and transport costs) the market orientation of multiple functions in a dispersed market and their spatial equilibrium of supply and demand, results in a hierarchical structure. Furthermore, not only are the mechanisms similar to Lösch's theory, but the general outcome is also similar, in that assorted hexagonal market areas become superimposed upon one another with a primary center present. It is perhaps worth noting that the shape of the market area in Christaller's model is subject to variations, other shapes, like that of square (Hoover, 1971), have been applied, reaffirming the inductive nature of the theory. However, the triangular spacing observed in Christaller's system appears to be imposed because no justification for such a structure was offered and it was probably more of a case of such a structure conforming most closely to those observed in Southern Germany

The assumptions are few and basic. Christaller stated that a hierarchy consisting of *N* different functions (goods or services), will have *N* different market areas and *N* different levels of urban centers. Furthermore, two assumptions as to the interaction between levels and the relative size of market areas were also implied. Firstly, a function being supplied at a given market-area size from a particular center will also provide all functions which have the same or smaller market-area size. Secondly, assuming the population is uniform across space, market-area size would increase from the smallest to the largest size by a constant usually designated as *K*.

A variation of the Christaller system can be observed in figure 2.9, where the urban system is shown to contain three levels or N=3, further indicating that three functions are present, with three respective market areas. In terms of the supposed relationship between the three entities ([1] levels [2] functions, [3] market areas), as

Figure 2.9 The Christaller model of the urban system



suggested in the first implied assumption, a center existing at level m (where m = 1, 2, ... N) contains m market areas, this being the smallest market area, level 1, to the highest, level m. In the case of the smallest market area, level 1, it has a center with which it supplies only level 1 goods to (this particular level is usually considered to be rural). A center of level m, for example level 3, would have market areas of level 1, 2, and 3, or levels 1 through to m. This pattern, which is summarized in table 2.0, is

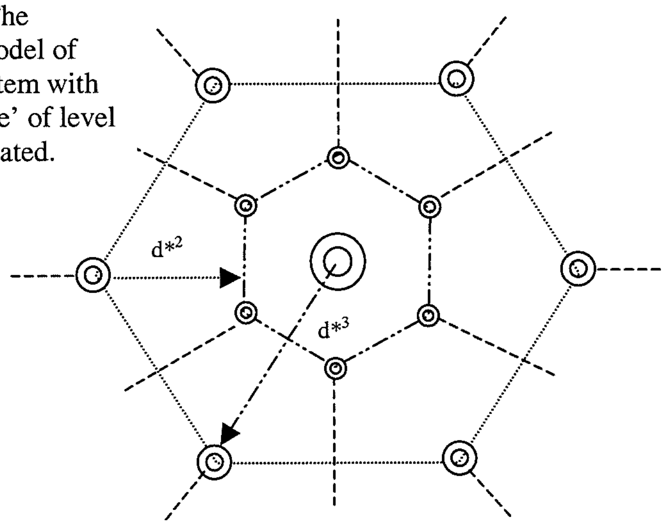
Table 2.0 Successively Inclusive Hierarchy of the Christaller Model where N=4

Level of set of functions supplied	Level of center				Level of market area served
	1	2	3	4	
1	x	x	x	x	1
2		x	x	x	2
3			x	x	3
4				x	4

generally referred to as a 'successively inclusive hierarchy', and as will be explored further later on in this section, represents both strengths and weaknesses of the theory.

In attempting to determine which level a particular function is supplied from, Christaller introduced the concept of the 'range', which was meant to represent the distance from a center the function in question would be supplied. The 'ideal range' represents the distance from a center at which demand for the function falls to zero, which is identical to the value d_{MAX} in Lösch's model as expressed in the previous sub-section and the corresponding figure 2.6. The 'real range' is the distance from the center at which competition is encountered, which is identical to the value of d* also found in the Lösch model and was exhibited in figure 2.7. More appropriately, the 'real range' for the functions of level 3(d^{*3}) and level 2 (d^{*2}) (a distance for level 1 is not shown), as exhibited in figure 2.10, has been superimposed upon the previously supplied variation of the Christaller model. The third type of range is the 'threshold range', which is the distance to the perimeter of the market where the level of demand for the firm is just sufficient to permit production or normal profits, assuming the cost condition provides allows it.

Figure 2.10 The Christaller model of the urban system with the 'real range' of level 2 and 3 stipulated.



Denoting the ideal range for function i as I_i and the 'real range' of any function which is supplied from centers of level m or higher as R_m, Christaller argued that function i would be provided by the center of highest level if the following condition holds:

$$R_m \leq I_i \tag{2.6}$$

Similarly, if the ideal range' is greater than or equal to d^{*1}, but less than d^{*2} the functions can be deemed as being supplied from centers of level 1; functions with ideal ranges greater than or equal to d^{*2}, but less than d^{*3} will be offered from centers of level 2; assuming the urban hierarchy in question is four levels, functions with ideal ranges greater than or equal to d^{*3}, but less than the real range of the level 4 functions are offered from centers of level 3.

2.4.2 Strengths, weaknesses and a theoretical alternative

However, with this type of arrangement, certain theoretical inconsistencies can be identified. One such inconsistency is the spatial structure, as suggested by formula 1, which dictates maximum coverage from a minimum set of supply points (Beavon, 1977). This result clearly contradicts the notion of free entry, which is usually the case in market economies, or some approximation of this, and is thus an unreasonable result; more so considering that Christaller never specified the mechanism within the system that would encourage the minimization of points. Assuming free entry prevails, the resulting spatial structure would be more like that of situation suggested by Losch where maximum coverage from a maximum set of supply points would occur. Secondly, functions are considered on an individual basis, whereas in reality they might be related. More specifically, it would seem logical to assume that consumers located at a level 1 centers will purchase level 1 goods/services while on their shopping trip to level 2 goods/services, so as to economize transportation costs. Such behavior would ultimately result in a lower value of the real range for each good/service, relative to if each good/service were purchased on separate trips (Eaton and Lipsey, 1982).

Christaller offers a more reasonable outcome in his later work (1960), which involves the application of his concept of the lower limit, or threshold range. As previously noted, this value represents the distance to the perimeter that encloses a market large enough to sustain commercial production. In other words, it represents the minimum geographic requirement necessary for commercial operation. This is identical to the market area in the single function Lösch model, which not only suggests that in a single market context the value of the real range and threshold range are equal, but under such a constraint all profits will be removed from the system as it will be supplied from the maximum number of points.

The application of the threshold range to derive which functions are supplied from the appropriate level of the hierarchy is similar to the perspective where the ideal range was implemented, except the ideal range perspective is a downward one, while the threshold range perspective is an upward one. For example, if it is known that the threshold range for function i is greater than the real range for the level m function, it can be concluded that this function cannot be supplied from centers of level m. Given the relationship of the two ranges it can be further concluded that too many supply points would be present for commercial production to be viable and the given function would have to be supplied from level $m + x$ ($x \geq 1$). Denoting the threshold range for function i as T_i, it can be further concluded that the allocation of functions among levels would be that function i is supplied from the lowest level of center m if the following condition holds:

$$T_i \leq R_m \tag{2.7}$$

Like that of formula 2.6, the real ranges applied in formula 2.7 are those exhibited in figure 2.9. Similarly, the previous exercise where formula 1 was used to determine the allocation of functions within the hierarchy from a downward perspective, formula 2 can be used to express the allocation of functions within the hierarchy from an upward perspective. For example, functions with threshold ranges of less than or equal to d^{*3}, but greater than d^{*2}, the functions will be offered from centers of level 2.

In regards to the prospect of multi-purpose shopping, such a notion is accommodated through the application of the threshold range, which is simply denoted by a reduction in the range to account for the savings in transport costs (Berry and Parr, 1988). However, when considered in conjunction with the successively inclusive hierarchy, it becomes apparent that the Christaller system is not feasible solely as a shopping model.

The majority of functions that characterize the higher levels of the hierarchy are not consumer-oriented, but are of an intermediate nature, e.g. wholesaling, financial services, construction, etc. Like any other market-oriented function, these particular functions require a market volume of a certain minimum. However, the nature of their product is not simply consumer-oriented goods/services, but rather the servicing of consumer-oriented goods/services as well as one another. Since consumer-oriented goods/services are located throughout space including the lower levels, the market area of such higher order functions is naturally larger in area. Thus, the reason for the successively inclusive hierarchy at higher levels could be considered partly on their need to be centrally location with respect to the market. However, as previously noted, such intermediate functions also serve one another, a notion which could be extended to that of an indirect manner, which could include some sort of common use of facilities i.e. transport facilities, municipal services and other infrastructure systems. Thus, co-location of certain higher order functions is for the purpose of centrality, but also to benefit from direct and indirect co-locational entities (Parr, 2002), also commonly regarded as agglomeration economies, which is the subject of the following section.

2.4.3 Variations and explanatory value of the Christaller system

Whether Christaller intended to bring the notion of agglomeration economies to light is not entirely known, for the reason that the successively inclusive hierarchy is simply assumed. However, considering there is no mention as to the potential mechanism(s) that contribute to the creation of a successively inclusive hierarchy it is unlikely. Regardless, as will be conveyed in the following sub-section, such structures have been observed in many central-place systems in reality. Thus, although the model clearly suffers from theoretical inconsistencies, it does have a certain explanatory value. Acknowledging the theoretical inconsistencies, in conjunction with the knowledge that the behavior expressed through the successively inclusive hierarchy has been observed to exist in some central place systems (Preston, 1971), suggests that additional forces are present, like that of agglomeration economies. Thus, the final aspect of the Christaller system subject to consideration is its explanatory value, or more specifically, its empirical significance. Over the years, numerous studies as to the presence, or extent to which central-places exist in reality have been carried out (Berry and Pred, 1961); Christaller offered such a study based on central-place systems in prewar southern Germany. The previously offered example of a Christaller system in figure 2.9, where K=3, is in fact just one variation of many. In Christaller's later work he proposed two additional central place systems, also involving hexagonal market areas: the K=4 system and the K=7 system (Christaller, 1960). Such variations, which function under the assumptions stated earlier, can be further related to unique functions that are more appropriate given the particular spatial organization. More importantly, however, are the extensions or modifications of the Christaller model, making it more flexible, thus enabling its application in an even wider context. Thus, while such systems function under the same principles, not only is the concept of the successively inclusive hierarchy capable of accommodating variations, conversely, in relating different types of systems to a general concept, similarities as to the behavior of all systems can be identified and reaffirmed. In a logistical capacity, the consideration of different systems within a uniform framework requires the specification of a general structure. This process will help to further define certain structural components in the methodology as well as contribute to their general familiarization.

The value of K, as noted previously, is the factor by which the market-area size increases (decreases) from one level of the hierarchy to the next highest (lowest) level. Similarly, as suggested by the models assumptions, K could also dictate the number of market-areas a function located in a level m+1 center supplies, or conversely, the number of m-1 market areas supplied to by a function located in a level m center. However, it is important to note that the value of K varies according to the shape of the market the centers involved serve. Assuming the centers are organized in a triangular pattern, Darcy (1964) has shown that the values K can assume are as follows: 3, 4, 7, 9, 12, 13, or more generally

$$K = x^2 + xy + y^2 \; (x \geq 1; y \geq 0) \qquad (2.8)$$

Christaller argued that his K=3 case (figure 2.9), in which each center at level m-1 is located in between the three surrounding level m centers, was based on Marketprinzip (market principle or supply principle). Corresponding to prior assertions about the initial downward prospective model, the K=3 model induces a system where level m-1 functions are provided from the minimum number of locations (figure 2.11a). In keeping with Christaller's later work (1960), which considers an upward perspective,

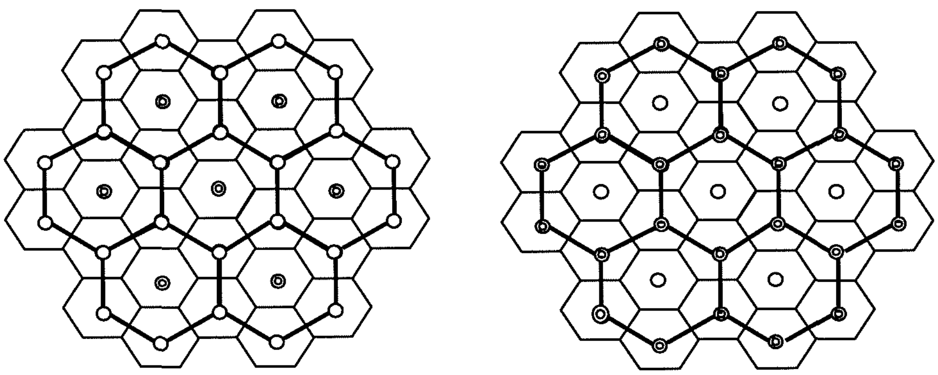
Figure 2.11a-b A Christaller K = 3 system – the market principle

(a)

Center	Level	Market area
○	m-1	———
◎	m	———

(b)

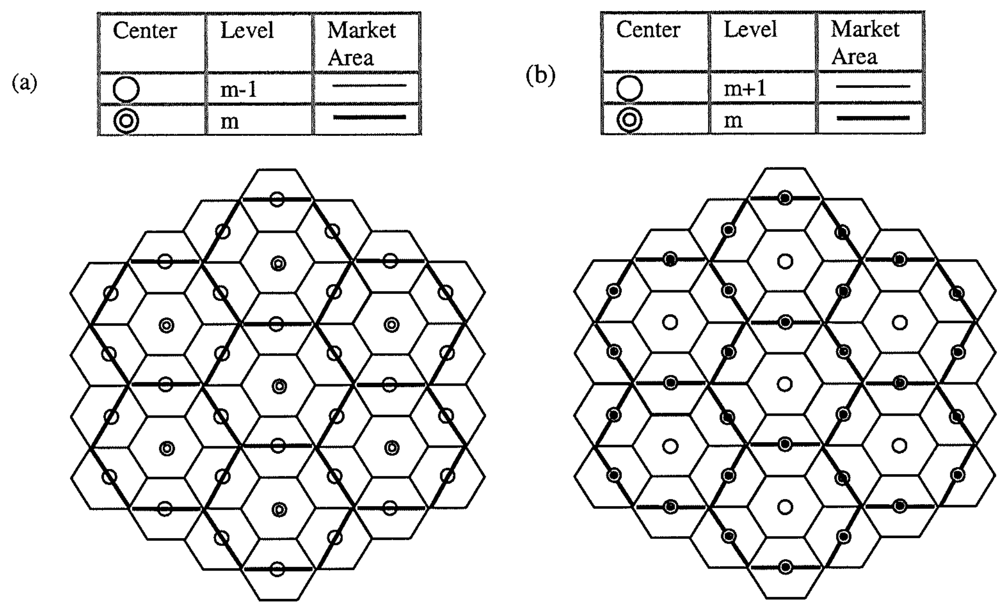
Center	Level	Market Area
○	m+1	———
◎	m	———



or frequency of level m+1, the *K*=3 results in an outcome where a maximization of supply points is observed (figure 2.11b).

The *K*=4 case, as observed in figures 2.12a-b, is based on the *Verkehrsprinzip* (transportation principle), and rather than level *m*-1 centers being located half way between three level m centers, level *m*-1 centers are located in between two level m centers. Furthermore, each level m center contains four market-areas of level *m*-1, relative to the *K*=3 case where each level m center contains three level *m*-1 centers (figure 2.11a). Such a locational arrangement is regarded as the transportation principle because it economizes mileage between points and thus reduces transport costs. This is because level m transportation routes are connected to each of its neighboring centers of level m or higher, and that level m-1 transportation routes connect each level *m*-1 center with its neighboring center of level *m*-1 or higher (figure 2.12a). In the *K*=4 case from an upwards perspective (figure 2.12b), a similar

Figure 2.12a-b A Christaller *K* = 4 system – the transportation principle



logic is applied, with the exception that m+1 transportation routes connect level m+1 centers with the neighboring centers of level m+1 or higher. Like that of a downward perspective, no additional route mileage is necessary for level m+1 routes.

In the *K*=7 case, as observed in figures 2.13a-b, each level *m* center contains the equivalent of seven level *m*-1 market areas, while each level m center dominates six centers of level *m*-1 (figure 2.13a). Christaller deemed this as the *Verwaltungsprinzip* or *Zuordnunugsprinzip* (the administration principle or inclusion principle), in that the location and frequency of level *m*-1 centers has been organized based on an administrative rationality. The *K*=7 case from an upward perspective results in same outcome as if it were developed from a downward perspective, with a technical discrepancy being that the administrative area of level *m*+1 encloses approximately all the relevant administrative areas of level m (figure 2.13b).

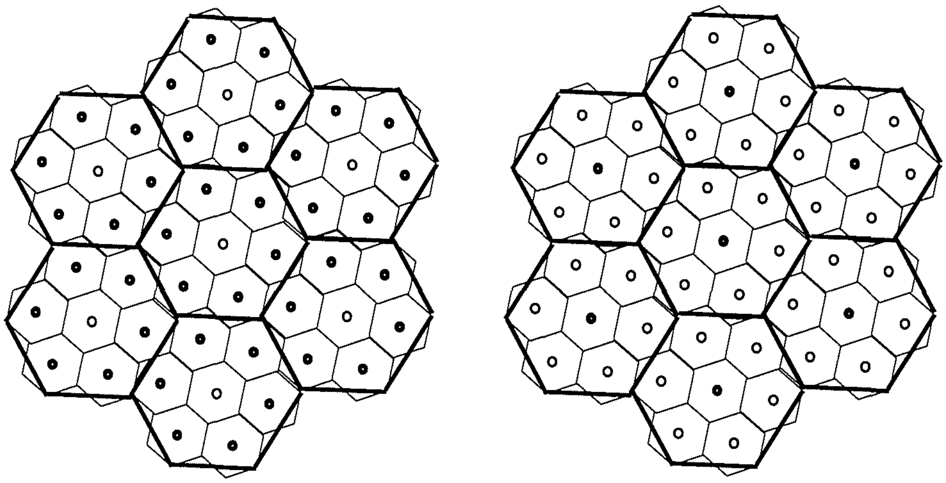
Figure 2.13a-b A Christaller K = 7 system – administration principle

(a)

Center	Level	Market Area
○	m-1	—
◎	m	━

(b)

Center	Level	Market Area
○	m+1	—
◎	m	━



The aforementioned cases, as conveyed through their graphical representations, are concerned with triangular spacing or hexagonal market areas. As previously noted, alternative forms have also been observed, such as the square, typically in situations where the original transportation system has been based on a square lattice and/or where the division of land has been rectangular in nature (Hoover, 1971). Figure 2.14, 2.15 and 2.16, are examples of central place systems based on the square market principle where *K* is equal to 2, 4 and 9, respectively. The possible values that can be assumed by *K* in a Christaller-type central place system based on square market areas are 2, 4, 5, 8, 9, 10, or more generally

$$K = x^2 + y^2 \ (x \geq 1; y \geq 0) \qquad (2.9)$$

The *K*=2 case, as exhibited in figure 2.15, is the square shaped market equivalent to the hexagonal market area *K*=3 case, which corresponds to the market principle and where maximum coverage is accomplished by minimum supply points. Like that of *K*=4 for hexagonal shaped market areas, the *K*=4 square shaped market area represents the transportation principle, while *K*=9 for the square shaped market area represents the administration principle.

Figure 2.14 A Christaller *K* = 2 system with square market areas – the market principle.

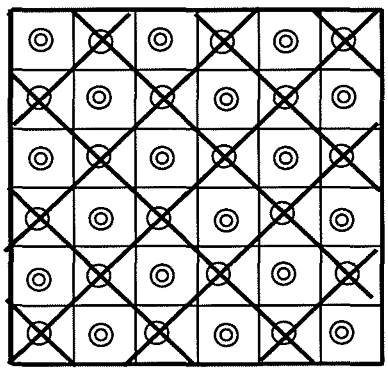


Figure 2.15 A Christaller *K* = 4 system with square market areas – the transportation principle.

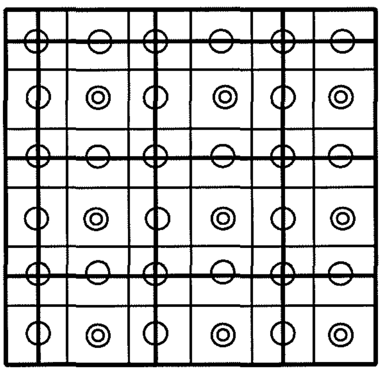
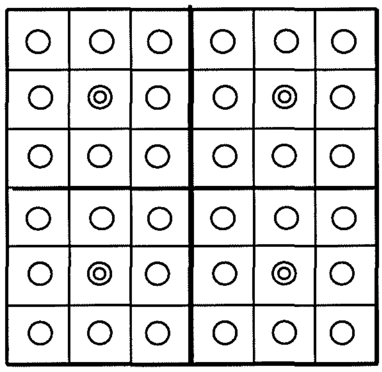
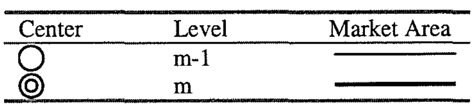


Figure 2.16 A Christaller *K* = 9 system with square market areas – the administration principle.





Before identifying those central place systems in reality that correspond to the theoretically derived models, although not particularly significant to the overall analysis, it is worth noting other regularities within the hierarchical urban system that can be described by the value of *K*. While *K* has been regarded as the rate at which the market-area size increase from one level to the next, it is has also been used to generalize the frequency of the market areas and centers within the hierarchy (Parr, 1980), generalization of the location or spacing of centers (Parr, 1978) and the size of such centers (Beckmann, 1958; Dacey, 1966; Parr, 1970).

While the aforementioned systems seem abstract and inflexible, in addition to the successively inclusive hierarchy being observed in reality, certain central place systems have been observed as personifying the previously noted structural aspects of the Christaller model as well. In addition to Christaller's observations of central-place systems in prewar Southern Germany, numerous other studies have since come to bear (Berry and Pred, 1961). Two such studies can be observed in table 2.1. The first is a $K = 3$ system observed by Rallis (1964) for Denmark, while the second is a $K = 4$ system observed by Losch for Iowa (1944/54).

Table 2.1 Application of the Christaller model to the central-place systems of Denmark and Iowa.

Denmark			Iowa		
M	Observed	K=3	M	Observed	K=4
7	1	1			
6	2	2			
5	5	6	5	3	3
4	13	18	4	9	9
3	43	54	3	39	36
2	147	162	2	154	144
1	458	486	1	615	576

Although the Christaller system has been observed in reality, the system, like that of Lösch's theory, is more noted for its theoretical contribution, as neither were especially useful in the examination of such urban system characteristics like that of size, spacing and frequency. Lösch's theory, although it does enlighten certain aspects of the urban system, never intended to explain actual systems, but rather an ideal system. Criticism of Christaller, as suggested previously, was directed towards its inflexibility, as conveyed through the imposed nature of the successively inclusive hierarchy as well as the necessity of K being constant throughout the hierarchy.

As conveyed earlier, each case, of both hexagonal (K=3, 4, and 7) and square market areas (K=2, 4 and 9), could be linked to a particular principle of spatial organization. The reality, however, is that it is unusual, more so in developed urban systems, for a single factor to be solely responsible for the spatial organization of centers. As previously implied, the spatial organization of centers is a result of a collection of forces. Thus, it seems more likely that an observed central place system in reality would be a by-product of a variety of the theoretical assertions; further explaining why few systems in the real world resemble Christaller's original system.

While a number of adaptations exist, only two of the models that encompass a more varied approach to Christaller's system will be offered: The Woldenberg System (Woldenberg, 1968) and The General Hierarchical System (GH system) (Parr, 1978). Both models consider K as subject to change. The former considers the mixing of K values within a particular level, while the latter mixes K values among levels.

Woldenburg and GH system base their argument on the suggestion that in reality all three of Christaller's organizing principles (market/supply [K=3], transportation [K=4], adminstration [K=7]) would be present and coexisting to some degree. By varying K, the systems in question accommodate, at least partially, the assortment of forces that influence the spatial organization of centers of an urban system. A point of argument being that, as suggested by the theoretical discrepancies of the model upon considering the successively inclusive hierarchy in conjunction with the proposition of multi-purpose shopping, is that while levels of the hierarchy no doubt interact, there are relationships within a given level, specifically the higher orders, that obscure the possibility of a single relationship. Whether the imposition of K as a variable completely captures this notion is not known, but since the impending models exhibit improved empirical accuracy, such an assertion cannot be dismissed either.

The mechanism that Woldenburg applied was effectively a grouping of hierarchical levels, based on arithmetic and geometric means, to establish the convergent mean for each level. As different groupings are possible, greater flexibility is permitted, and thus a greater explanatory value. One such grouping yields the following market area frequencies: 1, 3.38, 10.33, 37.18, 147.19, 517.86 and so on. From this the frequency of centers would be 'rounded off', providing the following system: 1, 2, 7, 27, 110, 371. See Woldenberg, 1968 for examples of actual urban systems that adhere to the Woldenberg system.

The GH system, as previously noted, allows the value of K to vary, within reason, between levels. Unlike Christaller, who assumes a particular organization principle is present throughout all the levels of the hierarchy, the GH system allows different organization principles to operate at different levels. While in the Christaller system K is a constant parameter (i.e. K=3 or $K = 4$), in the GH system the K value is rewritten as K_{m-1}, indicating the number of market areas of level m-1 contained within a market area of level m, or the rate of increase of market area size from level m-1 to level m. Additionally, instead of interpreting the elements of set K_i in terms of organizational principles, these are viewed as reflecting the manner in which the threshold-range characteristics vary among the different functions being supplied. See Parr, 1978 for examples of actual urban systems that demonstrate the GH system.

2.5 Agglomeration Economies

While the previously discussed central place theory offers pertinent insight into factors that contribute to the whole of the structure of the urban system, highlighting certain motivations for urbanization, it is widely acknowledged that not all activities locate according to the dispersed nature of markets or inputs. As previously noted, such activities are commonly regarded as 'specialized function activities', and while they may contribute or form the basis of urbanization at given points, their locational behavior is impossible to generalize for example functions relating to tourism, civil administration, military installations, etc, as well as during particular periods of history religious institutions and their infrastructure (Bourne and Simmons, 1978). Another important specialized function, which has given rise to urbanization, yet offers a clearer explanation for its location is resource extraction (Perloff et al, 1960), but at the same time the presence of a resource clearly does not ensure its exploitation and thus neither the associated urbanization. This is not to say that such elements of the urban system are unimportant, but rather their function(s) is (are) so unique that their inclusion towards a general statement on the nature of the urban system is simply impossible. Rather, the focus of this particular section is on those activities whose general character can potentially qualify as both 'specialized function activities' as well as 'central place activities', more specifically, services and manufacturing.

Both types of activities, regardless of whether a given service or manufacturing activity qualifies as a 'specialized function' or 'central place' activity, adheres to an identical set of principles. These include accessibility to those general factors noted by Weber, like that of markets (household and non-household consumers); material inputs to production (raw and/or intermediate); sources of energy; supplies of labor, etc. The defining aspect is the emphasis that is placed on the previously noted factors of consideration, a notion implied earlier. While variations of the central place system as well as successively inclusive hierarchy were observed, the proposed behavior of the successively inclusive hierarchy, specifically at the higher orders, was undermined by the prospect of multi-purpose shopping. Activities, like that of specialized financial and business services which are commonly found in higher ordered urban centers, optimize their location, but the degree to which factors considered by such functions which are responsible for the outcome of the overall structure are not of the same importance. Regardless, while the emphasis of those factors that determine an activity's location may be different than those central place activities previously considered, their functions can still be regarded as unique, making it impossible to offer any sort of generalization in context to the wider structure. It should, however, be noted that while a general theory as to the specialized functions and their location throughout the hierarchy is impossible correlations between activity types and city size have been observed (Norcliffe, 1975; Henderson, 1988), a notion which clearly corresponds with the presence of a logic of an urban hierarchy. Thus, the perspective of this section, from that of the firm, further indicates that theories of industrial location, such as those noted earlier of Launhardt (1885) and Weber (1909/1929), and extended upon by Hoover (1937; 1948) and Isard (1956), help to draw together the various locational forces based on least-cost and maximum-profit behavior, and are still applicable.

The reasoning provided for the occurrence of specialized functions locating in higher order centers is to benefit from certain agglomeration economies. Agglomeration economies, in this particular context, is regarded as cost savings to the firm, which result from the concentration of production at a given location, either on the part of the individual firm or a group of firms. Thus, such economies, which are evaluated in terms of their net value, may be internal or external to the firm in question. However, regardless of ownership, three types of agglomeration economies can be identified, these being economies of scale, scope and complexity, of which each is associated with a particular structure of production. The concept of net value highlights the fact that such benefits can be derived from an assortment of factors, be it individually or collectively. Secondly, a more (or less) optimal location can potentially exist, and thirdly, certain factors can be present at a given location that reduce potential benefits, i.e. congestion, pollution, etc, also commonly regarded as diseconomies. Consideration of the second and third notions collectively highlights the involvement of lower order urban centers, as an alternative location to functions, which may choose to relocate from higher order centers to escape unnecessary costs in larger centers. Although not a vital consideration in this section, it is relevant that the prospect of relocation, be it from a higher to lower order, or vice versa, is very much related to the central research question, since improvements in the ability to interact across space may provide functions with the opportunity to reevaluate their optimal location.

One such factor that is subject to a reduction in an agglomeration that is also of particular interest to this research effort is transaction costs. As will be further stipulated in this present section, certain benefits from agglomeration are derived through certain facets, which are difficult, if not impossible, to quantify, e.g. information spillovers. However, while relative transaction costs would further suggest ownership, and thus whether the benefit is internal or external to the firm, it is thus largely quantifiable, while also subject to distance given a particular level of technology. Thus, in consideration of the central research question, transaction costs are one of the variables implemented when examining whether an improvement in the ability to communicate might induce a reevaluation of a firm's optimal location. Another important component of the methodology offered in this section are the variable structures of production. As will also be conveyed beyond this current chapter, different structures imply different levels of interaction, further contributing to the relative level of net benefit experienced by a given activity or firm, more so if the ability to interact across space is subject to change.

2.5.1 Internal economies

Internal economies of scale, or horizontal integration, refer to a decrease in the unit cost of production. Efficiency gains are explicitly deemed a result of the size of an individual firm where production occurs at one or a few locations. This phenomenon is particularly prominent in the automobile and aircraft industries where large quantities of capital are employed in conjunction with a large labor force and are usually found to be located at the same place.

Internal economies of scope, or lateral integration, refers to the occurrence of joint production at a given point in space resulting in a lower total cost than would otherwise be the case if the products were produced by separate firms, either at a single location by two separate firms, or at two different locations. This is usually a by-product of the fact that an input is more efficiently utilized by more than one function. Furthermore, the input in question is either immobile or indivisible inducing the locational constraints on the activities in question.

Internal economies of complexity, or vertical integration, refer to a multi-process or multi-stage production, rather than the production of a single good. Similar to internal economies of scope, these arise when a lower total cost for the end product occurs when all levels of production are facilitated by a single firm at a given location, rather than numerous specialist firms. Such examples can be observed in the case of iron and steel works or in petrochemical plants. The advantages of such an arrangement would include improved managerial oversights, savings in energy costs, and relative efficient flows between the levels of the production process.

2.5.2 External economies

All of the previously noted internal economies can occur in the absence of a spatial concentration. While the structure responsible for the facilitation of the production process would remain, albeit at two or more distinct urban centers, agglomeration economies refer to the spatial concentration of the previously regarded forms. However, as already noted, the previously regarded perspectives are partial, in that each of the three types of internal economies has a corresponding external economy type (table 2.2). External economies refer to those economies beyond the control of the individual firm and typically arise from the presence or collective action of other

Table 2.2 Agglomeration economies to the firm

Dimension	Spatially constrained internal economies	Spatially constrained external economies
Scale	Economies of horizontal integration	Localization economies
Scope	Economies of lateral integration	Urbanization economies
Complexity	Economies of vertical integration	Activity-complex economies

firms. Thus, it is important to note that by considering the three external economy agglomeration types, the locational interdependence or interrelationships between firms in space are thus considered.

External economies of scale, also commonly regarded to as localization economies, are cost savings to the firm, which are derived from the common location of like firms (Marshall, 1892). Certain cost advantages are potentially induced by the availability of pools of skilled labor, the possibility of information spillovers, the presence of specialist services, and lower freight rates on inputs and outputs. Such factors are external to the firm and are correlated with the scale of the industry at a given location. It is important to also note that such economies are external to the firm, while internal to the localization. Historically, agglomeration economies of this type have been observed in numerous manufacturing industries, like that of the shoe industry (Hall, 1962), gun industry and jewelry industry (Wise, 1949), while at present they have been observed in the electronic industry (Corey, 2000; Castells and Hall, 1994).

External economies of scope, or urbanization economies (Hoover, 1937), refers to the cost savings to the individual firm which are dependent on the existence of firms in other industries concentrated within a given urban area. Like that of internal economies of scope, external economies of scope implies the shared use of inputs, but instead of a single firm, more than two firms share a given input. Such inputs could be either public or private, be it a common transportation infrastructure and public utilities, or specialized business and technical services. Urbanization economies are regarded as external to the firm, while internal to the urban concentration and like that of internal economies of scale are a function of size. Examples of economies are common across a wide range of industries, particularly where the firms in question are small and/or new and the sole facilitation of such external function offered in a large urban environment would not be efficient (Parr, 2002a).

Finally, external economies of complexity, or activity-complex economies, refer to the benefits a firm derives from being linked, be it in terms of input or output, with firms in other industries to produce an end product. A firm located within a relatively close spatial proximity of an activity complex economy might derive benefits through reduced transportation and communication costs, which might further provide lower inventory costs and improved information flows, respectively. Like that of external economies of scale and scope, economies of complexity are external to the firm, while internal to the activity-complex.

2.5.3 Transaction costs

As previously stated, whether or not an agglomeration economy is based on internal or the corresponding external economies is largely dependent on the relative level of transaction costs and following the work of Coase (1937) and Williamson (1975) has emerged as a useful concept in the analysis of industrial organization. Generally speaking, transaction costs are defined as 'the costs associated with exchange relationships as well as determining the most appropriate governance structure, or institutional matrix within which transactions should be negotiated and executed' (Goldsby and Eckert, 2003). Thus, the concept clearly implies two general dimensions, by no means irrespective of one another, both of which are relevant to this research effort.

Firstly, transaction costs refers to the determination of terms, i.e. price, as well as potential search, co-ordination and preparation costs that may be incurred while attempting to find the most opportune option of production, or component of production. Secondly, may also refer to the cost of the interaction between the relevant components of production, which could include the movement of information and goods alike. The relative level of both types of transaction costs collectively determines whether the dealings will occur in an inter-firm (market) or intra-firm (hierarchy) context. Relatively low transaction costs would imply that the former (market) would be utilized, while a relatively high transaction costs would suggest that the latter (hierarchy) structure would apply (Werthner and Klein, 1999).

Both of the previously noted aspects of transaction costs will be considered in this research effort. In relation to the second component, the prospect of different components implies a movement or transfer of goods and/or services involved in the production of a given process, further suggesting the presence of transport/transfer costs. Such factors, as conveyed through agglomeration economies, are a function of distance given a level of technology, implying that while transaction costs may influence the ownership of production they also influence the locational considerations of components. It is worth noting that with the possibility of shifting goods and/or services across distance the possibility of socio-economic and/or institutional considerations is introduced, which may generate additional transaction costs. This could include certain barriers like that of tariffs, language conflicts, additional legal considerations, etc. However, while such barriers may be a source of transaction costs and thus should be noted, they are difficult to generalize and will thus not be a major consideration in this particular research effort.

As will be further stipulated in chapter 5, in relation to the initial component of transaction costs previously noted, i.e. search, co-ordination and preparation costs, the Internet shares certain characteristics to that of a market, which in some cases naturally facilitates such activity. As noted through a number of earlier studies (see for example Bakos, 1998; Berthon et al, 2002), the Internet has increased the effectiveness of matching buyers to sellers leading to lower transactions costs.

However, it is important to further note that transaction costs and their relationship to locational considerations is not a simple linear relationship, in that as technology improves transaction costs subject to distance decrease. Particular technological advancements could also potentially remove certain transaction costs, as suggested by the production cycle (Norton and Rees, 1979). More specifically, certain capital-intensive advancements are responsible for the integration of processes, naturally removing related transactions. For example, in Smith's pin factory (Smith, 1776/1974), in which an individual was responsible for a different process in the pin's production, a pin is more efficiently produced by a single machine, and thus the transactions between the individuals, or processes, are made redundant. Thus, in regards to agglomeration economies, and as will be exemplified in the impending examination, the relative benefit from economies would be different for that of an individual involved in the pin making process compared to that of a single machine, further suggesting that their locational considerations are different because the involved processes require different interactions.

As will be observed in chapters 4 and 5, transaction costs makes up an important component of the analytical framework and therefore will be subject of further consideration upon presentation of the analysis.

2.5.4 *Activity and size of urban center*

The question of the relative benefit from economies between that of an individual involved in the pin making process and a machine that makes whole pins, further highlights the relative locational considerations of activities throughout the urban hierarchy. Conversely, locational decisions by a given firm influences the size of the center at which the location occurs, further affecting the size distribution of urban centers. Although it is difficult, if not impossible, to define the exact relationship between activity type and location, generalizations based on the character of an activity and urban center size can be offered (see Broad 'Dimensions: Function and Structure' in chapter 1). The logic employed is based on the reality, as previously implied in the justification of agglomeration economies, that an urban center of a particular size has certain functions (or lack there of), as suggested by central place theory, that a firm may need to locate within to maximize potential net benefits.

An example of such behavior was noted in regards to external economies of scope, where new or small firms might locate in an urbanization economy to benefit from the range of different industries present in such a concentration of activities. Such a location might be advantageous because a small or new firm they may not have had the time or capital to develop the means with which to provide such services for themselves. Such a relationship also tends to reinforce itself, in that a firm providing specialist services may need to locate in the proximity of their market, which might further suggest that the optimal location would be a larger urban center. Conversely, a relatively self-sufficient firm may select a relatively smaller urban center because not only might they not require additional services, but also to escape certain diseconomies in larger concentrations which may present the firm with additional costs that might be avoided in a smaller center.

As will be the subject of further consideration, the character of the activity, which further defines the nature and quantity of the interactions required are indeed facilitated by a certain technology, i.e. freight, telephone, etc. Thus, it is important to reaffirm the status of technological factors, which determine a firm's ability to interact across space. As Weber's classical location theory would suggest, a change in the manner of interaction potentially changes the location of the firm, or its requirement to locate in the proximity, or not, of the firms and markets it interacts with.

2.6 Conclusion

The purpose of this chapter was to review the structure and logic of the urban system with specific reference to the mechanisms that govern the locational decisions of activities. The review focused on two components. The first acknowledged the existence of a general structure based on central place theory as originally conceived by Losch and Christaller. While the original theories were highly abstract and limited in terms of their explanatory power, adaptations like that of the GH or Woldenberg system reaffirmed the empirical significance and thus applicability of the theory.

The second perspective, as alluded to by Weber's classic location theory, recognized the reality that certain activities do not adhere to laws of centrality or the dispersed nature of markets or inputs, but rather locate within the spatial proximity of unique features. Similarly, due to the ridgedness of certain assumptions employed in central place theory, specifically the 'successive inclusive hierarchy' in Christaller's model, behavior where lower orders served higher order, like that exhibited in the occurrence of branch production, could not be accommodated. Such aspects could, however, be explained in terms of agglomeration economies, which offered an explanation at the level of the activity as to the locational motivations of unique activities, or 'specialized functions' as they are commonly regarded.

In addition to providing a supplement to the general urban system framework, the notion of agglomeration economies implicitly introduced a series of production structures, or configuration, with which activities interacted with one another as part of wider process. Like that of certain elements of central place theory, the production structures will be applied in the analytical frameworks in chapter 4 and 5.

Both components highlight the importance of interactions, be it between points or components in the production process. As suggested in Weber's location-production triangle, a change in the cost of interacting across space may redefine the optimal location of the activities involved. Similarly, in market area theory, of which the fundamental principles of central place theory are based, a decline in transport costs potentially leads to an increase in market area. Agglomeration economies, on the other hand, are effectively describing an interaction between components. However, it is important to also note that both components also demonstrate that transportation costs are not the only locational determinant. For example, production costs or costs of inputs can also influence an activities location and thus have to be considered in accordance with changes in transportation costs.

In addition to highlighting the mechanisms that determine the location of activities, the purpose of such a review, in accordance with the central research question, was to provide the theoretical foundation with which to consider changes in the spatial structure of the urban system. As will be further observed in the following chapter, the two perspectives are analogous to the two types of change considered. The first type of change is effectively a 'uniform shift', which refers to a modification of the structure as a whole, while the second is a locational shift of a specialized function.

3 Change in the urban system as a result of technological shifts

The forth and final component of the provisional understanding of a functional definition for the urban system is two-fold in its objective. The previous chapter outlined two aspects of the urban system: the locational distribution of activities (the whole) and agglomeration economies (the part). As implied in the previous chapter, the difficulties of accepting the Christaller system based on the notion of the 'successively inclusive hierarchy' are exhibited through the fact that both components are clearly present in all developed urban systems. Equally importantly, however, is the relationship between the two. The interaction between the two aspects not only helps to define the overall structure of the urban system, but is a significant factor in its development as well. Thus, an objective of this current chapter is also to exhibit the relationship between the locational distribution of activities and agglomeration economies, and to explore how the urban system changes as a result of certain general shifts in technology of which the relationship between the two components contributes to a framework with which to explain and understand such changes.

As noted in the section on agglomeration economies in the previous chapter, the nature of such economies are essentially governed by interactions, which are further defined by the character of the activity in question. Change that relates to such interactions (be it through the improved ability to interact across space or an internalization of one or several of the interactions) could potentially redefine the costs associated with an activity functioning from a particular point in space and as a result possibly induce a reevaluation of its optimal location. The relocation of activities due to technological shifts is largely explainable because each activity adheres to a locational framework. Furthermore, each locational framework exists within a larger structure, this being the urban system, which further contributes to an activity's overall locational framework. As factors that govern the locational framework change, so does an activity's optimal location, which would naturally have implications on the overall structure of the urban system.

The evolutionary nature of the urban system has been widely recognized and is reflected through a wealth of studies on the historical-geographical development of individual cities that make up the urban physical plant (see for example Duncan and Lierberson, 1970; Pred, 1966). Cities, throughout much of their history, have functioned primarily as points with which activities collect, process, and distribute raw materials, goods and services. Such activities naturally represent capital, but more appropriate to this particular consideration is the role of labor, a key determinant in the size and thus order with which an urban center is part of. Therefore, all things being equal, changes in the physical make up of urban centers and their rates of growth can be attributed to changes in the size of the resource base of the surrounding area, as well as the relative efficiency with which such resources are processed and utilized (Borchert, 1967). Such changes are thus directly related to the technological *transport* of, e.g., goods, services, and energy, as well as the industrial *organization* of the production process. In other words, as the nature or character of an activity changes, so might the labor required for its facilitation, further implying that an increase or decrease would occur in the center where the activity was located or relocated, respectively. Similarly, as suggested by the locational interrelationship of activities, as an activity's market extends, identical activities not previously contained in the newly extended market area may no longer be competitive, thus making the activity and the labor involved redundant.

It is, of course, unrealistic to consider the implications of all the technological advancements that have had an influence on the structure of the urban system. Rather, while practical examples will be offered where appropriate, general technological advancements, representative of those previously noted, will be shown to induce two types of change in the urban system that are of particular relevance to the central research question and thus impending methodology.

The types of changes to the urban system considered are micro and macro in nature and like that of micro- and macroeconomics in general are by no means irrespective of one another (Romer, 1996; see for example The Euler equation). The micro perspective is analogous to the process previously described; a technological shift will potentially induce a redefinition of a given activity's optimal location, and thus contribute to a redefinition of the urban system as a whole. More specifically, given a level of technology, the nature and character of an activity suggests the necessary number and types of interactions required. The available level of technology determines the cost of the interactions, of which it is assumed their net value(s) will be minimized, which further indicates an optimal location or locations. Advancements that alter either the number or type of interactions required, or the cost of an interaction itself, potentially induce a change in the given activity's optimal location, by suggesting that the activity in question could be performed more efficiently from another location or locations. The second type of change, or macro-type changes, acknowledges a more general type of urban system change, involving the prospect of a shift in technology that potentially leads to a reevaluation of an entire level or order of the urban system. Thus, like that of the more general realm of micro- and macroeconomics, 'micro'-type entities culminate to create broad shifts in a given system, which in no way hinders the possibility of them functioning within a given environment as independent entities.

Thus, a central objective of this chapter is to convey the relationship between the two aspects of the urban system, and to apply this to an explanation of changes in the urban system. However, it is important to note that this chapter's contribution in context to the larger research question is the provision of a framework with which to consider the implications of advanced-telecommunications on the structure of the urban system. Before it is possible to review the manner in which the different technological shifts influence the structure of the urban system, it is important to further clarify the mechanisms that govern such changes in order to provide a generalized perspective with which to construct the analytical framework. The first component will involve a consideration of the differences and similarities that exist between the two types of change. This is intended to not only identify the nature of the changes in context to the locational framework, but also to provide an opportunity to identify the key factors that induce such changes. Amongst others, this involves the fundamental notion of transportation technology. However, while improvements in transportation technology has been considered a catalyst of structural change, its relevance in the contemporary economy has been the subject of debate and thus requires further stipulation as to its pertinence to this examination. The consideration of transportation technology also provides the opportunity to consider the various types of activities present within the urban system the viability of their movement, and thus a response to improvements in transportation technology. The third sub-section involves a consideration of the interaction between the two previously noted principal structural factors that govern the locational framework: agglomeration economies and the locational distribution of activities, how both factors, with respect to technological shocks, induce changes within the urban system, and the nature of such changes. Furthermore, with the advent of technological advances, the emphasis on the locational framework has shifted from one of a locational distribution of activities to that of agglomeration economies. The key term being 'emphasis', in that both have and will most likely continue to exert an influence on the locational consideration of the urban system as a whole, existing activities in an individual context as well as emerging activities.

3.1 Similarities and differences between the two types of change

Differences between the two types of change in regards to the different types of general technological shifts, i.e. an improvement in the ability to interact across space or an internalization of a transaction, are in fact nominal in regards to the fact that both can induce either type of structural change. As will be exhibited in this and the following sub-sections and further examined in the impending analysis, is that the difference in the occurrence of either type of change is a function of the type of activity that is being influenced. One defining factor is how a given activity is able to respond to technological changes while attempting to minimize costs, for the purpose of maximizing profits, relative to the cost of delivering the good or service to market. In other words, like that of Weberian location theory, given the character of the good or service, which effectively determines the method with which its inputs and outputs are delivered, in conjunction with the manner in which it is produced, both aspects which are, of course, subject to change, indicate the optimal point or points of production. In a particular context, this logic is not only compatible with the theoretical assertions responsible for the derivation of the urban hierarchy and agglomeration economies, but also, dynamically speaking, corresponds to the manifestation of innovation and subsequent diffusion throughout the urban system. However, it is important to note that in another context, an activity's motivation to optimally locate has also led to the increasingly observed trend of activities locating in lower orders while serving higher orders; a notion which clearly contradicts the previously noted mechanism of the urban hierarchy: the successively inclusive hierarchy. The process of innovations diffusing throughout the urban system, in conjunction with the increasingly observed trend of activities locating in lower order centers, while serving higher order centers, further highlights the precarious nature of issuing firm distinctions between the two types of change.

3.1.1 Uniform shifts

Classical manifestations of innovation diffusing down the hierarchy can be deemed as partially representative of one type of structural change observed in the urban system. Innovation, as applied in this particular context, is regarded as any new item, technique, organization, or idea that spreads. The introduction of an innovation can come by either a local inventor or by imitation from outside the urban system in question. However, as suggested by Pederson (1970), 'wherever the origin, the innovation is likely to occur first in the city, which has the highest exchange of ideas, people, and products with other cities in the country and with cities in other countries.' Earlier empirical studies such as McVoy (1940), Crain (1966) and Berry and Neils (1969), also indicate that both urban size and distance from earlier adopters are important factors in explaining the diffusion of innovations. Such a notion clearly conforms to those previously regarded assertions made in regards to spatially constrained external economies. External economies are not only closely correlated with size (Parr, 2002a), but relatively larger urban centers are thought to offer newer firms accessibility to goods and services that they would not have enough capital or time to acquire internally.

