INTRAMETROPOLITAN LOCATION OF NEW OFFICE FIRMS

INTRAMETROPOLITAN LOCATION OF NEW OFFICE FIRMS IN METROPOLITAN TORONTO

By

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ABSTRACT

This thesis attempts to unveil the underlying determinants of the geography of office location by examining the intrametropolitan location decisions of new office establishments in major industrial categories. Its empirical focus is the locations of new office establishments in metropolitan Toronto for the year 1995.

The specific objectives of the thesis are (i) to identify own-industry and inter-industry office clusters and, (ii) to identify the most significant factors responsible for major office industries locating in Toronto. Thus, the methodology is in two parts. The first part of the study addresses the first objective by utilizing powerful spatial statistical techniques. Spatial statistics are introduced as a new methodology for office and business location research. Kernel estimation and univariate *K* function techniques are conducted on twenty distinct office activity point patterns (i.e., event patterns) to identify the existence and geographic locations of intra-industry office clusters. Specifically, the *K* function is used to detect whether locational patterns are clustered, or alternatively, dispersed. Bivariate *K* functions are conducted to determine if inter-industry office activities are interacting.

The second part of the thesis attempts to further office location research by developing and testing an office location model to identify potential factors that might influence office location in Toronto. The analysis is similar to that of Ihlanfeldt and Raper (1990) and Shukla and Waddell (1991). It utilizes a multinomial logit model to estimate the effects of a set of explanatory variables defined as determinants of spatial choice. Real estate zones are used to characterize the set of alternatives available to profit maximizing firms. Unlike previous studies, this research uses disaggregated firm level data for twenty-two different office activity types. Logit models are estimated individually for each activity type.

Results indicate that the event patterns formed by all office industries in metropolitan Toronto are clustered in distinct office nodes and centres located throughout the city. Furthermore, significant interactions exist among certain pairs of office activities indicating the presence of possible agglomeration economies. Logit results confirm the existence of agglomeration economies among similar office activity functions. The results also display marginal evidence of polycentric locational tendencies in most activities. The results confirm the findings of previous studies which indicate that locational patterns of office activities in Canadian cities are unlike those in American cities.

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Mike Yarish, April, 1998

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

The beginning of the twentieth century found corporate head offices and the business services they relied on located in tight clusters around metropolitan central business districts (CBD's). The CBD at the focus of metropolitan transportation networks, was an ideal location for executives because it allowed them to be near potential meeting partners and exchange information and ideas. Since the executives also relied on office staffs, it was essential to be in a location where employees from a broad labour pool could be assembled. The CBD also provided a choice of shopping, entertainment and other amenities for office staff and management. Thus in the early twentieth century, office firms multiplied in the CBD's of major cities. As a result this created competition for office space and pushed rents up causing some firms to relocate their routine clerical functions to lower rent areas elsewhere (Evans, 1985). At the same time, consumer service offices followed the suburbanization of housing, manufacturing and retailing that began taking place in the 1920's (Matthew, 1993). However business service offices did not begin to decentralize until the 1960's and 1970's (Daniels and Holly, 1983).

By the mid 1960's a massive suburbanization of population and employment occurred. One of the major factors that contributed to the suburbanization process was the influence of the suburban freeway system. The freeway altered the accessibility in the metropolitan area, providing excellent access to both intrametropolitan markets and the metropolitan transportation network. Major intersections along circumferential highways, intrametropolitan highway corridors, or airport areas became popular locations for regional malls and office complexes (Erickson, 1983). Initially these suburban office complexes were composed of small office buildings and other activities centred around shopping malls or office parks. The arrival of high-order retailing and a wide range of specialized office jobs made suburban office nodes more attractive and largely independent of the central city. These locations not only provided superior access, but also visibility, advertising potential, image and prestige (Erickson, 1980:1983:1985, Conzen, 1983). As a result, demand for suburban offices increased as the locations displayed significant agglomeration economies similar to those of the CBD. Consequently these centres began functioning increasingly as metropolitan level downtowns (Garreau, 1991).

Aiding in the rapid development of suburban office clusters were government policies aimed at decentralizing economic activities from central areas to less developed suburban regions. In the 1970's some Canadian metropolitan areas (e.g., Toronto and Vancouver) introduced policies aimed at office decentralization (Gad, 1979). In metropolitan Toronto the central area was the dominant office area while other major office areas were located adjacent to subway stations and along highway corridors (Matthew, 1992:1993). There were major problems with this pattern of development. It greatly increased demands for transportation services. While the central area and a few other locations of high or medium density could be serviced by rapid transit, it was much more difficult and expensive to provide transit services to suburban employment areas given the centrally oriented rapid transit system (Metro Planning, 1989). While expressway construction proposals in the 1960's had come to a halt, auto-oriented suburban development continued. It also meant that most people did not live near where they worked with resulting long communing times (Metro Planning, 1989). In addition, the major cultural, entertainment and institutional facilities located in the central area were distant from suburban areas undergoing growth in population. As a result, three major alternatives to change the pattern of development were considered. The Metropolitan Official Plan adopted in 1980 chose a multi-centred structure as a means of modifying the land use\transportation relationship. The plan involved the creation of higher density mixed use centres along a rapid transit system with amenities to attract offices to these areas rather than to industrial areas (Metro Planning, 1989). The plan also adopted policies to contain existing suburban auto-oriented office concentrations within newly created office parks with restrictions on the range of support services and mix of uses within them. The plan aimed at maintaining a strong central area while at the same time focussing much of the suburban growth in a limited number of concentrations. Locating centres along the rapid transit system was intended to encourage two-way use of the subway, encourage greater use of transit, and reduce commuting distance and travel time (Metro Planning, 1989). The multi-centred concept utilized major transit facilities for travel across Metro. It provided job opportunities at more locations closer to where people lived. Centres enabled people to live close to their work by tying together new jobs and housing (Metro Planning, 1989). They also provided a greater range of urban amenities and services to suburban residents.

Since the end of the 1980's certain studies (Hartshorn and Muller, 1989; Garreau, 1991; Stanback, 1991) have considered the existence of a multi-centred phenomenon and state that it is in the process of modifying the urban structure of major North American metropolitan areas.

Hartshorn and Muller (1989) found that large multi-functional clusters of high-order activities or 'suburban downtowns' began serving as corporate headquarter locations and attractors for high-order support services thus accelerating the transformation of suburbia into a fully developed 'outer city'. Stanback (1991) observed that certain suburban zones are concentrating in a limited number of 'magnet areas' which demonstrate a sufficient power to attract types of activities normally found in the CBD. Garreau (1991) referred to these specialized clusters as 'edge cities' and argued that they are in direct competition with the CBD for high-order service functions. Garreau found that the types of firms that locate in these areas are the young, fast growing entrepreneurial start-ups, especially in high technology (Garreau, 1991). These are the firms who are attracted to places that are new, where things are more flexible. In fact, a majority of chief executive officers of big corporations interviewed by Garreau seemed to agree that moving out to 'edge city' environs was primarily for the advantage of being near a highway interchange which allowed people to get there from home, and from there to the rest of the world.

The newly emerging multi-centre phenomenon suggests a departure from the theoretical model of the monocentric city developed by Burgess (1925). The model locates all services and office activities in the CBD and then arranges other land uses in concentric bands focussed on the downtown core. The model was extended by Alonso (1964) to explain the monocentric city in terms of access, amenity and public policy factors discussed by Foley (1956). The extended model also locates the services and office firms in the CBD because these activities are dependent on accessibility to both clients and support services. The phenomenon observed by Garreau, Stanback and Hartshorn and Muller largely supports the multi-nuclei (polycentric) model developed by Harris and Ullman (1945). In this model the city has a number of foci, rather than just one CBD around which land uses are arranged. These separate clusters are developed to take advantage of agglomeration economies or the site requirements of activities. Consequently, separate concentrations of specific activities develop that are large enough to influence land use decisions in surrounding areas.

As these newly emerging intrametropolitan centres expand, central city and suburban policy makers will need to plan for future infrastructure and economic development improvements. The future well being of office centres and parks will depend on how successful they are in attracting new office developments and in maintaining what they presently have.

In order to be successful in these regards, planners and city officials must identify and understand those factors that lead office establishments to locate in the CBD or in a suburban location. Knowledge of these factors will aid in the development of policies and initiatives that will ultimately enhance the accessibility and quality of office centres and nodes and promote further development in less developed peripheral regions of metropolitan areas.

1.2 Problem Statement and Research Objectives

Since the end of the 1980's researchers have increasingly turned their attention to the factors influencing intrametropolitan location of office activities and the impacts of these location decisions on urban form and development policies. Ihlanfeldt and Raper (1990) found that variables measuring location differences in wage rates, transportation costs, distances to customers and suppliers, land prices and demand all had an influence on the locations selected by new offices in metropolitan Atlanta. Specifically, the authors found that proximity to support services influenced the locations of new firms. Their results indicated that small business incubators may be used as a development tool in that they appear to have some potential for swaying location decisions through providing in-house financial services, legal advice, consulting and other support services new firms may need (Ihlanfeldt and Raper, 1990). The authors concluded that in order to reduce the disparity found in most U.S. CBD's, public efforts should establish new entertainment and shopping complexes within the CBD as an approach to improving the attractiveness of downtown office locations.

Shukla and Waddell (1991) confirmed a considerable degree of decentralization in most office activities in Dallas-Fort Worth including manufacturing, construction, wholesale and retail trade, personal and business services. These industries preferred suburban locations with access to the airport and freeways and valued the presence of agglomeration economies. The finance, insurance and real estate (F.I.R.E.) industry preferred more central locations that were in proximity to perceived high prestige high income zones.

Sivitanidou and Sivitanides (1995) concluded that the locations best qualified to attract research and developement laboratories are those able to provide proximity to research universities, freeways, quality educational facilities, access to cultural, recreation, entertainment and retail activities, and areas with environmental quality. However, Gottlieb (1995) concluded that amenity orientation for firms is better described as avoidance of disamenities such as violent crime and toxic pollution rather than attraction to amenities.

McQuaid et. al. (1996) found access to markets a positive influence on location decisions for cental city firms but was unimportant for small peripheral firms. Accessibility to staff was significant for larger firms and accessibility to suppliers was especially important for firms relocating from outside Strathclyde, U.K. They concluded that accessibility is important for influencing location decisions, but that different types of accessibility influence different types of firms in various ways. They stressed that care needed to be taken in the development of policies related to transport infrastructure by disaggregating the likely effects caused by different types of firms in order to determine which types of policies will have the most significant impacts. Coffey et al. (1996) found that accessibility to the establishment for clients and rental prices emerged as major locational factors for firms in Montreal.

Several problems exist with the studies discussed above. With the exception of Ihlanfeldt and Raper (1990), all other studies were derived under the assumption that firms were at their long-run profit maximizing locations. For many firms this may not be true since the existence of moving costs suggests that firms do not respond rapidly to changes in locational determinants but remain where they are until profit differentials between old an new locations are sufficiently large enough to compensate for the cost of relocating (Code, 1983; Hanink, 1997). The inclusion within samples of firms who are not at their long-run locations causes independent variables that have changed over time to be measured with error, which may result in biased and inconsistent estimates (Ihlanfeldt and Raper, 1990). A second problem is that all studies use broad industrial aggregate data in their analyses. The use of one digit SIC groups as dependent variables causes low explanatory power of the results (Shukla and Waddell, 1991). Thirdly, all studies with the exception of Coffey et. al. (1996) focus on office location decisions in American or European cities. In the context of this research it is important to note the differences between Canadian and U.S. cities in terms of office location experience.

Canada's national approach to planning maintains stringent planning controls which have resulted in compact metropolitan areas. In addition, Canadians have remained willing to heavily rely on public transportation (Matthew, 1993). This has included expansion of fixed rail systems not only in Toronto and Montreal but also in Vancouver and Edmonton. All of these factors have contributed to the continuing vitality of Canadian metropolitan CBD's further lessening the need for flight to a peripheral areas. These observations are also confirmed by Gad (1975), Code (1983), Huang (1989), Matthew (1993) and Coffey et. al. (1996).

In U.S. metropolitan areas the poor image and uncertain financial ability of the central cities have led to new developments in safe greenfield sites in rural municipalities where planning controls are minimal and tax incentives are used to attract development (Matthew, 1993). Furthermore the building of circumferential and radial urban highways has resulted in continuing deterioration of downtown services only further provoking a city-suburb polarization.

Finally, none of the studies focused on office location decisions in metropolitan Toronto - the city under investigation in this thesis. In fact to date there have been no attempts at quantitatively examining the intrametropolitan office location factors and patterns in Toronto. Qualitative studies of office location in Toronto have been conducted in the past, however these studies used questionnaires, surveys, diaries, employment trends and office establishment characteristics to examine locational patterns and linkage characteristics. Gad (1975) examined offices and their linkage characteristics in Toronto's central corridor. He argued that linkage characteristics explained decentralization tendencies by finding that central area 'stayers' had higher meeting frequencies than did decentralized 'movers'. He suggested that activities which complement each other should be encouraged to locate in the same centre to offset the high cost of face-to-face information transfer (Gad, 1975). Gad concluded that most types of offices need not be geographically clustered but can survive in a wide range of locations within the central office district. Matthew (1993) extended this conclusion by stating that except for some high-order functions that still resist decentralization (such as banking) , most types of office activities can survive in a wide range of locations beyond the central office district. Code (1983) found face-to-face contact was an important office location factor. He argued that a substantial increase in the difference between CBD and suburban rents would be necessary before any establishments begin leaving the CBD. He also claimed that the quality and range of information in suburban office centres was much lower than in the core agglomeration and that any move from this core to the suburban centre would result in 'contact damage'. However, Matthew (1993) found that offices of all orders and most types can and do function in suburban centres regardless of information needs. In her Ph.D. dissertation of suburban offices in Toronto, Huang (1989) concluded that central city and suburban office nodes both contain a diversified range of jobs. Huang (1989) and Matthew (1993) found no difference in office employment by occupation or gender between the suburbs and the downtown areas of Toronto.

The purpose of this research is to contribute to the office location literature by developing and testing a model to explain the intrametropolitan location of new office firms. The research is unique for several reasons. First, it examines the locational factors of new profit maximizing firms which are not faced with relocation costs. Secondly, the use of disaggregated firm level data will provide a more accurate description of locational behaviour of certain firms otherwise uncapturable with aggregate data. Thirdly, the study utilizes powerful spatial statistical methodologies to determine the presence and significance of office clusters and interactions. Finally, statistical models will analyze the significance of the factors that influence office location. This type of analysis is unique in that it has never been attempted for metropolitan Toronto.

The results of this research will contribute to the Toronto office location literature by presenting statistical evidence of the presence of office clusters and interactions and by presenting evidence of the factors found to be the most significant determinants of office location by industry for metropolitan Toronto. This focus gives rise to the following specific objectives:

(i) the identification of own-industry and inter-industry office clusters and,

(ii) the identification of the most significant factors responsible for various office industries locating in Toronto.

These issues require a two part research plan. The first part of the research will require that a spatial statistical analysis be conducted to identify intra-industry office clusters and where these clusters are occurring. This analysis will also attempt to determine if inter-industry office activities are clustering which in turn may suggest the existence of possible agglomeration economies. The data for this analysis include twenty spatial point patterns each representing a specific office industry. The second part of the research will use a multinomial logit framework to test an office location model. The purpose of the model is to determine the significance of a set of locational factors specifically defined for this research. The significance of these factors will also determine the locational patterns of offices in metropolitan Toronto. The data used for this analysis includes the locations of offices comprising twenty-two disaggregate office industries.

1.3 Outline of Thesis

This chapter introduced the office location component of urban economic development; the purpose and objectives of the study have been identified. Chapter Two will review the findings of recent research that has contributed to the study of intrametropolitan office location. The chapter extends to a discussion of metropolitan Toronto as a case study and concludes by stating the hypotheses posed in this research. Chapter Three outlines the detailed data set used in the analysis. Chapter Four will introduce the concepts of spatial statistical analysis, will discuss in detail the methods used and will present and interpret the results of the analysis. Chapter Five will introduce the concepts of the random utility framework which will lead to the development of the multinomial logit model. The chapter will continue with the development of an office location model. The final sections will present and interpret the results. The final chapter will summarise the research findings and will draw out implications of the study for planning policy analysis and further research.

CHAPTER TWO

FACTORS INFLUENCING OFFICE LOCATION

2.1 Introduction

In the context of the newly emerging intrametropolitan dynamic, discussed in the introduction, it is important to identify those factors that lead office establishments to locate in the CBD or in a suburban location. Evidence and knowledge of these locational determinants is important for several reasons. Evidence on new office location is of interest to city policy makers because new firms are an important source of employment growth, consequently the location choices of new firms indicate where further employment growth is likely to occur. As well, an understanding of new firm location is useful in planning infrastructure improvements or designing policies to influence where developments take place throughout metropolitan areas. Finally, the future well being of central cities depends on how successful they are in attracting new offices.

Many qualitative studies of the locational behaviour of office firms have concentrated on the factors governing the choice of location (Foley, 1956; George et. al., 1980; Daniels, 1975, 1982; Noest, 1985; Gad, 1991). Common in all studies was the fact that decision makers, when faced with locating a new establishment or relocating or expanding an existing one, considered accessibility to clients, suppliers, staff, linkage costs as well as office space costs, including rent and amenity factors such as quality of life, prestige and proximity to shopping and entertainment facilities. These factors were mostly obtained from surveys and questionnaires. The following section reviews recent literature that has attempted to statistically test the significance of these factors. Section 2.3 focuses on metropolitan Toronto as a case study. In begins with a brief history of office development in Toronto and continues with a summary of the characteristics of office districts in Toronto. The last section gives a brief synopsis of the literature and outlines the hypotheses for this research.

2.2 A Literature Review of Office Location Factors

2.2.1 Linkage Cost Variables

In their study of location determinants of new office and new branch office firms in Atlanta, Ihlanfeldt and Raper (1990) constructed three variables to test the theory that prices of face-to-face meetings depend on transportation rates and distances between offices and the locations of suppliers. These variables were also constructed to test whether they influence office location by lowering the commuting costs of employees. The first variable was a dummy variable indicating whether an expressway ran through a particular census tract. A second dummy variable was constructed to indicate the presence of a rapid rail station. The third variable was constructed as a gravity variable to proxy the distance between sites within the tract and the locations of suppliers and support services. This 'service' variable measured the proximity to employment in financial, legal and business services. These variables measured the differences across locations in transportation rates. The expected signs on these variables was positive. The results showed that transit and freeway access were more important to branch office firms than to new office firms indicating that branch offices often must offer compensation in the form of better accessibility to those employees willing to relocate. The results showed that the 'service' variable was significantly important for new office establishments supporting the hypothesis that these services, acting as business incubators, exert a stronger locational influence on new independent offices. The authors also constructed a variable to measure accessibility to the airport. They hypothesized that the costs of transporting employees by air to meetings held outside the metro area would be lower at offices located closer to the airport. The results showed that the variable was significant for new branch offices.

Gottlieb (1995) used a tobit specification to model the impacts of amenities on high technology firm location in northern New Jersey. He hypothesized that firms evaluate certain amenities with respect to the likely residential locations of their employees. Similar hypotheses have been posed by Malecki (1984, 1986, 1992); Sivitanidou and Sivitanides (1995) and Coffey et. al. (1996). The above literature found high speed transport and communication important to the high-tech sector. Gottlieb (1995) found that professional service employers appeared to locate in municipalities with local rush-hour train service and availability of air operations.

Shukla and Waddell (1991) designed and tested a model to probe the underlying causes of spatial employment spread by examining the intrametropolitan location decisions of firms in the Dallas-Fort Worth (DFW) area. The dependent variable was the number of firms locating in one of 141 zip code zones. Multinomial logit models were specified for manufacturing, construction, wholesale and retail trade, F.I.R.E. and other business services. The authors defined two distance variables. Linear distance to the CBD measured the centralizing influences and distance to the DFW airport measured proximity to air operations. A freeway dummy variable was defined to account for the presence of a major highway in any given zone. The results showed that manufacturing, construction, wholesale and retail trade services favoured decentralized locations. Access to freeways and the DFW airport were also significant pull factors for these services. The F.I.R.E. and other business services group were found centralized around the Dallas CBD because of their locational affinity with urbanization economies, high prestige areas, high income zones and own industry linkages.

Vahaly (1976) conducted a linear discriminant analysis to explain the location of service and office activities at the census tract level for Nashville-Davidson county. Vahaly defined seven variables intended to measure accessibility and site amenities. Four variables were used to measure site accessibility. A dummy variable measured the need for access to the local river system. The second variable was an interstate highway dummy variable that measured the accessibility of a site to other sites in Davidson county. The third variable was an airport dummy variable that measured accessibility and proximity to the airport facility. The final accessibility variable was the number of arterial roads in a census tract. It attempted to measure accessibility of a site to the CBD. The results of the analysis showed that access to the river was most important for warehousing and manufacturing offices. FIRE services, professional services, warehousing, manufacturing, health and government offices required proximity to the local interstate network because of easy access to the population, and access to workers homes. Access to the airport was important to insurance, other business, engineering and government services. Access to the CBD was important to accounting firms, health and government services due to its availability of high income residences.

Clapp (1980) developed and tested a model of intrametropolitan office location for Los Angeles. In his model all office activities need access to the CBD in order to conduct business; they must transport their executives to the CBD in order to carry out face-to-face meetings. The dependent variable in this study was the rental rate. One of his main findings was that access to the CBD was an important determinant of office rents. The 'access to CBD' variable was twice as important as any other locational determinant. He found that buildings further away from the CBD commanded less rent, supporting the theory that face-to-face contact declines with distance from the CBD.

In their study of the determinants of the geography of research and development activities in Los Angeles, Sivitanidou and Sivitanides (1995) used regression analysis to test the hypothesis that variations in property rent reflect locational preferences of firms. They defined two variables that would capture proximity to high access points and high speed corridors of the urban transportation network. They found that research and development labs locating close to the airport did not command rent premiums. Therefore, research and development labs did not value close proximity to airports. In contrast they found that these labs significantly valued good freeway access.

Wasylenko (1980) and Erikson and Wasylenko (1980) developed a model to test the hypothesis that property taxes become statistically significant determinants of firms' locational choices when communities that zone out industry are excluded from the sample. A logit model was used to examine the site choice of firms in six industries, namely: construction, manufacturing, wholesale trade, retail trade, FIRE and other services that moved from Milwaukee to its suburbs between 1964 and 1974. The dependent variable was the probability of a firm choosing to relocate to one of 56 suburban jurisdictions. The authors defined a distance from the CBD variable to measure rent values and a dummy variable for interstate highways running through the suburban municipalities. The authors found that firms preferred less expensive land in areas farther from the CBD and locations that have access to highways.

Malecki and Bradbury (1992) examined the locational preferences of both research and development firms and their professional employees. Their study was concerned with the relative attractiveness of each location as a residential location for professional and technical workers, and with how well the local characteristics corresponded to the requirements of the firms that employ them. Unlike the findings of Sivitanidou and Sivitanides, Malecki and Bradbury found that proximity to an airport was ranked the most important locational factor to firms located in large urban areas.

Archer and Smith (1993) used regression analysis to explore three traditional explanations for suburban office clustering, one of which was demand for access. To test this explanation they hypothesized that the underlying motivation for office clustering is locational access to important urban facilities. The authors defined four distance variables: distance to the CBD, distance to major transportation nodes, distance from the most efficient limited access highway (a measure of congestion) and distance from the most preferred residential areas that would be probable choices of upper level management. The results indicated that no single variable had significant power to explain clustering.

2.2.2 Agglomeration Variables

Agglomeration economies are locational advantages gained by firms when choosing to locate in large metropolitan cities over smaller towns. Both urbanization and localization economies are subsets of, and define agglomeration economies. Urbanization economies are benefits attained by locating in a large metropolitan economy that enjoys higher incomes, larger populations, efficient public services and infrastructure and improvements in health, education, consumer, professional and social services. Therefore, a positive relationship exists between metropolitan size and the growth of a firm (O'Huallachain, 1989). Localization economies are benefits attained by co-location of competitors. These are advantages gained by locating in specialized clusters providing specialized labour and technological needs. Furthermore, these economies reduce production costs by allowing firms to identify rapidly changing needs and allowing them to experiment with new products and production processes that require frequent face-to-face contact.

Wasylenko (1980) and Erikson and Wasylenko (1980) defined an agglomeration variable to test localization economies for six principal industries. The variable was defined as the ratio of employees in a particular industry in each municipality to all non-central city employees in that particular industry. The studies found that the agglomeration variable was positive and statistically significant for manufacturing, construction, wholesale and retail trade and FIRE service industries.

Clapp (1980) concluded that groups of office activities with specialized needs can satisfy their contact requirements by clustering together. His results found that firms may choose to reduce their rental payments by locating in a suburban location. Other activities which require more intensive personal contact locate in central locations.