While it would be problematical to assert the relative cost effectiveness of integrating an idea into the social fabric of an urban center, the production or facilitation of an organization, or the integration of a new technique into existing production processes or organizations is assumed to be economically viable in the market with which the diffusion occurs. Market viability is a pertinent notion, in that it not only reaffirms the motivation for new firms to initially locate in the largest center in the urban system for the purpose of providing themselves with the largest immediate market in the region (Pred, 1977) as well as external economies, but also indicates the viability of the diffusion of a particular product, organization or applicable techniques at a particular point or points in space. Furthermore, the diffusion process abides to similar mechanisms to those considered in the derivation of successive inclusive hierarchy, where an activity locates according to its market threshold. The smaller the threshold, the lower the order the activity in question would be found. This process thus further suggests how the introduction of a new technology might influence the urban system in a uniform manner, in that a given market threshold applies to the range of urban centers in a given order.

However, the prior assertions as to the diffusion of innovations within the urban system are an oversimplification of what is, of course, a more varied process. Innovations passing on in their original form from higher order centers to lower order centers, while a possibility in itself, assumes that the innovation is being passed on in a particular form, and that the demand in smaller markets would be able to sustain production in that form. The precarious nature of such a process is highlighted through the Loschian framework where the markets' of firms providing identical goods are already functioning at normal profits (see chapter 2). This would further imply that without a change in the cost of producing the good or service in question, or a change in the cost of delivering the good or service, a reduction of market size would be impossible. Thus, as will be methodically exhibited later on in this chapter, a modification in the production process which decreases the marginal cost of production, or an improvement in that ability to deliver the good or service across space, potentially influences the structure of the urban system in a uniform manner.

The reduction in the cost of producing a particular good or service can obviously occur through a myriad of factors and any attempt to transcend beyond generalizations would no doubt be flawed. However, speaking in terms of the mechanisms that define the various agglomeration economies, a decrease in the marginal cost of a given product could occur through the internalization of one or several transactions. Furthermore, in addition to a relative change in production costs and thus a reconsideration of the required market area needed to sustain production, is the modification of attributes that represent the optimal net benefit of spatially constrained economies. All things being equal, the internalization of one, or several, necessary transaction(s) would imply a relative decline in the need for external type economies. Like that of Smith's pin factory compared to that of a single machine that produces pins, it is implied that such a shift requires a capital intensification relative to the necessary labor required, not only a common trend in developed regions, but also in accordance with those assertions regarding the internalization of necessary interactions.[6]

In acknowledging other such forms of uniform structural changes due to technological advancements, as will also be exhibited, advancements do not always result in a linear diffusion of activities. Rather, as noted through a number of studies regarding the expansion of the railway in the mid-west of the United States the increased ability to transport certain products at relatively lower costs leads to a redundancy of smaller orders, also regarded to as a 'thinning of centers' (Carter,

[6] This is what Robinson (1931) referred to as the *resynthesis* of the production process in which a single unit of fixed capital substitutes for was previously done in a series of discrete operations.

1984). In this particular situation, the improvement in the ability to interact across space has led to a widening of the existing market area in which the possible incorporation of lower order market areas becomes a possibility. However, regardless of whether technological change influences activities in the urban hierarchy in a linear manner, in the absence of natural disturbances, it can be asserted that structural change in the urban system occurs when the variables that define an activity or activities' market threshold becomes subject to change.

3.1.2 The relocation of a specialized economic function

The second type of change that has been observed is concerned with the change in the hierarchical position of certain specialized economic functions. This, at one time, was observed as occurring in an upward direction, but now the trend seems to be one of movement down the hierarchy. As previously noted, the increasingly observed phenomenon of activities relocating to lower orders, or decentralizing, while serving higher order centers is clearly a contradiction of the notion proposed by the successively inclusive hierarchy.

The mechanism for such relocation is varied, yet generalizations can be offered. Decentralization, similar to that of uniform changes, involves the internalization of transaction costs further implying that net benefits from agglomeration would be less inclined towards external economies present in larger urban centers. The greater the internalization of relevant functions the greater diseconomies, which are also positively related to an urban center's size (see chapter 2), accounting for a relatively larger portion of the overall net agglomeration relative to external economies. Thus, it would be reasonable to assert that an activity might shift to medium- or small-sized centers so as to benefit from lower factor costs in non-metropolitan centers, particularly with respect to land and labor, while at the same time, escape unnecessary diseconomies like that of congestion, pollution, crime, etc. Additionally, transportation advancements may also prove to be a factor in that savings from such advancements may offset additional distance costs that may come to bear as a result of decentralization. On the other hand, the motivation for the upward movement of activities, or centralization, can been regarded as similar to the initial stage of the innovation process, where activities relocate in higher orders to benefit from a certain external economies while at the same time acquiring accessibility to larger markets.

3.1.3 The association between the two types of change

It should, however, be noted that while an activity may be inclined towards a particular method of production and corresponding method of transportation, it is possible for an activity to not only change the manner in which it manifests itself within the urban system, but exhibit both types of structural change. This highlights the practical difficulties of offering firm distinctions between the two types of structural changes observed in the urban system. One such example is the provision of energy. Initially functions responsible for the production of energy were effectively locationally bound to the source from which it was derived, i.e. a river (Oliver, 1956). With the advent of such advancements like that of electrical energy and power plants, energy could be produced at more centrally located points benefiting from certain economies. However, while energy is still produced at central places, additional advancements like that of the battery or gas powered generators provide energy at a small, while sufficient, localized scale. Another such example is the computer. Before the microprocessor, computers had to function in terms of economies of scale (Evans, 1981; Redman and Smith, 1980). However, with the advent of the microprocessor, as embodied in the personal computer, computers have become widely available throughout the urban hierarchy and while some computers are still required to function in terms of economies of scale smaller scaled versions clearly exist super computers are still used (see for example Earth Simulator at JAMSTEC, 2004; Thunder at Lawrence Livermore National Laboratory, 2004; Mare Nostrum at Barcelona Super Computer Center, 2004). Regardless, the difference as to whether an activity diffuses in a uniform manner or simply relocates relates to technological change in that advancements are catalysts of the observed structural shifts. The character of such structural shifts is in fact more a function of the nature and character of the activity in question, in which a function can clearly assume different purposes and thus vary in regards to its nature and character.

3.2 The role of transportation costs in determining an activity's location

Before further considering the nature of change in the urban system and the interrelationship between the two principle factors that govern the structure of the urban system (locational distribution of activities and agglomeration economies) it is important to first acknowledge the criticisms directed towards transportation costs as a relevant factor for the locational consideration of activities. After having reaffirmed the importance of transportation costs, the viability of transporting the various activities within the urban system and the general impact of improvements in transportation technology on such activities will then be considered.

3.2.1 The relative importance of transportation through the ages

Classical location theory, as originally derived by Laundhart (1885) and Weber (1909/1929) and subsequently expressed by neoclassical theorists such as Hoover (1937), Isard (1956) and Moses (1958), as previously noted, suggests that each decision maker is assumed to seek out a location such that the transport costs incurred in assembling inputs from their sources and in dispatching outputs to their final markets are at a minimum. Criticism tends to be directed towards the fact that Weberian location theory was developed in the age of steam power, where today steam boiler equipment is indeed quite rare. Since that time transportation equipment has become more efficient, clearly leading to a reduction in the cost of moving goods (Karaska and Bramhall, 1969; Parr et al, 2002). Furthermore, the composition of manufacturing has radically changed in that there has been an increasing importance of high-value added industries (Karaska and Bramhall, 1969). Unsurprisingly, empirical evidence indicates a negative relationship between value-added industries and transportation costs as a proportion of total production costs (Hoover, 1971).

However, while classical location theory is perhaps dated in some ways, the fact that transportation costs account for a lower proportion of total production costs of some goods and services does not make it any less relevant. Expectedly, a decline in the cost of transportation has led to an increase in the average length of a haul (Parr et al, 2002). This can be further interpreted as resulting in an increase in the spatial scope of certain firms, which is also in accordance with the mechanisms that determine a firm's market threshold (see chapter 2). Similarly, and as will be further exhibited, spatial constraints prior to the decline of transportation costs have become relatively less so, allowing firms to manipulate benefits from economies that previously had not been viable. In doing so, major behavioral shifts have occurred, which have manifested themselves in terms of structural change within the urban system. Savings have clearly been generated through a decline in the cost of transport that has made such structural shifts feasible. Thus, while transport may not be as substantial in terms of direct costs, attributing the value-added and/or savings gained as a result of the structural shifts which have come to bear through a decline in transport rates, it can be further concluded that their role in the production process is no less important as it was in the era of the steam engine when considered a direct cost.

3.2.2 The nature of economic activities and their inclination towards transport

The previous consideration primarily relates to the movement of relatively high-value goods, and thus a particular aspect of manufacturing the activity. However, other types of products clearly exist within the urban system. In addition to, of course, low-value products, where transportation costs are a large component of production costs, is the presence of certain service activities, where the product in question can not simply be transmitted across space. This, of course, is in contrast to services that can be transmitted across space.

It is important to note, however, that before qualifying which services can be transmitted across space, the establishment of firm divisions between different types of services is a notoriously difficult task (Allen 1988). Numerous qualifications exist on the subject (see for example Price and Blair, 1989), all of which are perhaps more elaborate than this current research effort requires. Singelmann (1978), for example, purposes four groups: distributive services, i.e. retail, transportation; producer services, i.e. finance, insurance, banking; social service, i.e. education, medical, government; and personal services, i.e. hotels, laundry entertainment. Daniels (1985), on the other hand, establishes within the two generally accepted types of services, producer and consumer, three sub-groups: perishable, semi-perishable, and durable. The three sub-categories refer to the relative length of time a service in question provides utility to its user. For example a perishable consumer service could include a visit to the hairdresser, or the use of a dry cleaner, while a perishable producer service might include the daily cleaning of an office, or waste disposal. A semi-perishable consumer service includes advice from an accountant for the completion of tax returns, or advice from lawyer in regards to filing for divorce, while a semi-perishable producer service could include an advertising agency providing copy for the promotion of a product. A durable consumer service, for example, could include architectural advice and assistance for the design of a house, while a durable producer service might include financial analysis on issues such as possible locations for profitable new investment or prospects for long-term borrowing strategies.

With regards to the transport or delivery of such services, both classifications clearly negate any notion of mobility as a condition of categorization. However, considering the previously noted examples, it can be asserted that given a particular level of transportation technology, of which 'communication' is included, some of the previously noted services are subject to more locational restraints than others. For example, a perishable consumer service like that of a hairdresser can not be conveyed via advanced-telecommunications like that of the durable consumer service of long-term borrowing strategies. Similarly, improvements in the ability to communicate or interact across space, would, as previously noted, potentially contribute to an augmentation of previously established market area, and alleviate certain spatial constraints.

3.2.3 The simultaneity factor: tradable vs. non-tradable services

A classification that is more analogous to this current research effort is that of 'tradable' and 'non-tradable' services. As conveyed through the relative locational restraints facing the previously noted examples of perishable and durable services, not all services can be consumed at a point other than its place of production. Examples of such non-tradable services might include fast-food restaurants, warehousing, hotels, and public utilities. However, while traded services may involve similar interactions, they can often be facilitated through some kind of intermediary such as telecommunications or courier services. Hirsh (1989) uses the expression 'simultaneity factor' to explain the difference between tradable and non-tradable services, in that the lower the proportion of their total costs incurred by the producer and the user during their interaction, the greater the tradability of a particular service.

The notion conveyed through the 'simultaneity factor' is very similar to the concept of the value-weight ratio (Lever, 1974), but is perhaps less dated as it incorporates certain considerations that are increasingly common in modern economies. The value-weight ratio, which is clearly in reference to manufacturing activities only, suggests that high-value products can be transported over large distances because the higher the value of the product the lower transportation costs account for the cost of the good at market. Conversely, in regards to low-value products, the transportation costs will be high relative to the value of the product even for short distances, thus restricting the distance over which such goods can be shipped. Thus, generally speaking, it can be further asserted that the value of the product in question, in conjunction with the level of transportation technology, influences the market area in that the higher the value-weight ratio the larger the market area. Such an assertion is easily exemplified through such high-value products like that of cars or electronic goods which are shipped to markets all over the world, while low-value products, like that of bread and milk tend to be produced and sold locally.

However, the value-weight ratio, in addition to other incongruities,[7] is unable to account for such aspects found in the modern 'information economy' (Castells,

[7] Another such weakness of the term is that it is unable to explain why certain low-value products like that of agricultural and dairy products are shipped over relatively large distances like that of New

1989), like that of the increasingly observed trend of capital flows within and between nations (Sassen, 1994). The movement of capital is subject to a transportation cost, although less so today than in the past, is not priced in terms of 'weight'. A more appropriate qualification for the transportation of such services would be one of 'complexity'. As will be further considered in the following chapter, and ultimately applied in the impending examination, the transmission of information is facilitated in terms of 'bytes' per second, a 'byte' being a unit of information (see chapter 4). The more complex the service in question, the greater its number of bytes and thus, given a level of technology, the greater the amount of time and effort its transportation would incur.

There is no reason why the simultaneity factor cannot be applied to manufacturing-type activities. Like that of the value-weight ratio, the simultaneity factor implies a *relative* market area of a particular good or service. All things being equal, the lower the proportion of the total cost incurred by the producer and user during the interaction, the greater the market area, as further reaffirmed through the notion of the market threshold. Considering the prospect of change as a result of technological shifts, an improvement in transportation technology could potentially redefine the proportion of the total cost incurred by the producer and user during their interaction, increasing the 'tradability' of a particular good or service.

However, the simultaneity factor is not the mechanism that determines whether an activity diffuses in uniform manner or relocates within the urban hierarchy, but rather is indicative of the most opportune production function relative

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Zealand or parts of Africa for North American or European consumption. Nor is the ratio able to explain why low-value clothing and toys are shipped from developing to industrialized nations. The reason for this weakness is that the term implicitly assumes that the quantities of the total capital invested in all production processes, and the quantity of all types of output produced is to be equal.

to transportation costs; implying a particular type of behavioral response to a technological change. Furthermore, as noted in the previous chapter, some functions clearly benefit from the spatial consolidation of their activities, be in the form of economies of horizontal, lateral, or vertical integration (spatially constrained internal economies). As previously suggested, the justification for such behavior is that the benefits derived from agglomeration cover additional transportation costs brought on through the decision to consolidate in space. One the other hand, some activities like that of certain non-tradable services, may benefit from similar economies, yet the applicable transportation costs make it an inefficient option. Thus, it can be further asserted that an activity diffuses or relocates within the urban hierarchy depending on the potential values of the proportion of the total cost of production an activity would incur through a given production function relative to the corresponding level of transportation costs also incurred in the given situation.

Thus, the simultaneity factor corresponds to the previously asserted manner in which an activity locates within the urban system after having been subject to a technological advancement, which is a function of its optimum method of production in conjunction with its corresponding method of transportation. The optimization of a given activity's simultaneity factor, as previously noted, depending of the nature and character of the activity in question can be further achieved through certain agglomerations, internally or externally, this would, of course, have certain spatial implications.

The performance of a particular production function is not defined in terms of total profits, but in terms of rate of return.

3.3 How the two types of change influence the spatial structure of the urban system

Having considered the two general types of change that potentially come about in developed urban systems and their related mechanisms, this sub-section will attempt to convey the manner in which such changes manifest themselves in terms of the spatial structure of the urban system. The first types of change considered will be those that are uniform in nature, while the second will involve a consideration of specialized functions. However, barring all natural irregularities, the spatial structure is effectively a by-product of the interrelationship between the two components of the urban system, this being the locational distribution of activities and agglomeration economies. Agglomeration economies are mutually beneficial interactions that arise as a result of the spatial proximity of economic activities. Therefore, simple logic confirms that in order for agglomeration economies to occur, one or more types of activities have to already be present, which further implies that in order for agglomeration economies to come to bear, activities within the urban system in question have to acquire a relative level of complexity. Regardless, as additional types of activities come to bear, they effectively become affixed onto the preexisting spatial structure, redefining it.

It is worth reiterating that a myriad of factors can potentially induce not only both types of uniform changes, but a relocation of a given activity as well. Such shocks might include changes to demographic conditions, a change in the level of an activity of the regional export base, modifications in consumer's tastes, developments in production technologies, transport, etc. The defining factors, as exhibited in the previous chapter as well as derivation of a simple central-place system, is the potential adjustment to an activity's threshold range, which is not only determined through the nature and character of the activity or activities in question, but is a function of both supply and demand. The supply side is usually a function of such modifications in the realm of production and transportation, while the demand side is usually a function of consumer's tastes and demographic factors. While both are important, given the central research question, the emphasis of the current examination will be on the supply side.

3.3.1 A uniform shift

As will be exhibited, a uniform locational shift of a function or functions manifests itself within the central-place system in two broad ways. The first is a change in the allocation of individual functions within the hierarchy, while the second is similar to the first, but is more intense, in that a larger number of functions are influenced, resulting in a modification of the hierarchical structure. As noted in the previous subsection, the catalysts, which account for a wide variety of shocks, technological and otherwise, can induce either type of manifestation. It is also important to note that neither type of change results in a comprehensive redesign of the original system. Rather, changes occur within the *structural or locational confines of the system* with which the change has occurred.

The previously derived central place system will act as the framework for the consideration of functions shifting in a uniform manner within the urban hierarchy. Clearly the specifications of the above central-place model are a simplification of an actual urban system. Firstly, while the above model has three levels, as exhibited in the previous chapter, actual systems usually have many more. Secondly, the successively inclusive hierarchy has been assumed as present. However, while such an assertion is somewhat precarious, in that incongruities have been increasingly noted, as noted in the prior chapter, not only does the theoretical rationale for this exist, but empirical evidence also suggests that it is a well established feature in most regional central-place systems. Furthermore, as will be further exhibited through the relative consideration of the two types of the structural change (uniform and relocation), in the absence of the successively inclusive hierarchy, the range of outcomes for the possible adjustments are practically infinite.

In addition to a successively inclusive hierarchy it will be assumed that the centers within the framework of analysis or central-place system are arranged in terms of a functional hierarchy in that the number of levels in the hierarchy are equivalent to the number of distinct bundles of functions provided. Similar to the notation in the previous chapter, the levels of the hierarchy and their respective bundles of functions are labeled as follows: $m = 1, \ldots N$. Since the hierarchy is assumed as successively inclusive a center of the level m supplies the bundle of functions m, as well as bundles 1 through to m-1, which are characteristic of level 1 through to m-1, respectively. For example, a center of level 2 supplies the level 2 bundle of functions, as well as the level 1 bundle of functions.

3.3.2 A change in the allocation of an individual function within the hierarchy

The first facet of the uniform shift process to be considered is a change in the allocation of an individual function within the hierarchy. This involves a function, which is initially located at a given level and then becomes characteristic of a higher or lower level (Parr and Denike, 1970). In other words, the function in question ceases to be part of one bundle of functions and becomes part of another. The difference between this shifting process and the one to follow is that while it is possible for a number of functions in a given bundle to be reassigned, the focus of this particular consideration is that the shift in functions is not enough to modify the existing structure of the hierarchy or the number of centers in a given order.

Two simple examples will help to demonstrate the reallocation of a function within the urban hierarchy. The first scenario (1A) involves the provision of a function from level 3, i.e. banking services. It will now be assumed that a new production technique is introduced which reduces the marginal cost of production, and thus reduces the product's previous defined threshold range. Assuming the reduction in the threshold range is substantial enough, the product will now be supplied from level 2 centers. However, the downward shift of the function in question from level 3 to level 2 centers, and not level 1, implies that the reduction of the threshold range is below the range of a level 2 center, but remains above a level 1 center. Furthermore, as suggested by the successively inclusive hierarchy, the function will still be supplied from level 3 centers, but only in their capacity as level 2 centers. Thus, the function that was initially part of the level 3 bundle of functions, as a result of a shift in the production, has become characteristic of the level 2 bundle of functions. It is worth noting that a similar shift might come about through a change of factors on the demand side. For example, an increase in the population of the region in question could potentially increase demand for the given function sufficiently that it could be provided from a lower level.

The second scenario (1B) involves the consideration of a function that can be profitably supplied from level 2, i.e. a retail function. It is now assumed that a new production technique is introduced which requires substantial economies of scale. If, however, the newly defined function were installed in every level 2 center demand from each center in conjunction with its market area would be insufficient to permit profitable supply. In other words, the threshold range of the adapted function is greater than the real range of a level 2 center. Assuming the newly defined threshold range is less than a level 3 center's, in that the demand of the population of a level 3 center within its market area is sufficient to permit viable production an upward shift of the function in question would occur. Thus, the function, which was part of the level 1 bundle of functions in the initial period, has become part of the level 3 bundle of functions in the subsequent periods as a result of a shift in production. It is significant that, assuming transportation costs remain constant the locational shift implies that the benefits derived from the new method of production are substantial enough to cover additional transportation costs as a result of the enlarged market. However, assuming transportation costs were to also decrease, benefits acquired from the change in production would clearly not have to be as large.

However, before considering the second type of uniform change it is worth noting that the upward relocation of the function in question, as a result of a new production technique, highlights the prospect of the adjustment to production occurring at the initial location. And instead of the previously described outcome coming to bear, the function remains in a level 2 center and supplies level 3 centers as well as other level 2 centers. This is what has been regarded as the second type of structural change, or 'relocation'. Although a relocation in its purest sense has not occurred, it can be deemed in terms of the contradiction of the assumed successively inclusive hierarchy, which is not only contradicted because a lower center is supplying a higher order, but also because it is supplying centers of the same order as well. As noted in the previous subsection and the subject of further consideration in the following subsection, such an occurrence is not only increasingly common, but tends to highlight the shift of emphasis of the urban from the locational distribution of activities to that one of agglomeration principles.

3.3.3 Modification of the hierarchical structure

The second type of uniform change can be regarded as a more intense version of the two just offered (type 1A and 1B). Instead of causing a shift in the pattern of the provision of an individual function, or the subset of a bundle of functions, the shock in question induces a change in the pattern of the provision of an entire bundle, or enough of a bundle, that the hierarchy itself becomes modified. As previously noted, this could result in the adjustment in the number of levels in the hierarchy or the number of centers in a given order. However, it is worth reiterating that any such changes will occur within the preexisting locational confines of the system within which change has occurred. Furthermore, while additional levels may come to bear, or existing orders are redefined due to an adjustment in a center or centers' size, change occurs within the original number of centers in the given system.

Two types of structural change will be considered in this given subsection. The first will be the creation of a new level of the hierarchy, while the second will involve the disappearance of a level. However, as exemplified in the following examination, both a disappearance of a level and a creation of a level are in fact variations of one another and are thus considered in conjunction with one another. It should also be noted that other types of structural change are possible. Rather than a decisive creation or disappearance of a given level, a shock might result in the modification of a given level. Stabler and Williams (1973) offer an empirical analysis of particular modifications. However, a consideration of such modifications has not been included here because they are simply extensions of the two to be offered and thus their contribution to the overall understanding of how the urban hierarchy changes would be nominal.

The framework of the examination is the same as in the previous subsection, with the added stipulation that adaptations potentially result in need for a more general system than that of the Christaller model. This is because the K factor, which, as noted in the previous chapter, is the number of market areas of level m-1 contained in level m, is held as a constant in the Christaller; a notion which is usually unfeasible when the structure of the hierarchy is subject to change. As a result, the General Hierarchy (GH) model will be implemented where necessary, of which the Christaller model is a special case (see chapter 2). Like that of the previous subsection, each type of change will be considered as a two-stage model representing conditions before and after a shock.

The first type of change will consider the disappearance of a level (2A). Like that of 1A, the change is induced by the introduction of an improvement in a production technique, which reduces the cost of production. However, unlike the case in the previous sub-section, the change in question is more extensive in that it influences a range of functions, more specifically level 2's bundle of functions. Due to a reduction in the marginal cost of production of level 2 functions the necessary market threshold subsequently reduces allowing level 2's bundle of functions to be supplied from level 1. Level 2's bundle of functions can now be provided from the larger number of centers of level 1 or higher. Centers, which were formerly level 2, become indistinguishable from those of level 1, and thus the level 1 bundle of functions is thus upgraded to level 2 resulting in the disappearance of level 1. The structures before and after the change can be observed in table 1. Assuming before the change the urban system resembled a Christaller system with $K = 4$, where $K_2 = 4$ and $K_1 = 4$, after the change $K_2 = 16$. Note how the total frequency of centers in the system remains unchanged (see table 3.0).

Table 3.0 Disappearance of a level (upgrade)

Before change		After change	
Level, m	Frequency	Level, m	Frequency
3	1	3	1
2	3	2	15
1	12	1	-

However, it is also possible that the improvement in question would only be of a certain character that *some* of the functions in level 2 would experience a reduction in their market threshold. Unlike scenario 1A, the subset in question would be substantial enough that their relocation would have a noticeable affect on the original level 2 bundle of functions. The relocation of a large enough subset results in the second type of change: a formation of another level. While the overall number of centers in the system remain unchanged, the relocation of certain level 2 functions to some of the level 1 centers would lead to the creation of a new level in between levels 1 and 2 (3A). Thus, a new bundle also comes into existence, 2*, which will be composed of functions of the former level 2 bundle as well as the level 1 bundle. Level 2 centers, however, would provide the level 2 bundle as well as the 2* bundle of functions, in other words, all the functions of the previously unchanged level 2. This can be further exhibited in table 2. Maintaining the previous assumption of the initial system being a Christaller system with $K = 4$, however, after the shift there are fewer level 1 centers on account of some of them being upgraded to level 2*. Thus, after the change $K_2 = 4$, $K_{2*} = 2$ and $K_1 = 2$ (see table 3.1).

Table 3.1 The formation of a new level (upgrade)

Before change		After change	
Level, m	Frequency	Level, m	Frequency
3	1	3	1
2	3	2	3
1	12	2*	4
		1	8

However, while scenario 2A and 3A exhibited an upgrading of centers, it is possible for a level to disappear or a new level to be created through a downgrading of centers. This is similar, but of a greater intensity, to that of 1B, where a function was reassigned to a higher level. It is assumed that a new production technique is introduced that requires functions in level 2 to take advantage of economies of scale. As in scenario 1B, the market are of a level 2 center is insufficient to support the new production technique, because the threshold range is greater than the real range of a level 2 center. Thus, assuming the threshold range is less than a level 3 center's, level 3 centers would continue to produce the level 2 bundle of functions, while level 2 centers would cease to supply the level 2 bundle of functions and simply supply level 1 functions (2B). This can be observed in table 3, where before the change $K_1 = 4$ and $K_2 = 4$, while after the change $K_1 = 16$ (see table 3.2).

Table 3.2 Disappearance of a level (downgrade)

Before change		After change	
Level, m	Frequency	Level, m	Frequency
3	1	3	1
2	3	2	-
1	12	1	15

However, like that of 3A, it is possible that the improvement would apply to only some of the level 2 functions. Unlike 1B, this would account for enough of the functions that their relocation would have a noticeable affect on the original level 2 bundle of functions and thus some of the level 2 centers. As a result, while some of the level 2 centers remain unchanged, the remainders are downgraded to form a new level between level 1 and 2 (3B) to form level 2*. Similar to 3A, the level 2 bundle of functions will supply the level 2 bundle of functions in addition to level 2* and level 1 bundle of functions, while level 2* will only supply the 2* and level 1 bundle of functions. This is further exhibited in table 3.3. Maintaining the previous assumption of the initial system being a Christaller system with $K = 4$, however, after the shift there are fewer level 2 centers on account of some of them having been downgraded to level 2*. Thus, after the change $K_2 = 2$, $K_{2*} = 2$ and $K_1 = 4$ (see table 3.3).

Table 3.3 The formation of a new level (downgrade)

Before change		After change	
Level, m	Frequency	Level, m	Frequency
3	1	3	1
2	3	2	1
1	12	2*	2
		1	8

The two-stage models are, of course, generalizations of a more involved process. As previously noted, the models implemented had three or four levels, while urban systems in reality usually have several more. Similarly, unlike the theoretical models offered in which each case was concerned with the structure before and after a single technological shock, in reality an urban system may be subject to a variety of shocks over a period of time, which could run consecutively or even concurrently. Furthermore, while the models in question may convey the impression of instantaneous change, the transition from one equilibrium to the new equilibrium in reality is anything but instantaneous and usual extends over a period of time. Regardless of the representation of time, the approach of the previously derived models represents essential aspects of change with which countless real life examples can be cited (see Parr, 1981 for such examples as well as for a more extensive review of the previously cited adjustments).

Two types of uniform change were offered, the decentralization (type A), as a consequence of diffusion, and centralization (type B) of activities, both with differing degrees of affect. It is important to highlight that in all the scenarios offered, the number of centers was never subject to change. This, of course, implies that centers never disappear, nor are they created, which in both a practical as well as certain theoretical contexts is unrealistic. It is, however, important to note that the model is able to express such changes. For example, if in scenario 2B the change occurred to functions at level 1 rather than level 2, theoretically, the functions in question would drop to the level below level 1 causing new centers to be developed on greenfield sites. The motivation for emphasizing a system that can only experience changes within itself is two-fold. Firstly, as stated earlier, from a theoretical perspective, without the imposition of such constraints the outcome of such changes would be nearly infinite. And secondly, from a realistic perspective, while new centers have clearly come to bear over time, in most cases the existing infrastructure of a center would likely offer functions certain advantages through existing amenities, i.e. preexisting transportation linkages, suggesting a more favorable option than just that of one based purely on its spatial positioning.

The above models also exhibited the previously noted feature of how a general type of technological change can facilitate both a centralization and decentralization of activities within the urban system. This further confirms the previously offered notion that the type of change is not so much determined by the nature of the shift in technology, but rather the character of the activity that is subject to influence. However, as previously suggested, it would be difficult, if not impossible, to establish a definitive cataloging of which activity's adjust their location accordingly within the urban hierarchy as a result of a shift in technology. This is not only because of the vastness of the different types of activities that exist in the contemporary economy, but any such categorization would be stagnant, and thus to a certain degree misleading as it would constantly be subject to scrutiny as new developments which influence the nature of a given activity's function come to bear. It is worth noting that the simultaneity factor presented earlier, acts as an indicator with which a relative value would indicate an activity's optimal production function relative to the applicable transportation costs, and thus associated market threshold. A shift in the relative values of production costs to that of transportation costs would further imply whether the activity's market threshold would be subject to change, and the nature of that change.

Decentralization as a function of diffusion implies that the necessary market size required to sustain the activity in question has relatively decreased. Diffusion, as explained through the simultaneity factor suggests either an increase in the transportation cost or a decrease in the cost of production. While the former is highly improbable, the latter is possible as implied by the positive relationship between that of the diffusion process and standardization. This can be further exhibited through the previously stipulated mechanisms responsible for the diffusion of a given activity. As previously suggested, diffusion occurs because of a reduction in the marginal cost of production allowing production to be sustained in a smaller market. Assuming transportation costs per unit of distance remains, the simultaneity factor would be of a relatively lower value. The notion of centralization will largely be dealt with in the following sub-section.

3.3.4 The relocation of specialized functions within the urban hierarchy

Unlike a uniform shift, it is impossible to offer a systematic application to evaluate the manner specialized functions influence the spatial structure of the urban system. Like any other activity, specialized functions clearly locate at a given point for a logical set of reasons. However, while those reasons can perhaps be assessed, and insight into the wider implications at the point of location and perhaps urban system can be offered, the activities and thus circumstances are unique and thus generalizations are impossible.

Clearly the relocation of specialized functions influences their respective locales and thus wider urban system. Although centers in the urban hierarchy have been observed as being relatively stable (Eaton and Eckstein, 1997), in a system which experiences continuing economic growth in the form of the appearance of new industries, improvements in transportation, international trade and social change, to name a few, dramatic changes have been known to occur. Medium or even low-level centers have attracted enough specialized activities important in the supply of certain functions that have attracted other central place functions and thus caused a redefinition of the central place hierarchy.

One highly regarded example is the shift from St. Louis to Chicago as the dominant center in the Mid-West after the Civil War, which Duncan and Lieberson (1970) attributed to the consolidation of agricultural processing facilities made possible by the increased capacity of the railway. Or in the UK, where Glasgow replaced Edinburgh during the nineteenth century as the dominant center in Scotland, which could be attributed to a combination of advantages represented by port facilities and relative location to North America and thus international trade, to name a few. As a result, the previously established ship building industry experienced what has been commonly acknowledged as golden age, attracting additional industry and with that economic growth.

The previously cited examples are, however, the exception rather than the rule. As previously noted, centers within an urban hierarchy usual retain their relative importance or change only marginally. For example, in the case of France, eight of the ten largest cities in 1810 were still among the top ten 165 years later, giving an overlap of 80 per cent. For the top 20 cities, the corresponding overlap was 60 per cent. The main changes were the decline of historic regional centers in the Paris Basin (Orleans, Amiens, Caen, Reims) and the rise of cities of specialized in manufacturing (Lens, Valenciennes), tourism (Nice, Cannes), or both (Grenoble). The general impression is therefore one of stability, especially for the largest cities in the system. Paris, Lyon, Bordeaux, Rouen, Marseille and Lille represented the top six centers in descending order in 1810, while in 1975, Rouen had dropped to ninth and Marseille and Lille shifted up to third and forth respectively. Even in a time of great changes in absolute sizes of cities (the combined population of the top twenty cities rose from 1.6 million in 1810 to 18.5 million in 1975), the majority of cities still essentially retained their relative importance within the system (Dupeux, 1981).

The rank stability of large cities is a reflection of the fact that, generally speaking, the attractiveness of a city for new investment is directly proportional to its size. As noted in the review of external economies (see chapter 2), a large city offers several important advantages to potential activities including a relatively larger market, the presence of specialized business and technical services, transportation infrastructure, and public utilities to name a few; allowing such activities to benefit from functions that they would be unable to wholly internalize. The process where a city continually reaffirms its dominance over time by offering an opportune location to specialized functions is referred to by Pred (1966) as cumulative causation.

Clearly, a center whose ranking has been subject to change does not simply disappear. However, its inability to obtain specialized functions and thus the related central place activities, suggests that their relative attractiveness is subject to decline, as conveyed through the reduction of rank. Therefore the relative backdrop of influences contained within each center, which maintained the rank stability of the urban hierarchy, has been reorganized, specifically in those centers that have experienced an adjustment in their ranking.

It has been asserted that the improved ability to interact across space, in conjunction with certain technological advancements in the realm of production has led to the increasingly observed trend of branch production (Gilmour, 1974; Scott, 1987; Scott and Angel, 1987). Depending on the arrangement before the shift in location, branch production, which usually implies a manufacturing activity of some sort (although does not have to), could further suggest a consolidation of a number of activities at a given point in space, or a relocation of an activity that was already consolidated, but most likely originally located in a higher order urban center (Pred, 1977). It could be offered that the logic for the former is that benefits derived from certain economies are greater than the additional transportation costs brought on by the original set of activities shifting further away from their market. In regards to the latter, the logic is the same except for the additional benefits that might be incurred from avoiding certain diseconomies. Thus, as implied through the simultaneity factor, a decline in transportation costs clearly increases the potential market area, further suggesting that the activity in question would be more inclined towards a relocation within the hierarchy than a diffusion

Similar circumstances can be observed as a result of developments in the realm of advanced-telecommunications. For example, given the improved ability with which to communicate across space, functions like that of call or data processing centers have been increasingly observed as relocating in consolidated form to medium- or lower-ordered centers (Richardson and Gillespie, 1996; Bishop et al, 2003). Like that of branch production for manufacturing, benefits derived from certain economies, in addition to perhaps the avoidance of certain diseconomies, are greater than additional transportation costs brought on by the activities locating away from their market.

3.4 Conclusion

The central objective of the current chapter was to review the manner in which activities relocate within the urban system as a result of shifts in technology and how such changes influenced the spatial structure of the urban system. Two general types of change were identified, which were analogous to the two components defined in the previous chapter. The first was a uniform shift, or adjustment of the general structure, while the second was the relocation of a specialized function. Since either type of change could be induced through a reduction in transportation or production costs or both, the determining factor for the type of change brought on was deemed to be the character of the activity in question.

As implied in the final section of the chapter, a relationship between the two types of change is clearly present. Specialized functions have the capacity to redefine the urban hierarchy and thus the spatial structure of the urban system. Conversely, centers within the urban hierarchy are more appropriate for certain specialized functions than others. Thus, it can be further suggested that the types of change are effectively a framework within a framework functioning symbiotically. However, due to the unique nature of specialized functions it is difficult, if not impossible, to define an exact relationship between the two. This is not to say that insights as to the inclination developed urban systems might have towards a particular type of change could not be derived. For example, as conveyed in the final section, the decline of transportation costs could potentially provide certain activities the opportunity with which to derive benefits from certain agglomeration economies. Although only one of the factors responsible for a locational shift is acknowledged, it tends to highlight a shift in favor of the second type of change considered, or a relocation of specialized functions. While this assertion will be further considered in the model presented in chapter 6, it is worth noting that a potentially valuable future research effort could be one that investigates the properties associated with the characteristics associated with an activities' inclination towards diffusion or relocation. Such an effort would not only provide additional insights into the nature of both types of change, but also into prospective changes.

The purpose of identifying the manner in which the activities relocate was to not only highlight the mechanisms that govern change, of which interactions across space is clearly one of them, further validating the central research question, but to also provide a guide with which to model the nature of the changes considered in the analysis. The impending analysis will utilize both types of change to derive a positive explanation as to how improvements in the ability to interact across space as well as the Internet will influence the spatial structure of the urban system. As previously noted, the relationship between the two types of change is not entirely clear, thus the comparative-static models employed in the analysis will consider each type of change independent of one another. However, before the analysis, the following chapter will consider how technological advances in the realm of telecommunications have contributed to the adjustment of one of the fundamental mechanisms governing the locational decision of activities.

4 The ties that bind: A methodical evaluation of the implications of an improvement in the ability to interact across space, with specific reference to advanced-telecommunications

There is little doubt that advances that have occurred during the post-industrial era, as conveyed by Bell (1974), has and will most likely continue to have an influence on interurban form. Such changes can be attributed to a myriad of factors, of which the majority of such factors can be safely categorised under the concept of high technology (Hall and Preston, 1988; Toffler, 1980). A large component of these factors can be further placed under the more specific sub-category of advanced-telecommunications, in other words, the improved ability (of the majority of the population) to communicate with increasing ease across space instantaneously (Hepworth, 1990; Graham and Marvin, 1996). As already suggested in the Introduction, the implications of advanced-telecommunications on the spatial structure of the economy is thought to have a bipolar effect on the location of economic activity, in that it will induce both a centralisation and decentralisation (see Introduction for references), which (as noted previously and will be reaffirmed through a methodical evaluation in this current chapter) is further dependant on the character and nature of the activity in question (Chinitz, 1984; Goddard, 1983; also see chapter 3). Also considered in this current chapter, is the notion of the bi-directional hypothesis, which goes further to comment on the current general trend of structural changes within the urban system as more in terms of a reorganisation of the existing spatial structure than a physical expansion.

The character of such shifts can be further attributed to the changing role of production, which Castells describes the outcome as "*process-oriented,* rather than *product-oriented*" (Castells, 1985 pg. 11 [Castells' emphasis]). These 'processes' can be further characterised by the culmination of transactions between numerous components throughout the production sequence. The distinct activities that involve themselves in such sequences are becoming increasingly spread throughout the urban system (Parr et al, 2002). Thus, such changes force a consideration of the relevance of transactions between the components of production in and across space and their contribution to the structure and character of the urban system. It should, therefore, seem equally crucial that the manner in which these transactions are facilitated, i.e. via advanced-telecommunications, as well as how certain advances in the realm of advanced-telecommunications influence the relative location of the activities involved in this so-called 'process'.

While the location of activities is a thoroughly examined avenue of thought, as conveyed by the abundance of literature relating to location and central place theory (see chapter 2), there is a lack of consideration of transaction costs in economic models, let alone spatial economic models. Transaction costs – the costs of running the economic system – are often assumed away when, in reality, they represent a major impediment, being in many instances an obstacle to the formation of markets. Market failures can potentially occur when transaction costs are so high that the existence of a market is no longer worthwhile from an economic standpoint (Nicol, 1985). Where the costs of operating competitive markets are actually zero, there would be no economic justification whatsoever for the vertical, horizontal or lateral integration of activities. Additionally, and one of the themes of the examination in the following chapter, there are markets that solely facilitate the matching of a buyer and seller (brokers), or more appropriately, the transaction itself. The existence of what are essentially 'information' brokers can be justified in terms of specialization of labor leading to a comparative advantage; however, in a theoretical context where perfect information is assumed, such an occupation would not exist. Thus, economic theory in the past has been inclined towards assuming away what is a fundamental component for the production of goods and services.

In considering the notion of interrelationships in a spatial context, the two overall components of the urban system, as stipulated in chapter 2, are utilized, as well as the reasons as to why the urban system was implemented as a framework. The first is the range of economic activity, the locational pattern of which is governed by the principles of centrality, and which can therefore be approached in terms of central place theory, while the second, involves specialized function activity, the locational pattern of which results from a diverse set of influences.

The second component can be exemplified by location theory as conveyed by Weber (1909/1929), Isard (1956), and Hoover (1937) amongst others, as well as those notions of agglomeration and the closely related attributes of economies of scope, scale and complexity. Such principles of agglomeration, however generally, further suggest the *type of structure* activities are involved in, which further contributes to the analytical framework with which to consider the reasoning and thus motivation for the location of a firm (see chapter 2 for an explanation of economies of scope, scale and complexity). Conversely, the second component also refers to those factors that impact negatively on an activity's production costs, e.g. traffic congestion, which are commonly regarded as diseconomies.

The first component is an acknowledgement that economic activities are located throughout the urban landscape, culminating into what can be commonly regarded as the urban system. As has been previously noted, associations exist between the type of activity and level within the urban hierarchy (see chapter 1). Furthermore, the first component also suggests an interaction of points, or more appropriately, the interaction of activities, which are located at different points throughout the urban system. Therefore, economic activity is located throughout the urban system for reasons that can be attributed to locational attributes, but at the same time, occurs within a wider framework referred to as the urban system.

The two components, of which the latter is perhaps more of a residual, are obviously interrelated, but their relationship is by no means clear. However, while the general concepts of each are considered, their exact relationship is not of central concern and any points of contention, as a result, would not be applicable in this particular context.

Activities, however, by no means relate to their location as well as to one another in a uniform manner. As will be further conveyed through the following model, locational decisions are a result of the nature and character of the activity in question, in that the activity dictates the manner in which it interrelates with other activities. As already suggested, in adapting the manner in which activities interrelate, e.g. through a change in transportation and/or transaction costs, locational attributes at a given point in space would become subject to re-definition.

4.1 The assumptions and structure of the model

In attempting to consider how advanced-telecommunications influences the manner in which activities in the urban system interrelate and thus the implications of advanced-telecommunications on the structure of the urban system, a comparative-static variation of a central place model will be evoked. Variation in the sense that a limited urban system will be the framework of consideration; but as will be observed, several primary notions of the central place theory will be disregarded for the purpose of simplicity.

As conveyed in the earlier chapters, transportation costs of inputs and outputs and transaction costs, in conjunction with an array of one or several agglomeration principles, dictate an activity's optimal location. Thus, by subjecting any of those factors to change, for any number of reasons, an activity's optimal location may also be subject to change and thus the structure of the urban system.

The environment with which the analysis will occur is an urban system in Euclidean space comprised of five points, while uniform in terms of resource availability. It is important to note that the number of points is inconsequential, as the motivation of the analysis is to examine reconsiderations of an activity or activities' optimal location given changes in their production or interactive abilities given a certain framework, which will occur regardless of the number of points. As stipulated in chapter 3, changes in the actual number of points in the system is largely uncommon, further implying that changes will occur within a given structure, therefore the provision of a framework is complimentary.

4.1.1 Assumptions

Within this urban system a single good (α) is produced for a market that exists beyond the realm of the five points ('the other side of the room'). Three types of activities will be assumed as potentially existing within the urban system each being necessary for the production of the single good: manufacturing (*M*), intangible services (*IT*) and tangible services (*T*). The three activities, albeit general, are intended to capture the majority of activities that might be found within an urban system. Intangible services, like that of tradable services conveyed in chapter 3, are meant to represent services that have little or no physical component, i.e. accounting or legal services, and can thus be transmitted via advanced-telecommunications. Tangible services, like that of non-tradable services, are meant to represent services that require the handling of material goods, i.e. repair services or hairdressing. Manufacturing, on the other hand, is meant to represent the physical construction or assembly of commodities, for example, the production of steel or automobiles.

Each activity is subject to variations in terms of the manner in which it interrelates with other activities, the complexity of those interactions and thus cost of interaction across space, as well as potential stages of production. For example, as observed in figure 4.0 (in section 4.2.1), the manufacturing process involves three components (*M1*, *M2* and *M3*). As will be further observed, if more than one stage is necessary for the production of α, details as to the structure of production will be further stipulated in terms of principles of agglomeration.

It is also assumed that activities are initially located at their optimal location, as dictated by basic location theory, which goes further in defining the overall structure of the urban system. However, as the capabilities with which activities interact change, the optimal location of a given activity is also subject to change, once again further altering the structure of the urban system. Thus, while each activity dictates certain characteristics, variations as to the manner in which these characteristics manifest themselves, in terms of their ability to interact across space, will vary according to different assumptions. The majority of these assumptions will be in relation to advanced-telecommunications' ability to transmit information of varying complexities. The final two assumptions of the model are the opportunity to evoke economies of scale where stipulated; and f.o.b. pricing applying to the transportation of tangible goods.

As the framework is subjected to a variety of shocks changes to the original framework potential occur, however the basic logic remains. Intangible and tangible services are assumed as servicing the manufacturing process, while at the same time servicing one another.[8] The arrows in the figures are meant to represent a bundle or set of transaction costs, in that the component in which the arrow is pointing away from is accountable for that given transaction. This is similar to the notion of f.o.b., but without the same concept of movement. However, while the concept of movement does not apply, the notion of distance does; transaction costs are assumed as positively correlated to distance ($d > 1$), unless otherwise stipulated.

[8] It needs to be said that the author is aware of the precarious nature of the assumption that services function for manufacturing. However, given the assumption of one good, which is produced in a manufacturing context and is intended for a market 'on the other side of the room', it would be difficult to justify an interrelationship or alternative relationship.

4.1.2 Structure

Using figure 4.0 to exemplify the previously established notation, all five components can be observed at each of the five points. *M1*, *M2* and *M3* are in a separate box, which is meant to represent an associated process, but on the whole, separate from the services. In other words, the '*M*'s interact between themselves, while each of the services ('*IT*' and '*T*') interact with one another as well as the whole of the manufacturing process. Furthermore, also observed in figure 4.0, is the manufacturing process is involved in an activity complex, or economies of complexity, depending on ownership, a structure that has been established as part of the initial framework. This framework is subject to change, as observed in figure 4.2 (see section 4.2.1) by a different interaction of manufacturing components. As will be further conveyed, the lack of *M1* at points *A*, *B*, *D* and *E* implies that it is acquiring *M1* from *M1**, which further implies that this interaction occurs across space. The purpose of this change in structure is to explore the notion of how the structure of production, and thus interaction of components, reacts in a spatial context when either methods of production or methods of interaction are adjusted. This, of course, is to further justify the relationship between the nature and character of activities influencing the manner of interaction and thus response to changes in the manner of interaction. It is worth noting that while there were three types of agglomeration economies identified in chapter 2, only two have been utilized in the following analysis, these being economies of scale and complexity. The absence of economies of scope is due to the fact that it is effectively a variation of both scale and complexity and is thus implicitly considered. Furthermore, while the analysis is concerned about the details of each component and possible production structure, it is more concerned with deriving a general understanding, which, of course, is consistent with any potential variation of the model, but, due to the infinite potential variations, each possible permutation cannot be explored.

The overall structure of the following analysis will be divided into two major parts. The first part will consider how and why activities agglomerate (section 4.2), followed by the role of advanced-telecommunications in that process (section 4.3). The second part, will consider how and why activities disagglomerate (section 4.4) and the role of advanced-telecommunications in that process (section 4.5, 4.6 and 4.7). The analysis itself will involve the relative assessment of factor constraints facing different activities, which may, or may not, be involved in different structures. Thus, the conclusions are derived from the relative inclination that the activities in question have towards agglomerating or disagglomerating from the established framework.

4.2 The Scenarios (part I)

4.2.1 Scenario 1 – M1 as part of an activity complex (or economy of complexity) going on to benefit from economies of scale.

The first scenario considers a technological shift with respect to process *M1*, allowing its production to be subject to economies of scale (*M1**). Realistically, and as expressed in chapter 3, this could be induced with the introduction of a new machine or managerial method, both of which can be exemplified through countless examples. As observed in figure 4.1, *M1** is located at point *C*, as suggested by the f.o.b pricing assumption. The framework of figure 4.0 and 4.1 clearly convey the factors of consideration, which are the production of the input at the relative locations, the transportation of the input and the transaction costs of the integrating the input into the production of α.

Figure 4.0 'M's involved in an activity-complex

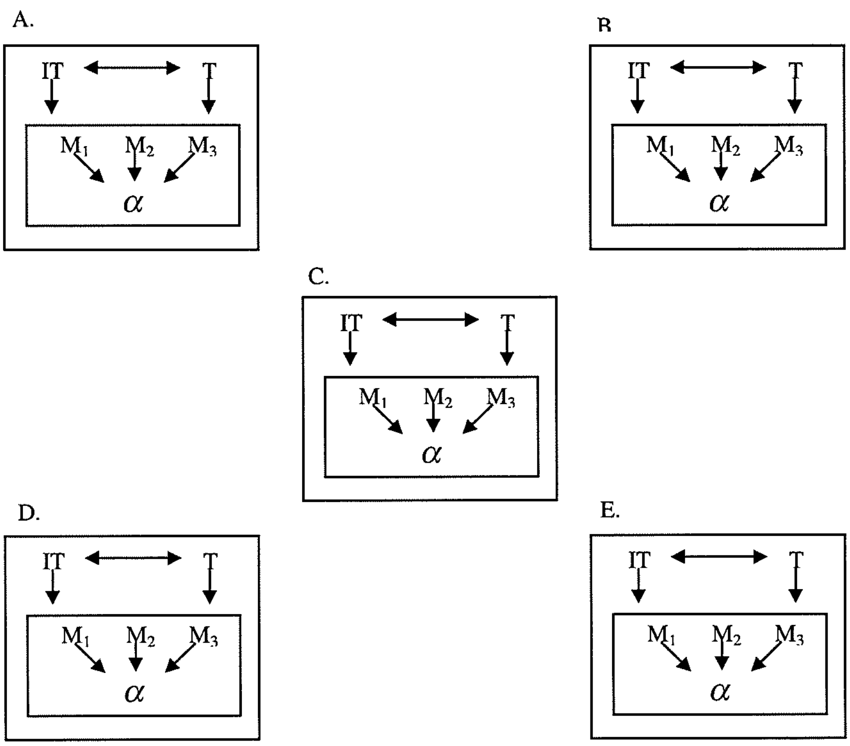
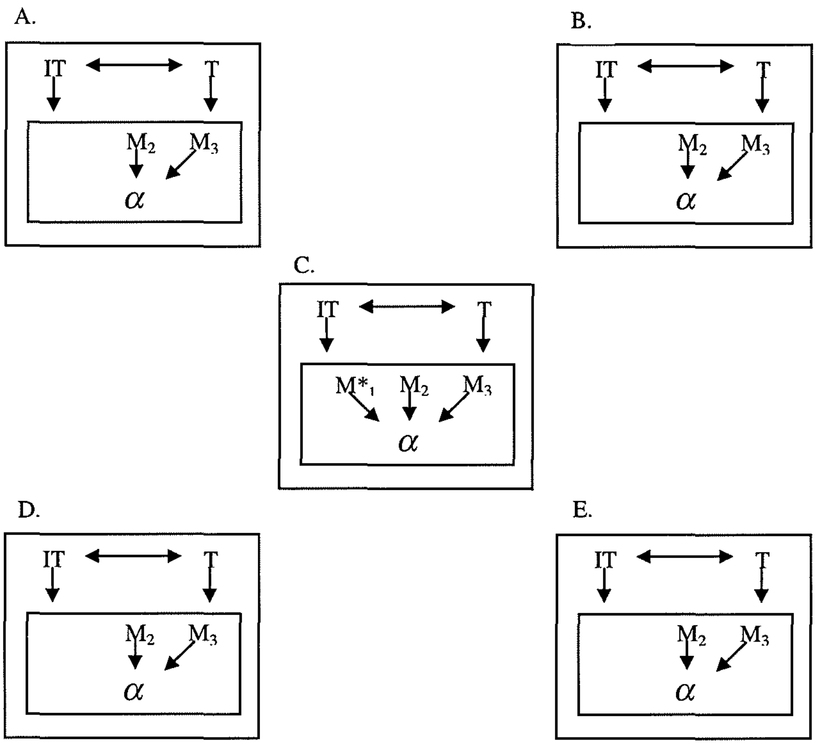
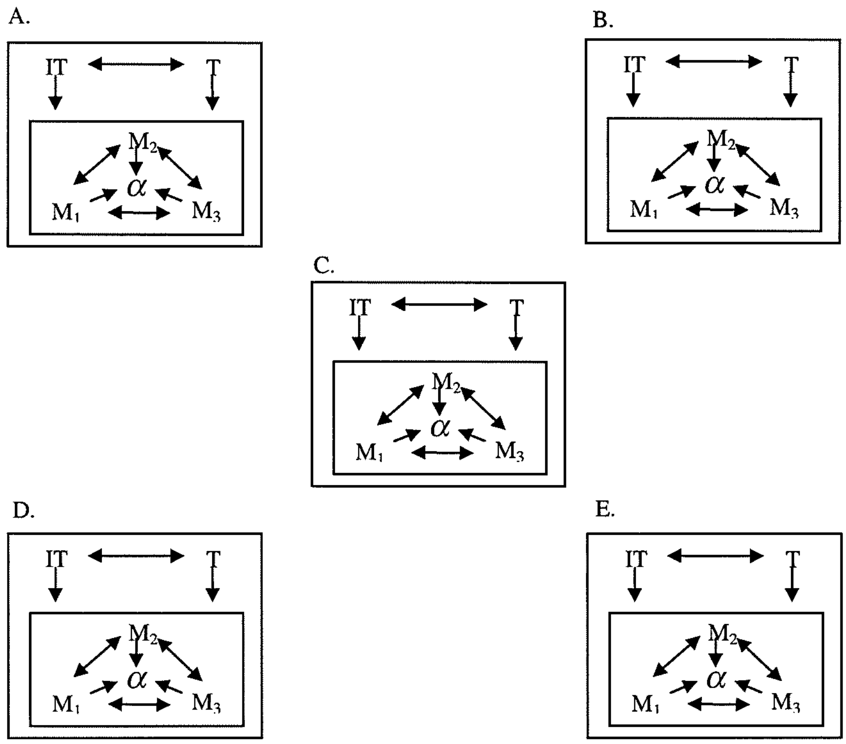


Figure 4.1 'M's involved in an activity-complex, while M1 is subject to economies of scale.



M1, as observed in figure 4.0 by its single arrow, is subject to only one bundle of transactions. This one bundle is a direct by-product of the type of production that *M1* has been deemed to be involved in. The '*M*'s in figure 4.0 are characterised as being part of an activity complex, or economies of complexity, depending on the nature of ownership. However, this is not the only possible configuration for manufacturing activities. For example, figure 4.2 shows the same five components, with the manufacturing components involved in a localisation economies or internal economies of scale, once again, depending on their ownership. In the latter case, as observed in figure 4.2, each of the manufacturing components have two bundles of transactions in addition to being subject to two bundles of transactions as well. Thus, even before methodically evaluating *M1*'s relationship with the other components at the same point and throughout the urban landscape, it is possible to initially conclude that the character of the activity, which further defines the extent of their involvement with other activities influences the nature of its interaction with other activities, and as will be shown later, influences its optimal location.

Figure 4.2 'M's involved in an economy of localization.



As already noted in figure 4.0, *M1* is only subject to a single set of transactions. Therefore, the transaction cost of points *A*, *B*, *D* and *E*'s own *M1* to the assembly of α is the following:

$$[A(M1)B(M1)D(M1)E(M1)] \rightarrow \begin{bmatrix} A(\alpha) \\ B(\alpha) \\ D(\alpha) \\ E(\alpha) \end{bmatrix} = \sigma \qquad (1)$$

In figure 4.1, the cost of transactions for *C*'s *M1* to *A*, *B*, *D* and *E*'s α is the same as the local transaction cost, but as stipulated by one of the central assumptions, is positively correlated to distance (*d*; $d > 1$). Therefore, non-local transaction cost of *C*'s *M1* to *A*, *B*, *D* and *E*'s σ can be defined as '$d \bullet \sigma$'.

The transportation cost of *C*'s *M1* to *A*, *B*, *D* and *E*'s α is the distance (*d*) of *C* to either *A*, *B*, *D* or *E*, which are assumed to be uniform in value, multiplied by the cost of haulage per unit of distance of *M1*:

$$[H(M1)]\begin{bmatrix} A(d) \\ B(d) \\ D(d) \\ E(d) \end{bmatrix} = \beta \qquad (2)$$

The notion of economies of scale automatically implies that the cost of *M1*, purely as an input, is cheaper per unit to produce at point *C* than any of the four points could provide for themselves. For the purpose of analysis, the cost of *M1* produced at *A*, *B*, *D* and *E* is *I*, while the cost of *M1* to be produced at point *C* is I-*x*, *x* being the difference of costs as a result of the new production method.

The total cost of '*M1*➔', at *A*, *B*, *D* and *E*, before the technological shift, or *T*, can be expressed in the following terms:

$$\mathrm{I} + \sigma = \mathrm{T} \qquad (3)$$

The total cost of '*M1*➔', for all points except point *C*, after the technological shock (*T**), can be expressed in the following terms:

$$(\mathrm{I}-\mathrm{x}) + \mathrm{d} \bullet \sigma + \beta = \mathrm{T}^* \qquad (4)$$

As already suggested, the only possible way *M1** would occur is if $T > T^*$ (5). In substituting the third and forth equation into the fifth, it is possible to convey the relationship between the different input costs, transportation costs, and transaction costs at their respective points:

$$I + \sigma > (I - x) + d \bullet \sigma + \beta \qquad (6)$$

Removing '*I*' from both sides of the forth equation

$$\sigma > (-x) + d \bullet \sigma + \beta \qquad (7)$$

or more appropriately,

$$\sigma > d \bullet \sigma + \beta - x \qquad (8)$$

Thus, it becomes apparent that in order for *M1** to occur at point *C*, the transaction cost of local M1 to the respective α's is greater than the transportation cost plus the transaction cost of *C*'s *M1* to any of *A*, *B*, *D* and *E*'s *α*, minus the difference in cost of the respective inputs. This relationship goes further to suggest that the differences in the cost of the respective inputs (x), is greater than the difference between the transaction costs plus transportation costs, as observed in relationship 9.

$$x > (d \bullet \sigma - \sigma) + \beta \qquad (9)$$

In other words, the benefits of *M1* relocating to point *C* have to be greater than the benefits available to *M1* at its original location as well as any additional costs, i.e. non-local transaction costs and transportation costs, that might be incurred through relocation.

4.2.2 Scenario 2 – M1 as part of a localisation economy (economy of scale) while going on to benefit from economies of scale.

M1 as part of a localisation economy or economy of scale, depending on ownership, implies, as observed in figure 4.2 (see section 4.2.1), a greater interaction of components within the manufacturing process; *M1* is subject to three interactions: *M2*, *M3* and the assembly of α. Therefore, the relative transaction costs σ requires reconsideration.

The transaction costs of points *A*, *B*, *D* and *E*'s own *M1* to *M2*, *M3* and α are the following:

$$[A(M1)B(M1)D(M1)E(M1)] \rightarrow \begin{bmatrix} A(\alpha) \\ B(\alpha) \\ D(\alpha) \\ E(\alpha) \end{bmatrix} = \sigma_1 \qquad (1a)$$

$$[A(M1)B(M1)D(M1)E(M1)] \rightarrow \begin{bmatrix} A(M2) \\ B(M2) \\ D(M2) \\ E(M2) \end{bmatrix} = \sigma_2 \qquad (1.1a)$$

$$[A(M1)B(M1)D(M1)E(M1)] \rightarrow \begin{bmatrix} A(M3) \\ B(M3) \\ D(M3) \\ E(M3) \end{bmatrix} = \sigma_3 \qquad (1.2a)$$

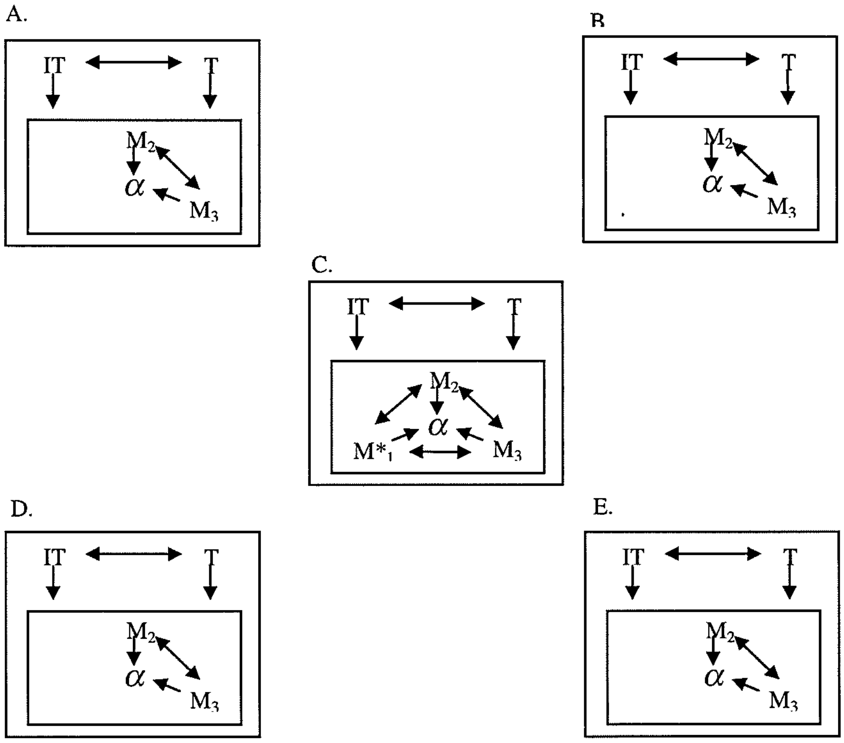
Therefore, the local transaction cost of *M1*, which is a culmination of three transactions, is written as σ^*.

$$\sigma_1 + \sigma_2 + \sigma_3 = \sigma^* \qquad (1.3a)$$

With respect to non-local transactions, the distance factor is applied to the previously derived transaction costs, $d \bullet \sigma^*$. Concerning transportation costs, these are the same as in the previously established relationship (β), and will simply be adopted.

As with the previous scenario, the notion of economies of scale, in that the cost of *M1* purely as an input, suggests that it is cheaper to produce at *C* than at any of the four points. Thus, the notation of '*I*' being the local production cost of *M1*, while *I-x* is the cost of *M1*'s production at point *C* (*M1**) still applies (figure 4.3).

Figure 4.3 'M's involved in an economy of localization., while M1 is subject to economies of scale



The input costs at the respective locations are the same as those derived in the previous scenario (relationship 3 and 4), but with the appropriate transaction costs substituted. Thus, relationship 3 and 4 can be re-written as the following:

$$I + \sigma^* = T \qquad (3a)$$

$$(I - x) + d \bullet \sigma^* + \beta = T^* \qquad (4a)$$

As already suggested, the only possible way *M1** occurs is if the previously noted fundamental relationship $T > T^*$ (5) holds.

$$I + \sigma^* > (I - x) + d \bullet \sigma^* + \beta \qquad (6a)$$

Removing '*I*' from both sides of equation 6a leaves

$$\sigma^* > (-x) + d \bullet \sigma^* + \beta \qquad (7a)$$

or more appropriately,

$$\sigma^* > d \bullet \sigma^* + \beta - x \qquad (8a)$$

As the only difference between this scenario and the previous one is in terms of $\sigma \rightarrow \sigma^*$ and thus $d \bullet \sigma \rightarrow d \bullet \sigma^*$, it is once again apparent that in order for *M1** to occur at point *C*, the local transaction costs of *M1* have to be greater than the transportation cost plus the transaction cost of *C*'s *M1* to any of *A*, *B*, *D* and *E*'s *M2*, *M3* and α, minus the difference in the cost of the respective inputs. The relationship goes further, suggesting that the differences in the cost of the respective inputs (*x*), is greater than the difference between the transaction costs plus transportation costs, as expressed by relationship 9a.

$$x > (d \bullet \sigma^* - \sigma^*) + \beta \qquad (9a)$$

4.2.3 A comparison between scenario 1 and 2 and some general comments (an interlude)

The second scenario, which is essentially a recreation of the first scenario, is of little consequence, considering the trivial difference in the relationships under consideration. Rather, as already stated, the objective of the exercise is to show how different activities have different optimal locations due to their character which further dictates the manner in which they interrelate with other activities throughout the urban landscape. Relationships 8 and 8a similarly suggest what is required for *M1* to relocate from *A*, *B*, *D* and *E* to point *C*. This is, of course, conveyed through the relative values of the right and left side. However, in comparing the right and left side of relationship 8 and 8a to one another (relationship 10 and 11) it is possible to suggest the relative flexibility, with respect to redefining the location of *M1* as follows:

$$d \bullet \sigma^* + \beta - x > d \bullet \sigma + \beta - x \qquad (10)$$

$$\sigma^* > \sigma \qquad (11)$$

Under the assumption that a unit of transportation and a bundle of transaction costs are equal, in both 10 and 11, relationship 8a is greater than 8. This would suggest that the *M1* in figure 4.0, which is subject to an activity complex (or economy of complexity), is less inclined to redefine its optimal location than the *M1* in figure 4.2, which is subject to an economy of localisation (or economy of scale). Thus, the activity's character, which further dictates the nature of interaction with other activities, further influences its optimal location, and thus the structure of the urban system.

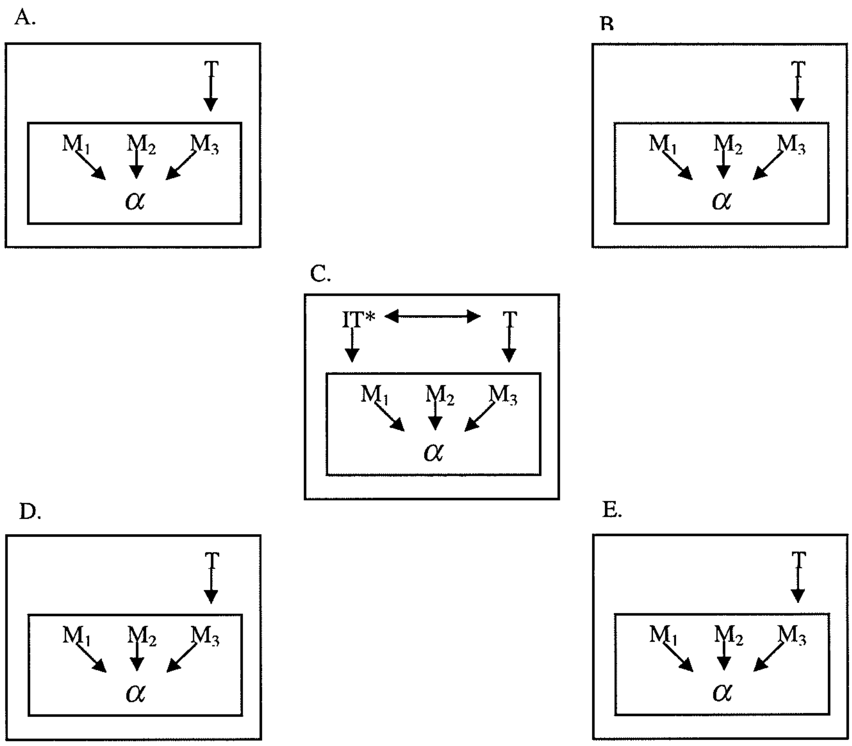
However, it should be further stipulated that this in no way suggests that components involved in an economy of complexity are always less inclined to redefine its optimal location than a component involved in an economy of scale. Rather, the essential point that should be drawn from the two previous scenarios is that some activities have stronger ties to their given location than others. These 'ties that bind' are a result of the components activity-type, which further defines the manner in which that activity interrelates with its location and other activities it is involved with. In changing the character of production the manner in which *M1* interrelate with other components become subject to question.

As will be exemplified later, the manner in which activities interrelate is facilitated by the available technology. Thus, technology that changes an activity's character or nature, or the means by which it interacts will also potentially redefine its location; the specific technology of particular interest being, of course, advanced-telecommunications. However, before applying the notion of advanced-telecommunications to the derived relationships, the remaining activity types will be considered, which involves the possible relocation of the service type activities. The first component of consideration is '*IT*' or intangible services, while the framework of consideration will be figure 4.0. As observed in figure 4.0, '*IT*' is subject to two transactions, one to '*T*', tangible services and the other to the whole of the manufacturing process (*M1*, *M2* and *M3*), which for purposes of notation will be referred to as *M*. As with the two prior scenarios, '*IT*' is subject to a technological shock, providing it with the opportunity to benefit from economies of scale.

4.2.4 Scenario 3 – 'IT' subject to economies of scale.

Similar to the previously derived scenarios, the notion of economies of scale automatically suggests that the cost of *IT*, as an input, is cheaper to produce at point *C* than any of the four points could provide for themselves (see figure 4.4).

Figure 4.4 'IT' is subject to economies of scale



Maintaining the same notation, the cost of producing '*IT*' locally is '*I*', while the cost of producing '*IT*' at point *C*, which will be referred to as *IT**, is *I-x*, *x* being the savings derived through the new production method. Local transaction costs are the following:

$$[A(IT)B(IT)D(IT)E(IT)] \rightarrow \begin{bmatrix} A(T) \\ B(T) \\ D(T) \\ E(T) \end{bmatrix} = \sigma_1 \qquad (1b)$$

$$[A(IT)B(IT)D(IT)E(IT)] \rightarrow \begin{bmatrix} A(M) \\ B(M) \\ D(M) \\ E(M) \end{bmatrix} = \sigma_2 \qquad (1.1b)$$

This can be further expressed in terms of

$$\sigma_1 + \sigma_2 = \sigma^{**} \qquad (1.3b)$$

Non-local transactions, which are subject to additional costs due to the distance factor are $d \bullet \sigma^{**}$.

Therefore, the total cost of '*IT*➔', for points *A*, *B*, *D* and *E* after the technological shock (T^*), can be expressed in the following terms:

$$(I-x) + d \bullet \sigma^{**} + \beta = T^* \qquad (4b)$$

'*IT*' before the technological shock, or *T*, is expressed in the following terms:

$$I + \sigma^{**} = T \qquad (3b)$$

It should be noted, however, that 3b and 4b are the exact same as relationships 3 and 4, with the exception of the newly derived local and non-local transaction costs inputted accordingly.

The fifth equation ($T > T^*$), or the prerequisite for IT^* to occur is thus the following:

$$I + \sigma^{**} > (I-x) + d \bullet \sigma^{**} + \beta \qquad (6b)$$

In removing '*I*' from both sides of equation 6b

$$\sigma^{**} > (-x) + d \bullet \sigma^{**} + \beta \qquad (7b)$$

or more appropriately,

$$\sigma^{**} > d \bullet \sigma^{**} + \beta - x \qquad (8b)$$

Thus, the difference between 8b and both 8 and 8a, is that *IT* is subject to two transaction costs, while 8b is subject to three and 8a to one.

Based on the assumption that transaction costs are only a function of distance as well as sets, which are equal regardless of the activity they are intended to represent, it can be concluded that the right side of 8a (*M1* as part of a localisation economy) is greater than the right side of both 8b (*IT*) and 8 (*M1* as part of an activity-complex).

$$d \bullet \sigma^{**} - x + \beta < d \bullet \sigma^{*} + \beta - x \quad (10b)$$

$$d \bullet \sigma + \beta - x < d \bullet \sigma^{*} + \beta - x \quad (11b)$$

With respect to 8b and 8, since 8b has one more transaction cost than 8, it can be concluded that 8b is greater than 8, further suggesting that '*IT*', in the given context, is more locationally flexible than M1 when involved in an activity complex, but less flexible than *M1* when it is involved in an localisation economy.

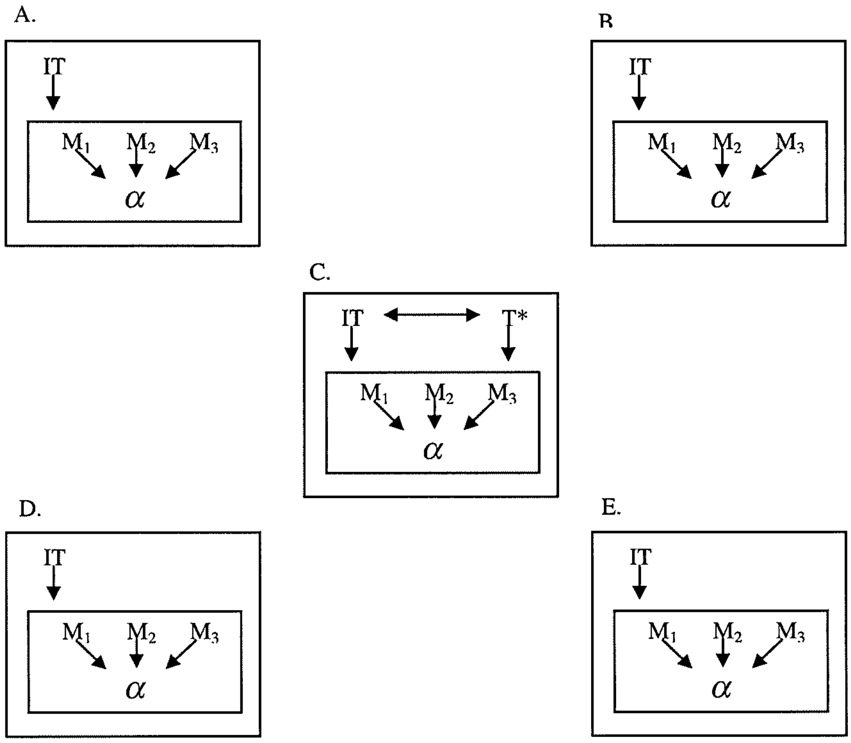
$$(d \bullet \sigma + \beta) - x < d \bullet \sigma^{**} - x + \beta < (d \bullet \sigma^{*} + \beta) - x$$

4.2.5 Scenario 4 – 'T' subject to economies of scale.

The final scenario of consideration, before applying the notion of advanced-telecommunications to the previously derived understandings, is that of '*T*' or tangible services being subject to economies of scale (see figure 4.5). Similarly to '*IT*', '*T*' is subject to only two transactions, '*IT*' and the whole of the manufacturing process.

Thus, while a different type of activity, the number of sets of transactions are the same as those derived in the scenario that considered '*IT*' (σ^{**} and $d \bullet \sigma^{**}$), as with transportation costs (β) as well as respective input costs ('*I*' and '*I-x*'). Thus, due to the identical notation, it is possible to simply state the relative input costs facing '*T*' at each of its potential locations, as it relates to relationship 5.

Figure 4.5 'T' is subject to economies of scale



$$I + \sigma^{**} > (I-x) + d\bullet\sigma^{**} + \beta \tag{6c}$$

Removing 'I' from both sides of equation 6c

$$\sigma^{**} > (-x) + d\bullet\sigma^{**} + \beta \tag{7c}$$

or more appropriately,

$$\sigma^{**} > d\bullet\sigma^{**} + \beta - x \tag{8c}$$

The relationship suggested by equation 8c, is similar to that of 8b, 8a and 8 in that in order for the variable in question (*T**) to occur in consolidated form at point *C*, the transaction costs and transportation costs of point *C*'s '*T*' to any of *A*, *B*, *D* and *E*'s '*IT*' and manufacturing components, minus the difference in cost of the respective inputs. This, of course, goes further to suggest that the difference in the cost of the respective inputs (*x*), is greater than the difference between the transaction costs plus transportation costs.

4.2.6. A comparison and consideration of the four prior scenarios

Thus, the four relationships of the four activities have been established, and are as follows:

$$\sigma > d \bullet \sigma + \beta - x \quad (8)$$

$$\sigma^* > d \bullet \sigma^* + \beta - x \quad (8a)$$

$$\sigma^{**} > d \bullet \sigma^{**} + \beta - x \quad (8b)$$

$$\sigma^{**} > d \bullet \sigma^{**} + \beta - x \quad (8c)$$

On the outset, given the initial assumptions, it is possible to prioritise the relative locational flexibility of all the activities in question. The right side of 8a (*M1* as part of an economy of localisation) has the least flexibility, followed by 8b and 8c (*IT* and *T*, respectively), which are of equal value, and then finally 8 (*M1* as part of an activity complex).

$$d \bullet \sigma^* + \beta - x \text{ (8a)} > d \bullet \sigma^{**} + \beta - x \text{ (8b)} = d \bullet \sigma^{**} + \beta - x \text{ (8c)} > d \bullet \sigma + \beta - x \text{ (8)} \quad (8z)$$

This is not to say that manufacturing, as part of an economy of localisation, will always be more locationally flexible than other types of manufacturing or any type of service. Similarly, transaction costs between different types of activities will no doubt vary (a point that will be considered in the following scenarios), and as implied by the previously derived relationships will potentially influence the locational flexibility of certain components, relative or otherwise. Rather, although a vast simplification of actual events, the point of the initial exercise was to suggest that even with identical structures different components within the chain of production interrelate differently and the number and nature of such interrelationships, upon subject to change and given certain levels of technology, can further influence an activity's optimal location.

4.3 The role of advanced-telecommunications with regards to the previously derived scenarios

While benefits of a change of production techniques (x) has been shown to induce a re-evaluation of optimal location, and thus structural change (which are potentially characterized by the nature of their interaction with other activities/components) it has yet to be considered how technological shocks further influence the very nature in which activities interrelate. As already noted, the previously established relationships (8, 8a, 8b and 8c) contain three other variables (σ, d and β), all which are potentially subject to change through technological shocks. Transportation costs (β), which was applied in all of the previously derived relationships, is not only subject to change through advances in technology, but with the advent of advanced-telecommunications, transportation costs of certain activities could be subject to removal. Similarly with transaction costs, advanced-telecommunications' ability to transmit increasingly complex forms of information may provide activities the opportunity to communicate across space unimpeded, thus potentially absolving the distance factor (d).

However, before considering how and why transaction costs are subject to change through the advent of advanced-telecommunications, a consideration of how advanced-telecommunications stand to influence transportation costs of different activities will be offered. The first scenario will apply the assumption that '*IT*' and '*T*' will no longer be subject to transportation costs. The logic of such an assumption is that advanced-telecommunications would be able to transmit inputs across space at no additional marginal cost. However, such an assumption is mildly presumptuous in that the very nature of tangible services suggests that some kind of locational restraint is present. Thus, the second scenario will thus only consider '*IT*' as being free of transportation costs.

4.3.1 Scenario 1 – No transportation costs for 'IT' and 'T'

The following is a re-evaluation of the previously derived fundamental relationships in accordance with '*IT*' and '*T*' no longer being subject to transportation costs. Note, that transportation costs (β) have been removed from both equation 8b and 8c and renamed 8.1b and 8.1c, respectively. They, of course, remain identical, as the manner in which they interrelate changed and not the structure with which they are situated in.

$$\sigma > d \bullet \sigma + \beta - x \quad (8.1)$$

$$\sigma^* > d \bullet \sigma^* + \beta - x \quad (8.1a)$$

$$\sigma^{**} > d \bullet \sigma^{**} - x \quad (8.1b)$$

$$\sigma^{**} > d \bullet \sigma^{**} - x \quad (8.1c)$$

As a result, the relationship conveyed in 8z potentially remains.

$$d \bullet \sigma^* + \beta - x \text{ (8.1a)} > d \bullet \sigma^{**} - x \text{ (8.1b)} = d \bullet \sigma^{**} - x \text{ (8.1c)} > d \bullet \sigma + \beta - x \text{ (8.1)} \quad (8.1z)$$

However, this entirely depends on the relative values of β and σ, in addition to the value of *d*. For example, assuming '*d*' was a value of one and $\beta > \sigma$, than it could be concluded that '*IT*' and '*T*' relocate more readily than *M1*, as part of an activity complex (8y); if it was vice versa ($\beta < \sigma$), than *M1* would relocate more readily (8z).

$$d \bullet \sigma^{*} + \beta - x \ (8.1a) > d \bullet \sigma + \beta - x \ (8.1) > d \bullet \sigma^{**} - x \ (8.1b) = d \bullet \sigma^{**} - x \ (8.1c) \qquad (8y)$$

4.3.2 Scenario 2 – No transportation costs for 'IT'

The following is a re-evaluation of the previously derived fundamental relationships in accordance with the single assumption of '*IT*' no longer being subject to transportation costs.

$$\sigma > d \bullet \sigma + \beta - x \qquad (8.2)$$

$$\sigma^{*} > d \bullet \sigma^{*} + \beta - x \qquad (8.2a)$$

$$\sigma^{**} > d \bullet \sigma^{**} - x \qquad (8.2b)$$

$$\sigma^{**} > d \bullet \sigma^{**} + \beta - x \qquad (8.2c)$$

As can be observed in the above relationships, 8.2b is the only relationship of the four that does not have a β term. As a result, '*T*' is definitely less locationally flexible than '*IT*', which is to be expected, considering that 8.2b is now subject to an additional cost. However, because β and σ's relative values are undefined a similar situation observed in previous scenario occurs again, but this time it is only between 8.2 (*M1* in an activity complex) and 8.2c (*IT*). Assuming 'd' was a value of one and $\beta > \sigma$, than it could be concluded that '*IT*' relocates more readily than *M1*, as part of an activity complex (8x); if it was vice versa ($\beta < \sigma$), than *M1* would relocate more readily (8w).

$$d\bullet\sigma^* + \beta - x\ (8.2a) > d\bullet\sigma^{**} + \beta - x\ (8.2b) > d\bullet\sigma^{**} - x\ (8.2c) > d\bullet\sigma + \beta - x\ (8.2)\ (8x)$$

$$d\bullet\sigma^* + \beta - x\ (8.2a) > d\bullet\sigma^{**} + \beta - x\ (8.2b) > d\bullet\sigma + \beta - x\ (8.2) > d\bullet\sigma^{**} - x\ (8.2c)(8w)$$

4.3.3 Some general comments

The observed re-assessment, as a result of the application of advanced-telecommunications, is also representative of advanced-telecommunications potential impact on an activity's optimal location. However, in employing the notion offered by equation 9 ($x > (d\bullet\sigma - \sigma) + \beta$), it could be further suggested that the benefits incurred by, in the case of economies of scale, do not have to be as large because the costs of interacting across space is less due to the absence of the β term.

Thus, if '*x*' is treated in terms of a benefit, rather than simply a benefit from economies of scale or an activity complex, but as a benefit from agglomeration, a reasonable assertion may be one that suggests that certain intangible activities agglomerate because their potential costs of interacting are lower and thus the benefits from agglomeration can also be lower.

However, while this may offer insight into why certain services have been observed as agglomerating in higher order urban centres,[9] it is only a partial explanation. As conveyed by the bi-direction hypothesis, the relationship has been observed as not linear, in that activities simply evolve towards agglomeration, but agglomeration and disagglomeration occur simultaneously. As will be exhibited after the consideration of how advanced-telecommunications influences location through transaction costs, disagglomeration, like agglomeration, is very much related to the character of the activity and the manner in which that activity interrelates with other activities, which work simultaneously on the overall urban structure.

4.3.4 Scenario 1 – Advanced-telecommunications has unlimited influence

The next scenario to be considered in this section will be the complete removal of the distance factor (*d*) from the previously derived relationships (relationship 8.2, 8.2a, 8.2b and 8.2c). The logic behind this assumption is that advanced-telecommunications is capable of facilitating any interaction, beyond that of the physical movement of tangible goods (β). The by-product of such an assumption, however, is the forced removal of transport costs of intangible services (*IT*), which would most likely also benefit from the superior capabilities of advanced-telecommunications. For reasons stated in the previous section, advanced-telecommunications will have no affect on tangible service's transportation costs. The following scenario involves the application of relative transaction costs in addition to the removal of the distance factor. The purpose of relative transaction costs is an attempt to capture the notion that (a) transaction costs vary in terms of activity type and (b) that all types of information are not transmitted at an equal cost.

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[9] This is in specific reference to the disproportionate amount of F.I.R.E services located at the highest order urban centres in developed economies (Feagin and Smith, 1987).

The point of departure for the first scenario is the result of scenario 2 in section, 'advanced-telecommunications and transportation costs (*β*)'. As already noted, the first scenario in this section stipulates the complete removal of '*d*', in conjunction with '*IT*' not being subject to transportation costs. As observed below, 8.2b is the only relationship of the four relationships that does not have a transportation variable.

$\sigma > d \bullet \sigma + \beta - x$ (8.2)

$\sigma^* > d \bullet \sigma^* + \beta - x$ (8.2a)

$\sigma^{**} > d \bullet \sigma^{**} - x$ (8.2b)

$\sigma^{**} > d \bullet \sigma^{**} + \beta - x$ (8.2c)

Removing the distance factor the results in the above relationships are reworked accordingly:

$\sigma > \sigma + \beta - x$ (8.3)

$\sigma^* > \sigma^* + \beta - x$ (8.3a)

$\sigma^{**} > \sigma^{**} - x$ (8.3b)

$\sigma^{**} > \sigma^{**} + \beta - x$ (8.3c)

As observed in 8.3, 8.3a, 8.3b and 8.3c all activities in the derived urban system become more locationally flexible. In fact, with respect to 8.3, 8.3a and 8.3c relocation would occur as so long as the benefits from economies of scale were greater than potential transport costs ($x > \beta$). With respect to 8.3b, intangible services, as so long benefits from economies of scale occurred, relocation would also occur. However, it is important to note that relative location flexibility has not changed. While this is no surprise, considering that the removal of the distance factor occurred uniformly, it does highlight the validity of the model, in that the removal of '*d*' could be representative of a general technological shift across the whole of the economy.

4.3.5 Scenario 2 – Advanced-telecommunications has limited influence in addition to potential variations of transaction costs

However, as already noted, transaction costs (σ), as they relate to different types of activities, can vary substantially beyond that of simply distance (d). Certain interactions can be quite complex and thus costly, and in context to the previously derived understanding, would further suggest that a component may be less inclined to relocate. Furthermore, in a particular context, it would be fair to assume that transaction costs reduce over time; as components interrelate more often their paths of communication become more familiar and thus less costly. Thus, there is no reason to think that all transaction costs remain at the same cost all of the time.

In attempting to further explore the implications of varied transaction costs, a hierarchy of values will be assigned to the different types of interactions and thus transaction costs and then applied to the right hand side of the previously established relationships 8.3, 8.3a, 8.3b and 8.3c. Two hierarchies in all will be applied, both of which will be based on the relative status of intangible services. The first hierarchy will consider a reality where intangible services can be transmitted across space with the least cost and, most importantly, are able to integrate into the process of production with the least cost as well. The second most costly transaction type will be deemed as manufacturing, followed by tangible services.

$\sigma^M = \sigma^* = \sigma$

$\sigma^T = \sigma^{**}$ (of 8.3c)

$\sigma^{IT} = \sigma^{**}$ (of 8.3b)

$\sigma^T > \sigma^M > \sigma^{IT}$ (relationship 1)

The second hierarchy of consideration will deem intangible service transactions to be so complex that they are the most costly of the three. The next costly will be manufacturing, followed by tangible services. The logic behind reversing the relative value of transaction costs of tangible services and manufacturing is to depict the relationship between those two specific types of activities.

$\sigma^{IT} > \sigma^M > \sigma^T$ (relationship 2)

Unsurprisingly, the result of the first hierarchy (relationship 1) is that '*IT*' has the potential of being the least flexible of all activity types, following by '*T*' and than '*M*'. Similarly with the second hierarchy (relationship 2), 'IT' is the most flexible, '*M*' being the second most flexible and then '*T*', the least flexible. Thus, given the previously derived relationships (8.3, 8.3a, 8.3b and 8.3c), variations in transaction costs, as a result, the character of activity can have additional implications on an activities optimal location and the re-defining of that location.

4.4 Agglomeration to disagglomeration

Having considered the role of advanced-telecommunications as a force for agglomeration, the purpose of this next section is to further explore what has been deemed as the second half of the bi-directional hypothesis; decentralization, or disagglomeration. As observed in the previous section, agglomeration occurred for two basic reasons, both of which were further defined by the nature and character of the activity in question which determined both the type of structure with which the activity was involved in, i.e. the number of interactions, as well as the character of those interactions and thus the manner in which it interacted i.e. via advanced-telecommunications. In accordance with elements considered in chapter 3, the two basic reasons for agglomeration were (a) a new method of production created enough of a benefit to cover any additional transportation or transaction costs that would be incurred through the relocation of production so as to generate such benefits and (b) benefits created by the new method of production were further complimented by advances related to the manner in which components interrelate. However, due to the differing nature of activity, agglomeration was a question of relative locational flexibility in that all activities would and could agglomerate given the appropriate circumstances, but that some were more inclined than others as a result of their character.

Disagglomeration, as will be exemplified, follows a similar set of principles. Like that of agglomeration, relocation only occurs if potential benefits at an alternative location outweigh those at the present location, which is further complimented by advances in the manner in which components interrelate. Thus, assuming the benefits outweigh the costs, any activity can potentially disagglomerate. However, as already noted with respect to agglomeration, all activities are not equally inclined towards disagglomeration. Such relative inclinations, as with agglomeration, are determined by the activity itself, and the nature and character of that activity which further defines the structure with which it is involved, and number and type of interactions it is accountable for.

The structure of this section is similar to that of the previous section, in that different activities existing in different structures will be considered in a series of comparative-static scenarios. However, unlike in the previous section, a shift in production is not the catalyst for relocation; disagglomeration as a result of diffusion will be the subject of consideration in the following chapter. Regardless, before the scenarios can be derived, additional assumptions, necessary for the functioning of the model have to be presented and justified. The initial framework, or point of departure, which is slightly different than the previous sections, also requires stipulation, and will follow the presentation of the assumptions.

Like that of section C, four scenarios in total will be offered. Two of the scenarios will consider the relocation of a manufacturing (*M*) component, of which each are involved in a unique structure, while two will consider the relocation of an intangible (*IT*) component. Thus, not only are the different types of activities in the framework subject to consideration, but structures are as well. After having derived the respective relationships for the requirements of relocation, aspects of the relationships will be compared and contrasted, like that of the previous section, so as to establish a sense of relative location flexibility as it pertains to the factors in question. The first set of comparisons will focus on the relevance of structure, i.e. activity complex or economy of localisation. The next series of comparisons will consider how the nature and character of the activities potentially influence the urban system's structure through the activities' relative inclination towards disagglomeration.

4.4.1 The assumptions

The primary aim of this effort is to examine the role of advanced-telecommunications in shaping the spatial structure of the urban system, which has been implied in the previous section as accentuating existing relationships. As observed in the previous section, centralization occurred as a result of a shift in production, which advanced-telecommunications further complimented. Decentralization could occur through a shift in production; as will be exhibited in the following chapter benefits from improvements in the production process could indeed cover the additional transaction and transportation costs necessary for the decentralization. However, what is to say that given a shift in production additional benefits exist only beyond the original location? In regards to the previous section, *M1** (see figure 4.1) could have located at a point other than C, but that would have been contrary to the f.o.b. pricing assumption, which further supported the consolidation of *M1* production at point C. Thus, it was not a shift in production alone that induced the relocation, but a shift in production in conjunction with the principles of centrality.

However, at the same time, activities within the urban system are not in a perpetual state of agglomeration, if so it could be suggested that the urban system is potentially gravitating towards a single centre. As has been noted throughout the course of this effort, activities exhibit both a tendency to agglomerate as well as disagglomerate. Therefore, in attempting to derive assumptions, which account for both forces, four assumptions, in addition to those already established, will be offered. The first three allow for the presence of positive externalities, while the forth subjects points in space to negative externalities. The first two assumptions are (1) the presence of positive externalities within individual sectors and (2) the presence of positive externalities across sectors, also know as Hooverian and Marshallian agglomeration (see chapter 3), respectively. Both assumption 1 and 2 represent what is commonly referred to as 'benefits from agglomeration' and will be identified as '*BFA*'. The third assumption is a variation of the first two in that it is an attempt to accommodate the notion that benefits beyond an agglomeration may exist. As noted in chapter 2, large urban centres can be characterized by relatively higher land prices, labour costs, etc, compared to that of more remote centres. Much like *BFA*, the third assumption is a benefit and reduces or restrains aggregate costs, thus it will be referred to as 'alternative advantages' or '*AA*'. The fourth and final assumption is the implementation of diseconomies (*D*), or dispersion forces. It is important, at this point, to note that it is possible to consider the first two assumptions and the fourth assumption in unison, resulting in what is commonly referred to as 'net agglomeration' forces (*NA*). Thus, both '*D*' and '*BFA*' could be treated separately, or as one, '*NA*', which will be stipulated accordingly.

However, it is important to further clarify the potentially different relationships between diseconomies (*D*) and benefits from agglomeration (*BFA*). As already noted, '*BFA*', like that of '*AA*' are forces that exist at a particular point which offer benefits to production that either restrain or reduce costs. Diseconomies, on the other hand, although not usually a direct additional cost, such factors that qualify as diseconomies tend to create additional costs or diminish the potential savings from cost saving devices. Thus, like that of transaction or transportation costs, diseconomies are a positive value, while *BFA* and/or *AA* are negative values. The relationship between *D* and *BFA* is further indicated through the value of *NA*, which, as previously suggested, is the direct result of *D* and *BFA*. It can, therefore, be further determined that when considering a specific activity in a given context the value of *NA* would indicate whether the component in question was in a favourable, in which *NA* would be negative ($BFA > D$), or an unfavourable environment where *NA* was positive ($BFA < D$).

The value of *NA*, when placed in context to relocation, is able to offer further insight into potential 'push' and 'pull' forces acting on the activity in question. For example, if *NA* was negative ($BFA > D$) and relocation occurred it could be concluded that the activity in question was 'pulled' from its original location. If, on the other hand, *NA* was positive ($BFA < D$) and relocation occurred, it could be concluded that the activity in question, while potentially 'pulled' was also 'pushed' from its original location.

The final point that needs to be addressed before continuing on to the 'The Model and its logic (part II)' is an acknowledgement of the relationship between the newly derived assumptions and those relationships established in the previous section. Although the notion of '*D*', '*BFA*' and '*AA*' were not explicitly acknowledged in terms of the notation used in this section, it could be suggested that the newly derived assumptions were partially included implicitly via the 'x' variable. The 'x' variable, which represented benefits, or the reduction in the cost of inputs as a result of a shift in production through benefit from economies of scale, as noted in the previous section, could in fact have represented a benefit from a variety of sources. As stipulated in agglomeration literature, economies of scale are one of the several benefits that fall within the realm of agglomeration (*BFA*). Thus, not only were the previously considered models more versatile, but positive externalities, although not mentioned out right, could be deemed as present. Diseconomies (*D*) on the other hand, were also not acknowledged in any way, but it could also be suggested were similarly present, although in a limited capacity, since '*x*' was always assumed to as negative.

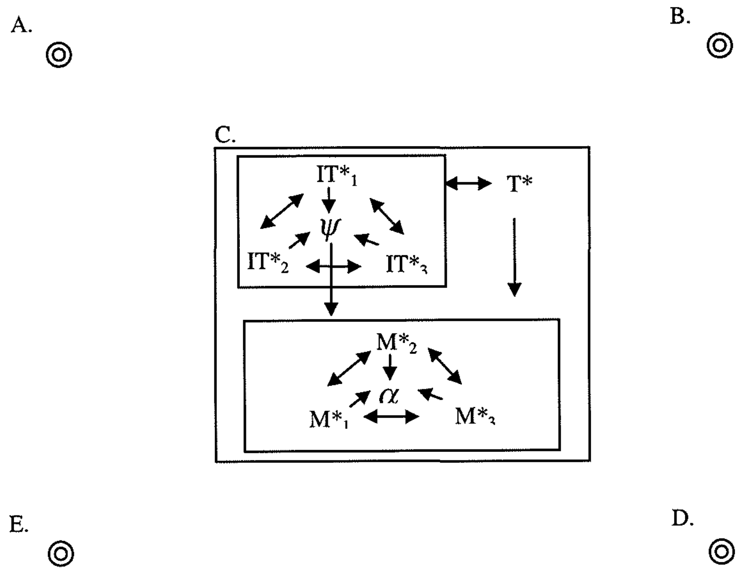
However, as a result of relating '*x*' to the newly derived assumptions, it is important to acknowledge its potential variableness. If '*x*' could potentially represent different types of benefits than it would be fair to suggest that '*x*' would not be of an equal value for all activities. While it was determined that activities exhibited different inclinations towards relocation, '*x*' was held constant and was thus not one of the defining factors, because the manner in which activities interrelated was of primary concern. It is thus important to highlight that since '*x*' is a relative value it would invariably further influence the relative locational flexibility of activities within the urban system and thus have even further implications on the spatial structure of the urban system. Regardless, the above terms could have been integrated into the previous sections, but for the purpose of simplicity were not.