O'Huallachain (1989) conducted a study based on a two part analysis of employment and establishment growth in 27 fast growing service industries across metropolitan statistical areas (MSA's) in the United States for the time period 1977 to 1984. His purpose was to explore the forces influencing service sector location and to investigate the recent locational patterns of fast growing service industries. The author hypothesized that a combination of agglomerative factors including: market penetration, rapid technology change, business climate, institutional and infrastructure constraints, efficiency in communications and the emergence of many specialized service enterprises favoured spatial concentrations of industries. In the first analysis, O'Huallachain performed a cross tabulation of employment and establishment change in each industry with several MSA size categories. The results indicated that services most often grew in larger metropolitan areas. This is also supported by the findings of Sui and Wheeler (1993) and Pivo (1990) who concluded that primary office activities are highly concentrated in a small number of metropolitan areas. The author conducted a second analysis to determine whether urbanization or localization economies were responsible for the agglomerations found in his first analysis. The analysis measured urbanization and localization effects by regressing employment and establishment growth on MSA size and with the level of employment in each industry. The results showed that the locations of accounting firms, engineering and architectural services, wholesale trade, insurance, legal services, business services and transportation services are dominated by industry specific externalities such as attraction to specialized technological clusters so as to reduce costs of searching for technological breakthroughs and developments in telecommunications. This may permit expansion of distribution service networks into cities of all sizes (O'Huallachain, 1989). The importance of telecommunications as a factor in office location is also supported and confirmed by Goddard and Pye (1977), Pye (1979), Kutay (1986) and Se-il and Yoshikawa (1993). The locations of radio and television communications, management consultants, personnel services, computer consultants and health services were dominated by urbanization economies. Employment growth for these firms was driven by initial size of the firm while establishment growth was driven by MSA size.

Shukla and Waddell (1991) defined three spatial interaction variables that measured agglomeration economies: accessibility to employment in construction, manufacturing and wholesale trade; accessibility to employment in mining, transport, communications, utilities and FIRE industries; accessibility to employment in retail trade and other services. These variables recognized possible urbanization and localization economies by accounting for own-industry and inter-industry spatial linkage opportunities. The results showed that urbanization and localization economies are significantly important for manufacturing and construction services. Wholesale firms tended to locate in proximity to manufacturing and other firms but also displayed strong inter-industry linkages with retail firms. The results for the retail industry showed the effect of pure urbanization economies to be significant. FIRE services enjoyed substantial urbanization economies and located near retail and service concentrations. Finally there were strong spatial linkages between service firm locations and employment in service and retail industries.

Coffey et. al. (1996) used a logit model in their study of intrametropolitan location of high-order services in Montreal. The dependent variable was the zone chosen by the firm. A set of independent variables were defined that covered a range of structural and behavioural characteristics of establishments including organizational stages, number and types of employees, type and location of clients and methods of furnishing services to clients. In particular, the authors defined a variable that measured the relative frequency with which a service was delivered to a client - either an individual or a representative of another establishment - that physically visited the producing establishment. The results showed that both FIRE and producer service establishments found accessibility to the establishments for clients significantly important. However, in a survey, when asked if accessibility to clients was an important locational factor, management officials of both FIRE and producer service establishments stated that access to clients was a much less important factor for CBD establishments than for establishments located elsewhere within the Montreal CMA reflecting the administrative function of CBD establishments.

The main objective of the study done by Clapp et. al. (1993) was to test the hypothesis that both U.S. and European office location variables are important to a full understanding of the growth and location of office employment. They used a multi-equation neo-classical model of office space (U.S. approach) that had as one of its inputs a measure of growth potential (European approach) that allowed evaluation of office agglomerations between 1980 and 1988 in the metropolitan Boston area. Growth quotients based on the weighted average office employment growth in a specific town were used to measure growth potential. These variables summarized agglomeration economies by industry in terms of growth potential for the local area. The growth quotients were used as inputs in the demand equations for office space. The results showed that the measure of growth quotient variables was positive and significant indicating significant locational specialization (agglomeration) was present within sub-sectors across the metropolitan Boston area. The authors concluded that spatial concentrations by industry are important determinants of growth in office demand.

2.2.3 Amenity Variables

Vahaly (1976) used median tract income to measure the general level of site amenities in the neighbourhoods of some office locations. He found that real estate services, banking, personnel, legal services, accounting firms and health services located at sites in areas where household incomes were high indicating that wealthy residents are capable of consuming more of these services.

Wasylenko (1980) and Erikson and Wasylenko (1980) measured amenities through public service and market variables. They defined two public service variables: per capita expenditures on police and fire services and sanitation and street services. They measured market characteristics of a municipality by population density and per capita income. The expected signs for these variables was positive. The results showed that all fiscal variables had the expected signs but were statistically insignificant for all industries.

Clapp (1980) defined a dummy variable for parking availability and a pollution variable measuring readings of carbon monoxide. The author found that availability of parking was a significant determinant of office location while smog deterred the location of offices.

Malecki and Bradbury (1992) have done extensive research on the geography of high technology complexes and their impacts on regional and economic development. They defined high technology as comprising two sectors. The manufacturing sector included guided missiles and space craft development, communications equipment development, office and computing machines development, professional and scientific instruments, engines and turbines development, etc. The service sector group included computer programming, research and development labs, management consulting and commercial testing labs. The authors designed questionaires and sent them to vice presidents and managers of research and development facilities located throughout the United States. In terms of locational amenities the authors found that firms located in large urban areas with excellent universities which train new personnel, allow professionals to improve their skills, have academic experts whose research can create or interact with commercial technology. Firms also located in areas with abundant social, cultural and recreational activities, environmental quality and a job market that allows individuals (and spouses) to switch jobs without relocating. Such urban areas attract scientists, engineers and administrative personnel that firms must attract and retain for their non-routine functions. Research and development personnel are attracted to areas that have a high reputation and high housing costs since these areas are associated with growing dynamic cities rather than static or declining ones. The authors found that research and development personnel prefer quality of life over wages, prefer working in proximity to families and prefer to live in areas that have low traffic congestion, low crime rates, quality schools for children, good public services and infrastructure. The findings of this research support the studies done by Malecki (1984:1986).

Archer and Smith (1993) concluded that firms select sites and environments to present favourable and prestigious images for themselves to ultimately gain client confidence and loyalty. Image and prestige is important in recruiting and motivating personnel. A quality building and neighbourhood may influence the prospective employees perception of the firm as an employer (Archer and Smith, 1993). Finally, they concluded that firms locate in office parks which provide various amenities which may only be financially feasible in a clustered environment where services are more readily available or cheaper.

Gottlieb (1995) defined a set of variables to measure the effects of traffic congestion, violent crime, pollution, recreation, public education and public services on the location of professional services. His results showed that professional services locate in municipalities with a high density of amusement employment. They are repelled by violent crime, toxic pollution an by high municipal expenditures.

Sivitanidou and Sivitanides (1995) defined and tested the significance of two sets of amenities: firm production and worker amenities. The variables used to capture firm amenities included a gravity variable designed to capture research interactions with university consultants, access to libraries, and recruitment programs and a variable which measured the distance of a community from the closest state campus reflecting the need for part time continuing education programs. The variables used to capture worker amenities included a proxy for public school quality which was defined as the number of teachers per student in the public school district; a proxy variable for localized cultural, recreational, entertainment and shopping opportunities defined as employment in entertainment, cultural, recreational, and retail establishments, a disamenity variable measured total crimes per resident and finally a variable measuring environmental quality was defined as the annual geometric mean concentration of suspended particulate. The results for firm amenities indicated that proximity to research universities was crucial for the intrametropolitan location of research and development firms. Research and development labs also valued proximity to smaller, non-research universities. These results support Malecki and Bradbury's (1992) research that proximity to any university is valued regardless of its research intensity. The results for worker amenities indicated that public school quality is an important consideration in research and development lab location choice which also supports the findings of Malecki and Bradbury (1992). It was also found that these labs have a locational affinity for entertainment, cultural and shopping opportunities. Finally, communities with low crime rates and good environmental quality influence location choices made by research and development workers once again supporting the findings of Malecki and Bradbury (1992).

In their study of high order establishments Coffey et. al. (1996) found that a principal reason for establishments wishing to relocate in the rest of the city of Montreal was improved availability of parking space. Also some establishments that chose a CBD location were motivated by the desire to obtain a more visible and prestigious address. This is contrary to the findings of many American studies of research and development firms (Malecki, 1984, 1986; Malecki and Bradbury, 1992; Sivitanidou and Sivitanides, 1995) which state that research and development firms are attracted to prestigious areas outside the CBD in high-tech corridors and areas such as Silicon Valley, Route 128 and the Boston Suburbs, the research triangle of North Carolina and Regions of Austin Texas. This observation suggests that the level of decentralization of high-order services is substantially less in Canadian cities than in U.S. cities. In fact Coffey et. al. (1996) argue that Canadian metropolitan areas remain 'highly livable' environments. They are not characterized by the same degree of social and economic problems that are found in American cities, and that represents the principal factor in the exodus of high order office activities from the CBD (Garreau, 1991).

2.2.4 Building Space Variables

Wasylenko (1980, 1984) found that local property tax differentials are a statistically significant determinant of relocation for manufacturing and wholesale trade firms when municipalities which zone out industry are excluded from the sample. For construction, retail trade, finance and service firms tax variables were not statistically significant determinants of firm relocation. Wasylenko conjectured that manufacturing and wholesale trade establishments are more sensitive to property tax rates than other industries because firms in other industries may follow consumer markets and place less emphasis on fiscal characteristics, while manufacturing and wholesale trade firms are more concerned with cost (Wasylenko, 1984). Erikson and Wasylenko (1980) also found that taxes were not significant determinants for any firms' suburban site choice. The authors state that the unimportance of the tax variable might have resulted from its lack of variation among suburban municipalities.

McGuire (1985) conducted a regression analysis to determine whether property taxes mattered in location decisions of firms in Minneapolis-St. Paul. McGuire regressed the number of new firms entering a community on characteristics of that community including its property tax rate. The author found that a one percent increase in tax rates would result in a two percent decline in location activity.

Erikson and Wollover (1987) examined the effects of local household tax burdens on the supply of business sites made available by local municipalities of metropolitan Philadelphia. The analysis is based on community site supply theory developed by Fischel (1975). The theory states that businesses locate to maximize profits and communities supply sites to maximize citizen welfare through tax dividends. Business location permits residents to increase consumption of local and private goods thereby increasing utility. However, the presence of firms also reduces environmental quality which, in turn decreases utility. Communities determine the level of business activity based on the tradeoff between fiscal (tax) dividends and environmental quality. Thus firms compensate communities for environmental degradation by increasing fiscal benefits. A situation may arise where higher income communities with strong preferences for environmental quality are less inclined to want business and respond by increasing property tax rates. However, property tax rates must be applied to both residential and non-residential property. Thus communities that raise taxes, trade tax revenue for losses in environment as well as losses in private consumption due to higher taxes. Municipalities which value environment but do not find the tradeoff acceptable cease tax increases at some threshold level and discourage further firm entry by imposing zoning constraints. The authors estimated a model that reflected an environment for tax tradeoff. They found that for a given local household tax burden reduction, communities must zone one and half times more industrial acreage than they supply for commercial use. They conclude that municipal taxes are likely to influence business location through their effect on community site supply.

Ihlanfeldt and Raper (1990) found tax rates to be insignificant in new firm location decisions due to the mobility of new firms. The authors also defined a variable to proxy for land price. It was defined as a gravity variable measuring the proximity of sites within a tract to local employment. Because land price varies directly with proximity to employment, a negative sign was expected on the gravity variable. The results showed that this variable and hence land prices was an important determinant of location of new office firms, that is new firms are attracted to locations with lower land prices.

Finney (1994) specified a logit model to estimate the location effects of local property tax differentials on intrametropolitan manufacturing firm location in Harris County, Houston, Texas. His results concluded that firms are deterred by property tax. Specifically he found that a one percentage point increase in a jurisdictions tax rate will cause the probability of firms locating in the jurisdiction to fall by 0.14 percent. This result further supports the findings of McGuire (1995) and Wasylenko (1980, 1984).

Sivitanidou and Sivitanides (1995) tested the significance of property specific attributes such as property size and building age in their study of locational determinants of research and development activities. They concluded that newer, smaller and multi-tenant research and development properties attract high technology employers.

The surveys administered to management officials of producer service and FIRE establishments by Coffey et. al. (1996) indicate that in terms of intrametropolitan mobility, insufficient space was a principal factor that caused producer service and FIRE establishments to leave their previous sites within the Montreal CMA. In terms of site attribute locational factors identified by management officials, rental prices ranked very high as locational determinants. However rental prices were less important for CBD producer service establishments than for those in other zones.

2.2.5 Labour Variables

Wasylenko (1980) and Erikson and Wasylenko (1980) measured the accessibility of firms in a given municipality to a labour supply by defining a variable measured as the number of employees by place of residence in an industry who are within a seven mile radius of the municipalities center. Since firms pay premium wages for employee transportation costs, when attracting employees who commute long distances, the authors hypothesized that firms would locate in areas which their employees found desirable as residential areas thereby minimizing wage premiums when attracting employees. The results indicated that construction firms, manufacturing firms, transportation firms, wholesale and retail firms, finance and service industries relocate in suburban sites on the basis of agglomeration economies and proximity to an available work force.

Ihlanfeldt and Raper (1990) also used the proximity of sites within a tract to residential location of office workers to measure spatial variation in labour costs. They constructed separate gravity variables for managerial and administrative support labour making proximity to these office workers a direct function of the number of workers living within a certain distance and an inverse function of distance. The variable representing managerial labour was positive and significant while the administrative support variable was significant with the wrong sign. The authors suggest that these results are typical of new office firm location. They suggest that managerial and clerical labour reside in different neighbourhoods. Because new office firms are typically small, they tend to have a high proportion of managerial labour (Ihlanfeldt and Raper, 1990). The authors continue by stating that the higher costs that executives and professionals place on their communitng time suggests that new office firms may find it necessary to locate near upper-income neighbourhoods and away from neighbourhoods where clerical workers reside (Ihlanfeldt and Raper, 1990). In addition to these variables the authors defined four attributes of the work location that may cause spatial variation in the cost of labour. The proportion of land in each tract in industrial or transportation land use and the tract density of households below poverty level are disamenities that may increase labour costs since workers dislike threatening and unsafe neighbourhoods. Two other variables, a dummy variable indicating whether or not a tract contained a regional shopping centre, and a gravity variable measuring access to restaurants and entertainment facilities were constructed to measure worker utility. The authors found that new offices displayed a strong attraction toward locations offering amenities, indicated by the statistical significance of the shopping and amenity variables, and an aversion for locations with disamenities, indicated by the statistical significance of the poverty and land use variables.

2.3 Metropolitan Toronto - A Case Study

Since the empirical study focuses on intrametropolitan office location in metropolitan Toronto, it is necessary to firstly establish the way in which the overall distribution pattern has developed and changed over time and secondly to characterize the patterns with respect to location and employment mix.

Toronto's office complex developed gradually during the nineteenth and first half of the twentieth century. In 1891 Toronto's downtown district had five buildings with six or more stories; this dramatically increased to forty-nine by the late 1920's and to fifty-three by 1951 (Gad and Holdsworth, 1984:1987). In that time the office buildings clustered around important nodes containing city hall, major banks and the stock exchange. Most of the buildings were occupied by many small establishments up to 1914. As demand for office space grew so did construction of larger office buildings. The demand for larger buildings grew for two reasons. Up until 1914 small to medium sized offices relied on close spatial proximity due to their interrelated functions. After World War I (WWI) rapidly growing corporations such as banks and insurance companies required large amounts of floor space to function. Growing competition for central office space resulted in higher rents causing certain office functions to locate or relocate in less central locations. These new sub-centers were later reabsorbed into the expanding central office district. Up until after WWII, two thirds of office employment was concentrated in the central area while a third was located throughout the metropolitan area (Gad, 1985). Since the end of WWII the office district has expanded westward and northward into the suburbs. In the forty five years since the early 1950's Toronto has experienced very rapid growth in office floor space and employment in offices. Toronto's office complex has grown from about 50,000 workers and 1.3 million square meters of office space in 1951 to about 750,000 workers and 13.2 million square meters in 1995 (Metro Planning, 1995; Colliers 1995). This growth has been fuelled by both the increase in activities of the tertiary and quaternary sector and by Toronto's ascendancy to the role as Canada's most important business centre. Within metropolitan Toronto, most of this growth in floor space and employment occurred in increasingly large suburban territories. In fact, in the early 1970's the city of Toronto adopted decentralization policies to slow the growth of office space in the CBD by encouraging some offices to locate in planned suburban centres which provided better services and more job opportunities for suburban residents. The rationale for these initiatives was a concern regarding increasing traffic congestion both within the CBD and of the transportation networks linking the CBD and suburbs. As a result, suburban municipalities began to promote office developments around rapid transit stations and near highway interchanges. By 1991, there were seven metropolitan office centres and twelve office parks in metropolitan Toronto all at or near either a highway intersection or an intersection of a highway or rapid transit station with a main road. All clusters have a highway or a subway link to the CBD. Figure 2.1 shows the main concentrations of office activity in metropolitan Toronto. Outside the central area (which is the main centre of office employment in the region) are several areas which have been designated in the metropolitan official plan as sub-centres and office parks. Two major centres, the North York centre and the Scarborough centre, together with several smaller intermediate centres make up the set of sub-centers. Although designated as multi-functional in terms of land use, offices account for a substantial portion of the jobs in each of these areas. The official plan and other planning documents refer to these centres as being transit oriented. The office parks are automobile oriented and are without exception bounded by an expressway on at least one side.

The following pages contain brief descriptions of the development of each of the most important centres and office parks, including their locational attributes, characteristics and

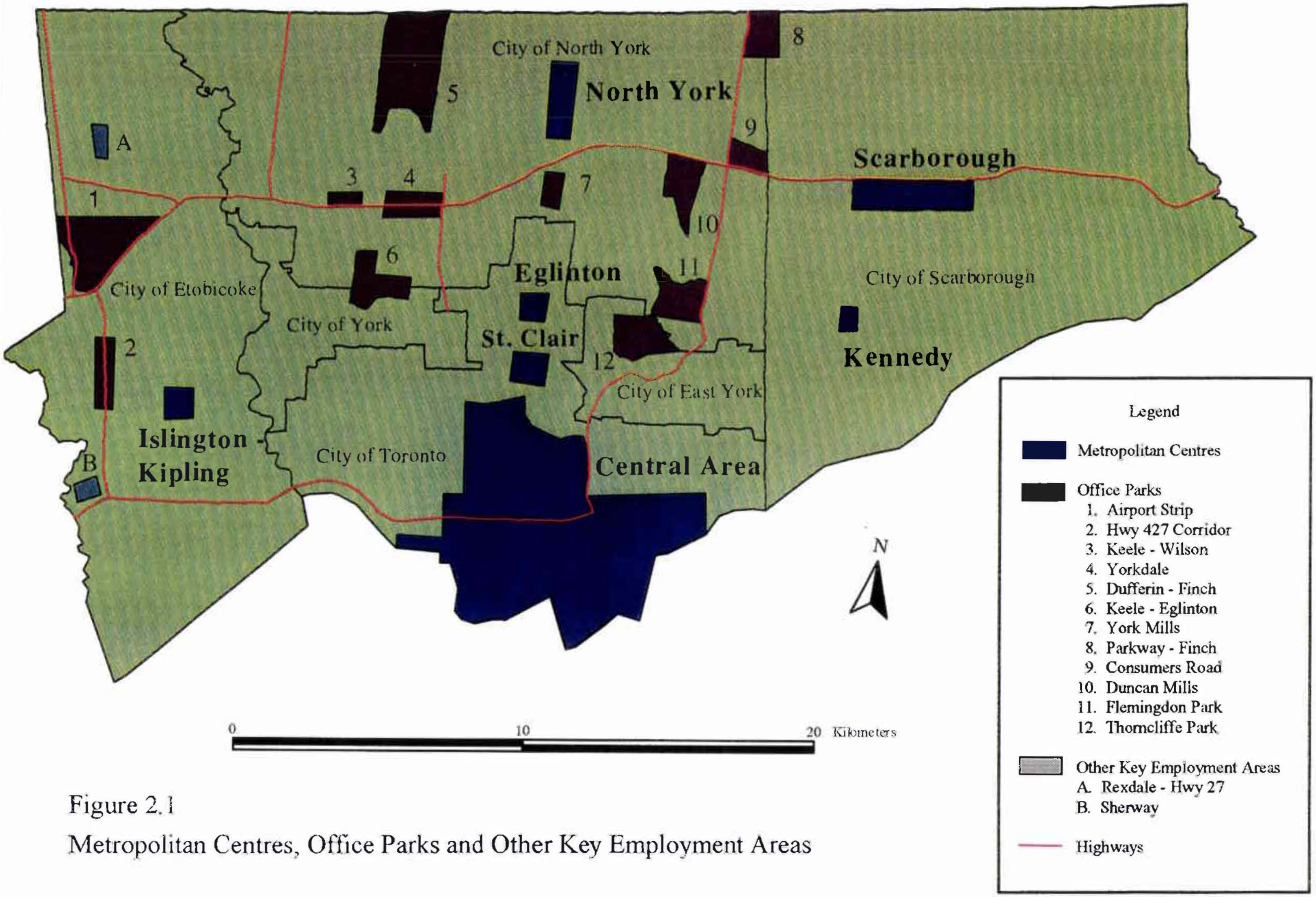


Figure 2.1

Metropolitan Centres, Office Parks and Other Key Employment Areas differentiation of office functions, and provide a context for the analysis of the locational determinants of office establishments. Unless otherwise stated, the main sources for the following discussion are Metropolitan Toronto Planning Department publications (1989, 1992).

2.3.1 Office Centres

While the centres are different there are a number of common elements to most. These include a predominant office and retail-service character, significant residential population, housing primarily in the form of apartments, government offices (especially in the Central Area, North York centre and Scarborough centre which have municipal, provincial and federal offices), and some recreational uses. Although most centres have a variety of activities within them, none can match the diversity of uses found in the Central Area. In terms of locational attributes only the Central Area, North York and Scarborough centres have good highway access. Most are served by one or two rapid transit stations with the Central Area having twenty stations. The four suburban centres have large commuter parking facilities adjacent to their rapid transit stations.

The Central Area

The Central Area is the predominant office and employment concentration in the metropolitan region. It is the financial and corporate centre of Canada and also has major retail, tourist and entertainment facilities, research, medical and educational institutions, and is a focus for local, provincial and federal government offices. The Central Area is a multi-functional area with industrial uses, residential areas and waterfront recreational uses. The Central Area is well serviced by rapid transit. Both the east-west and the north-south subway lines as well as the Government of Ontario (GO) commuter rail lines link the central core to the rest of the Toronto CMA. The Central Area is composed of the financial district and the outer core. The major concentration of office development is in the financial district which serves as the headquarters for most of Canada's financial, commercial and industrial institutions. The financial district is composed of law firms and various financial and real estate activities which together account for over 70% of the total office employment there (Gad, 1975:1991). There are also parts of the business services group, especially accounting and management consulting firms, that are represented and rapidly growing. The character of this area is determined by the large bank and trust company offices, stockbroker offices of every size, medium-size insurance companies (with fewer and fewer life insurance companies), the country's largest law and accounting firms, both very large and small mining companies, and a host of small offices of holding companies of different degrees of significance (Gad, 1975:1979:1985:1991).

Of all office nodes, the financial district has the highest proportion of high-level jobs (Matthew, 1993). It has also a fairly high level of clerical jobs, which are especially noticeable in the very large offices of the financial industries (Huang, 1989).

The outer core of the Central Area surrounds the financial district. In this area there exist government workers, architects, advertising specialists, and representatives of the media and entertainment industries. Radio, television, film and publishing as well as advertising agencies and graphic designers are also strongly represented here (Gad, 1975:

1985:1991, Huang, 1989, Matthew, 1993). The transportation construction, and utility group is also very strong, partly because of the large office of Ontario Hydro (with about 7,000 employees), the very large offices of Bell's Ontario region, and other large offices such as Toronto Hydro (Gad, 1975:1985:1991, Huang, 1989, Matthew, 1993). A smaller portion of employment is represented by scores of offices of the travel industry. The Bloor-Bay area especially houses not only airline ticket offices, but also regional sales offices, travel agencies, and both provincial and foreign tourist-industry representatives. Finally, mixed in between government offices and the various media, advertising, and travel industry offices are dozens of the very largest insurance company head offices (Gad, 1975:1985:1991, Huang, 1989, Matthew, 1993). Strong face-to-face linkages exist between advertising agencies, radio and television companies, public relations consultants, graphic artists and non-profit associations (Gad, 1991).

With a relatively small percentage (36 percent) of higher level office workers and a high percentage (47 percent) of clerical workers, the outer core's office jobs are more strongly biased towards the clerical end of the job hierarchy than most other office nodes (Gad, 1975:1985:1991, Huang, 1989, Matthew, 1993). Of the nine office areas examined by Huang (1989), the outer core was the area with the highest percentage (58 percent) of office jobs held by women.

Eglinton - Yonge and St. Clair -Yonge Centres

The Eglinton-Yonge Centre is located around the intersection of Yonge Street and Eglinton Avenue stretching several blocks north and east. It supports a large residential population and contains a diversity of land uses including office, retail and residential development. The centre also has provincial government offices, Bell Canada offices, a public library and a large transit bus garage and terminal. The centre is well served by rapid transit having a direct link to the Central Area as well as surface transit and roads. The centre includes large office buildings, apartment buildings, a retail mall and street related retail uses.

The St. Clair-Yonge Centre is located at the intersection of St. Clair Avenue and Yonge Street extending east and west along St. Clair Ave. and south along Yonge St. It is on the Yonge subway line served by two subway stations with a direct link to downtown Toronto. The centre contains a variety of office, retail, residential and entertainment uses and has a sizeable residential population. It includes large office buildings and provincial and federal government offices. Retail uses are found in the form of small shopping malls and street level shops and restaurants.

The industrial mix of both these centres is quite similar to that of the outer core: government, both federal and provincial, publishing, and radio, television, and film are all represented, as are business services other than law firms. As in the outer core, advertising agencies are strongly concentrated here and so are a wide range of other business and technical services (architects and also engineering consultants) (Gad, 1975: 1985:1991, Huang, 1989, Matthew, 1993). Finance, insurance, and real estate is slightly represented, largely due to the large number of small and medium sized insurance companies. The over representation of mining and oil companies is almost exclusively because of several very large office establishments of Imperial Oil (Gad, 1991). This area includes several of the head offices of industrial (that is, non-financial and non professional businesses) Canadian giants or large companies operating in Canada including: Imperial Oil, the Weston Group of Companies, Canada Packers, the Unicorp Group, Canadian Tire, Cineplex, Union Carbide, and several others (Gad, 1991).

Professional employment strongly characterizes these centres. Only the financial district and the Consumers Road office park have a higher percentage of executive, managerial, and professional employees (Matthew, 1993). Of particular interest is the observation that female high and middle level office workers of this district seem to have some of the most concentrated labour sheds in the metropolitan area. Eighty three percent of the female office workers in the highest level jobs, 97 percent in the middle level jobs and only 63 percent in the clerical jobs come from within an eight kilometre ring (Huang, 1989).

North York Centre

The North York Centre is the largest centre outside the Central Area. It is located along Yonge Street between Highway 401 and Cummer Avenue. It is linear in shape following the Yonge Street Corridor, with major concentrations of development at the intersections of Sheppard Avenue, Parkhome and Finch Avenue.

This has been an area of steady growth since the mid-1970's with large scale office development beginning at the time of the subway extension in 1974-1975. A large federal government building was opened in 1976 and the North York City Hall a year later. In the 1980's, about six office towers (10 to 25 storeys high) were added. The Metroplan of

1980 and North York's Official Plan have targeted the Yonge Street axis between Sheppard Avenue and Finch Avenue for office development. This node is accessible by the north-south subway line as well as by Highway 401.

The centre has a major government and institutional presence which includes the North York Civic Centre and library, Board of Education offices, federal government building, provincial courts and offices, and Separate School Board headquarters. There is a large retail service component which includes restaurants, shops and a retail mall and plaza and a large residential component with nearly all the housing in the form of apartment development. Surrounding the centre are low density residential neighbourhoods.

Apart from the strong government component, the mix of industries is close to that for metropolitan Toronto as a whole. There is a pronounced representation of personnel agencies, lawyers, accountants, insurance companies and mining and oil companies. However, the latter industry's stronghold depends almost entirely on the large regional office of Petro Canada (Gad, 1991). The availability of large amounts of space in the late 1980's, the accessibility by public transit, and the high profile of the new high-rise townscape proved to be very attractive.

Scarborough Town Centre

Large-scale development of this area began only in the 1970's with the decision by the then Borough of Scarborough to construct a town centre to attract office and retail activities (as well as to provide a civic focus for the residents of Scarborough). In 1980, the Official Plan for Metropolitan Toronto designated this node as a major metropolitan office sub-centre. This was revised in 1982 when the Scarborough Official Plan for the Town Centre set as its objective the provision of a major concentration of central area type office uses.

The Scarborough City Centre, being developed on vacant land, is rectangular in shape bounded by Highway 401 to the north and by industrial areas on its east and west axis. The centre is well served by rapid transit and highway access as well as including a bus terminal for local, inter-regional and inter-city buses. It has a rapid transit link to the subway system which then connects to downtown Toronto.

The heart of the centre is a large shopping mall which is surrounded by vast parking areas. The large government component in the centre includes the Civic Centre, municipal school board office and federal government offices. Two major office buildings are located on the eastern end of the centre which includes the head office for Prudential Insurance. A small manufacturing sector is located at the western end of the City Centre. There is currently no residential development in the centre.

The Scarborough Town Centre is also a major office sub-centre in metropolitan Toronto and here too the development of private office space was preceded by municipal government offices (Gad, 1975:1985:1991, Huang, 1989, Matthew, 1993). Government (municipal and federal branch offices), insurance (one large head office and a few smaller offices), the large Toronto east regional office of Bell Canada, the Yellow Pages publishing subsidiary of Bell, health care offices and personnel agencies make up the majority of office employment (Gad, 1991).

Kennedy - Eglinton Centre

The Kennedy-Eglinton Centre is located along Eglinton Avenue extending east and west of Kennedy Road. It is at the end of the Danforth Subway line and has a rapid transit link to the Scarborough City Centre. The area is divided by a rail line and hydro corridor. The lands at the west end of the centre contain low density unattractive suburban shopping plazas with large parking lots. The middle section of the centre contains a subway and bus terminal. The eastern third of the centre includes a public recreation centre, a new condominium development and a plaza. The area has only a small residential population and little employment or office development.

Islington - Kipling Centre

The Islington-Kipling Centre is irregular in shape and generally located between DundasWest and Bloor Streets from the area around Islington Avenue to west of Kipling Avenue. It is served by two subway stations at the end of the Bloor subway line. The area is well served by a network of arterial roads but is not readily served by the nearest highway access at highway 427 and Dundas West Street.

The most significant office development in this node was the completion of the Shipp Centre in 1983. Apart from the high-rise towers of the Shipp Centre, the area has a number of smaller office buildings. The centre contains light industrial uses, open space and recreational facilities and several schools. In addition, hydro corridors and transportation related uses take up a significant amount of land in the area and break the continuity of the centre. The centre has undergone little office development in the past decade, however, it has good development potential.

2.3.2 Office Parks

The development of office parks in metropolitan Toronto has fulfilled a need for auto-oriented office space. Some of the office parks are very significant employment concentrations with major office development. Most of the office parks have direct highway accessibility. Those along the Don Valley-Highway 404 corridor have a direct highway link to the Central Area. Most of the office parks have a mainly office and industrial character with few retail service amenities for employees in the area. Office parks are generally developed at a fairly low density.

There are five office parks located along the Don Valley Parkway-Highway 404 corridor. The five office parks include Thorncliff Park, Flemingdon Park, Duncan Mill, Consumers Road, and Parkway-Finch. Other significant office nodes located throughout metro Toronto include the airport node and the Highway 427 corridor.

Thorncliffe Park - Flemingdon Park and Duncan Mill Office Parks

The Thorncliffe Park office park is located between Millwood Road and Don Mills Road on either side of Overlea Boulevard in East York. The area is surrounded by an industrial area to the north and a residential community to the south. The office park has more of an appearance of an industrial area. It contains a variety of land uses including a large shopping mall, light industrial uses, offices, and an old age home and church. The area while located close to the Don Valley Parkway does not have good accessibility to it. There is only limited office development which includes provincial government offices.

The Flemingdon Park Office Park occupies a large area generally centered around Eglinton Avenue and Don Mills Road and the Don Valley Parkway. It has the largest employment base of all the office parks in metro Toronto. Flemingdon Park has a predominant office character with a significant concentration of office development as well as some manufacturing uses and a hotel. A large residential community is located adjacent to the office park. A number of major corporations have large offices in the area including the massive I.B.M. research and development complex, Canada Wire, McDonalds and Bata.

The Duncan Mill office park is triangular in shape located directly south of Highway 401 west of Don Mills Road. It has a mix of land uses, including parks and open space, industrial uses, offices, some retail-service uses and a hotel. The area has a substantial employment base with a large number of office buildings. The office park has had a steady rate of office development in the past decade and has significant potential for further growth.

These three office parks are the oldest of the major suburban office areas. They underwent rapid development from the mid 1960's to the mid 1970's and since then have grown primarily through in-filling by large office structures.

These nodes stand out because of the strong presence of offices of companies engaged in manufacturing, mining and oil, transportation, construction and utilities, publishing and high technology. Some of these industries or sub-sectors within industries are either completely or strongly represented by one or several large back offices (Gad, 1975:1985:1991, Huang, 1989, Matthew, 1993). It seems that these and other industries with a high clerical labour component have managed to outweigh those offices with generally low proportions of clerical work (technical services and manufacturing company head offices). Huang's study found that these nodes had the second lowest percentage for high level workers and highest percentage of clerical office workers (54.7 percent). With 57.8 percent, the share of office jobs occupied by women was second only to that of the outer core (Huang, 1989).

Consumers Road Office Park

The Consumers Road office park is a compact area with good expressway exposure and access next to Highways 401 and 404 and the Don Valley Parkway which provides a direct automobile link to downtown Toronto. Although it contains some industrial uses which are reflective of its industrial origins, the office park has developed a large high-rise office component with a major employment base. It contains the largest number office employees and office space of all metro Toronto's office parks. There are large parking areas reflecting the auto-oriented mode of travel.

The office park has a concentration of computer consulting firms, transportation, construction, utilities and other high-tech firms. Of all the office nodes it has the lowest share of clerical jobs (Gad, 1991).

Parkway - Finch Office Park

The Parkway - Finch office park is situated directly south of Steeles Avenue along the eastern side of Highway 404. It is part of a larger office-industrial area which includes the lands to the north in Markham. It is a fairly new area with a mixture of industrial uses and medium to low rise offices. There are few retail-service uses except for some restaurants. The area has a significant concentration of computer, electronics and other high-tech firms with several head offices. The office park has major growth potential through redevelopment of under-utilized lands and industrial sites. The office park is well located with direct highway access to locations in metro Toronto and the regions north of metro. Business services (largely data processing firms) and technical services (predominantly engineering consultants) are very strongly represented and account for nearly 35 percent of all employment (Gad, 1991). Oil companies and manufacturing companies are also strongly represented and this node is the only one outside the financial district that is represented in the bank category (Gad, 1975:1985:1991, Huang, 1989, Matthew, 1993).

Airport Strip Office Park

The Office Park is located just east of Pearson International Airport along Dixon Road. It is comprised of a strip of land on either side of Dixon Road. The area has excellent accessibility to major expressways (Highways 401, 409 and 427). While the office park is part of the larger industrial area, it is characterized by a concentration of hotels and a number of office buildings. Although there exists a moderate level of office development, the area has potential for additional growth.

Highway 427 Corridor

This Office Park is located on both sides of Highway 427 from Dundas Street West to Rathburn Road. It has excellent highway accessibility to Pearson International Airport. The area is characterized by medium density office buildings, high rise apartments and single family homes with a large residential population. The area includes the Etobicoke Civic Centre, a number of schools and hotels.

2.4 Synthesis and Hypotheses

According to the majority of studies on intrametropolitan office location, a clear picture of the factors that influence the choice of location is apparent.

All office firms depend on the availability of a transportation infrastructure for contact with their clients and suppliers, distribution of products and staff commuting. The costs of these linkages are captured by the availability of and proximity to a good highway and rapid transit network and airport facility. The availability and quality of such facilities are important factors when considering costs of face-to-face meetings and commuting costs of staff.

Accessibility to clients and suppliers can be attained by locating in specialized clusters thus taking advantage of agglomeration economies. Locating in specialized clusters reduces the costs of searching for suppliers, distributors, services and labour. Further, locating in specialized clusters allows firms to take advantage of technological advances by exchanging information between other firms on research and development, financing and marketing of products and processes. Locating in clusters also allows firms to find larger markets for increasingly specialized outputs and experience with new products that require frequent face-to-face contact between buyer and seller.

Amenities are regarded as increasingly important to the location decisions of certain types of firms. Shopping, restaurant, cultural and recreational facilities within reasonable distance of the office location are important attractors of firms. Prestige associated with a building or a district has an influence on the location of offices. The concentration of office nodes in high income residential sectors or expressway oriented campuses gives the appearance of respectability. Availability of good schools is also considered. Proximity to research universities is important for high technology firms that require contact with scientists who assist in research and development programs. Universities also attract professional labour and provide good recruitment programs. Finally, quality of life including the presence of country clubs, wilderness parks or lakes is also considered in office location decisions. Disamenities disqualifying a location choice include the presence of pollution, high crime rates and traffic congestion.

In large metropolitan areas office rents are not uniform between locations but decline with distance from the CBD. Decision makers must figure out what rent they can pay after considering labour costs and transportation costs. It is assumed that offices will locate wherever their profits are maximized. Most offices will choose a location with low rental rates. Usually large financial institutions will outbid small professional services such as architects, accountants and planning consultants. Firms are significantly deterred by high property taxes and finally high-tech firms are attracted to smaller and multi-tenant research and development properties.

Offices can benefit from a location that maintains an adequate supply of the right type of labour at a relatively low cost. Wage premiums may be reduced by locating near the residences of managerial and administrative support labour. This location must also be attractive to existing or future employment. For instance, a city centre location is advantageous when it offers reasonable access by car, a strong public transit network and local amenities. Disamenities such as industrial and low income areas compromise the safety of employees consequently increasing labour costs.

Offices in metropolitan Toronto are locating in multi-oriented centres and office parks. The current pattern of offices in Toronto indicates that high level activities including banks, trust companies, stockbroker offices, law firms and management consultants are locating in the financial district. The media and entertainment industry as well as the advertising industry characterize the area surrounding the financial district. Also a small portion of employment in the travel industry is located in this area. North of the central area is characterized by employment in government, advertising and insurance offices as well as the mining and oil industries. The remaining suburban office centres and parks with the exception of the airport strip are characterized by a mixture of industries ranging from high level and high-tech employment including engineers, computer consultants, lawyers and accountants to medium and low level employment including personnel services, health care services and data processing services. The airport node is characterized by employment in manufacturing, transportation and trade services.

The mixture of employment in these nodes is a direct result of planning initiatives implemented in 1980 which involved developing mixed use suburban centres and office parks for the purposes of improving the metropolitan urban structure.

The discussion leads to several specific hypotheses which will be tested in this study.

(1) Clusters of offices within the same activity occur in metropolitan Toronto

(2) Clusters made up of offices from two activity groups occur in metropolitan Toronto

(3) A combination of factors are responsible for the locations of various office activities in metropolitan Toronto

The first two hypotheses will be tested using spatial statistical analysis to determine if certain office activities are clustering. Evidence of own-industry or inter-industry clustering may suggest the presence of possible agglomeration economies. The last hypothesis will be tested using a multinomial logit model to test the significance of several variables representing various factors of locational choice. Together these analyses will illustrate where office activities are locating, where they are clustering and what factors are responsible for determining their locations.

CHAPTER THREE

DATA AND RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the data under investigation and methodology of the thesis. The data consists of the precise locations of new office establishments locating in metropolitan Toronto in 1995. The methodology is in two parts. First spatial statistics are used as an exploratory tool to enrich previous research by exploring the locational relationships among different office industries. A spatial statistical analysis will determine whether certain office activities display different types of locational pattern. Specifically spatial statistics is used to detect whether locational patterns are clustered, or alternatively, dispersed.

Second, this investigation attempts to further office location research by applying discrete choice model to identify factors that influence office location in Toronto. In this respect, this thesis is methodological in nature with an emphasis on the factors that influence office location for particular office industries. The present analysis is similar to that of Ihlanfeldt and Raper (1990) and Shukla and Waddell (1991). The analysis utilizes a logit model to measure the effects of various factors on location decisions. However, unlike previous studies, logit models are performed individually for twenty-two different office activity types. The investigation provides detailed and comprehensive observations on the factors that influence the location of a particular office establishment.

3.2 The Study Data Set

The data were obtained from the Employment Land Use and Assessment data base belonging to the Metropolitan Toronto planning department. The data consisted of street addresses (without postal codes) for 1,891 new office establishments (ie. start-ups or new locations) that located in metropolitan Toronto in 1995. Postal code directories were consulted to locate postal codes for each individual address for the purposes of geocoding the data. A postal code conversion file was obtained from Statistics Canada and used to match postal codes with their corresponding Universal Transverse Mercator (UTM) coordinates. This enabled each office location to be represented digitally as an event with its own X and Y earth coordinates. The raw UTM coordinates were individually separated and grouped according to the specific office activity types to which they belonged. Twenty separate office activity groupings, each containing a particular number of UTM coordinates, were imported into ARC/INFO GIS software and point maps were generated. A digital boundary file and skeletal street network file were also obtained from Statistics Canada. The digital boundary file consisted of census tracts for the Greater Toronto Area. The skeletal street network file consisted of all major streets, highways and expressways also within the Greater Toronto Area. These files were similarly imported into ARC/INFO and then edited to conform to the thesis study area. Finally, each point pattern and the corresponding study area boundary file were then imported into S-plus statistical software. A list of the twenty-two office establishment activity types used in this thesis is found in Table 3.1. The individual office point patterns developed for Chapters Four and Five are shown in Appendices One and Two.

Finally, the locations of these offices may have been influenced by various factors discussed in Chapter Five. Several Variables were defined based on these factors and are listed along with their sources in Table 3.2. A full description of these variables and the rationale for selecting them is discussed fully in Chapter Five.

3.3 The Study Area

The region chosen for this study is metropolitan Toronto which includes the cities of Toronto, North York, York, Etobicoke, Scarborough and East York. In terms of distance the east to west extent is approximately 43 kilometers, the north to south extent is approximately 21.4 kilometers. Metropolitan Toronto comprises approximately 653.8 square kilometers in total land area. The regional map of the study area are shown in Figure 3.1. The study area was selected primarily because of the availability of data. Furthermore, previous studies of office location in Toronto have provided comprehensive background information pertaining to the evolution, industry distribution and growth of the financial district and suburban office nodes. Metropolitan Toronto was also chosen because it is the centre of Canada's economic activity and it represents one of North Americas larger office centers.

Table 3.1
Office Activity Types

Activity Type	Total Number of events in activity point pattern	Corresponding Map Number *
1 Accounting Firms	54	1
2 Advertising Agencies	33	2
3 Photographers and Graphic Artists	186	3
4 Associations General Civic Associations (Children's Aid Society) Business Associations (Board of Trade Metro Toronto) Professional Associations (Associations of Chartered Accountants, C.I.P and Professional Engineers etc.) Labor Associations, Trade Unions Religious Organizations and Associations Miscellaneous Associations (including private business related clubs such as the National and Ontario Clubs)	76	4
5 Computer Services (Computer Programming, Computer Consulting)	112	5
6 Financial Services Bank and Trust Company Branches Investment Services (Investment Dealers, Mutual Funds, Exchanges and Exchange Services) Banks or Trust Companies: Administrative Offices Consumer and Business Finance, Consumer Loans, Business Finance, Mortgage Brokers	116	6
7 Government Agencies Federal Government Provincial - Exclude Legislative Bldg. [withing Queens Park Circle] and Law Courts Municipal - City of Etobicoke Regional or County - Metro Toronto Post Offices	33	7
8 Health Services (21 & 22) Doctors and Physicians Dentists Opticians and Optometrists Other Health Service Practitioners (Chiropractors, Physiotherapists, Nursing Agencies) Laboratories and other related services, Radiologists, etc.	297	8
9 Insurance Agencies Insurance Companies (Life Insurance, General Insurance, Mixed - Life and General) Other Insurance (Insurance Agencies and Insurance Adjusters)	32	9
10 Management Consultants (Placement Services, Actuarial Services, Market Research, Other Research)	99	10

See Appendix 1

Table 3.1 con't
Office Activity Types

Activity Type	Total Number of events in activity point pattern	Corresponding Map Number *
11 Law Firms	117	11
12 Media and Communication Periodical Publishers Program and Film Distributors Film and TV Recording Studios Radio and TV Stations Book Publishers Other Radio, TV, Motion Picture and Publishing Newspaper Publishers Program Producers	97	12
13 Manufacturing	31	13
14 Other Business Services (Investigation Services, Real Estate Management, Janitorial Services and Maintenance)	217	14
15 Real Estate Agents (Brokers)	48	15
16 Personnel Services (Including Theatrical Agencies)	39	16
17 Technical Services Architects and Town Planners (including Landscape Architects) Engineering Consultants (Diversified Engineering, Construction Engineering, Industrial Engineering, Mining Services, Other Engineers) Industrial Designers Other Technical Services (including Interior Designers)	70	17
18 Trade Wholesale Trade (Import and Export) Administration Manufacturer's Agent) Retail Trade Administration (Sales Representative)	121	18
19 Transportation Services Transportation Operations (Airlines, Railways, Bus and Trucking Companies, etc.) Other Transportation (Shipping and Forwarding Agencies, Brokers, Couriers)	40	19
20 Travel Agencies, Airline Reservations	73	20
***21 Doctors, Physicians and Dentists	146	1**
***22 Other Health Services Opticians and Optometrists Other Health Service Practitioners (Chiropractors, Physiotherapists, Nursing Agencies) Laboratories and other related services, Radiologists, etc.	151	2**

*See Appendix 1

**See Appendix 2

*** Office Activities analyzed only in Chapter 5

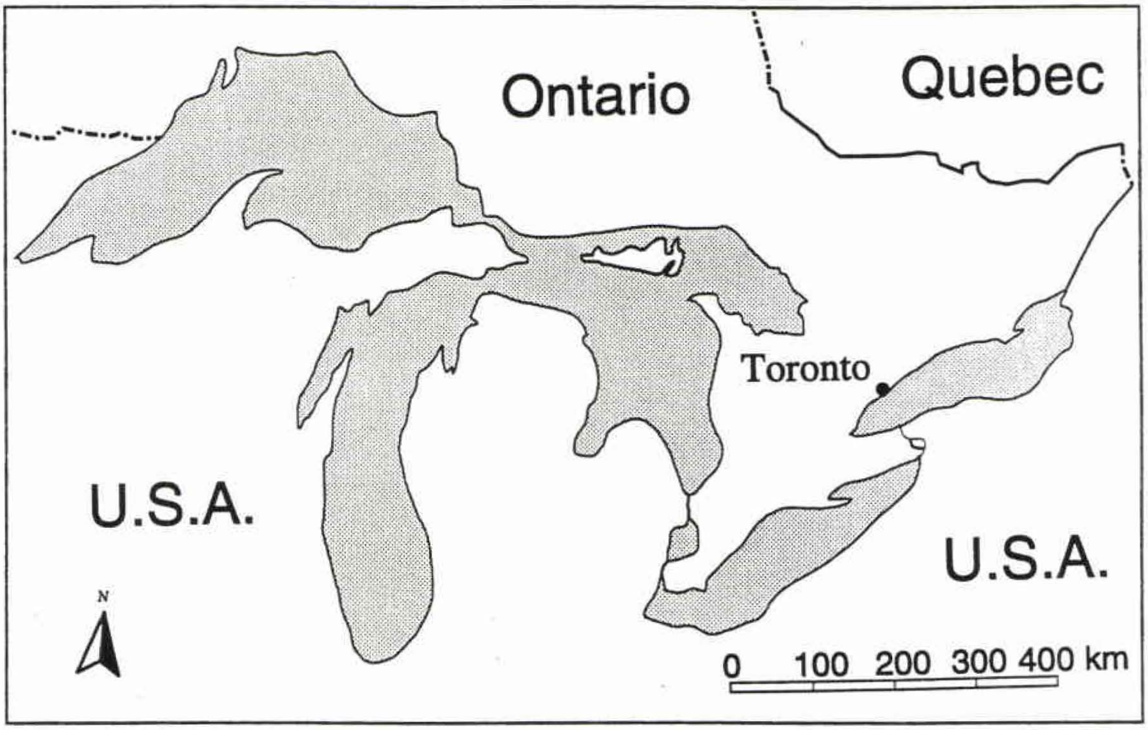
Table 3.2 Explanatory Variables

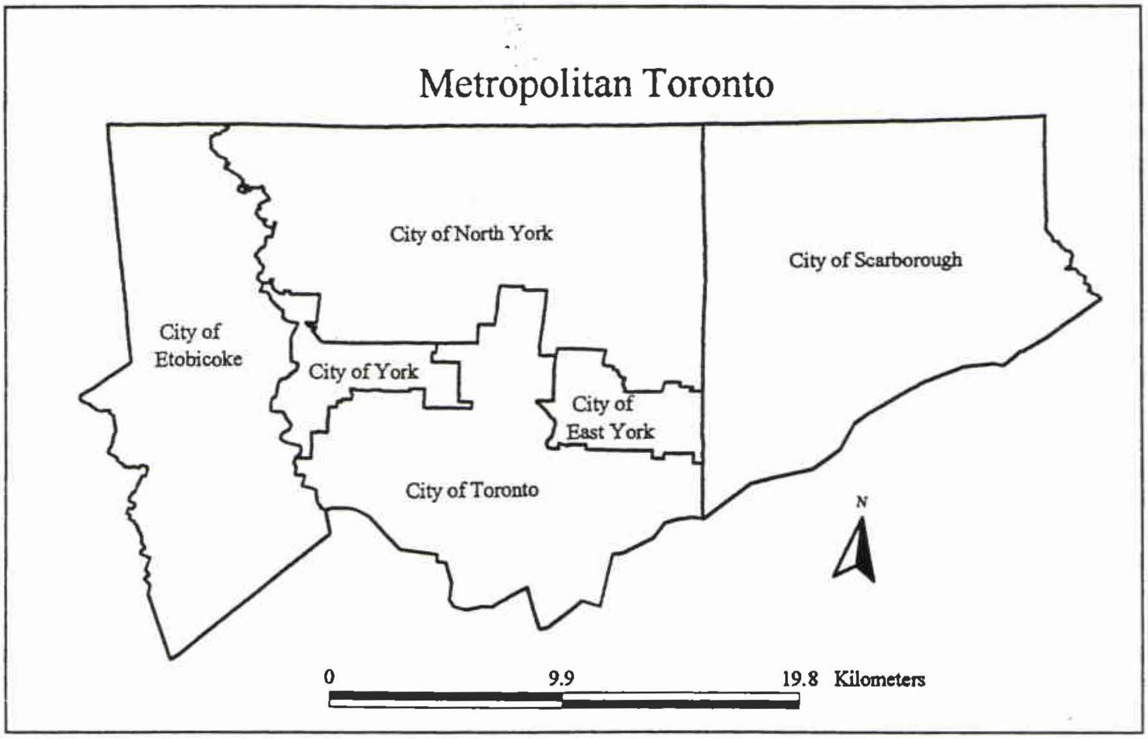
Variables		Data Source
MALLDIS	linear distance from zone centroid to nearest shopping mall	Metro Toronto Planning , 1995 ARC/INFO (GIS) Statistics Canada (Digital Boundary File), 1995
HWYDIS	linear distance from zone centroid to nearest highway/expressway interchange	Statistics Canada (Skeletal Street Network File), 1995 ARC/INFO (GIS) MapArt Publishing (street map of Toronto)
FINDIS	linear distance from zone centroid to center of zone containing the financial district	Statistics Canada (Digital Boundary File), 1995 ARC/INFO (GIS)
AIRDIS	linear distance from zone centroid to center of zone containing Pearson Int'l Airport	Statistics Canada (Digital Boundary File), 1995 ARC/INFO (GIS)
METWEST	dummy variable for zone chosen, yes=1	
METNORTH	dummy variable for zone chosen, yes=1	Metro Toronto Planning (ELA database), 1995
MIDTOWN	dummy variable for zone chosen, yes=1	Colliers International Real Estate (Boundary File)
DOWNTOWN	dummy variable for zone chosen, yes=1	
SHOP	dummy variable for local shopping center in zone, yes=1	Metro Planning (ELA database), 1995
TRANS	dummy variable for TTC or GO rapid transit rail stations in zone, yes=1	Metro Toronto Official Plan, Appendix C, 1994
OFFPARK	dummy variable for office park in zone, yes=1	Metro Toronto Planning, *Offices - Space and Employment Characteristics*, pg. 23.