4.4.2 The Model and its logic (part II)

Like that of the analysis in the following chapter, this section represents a point of departure, which is significant because the environment with which activities respond to technological shocks highly influences the response of the activity in question. Nowhere is this exemplified better than in the previous section where the initial framework was five uniform points of equal status situated in Euclidian space (see figure 4.0). It is obvious that an examination of the intra-urban agglomeration of activities could not be achieved through the consideration of any one of the points in isolation, suggesting that a suitable framework required at least two or more points. Thus, like that of the initial framework of the previous section that provided the opportunity for activities to agglomerate, the initial framework in this section, has to provide the opportunity for activities to disagglomerate.

Two initial points of departure will be utilized, both which can be further characterized as growth poles (Perroux, 1950), in that all the activity within the urban system are located at the central point (point C). The first, as observed in figure 4.6,

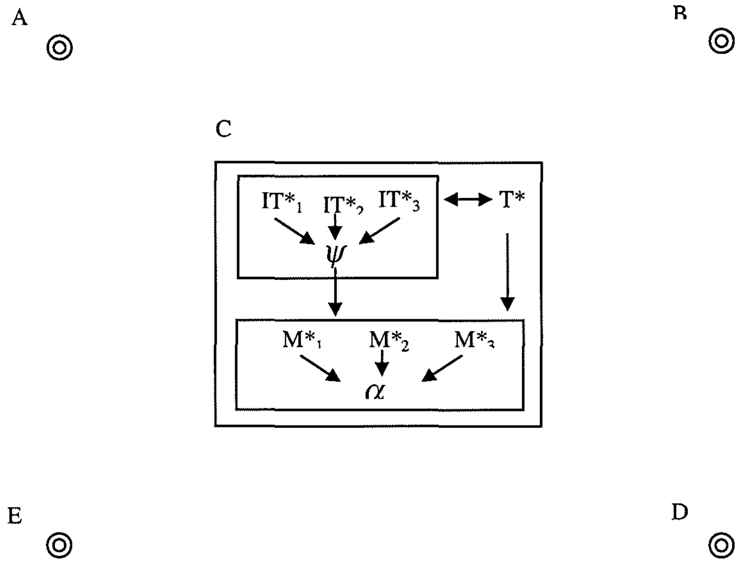
Figure 4.6 'IT's and 'M's involved in economies of localization while the individual components benefit from economies of scale resulting in a concentration of activities at point C



is a single tangible service (*T*), three manufacturing components (*M1*, *M2* and *M3*), which culminate to produce α, as well as three intangible services (*IT1*, *IT2* and *IT3*), which for the purpose of this section have been assumed as culminating to produce ψ. Furthermore, both the manufacturing and intangible service components are involved in an economy of localisation.

The second point of departure, as observed in figure 4.7, is a single tangible service (*T*), three manufacturing components (*M1*, *M2* and *M3*) as well as three intangible services (*IT1*, *IT2* and *IT3*), of which both the manufacturing and intangible service components are involved in an activity complex.

Figure 4.7 'IT's and 'M's involved in an activity complex while the individual components benefit from economies of scale - resulting in a concentration of activities at point C



Although different than the initial framework of the previous section, they are fundamentally linked. The five points (*A*, *B*, *C*, *D* and *E*) remain, but all the activity within the urban landscape can initially be found at point *C*. As already stipulated, *M1** represented the production of *M1* benefiting from economies of scale and is located at point *C* because as suggested in the previous section the benefits acquired through a change in production was greater than the additional transaction costs and transportation incurred through relocation. As observed in figure 4.6 and 4.7, all components, indicated by their respective '*'s are benefiting from economies of scale. Both figure 4.6 and 4.7 are fundamentally linked to the prior section's initial framework, in that the observed structure at point *C*, in both 4.6 and 4.7, could have existed at all of the five points, but not benefiting from economies of scale. These hypothetical structures can be observed in figure 4.8 and 4.9.

Figure 4.8 'IT's and 'M's involved in economies of localization while the individual components are not benefiting from economies of scale - resulting in the distribution of activities across the whole of the system

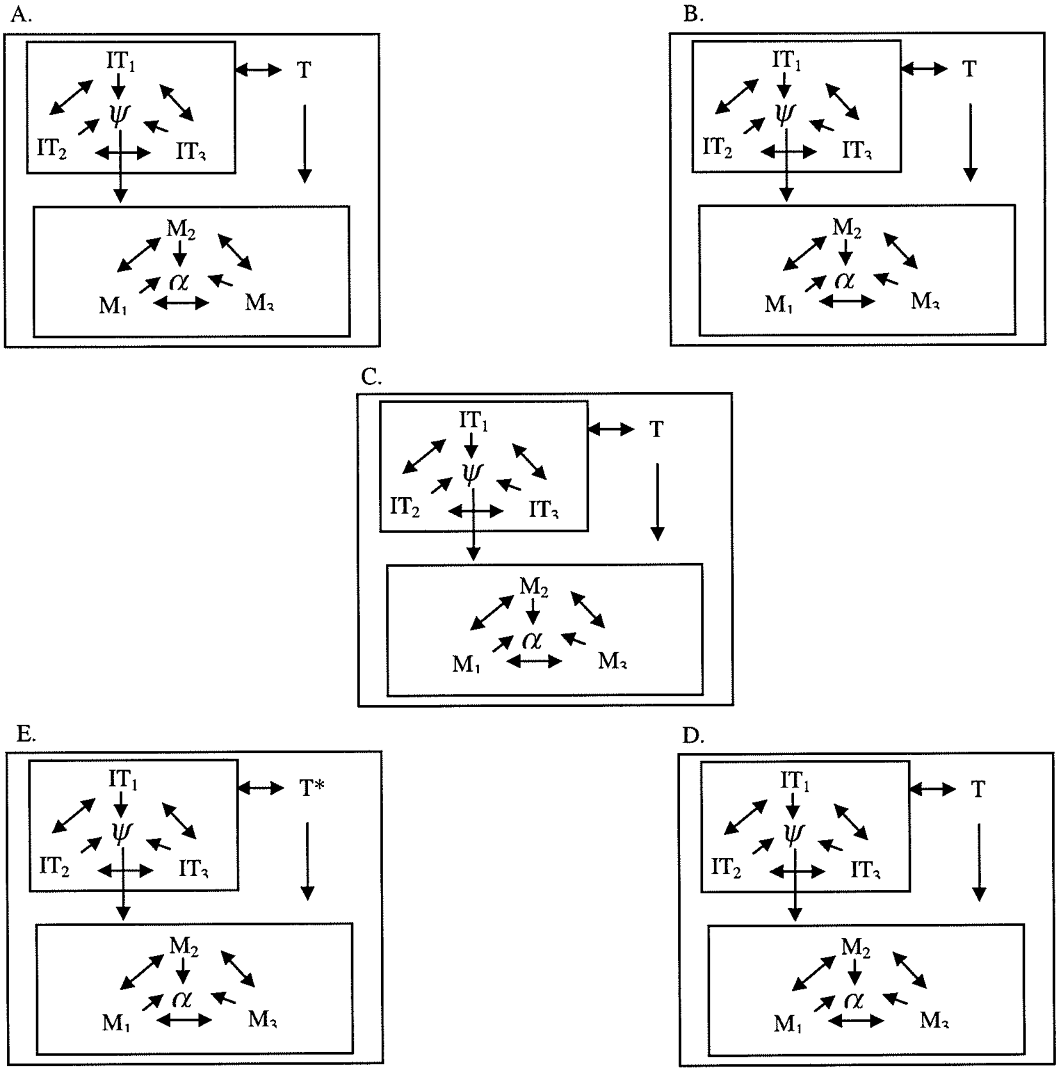
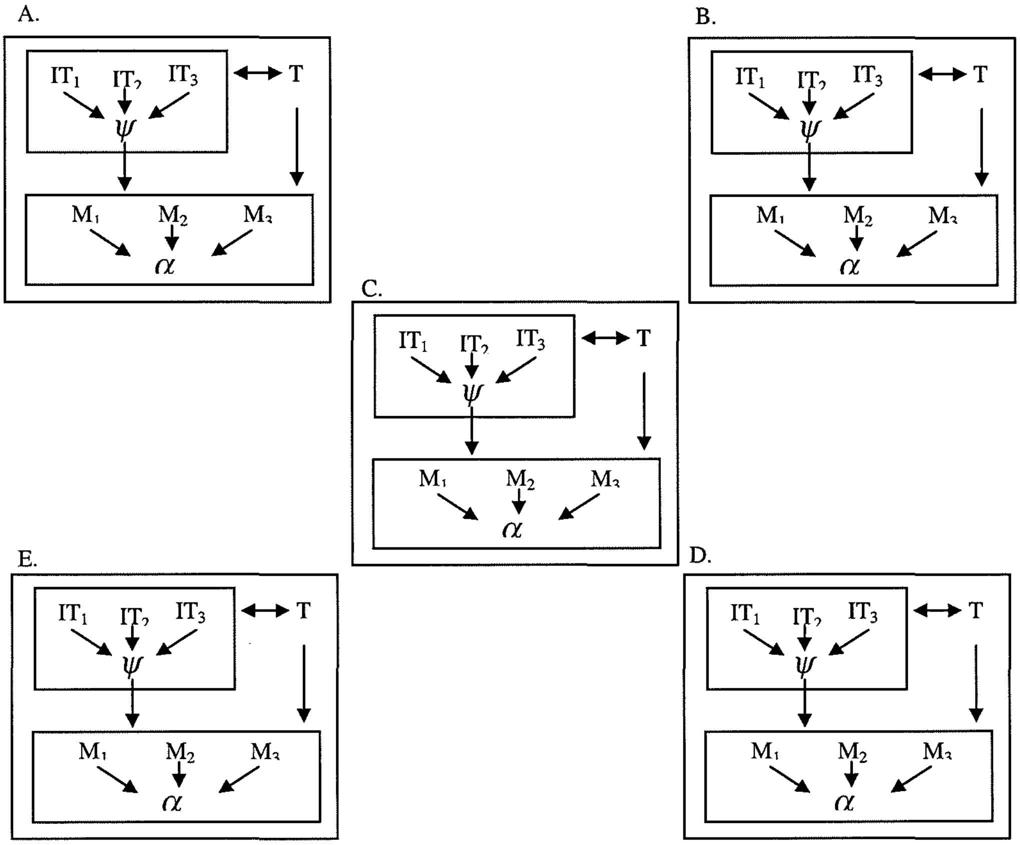


Figure 4.9 'IT's and 'M's involved in an activity complex while the individual components are not benefiting from economies of scale - resulting in the distribution of activities across the whole of the system



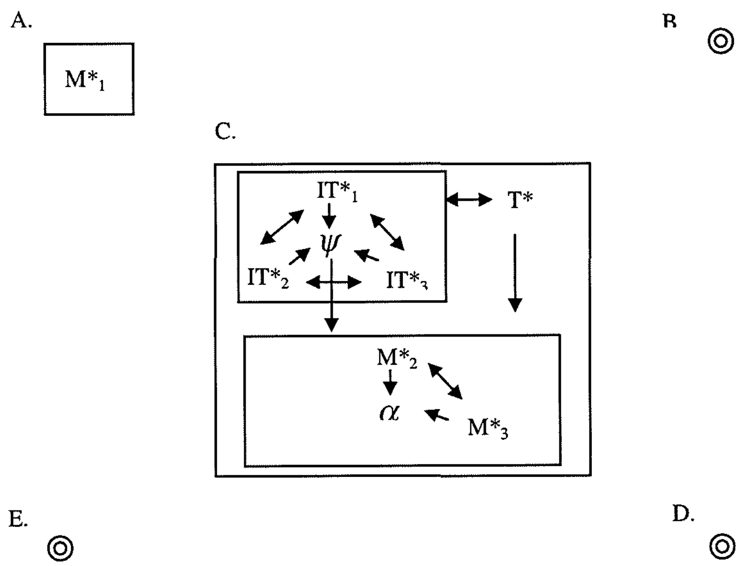
It is important to also note that the so-called, 'fundamental link', illustrates certain historical features, which further verifies the validity of the model. Industrialization induced a centralization of activity on an unparalleled scale. Thus, the shift from five uniform points, as observed in figure 4.0, to that of a growth pole, as observed in figure 4.7, although extremely general, could be deemed representative of the urban system's shift and/or response to industrialization. As modern economies transcend further into the post-industrial era centralization has been observed to occur, but in conjunction with decentralization. The relative locational flexibility of an activity throughout the urban system, as previously noted, is directly related to the nature and character of the activity in question, suggesting that activities are inclined towards different types of behaviour for different reasons.

4.5 The Scenarios (part II)

4.5.1 Scenario 1 – The decentralization of M1 while involved in a localisation economy*

The first scenario of this section considers the relocation of a manufacturing component (*M1**) involved in a localisation economy (see figure 4.6), from point *C*, to a point on the periphery. It is important to note that since the plain is uniform any one of the four points that is not point *C* is potentially suitable for the relocation of *M1**. In this particular case, as observed in figure 4.10, point *A* has been chosen as the point for relocation purely at random.

Figure 4.10 The decentralization of M1* while involved in a localization economy



*M1**, whether at point *C* or *A*, is involved in three transactions (*M2**, *M3** and α). Thus, at point *C*, *M1** has three local transactions, while at point *A*, three non-local transactions. Adopting the previously established transaction cost notation 'σ', local transaction costs of *M1** to *M2**, *M3** and α are the following:

$$[C(M1)] \rightarrow [C(\alpha)] = \sigma_1 \tag{20}$$

$$[C(M1)] \rightarrow [C(M2)] = \sigma_2 \tag{20.1}$$

$$[C(M1)] \rightarrow [C(M3)] = \sigma_3 \tag{20.2}$$

Local transaction costs are calculated further as

$$\sigma_1 + \sigma_2 + \sigma_3 = \sigma^{M1*} \tag{20.3}$$

As already established through one of the previously stated assumptions, non-local transactions are positively correlated to distance (*d*). Therefore, the total transaction costs of *A*'s *M1** to *C*'s α, *M3** and *M2** is $d \bullet \sigma^{M1*}$.

As with transaction cost notation transportation cost notation (β) is also carried over from the previous section. The transportation cost of *A*'s *M1** to *C*'s α, *M3** and *M2** is the distance (*d*) of point *A* to point *C*, multiplied by the cost of haulage per unit of distance of *M1*.

$$[H(M1)][C(d)] = \beta$$

However, in an attempt to justify the addition of the newly derived assumptions the circumstantial trade-off facing *M1** will be derived without '*BFA*', '*D*' and '*AA*'. Thus, at point *C*, the costs facing *M1** can be easily summarized in terms of the following:

$\sigma^{M1*(L)}$ (21)

At point *A*, the costs facing *M1** are the following:

$d \bullet \sigma^{M1*(L)} + \beta$ (22)

The two equations, can be placed relative to one another, so as to further indicate the potential constraints facing *M1** if it were to relocate to point *A*, from point *C*.

$\sigma^{M1*(L)} > d \bullet \sigma^{M1*(L)} + \beta \qquad (d > 1)$ (23)

Thus, as indicated by relationship 23, if *M1** were to relocate to point *A*, local transaction costs would have to be greater than non-local transaction costs plus the transportation costs of *M1*. This, of course, is impossible. Even if the distance factor (*d*) was deemed equal to one, transportation costs would have to be zero or negative for it to be economically viable for *M1** to relocate to point *A*.

Therefore, it can be concluded that the reasoning for relocation lie somewhere other than in the absolute advantage of transaction and transportation costs. As exemplified in the previous section, relocation was made possible through a shift in production, which provided a benefit that offset the additional transportation and transaction costs. While this will be further considered in the following chapter, in this particular set of circumstances, no such shift is considered. Yet, as conveyed in the previous chapters activities decentralize and for reasons other than shifts in production; highlighting the three newly derived assumptions of positive and negative externalities.

In applying the three new assumptions to the consideration relationships 21 and 22 are subject to adjustments. As observed in relationship 21.1, diseconomies (*D*) and benefits from agglomeration (*BFA*) are included with the transaction costs M1 is subject to at point *C*. As noted previously, diseconomies and benefits from agglomeration culminate into 'net agglomeration', which adjusts 21.1 in the following manner.

$$\sigma^{M1*(L)} + D - BFA \tag{21.1}$$

$$\sigma^{M1*(L)} + NA \qquad (D > BFA) \tag{21.2}$$

As observed in 21.2, net agglomeration (*NA*) has been expressed as positive, which would suggest that the agglomeration that *M1** is part of at point *C* creates more costs than it saves. Thus, the agglomeration at point *C*, with respect to *M1** is on the whole unfavourable, however, although *M1** may be experiencing forces of a 'pushing' nature, relocation is also dependent on the circumstances present at the potential point of relocation. If the circumstances at point *C* were in fact favourable, benefits from agglomeration would be greater than diseconomies, resulting in a negative value for net agglomeration, as observed in the following relationship.

$$\sigma^{M1*(L)} - NA \qquad (D < BFA) \tag{21.3}$$

At point *A*, the costs facing *M1**, in conjunction with the newly derived assumptions, are expressed in the following terms.

$$d \bullet \sigma^{M1*(L)} + \beta - AA \qquad (22.1)$$

'Alternative advantages' are observed as reducing the aggregate costs at point *A*, like that of 'benefits from agglomeration' at point *C*. While there is no reason as to why diseconomies, as well as benefits from agglomeration, could not exist at point A, but in this specific case *M1** is the only activity at point *A*, thus it would be impossible for such factors to be present.

Placing relationship 21.1 and 22.1 relative to one another provides the opportunity to further examine the relative constraints facing *M1** if it were to relocate from point *C* to point *A*.

$$\sigma^{M1*(L)} + D - BFA > d \bullet \sigma^{M1*(L)} + \beta - AA \qquad (d > 1) \qquad (23.1)$$

The above relationship (23.1) is more reasonable than that of relationship '23'. In fact, due to the number of unknowns on either side, relocation is not only plausible but numerous possibilities exist. One interpretation of the above relationship would be to assume net agglomeration was positive ($D > BFA$), which further suggests that in order for *M1** to relocate to point *A* local transaction costs plus net agglomeration were greater than non-local transaction costs plus transportation costs minus potential benefits from alternative advantages. A positive value for net agglomeration further suggests, as noted previously, that *M1** at point *A* would experience a less unfavourable situation than if it were to remain at point *C*; implying overall that *M1** was partially 'pushed' from point *C*.

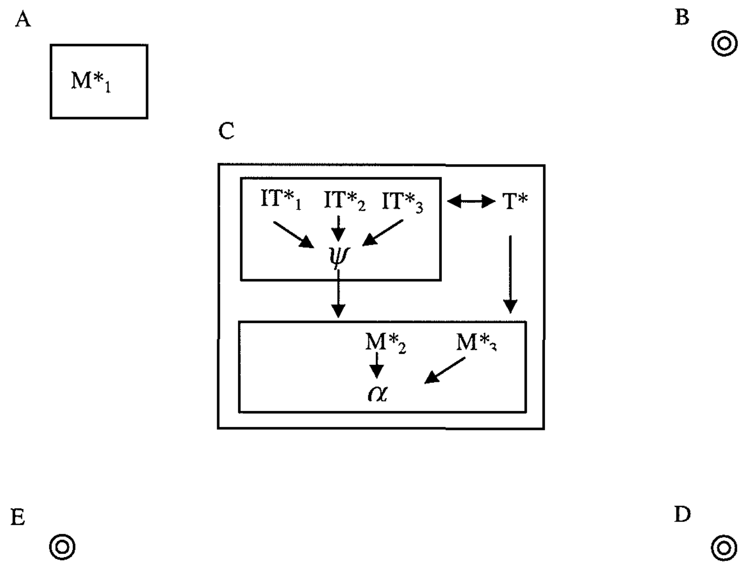
The alternative would be to assume that net agglomeration was negative (*BFA* > *D*), which, according to the above relationship would suggest that in order for *M1** to relocate to point *A*, local transaction costs plus net agglomeration was greater than non-local transaction costs plus transportation costs minus potential benefits from alternative advantages. However, unlike the previous interpretation, a negative value for net agglomeration further suggests that, *M1** experienced a favourable situation at point *C* and relocation occurred because the situation at point *A* was even more favourable; implying overall that *M1** was 'pulled' from point *C*.

4.5.2 Scenario 2 – The decentralization of M1 while involved in an activity complex*

This next scenario of this section is identical to the previous scenario except that manufacturing is involved in an activity complex rather than an economy of localisation. As observed in a relative consideration of figure 4.6 and 4.7, each manufacturing component was subject to one transaction in figure 4.7, while in figure 4.6 they were subject to three. Thus, in considering a potential relocation of *M1**, the only difference between the previously derived relationships and the soon to be derived relationships is that in this scenario potential transaction costs are subject to reconsideration.

As observed in figure 4.11, *M1** relocates from point *C* to point *A* (point *A* is chosen at random, like that of the previous scenario).

Figure 4.11 The decentralization of M1* while involved in an activity complex



*M1**, when at point *C*, is subject to a single transaction (α), which at point *A* is a non-local transaction. The local transaction can be expressed in the following terms.

$$[C(M1)] \rightarrow [C(\alpha)] = \sigma_1 \qquad (20a)$$

For notation purposes σ_1 will be represented by $\sigma^{M1*(AC)}$. As already established through one of the previously stated assumptions, non-local transactions are positively correlated to distance (*d*). Therefore, the total transaction costs of *A*'s *M1** to *C*'s α is $d \bullet \sigma^{M1*(AC)}$.

Thus, at point *C*, in accordance with the newly derived assumptions, the costs facing *M1** is as follows:

$$\sigma^{M1*(AC)} + D - BFA \qquad (21.1a)$$

At point *A*, also in accordance with the newly derived assumptions, the costs facing *M1** are the following:

$$d \bullet \sigma^{M1*(AC)} + \beta - AA \quad (d > 1) \qquad (22.1a)$$

Placing relationship 21a and 22a relative to one another provides the opportunity to further examine the relative constraints facing *M1** if it were to relocate from point *C* to point *A*.

$$\sigma^{M1*(AC)} + D - BFA > d \bullet \sigma^{M1*(AC)} + \beta - AA \quad (d > 1) \qquad (23.1a)$$

As with 23.1 a number of possible interpretations may apply to the above relationship, 23.1a, which are also identical to those highlighted when considering 23.1. Depending on the relative value of '*D*' and '*BFA*', *M1** could potentially be 'pulled' from point *A*, assuming '*BFA*' was greater than '*D*', further suggesting that *M1** was relocating from a favourable situation to an even more favourable situation. Conversely, *M1** could also be pushed from point *C* to point *A*, assuming '*D*' was greater than '*BFA*', point *C* would be relatively unfavourable, and relocation could take place as so long as point *A* was less unfavourable.

However, the motivation for establishing the circumstantial trade-off facing a single component in a given scenario is primarily for comparative purposes. By exhibiting the relative locational flexibility between the scenarios in question it is possible to reaffirm that certain aspects, like that of structure or character of the activity, have a certain degree of influence in shaping the spatial structure of the urban system. For example, in comparing the factor constraints facing the component subject to relocation in the two previously derived scenarios, it is easily observed that factor constraints for *M1** at point *A* are greater when manufacturing is involved in a localisation economy, due to the greater number of transactions, compared to that of manufacturing involved in an activity complex.

$$d \bullet \sigma^{M1*(L)} + \beta - AA > d \bullet \sigma^{M1*(AC)} + \beta - AA \quad (d > 1) \tag{24}$$

However, the above relationship (24) is based on the previously noted unrealistic assumption that all transaction costs are uniform. While such an assumption may be acceptable when comparing the same manufacturing component in two different contexts, comparing two entirely different types of activities potentially undermine the legitimacy of the framework. Thus, as already noted, it is important to consider and examine the interrelationships of different types of activities, so as to further establish the wider implications of the character and nature of activity on the spatial structure of the urban system. After which the role of advanced-telecommunications may be applied to the observed interrelationships and its role further deduced.

Thus, the next two scenarios of consideration are similar to the former two, but '*IT*' services. The first '*IT*' scenario (scenario 3) will consider the relocation of '*IT1**' from point *C* to point *A* (see figure 4.12 in section 4.5.3), while '*IT1**' is involved in a localisation economy, while the second of the '*IT*' scenarios (scenario 4) will consider the relocation of '*IT1**' from point *C* to point *A*, while '*IT1**' is involved in an activity complex (see figure 4.13).

4.5.3 Scenario 3 – The decentralization of IT1 while involved in a localisation economy*

As previously noted, this next scenario is a consideration of the potential factor constraints facing *IT1** if it were to relocate from point *C* to point *A*. As observed in

Figure 4.12 The decentralization of IT1* while involved in a localization economy

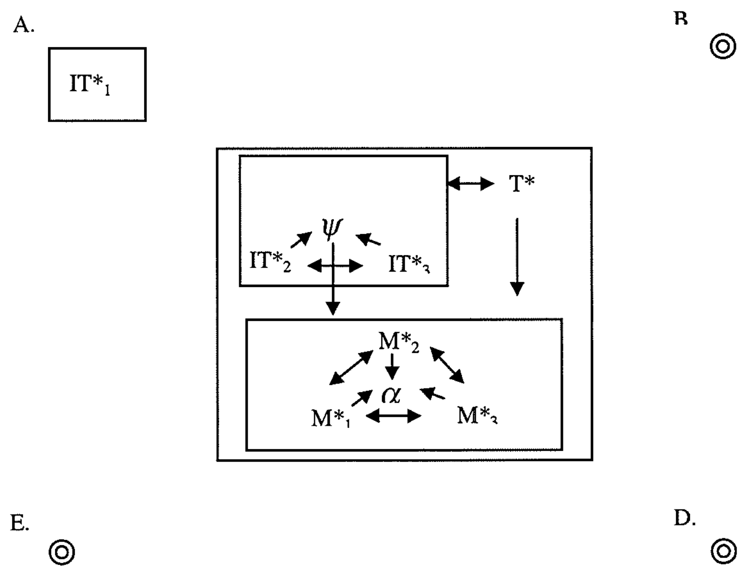


figure 4.12, *IT1** is subject to three transaction costs (*IT2*, *IT3* and ψ), which can be further expressed in the following terms:

$$[C(IT1)] \rightarrow [C(\psi)] = \sigma_1 \qquad (20b)$$

$$[C(IT1)] \rightarrow [C(IT2)] = \sigma_2 \qquad (20.1b)$$

$$[C(IT1)] \rightarrow [C(IT3)] = \sigma_3 \qquad (20.2b)$$

Local transaction costs are calculated further as

$$\sigma_1 + \sigma_2 + \sigma_3 = \sigma^{IT1*(L)}$$

As already established through one of the previously stated assumptions, non-local transactions are positively correlated to distance (*d*). Therefore, the total transaction costs of *A*'s *IT1** to *C*'s ψ, *IT3** and IT2* is $d \bullet \sigma^{IT1*(L)}$.

Transportation costs (β), which, due to the intangible nature of the activity, present some obvious contentious points, which will be included initially so as to further exhibit the presence of a relative difference between activities upon its removal when having to demonstrate the role of advanced-telecommunications in shaping the spatial structure through the interaction of certain activities. Thus, like those transportation costs before, the transportation cost of *A*'s *IT1** to *C*'s ψ, *IT3** and *IT2** is the distance (*d*) of point *A* to point *C*, multiplied by the cost of haulage per unit of distance of IT1.

$$[H(IT1)][C(d)] = \beta$$

In accordance with the newly derived assumptions the factor constraints facing *IT1** at point *C* and point *A* can be derived accordingly. At point *C*, *IT** is subject to three transaction costs in addition to diseconomies (*D*) as well as potential benefits from agglomeration (*BFA*).

$$\sigma^{IT1*(L)} + D - BFA \qquad (21.1b)$$

Similarly, *IT1**, at point *A* (see figure 4.12), is subject to three non-local transaction costs as well as potential alternative advantages (*AA*).

$$d \bullet \sigma^{IT1*(L)} + \beta - AA \quad (d > 1) \tag{22.1b}$$

Placing relationship 21a and 22a relative to one another provides the opportunity to further examine the relative constraints facing *IT1** if it were to relocate from point *C* to point *A*.

$$\sigma^{IT1*(L)} + D - BFA > d \bullet \sigma^{IT1*(L)} + \beta - AA \quad (d > 1) \tag{23.1b}$$

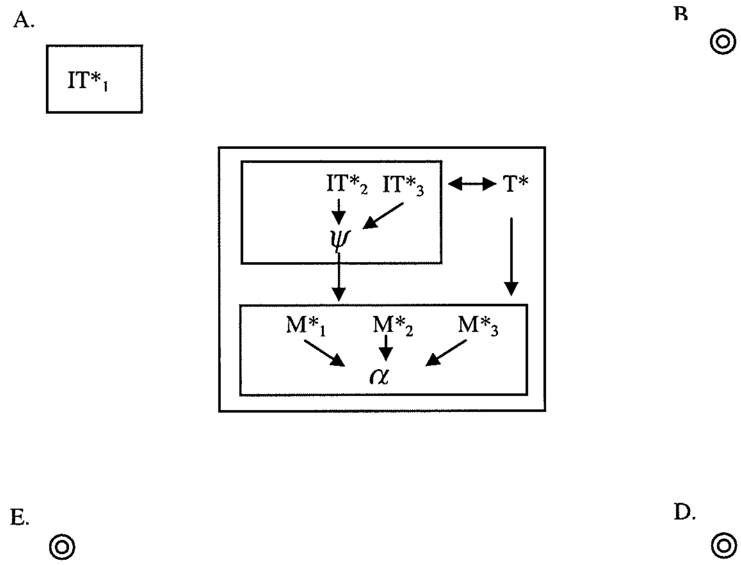
The above relationship's framework is very similar to that of 23.1a and more so to 23.1, given the similar structure the component of consideration is involved in. In fact, the only real difference between 23.1 and 23.1b is the one less set of transaction costs and activity type under consideration. Thus, analysis offered at this time would be identical to that offered in scenario 1 in regards to 23.1.

It is, however, important to further note that the transportation costs (β) are subject to removal given certain suppositions. This would, of course, not only transform 23.1b into something less similar to 23.1 and 23.1a, but it would remove additional costs facing *IT1** if it were to locate at point *A*, further suggesting that activities that are accessible via advanced-telecommunications may be more locationally flexible, or in this particular case, more inclined towards decentralization.

4.5.4 Scenario 4 – The decentralization of IT1 while involved in an activity complex*

The forth and final scenario considered in this section will be the potential relocation of *IT1** from point *C* to point *A* while involved in an activity complex. As observed

Figure 4.13 The decentralization of IT1* while involved in an activity complex



in figure 4.13, *IT1** is subject to one transaction (ψ), which can be expressed in the following terms:

$$[C(IT1)] \rightarrow [C(\psi)] = \sigma_1 \qquad (20c)$$

For notation purposes σ_1 will be represented by $\sigma^{IT1*(AC)}$. As already established through one of the previously stated assumptions, non-local transactions are positively correlated to distance (*d*). Therefore, the total transaction costs of *A*'s *M1** to *C*'s α is $d{\bullet}\sigma^{IT1*(AC)}$.

As noted in the previous scenario, the presence of potential transportation costs are a contentious point, but will initially be included for the same reasons that they were included in the previous scenario where an *'IT'* type activity was also considered. Thus, like those transportation costs before, the transportation cost of *A*'s *IT1** to *C*'s α is the distance (*d*) of point *A* to point *C*, multiplied by the cost of haulage per unit of distance of *IT1*.

$$[H(IT1)][C(d)] = \beta$$

In accordance with the newly derived assumptions the factor constraints facing *IT1** at point *C* and point *A* can be derived accordingly. At point *C*, *IT** is subject to one transaction cost ($\sigma^{IT1*(AC)}$) in addition to diseconomies (*D*) as well as potential benefits from agglomeration (*BFA*).

$$\sigma^{IT1*(AC)} + D - BFA \qquad (21.1c)$$

Similarly, *IT1**, at point *A* (see figure 4.13), is subject to one non-local transaction costs as well as potential alternative advantages (*AA*).

$$d \bullet \sigma^{IT1*(AC)} + \beta - AA \quad (d > 1) \qquad (22.1c)$$

Placing relationship 21a and 22a relative to one another provides the opportunity to further examine the relative constraints facing *IT** if it were to relocate from point *C* to point *A*.

$$\sigma^{IT1*(AC)} + D - BFA > d \bullet \sigma^{IT1*(AC)} + \beta - AA \qquad (d > 1) \qquad (23.1c)$$

Similar to that of the previous scenario, the above relationship is very similar to 23.1, 23.1a and 23.1b to reiterate the details of the above relationship (23.1c). It should come as no surprise that when comparing the relative locational flexibility of IT1* in 23.1c to that of 23.1b, 23.1c is more locationally flexible, as a result of its fewer transactions.

$$d \bullet \sigma^{IT1*(L)} + \beta - AA > d \bullet \sigma^{IT1*(AC)} + \beta - AA \qquad (d > 1) \qquad (25)$$

The above relationship is identical to that of the relationship where the activity in question was *M1* (24). Thus, as already stated, the structure, irrespective of the type of activity considered, accounts for certain relative locational flexibility. However, while a difference in structure clearly influences the relative locational flexibility of activities, the notion that all transaction costs are uniform remains and comparing the right side of 23.1, 23.1a, 23.1b and 23.1c with one another provides an expected outcome (26).

$$d \bullet \sigma^{IT1*(L)} + \beta - AA = d \bullet \sigma^{M1*(L)} + \beta - AA > d \bullet \sigma^{IT1*(AC)} + \beta - AA = d \bullet \sigma^{M1*(AC)} + \beta - AA$$

$(d > 1)$ (26)

4.6 Disagglomeration as a function of an activity's nature and character

While it is clear that the structure the activity is involved in has a certain influence on the locational flexibility of activities with regards to disagglomeration, it remains to be determined as to how the nature and character of an activity influences the previously established hierarchy of locational flexibility, as observed in relationship 26. Locational flexibility is not just simply a question of which activity involved in a given structure faces the lowest costs at the potential point of relocation. As already noted, the activity in question can also be 'pushed' from its original location to its point of relocation of which variation in the strength of the 'push' may be present. Similarly, relative 'pulling' strength is also important. The greater the difference in favour of the potential point for relocation, the more locationally flexible the activity is.

However, before attempting to evaluate the relative difference of costs between the potential points of locations, with respect to activity type, assumptions that account for the nature and character of the activities in question will be applied to the above relationship (26). As a result, the hierarchy of locational flexibility observed in relationship 26 will be subject to removal in terms of the additional criteria. It is important to highlight that this will place focus on the 'pulling' component of the relocation between two points. The first set of assumptions applied to the previously derived relationships will be in terms of the manner in which activities interrelate. Initially, transportation cost of certain activities will be subject to removal. The next set of assumptions to be applied, which is an extension of the first in that interrelationships are still the subject of consideration, is the adaptation of transaction costs, with respect to activity type.

After having re-evaluated the relative locational flexibility of both the structure as well as the nature and character of activities, it will then be possible to consider the relative difference of costs between potential locations. Considering the left side of 23.1, 23.1a, 23.1b and 23.1c, or 21.1, 21.1a, 21.b and 21.1c, respectively, certain assertions will have to be made in regards to the respective relationship of diseconomies (*D*), benefits from agglomeration (*BFA*) and local transaction costs (σ), before being compared to the respective points of relocation. As with prior assessments of locational flexibility, the difference in costs between points is also subject to comparison between all the relationships in question.

4.6.1 Transportation costs (β)

This particular section reconsiders relationship 26 in terms of a re-evaluation of transportation costs (β). Transportation costs are, of course, found in all four scenarios, but as previously noted, may be presumptuous as the transportation of some activities can be potentially facilitated via advanced-telecommunications. Thus, in attempting to account for this fact, the above relationship will be re-evaluated in terms of the removal of transportation costs for those scenarios that considered '*IT*' activity types (23.1b and 23.1c).

Relationship 26 is, of course, a culmination of four separate partial relationships (23.1, 23.1a, 23.1b and 21.1c/21.1c), or two separate whole relationships (24 and 25). Thus, before considering how the relative locational flexibility of all activities under consideration (relationship 26) is influenced by the introduction of the possibility that '*IT*' activity types can be facilitated via advanced-telecommunications at zero marginal cost the basic relationships have to be reconsidered. Of the four fundamental relationships (23.1, 23.1a, 23.1b and 23.1c) only two consider '*IT*' activity types: 23.1b and 23.1c. In removing transportation costs (β) from 23.1b and 23.1c, the relationships are rewritten accordingly.

$$\sigma^{IT1*(L)} + D - BFA > d\bullet\sigma^{IT1*(L)} - AA \qquad (d > 1) \qquad (23.1b[r1])$$

$$\sigma^{IT1*(AC)} + D - BFA > d\bullet\sigma^{IT1*(AC)} - AA \qquad (d > 1) \qquad (23.1c[r1])$$

Expectedly, '*IT1**' at the point of potential relocation (point A) is potentially subject to fewer costs than if positive transportation costs were still present. Furthermore, the relative locational flexibility between *IT1** in a localisation economy (23.1b) to that of *IT1** in an activity complex (23.1c) does not change (23.1b[r]). However, since both *IT1**s are still subject to the same number of transaction costs, the relative locational flexibility of all four of the previously derived relationships, as initially expressed in relationship 26 is subject to reconsideration.

$$d\bullet\sigma^{IT1*(L)} - AA > d\bullet\sigma^{IT1*(AC)} - AA \qquad (d > 1) \qquad (25[r1])$$

A re-evaluation of relationship 26, in accordance with the adapted 23.1b and 23.1c, which resulted in 23.1b[r] and 23.1c[r] respectively, leaves two possible options of which either outcome is dependent on the relative values of the transaction and transportation costs. The following outcome, relationship 26a, assumes that a single unit of transportation is greater than a single set of transaction costs ($\beta > \sigma$).

$$d \bullet \sigma^{M1*(L)} + \beta - AA > d \bullet \sigma^{M1*(AC)} + \beta - AA > d \bullet \sigma^{IT1*(L)} - AA > d \bullet \sigma^{IT1*(AC)} - AA$$
(d > 1) (26a)

However, if a single set of transactions was greater than a single unit of transportation ($\sigma > \beta$) than the manufacturing component involved in an activity complex would be more locationally flexible than the '*IT*' component involved in the localisation economy.

$$d \bullet \sigma^{M1*(L)} + \beta - AA > d \bullet \sigma^{IT1*(L)} - AA > d \bullet \sigma^{M1*(AC)} + \beta - AA > d \bullet \sigma^{IT1*(AC)} - AA$$
(d > 1) (26b)

While the implications of removing transportation costs for '*IT*' activity types results in different outcomes, both outcomes are fundamentally different than the original relationship (relationship 26). Thus, it can be concluded, albeit generally, that the nature and character of the activity influences the spatial structure by further defining the relative flexibility of certain activities.

4.6.2 Transaction costs (σ)

The next means with which to examine how the nature and character of activity influences the locational flexibility of activities with regards to disagglomeration is through the consideration of relative transaction costs like that of section 4.3.5. As suggested previously, the assumption of uniform transaction costs is an unreasonable one. Irrespective of distance, some are more involved or just simply more complex and therefore require more time and costs. Furthermore, due to technological restraints these differences may be further accentuated if the transaction itself is unable to be comprehensively facilitated via advanced-telecommunications. However, as already suggested, as advanced-telecommunications becomes more capable of facilitating increasingly complex interactions across space transactions become less costly, as the non-local becomes local. Similarly, transactions can become increasingly routine and thus reduce in cost over time.

Thus, two scenarios will be applied to the previously derived relationships (23.1, 23.1a, 23.1b and 23.1c). The first will involve the complete removal of the distance factor, while the second will involve the application of relative transaction costs. The purpose of the first scenario is to examine the relative implications on locational flexibility if advanced-telecommunications was so technologically capable that transactions could be facilitated as if they were all local. The purpose of the second scenario is to account for the notion that advanced-telecommunications may be unable to facilitate more complex forms of interaction.

4.6.3 Scenario 1 – The complete removal of the distance factor (d)

Upon removing the distance factor, the previous derived relationships of 23.1, 23.1a, 23.1b and 23.1c are reworked accordingly.

$$\sigma^{M1*(L)} + D - BFA > \sigma^{M1*(L)} + \beta - AA \qquad (d > 1) \qquad (23.1[r2])$$

$\sigma^{M1*(AC)} + D - BFA > \sigma^{M1*(AC)} + \beta - AA \quad (d > 1) \quad (23.1a[r2])$

$\sigma^{IT1*(L)} + D - BFA > \sigma^{IT1*(L)} + \beta - AA \quad (d > 1) \quad (23.1b[r2])$

$\sigma^{IT1*(AC)} + D - BFA > \sigma^{IT1*(AC)} + \beta - AA \quad (d > 1) \quad (23.1c[r2])$

As observed in the reworked relationships, all activities in question become more locationally flexible as an additional cost at the point of relocation is removed. However, in deriving the relative locational flexibility of all the activities in question an identical relationship to that of 26 comes to bear.

$\sigma^{IT1*(L)} + \beta - AA = \sigma^{M1*(L)} + \beta - AA > \sigma^{IT1*(AC)} + \beta - AA = \sigma^{M1*(AC)} + \beta - AA \quad (d > 1)$
(26c)

Similar to that of 8.3, 8.3a, 8.3b and 8.3c in the previous section, 'Advanced-telecommunications has unlimited influence' (4.2.4) where no change in the relative locational flexibility occurred either, relationship 26c is almost identical to 26 because the removal of the distance factor functioned in terms of a general technological shift.

4.6.4 Scenario 2 – The application of relative transaction costs

As already noted, the purpose of applying relative transaction costs to the previously derived relationships is to account, and thus further examine, the fact that not all transactions are uniform in cost. In applying relative transaction costs to the previously derived relationship (relationship 26) it is assumed that 'routine' (σ^{R}) and 'complex' (σ^{C}) transaction types exist, of which complex transactions are greater in cost than routine transactions ($\sigma^C > \sigma^R$). In attempting to further examine the implications of relative transaction costs in terms of character of activity activities characterized as '*IT*' activity types will be construed as complex transaction types, and thus subject to relatively higher transaction costs than manufacturing activity types, which will be construed as routine transaction types.

$\sigma^{IT} = \sigma^{C}$

$\sigma^{M} = \sigma^{R}$

In applying relative transaction costs in terms of activity type to the previously derived relationships the previously established hierarchies of relative locational flexibility are subject to change. However, the result is dependent on a number of factors that require further stipulation. The first is whether transportation costs are present for '*IT*' activity types, if so, this would further suggest the possibility that '*IT*' activity type transaction costs were so complex that advanced-telecommunications would be unable to transmit them without a cost. In some ways, this may conform to the assumption that '*IT*' activity types transaction costs were greater than manufacturing activity type transaction costs, but this would be mere supposition. The second aspect that would also have further implications on the results would be, like that of the previous section, 'Transportation costs (β)', the relative values of a '*IT*' transaction to that of a unit of transportation.

Assuming the presence of transportation costs for '*IT*' activities, in addition to the value of a single '*IT*' activity type transaction being greater than a unit of transportation, the relative locational flexibility of those activities in question would result as follows:

$d \bullet \sigma^{IT1*(L)} + \beta - AA > d \bullet \sigma^{IT1*(AC)} + \beta - AA > d \bullet \sigma^{M1*(L)} + \beta - AA > d \bullet \sigma^{M1*(AC)} + \beta - AA$ (d > 1) (26d)

Due to the application of relative transaction costs, in accordance with the previously noted stipulations, the '*IT*' activity types become the least locationally flexible, a result which tends to support the observation of agglomerations of advanced (producer) services in higher order cities. However, if the previously noted stipulations are subject to change, specifically in regards to the relatively higher value of '*IT*' activity type transaction costs to that of a single unit of transportation costs existing in terms of the opposite relationship the above relationship (relationship 26d) would be subject to change. As a result, it is possible that manufacturing activities involved in a localisation economy would be less locationally flexible than a '*IT*' activity involved in an activity complex, as expressed through the following relationship.

$d \bullet \sigma^{IT1*(L)} + \beta - AA > d \bullet \sigma^{M1*(L)} + \beta - AA > d \bullet \sigma^{IT1*(AC)} + \beta - AA \; d \bullet \sigma^{M1*(AC)} + \beta - AA$ (d > 1) (26e)

If, however, it is assumed that advanced-telecommunications was capable of transmitting '*IT*' activity types, than the previously established relationship is once again subject to reconsideration. While the relative value of '*IT*' activity type transaction costs and a unit of transportation costs would have significant implications on the ensuing relationship and a repeat of relationship 26d would be entirely possible assuming the difference between a '*IT*' activity type transaction and a unit of transportation were substantial enough. This would once again support the previously noted observation of advanced services agglomerating in higher order cities. However, if transportation costs were greater than '*IT*' activity type transaction costs then not only would 26e at least, but manufacturing activities may, on the whole, be less locationally flexible than '*IT*' activity types, as expressed in the following relationship.

$d \bullet \sigma^{M1*(L)} + \beta - AA > d \bullet \sigma^{M1*(AC)} + \beta - AA > d \bullet \sigma^{IT1*(L)} + \beta - AA > d \bullet \sigma^{IT1*(AC)} + \beta - AA$ $(d > 1)$ (26f)

4.7 Dissagglomeration as a result of a more favourable location

It is, however, important to note that the focus of both efforts, 'Transportation costs (β)' and 'Transaction costs (σ)' were defined solely in terms of the relative costs the activity in question would be subject to upon relocation, in other words, the 'pull' factor. As previously noted, while an activity may be 'pulled' towards a location, the original location may also exert a force, which could potentially also contribute to an activity's decision to relocate.

As already defined, the original location is represented by the left side of the previously defined relationships 23.1, 23.1a, 23.1b and 23.1c, or 21.1, 21.1a, 21.1b and 21.1c, respectively, further characterized by the three terms, transaction costs (σ), diseconomies (D) and benefits from agglomeration (BFA). When diseconomies are greater than benefits from agglomeration for an activity at a given point then it could be suggested that a force is 'pushing' the activity out of the given point. This so-called 'push' can be further characterized by an 'unfavourable' situation at the original location, or when an activity experiences more costs as a result of the location than benefits. However, an unfavourable situation does not ensure that the given activity will relocate, nor does an activity need to be in an unfavourable situation in order to relocate. As stated previously, an activity can be located at a point that could be 'favourable', but still relocate to a 'more favourable' location. Or, an activity can be in a 'unfavourable' position, but relocate to a 'less unfavourable' location. Thus, a location's 'favour ability' is relative to other locations.

In an attempt to examine how the relative difference in cost between locations influences the spatial structure of activities and thus the urban system with respect to activity type, additional assertions have to be stipulated in regards to the original location (point *C*). Considering the left side of relationships 23.1, 23.1a, 23.1b and 23.1c, the only factor that was subject to variation, was transaction costs ($\sigma^{M1*(L)}$, $\sigma^{M1*(AC)}$, $\sigma^{IT1*(L)}$ and $\sigma^{IT1*(AC)}$), as a result of their respective structures with which they were involved in any attempt to establish their relative values resulted in two levels, as observed in relationship 26.

$$\sigma^{M1*(L)} + D - BFA = \sigma^{IT1*(L)} + D - BFA > \sigma^{M1*(AC)} + D - BFA = \sigma^{IT1*(AC)} + D - BFA \quad (26)$$

However, as established, the transaction cost is not the only variable that potentially determines location. In constructing the current analysis, only situations that involve 'push' factors ($D > BFA$) will be considered. Benefits from agglomeration (*BFA*), rather, will be subject to consideration, in that relative values for *BFA* will be assigned with respect to the nature and character of the activity. Diseconomies, on the other hand, will be assumed as constant, and greater than all potential *BFA* values.

The fundamental assumption of this examination is that complex activities, which involve complex transactions, derive greater benefits from agglomeration than routine activities ($BFA^C > BFA^R$) and the greater number of transactions the greater the benefit ($BFA^{X+Y} > BFA^Y$). Additionally, the previously stated assumptions that established relative values for activity's transaction costs will remain. Thus, complex transactions will be assumed as more costly than routine transactions of which '*IT*' activity types will be assumed as complex type activities, while manufacturing will be assumed as routine type activities.