Table 3.2 con't Explanatory Variables

Variables		Data Source
RENT	gross average asking rental rate	Colliers International Real Estate, 1995
PARKING	average parking fees for buildings in zone	CB Commercial Real Estate, 1995
INVENT	amount of total office floor space in each zone (square foot)	
ABSORP	absorption of office floor space in each zone (square foot)	Colliers International Real Estate,
VSPACE	amount of vacant office floor space in each zone (square foot)	End of year report, 1995
VRATE	vacancy rate in each zone	
MANAGE	accessibility to workers employed in managerial and professional occupations living in zones i,j	Statistics Canada, 1991 Census ARC/INFO (GIS)
CLERICAL	accessibility to workers employed in administrative support occupations living in zones i,j	Statistics Canada, 1991 Census ARC/INFO (GIS)
SERVICE	accessibility to workers employed in financial, legal, business and miscellaneous services living in zones i,j	Statistics Canada, 1991 Census ARC/INFO (GIS)
EMPLOY	accessibility to workers employed in a given office activity working in zone i,j (varies according to model being tested, ie 20 different EMPLOY variables)	Metro Toronto Planning (ELA database), 1995 ARC/INFO (GIS)
AMENITY	accessibility to workers employed in eating, drinking and entertainment establishments working in zone i,j	Metro Toronto Planning (ELA database), 1995 ARC/INFO (GIS)
POOR	number of households in zone below $10,000 income level	Statistics Canada, 1991 Census
WEALTHY	number of households in zone above $70,000 income level	Statistics Canada, 1991 Census
INDUSE	proportion of zones land in industrial landuse	Metro Toronto Official Plan, Map 4, 1994

Figure 3.1
Study Area





3.4 Outline of Analysis

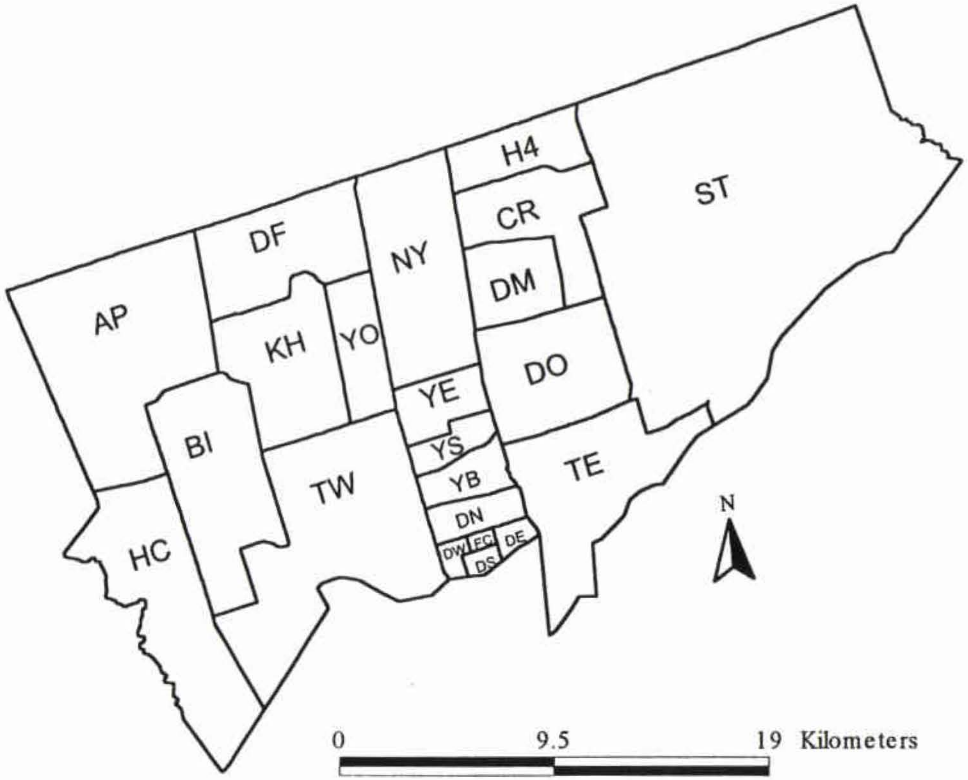
The methodology is in two parts. The first analysis utilizes spatial statistics to determine whether certain office activities display different types of locational pattern. Specifically spatial statistics is used to detect whether patterns are clustered, or alternatively, dispersed. The analysis begins with a technique termed the *kernel* estimate. This technique is used to estimate the intensity of the point pattern in question. The purpose of the kernel estimate is explore the variation in intensity across the entire region of the point pattern. The output is in the form of a smooth contour map displaying areas of high and low point intensities. The analysis continues with the use of a technique known as the *K* function which determines whether or not the set of events (offices), taken as a whole for each activity type, should be considered as randomly distributed or in some way clustered or regularly distributed (dispersed). It involves the modelling, via simulations, of a theoretical distribution to represent a completely spatial random (CSR) pattern in an area of the same shape and size as the study area and with the same number of points. The test proceeds by computing an empirical distribution function which is the observed proportion of nearest neighbour distances. The empirical distribution function is plotted against the theoretical distribution function derived from simulations. Interpretations of the plots are discussed in detail in Chapter Four. Finally, the Bivariate *K* function technique is conducted to determine whether the point locations of one office activity type is independent of the point locations of a second activity type as opposed to them being attracted or alternatively repulsed. The purpose of this technique is to determine whether the locations of a certain office activity will significantly interact with the locations of another office activity. The methods are similar to the methods of the univariate *K* function and are defined in greater detail in Chapter Four.

The second and more important phase of this investigation uses a multinomial logit model to determine the probability that a particular office activity will choose to locate in a particular zone based on that zones characteristics. The purpose is to determine the motives for the locational behaviour observed in Chapter Four. In order to perform the logit analysis the study area was subdivided into twenty two real estate zones shown in Figure 3.2. The zones were digitized from boundary maps supplied with permission by Colliers International Real Estate Group. The rationale behind using real estate boundaries is that they are more representative of office population densities than are major planning districts which are representative of residential populations. Furthermore, distinct office clusters represented by office centres and office parks are located in each real estate zone. Consequently the boundary definitions are based on the geographical locations of office clusters as well as rental rates. An office location model is derived which includes cost and profit functions defining the dependent and independent variables used in the analysis. Explanatory variable definitions and hypotheses concerning their influence on parameter coefficients are fully defined in Chapter Five.

3.5 Description of Software

The 'state of the art' software used for *kernel* estimates and *K* function simulations is known as 'SPLANCS' and was developed by Rowlingson and Diggle (1993) to explore and model spatial point patterns. It is incorporated in the flexible statistical software package

Figure 3.2
Real Estate Boundaries



Legend

AP Airport
HC Hwy. 427 Corridor
BI Bloor/Islington
TW Toronto West
YO Yorkdale
KH Keele/Hwy. 401
DF Dufferin/Finch
NY North Yonge
YE Yonge/Eglinton
YS Yonge/St. Clair
YB Yonge/Bloor
DN Downtown North
FC Financial Core
DW Downtown West
DS Downtown South
DE Downtown East
TE Toronto East
DO Don Mills
DM Duncan Mill
CR Consumers Road
H4 Hwy. 404 Corridor
ST Scarborough Town Centre

S-PLUS. S-PLUS is an interactive computing environment stressing graphics, statistics and mathematical programming. It is an extension of the S programming environment and was developed in 1995 by Mathsoft Inc., a division of AT&T Bell Labs, located in Seattle Washington. S-PLUS emphasizes graphical methods for exploratory data analysis, statistical methods and presentation graphics. S-PLUS provides data analysis tools consisting of a wide variety of functions for statistical and mathematical analysis and is a rich language for defining and analyzing statistical models. SPLANCS uses S-PLUS code and is command driven to provide powerful statistical and graphical results. The output found in Chapter Four was created by SPLANCS and S-PLUS.

Several powerful software packages for the logit analysis exist and one in particular, LIMDEP, provides all of the features required by this research. LIMDEP, (Greene, 1990), is a econometric software package which can be used to estimate a variety of models including the multinomial logit model which is used in this research. LIMDEP is command driven and provides many estimation procedures including maximum likelihood. Finally, LIMDEP allows for time saving and convenient user written procedures which were indispensable to this research. Custom estimation routines for LIMDEP were written by the author.

The other major software packages utilized in this research included two geographical information systems (GIS) packages. A GIS is a tool that uses the power of the computer to pose and answer geographic questions by arranging and displaying data about a phenomenon using maps, charts and tables. ARC/INFO (GIS) (Version 7.0) was developed by Environmental Systems Research Institute, ESRI (1994), in California and can be described as a vector based full featured GIS. ARC/INFO allows users to efficiently capture, store, update, manipulate, analyze and display all forms of geographically referenced information using a series of independent modules linked by a simple data structure. For this research ARC/INFO was utilized for importing and converting data, editing and digitizing boundary files and performing various spatial calculations.

The second GIS used was ArcView. ArcView (GIS), also developed by ESRI (1995), is a complete desktop system for storing, modifying, querying, analyzing and displaying information about various geographical phenomena. ArcView allows users to visualize and study information prepared by GIS users in government agencies, universities, environmental and political organizations and businesses of all types. As a multi-functional interactive geographic tool, ArcView allows users to display the results of queries and data analysis in the form of maps, charts and tables, perform statistical analysis and basic spreadsheet functions, add data sets, join data from outside sources, enter (digitize) geographic areas for custom mapping and analysis, lay out and print map, chart, table and graphic images, export maps, graphs and tables into other software packages. In this research ArcView was used for querying and displaying geographic data, performing statistical data analysis, digitizing and finally creating custom maps and figures which are displayed in Appendix One and throughout this thesis.

CHAPTER 4

SPATIAL POINT PATTERN ANALYSIS

4.1 Introduction

The intention of this chapter is to conduct a rigorous statistical point pattern analysis to determine: i) where different types of new office establishments locate, ii) whether they demonstrate specific and unique locational patterns, and iii) if these patterns are dependent on the location of other distinct office activities. The chapter begins with a brief overview of recent studies undertaken using spatial point pattern analysis. The chapter continues with a review of the general concepts involved when studying point patterns. The main body of the chapter is divided in sections that discuss the purpose of the experiments, the hypotheses, the data, the analytical methods used to conduct the experiments and finally the research findings. This chapter sets the stage for the fifth chapter where locational motives are examined to determine the "why" phase of locational decisions confronted by new office establishments.

4.2 Historical Background

A spatial point pattern is a set of locations irregularly distributed within a region of interest, which have been generated by some unknown random mechanism (Diggle, 1983).

The origins of the techniques currently used in the statistical analysis of point patterns arose over fifty years ago in plant and animal ecology. Plant and animal ecologists have used such techniques to explore both the spatial distribution of individual species and the interrelationships of two or more species. Their overall aim was to identify factors of the individuals and their environment that influence such patterns (Boots and Getis, 1988). During the quantitative revolution of the 1960's, techniques used by ecologists were embraced by many geographers who have since refined them to substantiate previous quantitative research (Dacey, 1960; King, 1962). Since then geographers have used point pattern analysis to examine the spatial characteristics of disease distributions and patterns of health care (Gatrell et. al., 1996), population distribution (Getis, 1983), spatial mobility of urban activities (Lee, 1974), spatial clustering of retail and corporate establishments (Rogers, 1965, Sibley, 1972, Semple, 1973) and volcanic craters (Tinkler, 1971). Point pattern analysis has also been introduced to researchers in other disciplines: eg. Biology (Clark and Evans, 1963); Geology (Tinkler, 1971); Forestry (Diggle, 1983); Astronomy (Peebles, 1974); Statistics (Riply, 1976); Criminology (Herbert, 1980) and Archeology/Anthropology (Cormack and Weeks, 1981). Finally, a number of researchers have attempted to unify these diverse approaches while developing a series of more sophisticated techniques of point pattern analysis (Boots and Getis, 1979:1988, Cliff and Ord, 1981, Ripley, 1977:1981, Diggle, 1979:1983, Upton and Fingleton 1985, Cressie, 1991, Bailey and Gatrell, 1995).

4.3 A Framework for Spatial Data Analysis

Spatial data analysis involves the accurate description of data relating to a process operating in space, the exploration of patterns and relationships in such data, and the search for explanations of such patterns and relationships (Bailey and Gatrell, 1995). The procedures and techniques used in this chapter are quantitative in nature. As such, a quantitatively - based framework for spatial data analysis must be defined. This analysis uses the framework developed by Bailey and Gatrell (1995). Three broad classes of methods are defined to assist in spatial data analysis.

The first of these methods concerns visualising the phenomenon under study. The primary tool in any geographical analysis is a map of the phenomenon which might show simply a dot distribution or a chloropleth map identifying certain attributes of a phenomenon. Raw data may also be plotted and displayed graphically. The purpose is to gain an initial impression of any obvious patterns present in the distribution of a phenomenon.

Second, explanatory methods are designed to summarize and describe map pattern and relationships within maps. Exploratory techniques in this chapter take the form of graphical plots. These techniques reveal broad patterns in data such as the various kinds of map smoothing and density estimation techniques.

The third set of methods include those for quantitative modelling. Unlike the previous two techniques, modelling spatial data allows for formal methods of analysis. Formal methods of analysis consist of statistically comparing various summary measures calculated from some observed distribution of events with various hypothesized models.

4.3.1 Statistical Terminology

Statistical models are concerned with phenomena which are *stochastic*. The term stochastic refers to any phenomenon which is subject to uncertainty. *Random variables* are used to represent stochastic phenomena mathematically. A random variable is a variable whose values are subject to uncertainty. A random variable may take different possible values. A *probability distribution* is a mathematical function which specifies the probability that particular values or ranges of values of a random variable will occur. A *cumulative probability distribution* of a random variable also referred to as a *distribution function* is a mathematical function which specifies the probability that a random variable takes any value less than or equal to the observed value of this random variable. The *expected value* or *mean* of a random variable is the average value of a random variable. It is the weighted sum of the possible values where the weights used for each value are the probability associated with that value (Bailey and Gatrell, 1995). The *variance* of a random variable is defined as the expected squared deviation of the random variable from its mean. It measures how much its values tend to vary around their mean. The positive square root of the variance is defined as the *standard deviation* of the random variable. If more than one random variable is present then the probability or *probability density* of random variable X taking a specific value x while at the same time random variable Y takes the specific value y is known as their *joint probability distribution function*. The *covariance* of two random variables measures the expected tendency for values of random variable X to be similar to values of random variable Y. The covariance of two random variables divided by the product of their standard deviations is referred to as the *correlation* between them.

In the context of this chapter, two random variables are said to be *independent* if the values of either one remains the same, no matter what values the other might take. Therefore their variance and correlation will equal zero. Furthermore, a set of random variables is referred to as a *spatial stochastic process*. When modelling bivariate or multivariate spatially stochastic processes, independence implies that the overall pattern in events is made up of independent component processes, one for each of the types of events; in other words spatial process A is independent of spatial process B. Finally, one observation from a probability distribution of a random variable is referred to as a *realization* of the spatial process.

4.3.2 Assumptions in Spatial Modelling

For a spatial model to provide a realistic representation of a real world phenomenon, assumptions about independence and/or stationarity among random variables need to be made.

The behaviour of spatial phenomena is the result of both *first order* and *second order effects*. As such, the variable of interest comprises two components. The first order component represents a global or large scale trend. It relates to the variation (heterogeneity) in the mean value of the process across space. First order properties are described in terms of intensity $\lambda(s)$ of the process which is the average or mean number of events per unit area at the point s. An example would be the average rainfall of the Amazon river valley. The second order component is concerned with local or small scale effects. It results from the spatial correlation structure or the spatial dependence in the process; that is to say the tendency for deviations in values of the process from its mean to follow each other in neighbouring sites (Bailey and Gatrell, 1995). An example of second order effects is the locations of cases of meningitis in parts of southern Ontario. The second order component is modelled as a *stationary* or *homogeneous* process. This implies that the mean and variance are constant across space. Stationarity also implies that the covariance depends only on the relative locations of sites, the distance and direction between them and not on their absolute location.

The spatial process is isotropic if in addition to stationarity the covariance depends only on the distance between sites and not on the direction in which they are separated (Bailey and Gatrell, 1995). *Non - Stationarity* or *heterogeneity* implies that the mean, or variance or covariance structure varies across space. According to Bailey and Gatrell (1995), heterogeneity in the mean, combined with stationarity in second order effects is a useful modelling assumption since it implies that the covariance among events is the same from area to area within the study region allowing local trends to be identified.

4.4 Purpose of Investigation

As noted in the first chapter, two of the primary hypotheses are to determine:
i) whether office establishments cluster and whether the degree of clustering varies across office activity type, and ii) whether the location of one type of office establishment is dependent on the location of a second type of office establishment. A further hypothesis, although statistically untestable and therefore informal, is to descriptively compare the general findings of Gad (1975) with those of this chapter. Particularly Gad (1975) identified functional linkage patterns among pairs of certain office activities within central metropolitan

Toronto. Gad termed his study area "The Central Office Complex" and defined it as a long rectangle centered on Yonge Street running from the shore of Lake Ontario in the south to Erskine Street (two blocks north of Eglinton Avenue) in the north. The western boundary approximately follows McCaul Street, Bedford Road and line closely parallel to, and west of, Avenue Road. In the east the boundary follows Sherbourne Street in the southern part and Mount Pleasant Avenue in the northern part of the study area (refer to Figure 4.1). He defined functional linkages as business transactions or exchanges which result in short term recurrent movements (Gad, 1975). Based on his results Gad (1975) constructed an (n × n) matrix of linkage intensities from which was extracted office pairings that demonstrated the highest levels of linkage intensities. The data were reconstructed and is shown in Table 4.1.

The basis of this chapter is to conduct a rigorous statistical point pattern analysis of new office firms that have located in metropolitan Toronto for the purposes of ascertaining the following:

1 Whether the locations of different office activities display different types of pattern
2 Whether the locations of office activity (*i*) are independent of the locations of office activity (*j*).

4.5 Hypotheses

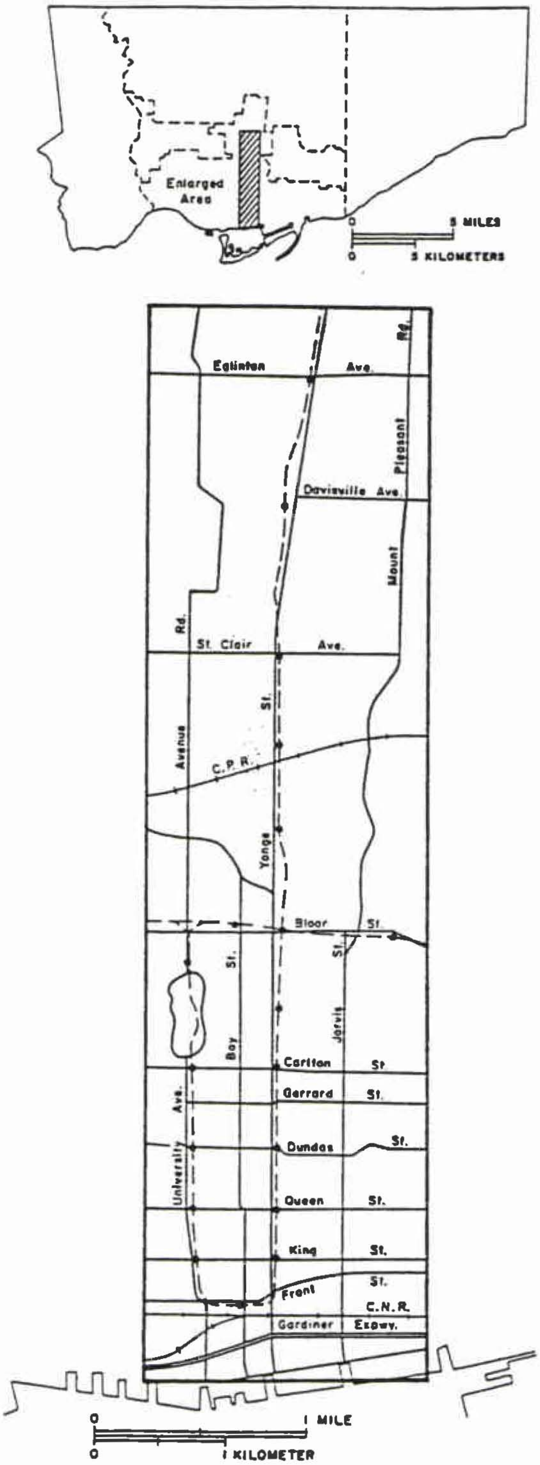
Most methods of spatial point pattern analysis proceed by comparing an actual pattern to a theoretical pattern generated by some statistical model. Formal hypotheses for this chapter are defined as follows:

<u>Hypothesis 1</u>

(H_o) The univariate point pattern under investigation is CSR resulting from a homogeneous planar poisson point process

Figure 4.1

Gad's Study Area:
Toronto's Central Office Complex



Source: Gad, (1975), pg. 145.