Summation of assumptions:

$BFA^{C} > BFA^{R}$

$BFA^{X+Y} > BFA^{Y}$

$\sigma^{IT} = \sigma^{C}$

$\sigma^{M} = \sigma^{R}$

As a result of the newly derived assumptions the previously stated relationship (26) is subject to reconsideration. However, while the assumptions manage to clarify certain indecisiveness present in relationship 26 additional uncertainties are induced through the conflict of potential relative values. Due to $BFA^{C} > BFA^{R}$, the net agglomeration (*NA*) for complex activities is less than the net agglomeration for routine activities ($NA^{R} > NA^{C}$), but at the same time, complex transactions are greater than routine transactions. Thus, without stipulating the relative values of transactions to net agglomerations with respect to activity, it is impossible to firmly establish the relative push factor acting on those activities in question. In an attempt to solve this conflict, the transaction costs from the left side of relationships 23, 23.1a, 23.1b and 23.1c will be removed. Similarly with the relationship between diseconomies (*D*) and benefits from agglomeration (*BFA*), which will be re-written in terms of net agglomeration (*NA*), which will also represent the activity and the activity's structure. It can be further warranted that, with regards to the current scenario, transaction costs, regardless of the activity could be deemed nominal relative to net agglomeration. Thus, relationships 23.1a, 23.1b and 23.1c can be re-written as follows:

$$NA^{M1*(L)} > d \bullet \sigma^{M1*(L)} + \beta - AA \qquad (d > 1) \qquad (23.1[r3])$$

$$NA^{M1*(AC)} > d \bullet \sigma^{M1*(AC)} + \beta - AA \qquad (d > 1) \qquad (23.1a[r3])$$

$$NA^{IT1*(L)} > d \bullet \sigma^{IT1*(L)} + \beta - AA \qquad (d > 1) \qquad (23.1b[r3])$$

$$NA^{IT1*(AC)} > d \bullet \sigma^{IT1*(AC)} + \beta - AA \qquad (d > 1) \qquad (23.1c[r3])$$

In accordance with the newly derived relationships, the relative locational flexibility for both the original point of location and the point of relocation can now be established, and then ultimately compared so as to derive the relative difference in costs between the two points.

For the original location:

$$NA^{M1*(AC)} > NA^{M1*(L)} > NA^{IT1*(AC)} > NA^{IT1*(L)} \qquad (27)$$

In stating the above relationship (27) it is important to note that it is assumed that the benefits from agglomeration of a complex activity with one transaction is greater than a routine activity with two transactions. However, if this was not the case and the benefits from agglomeration of a single complex activity were less than a routine activity with transactions then 26 would have to be rewritten as the following:

$$NA^{M1*(AC)} > NA^{IT1*(AC)} > NA^{M1*(L)} > NA^{IT1*(L)} \qquad (27a)$$

For the point of relocation:

$d \bullet \sigma^{IT1*(L)} + \beta - AA > d \bullet \sigma^{IT1*(AC)} + \beta - AA > d \bullet \sigma^{M1*(L)} + \beta - AA > d \bullet \sigma^{M1*(AC)} + \beta - AA$ (26g)

Similar to that of relationship 26 and 26a, the above relationship is dependent on the relative value of complex and routine transaction costs. Assuming one complex transaction is at least greater than two routine transactions than the above relationship (26g) would hold. However, if one complex transaction was less than two routine transactions than the above relationship would have to be re-written as follows:

$d \bullet \sigma^{IT1*(L)} + \beta - AA > d \bullet \sigma^{M1*(L)} + \beta - AA > d \bullet \sigma^{IT1*(AC)} + \beta - AA > d \bullet \sigma^{M1*(AC)} + \beta - AA$ (26h)

However, for the purpose of the analysis at this time, it will be assumed that one complex transaction is at least greater than two routine transactions as well as the benefits from agglomeration of a complex activity with one transaction is greater than a routine activity with two transactions. Thus, relationships 27 and 26g are adopted.

Considering relationship 27 and 26g in relation to one another, it can be determined that the activities in question display an inverse relationship. In other words, the ordering of 27, from greatest to least is *M1*(AC), M1*(L), IT1*(AC), IT1*(L).* In regards to 26g, the ordering from greatest to least is *IT1*(L), IT1*(AC), M1*(L), M1*(AC).* Thus, the activity that is subject to the greatest 'push' *(M1*(AC))* is subject to the lowest costs at the point of relocation and is thus subject to the greatest 'pull' force as well. On the opposite side of the spectrum, the activity subject to the lowest 'push' force *(IT1*(L))* is unsurprisingly also subject to the lowest 'pull' force as well.

Subjecting the above relationship to the notion of advanced-telecommunications where transportation costs and/or transaction costs are subject to change potentially alters the previously derived conclusions. Rewriting 23.1[r3], 23.1a[r3], 23.1b[r3] and 23.1c[r3] without transportation costs for *'IT'* activity types results in the following:

$$NA^{M1*(L)} > d\bullet\sigma^{M1*(L)} + \beta - AA \qquad (d>1) \qquad (23.1[r4])$$

$$NA^{M1*(AC)} > d\bullet\sigma^{M1*(AC)} + \beta - AA \qquad (d>1) \qquad (23.1a[r4])$$

$$NA^{IT1*(L)} > d\bullet\sigma^{IT1*(L)} - AA \qquad (d>1) \qquad (23.1b[r4])$$

$$NA^{IT1*(AC)} > d\bullet\sigma^{IT1*(AC)} - AA \qquad (d>1) \qquad (23.1c[r4])$$

Relationship 26g and 26h would be subject change, but only if the relative values of complex and routine transactions allow for it. Thus, it is still entirely possible to suggest that given the appropriate relative values of complex and routine transaction costs the relationships as expressed in 27 and 26g would remain.

In assuming that advanced-telecommunications is capable of transmitting even the most complex types of information at zero marginal cost, the distance factor becomes subject to a value of 1, which would effectively remove it from the right side as a difference between transaction costs, with respect to distance, is no longer applicable. Thus relationships 23.1[r4], 23.1a[r4], 23.1b[r4] and 23.1c[r4] would thus be rewritten as the following:

$$NA^{M1*(L)} > \sigma^{M1*(L)} + \beta - AA \qquad (d>1) \qquad (23.1[r5])$$

$$NA^{M1*(AC)} > \sigma^{M1*(AC)} + \beta - AA \qquad (d>1) \qquad (23.1a[r5])$$

$NA^{IT1*(L)} > \sigma^{IT1*(L)} - AA$ (d > 1) (23.1b[r5])

$NA^{IT1*(AC)} > \sigma^{IT1*(AC)} - AA$ (d > 1) (23.1b[r5])

Assuming 'alternative advantages' (*AA*) are of an equal value for all of the above relationships, in addition to the relative cost of transactions ($2\bullet\sigma^R>\sigma^C>3\bullet\sigma^R$), relationship 26g would be subject to uncertainty as the relative transportation costs to that of transaction costs are undefined. Assuming a complex transaction is equal to a unit of transportation ($\sigma^C = \beta$) than 26h would occur. However, clearly the assumption that '*AA*'s being uniform is an unreasonable one. Thus, depending on the relative value of the different *AA* values to one another, transportation costs as well as the different types of transaction costs an alternative relationship to that of 26h might occur. It is, however, important to further note that AA could be of such a value that the other potential costs facing activities could potentially be nominal. Such a relationship is similar to the one between net agglomeration and transaction costs stipulated at the beginning of the scenario. If so, than relocation would simply be based on the value of AA at the potential point of relocation.

4.8 Conclusion

The changing character of production from product-oriented to one of process-oriented, in conjunction with the increased spatial separation of activities involved in such processes, highlights the increasing prominence of interactions across space. Interactions effectively contain transaction costs, be it through the determination of terms, i.e. price, searching, coordination and preparation costs, as well as the transfer costs of interacting between the relevant components of production. While the following chapter will further examine the aspects relating to coordination and search costs, the previous analysis focused primarily on the transfer cost component, although not exclusively in that the initial aspects could also apply. The presence of transaction costs between components of production in and across space further necessitates certain locational considerations, and thus a contribution towards the assessment of an optimal location. Similarly, technological advancements that improve the efficiency of which such transactions are facilitated, i.e. advanced-telecommunications, in the spirit of classical location theory, would naturally contribute towards a revaluation of an applicable activity's original location.

In considering the implications of such technological advancements on the spatial structure of the urban system, a general framework was established in accordance with the locational distribution of activities, with a variation of certain activity specific production structures superimposed. In other words, like that of the relationship between the two main components of the urban system noted in chapter 2, a framework within a framework. A series of comparative-static scenarios were then induced, pre and post the applicable technological advancement, so as to establish the relative locational flexibility of the activities in question. The nature of the change induced corresponded to the second of the two types of change considered in chapter 3, this being the relocation of a given activity.

In relation to how an increase in the ability with which to interact across space influenced the location of certain activities and thus the spatial structure of the urban system, in one context the bi-directional hypothesis, to a certain degree, was effectively reaffirmed. Activities were shown as having the potential to both decentralize as well as centralize. The relative locational flexibility, or inclination towards the direction of change, was also shown to be determined by a combination of factors of which the nature and character of the activity in question was a fundamental determinant. The activity in question determined the number of interactions as well as the character of those interactions. Since interactions clearly vary in terms of method and complexity, improvements in the ability with which to interact across space were shown to influence activities that were previously inclined towards accommodating the technological shift.

However, as highlighted in section 4.4 and beyond (although implicitly considered in the initial sections), relative environmental considerations were also shown to play a significant part in influencing an activities location after the application of technological advancements. Characterized by benefits from agglomeration (*BFA*) and diseconomies (*D*) (culminating to that of net benefits [*NA*]) as well as additional advantages (*AA*), like that of number and nature of interactions, the character of the activity also defined the degree to which environmental factors were present. Having assumed an activity was located in its ideal location, which corresponded to an optimal net benefit, a locational shift as a result of the application of the increased ability with which to interact across space allowed activities to realize a relative improvement in the given activity's optimal net benefit. Furthermore, this was regardless of whether the shift that occurred was characterized as a centralization or decentralization or whether the activity in question was 'pushed' or 'pulled'.

A potential contradiction of the bi-directional hypothesis is, however, highlighted in the case where the relative transaction costs for intangible services are the highest and as a consequence are the least locationally flexible of all the activities considered. The fundamental assumption being that the nature of the information passing between the components in question is so complex that the transmission of such information would be a relatively more costly process. As previously noted, such a situation is analogous to the centralization as well as agglomeration of certain advanced producer services. In one context it suggests that advanced-telecommunications is capable of dealing with interactions that occur beyond the agglomeration in an efficient manner, but in another context it also suggests that advanced-telecommunications is less capable of dealing with interactions that require 'human contact' or contact that occurs within a given locational proximity. Thus, a pertinent question that comes to bear is whether advanced-telecommunications will ever evolve to such a level where it will be able to facilitate interactions that necessitate direct locational proximity?

The notion that advanced-telecommunications could in fact transmit even the most complex interactions is considered through the application of intangible service transactions being applied in the model as the relatively lowest of all transaction costs. Unsurprisingly, intangible services becomes the most locationally flexible of all the activities considered. Such a result could be interpreted that over time certain activities that once required 'human contact' could in fact be facilitated from a distance. As implied above, this is, however, only one perspective of centralization component of the bi-directional hypothesis, in that centralization could also be construed as a type of consolidation in space for the purpose of benefiting from certain agglomeration economies. Thus, while the improved ability with which to interact across space not only allows activities to optimize their net benefit in terms of their environment this also occurs at the level of activity (firm) as well.

Utilizing the analytical framework established in this chapter, the following chapter will consider how the Internet, or the consolidation of information in non-space, will influence the spatial structure of the urban system. As already noted, the specific aspect of the Internet under consideration relates to the aspect of transaction costs that deals with searching and coordination costs. Furthermore, while the current chapter focused on a relocation of an activity the following analysis will primarily consider the implications of an activity diffusing, the first of the two general types of change stipulated in chapter 3.

5 The implications of dynamically consolidated information becoming accessible in non-space on the spatial structure of the urban system

The dynamic consolidation of information for the purpose of organizing and accessing later has been occurring since the beginning of antiquity. In fact, one could offer the argument that antiquity, as it is known, began with the consolidation of information in one form or another (Diamond, 1998). Nevertheless, while the basic motivation for the consolidation of information has arguably been consistent throughout time, the process and techniques that have dictated the nature of the activity has evolved drastically, as personified by the overwhelming trend of labor-intensive methods of production shifting to that of capital-intensive methods of production (Bell, 1974; Castells, 1989).

One such evolution, and the focus of the examination in this chapter, is the amalgamation of the personal computer (PC) with that of the advanced-telecommunications network, which has ultimately led to the conception of the Internet, or World Wide Web (WWW) as it is also commonly referred to, as noted in chapter 4. Generally speaking, before the Internet, consolidated information was restricted to a unique point in space and subject to a distance factor (*d*; see chapter 4), forcing the locational decisions of activities involved in the consolidation of information, as well as those interacted with, to be mindful of certain spatial realities. However, as a result of the wide spread availability of the Internet, the individual and/or firm has been endowed with the opportunity to access consolidated information from any point (in space) that information, for the purpose of consolidation, can be offered, regardless of distance, and/or vice versa (to allow information to be offered for consolidation from any point that consolidated information can be accessed). While consolidated information technically still exists at a single point, an illusion that is impossible to negate has been induced, that consolidated information is no longer subject to restrictions at a single point, but appears to exist at any point that is capable, accessing or offering pertinent information.[10] As will be exhibited in the following examination, the ability to access consolidated information from a non-point in space has and will continue to bring about a redistribution of processing responsibilities within the urban system, further influencing its spatial structure not only through the relocation of activities, but also through modification of firms' structural behavior.

Before any methodical analysis is possible certain fundamental attributes require further clarification. Since the Internet deals specifically with information, an assessment of information concerning its general purpose and application, with specific reference to advanced-telecommunications is required. The impending analysis is based on, and ultimately extends, the previous chapter's model, 'The ties that bind', but as will be further stipulated, the treatment of information slightly differs between the two models.

The analysis itself consists of three sub-sections. The first section will review the assumptions as well as adaptations with regard to the previous chapter's model. The two final sub-sections involve the presentation of the models themselves. However, unlike the 'The ties that bind', the models in this chapter are more evolutionary. Feature 1, as previously noted, is the more extensive version of the

[10] For the purpose of brevity it is deemed from this point forth that the notion of consolidated information existing at any number of unique points is assumed to exist in non-space.

plain old telephone system (POTS) and is a prerequisite for feature 2, the consolidation of information shifting from a point to a non-point. Thus, in order to examine the implications of feature 2, feature 1 has to be applied to those elements under specific consideration, so as to establish their locational status before the application of the second feature.

5.1 Information and the market

As implied by the 'The ties that bind', the implications of consolidated information shifting from a unique point to a non-point in space on the spatial structure of the urban system, as already noted, is dependent on the function that consolidated information serves within the urban system, in conjunction with the method of interaction with other activities. Furthermore, the prior chapter's exploratory model indicated that technological shifts that increase the efficiency of interactions across space not only have potential structural implications on the spatial structure of the urban system, but also offers a format with which to extract further insight into the character of such changes.

Given a uniform plain, 'The ties that bind' theoretically demonstrated that the optimal location of activities is determined through the method with which interaction with other activities occurs, which is directly determined by the character of the activity in question (i.e. manufacturing [*M*], tangible service [*T*] and intangible service [*IT*]) in conjunction with the available level of technology. Changes in the technology available (i.e. improvement in advanced-telecommunications [feature 1]), which subsequently altered the cost of the interaction in question, potentially induced a reevaluation of the activity's optimal location subject to the structure the activity was involved in (i.e. economy of scale/scope/complexity or economy of localization/urbanization/activity-complex, respectively depending on ownership). As observed in sub-sections of the previous section, an improvement in advanced-telecommunications, and thus reduction in the cost of communicating across space, allowed certain activities to reevaluate their optimal location, and in doing so, utilize the opportunity to relocate and manipulate certain benefits from agglomeration (*BFA*) or locationally remote attributes (*AA*) that were previously not cost effective. Thus, like that of an intangible service endowed with the ability to communicate at zero marginal cost, it would seem logical to assert that an activity like that of one responsible for the consolidation of information becoming freely accessible at any point would be subject to a similar reconsideration. However, as will be further stipulated, while the activity responsible for consolidating information may be subject to relocation (see the first set of scenarios; scenario 1.a, 1.b.i, 1.b.ii and 1.b.iii) the function of certain types of consolidated information is more extensive in its function in modern economies and may induce far greater structural changes in the urban system than just the relocation of a few select activities (see the second set of scenarios; scenario 2.a, scenario 2.b and scenario 2.c).

5.1.1 Potential variations of the state and application of 'information' in the modern urban system

While the aforementioned assertion that a zero marginal cost of communicating could potentially induce a re-evaluation of the optimal location for activities involved directly or indirectly in the consolidation of information, the treatment of the notion of 'information' or that of an intangible service 'providing information', as employed in the previous section, is not entirely adequate when attempting to wholly implement the notion of 'consolidated information'. The notion of information was applied in a single context and while adequate for the particular examination, it did not fully acknowledge the multi-dimensional function that information potentially serves in today's modern urban systems.

In 'The ties that bind', three types of activities were introduced, two types of services and one type of manufacturing. Services that dealt with the exclusive production and distribution of information were referred to as intangible services (*IT*). Services that required interaction with a physical entity, i.e. maintenance, were referred to as tangible services (*T*). And finally, activities that produced goods were referred to as manufacturing (*M*). Due to the nature of the activities in question, access to advanced-telecommunications benefited each type of activity differently because they all receive and deliver their respective goods and services differently. However, in regards to the previous analysis, before an evaluation could occur as to how different facets of advanced-telecommunications potentially induced a reconsideration of certain activities' optimal location, a point of reference in regards to the function and value of the good and/or service had to be offered. As a means of inducing the ideal comparative situation, information had to initially be treated like that of a tangible service, which carries its value similar to that of a good, in that the value and the good are always in the same place at any given moment. So, even when intangible services were able to transmit their service across space instantaneously, the state and potential application of the service did not change, just the method of interaction.

Services that produce information in which the value does not transcend beyond the information itself, similar to the manner in which a good is valued, are not uncommon, e.g., suppliers of textbooks, census data, etc, but, as already implied, are not the only type of intangible services (*IT*) found in modern urban systems. A considerable amount of the information that is transmitted across space is *representative* of entities that cannot be transmitted in the same manner. Such behavior is indicative of the modern urban system, which is further exemplified by the observed trend of the decision making process, an obvious information rich activity, often disassociated from the production process (Gillespie and Williams, 1988).[11] The disassociation from the production process can be further explained by the 'The ties that bind', as certain activities (i.e. the decision making process) being able to redefine their optimal location to one physically away from the production process because the nature of the interaction with those factors found at the new location can be extracted more cost effectively being within physical proximity than the new cost of interacting with the production process across space via advanced-telecommunications.

5.1.2 Consolidated information and the 'market'

In regards to the activity of consolidating information, certain activities specialize in the collection and dispatch of representative information, i.e. stock exchanges and financial brokerage houses. One such type of representative information that is collected, organized and dispatched are prices, which are assembled for the purpose of exchange. A point of exchange in whatever form, is a market, further suggesting that such activities like that of a stock exchange or financial brokerage houses are effectively markets. More so, such firms are clearly disassociated from those entities with which they represent, therefore exhibiting similar behavior, spatial and otherwise, to that of head offices (see footnote 11). Thus, it would be fair to suggest that advanced-telecommunications has effectively begun to nurture a relationship

[11] It should also be noted that this general trend can be characterized through the previously stated observed occurrence of the disproportionate number of corporate head offices located in higher order urban centers, which are remotely located from the production processes that they are responsible for (Feagin and Smith, 1987).

between the market and consolidated information. As the relevant technology improves, not only has the market become increasingly integrated with consolidated information, but the physical disassociation from the very entities that it functions for has become increasingly extreme (Hepworth and Ducatel, 1992; Martinelli, 1991; Moulaert et al, 1991).

According to central place theory and urban system literature, markets are subject to certain principles of centrality (Parr, 2002). According to Parr (2002), in the spirit of industrial location theories as those of Launhardt (1885) and Weber (1909/1929), which were extended and generalized by Hoover (1937; 1948) and Isard (1956), accessibility to markets is one of four factors which influence the location of specialized-functions (the other three factors being (1) material inputs to production, (2) sources of energy and (3) supplies of labor). A firm's preference or particular orientation towards the four factors in question, most likely dictated by the nature of the firm's output, results in a greater inclination towards one location more than others, in an attempt to derive a least-cost as well as maximum profit solution.

However, as established through 'The ties that bind', while some of the previously noted factors require relatively close locational proximity, certain methods of interaction can effectively make locationally remote entities appear 'close'. Thus, a shift in possible methods of interacting could effectively modify the previously regarded orientation towards the noted factors, potentially altering a firm's inclination towards a specific location to that of another location. The Internet, in its ability to provide consolidated information to any point in space, is one such possible shift in the method of interacting that could potentially cause a re-evaluation in the preference or orientation of the previously noted four potential factors of centrality. It is, however, important to clarify that in order for such a re-evaluation to occur the transmission of consolidated information, prior to the conception of the Internet and the more extensive version of the plain old telephone system, had to be subject to distance.

5.1.3 The nature and subsequent justification of consolidated information in the urban system

Before an examination as to how accessibility to the market from any point in space influences the wider spatial structure of the urban system, it is important to further consider those involved in the consolidation of information and their defining characteristics. Consolidated information requires two definitive actors, both of which are intangible in nature, like that of an intangible service (*IT*). One is, of course, the consolidator of information, the second being the consolidated. The consolidator acts as a designated point in space with which a certain type of representative information is expected to exist. As implied by their assigned terms, the consolidator collects and/or accepts the pertinent information from those who wish to be consolidated and processes and/or organizes the information accordingly for more efficient access. As already suggested in the previous sub-sections, both the consolidator and consolidated are highly influenced by the available level of technology, which not only determines the efficiency with which both participants interact, but in regards to the consolidator, the necessary market size required to sustain operations.

Thus, the task of the following sub-section is to further define the logic for the act of consolidating information in an economic geography context and the pertinent attributes that govern such an occurrence. These notions will then be extended into the realm of market functions, thus further validating the role consolidated information plays in the urban system. After having considered the market and consolidated information, a brief non-spatial model will be offered, further exemplifying how consolidated information and those activities wishing to be consolidated interact with one another and the factors that sustain their relationship. Once their relationship has been established, the implications of technology shifts will be considered in regards to how such changes potentially influence the relationship between the two participants. As will be further noted, the application of technology onto the relevant components inherently introduces the notion of space into the consideration.

5.1.4 A non-spatial justification for the existence of consolidators within the urban system

The incidence of consolidated information, in any given context, lends itself well to economic geography's terms and concepts. Placing information related or otherwise in the same environment creates an agglomeration of sorts, which potentially reduces costs, relative to a situation where the co-functioning attributes were unassociated. A saving in cost is achieved through the manipulation of economies of scale, or economies of localization (this depends on the number of components involved and the ownership of those components). In real terms, the occurrence of the agglomeration can be explained as the aggregate reduction in the number of transactions facilitated, translating further into a reduction in the operating costs for those that require the consolidated information.

In accordance with market functions, assuming a good or service requires multiple components, a financial brokerage house or stock exchange also serves as a type of production coordinator, as price for a given good or service is an inherent indicator of quantity and quality. Thus, the consolidation of pricing information serves two purposes; the first is as a method to cut total costs through the manipulation of economies of scale/localization and the second is the coordination of production through its inherent facilitation of market functions.

In an attempt to further exemplify how the dual process manifests itself as an integral component of the production process, thus justifying its presence in the urban system, a brief, but effective model follows:

Assume there are six unique points in space, A, B, C, D, E, and F, all which produce a single unit of the unique good, *A*, *B*, *C*, *D*, *E*, and *F*, respectively, per period. In addition to each point's production efforts, each point is also involved in the assembly of a unit of good *X* per period, which is supplied to the local market. Each unit of *X* requires 12 units, which have the same assembly cost at each of the 6 points. Of the 12 units, 6 have to be *A*, *B*, *C*, *D*, *E*, and *F*, while the remaining 6 can be any combination of *A*, *B*, *C*, *D*, *E*, and *F*, as after the initial 6 all units are perfect substitutes of one another.[12] While transportation costs are assumed to be zero, on account of the model being non-spatial in nature, in each period all units are subject to a unique fluctuation in price. As a result of price fluctuations, each point of production is forced to inquire about each price before the beginning of every period, so as to maximize profits through the minimization of production costs. In the absence of a consolidator of pricing information, each activity is required to contact

[12] This assumption is similar to the Solow growth model where labor and capital are assumed as substitutes for one another (Solow, 1956).

each unique point at a cost of δ (see figure 5.0). However, if a consolidator is present, which will be assumed to exist at point G, each point is required to make a single inquire at a cost of ϕ (see figure 5.1).[13]

Figure 5.0 A graphical representation of the necessary interactions between firms in a given market in the absence of a consolidator.

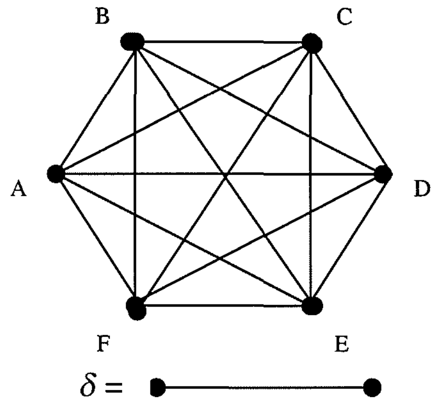
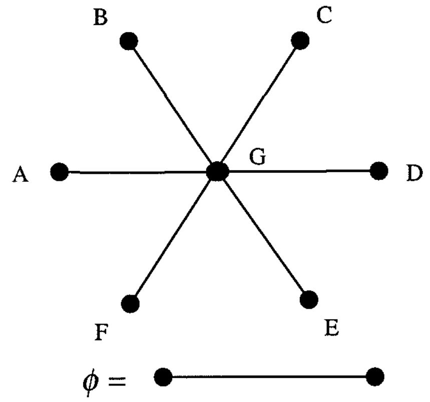


Figure 5.1 A graphical representation of a consolidator (G) facilitating the necessary interactions between firms.



Thus, if $\phi < \delta$ were true than there is no doubt that a the consolidator would be a cost effective option for all of the six activities involved; the reason being, the required sole inquiry to a consolidator is less than one of the required five to each of the activities involved. If the opposite were true, however, and $\phi > \delta$, than the presence of a consolidator would be determined by the relative value of the two types of inquiry, which is further determined by the number of inquiries that would be required in the absence of a consolidator. For example, if ϕ was greater than five times the cost of δ than a consolidator would not be a cost effective option. Or, another pertinent scenario would be if there were less activities involved in the production of X, which assuming $\phi > \delta$ still applies, would suggest that if ϕ was less than the number of activities multiplied by δ, a consolidator would be a cost effective

[13] This is assuming each additional inquiry the consolidator incorporates into its operations is at zero marginal cost.

option. Thus, it can be further concluded that in the situation of $\phi > \delta$, a *critical mass* exists that is determined through the relative costs of the previously noted relationship. In this given scenario, it is the cost of using the consolidator relative to the cost of an inquiry with a single activity times the number of relevant activities.

The aforementioned notion of a 'critical mass' does not, however, solely apply to the minimum number of potential inquires at which those activities allowing themselves to be consolidated would deem as a cost effective option. Since the consolidator is, of course, an activity, it is thus subject to an operating cost as well. As noted in the previous sub-section, the level of technology determines the necessary market size required to sustain operations. Or, as suggested by the above relationship, $\phi > \delta$, a certain number of activities that wish to be consolidated are required to participate in the consolidator's service, so as to induce a situation where relative costs would justify the presence of the consolidator's service. Thus, the greater the number of activities that allow themselves to be consolidated the larger the potential benefit to the user utilizing a consolidator. This would further suggest that a relationship between the potential number of inquires facing a consolidated activity to that of costs saved from using a consolidator is present.

As previously noted, an improvement in the 'processor' and 'carrying capacity', through a technology shift, not only increases the ability to transmit larger amounts of information in a given interval of time, but also increases the relative efficiency of a consolidator's operations as well. The enhancement of both the ability to interact across space and the consolidator's capacity to process and organize information related to consolidated activities is through the previously noted integration of both the processing of transmissions as well as processing and manipulation of information, as facilitated by a PC. Thus, an increase in the efficiency of the consolidator's ability to operate would effectively reduce operating costs, further translating into the necessary market size being relatively smaller. As suggested by the above relationship, $\phi > \delta$, because the cost of using the consolidator's service is less, the number of inquiries a potentially consolidated activity would have to make in order for a consolidator to be cost effective would be less.

A decrease in the necessary market size, however, creates a slight incongruity that will be of particular relevance in the following sub-sections. As previously suggested, improvements in advanced-telecommunications have been nurturing the unique relationship between the market and consolidated information, more specifically, as technology improves so does the integration of consolidated information and the market. This, for all intents and purposes has been largely explained by 'The ties that bind', similar to the previously explained notion of the decision making process becoming locationally disassociated from the production process, assuming a component of an activity, or an activity in its entirety, has free movement in space, its optimal location will be at a point that will provide it with the greatest net benefit. The usefulness of information, as exemplified by a library, corresponds to its size and value, which is directly determined by the number of users it can benefit and the extent of such benefits. Thus, it seems logical to assert that if information can consolidate, so that it may benefit from agglomeration economies, it will. The incongruity that comes to bear is that as the market becomes larger, due to its improved accessibility provided through advanced-telecommunications, the equipment required to facilitate such markets requires a smaller market to sustain itself. As will be exemplified in the scenarios to follow, this incongruity has helped, and will most likely continue to help, shape structural transformations in the urban system through redefining the basic structure of the firm.

5.2 The analysis

The next component of this chapter will be the examination of how consolidated information moves from a unique point to a non-point in space and the potential impact of such a shift on the spatial structure of the urban system. As noted in the earlier sub-sections, the analysis will be based on the variation of the central place format that was implemented for 'The ties that bind'. Thus, the three types of activities (tangible services [*T*], intangible services [*IT*] and manufacturing [*M*]) as well as possible variations in their structure (economy of scale/scope/complexity or economy of localization/urbanization/activity-complex, depending on ownership, respectively) still apply, as well as those assumptions that govern their interaction, and locational behavior, are assumed as carrying over as well ('4.1 The assumptions and structure of the model' for the applicable assumptions). However, as will be further stipulated, certain adaptations have been implemented to accommodate those technical realities noted in earlier sub-sections.

'The ties that bind' focused on the implications of the improved ability to interact across space. In attempting to evaluate such affects, a relative consideration of an urban system pre- and post-technological shift was conveyed. The impending models are similar in their analytical framework, in that comparative scenarios with respect to periods will be induced through the application of technological shifts. However, the focus of this current analysis is also on certain activities, specifically the consolidator and the consolidated, and how changes in their productive abilities', as well as their ability to interact, potentially influence their locational behavior and thus the spatial structure of the urban system.

The following model thus effectively integrates aspects of the examination in the previous section, building on and ultimately extending their main themes. For example, in sub-section 4.2 of the previous chapter, a shift in the productive capabilities of specific individual components of certain activities was induced (for example, 4.2.1: $M1 \rightarrow M1^*$; 4.2.4: $IT \rightarrow IT^*$; 4.2.5: $T \rightarrow T^*$) of which the implications on the spatial structure of the urban system were evaluated. However, as noted in the brief review of the relevant technology, the advancement of such devices responsible for the consolidation of information, one of many facets of the post-industrial movement, further suggests an overall decline in the number of the necessary components in conjunction with a relative increase in the efficiency of a single component. The motivation for both changes are the same (an increase in production efficiency), however, as will be further stipulated in the following paragraphs, the physical impact on the activity in question, in accordance with the format of the model, would suggest alternative reactions.

Thus, the following examination will consider the location of the activity responsible for the consolidation of information in the urban system (scenario 1.b). This, however, will be preceded by the spatial application of the previous non-spatial justification for the presence of a consolidator of information presented in the previous sub-section (scenario 1.a). Scenario 1.a does not simply act as a means of justifying the presence of a consolidator of information pre-technology shift in a spatial context, but also provides the opportunity to integrate, and thus validate the activity of consolidating information into the previously established analytical framework, while providing a valuable point of departure with which to consider the implications of those technology shifts in question.

Scenario 1.b will be followed by scenario 1.b.i, which is simply the reconsideration of the location of the activity responsible for consolidating information after the application of feature 1 (a more extensive version of the plain old telephone system). As already noted, feature 1 is a prerequisite for feature 2 (consolidated information shifting from a point to a non-point). Thus, considering the potential optimal location of consolidated information pre- and post feature 1, similar to scenario 1.b, not only validates the present examination by conforming to the previous section's model and assertions, but also confirms the location of the activity in question before the application of feature 2 as well. For similar reasons to that of scenario 1.b and 1.b.i, scenario 1.b.ii will consider the location of those activities that allow their information to be consolidated, relative to their interaction with the consolidator as well as the activity they are meant to be serving. The first set of scenarios (1.a, 1.b, 1.b.i and 1.b.ii), as implied in the previous set of paragraphs, has more of a preparatory role in this current examination. As will be further stipulated, the second set of scenarios extend upon the fundamental notions established through, 'The ties that bind'. However, before adapting the consolidator and consolidated in this current theoretical context it is essential that they are dynamically integrated into the previously established notions of the 'The ties that bind.'

The second set of scenarios extends upon the first set through the consideration of the second technological shift, as represented by feature 2, or the inducement of consolidated information shifting from a point to a non-point. In a purely technical context the reasoning for this phenomenon has been previously acknowledged, however, in brief, the second technological shift is the continued improvement of 'the processor', in conjunction with the arrival of 'binary code' and 'network protocol'. This, as already noted, is not only responsible for the reduction in the number of components required for the activity responsible for the consolidation of information, but the notion that less components are further associated with a smaller market size. As will be further stipulated and ultimately exhibited through the analytical framework, such technical advancements lead to the redistribution of processing responsibilities, analogous to the process of diffusion conveyed in chapter 3, which further translates into changes in the spatial structure of the urban system.

5.2.1 Adaptations to the model

Before implementing the aforementioned scenarios and thus models, it is important to introduce, as well as justify, the previously noted adaptations to the prior chapter's analytical framework. Such adaptations are a result of an attempt to accommodate certain technical realities that have come to bear through the review of the technology that has been involved in the development of the Internet. In the previous section, the transmission of information across space was simply determined through the transaction costs (σ) and the distance factor (d), and because both intangible and tangible entities were being considered, at times, transportation costs (β). The distance factor was meant to capture the notion that the cost of an interaction between two unique points was subject to distance. Therefore, the distance factor, as well as transportation costs, applied to transaction costs increased linearly subject to distance. Thus, when attempting to examine the implications of the ability to transmit an intangible service across space at zero marginal cost the distance factor and transportation costs were simply removed.

The inclusion or exclusion of the distance factor represented two extremes. When included, it indicated that transaction costs were subject to distance, while when it was excluded, it suggested that the technological level of advanced-telecommunications was capable of transmitting the information in question instantaneously, which was, of course, the general concept conveyed through feature 1 and thus the motivation for the analysis. While this method was valid for the analysis in question, more so because it incorporated the previously stated transition of the cost function from one of *distance* to one of *infrastructure*, it failed to explicitly incorporate the notion that telecommunications, regardless of the level of technology, is capable of transmitting any given piece of information across space (although arguably implicit through the value of 'd'). Rather, variations were imposed through the introduction of relative level transaction costs subject to the type of activity. As noted in chapter 4, the cost of transmitting information across space is a function of its volume (V) (or complexity, which is assumed to be positively correlated), in conjunction with the ability of the level of technology available (information per unit of time [i / t]).

However, as already suggested, the cost of interacting across space has not been, nor is, simply a case of the amount of information and the speed at which it is passed. Physical distance, albeit an increasingly less significant factor as advanced-telecommunications continues to improve in its ability to transmit larger amounts of information faster, did and still does factor into the cost of communicating across space. In attempting to express the evolutionary nature of advanced-telecommunications and how such variations in the level of technology influence the cost of transmitting information across various distances, the distance factor will be expressed as the distance in question divided by the amount of information (i) per unit of time (t) [i / t].

Distance factor[14] (DF) = d / (i / t) (1)

The *value* of information per unit of time (i / t), however, will range between zero and the distance in question ($0 < i / t < d$). The lower the value for information per unit of time i.e. $0 < i / t < d \bullet 1/2$, which, of course, suggests a relatively less capable telecommunications system is being operated, resulting in a higher distance factor, and thus the greater the cost of interacting across space. Conversely, the higher the value for information per unit of time i.e. $d \bullet 1/2 < i / t < d$, the relatively smaller the cost of interacting across space. Thus, as the value for information per unit of time increases and the distance factor approaches a value of 1, which as previously noted, is meant to represent the availability of a relatively more capable telecommunications system, the issue of distance becomes less of a factor. It is important to further note that the above function tends captures the realistic situation of efficient interaction across space is becoming less related to the space between points and more related to the infrastructure that exists within the points.

After having determined the level of technology, which further determines the value of the information per unit of time, the volume (V) of the information intended for transmission is then multiplied to the distance factor to further assess the cost of the interaction across space. With regards to 'The ties that bind' prior to the application of feature 1, the volume variable could be related to transaction costs (σ)

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[14] It is important to note that in the previous section the 'distance factor' was represented by '*d*', while in this section, due to the added complexities, will be denoted by '*DF*'.

of either three activity types as well as the transportation costs (β) when it applied to intangible services (*IT*). After the introduction of feature 1, volume would be associated with just transaction costs, since transportation costs for intangible services had been removed.

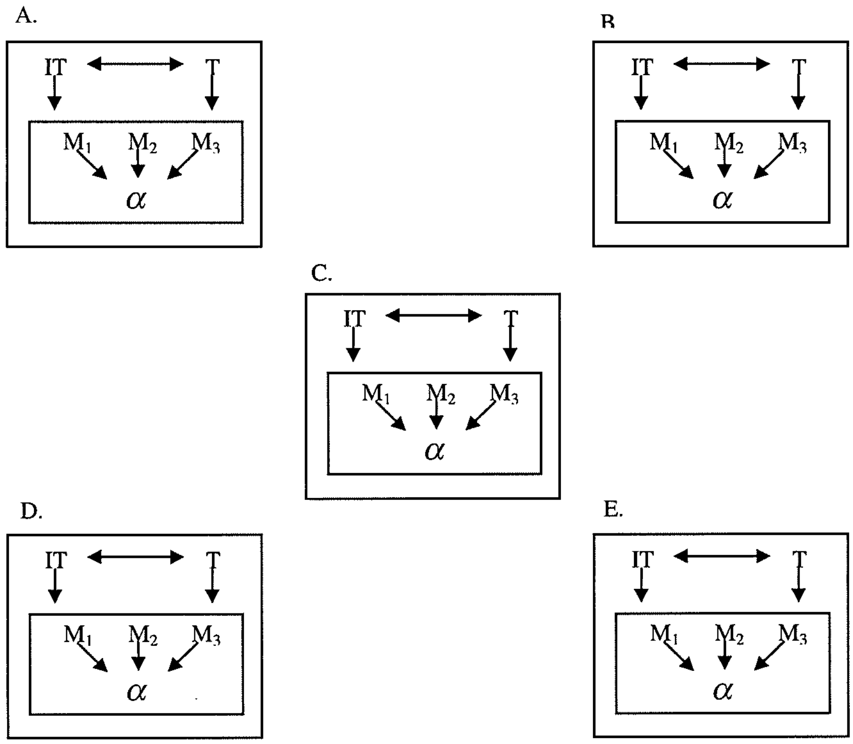
Another adaptation is based on the prior suggestion that the improvement of advanced-telecommunications has been responsible for facilitating the physical separation between the market of tangible goods and the information relating to those goods. Considering the previously derived analytical framework, the presence of only one tangible good (α) was assumed to be present, albeit the result of several processes. This situation does not lend itself to justifying an activity that facilitates consolidated information, because as stipulated in the non-spatial justification, numerous components have to be present if any benefit from economies of scale is to be realized. Thus while the possibility of benefiting from economies of scale remains from the previously established model, the process of *M1*, *M2* and *M3* do not only represent processes, but *tangible inputs* necessary for the production of α, which will continue to be exported beyond the urban system in question.

Finally, as suggested in the previous chapter (chapter 4) and sub-sections, concerning the cost of communicating across space, the improved ability of advanced-telecommunications has begun to shift the emphasis from one of distance to one of infrastructure. In an attempt to express this notion via the model, interactions will be deemed to occur between activities, regardless of their location, rather than points. Thus, as will be observed in the following examinations, activities will not only interact with one another across space, but potentially the same point as well. This practice was not implemented in the previous chapter for reasons of simplicity, although the removal of '*d*' did partially convey such a notion, it should however be noted that if it was the outcome would have been identical.

5.2.3 Scenario 1.a – Spatial application of the non-spatial justification for the presence of consolidated activity in the urban system.

While any one of the figures from the prior section can be adopted as a format for a spatial application of the previously established non-spatial justification for the presence of the activity responsible for the consolidation of information in the urban system (5.2.3), figure 4.0, which will be renamed figure 5.2 for this chapter's use, will be adopted because of the presence of uniform points.

Figure 5.2 'M's involved in an activity-complex



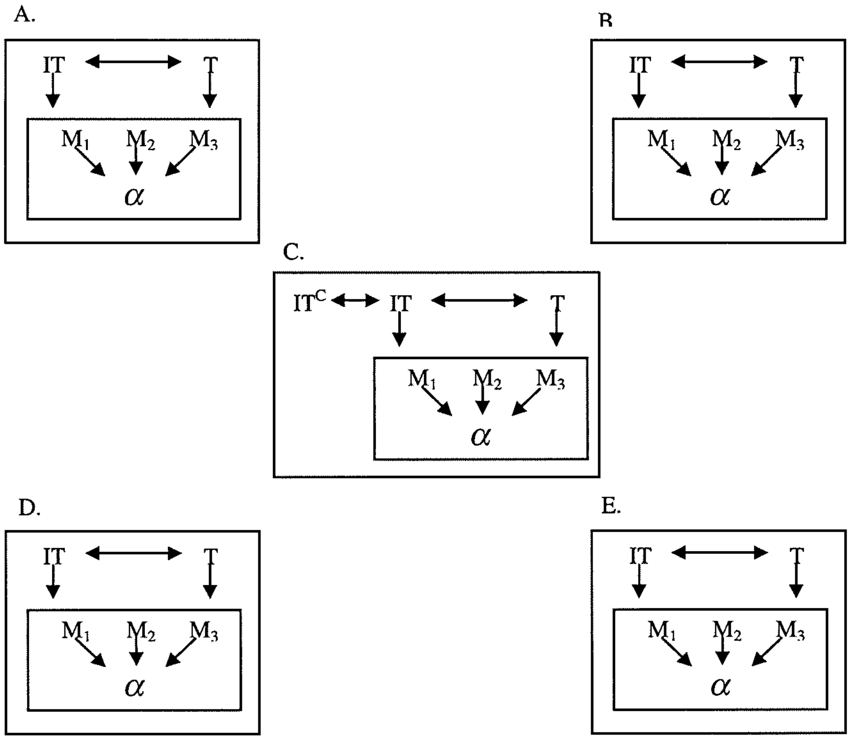
Of the three inputs, *M1* will be assumed as being produced locally, while each *M2* and *M3* are imported from beyond the urban system in question from potentially more than one source. Like that in the non-spatial model, the prices of all potential imports are assumed to be subject to fluctuations each period. It is further assumed that α is produced in the most efficient manner possible. Thus, due to price fluctuations, pursuit of cost effective production and the realistic predicament of imperfect information, attempts to produce α in a cost effective manner necessitates a reevaluation of each price from every source each period.

Thus, the presence of a consolidator of pricing information, as suggested by the previously established relationships: $\phi > \delta$ and $\phi < \delta$, is determined by the relative values of both ϕ and δ. If the latter relationship were true ($\phi < \delta$), in that a sole inquiry to a supplier of either *M2* or *M3* was greater than an inquiry to a consolidator, then a consolidator would no doubt be present. If the former were true ($\phi > \delta$), then much like in the non-spatial justification, it would be determined by the relative value of both an enquiry to a supplier and consolidator and the number of potential suppliers. For example, assuming there were at least two suppliers for both *M2* and *M3*, as so long as ϕ was less than four times δ a consolidator would be a cost effective option.

5.2.4 Scenario 1.b – The location of the activity responsible for the consolidation of information in the urban system in question pre-technology shift #1

Assuming a distance factor is present ($0 < i / t < d \bullet 1/2$), as pre-technology shift #1 would further suggest, in conjunction with all points within the urban system in question being uniform, as well as the assertion that the interaction between the activity responsible for the consolidation of information and the consolidator is equal, the location of the activity responsible for the consolidation of activity would tend to locate at point C (the central point [see figure 5.3]). This logic is similar to the previous section's sub-section 4.2, in that the central point offered the lowest total aggregate f.o.b. pricing to all points in question.

Figure 5.3 'M's involved in an activity-complex, with the addition of the activity responsible for the consolidation of information



Assuming the interaction between IT^C was with the IT activity at each of the points A, B, C, D and E, the total aggregate cost of interacting across space could be calculated as follows:

$$[C(IT^C)] \rightarrow \begin{bmatrix} A(IT) \\ B(IT) \\ C(IT) \\ D(IT) \\ E(IT) \end{bmatrix} = d \qquad (2)$$

$$\mathrm{DF} \bullet V = \left(\frac{d}{i/t} \right) \bullet V = \Sigma^{A} \qquad (0 < \mathrm{i} / \mathrm{t} < \mathrm{d} \bullet 1/2) \tag{3}$$

In considering an alternative location within the urban system in question a random, under identical constraints, Σ would require reconsideration.

$$[A(IT^{C})] \rightarrow \begin{bmatrix} A(IT) \\ B(IT) \\ C(IT) \\ D(IT) \\ E(IT) \end{bmatrix} = d^{*} \tag{4}$$

$$\mathrm{DF} \bullet V = \left(\frac{d^{*}}{i/t} \right) \bullet V = \Sigma^{B} \qquad (0 < \mathrm{i} / \mathrm{t} < \mathrm{d} \bullet 1/2) \tag{5}$$

$$\Sigma^{B} > \Sigma^{A} \tag{6}$$

As observed in figure 5.2 and 5.3, while points *B*, *C* and *D* are of the same distance from *A* as point *C* is from *A*, *B*, *D* and *E*, point *E* is twice as far from *A* as anyone of the points is from *C*. Therefore, it can be asserted that $d^* > d$, which assuming the volumes (V) in question are identical, as well as the available technology, $\Sigma^B > \Sigma^A$. Thus, if the interaction between points is subject to distance and all the points are uniform the locational decision of the activity responsible for the consolidation of information will adhere to the principles of centrality.

5.2.5 Scenario 1.b.i – The location of the activity responsible for the consolidation of information in the urban system in question post-technology shift #1

In accordance with 'The ties that bind', this next scenario considers the implications of an improvement in the ability to transmit larger amounts of information faster, which would suggest that the distance factor approaches a value of one. Maintaining the previously stated assertions that all points in the urban system in question are uniform as well as the interaction between the activity responsible for the consolidation of information and the consolidator to all points is equal, it can be asserted that speaking in the most technical sense, only if the distance factor is a value of one does the activity responsible for consolidating information have the ability to locate any where throughout the urban system.

$$[C(IT^C)] \rightarrow \begin{bmatrix} A(IT) \\ B(IT \\ C(IT) \\ D(IT) \\ E(IT) \end{bmatrix} = d \qquad (7)$$

$$\mathrm{DF} \bullet V = \left(\frac{d}{i/t} \right) \bullet V = \Sigma^C \qquad (d \bullet 1/2 < i / t < d) \qquad (8)$$

$$[A(IT^C)] \rightarrow \begin{bmatrix} A(IT) \\ B(IT) \\ C(IT) \\ D(IT) \\ E(IT) \end{bmatrix} = d^* \qquad (9)$$

$$\mathrm{DF} \bullet V = \left(\frac{d^*}{i/t} \right) \bullet V = \Sigma^D \qquad (d \bullet 1/2 < i/t < d) \qquad (10)$$

$$\Sigma^D > \Sigma^C \qquad (11)$$

As observed in the above relationships, where *i / t* is less than *d*, much like that in the previous sub-section (scenario 1.b), $\Sigma^D > \Sigma^C$. Furthermore, if the distance factor does not equal one than the activity responsible for consolidating information will continue to locate at point *C*. However, if *i / t* is equal to *d*, than as observed in the following set of relationships the cost of interacting across space, regardless of distance, any and all interactions will be equal.

$$\left[C(IT^C)\right] \rightarrow \begin{bmatrix} A(IT) \\ B(IT) \\ C(IT) \\ D(IT) \\ E(IT) \end{bmatrix} = d \qquad (12)$$

$$\mathrm{DF} \bullet V = \left(\frac{d}{i/t} \right) \bullet V = \Sigma^E \qquad (i/t = d) \qquad (13)$$

$$\left[A(IT^C)\right] \rightarrow \begin{bmatrix} A(IT) \\ B(IT) \\ C(IT) \\ D(IT) \\ E(IT) \end{bmatrix} = d^\circ \qquad (14)$$

$$\mathrm{DF} \bullet V = \left(\frac{d^{\circ}}{i/t} \right) \bullet V = \Sigma^{F} \qquad (\mathrm{i} / \mathrm{t} = \mathrm{d}) \qquad (15)$$

$$\Sigma^{F} = \Sigma^{E} \qquad (16)$$

As a result of the distance factor being valued at one, $\Sigma^F = \Sigma^E$ further suggests that the activity responsible for the consolidation information could location any where throughout the urban system in question.

5.2.6 Not uniform?

The prospect of an urban system in which the points are not all uniform, further suggests that even if the distance factor is not a value of one the optimal location could potentially be something other point *C*. 'Non-uniform' refers to the possibility of certain locations containing advantages or disadvantages that may decrease or increase the cost of providing consolidated information, respectively. Thus, it would be entirely possible to suggest that certain advantages that may exist at points other than point *C* could reduce the cost of facilitating the activity responsible for the consolidation of information to such a extent that even with additional transport and/or interaction costs, it may still be more beneficial to locate at the point that is not point C.

In attempting to methodically evaluate the potential optimal location for IT^C in an urban system with unequal points, the cost of IT^C, as it would exist at each of the five points, is subject to reconsideration. The relative cost function of IT^C, as it locates at each of the points in question, will be comprised of the respective distance factor, of which *A*, *B*, *D* and *E* are, of course, equal, multiplied by the volume of the information transmitted (*DF•V*). The second component of the cost function will be potential advantages and/or disadvantages that are present at the location in question. As in the previous chapter, these two factors, advantages and disadvantages, were deemed benefits from agglomeration (*BFA*) and diseconomies (*D*), respectively, and were further assumed as culminating into net agglomeration (*NA*).

It is important to further note, as stated in the previous chapter, that the relative values of *BFA* and *D* at a given point in the urban system has further implications on whether a point is a desirable location or an undesirable location. If $BFA > D$ was assumed for a given activity at a given point, it could be suggested that the potential advantages at the point are greater than the potential disadvantages, which further suggests that the location was 'pulling' the activity towards the point. Conversely, if $D > BFA$ was assumed for a given activity at a given point, it could be suggested that the point in question offers more of a disadvantage if the activity was to locate at the point, further suggesting that the location in question was 'pushing' the activity away from the point.

Also of particular relevance, are the implications of the relative net agglomeration values on the possible optimal location of a given activity. For example, two points within an urban system may demonstrate positive net agglomeration values ($BFA > D$). However, assuming potential interaction costs from the two points in question are equal, an activity would be more inclined towards the point that contained the greatest net agglomeration value. It is important to note for the purpose of the examination, that similar to the format in the previous section, *BFA*, since it is an advantage and thus a cost-reducing element will be considered a negative value, while *D*, since it is a disadvantage and thus a cost inducing element will be considered as a positive value.

Thus, in deriving the relative cost of IT^C locating throughout the urban system both the value of the interaction, from the respective location, between that of the activity responsible as well as require consolidated information, of whom are located throughout the urban system, add to the respective net agglomeration, which, of course, could be either positive or negative.

$$\mathrm{DF}^{*} \bullet V + \mathrm{NA}^{(A)} \tag{17}$$

$$\mathrm{DF}^{*} \bullet V + \mathrm{NA}^{(B)} \tag{18}$$

$$\mathrm{DF} \bullet V + \mathrm{NA}^{(C)} \tag{19}$$

$$\mathrm{DF}^{*} \bullet V + \mathrm{NA}^{(D)} \tag{20}$$

$$\mathrm{DF}^{*} \bullet V + \mathrm{NA}^{(E)} \tag{21}$$

Assuming the i / t is less than d ($i / t < d$) and the net agglomeration at each of the points is equal ($NA^{(A)} = NA^{(B)} = NA^{(C)} = NA^{(D)} = NA^{(E)}$) then, as suggested by the previous sub-section, the activity responsible for the consolidation of information will locate at point *C* because $DF \bullet V$ is less than $DF^{*} \bullet V$ ($DF \bullet V < DF^{*} \bullet V$).

$$\mathrm{DF} \bullet V + \mathrm{NA}^{(C)} < \mathrm{DF}^{*} \bullet V + \mathrm{NA}^{(A)} = \mathrm{DF}^{*} \bullet V + \mathrm{NA}^{(B)} = \mathrm{DF}^{*} \bullet V + \mathrm{NA}^{(D)} = \mathrm{DF}^{*} \bullet V + \mathrm{NA}^{(E)} \tag{22}$$

Similarly, if i / t was equal to d ($i / t = d$), which would dictate a distance factor with a value of one, the location of the activity responsible for the consolidation of information could feasibly locate at any of the points in the urban system while experiencing no more or less of an advantage or disadvantage.

$\mathrm{DF}^{*} \bullet V + \mathrm{NA}^{(A)} = \mathrm{DF}^{*} \bullet V + \mathrm{NA}^{(B)} = \mathrm{DF} \bullet V + \mathrm{NA}^{(C)} = \mathrm{DF}^{*} \bullet V + \mathrm{NA}^{(D)} = \mathrm{DF}^{*} \bullet V + \mathrm{NA}^{(E)}$ (23)

Maintaining the previously stated assumption of i / t being equal to d ($i / t = d$), but assuming a random hierarchy of values is present in regards to net agglomeration, as further stated in relationship 24, will reorder the inclination the activity responsible for the consolidation of information has towards specific points in the urban system.

$$\mathrm{NA}^{(A)} > \mathrm{NA}^{(B)} > \mathrm{NA}^{(C)} > \mathrm{NA}^{(D)} > \mathrm{NA}^{(E)} \qquad (24)$$

Since all net agglomeration values are positive it can be further suggested that all points in question have more disadvantages (D) than advantages (BFA) ($D > BFA$). Thus, in considering the optimal location for the activity responsible for the consolidation of information, under the assumption that the distance factor is a value of one, it can be declared that the point with the least net agglomeration will also be the most desirable location. Therefore, as suggested by relationship 24, the most desirable location for the activity responsible for the consolidation of information is as follows: *E*, *D*, *C*, *B* and *A*, as further expressed through relationship 25.

$\mathrm{DF}^{*} \bullet V + \mathrm{NA}^{(A)} > \mathrm{DF}^{*} \bullet V + \mathrm{NA}^{(B)} > \mathrm{DF} \bullet V + \mathrm{NA}^{(C)} > \mathrm{DF}^{*} \bullet V + \mathrm{NA}^{(D)} > \mathrm{DF}^{*} \bullet V + \mathrm{NA}^{(E)}$ (25)

However, if the distance factor is not a value of one, than it could be possible that the difference in disadvantages between that of point *A* and *C*, may not be great enough to account for the additional interaction costs that the activity responsible for the consolidation of information would experience if it were to locate at point *A*. However, if the difference in the potential disadvantages were greater than the additional interaction costs, as a result of locating at point *A*, then point *A* would remain as the optimal location. This can be expressed in the following terms:

$$DF^{*} \bullet V - DF \bullet V = \lambda \tag{26}$$

$$NA^{(C)} - NA^{(A)} = \eta \tag{27}$$

$$\lambda > \eta \tag{28}$$

Thus, if the value of λ is greater than the value of η (relationship 28) than point *A* will remain as the optimal location. Similarly, if the difference in potential disadvantages between that of point *B* and *C* (point *B* containing the lesser of the disadvantages as expressed through relationship 24) was large enough to account for point *C*'s relative cost advantage when interacting across space, point *B* would also be a more optimal location for the activity responsible for the consolidation of information than point *C*.

$$DF^{*} \bullet V - DF \bullet V = \lambda \tag{26}$$

$$NA^{(C)} - NA^{(B)} = \upsilon \tag{29}$$

$$\lambda > \upsilon \tag{30}$$

5.2.7 Scenario 1.b.ii – The location of the consolidated activity relative to the location of the activity responsible for the consolidation of information in the urban system in question pre- and post-technology shift #1

The final consideration of the first set of scenarios is the examination of the implications of technology shift #1 on the location of the activities that allow their information to be consolidated. Much like in the previous set of scenarios, it will be assumed that figure 5.3 will represent the structure of the urban system in question and the component labeled *IT*, will represent the entity that IT^C interacts with at each of the respective points.

In addition to the newly established interaction between *IT* and IT^C, is *IT*'s original interaction with two separate entities: tangible services (*T*) and the whole of the manufacturing components (*M1*, *M2* and *M3*). Thus, as suggested by the central principles of 'The ties that bind', it remains to be determined whether it would be more beneficial for *IT* to locate at point *C* and interact with *T* and the whole of the manufacturing components from a distance, or to remain at the original location and interact with IT^C from a distance, as expressed through figure 5.4a and 5.4b.

Figure 5.4a IT nor benefiting from economies of scale

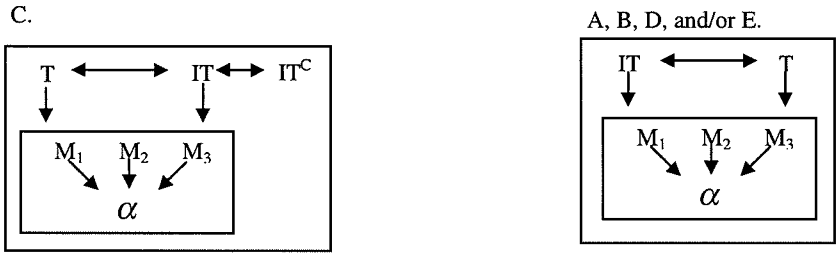
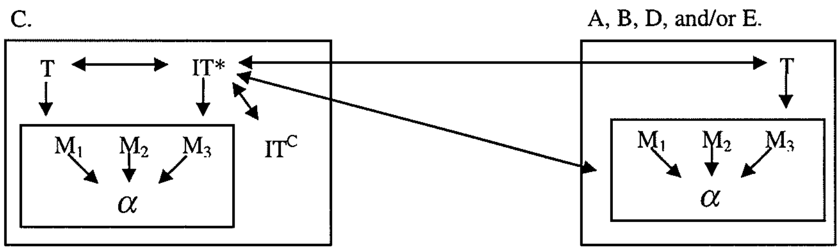


Figure 5.4b IT benefiting from economies of scale



The analysis for this sub-section will consider the locational restraints facing a single IT component, selected at random, which will be representative of all IT components originally located on the periphery (points *A*, *B*, *D* and *E*). The interaction between *IT* and IT^C across space is almost identical to the one established through relationship 2 and 3 in scenario 1.b, except for the fact that relationship 2 totaled the four interactions into one. The single interaction between *IT* and IT^C, pre-technology shift #1, can be expressed as follows:

$$[A(IT)] \rightarrow [C(IT^C)] = d* \qquad (31)$$

$$\mathrm{DF} \bullet V = \left(\frac{d*}{i/t} \right) \bullet V = \Sigma^G \qquad (0 < i/t < d \bullet 1/2) \qquad (32)$$

Similarly, the interaction between *IT* and *T* as well as the whole of the manufacturing components, both which occur at point *A*, can be expressed as follows:

$$[A(IT)] \rightarrow [A(T)] = d^{\bullet} \quad (33)$$

$$\mathrm{DF} \bullet V = \left(\frac{d^{\bullet}}{i/t} \right) \bullet V = \Sigma^{H} \qquad (0 < i / t < d \bullet 1/2) \quad (34)$$

$$[A(IT)] \rightarrow [A(M1, M2, M3)] = d^{\bullet} \quad (35)$$

$$\mathrm{DF} \bullet V = \left(\frac{d^{\bullet}}{i/t} \right) \bullet V = \Sigma^{I} \qquad (0 < i / t < d \bullet 1/2) \quad (36)$$

Thus, the cost of *IT* locating (remaining) at point *A* can be expressed as follows:

$$\Sigma^{G} + \Sigma^{H} + \Sigma^{I} = \Sigma^{GHI} \quad (37)$$

It is important to further note that, as established in the previous scenario, assuming the points in the urban system in question were not uniform, *IT* would be subject to certain relative agglomeration economies and diseconomies, which may ultimately reduce or increase total costs. However, since any net agglomeration values would simply be assigned, it has been assumed that all points within the urban system are once again uniform.

Thus, if *IT* were to locate at point *C*, the above relationships would be subject to reconsideration. Firstly, the interaction between *IT* and IT^{C} would be a local one and secondly, instead of the one interaction between two unique points, *IT* would be subject to two.

$$\left[C(IT^{C})\right] \rightarrow \left[C(IT)\right] = d^{\bullet} \tag{38}$$

$$\mathrm{DF} \bullet V = \left(\frac{d^{\bullet}}{i/t} \right) \bullet V = \Sigma^{J} \qquad (0 < \mathrm{i} / \mathrm{t} < \mathrm{d} \bullet 1/2) \tag{39}$$

Similarly, the interaction between *IT* and *T* as well as the whole of the manufacturing components, both which occur at point *A*, can be expressed as follows:

$$\left[C(IT)\right] \rightarrow \left[A(T)\right] = d\,* \tag{40}$$

$$\mathrm{DF} \bullet V = \left(\frac{d^{*}}{i/t} \right) \bullet V = \Sigma^{K} \qquad (0 < \mathrm{i} / \mathrm{t} < \mathrm{d} \bullet 1/2) \tag{41}$$

$$\left[C(IT)\right] \rightarrow \left[A(M1, M2, M3)\right] = d\,* \tag{42}$$

$$\mathrm{DF} \bullet V = \left(\frac{d^{*}}{i/t} \right) \bullet V = \Sigma^{L} \qquad (0 < \mathrm{i} / \mathrm{t} < \mathrm{d} \bullet 1/2) \tag{43}$$

Thus, the cost function of *IT*, if it were to locate at point *C*, can be expressed as follows:

$$\Sigma^{J} + \Sigma^{K} + \Sigma^{L} = \Sigma^{JKL} \tag{44}$$

Whether *IT* locates at point *C* or *A* is by no means obvious and depends specifically upon the relative values of the amount of information (*V*) being passed between the components as well as the level of technology which facilitates the passage of information. It should, however, be further noted that since the amount of information per interval of time is uniform, whether *IT* is interacting with *T* and the whole of manufacturing from a distance or just IT^C from a distance the central determinant, as suggested through the above relationships, becomes the relative volume of information (V). For example, if Σ^{JKL} (44) was greater than Σ^{GHI} (37) ($\Sigma^{JKL} > \Sigma^{GHI}$), than it cannot only be asserted that *IT* would remain at point *A*, because the interaction with all the components in question would be the most cost effective from point *A*, but it would also suggest that more information is being passed between *IT* and *T* and *IT* and the whole of manufacturing than *IT* and IT^C. If, however, the previously suggested relationship was reversed ($\Sigma^{JKL} < \Sigma^{GHI}$), then the opposite could be asserted, that being, that the volume of information was greater between *IT* and IT^C than that of *IT* and *T* and *IT* and the whole of manufacturing. Thus, reiterating the previously noted relationship between that of volume and complexity, it can be further concluded that the type of information being passed between components potentially has influence over locational decisions.

It is important to reaffirm that the relative number of interactions *IT* faces at point *A* (2) and point *C* (1) are completely fabricated. There is no reason, other than through assumption, to consider such relative interactions exists at either point.

Nevertheless, the previous examination highlights the potential implications that structure as examined in greater depth in the previous chapter has on potential relocation. While there is no reason to suggest that there is a relationship between structure and volume, it could be offered, that the greater number of interactions within a structure the greater the volume of information being passed between the components. Furthermore, while all the points were assumed as uniform certain relative advantages or disadvantages, as expressed through net agglomeration forces at a specific point, could perhaps lessen (or increase) the influence of the relative volume between the interactions.

5.2.8 Post-technology shift #1

The application of a distance factor with a value of one to relationships 32, 34, 36, 39, 41 and 43 tends to highlight the value of relative net agglomeration forces. Applying a distance factor of one to the previously noted relationships suggests that no matter where *IT* locates the cost functions will consequentially produce equal values ($\Sigma^{JKL} = \Sigma^{GHI}$). Thus, the defining determinants become something other than the cost of interacting across space, but rather elements present at the location in question that either create advantages or disadvantages that ultimately decrease or increase costs.

5.3 The implications of an improvement in the 'processing capabilities' and 'carrying capacity' on the spatial structure of the urban system

It is important, at this time, to recall the previously noted incongruity: as the technology in question improves and becomes capable of managing a larger market, the required market size needed to sustain the device in question decreases. As will be further exemplified in the following model, this phenomenon potentially influences the wider spatial structure of the urban system through the redistribution of basic processing responsibilities. Like that of the Internet, where several advancements culminated in its conception, the mechanism responsible for the so-called incongruity is by no means the by-product of a single factor. The basis of the phenomenon can be attributed to two key factors: (a) an increase in the *general* capabilities of 'the processor', of which the previously reviewed technological advancements were major contributors, and (b) an increase in the ability to transmit more extensive amounts of information in a given interval of time (feature 1). The second factor, as conveyed in the previous chapter as well as sub-section, not only allowed for an increase in the relative margin with which an activity is potentially able to disassociate itself from other activities, thus allowing it to evoke certain benefits at other points in the urban system. With regards to the activity responsible for consolidating information the second factor also removed the distance factor from certain activity's locational consideration, subsequently extending its potential market area.

In terms of the potential market area, theoretically established by Hyson and Hyson (1950) and further developed by Parr (1995) (see chapter 2), the area is determined by the efficiency with which a firm/individual delivers goods and/or services, relative to other firms that produce similar goods and/or services. As location theory would suggest, and further characterized by f.o.b., the further the receiver of the good or service is located the more costly the good/service. Thus, if the service in question is an intangible service (*IT*) and the distance factor (*DF*) is removed from consideration, in that the service can be delivered free of charge, then the market available to the firm/individual is effectively infinite (see figure 5.5a). Further, an infinite market compliments those assertions established in 'The ties that bind'; assuming intangible services are the service in question, the activity will locate in the location that will provide the lowest operating costs, and thus consolidating the whole of the market (see figure 5.5b).

Figure 5.5a The market area of ρ

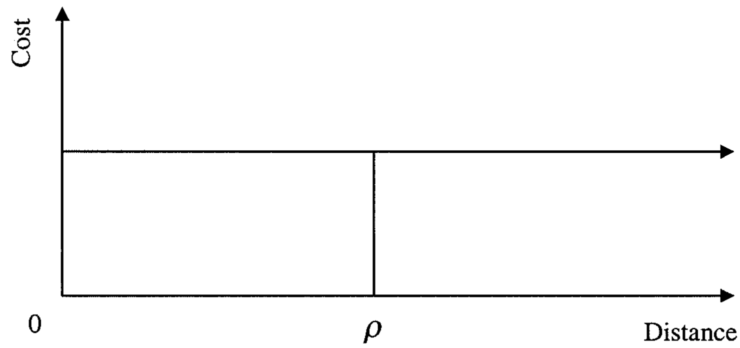
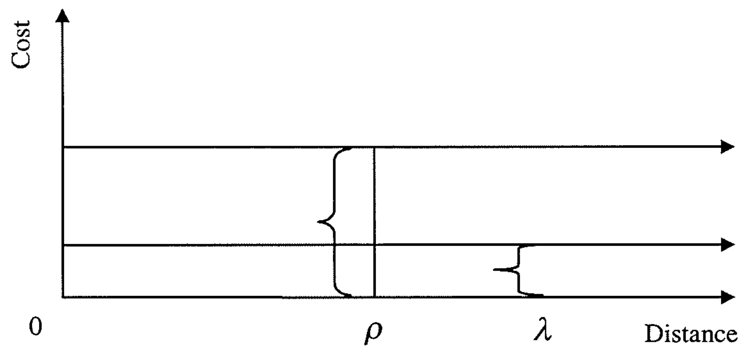


Figure 5.5b The relative market areas of ρ and λ



The first key factor, an increase in the general capabilities of 'the processor', which is also directly tied to an increase in its availability, not only ensures the lowest possible cost for the service of consolidating information, under the pretense of features 1 and 2 being present, but potentially redistributes a portion of the processing responsibilities. As exhibited in figure 5.5b, if the appropriate technology were present at every point, as would be the case after feature 2 had taken effect, the ability to transmit information across space freely from any point in space would further suggest that an individual/firm would transmit information from their ideal location. As exemplified in 'The ties that bind' and figure 5.5b, locationally speaking, the minimization of production costs is achieved through the maximization of net agglomeration factors.[15]

The structural implications on the urban system of both the increased accessibility to processing capabilities (key factor [a]) and the increased ability to transmit more extensive amounts of information in a given interval of time (key factor [b]), as already noted and will be further exemplified the scenarios in this particular section, is the redistribution of processing responsibilities. The mechanism behind the potential redistribution can effectively be deemed as the inverse of the phenomenon observed in sub-section *C* of the previous chapter. As already restated in this very section, a technology shift that allowed activities to benefit from economies of scale potentially induced a re-evaluation, in the case of sub-section *C*, in favor of centralization, provided their new found ability allowed them to cover the additional transportation costs that had come to bear as a result of their consolidation and thus centralization. However, the increased availability of the processor, potentially represents a decline in the relative benefit induced through economies of scale. As processing technology becomes less costly and more capable, the relative costs saved from consolidating processing responsibilities, so as to benefit from economies of scale, become less real. In conjunction with the ability to transmit more extensive

[15] This, of course, is assuming that the individual/firm in question functions in terms of maximizing profits through the minimization of production costs.

amounts of information faster, as suggested through 'The ties that bind', activities, assuming they are intangible in nature, are able to re-evaluate the optimal location with less emphasis on essential interactions.

5.3.1 Terms and assumptions

'The activity responsible for the consolidation of information' is, of course, a generalization of more than one component. In an attempt to methodically evaluate the spatial implications of improvements in processing abilities, in conjunction with improvements in carrying capacity, the activity responsible for the consolidation of information (IT^C) will be split into two fundamental components. The first component will be deemed the processing/manipulation of the consolidated information (IT^P), while the second component will be regarded as the organization/collection of the consolidated information (IT^O).

There is, of course, an interaction between the two distinct components (see figure 5.6a) as well as an interaction between the processing/manipulating component (IT^P) and the activity that allows its information to be consolidated, as represented by *IT* in scenario 1.b.ii (see figure 5.6b). As suggested through figure 5.6b, the relationship between the activities that allow their information to be consolidated is ultimately facilitated by IT^P. The logic behind this particular assertion is based on the nature with which consolidated information is utilized. As already noted, activities that allow their information to be consolidated also require such information. While the IT^P processes the information at IT^O, ultimately transmitting the results of its efforts to *IT*, it also receives *IT*'s requests for a specific portions of the information that essentially exists amongst other less important information.

Figure 5.6a A graphical representation of the interaction between IT^P and IT^O

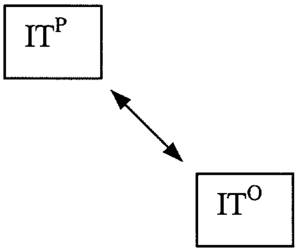
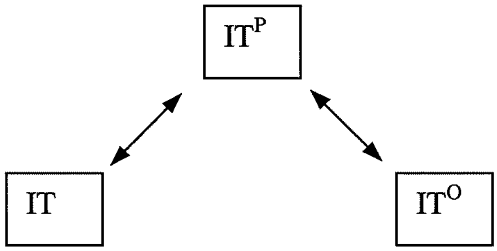


Figure 5.6b A graphical representation of the interaction between IT^P with that of IT^O and IT



Thus, it can be further asserted that because IT^P transmits a specific portion of the consolidated information to *IT*, less information passes between that of IT^P and *IT* than IT^P and IT^O.

$$IT^O \Leftrightarrow IT^P > IT^P \Leftrightarrow IT \quad (45)$$

This fundamental relationship can also be further expressed in the following terms:

$$IT^P \Leftrightarrow IT = V \quad (46)$$

$$IT^P \Leftrightarrow IT^O = r \bullet V \qquad (r > 1) \quad (47)$$

In other words, the interaction between IT^P and IT^O is proportionally greater than the interaction between IT^P and *IT*.

However, in addition to the newly defined components and the relative amount of information that passes between them and the activities within the urban system that requires such information, it is essential that the relative operating costs are also established. As noted previously, feature #2 induces the ability to operate the activity responsible for consolidating information with a smaller required market, further suggesting a decrease in the relative benefits from consolidating the activity at a given point for the purpose of deriving economies of scale. Therefore, for the purpose of the examination to follow, it is important that the potential operating costs of the relevant components before and after the implementation of feature #2 are stipulated.

If the operating cost of IT^C before the advent of feature #2, while at the same time not attempting to benefit from economies of scale is θ, it can be further asserted that the sum of the operating cost for IT^P and IT^O, under the same circumstances, is also θ.

$$IT^P + IT^O = IT^C \qquad (48)$$

Using figure 5.3 as the initial format of the urban system, figure 5.7 and 5.8 exhibits the equality of IT^C and that of IT^P and IT^O if they were to locate at every point throughout the urban system.

Figure 5.7 IT^C located at every point

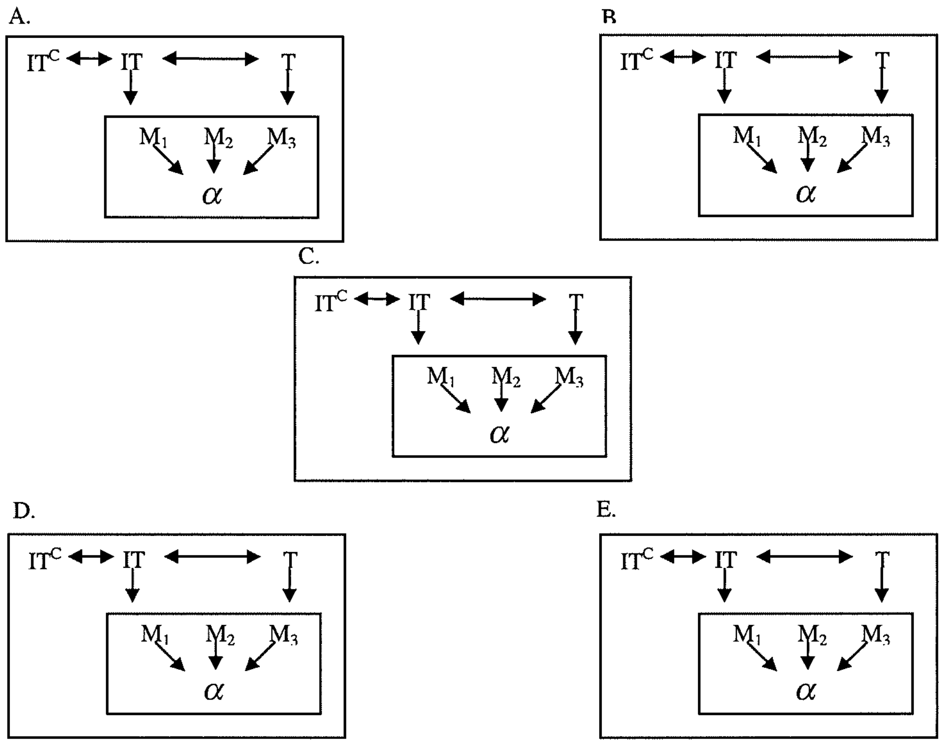
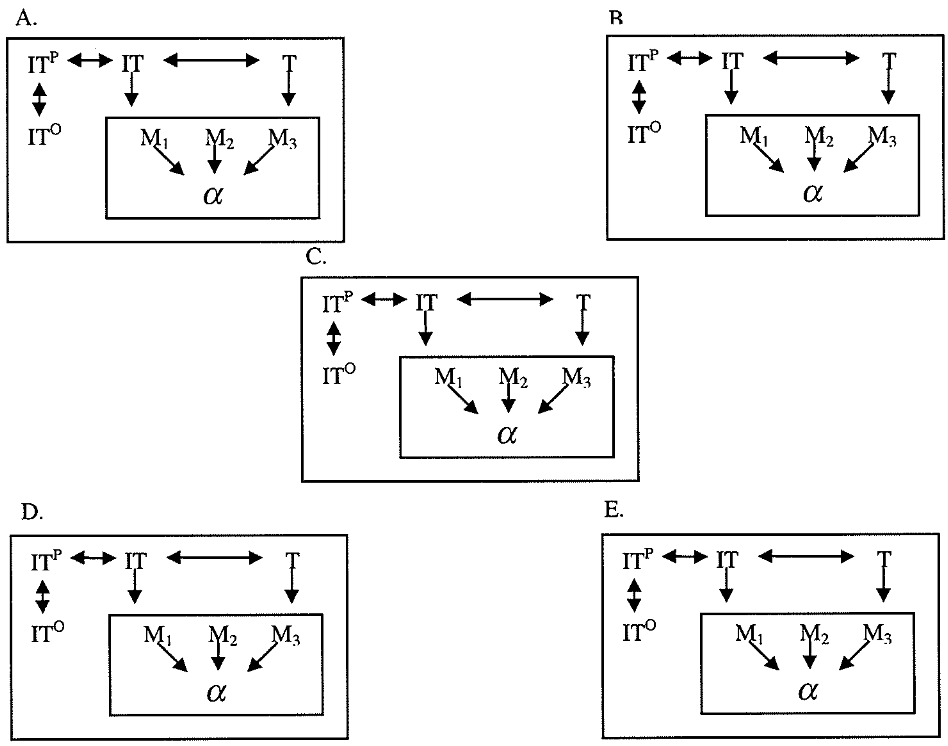


Figure 5.8 IT^P and IT^O (the components of IT^C) located at every point



If, however, IT^C was to attempt to benefit from economies of scale, before feature #2 came into effect, as the previously established assumptions would permit, the cost of IT^C would be less than if it were not attempting to benefit from economies of scale and would be expressed as follows:

$$IT^C - x^{ITC} = IT^P + IT^O - x^{ITC} \tag{49}$$

More appropriately, however, is the assignment of the specific cost savings for IT^P and IT^O, in accordance with the potential savings that would be realized if the activity responsible for consolidating information attempted to benefit from economies of scale.

$$x^{ITC} = x^{ITP} + x^{ITO} \tag{50}$$

Therefore, relationship 49 can be rewritten as follows:

$$IT^C - x^{ITC} = IT^P + IT^O - x^{ITP} - x^{ITO} \tag{51}$$

Or, more appropriately:

$$IT^C - x^{ITC} = ([IT^P - x^{ITP}] + [IT^O - x^{ITO}]) \tag{52}$$

The focus of the impending examinations is, of course, on processing abilities, as represented through feature #2, and how the application of such a feature stands to influence the location of processing responsibilities within the urban system and thus the spatial structure of the urban system as a whole. As already noted, feature #2 can only come about if feature #1 has already occurred. Thus, while the focus of this current examination is feature #2, feature #1 will be initially included in the first set of scenarios. As will be observed, the inclusion of feature #1 is not only meant to establish an initial point of reference, but will also aid in the differentiation between the factors of influence.

5.3.2 The ordering and logic of the remaining scenarios

The first scenario (scenario 2.a) will consider the location of IT^P relative to IT^O and IT, pre-feature #1 and #2. Thus, not only will the passage of information be subject to a distance factor with a value of less than one (lack of feature #1), but IT^P, not involved in a consolidated effort will, of course, not stand to benefit from economies of scale (lack of feature #2). The second scenario (scenario 2.b) will then consider the location of IT^P post-feature #1, but pre-feature #2. This will, of course, involve a distance factor with a value of one, while the previous established assumption of not deriving economies of scale benefits in an unconsolidated effort remains. The third and final scenario (scenario 2.c) will consider the location of IT^P post-feature #1 and #2. Thus, much like scenario two, the distance factor will be assumed to be a value of one, while unlike scenario one and two, the operating costs of IT^P in an unconsolidated situation will be comparable to if it were deriving benefits from economies of scale pre-feature #2.

Since the format for the urban system will be based on figure 5.3, for all three scenarios, it is important to establish that for each scenario noted only two variations of the given format are possible, as observed in figure 5.10a and 5.10b. Furthermore, of the two newly introduced components, as observed in figure 5.10a and 5.10b, only IT^P is subject to relocation. The logic behind this assertion is twofold. Firstly, while IT^O is the activity responsible for the physical collection of information it is also the point at which the consolidated information itself exists, of which a consideration of the location of that specific entity subject to changes in the ability to interact across space was considered in the first set of scenarios. Secondly, in this particular analysis, the decentralization of IT^P is synonymous with diffusion and, as observed in figure 5.10b, the motivation of this analysis is not purely one of relocation, but of redistribution as well. Thus, while it may be possible for IT^O to redistribute in a similar fashion, the motivation behind such a redistribution transcends the focus of this particular analysis, in that it would require a reconsideration of the earlier proposed notion of the critical mass and whether it would be cost effective for those activities that offer their information for consolidation to interact with more than one activity responsible for the consolidation of information.

Figure 5.10a IT^P serving the urban system from a centralized point

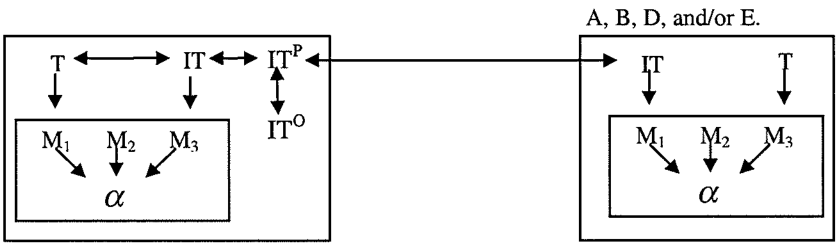
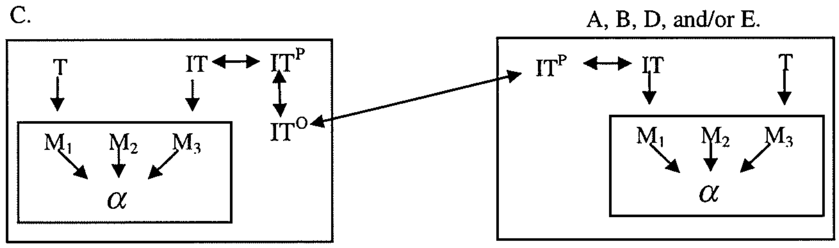


Figure 5.10b IT^P diffused to all points in the urban system



It is also important to note that although the focus of this examination is specifically in regards to processing responsibilities, the optimal location is determined relative to both IT^O and *IT*, and as suggested in Scenario 1.b.ii, *IT* could also potentially be subject to a reconsideration of its location (see figure 5.4a and 5.4b). Assuming the distance factor is less than a value of one, the optimal location of *IT*, in addition to certain locational attributes as represented through net agglomeration forces, is determined by the relative volume of information that passes between *IT* and the components with which it interacts, and the location of these components.

In the impending scenarios, there is no reason to suggest that the relative volume of information passing between *IT* and IT^P is greater or less than that of *IT* to *T* and the whole of manufacturing (*M1*, *M2*, *M3*). Assuming the points throughout the urban system were equal, if the relative volume of information was greater for the former than the latter, than it could be asserted that *IT* would locate at point *C*. However, for the purpose the impending analysis, it will be assumed that the relative amount of information is in favor of *IT*'s interaction with *T* and the whole of manufacturing (*M1*, *M2*, *M3*).

5.3.3 Scenario 2.a – The location of processing responsibilities pre-feature #1 and #2

The first scenario is the relative locational consideration of IT^P prior to the introduction of feature #1, the more extensive ability to transmit larger amounts of information faster, and feature #2, an improvement in processing capabilities. Thus, not only is the distance factor subject to a value of less than one, but processing abilities in an unconsolidated state are subject to a zero reduction in cost, unlike if IT^P was consolidated, allowing it to reduce costs through its benefits from economies of scale.

Assuming IT^P is located at point *C*, the operating costs, as well as costs of interacting across space between that of IT^O at point *C* and *IT* at point *A*, *B*, *C*, *D* or *E* can be expressed as follows:

$$C(IT^P) \leftrightarrow C(IT^O) = d^{OP} \tag{53}$$

$$\mathrm{DF} \bullet V \bullet \mathrm{r} = \left(\frac{d^{OP}}{i/t} \right) \bullet V = \Sigma^M \qquad (\mathrm{i / t < d}) \tag{54}$$

$$C(IT^P) \leftrightarrow A(IT) = d^{P*} \tag{55}$$

$$\mathrm{DF} \bullet V = \left(\frac{d^{P*}}{i/t} \right) \bullet V = \Sigma^N \qquad (\mathrm{i / t < d}) \tag{56}$$

$$\Sigma^M + \Sigma^N + ([\mathrm{IT^P} - \mathrm{x^{ITP}}] + [\mathrm{IT^O} - \mathrm{x^{ITO}}]) = \Sigma^M + \Sigma^N + \mathrm{Y}^{\Omega} \tag{57}$$

$$\mathrm{Y}^{\Omega} = ([\mathrm{IT^P} - \mathrm{x^{ITP}}] + [\mathrm{IT^O} - \mathrm{x^{ITO}}])$$

Assuming IT^P is located at point A, the operating costs, as well as costs of interacting across space between that of IT^O at point C and IT at point A, B, C, D or E can be expressed as follows:

$$A(IT^P) \leftrightarrow C(IT^O) = d^{OP*} \tag{58}$$

$$\mathrm{DF} \bullet V \bullet \mathrm{r} = \left(\frac{d^{OP*}}{i/t} \right) \bullet V = \Sigma^O \qquad (\mathrm{i} / \mathrm{t} < \mathrm{d}) \tag{59}$$

$$A(IT^P) \leftrightarrow A(IT) = d^* \tag{60}$$

$$\mathrm{DF} \bullet V = \left(\frac{d^P}{i/t} \right) \bullet V = \Sigma^P \qquad (\mathrm{i} / \mathrm{t} < \mathrm{d}) \tag{61}$$

$$\Sigma^O + \Sigma^P + ([\mathrm{IT^P}] + [\mathrm{IT^O} - \mathrm{x^{ITO}}]) = \Sigma^O + \Sigma^P + \mathrm{X}^\Phi \tag{62}$$

$$\mathrm{X}^\Phi = (\mathrm{X} = [\mathrm{IT^P}] + [\mathrm{IT^O} - \mathrm{x^{ITO}}])$$

It can be asserted from the previously derived relationships that the optimal location is for IT^P is undoubtedly point C, as summarized through relationship 63.

$$\Sigma^M + \Sigma^N + \mathrm{Y} < \Sigma^O + \Sigma^P + \mathrm{X} \tag{63}$$

While Σ^N is greater than Σ^P, the difference between the two variables is less than the difference between Σ^M and Σ^O ($\Sigma^M < \Sigma^N$), on account of the relative volume of information being passed between IT^P and IT^O and that of IT^P and IT, as represented by r. Furthermore, given the pre-feature #2 status of the scenario, IT^P can only realize a reduction in its operating costs through the consolidation of its activity, allowing it to benefit from economies of scale.

5.3.4 Scenario 2.b – The location of processing responsibilities post-feature #1 and pre-feature #2

The only difference between this current scenario and the scenario (2.a) prior is the adjustment to the distance factor, which had previously been valued at greater than one. With regards to the operating costs of IT^P, the notion of that reduction in cost can only be induced through its consolidation, which provides it with the opportunity to induce benefits from economies of scale, remains, while the distance factor will be assumed as having a value of one.

Thus, assuming IT^P is located at point *C*, the operating costs, as well as costs of interacting across space between that of IT^O at point *C* and *IT* at point *A*, *B*, *C*, *D* or *E* can be expressed as follows:

$$C(IT^P) \leftrightarrow C(IT^O) = d^{OP} \tag{64}$$

$$\text{DF} \bullet V \bullet \text{r} = \left(\frac{d^{OP}}{i/t} \right) \bullet V = \Sigma^Q \qquad (\text{i / t = d}) \tag{65}$$

$$C(IT^{P}) \leftrightarrow A(IT) = d^{P*} \tag{66}$$

$$\text{DF} \bullet V = \left(\frac{d^{P*}}{i/t} \right) \bullet V = \Sigma^{R} \qquad (\text{i / t = d}) \tag{67}$$

$$\Sigma^{Q} + \Sigma^{R} + ([\text{IT}^{\text{P}} - \text{x}^{\text{ITP}}] + [\text{IT}^{\text{O}} - \text{x}^{\text{ITO}}]) = \Sigma^{Q} + \Sigma^{R} + \text{Y}^{\Psi} \tag{68}$$

$$\text{Y}^{\Psi} = ([\text{IT}^{\text{P}} - \text{x}^{\text{ITP}}] + [\text{IT}^{\text{O}} - \text{x}^{\text{ITO}}])$$

Assuming IT^{P} is located at point *A*, the operating costs, as well as costs of interacting across space between that of IT^{O} at point *C* and *IT* at point *A*, *B*, *D* and/or *E* can be expressed as follows:

$$A(IT^{P}) \leftrightarrow C(IT^{O}) = d^{OP*} \tag{69}$$

$$\text{DF} \bullet V \bullet \text{r} = \left(\frac{d^{OP*}}{i/t} \right) \bullet V = \Sigma^{S} \qquad (\text{i / t = d}) \tag{70}$$

$$A(IT^{P}) \leftrightarrow A(IT) = d^{*} \tag{71}$$

$$\text{DF} \bullet V = \left(\frac{d^{P}}{i/t} \right) \bullet V = \Sigma^{T} \qquad (\text{i / t = d}) \tag{72}$$

$$\Sigma^{S} + \Sigma^{T} + ([\mathrm{IT^P}] + [\mathrm{IT^O} - \mathrm{x^{ITO}}]) = \Sigma^{S} + \Sigma^{T} + \mathrm{X}^{\Theta} \tag{73}$$

$$\mathrm{X}^{\Theta} = ([\mathrm{IT^P}] + [\mathrm{IT^O} - \mathrm{x^{ITO}}])$$

As in the previous scenario, the optimal location for IT^P is point *C*, as expressed through relationship 74.

$$\Sigma^{Q} + \Sigma^{R} + \mathrm{Y} < \Sigma^{S} + \Sigma^{T} + \mathrm{X} \tag{74}$$

Due to the distance factor having a value of one the respective interactions are equal regardless of distance, as expressed through relationship 75 and 76.

$$\Sigma^{Q} = \Sigma^{S} \tag{75}$$

$$\Sigma^{R} = \Sigma^{T} \tag{76}$$

However, given the pre-feature #2 status, IT^P can only realize a reduction in its operating costs through the consolidation of its activity, allowing it to benefit from economies of scale. Thus, while the value of *Y* contains '$- x^{ITP}$', the *X* variable does not, dictating that IT^P is subject to lower total costs at point *C*.

5.3.5 Scenario 2.c – The location of processing responsibilities post-feature #1 and #2

In the third and final scenario, not only is the distance factor assumed as having a value of one, like that of the previous scenario, but the presence of feature #2 suggests that the operating costs of IT^P in an unconsolidated state will be relatively lower than that of its pre-feature #2 levels.

Thus, assuming IT^P is located at point *C*, the operating costs, as well as costs of interacting across space between that of IT^O at point *C* and *IT* at point *A*, *B*, *C*, *D* or *E* can be expressed as follows:

$$C(IT^P) \leftrightarrow C(IT^O) = d^{OP} \tag{77}$$

$$\mathrm{DF} \bullet V \bullet \mathrm{r} = \left(\frac{d^{OP}}{i/t} \right) \bullet V = \Sigma^U \qquad (\mathrm{i} / \mathrm{t} = \mathrm{d}) \tag{78}$$

$$C(IT^P) \leftrightarrow A(IT) = d^{P*} \tag{79}$$

$$\mathrm{DF} \bullet V = \left(\frac{d^{P*}}{i/t} \right) \bullet V = \Sigma^V \qquad (\mathrm{i} / \mathrm{t} = \mathrm{d}) \tag{80}$$

$$\Sigma^U + \Sigma^V + ([\mathrm{IT}^P - \mathrm{x}^{\mathrm{ITP}}] + [\mathrm{IT}^O - \mathrm{x}^{\mathrm{ITO}}]) = \Sigma^U + \Sigma^V + \mathrm{X}^{\Delta} \tag{81}$$

$$\mathrm{X}^{\Delta} = ([\mathrm{IT}^P - \mathrm{x}^{\mathrm{ITP}}] + [\mathrm{IT}^O - \mathrm{x}^{\mathrm{ITO}}])$$

Assuming IT^P diffuses to point *A*, *B*, *D* and/or *E* the operating costs, as well as costs of interacting across space between that of IT^O at point *C* and *IT* at point *A*, *B*, C, *D* or *E* can be expressed as follows:

$$A(IT^{P}) \leftrightarrow C(IT^{O}) = d^{OP*} \tag{82}$$

$$\mathrm{DF} \bullet V \bullet \mathrm{r} = \left(\frac{d^{OP*}}{i/t} \right) \bullet V = \Sigma^{W} \qquad (\mathrm{i} / \mathrm{t} = \mathrm{d}) \tag{83}$$

$$A(IT^{P}) \leftrightarrow A(IT) = d^{*} \tag{84}$$

$$\mathrm{DF} \bullet V = \left(\frac{d^{P}}{i/t} \right) \bullet V = \Sigma^{X} \qquad (\mathrm{i} / \mathrm{t} = \mathrm{d}) \tag{85}$$

$$\Sigma^{W} + \Sigma^{X} + ([\mathrm{IT^{P}} - \mathrm{y^{ITP}}] + [\mathrm{IT^{O}} - \mathrm{x^{ITO}}]) = \Sigma^{W} + \Sigma^{X} + \mathrm{Y}^{\Lambda} \tag{86}$$

$$\mathrm{Y}^{\Lambda} = ([\mathrm{IT^{P}} - \mathrm{y^{ITP}}] + [\mathrm{IT^{O}} - \mathrm{x^{ITO}}])$$

Unlike the prior two scenarios, it is not obvious as to what the optimal location of IT^{P} is. As in the previous scenario, due to a the distance factor having a value of one, the cost of the respective interactions are equal, regardless of distance, as expressed through relationship 87 and 88.

$$\Sigma^{U} = \Sigma^{V} \tag{87}$$

$$\Sigma^{W} = \Sigma^{X} \tag{88}$$

However, while relationship 87 and 88 can be paralleled to that of 75 and 76 in previous scenario, respectively, as observed in relationship 89 and 88, the induction of feature #2, further suggests a reduction in the operating costs of IT^P beyond that of a consolidated environment are present, as represented through '$- y^{ITP}$' in relationship 86.

$$\Sigma^U = \Sigma^V = \Sigma^Q = \Sigma^S \tag{89}$$

$$\Sigma^W = \Sigma^X = \Sigma^R = \Sigma^T \tag{90}$$

Thus, since the costs of the respective interactions are equal, the optimal location of IT^P is determined by the relative values of 'y^{ITP}' to that of 'x^{ITP}'. If 'y^{ITP}' is greater than 'x^{ITP}' (relationship 91) than it can be asserted that the costs saved through the improvements in the processor, characterized by IT^P locating at point *A* are greater than those saved through consolidating IT^P at point *C* (relationship 92).

$$\text{'y}^{\text{ITP}}\text{'} > \text{'x}^{\text{ITP}}\text{'} \tag{91}$$

$$\Sigma^W + \Sigma^X + \mathrm{Y}^{\Lambda} < \Sigma^U + \Sigma^V + \mathrm{X}^{\Delta} \tag{92}$$

The sentiment proposed through relationship 91 and 92 is somewhat precarious, in that any advancements in processing capabilities would not be exclusive to just the points on the periphery (Pred, 1977). More probable is that the reduction in operating costs realized at the periphery would be equivalent to those costs saved through the consolidation and thus benefits from economies of scale (see relationship 93 and 94).

$$ `y^{ITP}' = `x^{ITP}' \tag{93} $$

$$ \Sigma^{W} + \Sigma^{X} + Y^{\Lambda} = \Sigma^{U} + \Sigma^{V} + X^{\Delta} \tag{94} $$

5.4 Conclusion

The current chapter not only reaffirms the assertions conveyed in the conclusion of chapter 4, but the consideration as to how the ability to access consolidated information from a non-point in space (feature 2) offers additional insights as to the character of the changes that will potentially occur as a result of certain developments in advanced-telecommunications. The initial scenarios (scenario 1), like that of the previous chapter, where processing responsibilities were subject to a relocation (the second of the two types of change considered in chapter 3), exhibited how the potential relocation of processing responsibilities is a function of the relative values of environmental favor ability (also relative) and interactive capabilities. The latter scenarios (scenario 2), reducing the practice of consolidating information, and those involved in the process, into three essential components (IT^P, IT^O and IT^C), considered the viability of processing facilities diffusing, or the first of the two types of urban system of change considered in chapter 3. Like that of the increased ability with which to interact across space, the ability to access markets from a distance also induced spatial structure changes that could be deemed to occur at both the level of the system as well as the activity (firm). The diffusion of processing facilities, which could be further interpreted as representing the diffusion and increased use of the Internet, suggested that activities that could be facilitated via advanced-telecommunications would potentially be redistributed amongst those activities that had previously utilized such services. Consequently, the redistributed activity would cease to exist in consolidated form, effectively removing the original form of the activity from the spatial structure of the urban system. As conveyed in the model, the activity itself does not cease to exist, but rather becomes further integrated into the process that had previously utilized it.