Table 4.1
Linkage Intensities among Office Activities

Office Activity Type	Linkage Partners	Intensity Rank
Manufacturing	Trade	1
	Transportation Services	2
Transportation Services	Manufacturing	1
	Trade	2
Financial Services	Manufacturing	1
	Law Firms	2
	Real Estate Agencies	3
	Trade	4
	Insurance Agencies	5
Insurance Agencies	Manufacturing	1
	Trade	2
	Real Estate Agencies	3
	Law Firms	4
Accounting Firms	Manufacturing	1
	Law Firms	2
	Trade	3
	Health Services	4
	Finance	5
Management Consultants	Manufacturing	1
	Law Firms	2
	Health Services	3
	Financial Services	4
Advertising Agencies	Manufacturing	1
	Media and Communications	2
	Technical Services	3
Technical Services	Manufacturing	1
	Trade	2
	Law Firms	3
	Real Estate Agencies	4
	Computer Services	5
Associations	Manufacturing	1
	Transportation Services	2
	Media and Communications	3
Real Estate Agencies	Law Firms	1
	Technical Services	2
	Manufacturing	3
	Finance	4
Law Firms	Real Estate Agencies	1
	Financial Services	2
	Manufacturing	3

Source: Gad (1975)

(H_1) The univariate point pattern under investigation is not CSR

Hypothesis 2

(H_0) The bivariate point pattern under investigation exhibits independence
(H_1) The bivariate point pattern under investigation does not exhibit independence.

To test the second hypothesis, office pairings were constructed from the given office activity data set. These pairings were constructed based on the linkage intensities found in Table 4.1. Other pairings not found in Table 4.1 were constructed based on the similarities of their observed locational intensities derived from kernel estimation, which is discussed in section 4.7. All office pairings used to test the second hypothesis are shown in Table 4.2. At this point it must be stated that upon testing the second hypothesis linkage intensities do not imply significant statistical locational attraction between two event processes. Gad's linkage intensities are a product of a descriptive survey and were not derived from statistical modelling. Therefore in this thesis they are used only as a descriptive benchmark from which to develop potential hypotheses.

4.6 Data

The data used in this chapter consist of street addresses for 1,891 new office establishments that located in metro Toronto in 1995. They are described in detail in section 3.2. A list of the twenty office establishment activity types used in this chapter is found in Table 4.3.

Table 4.2
Office Pairings Constructed to Test Hypothesis 2

Office Activity Type	Possible Dependencies	Office Activity Type	Possible Dependencies
Transportation Services	Manufacturing	Associations	Manufacturing
			Transportation Services
Financial Services	Manufacturing		
	Law Firms		
	Real Estate Agencies	Technical Services	Manufacturing
	Insurance Agencies		Trade
			Law Firms
Insurance Agencies	Manufacturing		Real Estate Agencies
	Real Estate Agencies		Computer Services
	Law Firms		
		Media and Communications	Photographers and Graphic Artists
Real Estate Agencies	Manufacturing		Associations
Law Firms	Real Estate Agencies		
	Manufacturing	Health Services	Management Consultants
			Accounting Firms
Accounting Firms	Manufacturing		Insurance Agencies
	Law Firms		
	Finance	Trade	Manufacturing
			Transportation Services
Management Consultants	Manufacturing		Financial Services
	Law Firms		Insurance Agencies
	Financial Services		Accounting Firms
Advertising Agencies	Manufacturing	Computer Services	Financial Services
	Media and Communications		Insurance Agencies
	Technical Services		Accounting Firms
			Management Consultants
			Law Firms

Table 4.3
Office Activity Types

Activity Type	Total Number of events in activity point pattern	Corresponding Map Number *
1 Accounting Firms	54	1
2 Advertising Agencies	33	2
3 Photographers and Graphic Artists	186	3
4 Associations General Civic Associations (Children's Aid Society) Business Associations (Board of Trade Metro Toronto) Professional Associations (Associations of Chartered Accountants, C.I.P and Professional Engineers etc.) Labor Associations, Trade Unions Religious Organizations and Associations Miscellaneous Associations (including private business related clubs such as the National and Ontario Clubs)	76	4
5 Computer Services (Computer Programming, Computer Consulting	112	5
6 Financial Services Bank and Trust Company Branches Investment Services (Investment Dealers, Mutual Funds, Exchanges and Exchange Services Banks or Trust Companies: Administrative Offices Consumer and Business Finance, Consumer Loans, Business Finance, Mortgage Brokers	116	6
7 Government Agencies Federal Government Provincial - Exclude Legislative Bldg. [withing Queens Park Circle] and Law Courts Municipal - City of Etobicoke Regional or County - Metro Toronto Post Offices	33	7
8 Health Services Doctors and Physicians Dentists Opticians and Optometrists Other Health Service Practitioners (Chiropractors, Physiotherapists, Nursing Agencies) Laboratories and other related services, Radiologists, etc.	297	8
9 Insurance Agencies Insurance Companies (Life Insurance, General Insurance, Mixed - Life and General Other Insurance (Insurance Agencies and Insurance Adjusters)	32	9
10 Management Consultants (Placement Services, Actuarial Services, Market Research, Other Research)	99	10

See Appendix 1

Table 4.3 con't
Office Activity Types

Activity Type	Total Number of events in activity point pattern	Corresponding Map Number *
11 Law Firms	117	11
12 Media and Communication	97	12
Periodical Publishers		
Program and Film Distributors		
Film and TV Recording Studios		
Radio and TV Stations		
Book Publishers		
Other Radio, TV, Motion Picture and Publishing		
Newspaper Publishers		
Program Producers		
13 Manufacturing	31	13
14 Other Business Services (Investigation Services, Real Estate Management, Janitorial Services and Maintenance)	217	14
15 Real Estate Agents (Brokers)	48	15
16 Personnel Services (Including Theatrical Agencies)	39	16
17 Technical Services	70	17
Architects and Town Planners (including Landscape Architects)		
Engineering Consultants (Diversified Engineering, Construction Engineering, Industrial Engineering, Mining Services, Other Engineers)		
Industrial Designers		
Other Technical Services (including Interior Designers)		
18 Trade	121	18
Wholesale Trade (Import and Export) Administration Manufacturer's Agent)		
Retail Trade Administration (Sales Representative)		
19 Transportation Services	40	19
Transportation Operations (Airlines, Railways, Bus and Trucking Companies, etc.)		
Other Transportation (Shipping and Forwarding Agencies, Brokers, Couriers		
20 Travel Agencies, Airline Reservations	73	20

*See Appendix 1

4.7 Methods for Spatial Point Pattern Analysis

4.7.1 Visualising Spatial Point Patterns

The dot or point map is one of the most common tools used by geographer's to display the distribution of events in space. Maps give an impression of the shape of the study area and any patterns present in the distribution of events. Researchers are interested in maps for a variety of reasons. One reason is that with an appropriate choice of scale even large objects may be best represented by an event location (Upton and Fingleton, 1985). A second major reason is their belief that maps represent one source of evidence that may be helpful in learning more about a phenomenon represented and the processes responsible for generating it (Boots and Getis, 1988). Generally a dot map contains two major types of components: the points representing the objects being studied referred to as the *point pattern* and the geographical area in which they are located referred to as the *study area* (Unwin, 1981; Boots and Getis, 1988). In this chapter specific points represent office establishments and are referred to as *events*. The theoretical principle here is that every pattern of events is the result of some process which operated over a region over a time period. The geographic study area is metropolitan Toronto. The locations of events were captured after one time period, that being 1995. The distribution of twenty office establishment types used in this analysis are found in Appendix One.

4.7.2 Exploring Spatial Point Patterns

The traditional method concerned with investigating first order properties of a point process is referred to as the quadrat method. The quadrat method summarizes the spatial pattern in the locations of events in a two dimensional region $\mathbb{R}$ by dividing $\mathbb{R}$ into sub-regions of equal area. The number of events in each quadrat is counted. This creates a two-dimensional frequency distribution of the observed events. The counts are then converted to an intensity measure by dividing by the area of each of the quadrats. The result will give an indication of whether and how the intensity of the process $\lambda(s)$ is changing over $\mathbb{R}$.

The problem with quadrat analysis is that it discards much of the spatial detail in the observed pattern. Quadrat counts give no information on pattern at a scale below that of the grid, and are very dependent on quadrat size and shape. If the quadrats are made smaller to retain more spatial variation, then it will lead to a very high variability in quadrat counts. The result is a grid with many empty quadrats hindering meaningful interpretation. Another problem with quadrat counts is that they give no information on the relative location of individual quadrats. Information on the locations of the quadrats with respect to each other is lost when the map is converted into a frequency distribution.

Bailey and Gatrell (1995) found that a possible solution to the quadrat problem would be through the use of counts per unit area in a 'moving window'. They found that instead of superimposing a regular grid of quadrats on an event distribution, one could form a count of events per unit area within a moving quadrat or window of fixed size. The window centers on a number of locations which are arranged in a grid that is much finer than the regular sized grid. This grid is superimposed on $\mathbb{R}$. The intensity at each grid point is estimated from the event count per unit area within the window centered on that point. This could provide a more spatially 'smooth' estimate of the way in which the intensity $\lambda(s)$ is varying. In other words the intensity of the mean values of the process is being estimated - hence a first order effect. A problem exists in that no account is taken of the relative location of events within the window and the choice of the suitable window size is not clear.

Recently, however an advanced extension of quadrat analysis referred to as a *Kernel Estimate* has been developed and used to correct for the above limitations (Cressie, 1991; Bailey and Gatrell, 1995).

The Kernel Estimate

In kernel estimation the window discussed above is replaced with a three dimensional function (the kernel) which weighs events according to their distance from the point at which intensity is being estimated. This method is used to obtain a smooth estimate of a univariate or multivariate probability density from an observed sample of observations (Bailey and Gatrell, 1995). In other words, it is used to estimate the intensity of the mean value of events belonging to a spatial process across $\mathbb{R}$.

Formally, s represents a vector point location anywhere in the two dimensional area $\mathbb{R}$ and $s_1 \ldots s_n$ are the locations of the n observed events. The intensity, $\lambda(s)$ at s is estimated by

$$\hat{\lambda}_{\tau}(s) = \frac{1}{\delta_{\tau}(s)} \sum_{i=1}^{n} \frac{1}{\tau^2} k\left(\frac{(s-s_i)}{\tau}\right) \tag{4.1}$$

where $k()$ represents the kernel weighting function which takes the form of a decreasing radially symmetric bivariate function. In other words it is a three dimensional 'bell' which centers on a given point s and provides a uniform weight surrounding the region around point

s. This 'bell' is centered on s and stretched according to the parameter $\tau > 0$ which is referred to as the bandwidth. It is the radius of the disc found at the base of the bell shaped function which is centred on s. The kernel estimate is sensitive to the choice of bandwidth τ. The value of τ is chosen to provide the required degree of smoothing in the estimate. As τ is increased, there is more smoothing of the spatial variation in intensity; that is the estimate will appear flat and local features will be obscured. As it is reduced the outcome is an increasingly 'spikey' estimate. The value chosen for τ is experimental . The value of kernel estimation is its flexibility to experiment with different values of τ. Experimenting with τ permits exploration of the surface $\hat{\lambda}_\tau(s)$ using different degrees of smoothing in order to look at the variation in $\lambda(s)$ at different scales.

Various choices of functional form of the kernel have little effect on the resulting intensity estimate $\hat{\lambda}_\tau(s)$. Usually the typical choice among researchers is the quartic kernel illustrated in Figure 4.2.

$$k(u) = \begin{cases} \frac{3}{\pi}(1 - u^T u)^2 & \text{for } u^T u \leq 1 \\ 0 & \text{otherwise} \end{cases} \tag{4.2}$$

The estimate $\lambda_\tau(s)$ can then be expressed as

$$\hat{\lambda}_\tau(s) = \sum_{d_i \leq \tau} \frac{3}{\pi\tau^2}\left(1 - \frac{d_i^2}{\tau^2}\right)^2 \tag{4.3}$$

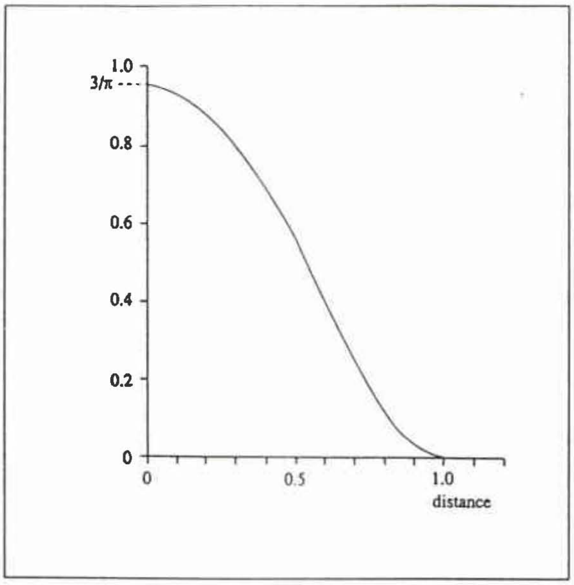


Figure 4.2 Slice through a quartic Kernel

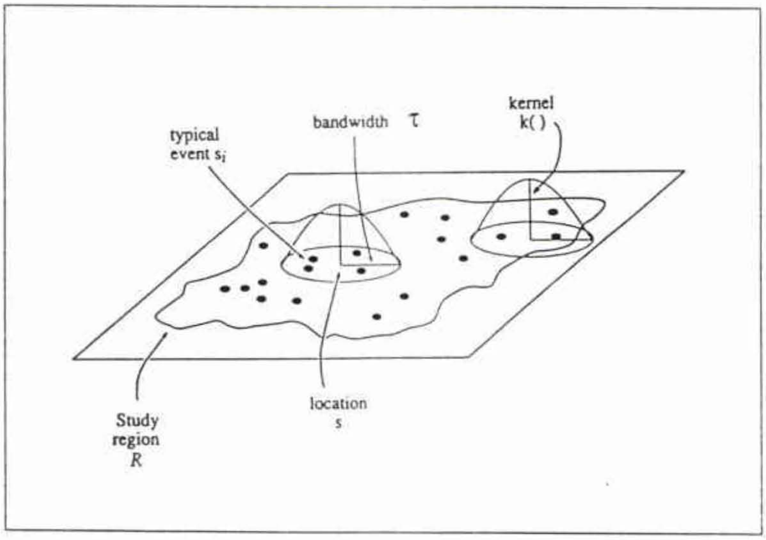


Figure 4.3 Kernel estimation of a point pattern

Source: Bailey and Gatrell (1995), p. 86

where d_i is the distance between the point s and the event location s_i. The summation is only over values of d_i which do not exceed τ. At the site s (a distance of zero) the weight is $3/\pi\tau^2$ and drops smoothly to a value of zero at a distance τ. The factor

$$\delta_\tau(s) = \int_R \frac{1}{\tau_2} k\left(\frac{(s-u)}{\tau}\right) du \tag{4.4}$$

is an edge correction term. Edge effects distort kernel estimates close to the boundary of $\mathbb{R}$ because an event near the boundary is denied the possibility of neighbours outside the boundary. Equation 4.4 is the volume under the scaled three dimensional kernel (bell) centered on s which lies inside $\mathbb{R}$. In other words the edge correction only measures the events under the part of the function which lies inside $\mathbb{R}$.

To graphically summarize the above, imagine a three dimensional function that 'visits' each point s on the fine grid (refer to Figure 4.3 on page 81). Distances to each observed event s_i that lies within the region of influence (as controlled by τ) are measured and contribute to the intensity estimate at s according to how close they are to s. The result is a contour map which represents the resulting intensity estimates as a continuous smooth surface showing how intensity varies over $\mathbb{R}$.

4.7.3 Modelling Spatial Point Patterns

Complete Spatial Randomness (CSR)

The models that explain patterns of events on maps are called point process models. A point process is a stochastic model governing the location of events in a study region. Models of spatial point pattern analysis proceed by comparing an actual pattern to a theoretical model generated from certain assumptions. The most basic hypothesis tested is that of Complete Spatial Randomness (CSR), which arises from the homogeneous planar point process. The poisson model is defined by two fundamental properties. First the number of events in any bounded planar region, A, follows a Poisson distribution with mean $\lambda(A)$. Mathematically the poisson distribution can be written as

$$P(n;\lambda) = \frac{\lambda^n e^{-\lambda}}{n!} \qquad for\ n = 0,1,2,3,..., \tag{4.5}$$

where the parameter λ is the intensity of the process defined as the expected number of events per unit area, while n is considered a random variable representing the observed number of events in the region. According to this assumption CSR implies that the intensity of events does not vary over the region. The second property is dependent upon the conditions of uniformity and independence. Uniformity implies that each location in the study area has an equal chance of receiving an event, that is, the study area is completely homogeneous. Independence implies that an event in no way influences the selection of locations for any other events. In other words according to CSR there are no interactions between events. Ultimately these assumptions generate a random point pattern of n events located in $\mathbb{R}$. In terms of modelling spatial point patterns the interest in CSR is threefold. Firstly, if CSR is not rejected for a point pattern then further formal statistical analysis is not needed. Second, CSR tests are used as a means of exploring a set of data and thirdly, CSR represents a benchmark hypothesis which distinguishes between patterns which are classified as *regular* or *dispersed* and *clustered*. Dispersed patterns arise as a result of violating the assumption of independence in such a way that the events interact by repelling each other. The characteristic of repulsion may indicate that some sort of competition or constrainment is taking place. Clustered patterns also arise as a result of violating the assumption of independence. Clustered patterns can be explained by environmental heterogeneity. This implies that some locations are more likely to receive an event than others. Clustered patterns may indicate that groups of events are forming because the events within the groups are attracted to each other.

Distance Based Methods under CSR

Distance based analysis, also known as nearest neighbour analysis, proceeds by comparing the characteristics of the distribution of distances between events and their nearest neighbours in the empirical spatial point pattern with those expected in a theoretical spatial point pattern. However there are a few limitations to nearest neighbour analysis. First, nearest neighbour analyses use distances only to the closest events and therefore only consider the smallest scales of pattern. Information on larger scales of pattern is lost. A second problem of distance based methods which is of particular importance in this thesis is that of *edge effects*.

Edge effects arise in application of spatial point pattern analysis where some events may be closer to the border or edge of the study area than to their nearest neighbours because the nearest event may be located outside the study area, distance to the nearest event is unknown. If the nearest neighbour is taken to be the closest event within the study region, expected nearest neighbour distances for an event near the edge will be greater than for an event well inside the region, because the former is denied the possibility of neighbours outside of the edge. Thus, nearest neighbour measurements on the events close to the boundary will overestimate the mean nearest neighbour distance (Hagget et. al., 1977, Griffith and Amrhiem, 1983, Upton and Fingleton, 1985, Cressie, 1991). Fortunately the techniques used in this chapter, including kernel estimation, have edge correction factors built into their equations. Detailed descriptions of these factors and other edge correction procedures are provided in later sections.

The K function and CSR

An alternative approach to the nearest neighbour method is to use an estimate of the reduced second moment measure or K function of the observed process. The K function is related to second order properties of an isotropic (stationary) process. Therefore, when investigating second order properties the assumption is that the process is isotropic over the whole region $\mathbb{R}$. Hence, the K function provides a more effective summary of spatial dependence among events over a wider range of scales. In other words the covariance among events only depends on the distance between them plus the mean and variance of events are constant across space. The K function involves the use of precise locations of events and includes all event - event distances not just nearest neighbour distances. The formal definition of the K function is

$$\lambda K(h) = E(\#(\text{events within distance } h \text{ of an arbitrary event}))$$

where # means 'the number of ' $E()$ is the normal expectation operator and λ is the intensity or mean number of events per unit area, assumed constant throughout the region $\mathbb{R}$. It is not possible to estimate the second order intensity directly however $K(h)$ is a summary measure of second order effects and so it is possible to obtain a direct estimate of it (Bailey and Gatrell, 1995). The estimate of $K(h)$ is given by

$$\hat{K}(h) = \frac{R}{n^2}\sum_{i \neq j}\sum_{j \neq i}\frac{I_h(d_{ij})}{w_{ij}} \qquad (4.6)$$

here R is a sub area of $\mathbb{R}$. The intensity λ is defined as n/R where n is the number of events. The expected total number of events in R is λR. The definition of the K function states that we are investigating ordered pairs of events which are separated at a distance h therefore the first event in $\mathbb{R}$ is $\lambda^2 RK(h)$. Isolating $K(h)$ on the left side of the equation results in the term $1/\lambda^2 R$. Since λ is estimated as n/R the expression can be rewritten as R/n^2. The expression $\sum_{i \neq j}\sum_{j \neq i} I_h(d_{ij})$ gives the total number of events that lie within a distance h from any other given event. The term d_{ij} is the distance between the ith and jth observed events in $\mathbb{R}$. The term $I_h(d_{ij})$ is an indicator function (or counter) which equals 1 if the distance between the ith and jth event d_{ij} is less than or equal to h. $I_h(d_{ij})$ equals zero if d_{ij} is greater than the distance h. To better understand the notion of the K function a graphical representation is provided in Figure 4.4. Imagine an event is visited and is surrounded by a set of concentric circles. The distance from the outermost circle to the event is the radius distance h. The distances between the distance bands are evenly spaced and sum up to the radius h. The number of events within each of the distance bands is counted. Every other event is visited and the number of events within each of the distance bands up to the radius h are counted using $\sum_{i \neq j}\sum_{j \neq i} I_h(d_{ij})$. These counts are scaled by the intensity R/n^2 to give the estimate of $K(h)$.

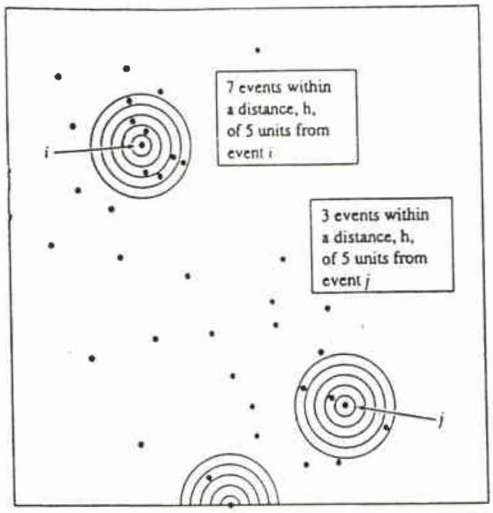


Figure 4.4 Estimation of the *K* function

Source: Bailey and Gatrell (1995), p. 93.

The radius h used in this analysis was 7.5 kilometers. Five distance bands were evenly spaced with 1.5 kilometers separating each band.

In a situation where one event lies within the boundary $\mathbb{R}$ and the second event lies outside $\mathbb{R}$ and therefore unobservable (missed) we need to consider the effect of the edge of $\mathbb{R}$ on the estimate $\hat{K}(h)$. The term w_{ij} is an edge correction factor. Referring to Figure 4.4, imagine a circle centred on event i found within the boundary $\mathbb{R}$, passing through the point j found outside the boundary $\mathbb{R}$, then w_{ij} estimates the proportion of the circumference of the distance band which lies inside $\mathbb{R}$. Formally the term w_{ij} is the conditional probability that an event is observed in $\mathbb{R}$, given that it is a distance d_{ij} from the ith event. The edge correction factor is used for regular boundaries, that is boundaries in the form of a rectangle or square. The study area in this analysis is irregular and therefore the weights w_{ij} are hard to derive. A way around this problem is to use a Monte Carlo simulation developed by Bartlett (1963) and revised by Barnard (1963) which will be discussed shortly.

At this point the K function is being used as an exploratory device. Its plot is inconclusive and requires some basic comparison which allows one to detect whether clustering or dispersion is present. This can be achieved by comparing $K(h)$ estimated from the observed data with the theoretical pattern of CSR. Intuitively 'random' implies that under CSR the probability that an event occurs at any point in $\mathbb{R}$ is independent of what other events have occurred and equally likely over the whole of $\mathbb{R}$. Thus if the process is random the number of events found within a circular area at distance at most h from a randomly chosen event would be $\lambda\pi h^2$. Since we observe a circular area centering on a particular event, the area of that circle is πh^2. Hence theoretically under CSR $K(h) = \pi h^2$ for a homogeneous isotropic process with no spatial dependence among events.

Under dispersion $K(h)$ would be less than πh^2, whereas under clustering $K(h)$ would be greater than πh^2. The K function can now be modelled in a formal way by comparing K(h) estimated from the observed data with the theoretical value of it under CSR ($\hat{K}(h) = \pi h^2$). This can be accomplished by defining $\hat{L}(h)$. $\hat{L}(h)$ is defined by isolating h on the right hand side of the expression to give:

$$\hat{L}(h) = \sqrt{\frac{\hat{K}(h)}{\pi}} - h \tag{4.7}$$

$\hat{L}(h)$ is used as an index which determines if clustering or dispersion is present. The initial value of the index is zero. If the estimated $K(h)$ is positive for all distances then $\hat{L}(h)$ will also be positive. The corresponding plot will have peaks in positive values indicating clustering or spatial attraction of events. If the estimated $K(h)$ is negative for all distances then $\hat{L}(h)$ will also be negative. The corresponding plot will have troughs in negative values indicating spatial dispersion.

Formal assessment of the significance of these peaks and troughs requires knowledge of the theoretical distribution of $\hat{L}(h)$ and $\hat{K}(h)$ under CSR. This is difficult to obtain because of the edge correction built into $K(h)$ described earlier. To solve this problem a simulation estimate of the theoretical distribution can be used. Simulations can provide a test of CSR while also correcting for edge effects in an irregular study region by using a test similar to a monte carlo test developed by Barnard (1963). The test procedure begins by simulating the estimate for $K(h)$ and hence $L(h)$ under CSR. The estimate is calculated as $\overline{L}(h) = \sum\hat{L}_i(h)/m$. $L_i(h)$, $i = 1....,m$ are empirical distribution functions each of which is estimated from one of m independent realizations (simulations) of n events independently and uniformly distributed in $\mathbb{R}$. In other words for a particular point process, n number of events are randomly generated within the irregular boundary $\mathbb{R}$ m number of times. The statistic $L_i(h)$, the mean of each distribution, is calculated for each simulation and its average over all m is calculated. The average $\overline{L}(h)$ and its associated distribution becomes the theoretical distribution of $L(h)$. If the empirical data $\hat{L}(h)$ is compatible with CSR (or null hypothesis) then the plot of $\overline{L}(h)$ against $\hat{L}(h)$ will be roughly linear at 45 degrees. If clustering is present then the plot $\hat{L}(h)$ will be above the line. To assess the significance of departures of $\hat{L}(h)$ from the simulated CSR distribution $L(h)$, upper and lower simulation envelopes are defined as

$$U(h) = \max_{i=1,\ldots,m} \{\hat{L}_i(h)\} \tag{4.8}$$

$$\mathcal{L}(h) = \min_{i=1,\ldots,m} \{\hat{L}_i(h)\} \tag{4.9}$$

$U(h)$ and $\mathcal{L}(h)$ help to assess the significance of departures from the 45 degree line in the plot. They are the extreme values of $L_i(h)$ from m simulations. The significance of departures from the hypothesis of CSR is based on the property

$$Pr(\hat{L}(h) > U(h)) = Pr(\hat{L}(h) < \mathcal{L}(h)) = \frac{1}{(m+1)} \tag{4.10}$$

In this analysis $m = 99$. The choice of m is based on the desired size of the significance level. The maximum and minimum plots are added to the plot containing the observed distribution

$\hat{L}(h)$ and the significance level of $\hat{L}(h)$ lying above $U(h)$, indicating clustering, or below $\mathcal{L}(h)$, indicating dispersion is 0.01 or 1 percent.

As stated earlier, monte carlo simulations also correct for edge effects. This occurs when random events are simulated onto an irregular surface ninety-nine times. Diggle (1983) found that when each random event is simulated within the irregular boundary and therefore not simulated outside the boundary, then boundary correction becomes irrelevant through each consecutive simulation. In other words, the bias introduced by edge effects is ignored because the same effects are present in the simulations of CSR with which the data are compared (Diggle, 1983).

A Monte Carlo test for CSR when used in modelling K functions is a quantitatively more advanced measurement technique than the traditional *t* test statistic. Furthermore, the strength of the graphical tests cannot be underestimated. Diggle (1983) suggests that they often make further testing of the spatial point pattern unnecessary and are almost always informative. Indeed, Diggle (1983) goes on to say that no single test statistic should be allowed to over-ride a critical inspection of the empirical distribution plots.

The Bivariate K function

The bivariate *K* function is used to analyze a bivariate point process. The aim of analyzing a bivariate point process is to ask the following questions: is pattern in the occurrences of one type of process related to that in the occurrences of another? Does the distribution of one event pattern explain the distribution of the other? In the univariate case CSR provided the basis from which to compare the degree of clustering or dispersion. Unlike the univariate case, when examining a bivariate point process the null hypothesis tests for evidence of independence between types of event patterns as opposed to either attraction or repulsion. Independence implies that the composite pattern in events is made up from two independent component processes, that is, two separate point patterns. It is also important to note that these point patterns necessarily need not be CSR processes. Any one of the two point processes may be dissimilar in pattern, both from each other and from the composite pattern. The purpose of the bivariate *K* function is to determine whether event pattern *A* is independent of the locations of event pattern *B*. Rejection of the null hypothesis, that is, departures from independence, will provide evidence of repulsion or attraction in the observed bivariate point pattern through the use of simulation envelopes.

The bivariate *K* function is defined as:

$$\lambda_j K_{ij}(h) = E(\#(\text{type } j \text{ events} \leq h \text{ from an arbitrary type } i \text{ event}))$$

$K_{ij}(h)$, $i \neq j$, is known as the *cross K function*. Under the assumption of independence the expected number of type j events within a distance h of a randomly chosen type i event is λ_j. Hence theoretically under independence

$$K_{ij}(h) = \pi h^2 \tag{4.11}$$

If repulsion is evident $K_{ii}(h)$ will be less than πh^2. If attraction is evident $K_{ii}(h)$ will be greater than πh^2. The null hypothesis is tested by comparing the estimated $K_{ij}(h)$ from observed data with its theoretical value.

The estimated bivariate *K* function is an extension of the univariate case. The edge corrected estimate is given by

$$\tilde{K}_{12}(h) = \frac{R}{n_1 n_2}\sum_{i=1}^{n_1}\sum_{j=1}^{n_2}\frac{I_h(d_{ij})}{w_{ij}} \tag{4.12}$$

where n_1, n_2 define type 1 and type 2 events. The term d_{ij} is the distance between the ith type 1 event and the jth type 2 event. Theoretically $K_{12}(h) = K_{21}(h)$ but this will not always be the case for their corresponding estimates. To correct for this anomoly a better estimate is obtained by taking the average between $K_{12}(h)$ and $K_{21}(h)$ thus giving

$$\hat{K}_{12}(h) = \frac{(n_2\tilde{K}_{12}(h) + n_1\tilde{K}_{21}(h))}{n_1 + n_2} \tag{4.13}$$

The use of the bivariate K function is similar to that in the univariate case. $\hat{L}_{ij}$ is plotted against h where

$$\hat{L}_{ij}(h) = \sqrt{\frac{\hat{K}_{ij}(h)}{\pi}} - h \tag{4.14}$$

Simulation envelopes are constructed to test the significance of this plot. The calculation of the simulation envelopes for the bivariate case differs from that of the univariate case. Under the assumption of independence, in the bivariate case, the theoretical value of $K_{ij}(h)$ does not depend on CSR in the separate point patterns. When calculating the simulation envelopes for the bivariate case the separate event patterns must be preserved in their observed form in any simulations. The simulation are performed by using random shifts (Riply, 1981). The computer randomly shifts the whole of event pattern A while keeping event pattern B fixed.

For irregular boundaries $\mathbb{R}$ is shifted by the same amount as event pattern A. Each random shift represents one simulation. After each simulation the $L_{ij}(h)$ statistic and its associated distribution is calculated. One hundred simulation are performed to produce the theoretical distribution $L_{ij}(h)$. Maximum and minimum values as well as their associated distributions are plotted to form the simulation envelopes. If the observed $\hat{L}_{ij}(h)$ lies above the upper simulation envelope, attraction is evident between the two types of event processes. If the observed $\hat{L}_{ij}(h)$ lies below the lower simulation envelope, repulsion is evident between the two types of event processes.

4.8 Research Findings

Results for Kernel Estimates

The kernel estimate is an exploratory technique that was used to study the way in which pattern intensity varies across space. The estimates were performed by using specific commands found in the "SPLANCS" submodule of S-Plus statistical software. Kernel estimates for all twenty office activity types are provided in Figures 4.6 to 4.10. Different values of τ were used to explore each of the twenty surfaces shown in Figures 4.6 to 4.10. Experiments with τ were conducted to ultimately arrive at suitable values which provided the required degrees of smoothing for each point pattern. Visually, areas displaying the highest event - event intensity are illustrated by the purple and pink shaded rings. Areas demonstrating lower levels of event intensity are illustrated by yellow and green shaded rings (see key in Figure 4.5). The shaded rings correspond to the same intensity in each figure.

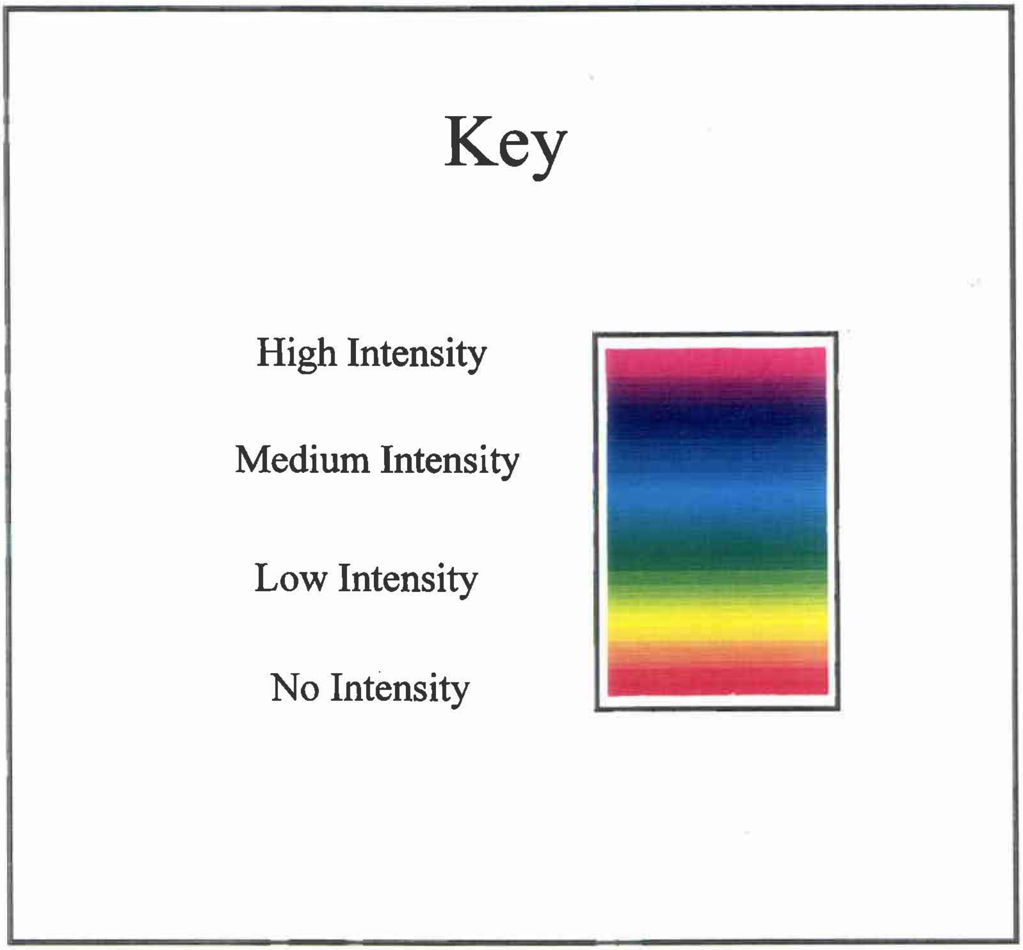


Figure 4.5 Kernel Estimate Key

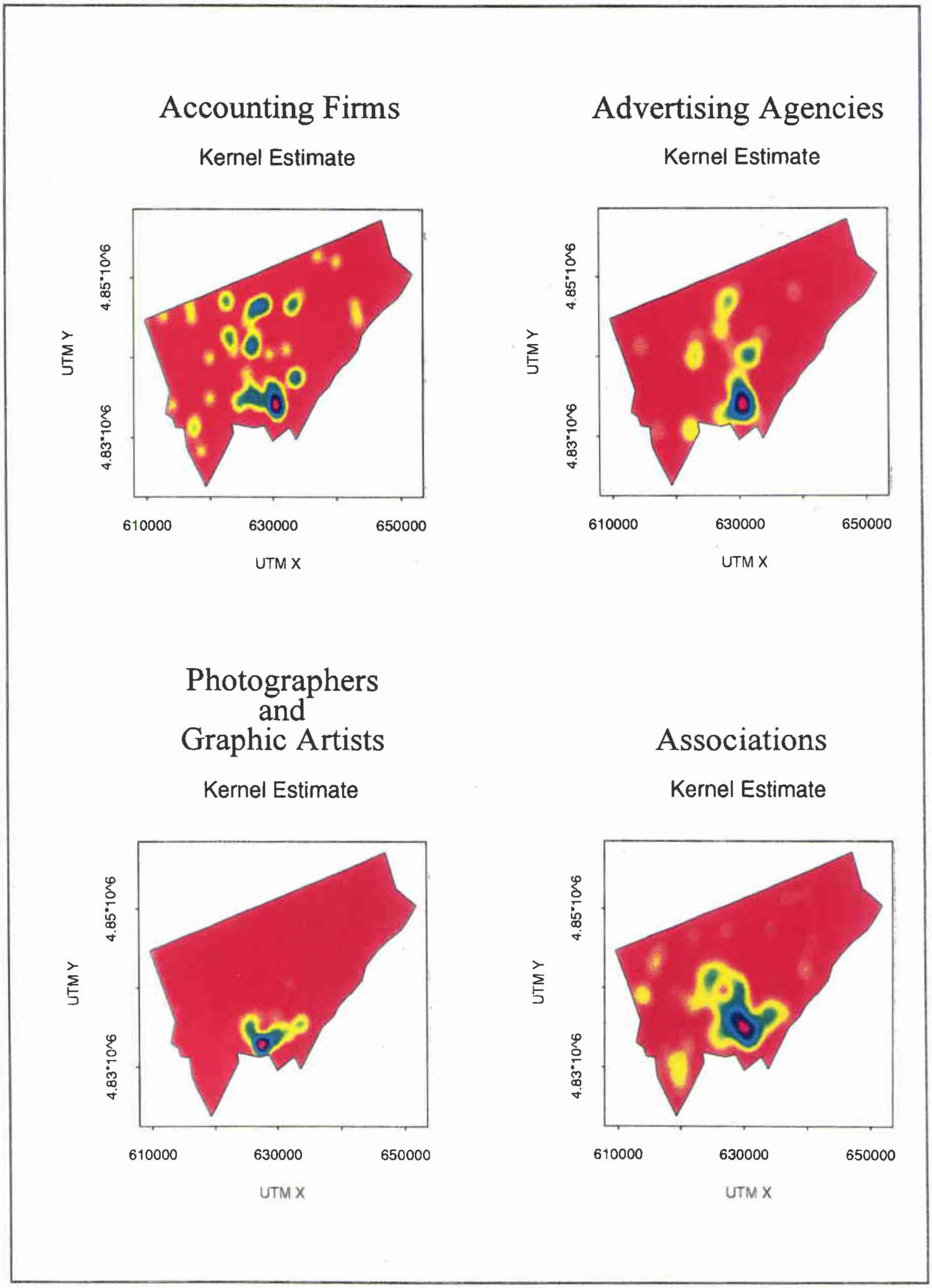


Figure 4.6 Kernel Estimates for Accounting Firms; Advertising Agencies; Photographers and Graphic Artists; Associations

Figure 4.7 Kernel Estimates for Computer Services; Financial Services; Government Agencies; Health Services

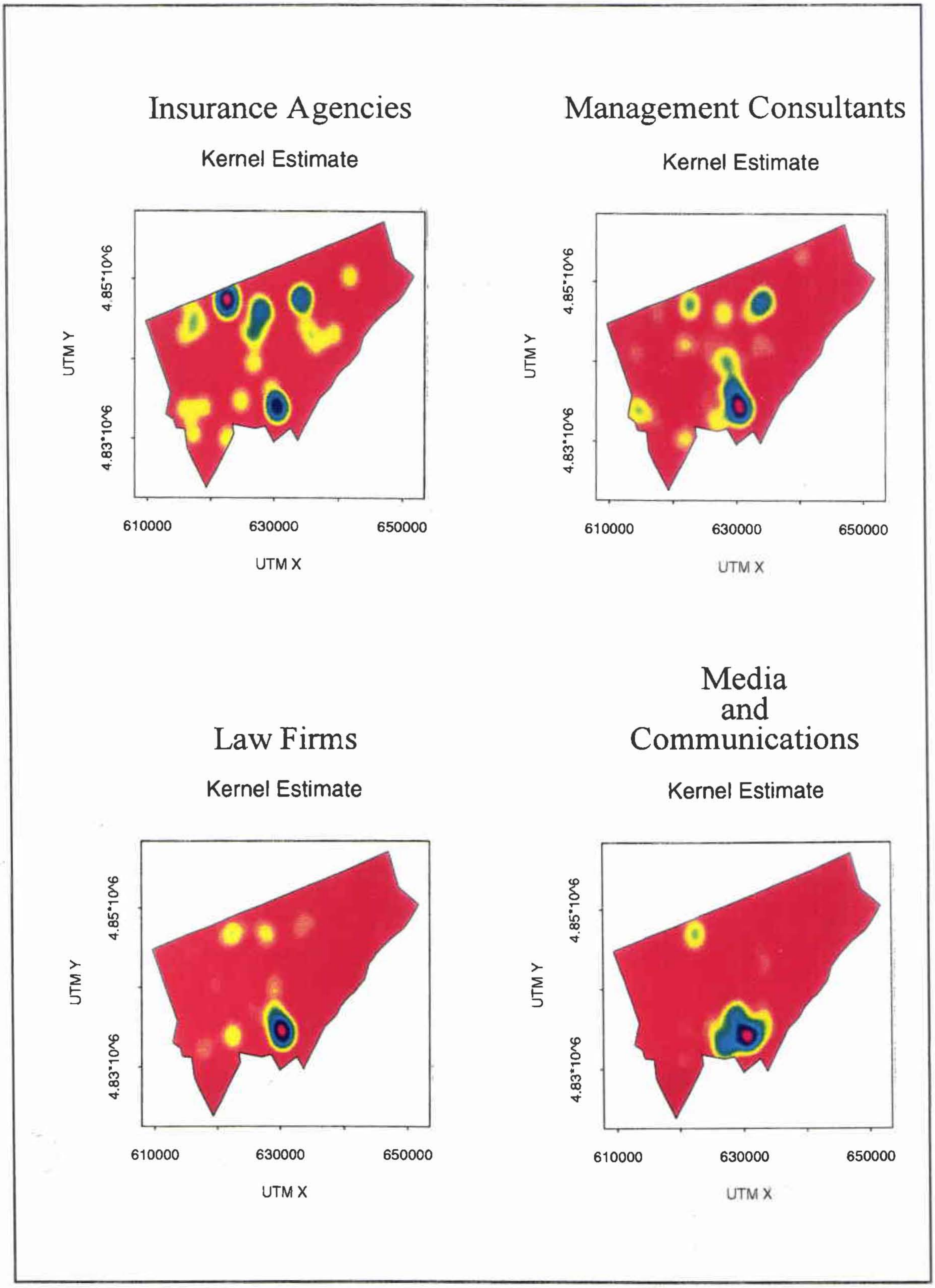


Figure 4.8 Kernel Estimates for Insurance Agencies; Management Consultants; Law Firms; Media and Communications

Figure 4.9 Kernel Estimates for Manufacturing; Other Business Services; Real Estate Agents; Personnel Services

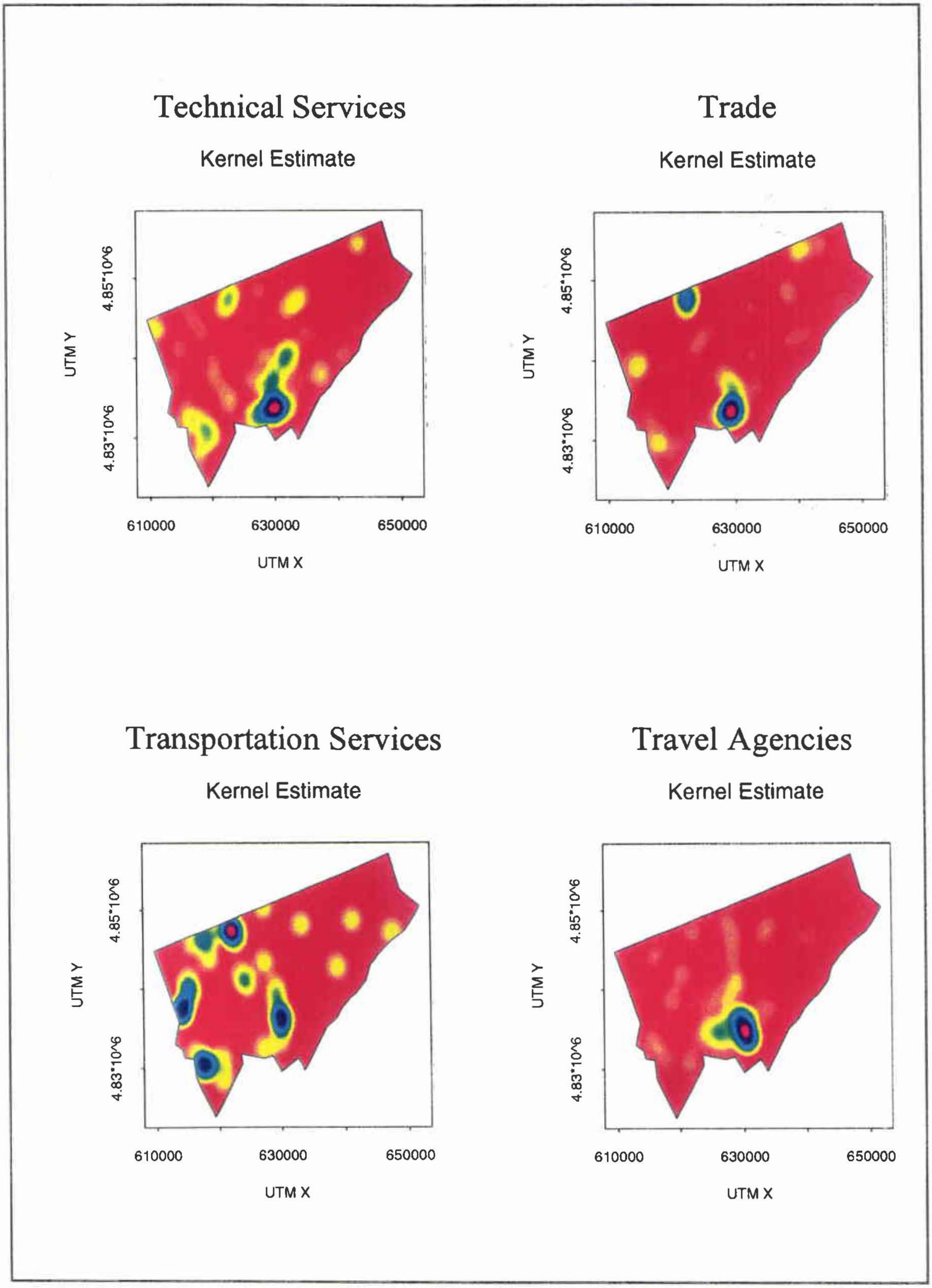


Figure 4.10 Kernel Estimates for Technical Services; Trade; Transportation Services; Travel Agencies

Generally, estimates for all event patterns with the exception of offices of photographers and graphic artists and offices of manufacturing services reveal that location intensity for office activities is predominant in downtown Toronto. The predominant location intensity for photographers and graphic artists is naturally focused in the entertainment district found in the southeastern portion of Toronto West and Downtown West. The predominant location intensities for offices of manufacturing services are focused in the Dufferin - Finch and Airport zones found in northwestern metropolitan Toronto. An explanation for this type of intensity pattern may lie in the fact that manufacturing services need ample amounts of space in order to function under efficient scale economies.

The most interesting results of the kernel estimates are reflected by the office activities that posses multi-locational intensity patterns. These activities include accounting firms, insurance agencies, management consultants, offices involved in computer services, manufacturing services, trade services and transportation services.

Accounting firms display predominant locational intensities in the financial core and secondary locational intensities in the North Yonge zone. Accounting firms may be locating in the financial core to remain in proximity to law firms and financial services. This hypothesis will be tested with the use of the bivariate *K* function. Location in North Yonge may be the result of the fact that accounting firms have a very low intensity for face-to- face contacts with meeting partners (Gad, 1975). Another reason may be that accounting firms may be attracted to zones which have high growth potential and attractive qualities.

Looking at the estimates for computer services it is evident that the highest locational intensities are in the financial core. Secondary intensities exist in the Dufferin - Finch office park next to York University. Other areas of lesser locational intensity include the Yonge - Eglinton zone and the Consumers Road office park. Computer services function as support services and thus may locate in the financial core to provide technical assistance to accounting firms, law firms and financial services. Formal tests of this hypothesis will be conducted via the bivariate *K* function method. Suburban locations may be the result of lower rent preferences or greater space requirements. These types of hypotheses will be tested in the next chapter.

Similar locational intensities exist for new insurance agencies. The highest intensities are found in the Dufferin - Finch office park as well as the more traditional Financial Core zone. Secondary intensities include the Consumers Road office park and the North Yonge zone. Less central locations may be the result of preferences for areas displaying new development potential making proximity to potential customers (households) more attractive.