Coase's (1937) answer to his fundamental question, 'what determines the size of the firm?', provides insight into whether or not such redistribution occurs and in what context. Coase suggests that the size of a firm is determined such that the cost of internalization an extra transaction will be equal to the costs of organization that transaction in a market or in another firm.[16] The notion of 'cost' could not only be adjusted to include an improvement in the method of production, like that of I-x in sub-section 4.2 of the previous chapter or this current set of scenarios, but the cost of the interaction between activities (i.e. via advanced-telecommunications and/or agglomeration principles) and, assuming the interaction was geographically remote, the relative time and overall transaction cost of the interaction across space, could also effectively be included and/or sustained. This, of course, is 'The ties that bind's' method of evaluation, in that the respective sum of production processes, net agglomeration factors were offset with one another in conjunction with prospective communication and transport costs so as to apply the relevant spatial predicament of the activity in question.

Needless to say, as observed in relationships 93 and 94, due to the application of feature #2, the operating costs for local processing responsibilities in addition to their necessary interactions, is potentially of an equal cost in an non-local consolidated form to that of a local unconsolidated form. While it has already been assumed that the urban system in question is made up of uniform points, adding the

[16] While Coase acknowledged the notion of space, little elaboration was offered, further suggesting that a distinctly spatial application like that of 'The ties that bind' would be valuable.

additional assumption that separate firms exist at each point, the outcome conforms to Coase's reasoning for a structural shift at a particular point in space.

Furthermore, in removing the previously applied assumption of uniform points, it becomes possible that factors in the form of agglomeration forces could in fact further reduce processing costs in favor of points on the periphery. Thus, redefining relationships 93 and 94, as observed in 95 and 96, this would further suggest that processing responsibilities are being pulled from consolidated format to that of an unconsolidated one.

$$(\text{'}y^{ITP\text{'}} + NA) = \text{'}x^{ITP\text{'}} \tag{95}$$

$$\Sigma^{W} + \Sigma^{X} + Y^{O} = \Sigma^{U} + \Sigma^{V} + X^{\Delta} \tag{96}$$

$$Y^{O} = [IT^{P} - (y^{ITP} + NA)] + [IT^{O} - x^{ITO}])$$

Such a notion conforms well to the overtly generalized term: 'processing responsibilities'. Anecdotally speaking, tools like that of the personal computer are capable of an assortment of tasks and, more importantly, are rarely used for a single application.

6 A general model

The central objective of this chapter is to consider the implications of advanced-telecommunications on the spatial structure of the urban system in a more general context then had been offered and in so doing reaffirm and ultimately extend the conclusions derived from the previous model. Chapters 4 and 5 examined the reasoning for potential locational shifts of specific activities as they functioned in an explicit context (i.e. the disagglomeration of routine manufacturing while benefiting from economies of scale). The development of the previous model was, of course, necessary to apply and thus further examine, the complex set of factors that govern the locational decisions of a given activity, of which the interaction across space was just one aspect, and thus consider the equally complex association between the factors in question in an applicable context. Generalizations as to the potential implications of an improvement in the ability to interact across space, or the ability to access consolidated information from a non-point in space on the spatial structure of the urban landscape, to a certain extent, can and were extrapolated, but the environment constructed for the purpose of the analysis in question was clearly contrived. In an attempt to provide a more complete perspective of the primary consideration while at the same time validating those notions developed in the previous model, the application of the standardized set of activities, in conjunction with a series of assumptions relating to an activity's capacity to interact across space will be used generate a series of conceptual urban systems.

Unlike the model in the previous chapters, the derived systems in question will not be defined by a finite set of points or number of activities. As conveyed in chapters 1 and 2, while an urban system is clearly a collection of urban centers, it does not adhere to a strict set of points, but rather 'above a given quantity' of centers. Thus, any attempt to impose or adhere to a strict numerical structure would be restrictive. The outcome, or context with which the character of points are depicted, is as an assortment of urban centres that vary in terms of their internal structure. In other words, while all activity-types are present in each urban system their distribution across centers may vary between systems. Like that of Duranton and Puga's (2000) static theoretical model, the set of urban centers will then be compared to empirical regularities as defined by the notions of specialization and diversity (internal geography) as a function of city size.[17] This will provide the opportunity with which to compare and contrast the theoretically derived urban systems to that of variations of reality, which will validate the model as a method of analysis, and thus further verify the relevant mechanisms under consideration, and by adjusting the assumptions of the model in accordance with the primary consideration it provides the opportunity with which to derive a hypothesis as to the implications of an increased ability with which to communicate across space.

The previous model considered activities individually, or from a 'micro' perspective, the general model, on the other hand, considers the urban system as a whole, or from a 'macro' perspective. Both models are depictions of urban systems, which in *specific* situations could thus be regarded as representative of one another. However, while an association between the models is present, the models relate to one another differently.

[17] It is worth noting that the Duranton and Puga's (2000) analysis is one of several research efforts that attempt to derive general urban systems consisting of diversified and specialized cities (see for example Henderson, 1974; Abdel-Rahman and Fujita, 1993; Abdel-Rahman, 1996).

In determining the location of the activity-types and thus the internal structure of the centers found within the urban system, the reasoning deduced from the analytical framework developed in the previous model is utilized. As further noted in chapter 4, the analytical framework effectively integrated the set of factors that determine the relative optimal location of a given activity. The applied reasoning, generally speaking, is that given a previously established locational framework, in this case a variation of an urban system, a modification of a factor (i.e. an improvement in the ability to interact across space) or factors may lead to a re-evaluation of the given activity's optimal location. However, instead of considering how a specific activity responds to a particular technological shift, the impending model considers all activity-types at a given point in time, culminating to produce an entire urban system. As previously noted, the assumptions, like that of the previous model, stipulate the extent and/or manner in which the activity-types in question interact across space, which in conjunction with the reasoning derived from the previous model, further conveys the location of activity-types will be further determined. A center can consist of one or several activities, but more important is that the resulting co-location (or not), which represents the internal structure of the center(s) found within the urban system. A relative shift in the location of an activity-type due to, for example, a technological shift will potentially redefine the size and character of the previously established points within the system, adjusting the system as a whole.[18] The general model provides the opportunity to effectively assess those assertions derived in the

[18] It is worth noting though that in a purely technical context the locational shift of a single activity, like that in the previous model, does in fact redefine the whole of the system, more so when considering that the activity in question is a representation of comparable activities, the implications in a wider context were not explicit.

previous set of models through their application in a recognizable context (an urban system), which is more conducive to an empirical assessment.

As implied above, both the assumptions and empirical regularities have, for the most part, largely been conveyed in various forms in the previous chapters. However, in an attempt to place the two components in the appropriate context for the impending analysis both will be reconsidered before the presentation of the theoretical urban systems.

6.1 The empirical regularities

The purpose of this current sub-section is to establish the three empirical regularities, which depict the internal geography or composition of economic activity of cities in developed urban systems. Like that of Duranton and Puga's (2000) model, of which the current three are only a selection, the empirical regularities in question are in reference to the notions of specialization and diversity and will ultimately be used as points of reference with which to compare and contrast the derived urban systems.

Specialization and diversity refer to the relative proportion employment in a given activity, or activities, accounting for the center's total local employment. The first is the acknowledgement that both specialized and diversified cities are present in developed urban systems and that they co-exist. The second and third regularities are in relation to the relative size of city centers and internal character. It is relevant to note that the use of the term 'regularity' is an attempt to acknowledge that the assertions offered are by no means fact, but rather very common associations. In other words, while exceptions can be identified, the previously noted relationships are more probable.

6.1.1 Empirical regularity I

Concerning the first empirical regularity, relatively recent empirical literature clearly observes *specialized and diversified cities co-existing* within developed urban systems. In attempting to measure specialization, while methods differ, the simplest technique would be to quantify the share of a given sector as a proportion of local employment. However, since industries differ between cities, a more effective means with which to compare levels of specialization between centers would be to consider the largest industry in a given center. This can be further expressed in terms of an index. If s_{ij} represents the share of industry j in city i, the specialization index would be as follows:

$$SI_i = \underset{j}{Max}(s_{ij}) \tag{1}$$

Similarly, since some sectors account for a larger share of overall employment, be it nationally or regionally, the share of the largest sector in a given city could be divided by the sectors total employment for a nation or region to provide a relative rather than absolute value. Like that of the specialization index, the relative-specialization index can be expressed formally, which is as follows:

$$RSI_i = \underset{j}{Max}\left({s_{ij}}/{s_j} \right) \tag{2}$$

Where s_j is the total employment of the industry found nationally, or perhaps regionally.

Diversity, on the other hand, like specialization, can be considered in both absolute as well as relative terms. The absolute measurement considers the number of sectors in a given center and their share of local employment. Formally, this can be expressed in terms of the inverse of the sums of the square value of all sectors' share in local employment, which can be expressed as follows:

$$DI_i = 1 \Big/ \sum_j s_{ij}^2 \tag{3}$$

Assuming economic activity in a given city was entirely concentrated in a single industry, the value of the diversity index would be equal to 1. With increasing variation in the number of industries and the share of local employment in such industries in a particular city, the diversity index would subsequently increase in value.

However, like that of the specialized index, the diversity index is an absolute measurement that fails to account for the differences in sectoral employment shares be it at the national or regional level. In computing the relative-diversity index, the inverse of the sum of the absolute value of the difference between each sector's share within a city to that of total employment is computed, which can be expressed as follows:

$$RDI_i = 1 \Big/ \sum_j \left(s_{ij} - s_j\right) \tag{4}$$

The relative diversity index will subsequently increase the more the composition of activities in a given city reflects that of the economy with which the city is being considered in relation to.

Black and Henderson (1998) applied both the relative specialization and diversity index for two-digit manufacturing in 317 US cities (urban centers consisting of more than 50 000 inhabitants) for the year of 1992. In accordance with the initially purposed empirical regularity, they observed specialized centers as well as diversified centers. With regards to relative-specialization, at the lower end, or centers that exhibited low levels of specialization, Buffalo (NY), Cincinnati (OH), and Chicago (IL), exhibited values of 1.6, 1.5 and 1.5, respectively. The value of 1.6 for Buffalo, for example, as conveyed by formula 2, suggests that Buffalo's sector which accounts for its largest share of employment (this being rubber and plastics) is 1.6 times larger than its share in national employment. Conversely, at the higher end, or centers that exhibited a high degree of specialization was Richmond (VA), Macon (GA), and Lewiston (ME), with values of 64.4, 55.0 and 49.6, respectively. Like that of relative-specialization, the relative-diversity index also produced a wide range of values. At the lower end of the index, Lawton (OK), Richland (WA) and Steubenville (OH) produced values of 2.4, 2.4, and 2.4. However, on the upper end, Cincinnati (OH), Oakland (CA), and Atlanta (GA) had values of 166.6, 161.2, and 159.4 respectively.

6.1.2 Empirical regularity II

It should be further noted that while Cincinnati exhibits high relative-diversity (1) and low relative-specialization (316) the two indexes are not exact opposites. A city can be both diversified as well as specialized if, for example, it contains a main industry along with a broad base of other industries. Regardless, like that of Cincinnati, cities that also ranked high on the relative-diversity index do not exhibit especially high levels of specialization either.

The second and third empirical regularities recognize the relationship between that of a center's size and its internal character. The second regularity refers to *the positive correlation between that of city size and the previously noted relative-*

diversity index (Duranton and Puga, 2000). Although discrepancies can be identified, like that of Los Angeles or New York which relative to their size are observed to be somewhat more specialized in entertainment and business services, respectively, or certain smaller cities, like that of Buffalo, or Portland, are observed as relatively more diversified given their size, therefore an over all relationship between relative-diversity and city size is observed.

It is also worth noting that in a theoretical context, the second regularity partially adheres to the concept of the successive inclusive urban hierarchy offered in chapter 2. Recall that the successive inclusive hierarchy proposed that the higher the order, and thus the greater the size of a given center, the more numerous the activities contained within the centers. However, while the theory does not stipulate as to the relative proportion of employment between sectors, in addition to the fact that urban size is assumed as being a direct by-product of the number of activities, the theory clearly conveys a positive relationship between that of size and number of activities in a given center.

6.1.3 Empirical regularity III

The third empirical regularity refers to the character of the activities found in relatively diversified and specialized cities. According to Henderson (1997), large cities (over 500 000) tend to be, on average, more specialized in services (finance, insurance and real estate sectors) and less in manufacturing than medium-sized cities. Similarly, medium-sized cities (50 000 – 500 000) were observed to be more specialized in mature industries (i.e. textiles and food) and less so in new industries (i.e. electronic components), of which a significant amount were found in larger cities (Henderson, 1997). Thus, the third empirical regularity offered is *larger cities are disproportionately comprised of services along with a tendency towards new industries, while relatively smaller cities are comprised of more traditional manufacturing activities.*

Like that of the second regularity, aspects of the third regularity are also reaffirmed through the successive inclusive hierarchy. In successive inclusive hierarchy, centers in a given order are, in a purely theoretical sense, considered identical, which conforms to a certain degree to the notion that similarities are present between centers of similar size. This is reaffirmed through Henderson's (1988) earlier work, which was also acknowledged in chapter one, where cities that specialized in similar activities also tended to be of a similar size. However, while the successive inclusive hierarchy supports the notion that cities of similar size elicit a similar internal geography within a given urban system, as noted in chapter 2, its structure is too rigid to allow for the possibility that lower orders serve higher orders as suggested by the fact that different activity types are found in different sized cities.

A summary of the three empirical regularities is as follows:

I – in developed urban systems specialized and diversified cities co-exist

II – larger cities are relatively more diverse, while smaller cities are relatively more specialized

III – larger cities contain services in addition to new industries, while smaller cities contain manufacturing or more traditional industries

6.2 Assumptions

In the attempt to characterize the previously noted empirical regularities as well as provide the opportunity with which to further hypothesize the implications of an improved capacity to interact across space on the spatial structure of the urban system, five types of assumptions will be offered. The first two assumptions concern the size and structure of the urban centers in space, the third and fourth involves their interaction and the fifth their conception. After having derived the assumptions a number of scenarios will be induced, which are effectively different combinations of the assumptions. The results, in conjunction with the empirical regularities, provide the opportunity with which to further consider the mechanisms that govern the spatial structure of the urban system and the potential implications if they were subject to change.

One perspective of the city is as an outcome of equilibrium, whether static or dynamic, which is balancing agglomeration and dispersion forces. As noted in chapter 2, agglomeration economies provide a basic rationale for the formation and existence of cities. In a given context, the term can be generalized to represent two perspectives, which will form the basis of the first set of assumptions of the model. Marshallian agglomeration (1920), suggests that firms that have displayed a tendency to agglomerate must achieve increasing returns to scale. Marshall provided three possible sources or origins of such economies of scale: information spillovers, local non-traded inputs, and a local skilled labor pool. The second characterization was provided by Hoover (1937, 1948), which splits agglomeration economies into three types: internal returns to scale (economies of scale), economies of localization (agglomeration forces within individual sectors) and economies of urbanization (agglomeration forces across different sectors). Clearly, the last component of Hooverian agglomeration, 'economies of urbanization' is similar, if not identical to Marshallian agglomeration. For the purpose of the model, Marshallian agglomeration will be Assumption 1A, while Hooverian agglomeration, without economies of urbanization, will be Assumption 1B. Thus, while Marshallian agglomeration represent positive external economies, or cross-sector externalities, Hooverian agglomeration represents positive internal economies, or own-sector externalities.

The second assumption is related to the presence of dispersion forces, or diseconomies as noted in chapter 2. This is easily justified through such notions as commuting costs and increasing land rents as a function of size or population density, also pollution and traffic congestion, to name a few. More specifically, as a city increases in size, a worker located at the edge of the city in question will potentially face longer, and thus more costly commuting costs than the worker who was formerly located at the edge of a city. As a result, the closer the real estate is to the center the higher its demand, thus increasing the cost of rent. Congestion may also create excess pollution, for example in terms of noise or waste, both which have potentially adverse affects on the cost of production. These are, of course, over simplifications of somewhat complicated scenarios, but it is by no means unreasonable to establish Assumption 2 as cities are subject to diseconomies, which increase with population.

The third and forth set of assumptions relate to the potential method of interaction between the activities found in the urban system. As already noted, the activities assumed present in this current model are the same as those standardized activities found in chapter 4. Thus, manufacturing is assumed present, along with both tangible and intangible services, of which both routine and complex forms are possible for all types of activities noted. Like that of the previous model, the notions of 'routine' and 'complex' suggest that activities will derive a positive net benefit from internal (Assumption 1A) and external economies (Assumption 1B) relative to potential diseconomies (Assumption 2).

The third set of assumptions refers to the potential mobility of manufactured goods within the urban system. Initially, goods will be assumed as being perfectly mobile, and thus their transportation will be subject to zero marginal cost (Assumption 3A). It is worth noting that for reasons stated in chapter 3, such an assumption is not as precarious as it may seem. Classical location theory, as originally codified by Weber (1929), Isard (1956), and Moses (1958), suggests that each decision maker is assumed to seek out a location such that the transportation costs incurred in assembling inputs from their sources and dispatching outputs to their final markets are at a minimum. However, as suggested in chapter 3's 'The role of transportation costs in determining an activity's location', it would be fair to suggest that the role of transport costs in determining the location of economic activity have been subject to decline. This is not to say that transportation costs are no longer a factor, as assumption 3A would imply, but rather that attempts to exemplify the pertinent situation of transport costs becoming less of a defining factor than had previously been the case.

Assumption 3B, on the other hand, assumes that goods will be subject to a transport cost. While goods are assumed to be subject to a transport cost a value, relative or otherwise, has not been stipulated. An unspecified value still provides the opportunity with which to assess a result relative to the other locational determinants. For example, if transport costs were greater than the net benefit gained through agglomeration economies situation *A* would be more probable. Or conversely, if transport costs were less than the net benefit gained through agglomeration economies situation *B* would be more probable. Such a method of assessment is clearly analogous to the one derived and employed in chapters 4 and 5.

The fourth set of assumptions refers to the potential mobility of both tangible and intangible services. Assumption 4A, similar to that of 3A, assumes that the transportation of all types of services are subject to zero transportation costs. Such an assumption, for reasons stated in the two previous chapters, is unreasonable, not only because the essential nature of tangible services suggests that some kind of physical interaction is required, but also because certain intangible services are potentially to complex to be transmitted across space at no cost. Assumption 4B partially acknowledges the unreasonable nature of 4A by assuming that tangible services are subject to a transportation cost, while intangible services will be subject to zero transportation cost. And finally, assumption 4C is 4B with the additional consideration that complex intangible services are subject to transportation costs.

The final assumption of the model is a logistical point in that the number and location of centers can either be taken as exogenous, or a mechanism for city formation is required. In one of Henderson's (1974) models, which was in fact developed from the Alonso-Muth (Alonso, 1964; Muth 1969), he assumes that large agents, which could take the form of urban developers, can create new cities. This will be adopted as Assumption 5, however, it should be noted, that it will have little functional bearing on the development of the model.

It is also worth noting that as in the previous model, it will also be assumed that services 'serve' manufacturing activities. While such an assumption is precarious under certain circumstances, i.e. a center dominated by tourism, it provides a valuable logic that will impose necessary constraints on the results that would be potentially infinite without it. Finally, labor is assumed as perfectly mobile and will locate wherever capital requires it. However, like that of Assumption 5, labor does not have a functional role in this model.

A summary of the five types of assumptions is as follows:

1A – Presence of own-sector externalities (Marshallian agglomeration)
1B – Presence of cross-sector externalities (Hooverian agglomeration with the exception of urbanization economies)
2 – Presence of diseconomies
3A – Goods are subject to zero transportation costs
3B – Goods are subject to transportation costs
4A – Services are subject zero transportation costs
4B – Tangible services are subject to transportation costs
- Intangible services are subject to no transportation costs

4C – Tangible services are subject to transportation costs
- Intangible services are subject to no transportation costs
- Complex services are subject to transportation costs

5 – Agents can create new cities

As noted previously, the five types of assumptions will be considered in terms of a series of scenarios. As observed in table 1, the scenarios are comprised of varying combinations of the previously noted assumptions. Each scenario, while an entity unto itself with which consider the possible outcomes of those factors under consideration, also provides points of relativity with which to attribute changes to particular mechanisms. The ordering is progressive in nature, with each scenario being a slight modification of the one previously. Thus, while each scenario is a unique entity with which to consider the potential implications as to how the factors under consideration contribute to a type of spatial structure, by providing points of reference, it is also possible to attribute observed changes to more specific mechanisms.

Table 6.0 A summary of assumptions implemented in each

Assumptions	1A	1B	2	3A	3B	4A	4B	4C	5
Scenario 1	♦		♦	♦		♦			♦
Scenario 2	♦	♦	♦	♦		♦			♦
Scenario 3	♦	♦	♦		♦	♦			♦
Scenario 4	♦	♦	♦		♦		♦		♦
Scenario 5	♦	♦	♦		♦			♦	♦

6.3 Results

6.3.1 Scenario 1 – Assumptions 1A/2/3A/4A/5

Assuming the initial points are sufficient and do not overlap, an assumption that will apply to all scenarios, the most probable result for the corresponding set of assumptions is an urban system that is composed solely of specialized cities. This can partially be attributed to the absence of transportation costs (3A), which would further suggest that an activity does not require locational proximity to that of its potential market or inputs. Due to activities' lack of spatial constraints, they would then be able to function purely in a manner that would allow them to optimize benefits from positive externalities. Assumption 1A, in conjunction with a lack of assumption 1B, suggests that while own-sector externalities are present beyond that of potential diseconomies at a given point, locating in the locational proximity of activities other than those of their own sector would be an inefficient option because no cross-sector externalities could be derived to counter the potential diseconomies.

The results of the current scenario clearly do not conform to the any of the three empirical regularities. Furthermore, while the relative size of centers is impossible to assert, due to the fact that size is directly related to the size of a sector's labor force, the results clearly lack the presence of diversified cities. The lack of realism, as suggested above, and the subject of further consideration in the following scenarios, can partially be attributed to an application of the somewhat unreasonable assertion of the free mobility of goods (3A) as well as absence of cross-sector externalities (1B). Thus, while the results of scenario 1 might be unlike the previously noted empirical regularities, they tend to highlight the presence of either transport costs or agglomeration economies beyond that of the same sector, or both, within the urban system, and thus the need to consider them.

6.3.2 Scenario 2 – Assumptions 1A/1B/2/3A/4A/5

The assumptions of the second scenario are the same as the first, except for the addition of assumption 1B, or the presence of cross-sector externalities. As will be further exhibited the results are highly dependent on the type of activities present in the urban system. Assuming all manufactured goods are routine (benefits that might be derived through externalities of a cross-sector nature have been internalized), while services will be assumed to be complex (benefit from cross-sector externalities beyond that of potential diseconomies), it is possible to assert that the urban system will be comprised of specialized points consisting of individual manufacturing activities (sectors) and larger more diversified centers consisting of services. Although complex manufacturing has been assumed absent, in addition to the free mobility of goods, the results conform quite well to the empirical regularities. This is not to say that transport costs are unimportant, but rather, as conveyed in chapter 4, which is also in agreement to those assertions offered in chapter 3's 'The role of transportation costs in determining an activity's location', given a particular type of production, transport costs potentially represent a marginal share of total production costs.

Assuming routine services are present, in addition to complex manufacturing, it would be reasonable to assert that routine type services, or those that do not require cross-sector externalities, could potentially exist, as specialized centers, like that of routine manufacturing. Although not apparent in the empirical regularities, it could be considered analogous to the observed decentralization of certain routine services, like that of data processing or call centers (Daniels, 1979, 1985). It is, however, important to further note that such activities are intangible in nature, and the prospect of routine tangible type services decentralizing in the form of specialized centers, as suggested by the empirical regularities and for reasons that will be considered in scenario 4, is a slightly less reasonable prospect.

Complex manufacturing, or manufacturing type activities which require cross-sector externalities, could potentially be found in larger more diverse cities, as the diseconomies induced through such environments would be less than the cross-sector externalities that are potentially present. Thus, the spatial structure of the urban system with the addition of routine services and complex manufacturing is potentially comprised of specialized centers consisting of either individual routine manufacturing and service activities, as well as larger more diversified centers consisting of complex services and manufacturing.

The consideration of complex and routine services and manufacturing, although in the absence of transport costs, creates an urban system that embodies all three empirical regularities, with the exception of the prospect that certain routine tangible services will exist in smaller specialized centers. Regardless, this not only highlights agglomeration forces as an important factor of the locational framework, but also the importance of standardization, or the internalization of cross-sector externalities, as a factor that potentially leads to decentralization.

6.3.3 Scenario 3 – Assumptions 1A/1B/2/3B/4A/5

The third scenario involves the amendment of assumption 3A to that of 3B, or the inclusion of transportation costs for goods. Once again, the spatial structure of the urban system is subject to variation depending the types of activities present (i.e. complex and/or routine). Furthermore, while the prior locational considerations for manufacturing was based on the relative values of positive agglomeration forces to that of diseconomies, the addition of transportation costs introduces an additional variable with which to factor into the locational framework of manufacturing activities.

Assuming complex and routine services and manufacturing are once again present, the resulting spatial structure is potentially identical to that of the previous scenario: specialized centers consisting of either individual routine manufacturing or service activities, as well as larger more diversified centers consisting of complex services and manufacturing. With regards to services, since they are still subject to zero transportation costs, the previously noted outcome can still be attributed to the relative values of potential diseconomies and benefits from certain agglomeration economies, in conjunction with unhindered access to markets and inputs.

In relation to routine manufacturing, which does not require cross-sector externalities for reasons stated earlier, transportation costs become factored into the previously established logic offered for such an activity locating in the form of a specialized center. Like that of the situations conveyed in chapter 4, the benefits derived from avoiding diseconomies, in conjunction with a lack of a need to benefit from cross-sector externalities, would have to be greater than the additional transportation costs that would be created as result of decentralization.

However, unlike the structural environment induced in chapter 4, the current model does not presuppose a compulsory process with which certain manufacturing activities interact. In other words, while the situation in chapter 4 can be applied to the current scenario, there is no reason to suggest that a decentralization of an activity that is subject to transportation costs would induce an increase in costs anymore than its centralization, for the reason that the exact location of the market and inputs were not defined. Although, regardless of whether a centralization or decentralization were to occur, the previously stated logic, in relation to the continued presence of specialized centers characterized by routine manufacturing, conforms to the results, as well as the empirical regularities, which are further supported by those assertions noted in chapter 3's, 'The role of transportation costs in determining an activity's location'.

The type of externality is the only factor that differentiates the locational frameworks of routine and complex manufacturing. The need for cross-sector externalities beyond that of potential diseconomies leads to complex manufacturing activity types locating in larger more diversified centers. The additional consideration of transport costs could potentially influence the original location to one perhaps less diversified if those net benefits (net loss) derived from locating in a diversified center, minus (plus) the transportation costs, were greater than the net benefits (net loss) minus (plus) the transportation costs from another point. Thus, the outcome, like that of routine manufacturing, not only depends on the relative location of production to that of its points of transport, but the proportion of transportation costs to that of production costs, of which the 'net benefits (or net loss)' would be expected to directly influence. However, given the nature of the activity, this being complex, it would be fair to suggest that transport costs represent even less of a share of total production costs than routine type manufacturing, and thus relocation for the purpose of reducing transportation costs would be even more unlikely. Therefore, the previously stated results would most likely remain.

6.3.4 Scenario 4 – Assumptions 1A/1B/2/3B/4B/5

Having considered the implications of applying transport costs for goods, the fourth scenario introduces the prospect of transport costs for tangible services. In both scenarios 2 and 3, complex tangible services were to locate in larger diversified centers, while routine tangible services would be found in relatively smaller specialized centers. The locational framework of both types of activities is similar, if not identical, to that of scenario 2's complex and routine manufacturing, respectively. Concerning complex activity types, the relative benefits derived through cross-sector externalities outweighed potential diseconomies associated with large center. In relation to routine type activities, the nature of the activity implied that externalities beyond that of their own sector had been internalized and benefits from cross-sector externalities would be less than the potential diseconomies that accompanied them. Furthermore, the results of scenario 2 were very similar to the empirical regularities, with the exception of routine tangible type activities locating in the form of specialized centers.

The modification of assumption 3A to that of 3B (scenario 3), or the introduction of goods being subject to transport costs, in light of the empirical regularities, had a marginal influence or partial influence in accordance with improvements in the production capabilities of routine manufacturing (improvement in the ability to derive own-sector externalities). In relation to tangible services, assumption 4B as a replacement for 4A induces the identical locational framework brought on for manufacturing when assumption 3A was replaced with 3B. However, as conveyed in chapter 4, the character of change is by no means the same, due to the unique characters of the two activities. While it was reasonable to suggest that own-sector externalities experienced by routine manufacturing activities in specialized centers could outweigh potential transportation costs, such a notion in relation to routine tangible services, as further suggested by the empirical regularities, might not be as plausible.

Why certain routine tangible services are unable to benefit from own-sector externalities beyond that of potential transport costs is not clear, but suggestions can be offered. Tangible and intangible services were based on the notions of non-tradable and tradable services, respectively, as stated in chapter 3's, 'The role of transportation costs in determining an activity's location'. While tradable services were capable of being facilitated through some kind of intermediary, such as telecommunications or courier services for example, non-tradable services, which might include for example fast-food, warehousing, hotels, and public utilities, would have to be consumed either at the point of production or relatively soon after their purchase. Therefore, regardless of certain benefits that might be derived through production methods, delivery methods, or locational attributes, limitations are present, which make the transfer of such services uneconomical, or even unfeasible, beyond a certain limit that could be deemed relatively lower than that of a manufactured good. Thus, it could be further suggested that relative to certain manufacturing activities, routine tangible services potentially favor locational proximity over own-sector externalities. In relation to the present scenario, assuming the benefits derived from own-sector externalities were outweighed by potential transportation costs, the resulting location would be more inclined to locate in the proximity of where they were required.

For complex tangible services to continue in the previously defined location, the net benefits gained from cross-sector externalities to that of potential diseconomies would have to be greater than potential transportation costs. However, since it is difficult, if not impossible, to stipulate the relative value of net benefits derived through cross-sector externalities to that of own-sector externalities, it remains to be seen whether a routine tangible service would favor locational proximity over externalities more than that of a complex tangible service.

In an attempt to account for the varied perspectives conveyed with regards to complex tangible services, two results will be offered. The first assumes that complex tangible services favors locational proximity over net benefits from externalities as much or more than routine tangible services, while the second will assume that complex tangible services favors net benefits from externalities over locational proximity. The first assumption produces an urban system that is characterized by larger diversified centers consisting of complex manufacturing activities, complex intangible services, as well as routine and complex tangible services, with smaller less diversified centers consisting of routine manufacturing activities, and routine and complex tangible services, and finally even smaller more specialized centers consisting of routine intangible services. The second, is an urban system that is characterized by larger diversified centers consisting of complex manufacturing activities, complex and routine tangible services and complex intangible services, with smaller less diversified centers consisting of routine manufacturing activities along with routine tangible services, and finally, even smaller centers specializing in routine intangible services.

It is important, to further stipulate that the occurrence of routine and complex tangible services locating at a 'less diversified' point implies that the points in question are also able to support the intangible service activities, as further noted in chapter 3's 'Similarities and differences between the two types of change'. If the presence of either routine or complex tangible services were not sustainable in 'less diversified' centers on account of the smaller market, it is possible that the spatial structure of the urban system would be that of scenario 3.

Both of the results derived through scenario 4 relate reasonably well to the empirical regularities. Not only are specialized and diversified centers present, but if the number of activities is an indication of size, diversified centers could be considered relatively larger than specialized centers. And finally, the diversified centers, specifically the 'larger diversified' centers, were found to contain service-type activities in conjunction with complex manufacturing. However, for centers that contained routine manufacturing ('less diversified' centers) two possibilities were offered. In the first result the only difference between the 'larger diversified' and 'less diversified' centers was the presence of complex intangible services, while in the second result 'less diversified' centers were found to only contain routine manufacturing and routine tangible services. The determining factors were the assumptions that 'less diversified' centers offered an adequate market with which to sustain activity, in conjunction with the fact that complex tangible services favored locational proximity to net benefits offered through cross-sector externalities.

It could be offered that the incidence of routine manufacturing locating in centers with certain tangible services offers an additional realism. Separate from that of the empirical regularities, not only are the results more hierarchical, clearly a common feature of urban systems, but it would also fair to suggest that most centers have some semblance of service-type activities. However, it is important to also highlight that the initial results convey an environment where the two types of diversified centers are only slight variations of one another. Similarly, the notion of routine manufacturing would potentially imply that certain processes have been internalized and the market for such activities would not be present. Thus, while it may be reasonable to accept the premise that complex tangible services favor locational proximity to that of net benefits offered through cross-sector externalities the prospective location may not be a viable one. It is, however, also possible that both variations are to a certain extent possible, like that of the different forces acting on the spatial structure of the urban system noted in chapter 2 (i.e. transport, administration and market principles).

6.3.5 Scenario 5 – Assumptions 1A/1B/2/3B/4C/5

The final scenario involves the slight adjustment of assumption 4B to include the assertion that complex intangible services are subject to a transportation cost. The logic of the adjustment, as noted in the assumptions, is to capture the notion that certain services are too involved or complex to be facilitated across space without a cost. The adaptation of assumption 4B to that of 4C is analogous to scenario 3 and 4 where assumption 3A was changed into 3B and where 4A was changed into 4B, respectively. And like that of scenario 3 and 4 where the locational framework of the applicable activities (scenario 3: complex and routine manufacturing; scenario 4: complex and routine tangible services) were subject to change, complex intangible services is subject to the identical considerations.

Prior to the aforementioned adjustment, complex tangible services were regarded as locating in larger diversified centers, since net benefits derived from cross-sector externalities were beyond that of the potential diseconomies. Like that of manufacturing and tangible services in scenario 3 and 4 respectively, the application of transportation costs to complex tangible service activities' locational framework suggests that if net benefits are less than potential transportation costs complex tangible services will favor locational proximity over the accessibility to cross-sector externalities.

Since it is difficult, if not impossible, to assert whether or not transport costs for complex intangible services are greater than the potential net benefits derived from cross-sector externalities over potential diseconomies, like that of complex tangible services in scenario 4, two results will be offered. Recall, however, that 4C includes 4B, which also required stipulation as to whether complex tangible services will favor the net benefits derived from cross-sector externalities beyond that of locational proximity.

Scenario 4's first result (complex tangible services were assumed as favoring locational proximity over net benefits from externalities) when complex intangible services are assumed to favor net benefits from cross-sector externalities over locational proximity remains unchanged. However, assuming complex intangible services favors locational proximity over net benefits, the only change that would occur would be that 'less diversified' centers would contain as many activities as 'larger diversified'. The only difference between the two types of centers would be the presence of routine or complex manufacturing.

Scenario 4's second result (complex tangible services were assumed as favoring net benefits over locational proximity) when complex intangible services are assumed as favoring net benefits from cross-sector externalities over locational proximity remains unchanged. Assuming complex intangible services favors locational proximity over net benefits, similar to that of the previous result, complex intangible services would be found in 'less diversified' centers in addition to 'larger diversified' centers. However, since complex tangible services remained in 'larger diversified' centers, 'less diversified' centers would contain routine manufacturing, routine tangible services, as well as complex intangible services.

Of the four results derived, the two where it had been assumed that the net benefits experienced by intangible complex services were greater than locational proximity had no influence on the previously derived results. The result of the first of the two models which exhibited a change is difficult to accept because the 'less diversified' center was in fact the same as 'larger diversified' centers with the exception of routine manufacturing being present instead of complex manufacturing. Such a result would imply that the capacity of the market is the same for both activities, which is unreasonable considering that the relative notions of 'routine' and 'complex' would indicate that this is simply not the case. The second changed result was essentially the first result of the previous scenario, except for complex intangible services having replaced complex tangible services in 'less diversified' centers and is thus subject to those considerations offered in the previous scenario.

Before concluding this chapter it is worth highlighting that the adjustment of assumption 4C to include transportation costs for routine intangible services would potentially remove the occurrence of specialized centers. Like that of other services-type activities subject to transportation costs, the additional cost of may cause routine tangible services to favor locational proximity over benefits from consolidating in specialized centers so as to derive own-sector agglomerations. As a result, assuming the markets in question were large enough to sustain such activities, centers within the urban system would contain routine intangible type services.

6.4 Conclusion

With the aid of the locational framework derived in chapter 4, a series of general urban systems were generated for the purpose of comparison, so as to provide a general perspective as to how improvements in the ability to communicate across space stands to influence the spatial structure of the urban system. Individually, the models clearly highlighted the various and contrasting variables that govern the locational decisions of activities of which interactions was just one. Other such variables were the relative values of locational proximity to that of net benefits derived through cross- and own-sector agglomerations as well as the capacity of the market with which to sustain a particular activity. As initially conveyed in chapter 4, the ability with which to interact across space was an additional factor in the relationship between the need for locational proximity (assuming the activity could be sustained by the market in question) to that of potential net benefits from agglomeration. The increased ability with which to interact across space provided activities with the opportunity to further optimize net benefits from agglomeration, which could lead to both a centralization and decentralization of activities.

While a general locational criteria could be applied to the standardized set of activities, as also initially conveyed in chapter 4, the emphasis of the factors involved and their subsequent location(s) were effectively determined by the nature and character of the activity in question. For example, routine type activities, on account of having internalized certain own-sector externalities, were more inclined to locate in the form of specialized centers, more so when the delivery of their goods or services were subject to zero transportation costs. Conversely, complex type activities, on account net benefits from cross-sector externalities being greater than potential diseconomies, were more inclined to locate in diversified centers. Thus, given the relative level of standardization, certain activities required/benefited from different types of externalities further influencing their location.

Although the models were static, when considered in reverse order they exhibited how improvements in the ability to interact across space elicited changes that were analogous to certain aspects observed in the evolution of developed urban systems. Like that of Henderson's (1974) earlier model, the absence of transportation costs led to an increase in the incidence of specialized centers. Similarly, during the Industrial Revolution, lower shipping costs coincided with the rise of specialized cities (Bairoch, 1988).

Centralization, on the other hand, functioned under a similar set of principles, in that the improved ability to interact across space provided certain activities the opportunity to benefit from certain types of agglomeration economies, albeit different than those involved in the decentralization process. As observed in the latter scenarios, due to excessive transportation costs, certain complex services were more inclined towards locational proximity (assuming the market could sustain them) than consolidating at diverse centers so as to derive additional benefits from agglomeration economies. The improved ability with which to interact across space allowed such activities the opportunity to provide their services from a distance while at the same time optimizing net benefits at a given point in space. Such a process, as noted previously, also contains certain aspects observed in the evolution of developed urban systems.

It is also worth noting that the centralization process observed in the previously derived scenarios offers additional insight into the question posed at the conclusion of the previous chapter, this being whether advanced-telecommunications will replace 'face-to-face' interactions, and thus the inevitable dispersion of intangible service-type activities? While this will no doubt be the case for certain interactions, the aspect of cross-sector externalities highlights the fact that certain interactions between activities and their location are not purely intangible, i.e. local skilled labor, even if the activity itself is. Thus, while the consolidation of a given activity does not have to occur within a diversified point, an activity might require other agglomeration economies than that of scale.

Conclusion

Since the turn of the twentieth century massive occupational and structural changes have been observed within developed economies that would have been impossible without the improved ability with which to interact across space. However, the implications of the increasing use and capacity of advanced-telecommunications continues to be the subject of considerable speculation. Past research efforts have tended to overly generalize the alleged process, while offering little or no insight into the mechanisms responsible for such changes. In relation to the subsequently conceived Internet, a methodical spatial analysis of its potential implications on the location of economic activity has yet to be produced, however this is probably more a by-product of its relative youthfulness than whether it represents a viable force of change.

As noted at the outset of this study, a lack of systematic considerations as to how advanced-telecommunications has and will potentially continue to influence the location of economic activity has allowed some relatively ambiguous and unhelpful conclusions to emerge. Such conclusions are based on a limited perspective and tend to rely on the acceptance of 'grand metaphors', of which their appeal tends to lie in the aesthetics of the term employed rather than on the rigor of the analysis. This, however, is not to suggest that no worthwhile research efforts have been carried out. The bi-directional hypothesis, which suggests that the advent of telecommunications will cause economic activities to centralize as well as decentralize, was not only implemented as an initial point of reference, but was reaffirmed at several points throughout the course of this analysis.

The missing element of those considerations that offer conclusions in the form of 'grand metaphors' and, to a lesser extent, the bi-directional hypothesis, was the application of a viable structure. The urban system, from the perspective where it represents a spatial account of the culmination of economic activities in space, offer the necessary framework with which to consider an improvement in the ability to interact across space. As conveyed in the sub-section '1.3 Conceptual attributes', the urban system implicitly accounts for all types of activities and the interactions between them through space, of which advanced-telecommunications is an increasingly important medium. More importantly, however, are how changes in the spatial structure due to shifts in technology are inherently limited to the framework of the system, thus placing helpful as well as valid constraints on the analysis.

In addition to providing the means with which to evaluate changes in the spatial structure, the implementation of the urban system also helped to define the nature of such changes, offering additional constructive controls to the analysis. The structure of the urban system, as stipulated in chapter 2, is determined by the symbiotic relationship, or framework within a framework, of two general components, these being the locational distribution of activities and agglomeration economies. As further conveyed in chapter 3, the two components corresponded to the two general types of spatial structure changes that could potentially occur. The first being a uniform shift, where an entire order or level of the urban system is redefined, while the second was the relocation of a function.

The review of different types of change highlighted the essential notion that the type of change is not so much determined by the shift in technology, but rather the character of the activity subject to the shift in technology. This phenomenon could be attributed to the fact that the locational framework of economic activities are similar, if not identical, in that they are primarily governed by production costs in conjunction with the cost of interacting across space. In an attempt to minimize costs, while maximizing profits, an optimal location would be specified. Furthermore, in accordance with the central research question, a change in the ability to interact across space would further imply a possible shift in a given activity's location.

In an attempt to methodically assess the potential implications of technological shifts on the spatial structure, with specific reference to advanced-telecommunications, the two general components of the urban system were integrated to form a variation of a standardized urban system. A series of comparative-static scenarios, pre- and post-technological shift, were then induced for the purpose of evaluating the relative locational flexibility of standardized activities involved in particular production structures. The first analysis, which was primarily concerned with the improved ability with which to interact across space, reaffirmed the bi-directional hypothesis, in that certain activities were shown to centralize, while others decentralize. Thus, the model tended to support the notion that the production process was becoming increasing spatially disintegrated. As noted previously although in relation to established urban system theory, the model also showed that an activity's inclination towards centralizing or decentralizing was related to the activity's nature and character. However, regardless of whether an activity was inclined towards centralizing or decentralizing, in accordance with the fact that activities possess an identical locational framework an improvement in the ability to interact across space provided activities with the opportunity to maintain the necessary interactions, while further optimizing potential net benefits at a given location.

The second part of the analysis, while utilizing the analytical framework established in the first part, considered the implications of the ability to access consolidated information from any point in space (the Internet) on the spatial structure of the urban system. While the nature of change in the first analysis was a relocation of a given activity, the second analysis was primarily concerned with the other type of general change that could potentially occur, this being a diffusion of activities. As was exhibited through the model, the increased availability of processing capabilities, as represented by the general availability of the personal computer, in conjunction with the improved ability with which to interact across space, potentially led to a redistribution of certain activities that had previously existed in consolidated form at a given point in space. This would not only suggest that the spatial structure of the urban system would be subject to change, but the internal structure of the firm as well.

In relation to the wider structure of the urban system, activities that had once existed in space would be redistributed to points which contained activities that had utilized the once consolidated activity. The nature of the redistribution could also be extended to include the capital and resources that had once been used to obtain the services of the once consolidated activity. Thus, while the point that contained the service would effectively lose a revenue generating activity, the loss also represents potential gains for other points throughout the system. Furthermore, assuming the redistribution of capital is substantial enough, economic theory, which assumes profits are reinvested into production, would further suggest activities that captured such gains could effectively reduce the cost of their production. A decline in costs would increase aggregate demand; ultimately increasing revenues generated in the region the activity was located, potentially inducing a type of regional multiplier effect. In relation to the firm, assuming the activity that had been subject to redistribution was integrated into the structure of those firms that had previously utilized the service, it could be suggested that such reorganization would further imply that the Internet has and will continue to induce a general trend towards the horizontal integration of such applicable services.

The final component of the analysis took a more general perspective than the previous two. Utilizing the logic developed by the locational framework applied in the first analysis, the third and final component developed urban systems in their entirety through the application of a series of assumptions as to the manner in which standardized activities, like those utilized in the first analysis, interacted across space. The resulting urban systems were characterized in terms of specialized and diversified centers, providing the opportunity with which to compare and contrast the results with empirical observations of the U.S. urban system. The trend conveyed through the series of models not only reaffirmed the bi-directional hypothesis, but also provided additional insight into the mechanisms that governed such changes.

Henderson's (1974) hypothesis that a decline in transportation costs led to an increase in the incident of specialized centers was effectively reaffirmed. The model also went on to exhibit how the increase in specialized centers was not just due to a decline in transportation costs, but tended to function in conjunction with the standardization of activities. As activities standardized, their need for external economies diminished and could thus relocate on the periphery away from unnecessary diseconomies, which prior to their standardization represented certain positive external economies. As conveyed through the logic of the locational framework established in the initial analysis, given a particular level of production the activity in question would decentralize if the benefits from escaping the unnecessary diseconomies were greater than the additional transportation costs incurred at the new location. Therefore, part of the increase of specialized centers as a result of lower transportation costs could be explained in terms of the inclusion of activities that are relatively less standardized than had previously been the norm. This trend, however, requires further stipulation. While it has been theorized that the improved ability to interact across space will result in an increase of specialized centers, the second analysis suggested that firms could potentially experience a shift towards one of horizontal integration. While the proportion of labor involved in a given industry or type of activity at a given point may or may not change, additional processes that have been integrated through the increased availability of the Internet could be deemed uncharacteristic of the classification with which they have been labeled. Thus, as the spatial structure of the urban system becomes subject to change so does the internal structure of the certain firms.

The model also conveyed the circumstances under which activities were inclined to centralize. An improvement in the ability to interact across space also provided certain activities the opportunity to benefit from certain types of agglomeration economies while providing their services from a distance. Prior to the improved ability with which to interact across space, such economies could previously not be realized due to excessive transportation costs, which forced such activities to favor locational proximity. Thus, regardless of the direction of change, like that of the initial analysis, the improved ability to interact across space provided activities the opportunity with which to further optimize net benefits at a given location.

The urban system, or previously regarded 'framework within a framework', provided the opportunity to consider the manner in which an activity relates to its environment in conjunction with the structure of production it is involved with. The analysis as a whole tended to suggest that the improved ability with which to interact across space, as well as the conception and application of the Internet, will provide firms, or their applicable collection of their activities, the opportunity to further optimize components of the production process as they relate to one another and their environment or environments.

Finally, it is worth further noting that the analysis not only implies viable avenues of future research efforts, but provides the analytical structure with which to pursue them. Clearly, the nature and character of the activity in question played a central role in the determination of the direction or type of change observed. An analysis into how the mechanisms involved in the process of change represent aspects of actual functions would not only provide insight into the manner in which the urban system will continue to develop, but the magnitude of such changes. As noted in chapter 4, '4.2.1 Forces of change' entire sectors of industries, like that of low cost airlines in Europe for example, have begun to be facilitated through the Internet, which has led some to believe that within a decade most travel bookings will follow. More importantly, travel is just one of many industries that could be facilitated via the Internet. The second analysis conveyed how, why and the consequences of such a shift, thus it would seem worthwhile to apply that format onto similar economic functions so as to more accurately explain as well as anticipate such changes. The extent of the transition of activities from space to that of the Internet is, of course, representative of a larger question. An activity has an inclination towards diffusion, as exhibited through that of the Internet, or relocation, as exhibited through the occurrence of branch production. While the previous analysis provides certain insights into how and why this is the case, it might be possible to extend upon such assertions for the purpose of developing a more extensive criteria of the factors responsible for such tendencies.

Looking forward...