Management consultants display predominant locational intensities in the Financial Core zone. Secondary intensities exist in the Yonge - Bloor zone, Consumers Road office park, Duncan Mills office park and the Dufferin - Finch zone. Management consultants have traditionally located in the financial core however recently the locational trend has been to locate in built up suburban office parks and centres. A possible explanation may be that this activity provides services for accounting firms, advertising agencies or health services which also share similar locational patterns. Again this hypothesis will be tested by using the bivariate *K* function.

As mentioned earlier, offices of manufacturing services do not display high locational intensity in the central area of metropolitan Toronto. Intensity for manufacturing offices is highest in the Dufferin - Finch office park and the Airport zone of north Etobicoke. These patterns may be the result of preferences for large amounts of land for production and storage purposes. Manufacturing services also need to be in proximity to the airport in order to ship new products or receive supplies. Locating near the airport and to various shipping agencies will also cut transportation costs.

Offices involved in trade services also posses multi-locational intensities. The highest intensities belong to the Downtown West and Financial Core zones. Secondary intensities belong to the Dufferin-Finch office park. Earlier studies have found that trade services locate in the financial core (Gad, 1985). However new intensities in northwestern Toronto may be the result of preferences for locating near the airport as well as near manufacturing and transportation services with which they may share agglomeration economies. These hypotheses will be tested via the bivariate *K* function and the logit analysis of the next chapter.

Finally, offices involved in transportation services display similar locational intensities as those of manufacturing services. The highest intensities belong to the Dufferin-Finch zone. Secondary locational intensities include the airport, the highway 427 corridor and the Yonge - St. Clair zones. Like manufacturing services, transportation services require large amounts of space for storage and receiving. For this reason they may prefer locating in less central locations where industrial land is abundant and cheaper as well as in proximity to major highways and an international airport.

Location intensities for the remaining office activities are generally found in the central area of Metropolitan Toronto. The intensities are summarized in Table 4.4. Intensities are

Table 4.4
Locations of Office Intensity

Office Activity Type	Locations of Intensity	Office Activity Type	Locations of Intensity
Accounting Firms	Financial Core	Media and Communications	Financial Core
	North Yonge		Downtown West
			Downtown East
Advertising Agencies	Financial Core		Yonge - Bloor
	North Yonge		Dufferin - Finch
Photographers and Graphic Artists	Toronto West	Manufacturing	Dufferin - Finch
	Downtown West		Airport
Associations	Downtown North	Other Business Services	Financial Core
	Financial Core		Downtown West
	Yonge - Bloor		Downtown East
	Toronto East		Yonge - Bloor
			North Yonge
Computer Services	Financial Core		Dufferin - Finch
	Yonge - Eglinton		
	Consumers Road	Real Estate Agencies	Financial Core
	Dufferin - Finch		Downtown South
			Yonge - Eglinton
Financial Services	Financial Core		Duncan Mills
	North Yonge		Consumers Road
	Yonge - Bloor		
		Personnel Services	Financial Core
Government Agencies	Financial Core		Downtown North
	Don Mills		
		Technical Services	Financial Core
Health Services	Downtown North		Downtown West
	Yonge - Eglinton		Yonge - Bloor
	Yonge - St. Clair		Don Mills
	Yonge - Bloor		Dufferin - Finch
	North Yonge		
	Consumers Road	Trade	Downtown West
	Dufferin - Finch		Dufferin - Finch
			Highway 427 Corridor
Insurance Agencies	Financial Core		Airport
	North - Yonge		
	Consumers Road	Transportation Services	Dufferin - Finch
	Dufferin - Finch		Airport
			Highway 427 Corridor
Management Consultants	Financial Core		Yonge - Bloor
	Yonge - Bloor		
	Duncan Mills	Travel Agencies	Financial Core
	Consumers Road		Yonge - Bloor
	Dufferin - Finch		Toronto West
	Highway 427 Corridor		
Law Firms	Financial Core		
	Downtown North		
	Downtown West		
	Yonge - Bloor		
	Toronto West		

shown graphically in Figures 4.6 to 4.10. Queries concerning the motives for varying locational intensities among independent office activities are examined in Chapter Five.

Results of Univariate K function tests

The *K* function was used to test the first hypothesis. This method, when modelled for CSR, utilizes powerful graphical tests that determine whether an independent set of events, taken as a whole has a tendency toward being randomly distributed or a tendency toward being clustered or dispersed. The graphical results of the estimated $K(h)$ and the corresponding $L(h)$ tests for CSR are shown in Figures 4.11 to 4.20. The estimated results indicate that the estimated $L(h)$ for all but one activity type displayed significant tendencies toward clustering at all spatial scales throughout their respective point patterns. The estimated $L(h)$ for insurance agencies varies across space. Locations of new insurance agencies tend to cluster up to a distance h = 25 or 3.7 kilometers. Location patterns are random but tend toward clustering between h = 25 to h = 40 or 3.7 to 6.0 kilometers (note each increment of 10 staring from $h(0)$ represents 1.5 kilometers, ie., h = 50 represents 7.5 kilometers). This is illustrated graphically by the estimated $L(h)$ curve falling between the upper and lower simulation envelops at the specifies scales. Clustering resumes from a distance of h = 40 or 6 kilometers.

Variations in the level of clustering differ among these office activities. Table 4.5 summarizes locational clustering for each independent office activity. In order to discuss the variations in the levels of intensity among these activities the results must be divided into two classifications. The first classification is defined as clustered locational patterns which exhibit

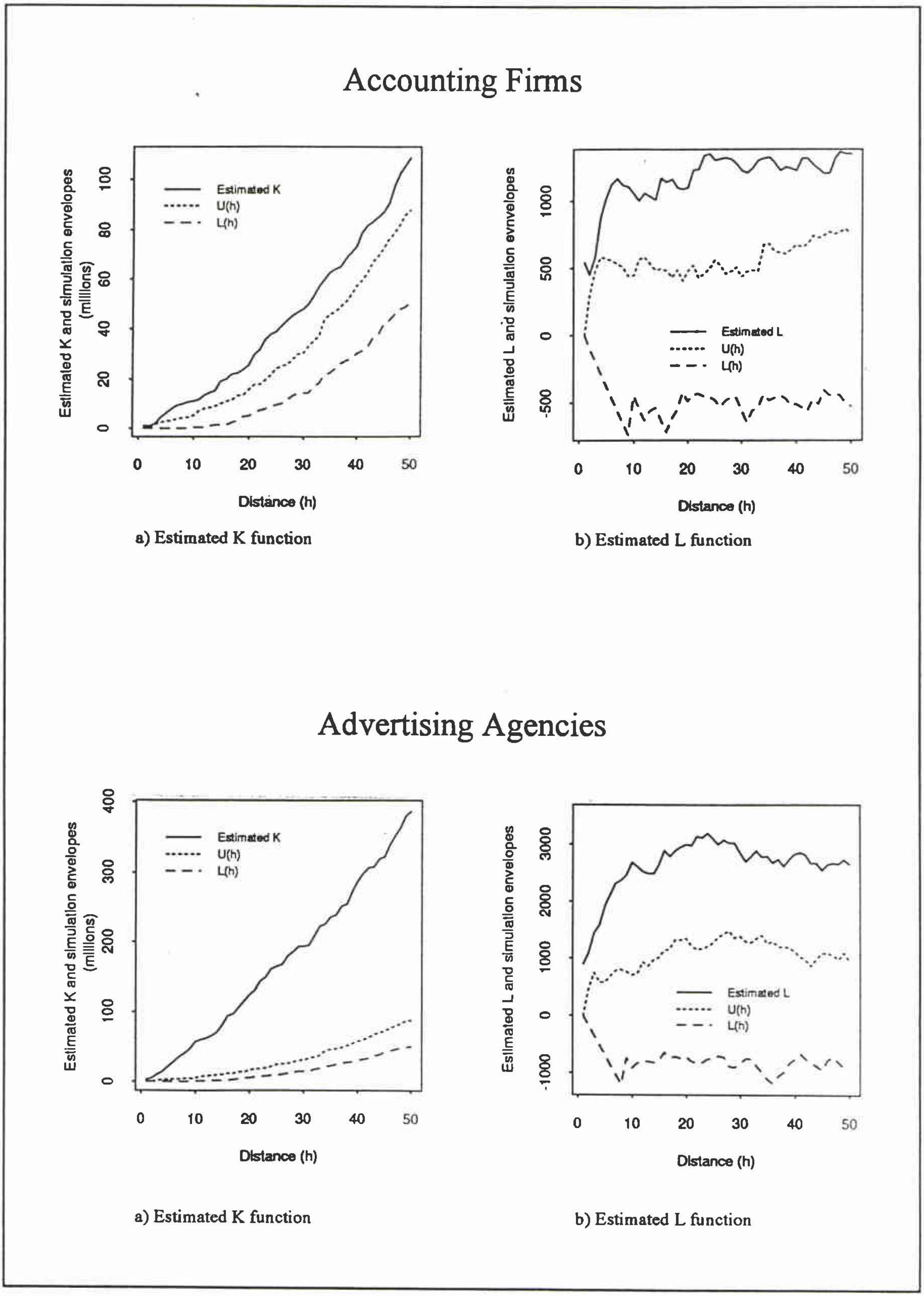


Figure 4.11 K Function Estimates for Accounting Firms; Advertising Agencies

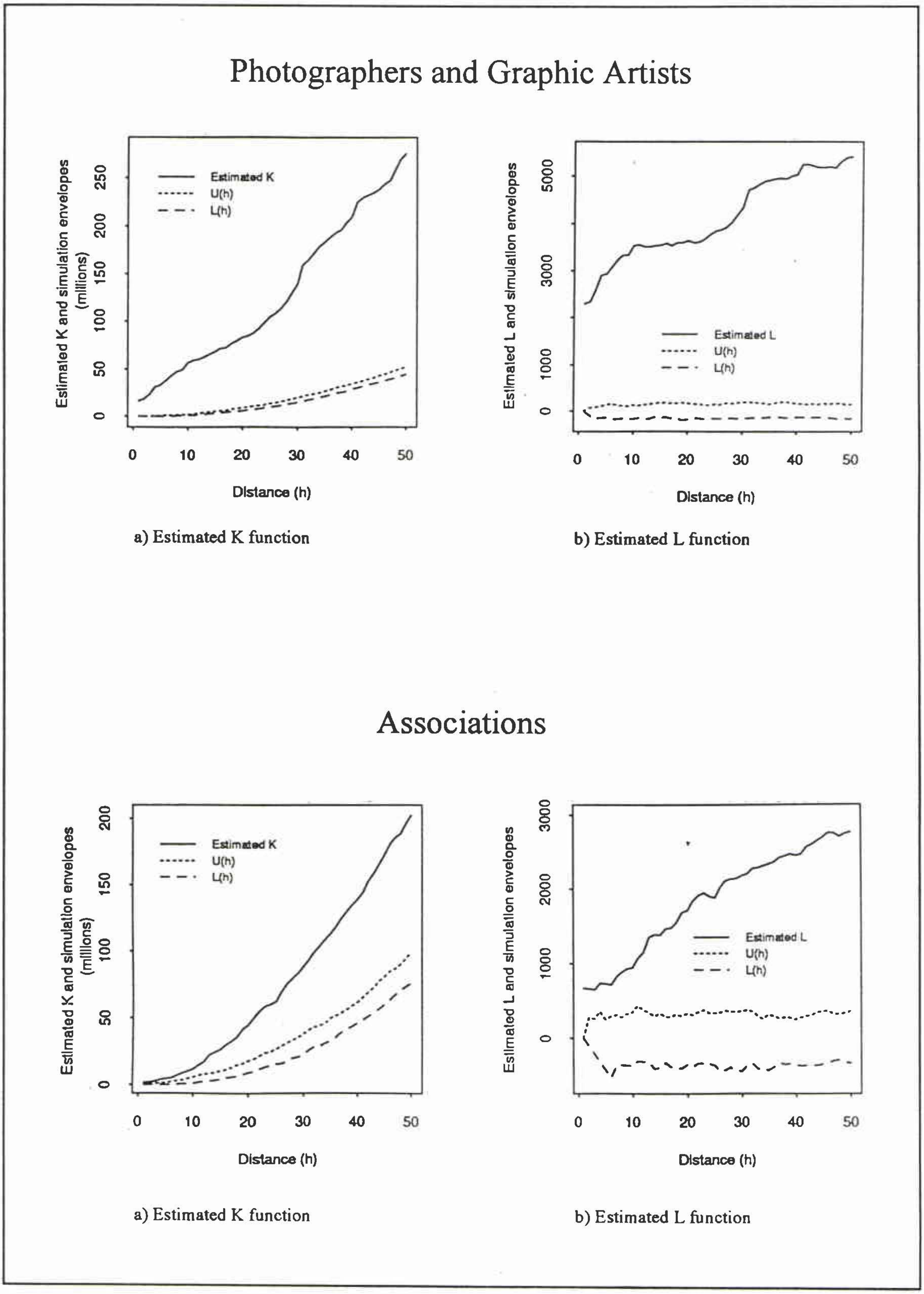


Figure 4.12 K Function Estimates for Photographers and Graphic Artists; Associations

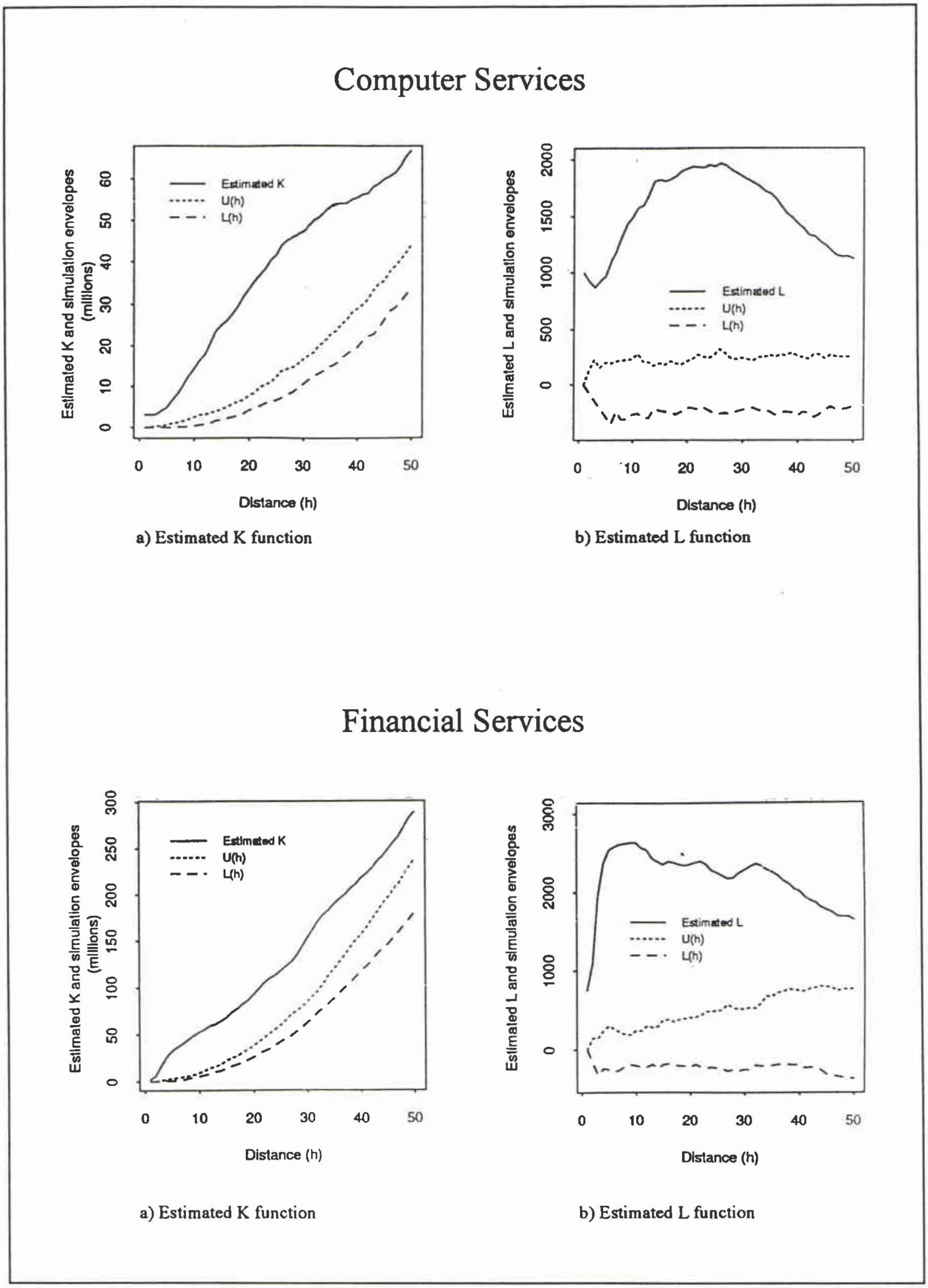
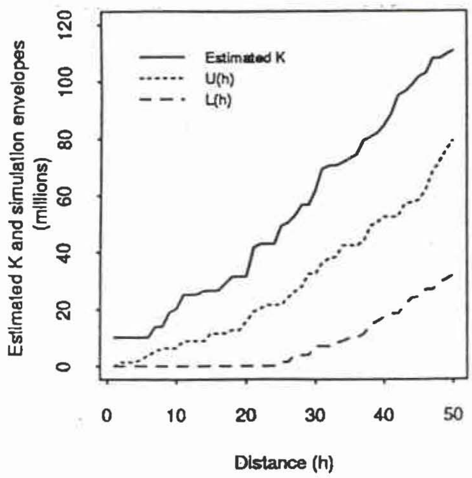
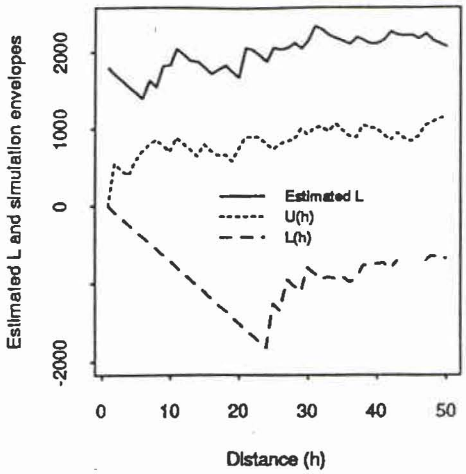