Like most, if not all, academic investigations, the analysis and subsequent conclusions generate more questions than provide answers. Some of these questions highlight deficiencies present in the study, while others indicate potential avenues for future research, notions that are by no means irrespective of one another. Similarly, given the explanatory as well as foretelling character of the analysis, certain policy considerations come to bare that are also worth noting.

One such deficiency is that the study offered is predominantly theoretical in its perspective and thus analysis. Chapter 6 offers some empirical evidence that supports the examination as well as the conclusions established in chapter 4, but such evidence could be deemed somewhat limited in that it is by no means thorough, nor does it offer a direct assessment of the key variables. As a result, a prospective research effort could perhaps offer a more empirically oriented consideration of the theories presented. However, it is important to note that a lack of empirical evidence, and thus the disproportionate emphasis on a theoretical analysis was more a by-product of the complex associations between the variables in question rather than inadequacies in the methodology. While such factors like that of transportation costs are easily measured, the majority of factors, like that of agglomeration economies and to a certain degree transaction costs are difficult, if not impossible, to quantify (see chapter 2). For example, studies that attribute the occurrence of technopoles to agglomeration economies (Scott, 1993; Castells and Hall, 1994) do so through a relative assessment of general associations, i.e. co-location of certain amenities. With regards to associations between the variables in question, while a firm's motivation to agglomerate can largely be attributed to a desire to reduce transaction costs, the savings gained from such a decision not only vary between activity types, but are impossible to measure beyond that of relative generalizations. Thus, while the logical progression of research might suggest a need for additional empirical analysis, the factors considered do not lend themselves well to precision testing.

However, while the analysis itself may not be conducive to direct empirical testing, it does indicate viable avenues for future research of both an empirical and theoretical nature, in addition to providing the analytical structure with which to pursue them. As noted in chapter 3, an activity's location is subject to modification in two ways (a relocation and/or diffusion), which is determined by not only the type and extent of the technological shift, but by the nature and character of the activity in question. Furthermore, in the analysis, activity types were assumed as present (or not), while assumptions as to their behavior, albeit fair, were also applied, so as to further derive a general understanding of how such activities might respond to technological change and how such changes influence the spatial structure of the urban landscape. The analysis provided lends itself well to a further theoretical as well as a practical assessment of activity types' inclination towards the two types of locational change through its provision of a locational framework derived in chapter 4.

Such an analysis could take multiple forms and while there are details that require further consideration, initial insights suggest that some kind of association could be made between that of an activity types' location within the urban system with that of a ratio consisting of transportation costs to that of production costs. The ratio in question is similar to the previously noted value-weight ratio, but as noted in chapter 3, the value-weight ratio is inherently flawed, not only in that it can only be applied to tangible goods, but also fails to account for economies of scale in transportation. Placing the transportation-production cost ratio in a dynamic context, or in relation to a period of time where identifiable shifts in technology occurred (most likely very general shifts like those identified by Bourchert, 1967), potential locational shifts and the types of shifts could be further attributed to relative changes in the ratio. Such locational changes like that of branch production or the diffusion of activities, due to such technology like that of the Internet, would effectively adjust the ratio, which could then be associated with the type of locational shift. Speculation based on the previously established analysis and framework would suggest, for example, that an activity diffuses because it requires a smaller market, which would further imply relatively lower production costs and thus modification of the ratio. Similarly, the occurrence of branch production has been attributed to a reduction in transportation costs, which would potentially adjust the ratio in an alternative manner.

An assessment of the types of change a certain activity might be more inclined towards, placed in a general context, would provide a unique perspective into the manner in which the urban system might develop as well as the magnitude of such changes. By utilizing the locational framework developed in the previous analysis, locational shifts in conjunction with relative shifts in the transportation-production cost ratio would not only provide the opportunity to further characterize activities inclined towards certain types of locational shifts, but also the factors and possibly the environment responsible for such shifts. Although this research effort was by no means policy driven, it is worth noting that such environmental considerations, specifically those that 'pull' activities to a given region, might prove valuable to regional developers or policy makers involved in process of regional development.

However, before offering brief insight into potential policy considerations brought to bear through analysis, other potential studies specifically related to the consolidation of information in non-space (the Internet) are worth considering. As noted in the Introduction, entire sectors or industries, like that of low cost airlines in Europe, for example, have begun to be facilitated through the Internet, which has led some to speculate that within a decade most travel bookings will follow. More importantly, travel is just one of many industries that could be facilitated via the Internet. Not unlike the potential research effort previously noted, it might prove worthwhile to further examine the criteria of those activities facilitated via the Internet, i.e. price and character of the commodity in question. Such a consideration might also provide the necessary framework with which to further speculate as to what other types of activities could be provided via the Internet given additional technological advancements.

With regards to the Internet and the wider spatial structure of the urban system, as note in the conclusions of chapter 5, activities that had once existed in space might be subject to a redistribution in the direction of the points which contained activities that had utilized the once consolidated activity. Considering the magnitude of such a shift induced by the advent of the Internet, in both a occupational and structural context, it would also be worth considering how the nature of such redistribution could be extended to include the capital and resources that had once been used to obtain the services of the once consolidated activity. More specifically, while the point that contained the service would effectively lose a revenue generating activity, the loss also represents potential gains of other points throughout the system.

Assuming the redistribution of capital is substantial enough, economic theory, which assumes profits are reinvested into production, would further suggest activities that captured such gains could effectively reduce the cost of their production. A decline in costs would increase aggregate demand; ultimately increasing revenues generated in the region the activity was located, potentially inducing a type of regional multiplier affect. In relation to the firm, assuming the activity that had been subject to redistribution was integrated into the structure of those firms that had previously utilized the service, it could be suggested that such reorganization would further imply that the Internet has and will continue to induce a general trend towards the horizontal integration such services.

Returning to potential policy considerations, a framework with which to assess environment factors in relation to the support and/or promotion of regional development is just one of two policy areas that stand to be informed through the analysis and future research considerations. The second area, relates to the changing structure of the market, as a result of information having a greater ability to consolidate in non-space through the advent of the Internet. With regards to the former, the pertinence or value of a criteria that would further inform policy makers as to what activities might successfully relocate to a given area, or the factors required for such success, requires little validation. Needless to say, any tool(s) which stands to optimise efforts extended towards regional development would no doubt be welcome.

Finally, it has been commonly hypothesized that the Internet has and will continue to induce an increase in consumer sovereignty through a decentralization of producers and suppliers as well as the removal of certain barriers to entry (The Economist, 2005). However, the increased ability to consolidate information in non-space could also potentially cause a monopolization of certain aspects of the consumer-producer relationship, ultimately introducing inefficiencies into certain markets. As conveyed in the Introduction and chapter 5 was how the advent of advanced-telecommunications was causing a spatial detachment between the value of a good and/or service and its related information, as further exemplified by stock exchanges and financial/commodity brokers. Also noted in the Introduction and further exemplified in chapter 5 was how information benefits from certain types of agglomeration when it consolidates, provided the technology is available. A continued trend of such consolidation could potentially lead to the single control or monopolization of the information in a given market. While an increase in the ability to interact across space, as stipulated in chapter 5, potentially removes the possibility for spatial monopolies for a given product, it is important to bear in mind that the efficient provision of such information requires a critical mass (see chapter 5), which may introduce barriers to entry that have yet to fully realized.

A critical mass in this particular context shares certain characteristics to that of the design and use of software in networks. This is not unlike Windows operating system, where the value of the software is not just realized through the effectiveness of the design, but in its compatibility with other users and related software applications. In relation to consolidated information, a user derives benefits from the economies of scale, which is effectively realized through the participation of other users. Thus, the introduction of a competing facilitator for the same consolidated information would be unable to provide the same quality of service without the participation of the users in the original system. The users of the original system could potentially diffuse to the new system, but this would have to be in a timely manner in order for the applicable users to derive benefits comparable to that of the original system. Naturally, the relative cost of the competing facilitators would most likely determine the length of time and effort a new user would attempt to utilize the new system before returning to the original. Thus, a facilitator, which has achieved such a critical mass, is able to inflate prices above costs, or a competitive level.

The details of the aforementioned relationship require addition consideration and would clearly benefit from additional research efforts. Regardless, initial thoughts clearly convey the possibility of inefficiencies being introduced through that of the Internet, which governing bodies should be aware of.

Appendixes

Appendix - A

A.1 Switching Technology

Before the introduction of switching technology, the instantaneous communication between points was restricted solely to the exclusive interaction between two specific points. For example, point *A* could interact with point *B*, and vice versa, due to a previously established connection between the two points (see figure A.1). However, if point A wished to interact with a point other than point *B*, i.e. point *C*, a connection like that of the one between point *A* and *B* had to also be established between point *A* and *C* (see figure A.1). Thus, in the absence of switching technology, in order for a firm or individual to communicate with locationally remote points, they would require as many individual lines as there were points sought for communication.

Figure A.1 The necessary requirements for the interaction between two points.

With the introduction of the first manual exchange in 1878 in New Haven, USA (The New Encyclopedia Britannica, 1998) came the first form of networked communications. As a result, a series of points could be connected to a common point where a so-called switching station was located, which facilitated the communications between any of the connected points. Thus, rather than a need for a unique line between two points, like that of point *A* to *B* or *A* to *C* as observed in figure A.2, a line would be connected to a switching station and the station would redirect communications traffic accordingly. As observed in figure A.3, points *A*, *B* and *C* are all connected to a switching station (*SS*), and as a result point A is able to communicate with both points *B* and *C* via a single line.

Figure A.2 The necessary requirements for the interaction between three points pre-switching technology.

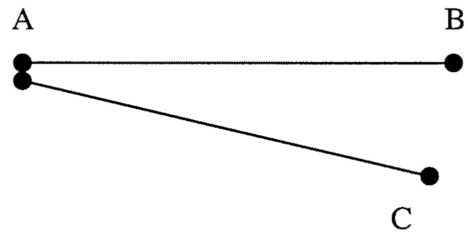
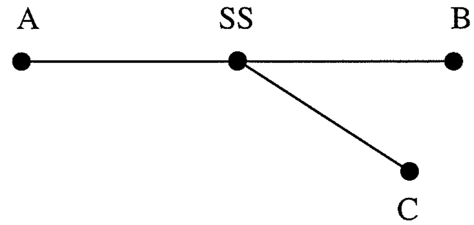


Figure A.3 The necessary requirements for the interaction between three points post-switching technology.



The need for switching is clearly an economic trade-off among transmission, switching, and the terminal equipment (i.e. telephones) that provides telecommunication services. Centralized switching is aimed at reducing the number of interconnecting links, as is conceptually illustrated between the relative number of links between figure A.4a and A.4b. By introducing a centralized common switch point, the number of interconnecting links is reduced from $N\ (N\text{-}1)/2$ to N links between subscribers and the common switching point. As observed in figure A.4a and A.4b, given 6 unique points, without a common switching point 15 links are required, while with a common switching point only 6 unique links are required.

Figure A.4a and A.4b The number of necessary links with (b) and without (a) a common switching point.

Another advantage of such a system is its ability to integrate new users, or even entire new systems, with relative ease. A new user (NU) is simply connected directly to the switching station, allowing communication with the other previously connected users and, of course, vice versa, with little or no change to their original behavior (see figure A.5a and A.5b). Similarly, entire switching stations, each facilitating a different set of users can be connected to one another, subsequently connecting the users of each station with one another via the switching stations in question (see figure A.6a and A.6b). Thus, through the application of a centralized point directing traffic, the system is able to grow without users having to change their general behavior.

Figure A.5a and A.5b Before (a) and after (b) the integration of a new user (NU) into a system facilitated by a switching station.

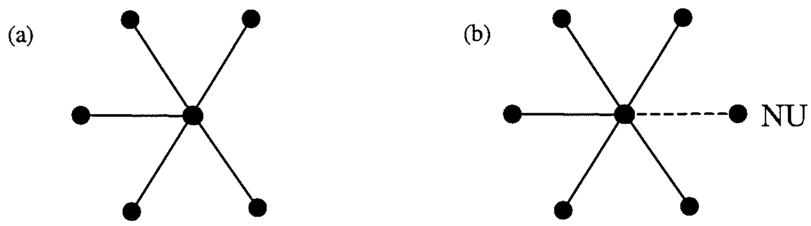
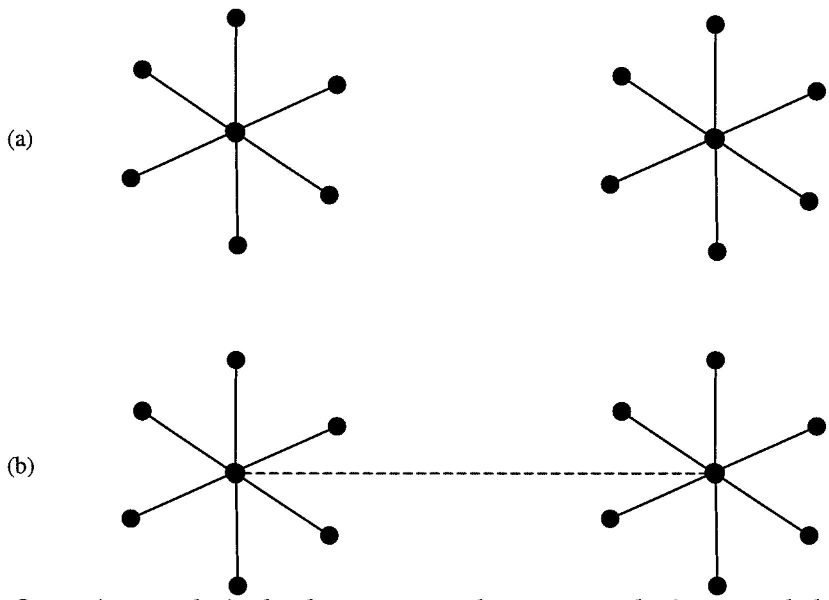


Figure A.6a and A.6b Before (a) and after (b) two switching stations become connected to one another.



Over time technical advancements have not only increased the efficiency of switching technology, but have allowed them to facilitate the different types of transmissions available, of which both developments have contributed to the relative acceleration of the telecommunications process. The first switching station in 1878 was operated manually. A control office, in which the switching station was located, would receive a telephone call which would then require a human operator to establish a 'circuit' between the caller and the caller's desired destination. However, in 1889 Strowger developed the automatic electromechanical switching systems, which would soon replace manual type switches (Cole, 2000). Automatic switching systems provided increase traffic capacity, while at the same time reducing required labor costs. In 1960 electromechanical switches would be replaced by semi-electronic switches, which would be joined by electronic switches in 1976 as digital transmissions came into service (see table A.1).

Table A.1 Types of switching and their evolution (The New Encyclopedia Britannica, 1998)

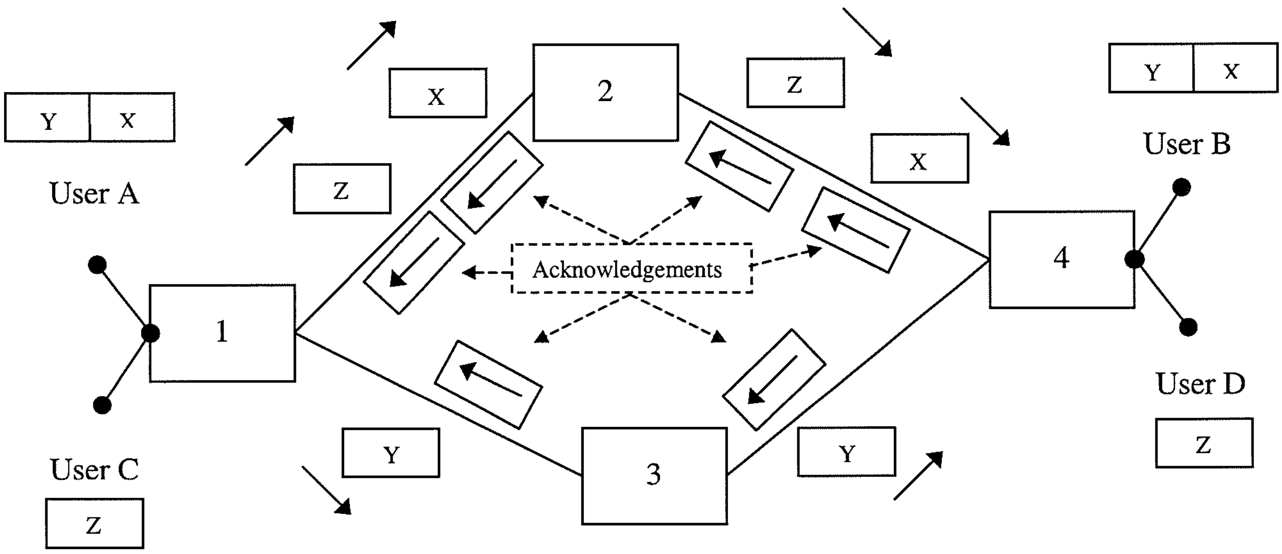
Switching System	Operation
1878 manual operator	Manual
1892 step-by-step	Electromechanical
1918 cross-bar	Electromechanical
1960 electronic switching system	Semi-electronic
1976 electronic switching system	Electronic

The previously noted 'circuit' that is established between two points, so that communication via telecommunications can occur, is commonly referred to as *circuit switching* and is just one type of switching system. Circuit switching refers to the creation of a physical path between the two entities that wish to communicate with one another. It is comparable to an *analog* signal, which refers to a physical signal, be it a sound or electrical, whose energy level varies over an interval of values continuously. Thus, due to the very nature of the signal, a channel, which is continuously open, is necessary to facilitate its transmission. However, as will be considered further, while analog signals are related to circuit switching it is not to suggest that a circuit switch is only capable of facilitating an analog-type signal.

The relationship between analog signals and circuit switching can be attributed to the initial methods of telecommunications (i.e. the telegraph, telex and telephone), which utilized analog signals; thus circuit switches were designed to facilitate a continuous signal. This process, however, has certain inherent inefficiencies, in that the connection between the two points is potentially not optimized. For example, a circuit switch is capable of facilitating communication *between* points, further suggesting that if communication occurs in only one direction the circuit is only being used at half of its capacity.

However, as will be further considered in the following sub-section, 'binary code', with the advent of digital signals, which facilitates information in terms of a series of '1s' and '0s', signals can be dealt with discretely. This has led to the development of *packet switching*, which divides the information in question into a series of segments called *packets*. Each packet is assigned a *packet header*, which is meant to identify the packet and indicate its destination. Packets are then treated individually, each forwarded along the best available path through the network at any given instant.[19] This is process is further exemplified in figure A.7.

Figure A.7 Packet switching



User *A*'s message is divided into packets *X* and *Y*, which is intended for user *B*. User *C* has a single packet *Z* intended for user *D*. Packets *X*, *Y*, and *Z* are transmitted independently through the network towards their intended destination. Acknowledgements are sent back stating whether the packet had been received or not, and if an error occurs, the packet is resent. Packets are then reassembled at the their destination and thus delivered to their respective user.

[19] It should also be noted that another type of switching technology exists called *store-and-forward switching*. This is, however, identical to packet switching except instead of functioning in real time the

While the overall advantages of digital signals compared to that of analog signals will be considered in the following sub-section, it is important to note that packet switching in conjunction with digital signals has led to an more efficient use of the communications system through its ability to utilize unused capacity on channels.

A.2 Binary Code

Binary code, to put it simply, is a language with which machines use to process information. Its form being combinations of '1s' and '0s', with each individual number referred to as a 'bit', which are placed in specific sequences to represent the appropriate commands. As will be further noted in the following section, 'The processor', bits are rarely observed on their own. Rather, depending on the machine in question, they are bundled into predetermined groups of varying amounts, referred to as 'bytes'. For example, PCs utilize eight bits in a byte allowing them to represent 256 values ranging from 0 to 255, as shown here:

0 = 00000000
1 = 00000001
2 = 00000010
...
254 = 11111110
255 = 11111111

Compact disc (CD) players, on the other hand, use a system with 2 bytes, or 16 bits per value, endowing them with a range from 0 to 65,535, as shown here:

0 = 0000000000000000

---

message in question stored until the moment presents itself and is then transported as a whole. Automatic teller machines (ATMs) are an example of something that utilizes such technology.

1 = 0000000000000001
2 = 0000000000000010
...
65534 = 1111111111111110
65535 = 1111111111111111

As a language consisting of numbers, communication transmissions in binary code are also referred to as digital transmissions. As implied in the previous sub-section, digital transmissions are a series of electrical pulses, each pulse representing one or zero bits, unlike analog transmissions, which function as continuous electrical waves. Many of the advantages from digital signals, compared to that of analog signals, are derived from the increased efficiency and capacity of their transmission between points, which will be considered in the following sub-section, 'carrying capacity'. However, the application of binary code as a system with which to process information also possesses certain advantages. Mirabito (1994), recognizes three such advantages: computer (PC) compatibility, data integrity, and flexibility.

In regards to PC compatibility, PCs already manage information in terms of binary code, thus assuming their connection facilitates digital signals, upon receiving a transmission from another PC, are able to instantly process the transmission in question. With the use of modems, it is, however, possible for PCs to transmit digital messages to one another in analog form. As will be further considered in the following section, 'carrying capacity', a modem effectively reduces the speed and size of the message, so that an analog network is able manage the transmission. Regardless of the method of transmission, binary code represents a standard format with which PCs use to communicate with one another. As a result, assuming the method of interaction is an efficient one, PCs are able to benefit from previously stored and/or processed information, and thus the efforts, of a remotely located PC.

Since information in analog form exists as complete streams of sound, the relative process ability to that of a digital transmission is relatively lower. This is easily exemplified through the consideration of common word processing methods, which in modern economies is, of course, computerized. Computerized word processors do not store or process streams of sound, but rather digital sequences. As a result, transmissions in digital code are immediately processable, while an analog transmission would require additional transactions before the information is capable of being processed. Furthermore, the reproduction of a piece of information in digital form is simply the duplication of the sequence, which is an instantaneous process. Reproducing information stored in analog form, however, requires the same amount of time it would take to 'play' the transmission. This further relates to data integrity, because like that of transmitting an analog signal, any reproduction has an inherent susceptibility to external 'noise', which will naturally have perverse affects on the quality of the recording.

Information is clearly not expressed in any one form, but rather numerous forms, i.e. video, speech, etc. Before digital code, such forms of information were stored in a variety of ways. For example, video and speech were usually stored in tapes in analog form, while documentation would be stored in 'paper and ink', and perhaps later on microfilm. As previously suggested, processing or duplicating such forms of information would not only be different, but relatively more effort than if they existed in digital form.

Digitized information has not only provided the groundwork for new and improved methods of communications, but has also allowed for the convergence of media, computing and telecommunications. The consolidation of technology is commonly referred to as 'telematics', originally introduced in a report to the President of France (Nora and Minc, 1980). Telecmatics has been more recently been defined as the 'technical and economic phenomena arising at the intersection of the progressively merging computing and telecommunications industries' (Snow, 1988, p. 171). It has provided the technological foundation for rapid innovation and technological convergence in computer networking, voice, data, image and video communications and thus the ability to transmit all types of information through one transmission system (Martin, 1978; Batty and Barr, 1994). Furthermore, since the information, regardless of its format, exists in digital code it can be stored and processed by a processor, provided the processor is sufficient in its capabilities, as will be further considered in the following sections.

A.3 The Processor

As previously noted, the term 'processor' is intended to represent the two initial and two final components of the telecommunications system (input device [transducer], sending equipment, receiving equipment, and output device [transducer]), in other words, the mechanism that transmits and deciphers transmissions for human consumption. It is important to further note that 'processor' also refers to 'microprocessors', which are found in PCs, and as in the realm of telecommunications, are responsible for data manipulation/processing.

As already noted, transmissions have been either in an analog or digital form, which without the appropriate device are nearly, if not entirely, impossible for the human brain to comprehend without some kind of mechanical assistance. Over time, the form and capabilities of such devices have evolved considerably, as characterized by the relative abilities of the Wheatstone telegraph to that of a PC. Similarly, because of microprocessor development, PCs in and of themselves have also been subject to considerable improvements over the past few decades. As processors have become more capable, not only has their ability to transmit and decipher larger transmissions faster developed, but this has also corresponded to their wider availability and thus increasing use of digital communications (Lyman and Varian, 2000).

The first microprocessor, the Intel 4004, was first introduced in 1971, which had a processing capacity of 4 bits (see previous sub-section for an explanation on 'bits'). Such a processor, however, was only capable of very simple procedures, i.e. adding and subtracting, and was thus only used to develop one of the first portable calculators. It was not until 1974 when the Intel 8080, a complete 8-bit microprocessor, was made available in PCs. As observed in table A.2, microprocessor development has improved considerably between their initial application in PCs in 1974 to 2000. It should, however, be noted that while table A.2

Table A.2 Processors produced by Intel 1974 – 2000 and their specifications (Intel museum, 2004)

Name	Date	Clock speed	Data width
8080	1974	2 MHz	8 bits
8088	1979	5 MHz	16 bits 8-bit but
80286	1982	6 MHz	16 bits
80386	1985	16 MHz	32 bits
80486	1989	25 MHz	32 bits
Pentium	1993	60 MHz	32 bits 64-bit bus
Pentium II	1997	233 MHz	32 bits 64-bit bus
Pentium III	1999	450 MHz	32 bits 64-bit bus
Pentium 4	2000	1.5 MHz	32 bits 64-bit bus

is just an account of a single producer of microprocessors (Intel), it is nonetheless representative of microprocessor development since their conception to the approximate present.

'Clock speed' is an approximate representation of a given microprocessor's processing speed. For example, the 80486 is capable of processing 4 bytes (32 bits ÷ 8) 25 million times per second. The 'bit-bus' in the 'Data width' category refers to the amount of information the microprocessor is capable of sending and receiving in a given cycle. It can thus be concluded that microprocessors have become more capable in processing, receiving, and transmitting larger amounts information. Larger transmissions represent, of course, more complex forms of information and thus the improved ability of processors is directly related to humans' ability to transmit increasingly complex forms of information across space instantly (feature 1). As will be considered in the following sub-section, the development of the microprocessor has also allowed for certain technological developments that increase the efficiency of the element of the telecommunications system responsible for carrying the signal, or channel proper.

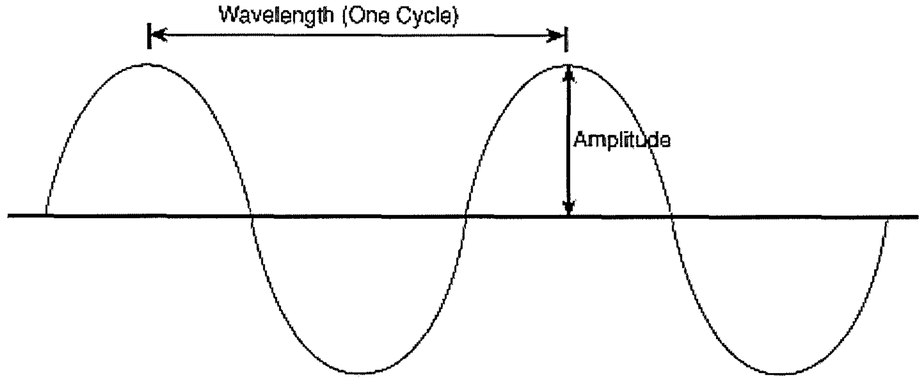
The development of the processor has also allowed for its increasing availability within the urban system, and thus an improved capacity with which to communicate across space uniformly. As noted by Pred (1977) in his *City-systems in advanced economies*, pre-advanced-telecommunications could be characterized as higher order cities communicating exclusively with one another, due to the potential level of traffic, further justifying the presence of a connection. Conversely, higher order centers did not extensively communicate with lower order centers because such means were not sustainable in lower order centers. However, as processor production and design improved, in conjunction with the general availability of carrying capacity infrastructure, (as will be further considered in the following sub-section) points were increasingly capable of communicating with a wider range of points throughout the urban system. Not only had the production process improved, reducing their relative cost, but their use became increasingly efficient, reducing their relative operating costs as well (Malone, 1995). Thus, in conjunction with those assertions offered in the previous chapters, the necessary market size required to sustain their operation decreased, inducing their greater availability and thus increasing the ability with which to communicate across space, in volume as well as geographically.

A.4 Carrying capacity

The notion of 'carrying capacity' refers to the middle, or third, essential component of the previously noted telecommunications system. The ability with which to transmit and decipher increasingly complex forms of information due to the increased ability of microprocessors has been met by the improved ability to 'carry' such transmissions.

The movement of all information in modern communications, analog or digital, depends on the manipulation and controlling of signals within the electromagnetic spectrum. Electromagnetism refers to the movement of electrons, which as predicted by James Maxwell in 1865 and later observed by Heinrich Hertz in 1887 results in electromagnetic waves propagated through space. Like that of 'Clock speed' in the previous sub-section, electromagnetic waves are measured in terms of cycles per second, or Hertz after their discoverer. The electromagnetic spectrum ranges from an extremely low number of cycles per second, like that of certain radio waves which have been observed at 30 Hz, to that of cosmic rays, which have been observed at more than 10 million trillion Hz (see figure A.8 for an example of an analog signal).

Figure A.8 An analog signal



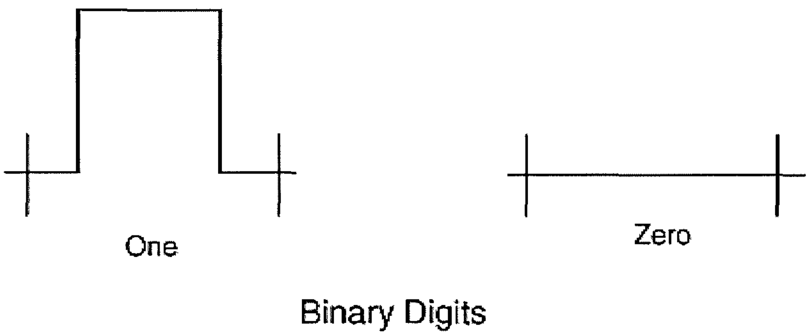
Upon attempting to harness electromagnetic signals for the purpose of communications, different types of materials, e.g., copper, or lack thereof, i.e. radio waves, facilitate various ranges of the spectrum. The range of frequencies (difference between the lowest and highest frequencies carried) that make up a signal is referred to as the *bandwidth*. Other important aspects of an electromagnetic wave include the *amplitude*, or height of the wave, which indicates its strength and the *phase*, which refers to the angle of the wave form at any given moment. Copper wires, the original foundation of the telecommunications network, have the ability to facilitate a bandwidth of about 1 MHz. Coaxial cable, which is an adaptation of copper wire, can contain about 1 GHz of the frequency spectrum. Radio waves, particularly microwaves, are capable of managing a 100 GHz bandwidth, while fiber optics, the newest addition to the communications infrastructure, can operate a bandwidth over 200 THz (terahertz) (Lax, 1997).

With the aid of modulation technology, a key function of 'sending' and 'receiving' equipment, information is superimposed upon an electromagnetic signal subsequently manipulating the signal into that of a carrier; a process that varies depending on the nature of equipment and signals being employed. Analog waves, which as stated in the previous sub-sections, are characterized as a continuous wave, vary in amplitude and frequency. In regards to a telephone, for example, changes in air pressure from an individual's mouth directed into the handset are converted into current, or voltage, fluctuations, which represent an analog of the actual voice pattern. The transmission of data via an analog signal requires the use of a modem at the respective sender and receiver, which converts digital into analog form, and upon reception of the signal, back to digital. Three such modulation techniques are commonly used: amplitude modulation, frequency modulation, and phase shift modulation. All three processes effectively apply a two-level coding system to the aspect of the analog wave in question (amplitude, frequency, or phase) and are thus able to represent 0s or 1s as a result. However, as previously noted, the purpose of the modem is to limit the frequency of the digital signal so that it conforms to the typical allotted bandwidth of analog network limits, which usually has a bandwidth of approximately 3,100 Hz (min frequency – 300 Hz max. frequency 3,400 Hz) (Lax, 1997). In terms of the maximum data transfer rate, this translates into 33.6 Kbps.[20]

As previously noted, digital transmissions, unlike analog signals, use discrete pulses to represent 1 or 0 bits (see figure A.9 for an example of digital signals). In electrical networks, i.e. coaxial cable, 1 bits are represented as high voltage, and 0 bits are represented as null, or low voltage. In optical networks, i.e. fiber optics, one bits

[20] It should be noted that this rate can be increased to 56Kpbs if the modem is connected directly to an Internet service provider (ISP).

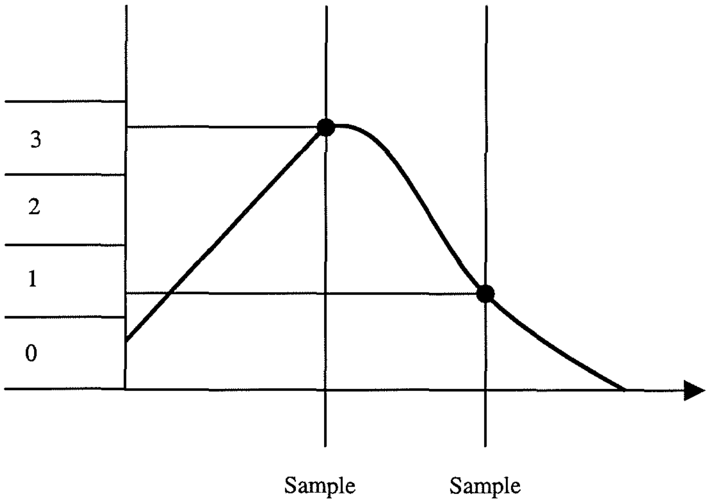
Figure A.9 Digital signals



are represented by the presence of light, and zero bits are represented by the absence of light. Opposite to that of digital signals being converted to analog so that PCs are able to communicate with on another via the telecommunications network, analog signals, i.e. voice and video, are converted to digital signals for more efficient transmission through a technique known as *pulse code modulation* (PCM). As conveyed through figure A.10, PCM involves three equally important steps: sampling, quantization, and coding. Sampling consists of periodic measurements (in the case of telephony sampling occurs 8,000 time a second), which rise and fall with the amplitude of the original signal. Quantization consists of the samples being applied to a previously established finite set of discrete quantities that the original analog signal could assume. Coding entails taking the quantized values and representing them, usually as 8-bit binary numbers, which are then relayed through a series of pulses (see Griffiths 1990, chapter 2 for more on PCM).

Figure A.10 A PCM operation. The diagram has been simplified for illustration purposes. The two sampling points have been indicated by samples 1 and 2 (A). Sample 1 is 2.7 volts and is assigned to the nearest step, 3 volts. Sample 2, 1.3 volts, is assigned to the nearest step, 1 volt. Based on the chart (B), the samples are coded as 1-1 and 0-1 respectfully. The result is the PCM signal (C).

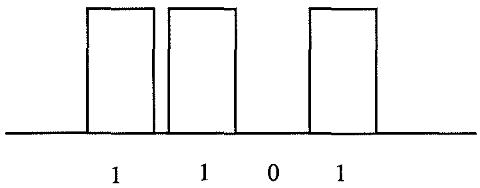
A



B

Steps (volts)	Binary code
3	1-1
2	1-0
1	0-1
0	0-0

C



In addition to an improvement in the quality of transmissions, the application of digital code has also led to a substantial increase in the amount of data that can be potentially transmitted between points. Analog facilities, in addition to having a limited bandwidth, which means they are unable to support high-speed data, are also more susceptible to external disturbances, further affecting the quality of the transmission. Disturbances can be internal, introduced by the communications system itself, or external, originating from outside sources and once such discrepancies have become part of the signal it is impossible to separate them.

As a signal moves across distance, as basic physics would dictate, it loses power. As a result, network facilitators apply amplifiers, which are normally placed on circuits over 18,000 feet to bring the signal back to its original power. However, analog amplifiers are noted as 'dumb devices' in that they simply add power to a signal including the errors that have perversely affected the integrity of the signal. A digital signal, on the other hand, uses *regenerative repeaters,* or *signal regenerators.*[21] Unlike that of an analog amplifier, a regenerative repeater examines the content of the signal and then reissues the signal to the next part of the network, in essence eliminating inconsistencies before they can corrupt the integrity of the signal and thus improving the error rate, which as observed in table A.3 is clearly superior to that of an analog network.

Table A.3 Comparison of error rates between analog and digital networks (Goleniewski, 2001)

	Analog network	Digital network
Error rates	10^{-5} (1 in 100,000 bits) is guaranteed to have an error	Copper; 10^{-7} (1 in 10 million bits) will have an error Satellite; 10^{-9} (1 in 1 billion bits) will have an error Fiber optics; 10^{-11} (1 in 10 trillion bits) will have an error

In regards to relative capacity, as previously noted, such transmission carriers like that of cable or fiber optics facilitate higher frequencies, and thus provides a greater number of 'waves' with which to modulate information. Furthermore, digital transmissions have a lower requirement for bandwidth allowing digital network facilitators to apply multiplexing technology (frequency-division multiplexing [FDM] and time-division multiplexing [TDM] see reference for more info). This entails dividing the transmission facility into different paths either by frequency ranges, or time slots, so that a given line can facilitate a greater number of signals (see figures A.11a and A.11b for a conceptual illustration). It should, however, be noted that

[21] On copper wire services regenerative repeaters are usually placed on circuits over 6,000 feet, however new technology for fiber optics allows signals to travel over 7,500 km without regeneration (Goff, 2002)

time-division multiplexing cannot be used for the transmission of telephone conversations.

Figure A.11a Frequency-division multiplexing - The frequency range is divided into separate paths to accommodate multiple transmissions.

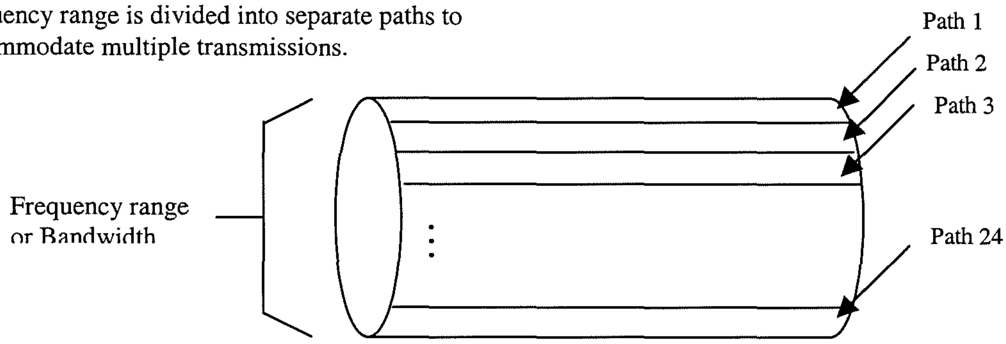
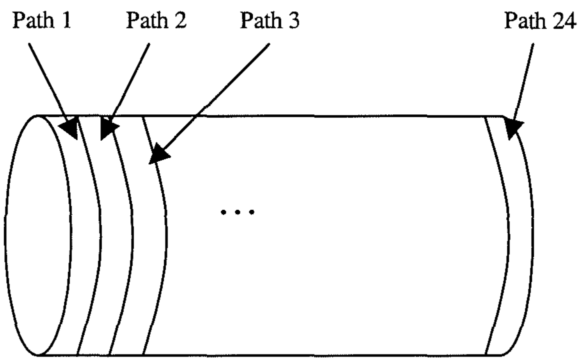


Figure A.11b Time-division multiplexing – The capacity of the transmission facility is divided into slots.



With multiplexing technology a copper wire is capable of transmitting 24 digital signals at a time, several times more than if the same line was facilitating analog signals. In terms of data, this translates into 1.544Mbps, which is approximately 46 times greater than the data transfer rate of an analog signal. A coaxial cable is capable of transmitting data at a rate of 1.5Gbps (1.5 billion bits per second), which is approximately 44653 times greater than the data transfer rate of an analog signal. Finally, fiber optics cable, although developments continue to expand its capacity, at present is capable of transmitting over 10Gbps, or approximately 297619 times greater than the data transfer rate of an analog signal. To place such rates in a more practical context, all 32 volumes of the *Encyclopedia Britannica* is approximately 1 Gigabit. Thus, over a fiber optic cable the transfer would occur in 1/10 of a second.

Thus, the development of new forms of transmission facilities like that of coaxial cables and fiber optics, in conjunction with such technological developments as multiplexing and pulse code modulation, has led to the increased ability to transmit larger amounts of information in a relatively less amount of time.

A.1.5 Network Protocol

The fifth and final factor that has contributed to the conception of the Internet is the introduction of network protocol. This feature is slightly different than the previously presented factors in that it is exclusively in regards to the interaction of PCs, unlike the previous four, which have been utilized in other telecommunication, not to mention scientific, applications.

Before the introduction of network protocol, communication was limited to between a unique sender and receiver. In other words, a sender had to explicitly contact a receiver in the same way an individual dials a phone number to speak to a specific individual, firm, or institution. Thus, if a sender was attempting to acquire transmittable information, the sender would thus explicitly contact a receiver and that same receiver would have to subsequently accept the sender's transmission (metaphorically speaking: pick up the phone). Upon receiving the request, and assuming the request was to be granted, the receiver would then become the sender, explicitly contacting the original sender, whom would subsequently have to accept the original receiver's transmission.

With network protocol, in conjunction with PCs and their ability to receive and store data, the previously noted explicit process became expedited. The original receiver simply made the potentially requested information available in digital form at their given terminal, i.e. PC. The original sender was thus able to contact the original receiver's terminal and access the information in question without permission having to be granted for each individual request. Once the information had been accessed, it could be transferred to the original sender's own terminal where it could be stored and/or processed accordingly. This process is not limited to accessing information located at remote points in space, but could also be used to deposit information at a given terminal as well.

With the aid of Internet 'search engines', like that of www.yahoo.com or www.google.com, it has become increasingly possible to seek out desired information that has been made available on remotely located terminals. Search engines assess information made available to network users and provide the opportunity to interact with these so-called 'original receivers' without having to explicitly contact them. Thus, network protocol, not only allows individuals, firms, or institutions to access or deposit information from remote points in space, but provides the opportunity to contact individuals, firms, or institutions that have common interests, but without a previously established relationship.

Glossary of Abbreviations used in the First Model

AA – alternative advantages

BFA – benefits from agglomeration

D – dispersion forces

DF; **d** – distance factor

IT – intangibles

M – manufacturing

NA – net agglomeration

T – tangibles

V – volume

Glossary of Terms

Advanced-telecommunications – Refers to all types of data transmission, from voice to video.

Analog – Describes a device or system that represents changing values as continuously variable physical quantities.

ARPANET – The precursor to NSFNET, ARPANET was a large wide-area network created by the United States Defense Advanced Research Project Agency (ARPA). Established in 1969, ARPANET served as a testbed for new networking technologies, linking many universities and research centers. The first two nodes that formed the ARPANET were UCLA and the Stanford Research Institute, followed shortly thereafter by the University of Utah.

B2B – (**B**usiness-**To**-**B**usiness) The exchange of services, information and/or products from one firm to another.

B2C – (**B**usiness-**To**-**C**onsumer) The exchange of services, information and/or production from a firm to a consumer.

Bandwidth – The amount of data that can be transmitted in a fixed amount of time. For digital devices, the bandwidth is usually expressed in bits per second (bps) or bytes per second. For analog devices, the bandwidth is expressed in cycles per second, or Hertz (Hz).

BITNET – (**B**ecause **I**t's **T**ime **Net**work) One of the oldest and largest wide-area networks, used extensively by universities.

Bit – Are either a '0' or a '1' that are grouped together in groups, of usually 8, to create bytes.

Bit-bus – A collection of wires through which data is transmitted from one part of a computer to another. In reference to PCs, a bus usually refers to *internal bus.* The internal bus connects all the internal computer components to the CPU and main memory. All buses consist of two parts: an *address bus* and a *data bus.* The data bus transfers the actual data, while the address bus transfers the information as to where the data should go. The size of a bus is known as its *width.* The width determines how much data can be transferred at one time.

Bps – (**B**its **P**er **S**econd) The standard measure of data transmission speeds.

Byte – (**Bi**nary **te**rm) A unit of storage capable of holding a single character. On almost all computers, a byte is equal to 8 bits. Large amounts of memory are indicated in terms of kilobytes (1,024 bytes), megabytes (1,048,576 bytes) and gigabytes (1,073,741,824 bytes).

Carrying Capacity – Like that of bandwidth, carrying capacity is the amount of data that can be transmitted in a fixed amount of time.

Circuit Switching – A type of communications in which a dedicated channel (or circuit) is established for the duration of a transmission. The most ubiquitous circuit-switching network is the telephone system, which links together wire segments to create a single unbroken line for each telephone call.

CPU – (**C**entral **P**rocessing **U**nit) Sometimes referred to as the processor, or central processor, the CPU is where most of the calculations within a computer occur.

Digital – Describes a device or system that is based on discontinuous data or events. PCs, for example, are digital machines. All data that a computer processes must be encoded digitally, as a series of zeros or ones, or 'on' and 'off'.

FDM – (**F**requency **D**ivision **M**ultiplexing) A multiplexing technique that uses different frequencies to combine multiple streams of data for transmission over a communications medium.

Internet – A global network connecting millions of computers. The Internet by design is decentralized. Each computer, called a host, is independent. Its operators can which service offered through the Internet to use and which service to make available to the global Internet community. Remarkably, this anarchy by design works exceedingly well.

MHz – (**M**ega**h**ert**z**) A megahertz represents one million cycles per second. The speed of microprocessors, also know as clock speed, is measured in megahertz.

Modem – (**Mo**dulator-**Dem**odulator) A device or program that enables computers to transmit data over, for example, telephone or cable lines. Computer information is stored digitally, while information transmitted over telephone lines is transmitted in the form of analog waves. A modem converts between these two forms.

NSFNET – A wide-area network developed with the support of the National Science Foundation (NSF). NSFnet replaced ARPANET as the main government network linking universities and research facilities. In 1995, however, the NSF dismantled NSFnet and replaced in with what has become known as the Internet.

Network – A group of two or more computer systems linked together. There are many types of computer networks, including:

- **Local-area networks (LANs)**: The computers are geographically close together (for example, in the same building).
- **Wide-area networks (WANs)**: The computers are relatively farther apart than that of LANs connected by telephone lines, cables (coaxial or fiber), or radio waves.
- **Campus-area networks (CANs)**: The computers are within a limited geographic area, such as a campus or military base.

- **Metropolitan-area networks (MANs)**: A data network designed for a town or city.
- **Home-area networks (HANs)**: A network contained within a user's home that connects to a person's digital devices.

Network Protocol – An agreed-upon format for transmitting data between two devices.

Operating System – An operating system is arguable the most important program that runs on a computer. It performs basic tasks such as recognizing input from the keyboard, sending output to the display screen, keeping track of flies and directories on the disk(s), and controlling peripheral devices such as disk drives and printers.

P2P – (**P**eer-**To**-**P**eer) A type of network in which each workstation has comparable capabilities and responsibilities.

Packet Switching – Refers to protocols in which messages are divided into packets before they are sent. Each packet is then transmitted individually and can even follow different routes within the network before arriving at its destination. Once all packets forming the message arrive, they are recompiled into the original message.

PC – (**P**ersonal **C**omputer or IBM PC) The first personal computer produced by IBM was called the PC, and increasingly the term PC came to mean IBM or IBM-compatible personal computers, to the exclusion of other types of personal computers, such as Macintoshes. In recent years, the term PC has become increasingly ambiguous. In general, it applies to any personal computer based on the Intel microprocessor, or Intel-compatible microprocessor. For nearly every other component found within a computer, including the operating system, there are several options, all of which fall under the term PC.

PCM – (**P**ost **C**ode **M**odulation) A sampling technique for digitizing analog signals. PCM samples the signal 8000 times a second; each sample is represented by 8 bits for a total of 64 kilobytes.

POTS – (**P**lain **O**ld **T**elephone **S**ystem) Refers to the standard telephone service that most homes use. In contrast, telephone services based on high-speed digital communications lines, such as fiber optics, are not POTS. The main distinction between POTS and non-POTS services is the speed and bandwidth.

SPRINT – A public packet-switching network operated by US Sprint. Also known as 'SprintNet'.

Telematics – Refers to the broad industry related to using computers in concert with telecommunications systems.

TDM – (**T**ime **D**ivision **M**ultiplexing) A type of multiplexing that combines data streams by assigning each stream a different time slot in a set. TDM combines PCM streams created for each conversion or data stream.

Website – A site (location) on the World Wide Web. Each Web site has an address, which corresponds to a home page. The site may contain additional documents and files. Each site is owned and managed by an individual, company or organization.

Windows – (Microsoft Windows) A family of operating systems for personal computers. Windows dominates the personal computer world, running, by some estimates, on 90% of all personal computers. Windows provides graphical interface, memory management, multitasking, and support for many peripheral devices.

World Wide Web – A system of Internet servers that support specially formatted documents that contain links to other documents, as well as graphics, audio and video files.

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