Figure 4.13 K Function Estimates for Computer Services; Financial Services

Government Agencies

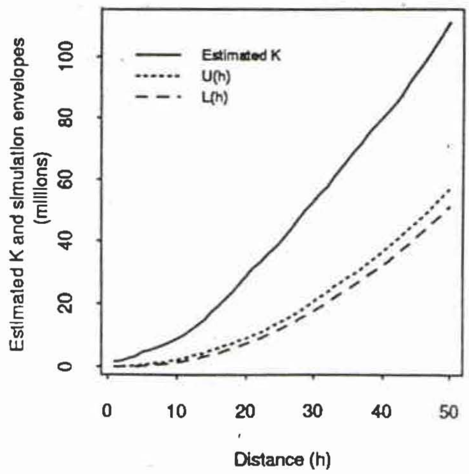


a) Estimated K function

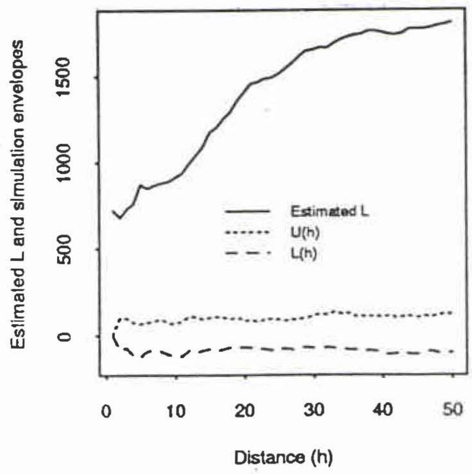


b) Estimated L function

Health Services



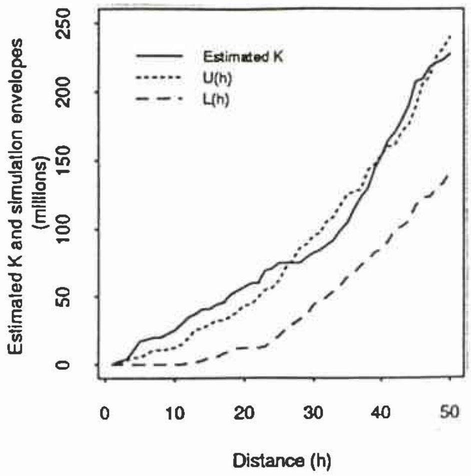
a) Estimated K function



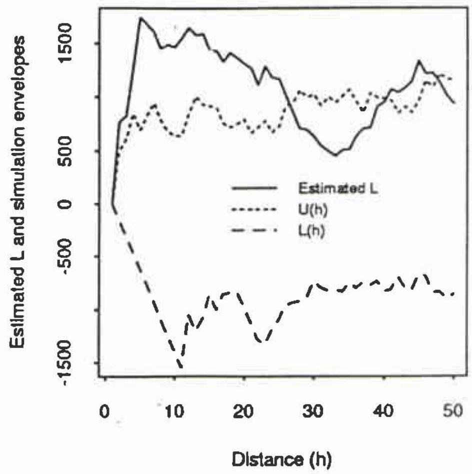
b) Estimated L function

Figure 4.14 K Function Estimates for Government Agencies; Health Services

Insurance Agencies

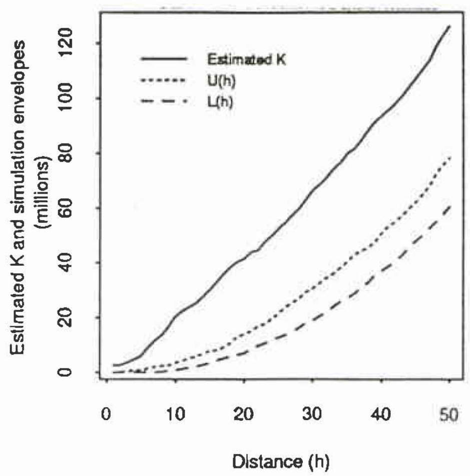


a) Estimated K function

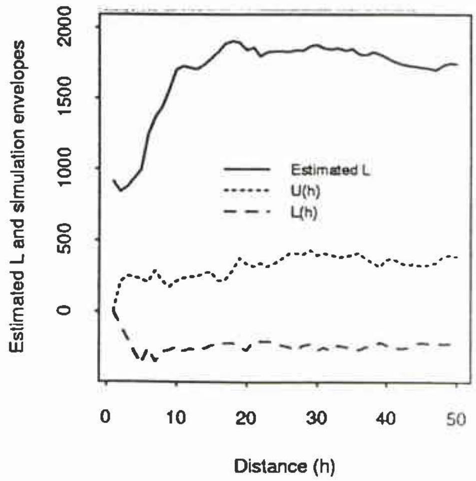


b) Estimated L function

Management Consultants



a) Estimated K function



b) Estimated L function

Figure 4.15 K Function Estimates for Insurance Agencies; Management Consultants

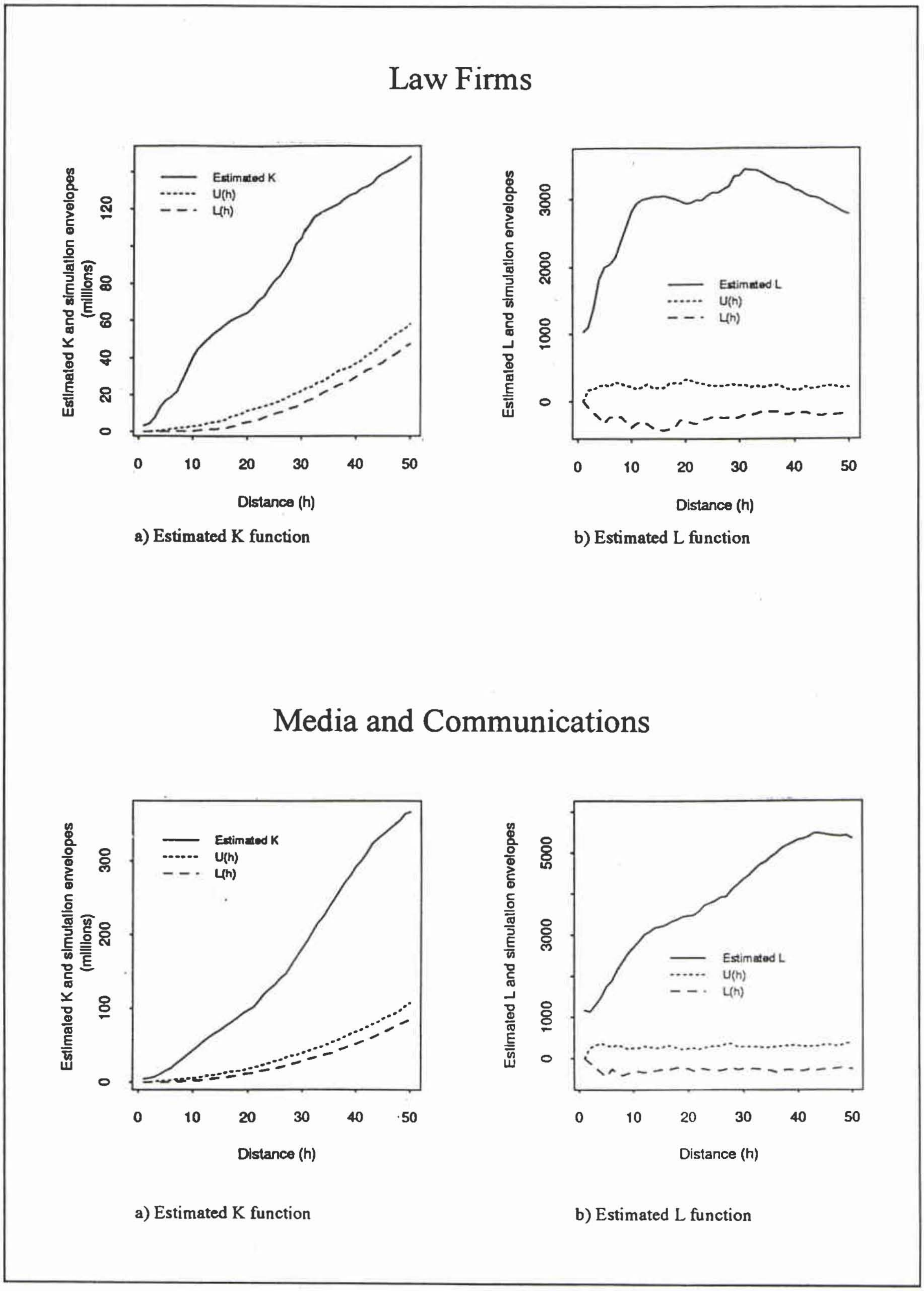


Figure 4.16 K Function Estimates for Law Firms; Media and Communications

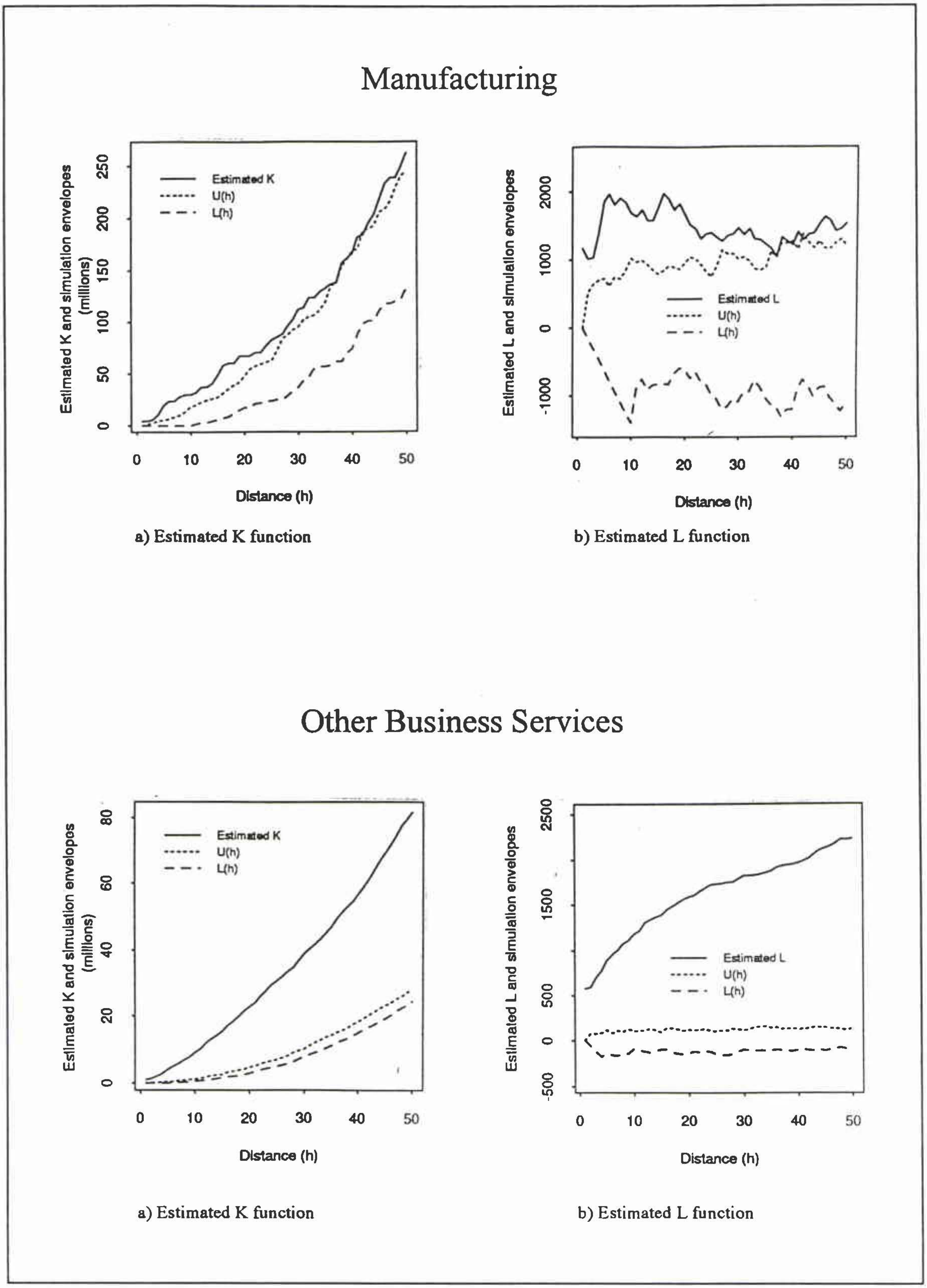


Figure 4.17 K Function Estimates for Manufacturing; Other Business Services

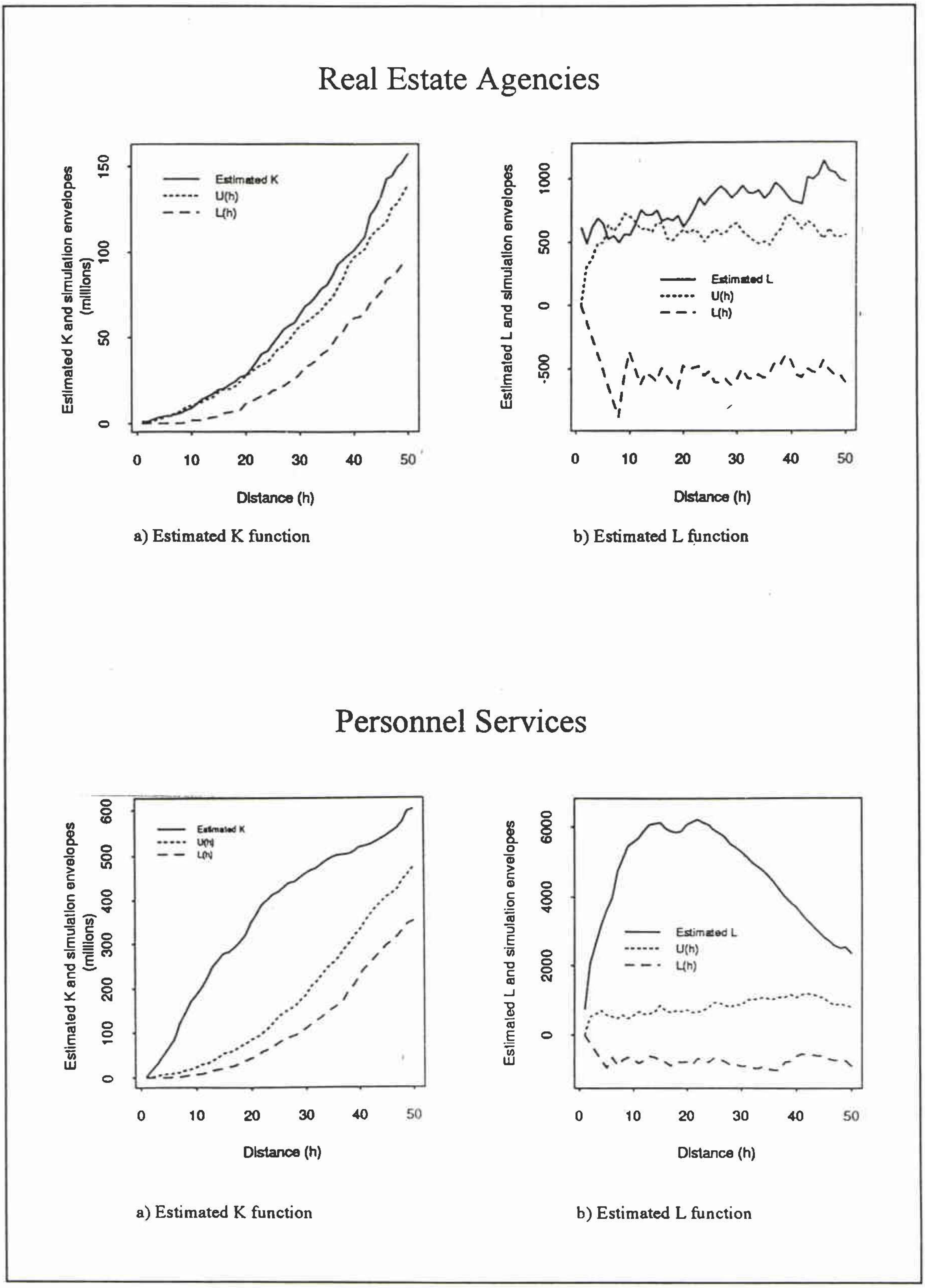
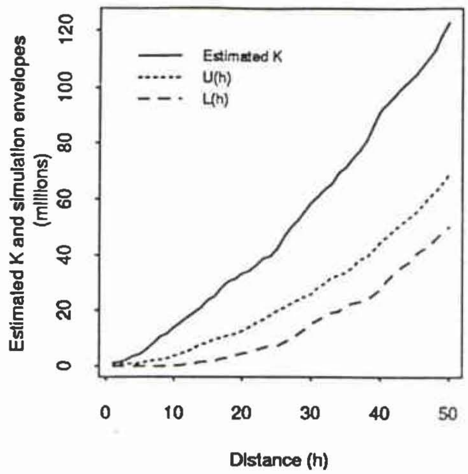
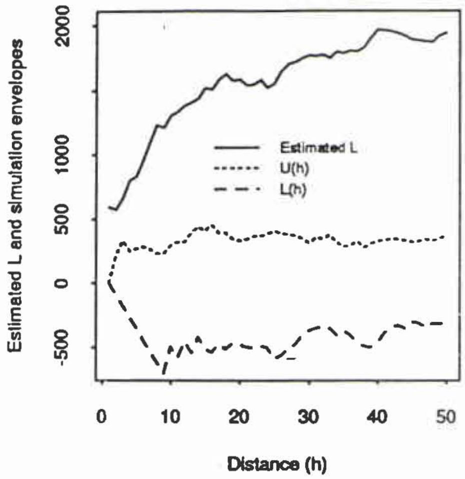


Figure 4.18 K Function Estimates for Real Estate Agents; Personnel Services

Technical Services

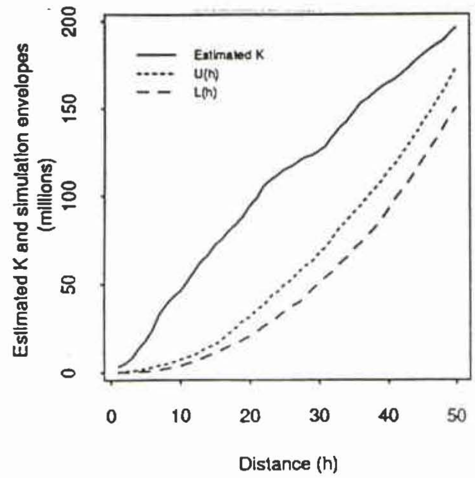


a) Estimated K function

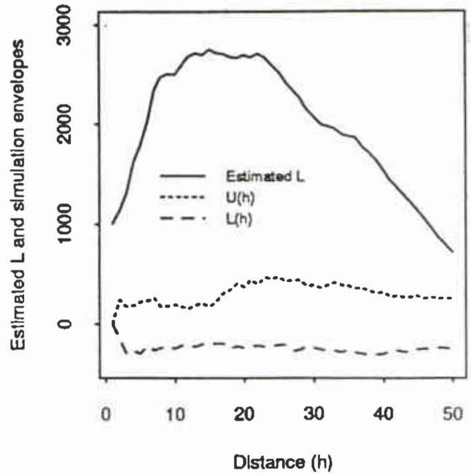


b) Estimated L function

Trade



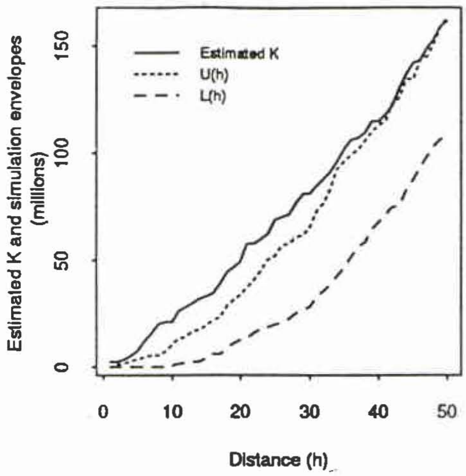
a) Estimated K function



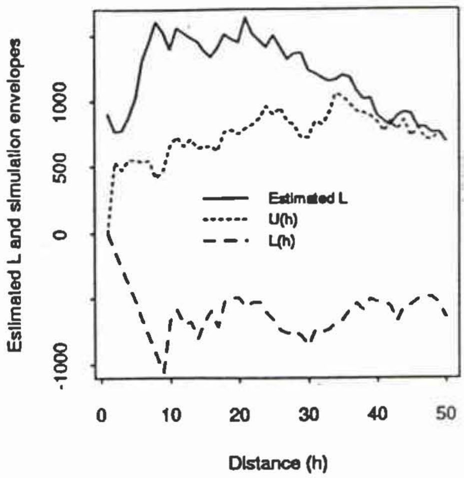
b) Estimated L function

Figure 4.19 K Function Estimates for Technical Services; Trade

Transportation Services

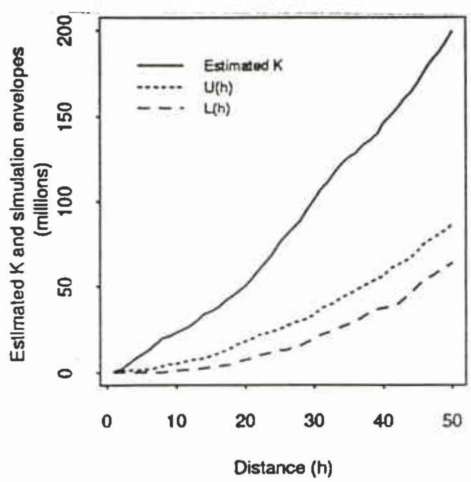


a) Estimated K function

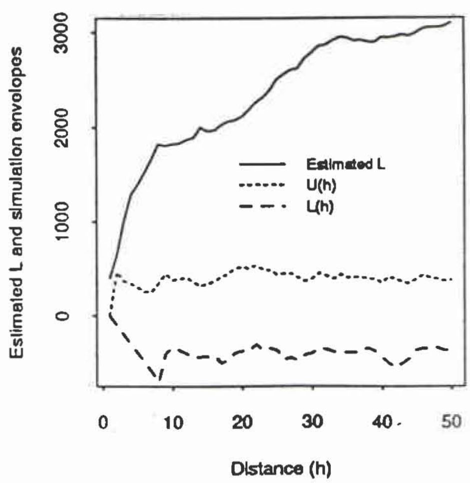


b) Estimated L function

Travel Agencies



a) Estimated K function



b) Estimated L function

Figure 4.20 K Function Estimates for Transportation Services; Travel Agencies

Table 4.5
Summary of Peak Locational Clustering

Office Activity Type	Type of Pattern Random/Clustering	Variation of clustering at Large/Small Distances
Accounting Firms	Clustering	Large
Advertising Agencies	Clustering	Small
Photographers and Graphic Artists	Clustering	Large
Associations	Clustering	Large
Computer Services	Clustering	Small
Financial Services	Clustering	Small
Government Agencies	Clustering	Large
Health Services	Clustering	Large
Insurance Agencies	Clustering	Small
Management Consultants	Clustering	Large
Law Firms	Clustering	Large
Media and Communications	Clustering	Large
Manufacturing	Clustering	Small
Other Business Services	Clustering	Large
Real Estate Agencies	Clustering	Large
Personnel Services	Clustering	Small
Technical Services	Clustering	Large
Trade	Clustering	Small
Transportations Services	Clustering	Small
Travel Agencies	Clustering	Large

concentrations of events (offices) at small distances. The office activities in this group include: advertising agencies, financial services, computer services, personnel services, transportation service, insurance agencies, manufacturing and trade services. The estimates for these activities are similar in that each display clustering at small distances h indicating that these activities form small distinct clusters. In other words, they locate in very specific areas. Financial services predominantly locate in the financial core which is very small in area thus the highest levels of clustering for offices in this activity are at distance $h \leq 10$ or 1.5 kilometers. Computer services are a specialized activity and thus only locate in specific areas meaning that the clusters they form will be small. The graph illustrates that the highest levels of clustering occur within distances $h \approx 20$ or 3 kilometers. This result is further supported by the specific locations of computer services found on Map 5 of Appendix One. In this map, computer services are clustered in three specific locations: Dufferin - Finch, Consumers Road and the Financial Core. Graphical results are similar for the remaining office activities within this group. Manufacturing and Transportation Services both demonstrate specific clustering patterns in the Dufferin - Finch and Airport zones as evidenced by Maps 13 and 19 in Appendix One. The highest levels of clustering for these activities occurs at distances $h \leq 20$ or 3 kilometers indicating small clusters at the respective locations. Trade Services, personnel services and advertising agencies all demonstrate the highest levels of clustering at $h \leq 20$ or 3 kilometers. Trade services have specific locational clusters in the Dufferin - Finch, Airport and Downtown West zones. New insurance agencies cluster specifically in the Dufferin - Finch zone and the financial core. Personnel services and advertising agencies both have distinct clusters in the financial core.

The second classification is defined as clustered locational patterns which exhibit concentrations of events at large distances; in other words events forming broad clustered patterns. Office activities in this group include: accounting firms, photographers and graphic artists, associations, government services, health services, management consultants, law firms, media and communications, other business services, real estate agents, technical services and travel agencies. The estimates for these activities are similar in that each displays clustering at large distances h indicating that these activities cluster in many areas across the entire region of metro Toronto. The estimates for accounting firms, photographers and graphic artists, associations, health services, media and communications, other business services, real estate agencies, technical services and trade services show that the highest levels of clustering occur at distances $h \leq 50$ or 7.5 kilometers. The estimates for government services, management consultants and law firms indicate that the highest levels of clustering occur at distances $h \leq 30$ or 4.5 kilometers. Associations, government services, health services and other business services are centrally clustered within the central area as illustrated in maps 4,7,8 and 14 of Appendix One. Travel agencies and real estate agencies are similar in that they both provide personal services to the general public. Estimates for these activities indicate that clustering occurs at distances $h \leq 50$ or 7.5 kilometers. These activities cluster in high density central neighbourhoods and therefore do not display specific concentrated clustered patterns. Accounting firms, photographers and graphic artists, management consultants, law firms, media and communication and technical services and all have multiple clusters found within a 7.5 kilometer radius of the central area as shown in maps 1, 3, 10, 11, 12, and 18 hence supporting the results of the respective estimates. However the specialized functions of technical services, management consultants and media and communications also display clusters in the Dufferin - Finch, Duncan Mills and Consumers Road zones suggesting a move away from the traditional downtown locations. Reasons supporting new locations away from the central area may include lower rental rates or possible increases in demand. Locations of new accounting firms and law firms in northern and western Toronto may be occurring for similar reasons. Further such hypotheses will be devised and tested in Chapter Five.

Results of Bivariate K function tests

The bivariate *K* function was used to test the second hypothesis. This method tests for evidence of independence between types of event patterns as opposed to either attraction or repulsion. Independence implies that the composite pattern of events is made up from two independent component processes. The purpose of the bivariate *K* function was to determine whether event interaction is present. Graphical output is shown in Figures 4.21 to 4.31. The results are summarized in Table 4.6 on pages 131 and 132. Office pairings were constructed based on the linkage intensities found in Table 4.1. Other pairings found in Table 4.6 were constructed based on their location intensities derived from the kernel estimates.

The following discussion is based on the graphical output. The figures vary for different industry pairs. Generally, most estimates lie above the upper simulation envelope at small distances (h) indicating spatial dependence. Spatial dependence at small distances indicates that the particular office pairings are clustered or spatially attracted in one or two localized areas of the city suggesting the evidence of possible localization economies. Spatial

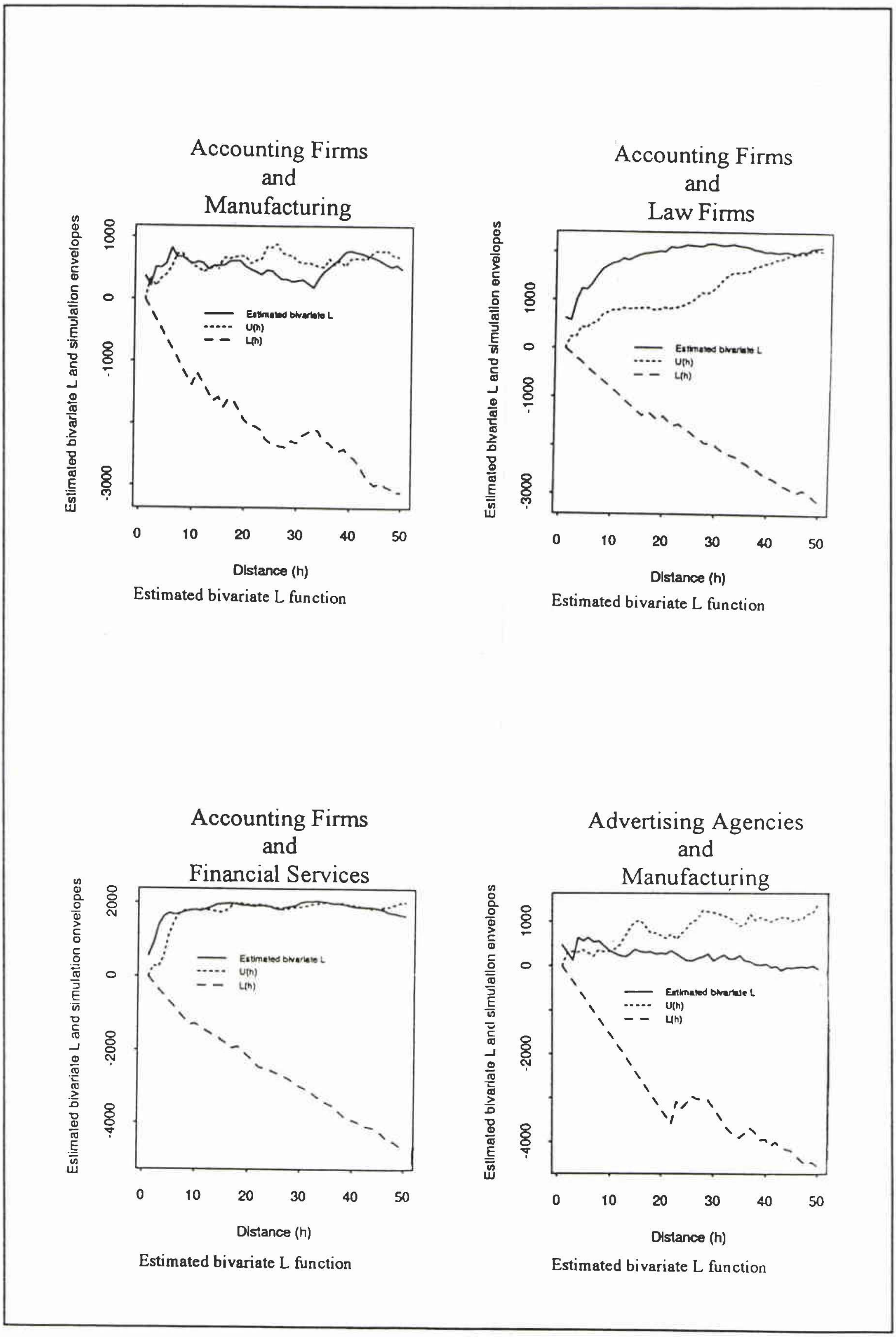


Figure 4.21 Bivariate K Function Estimates for Accounting Firms and Manufacturing; Accounting Firms and Law Firms: Accounting Firms and Financial Services: Advertising Agencies and Manufacturing

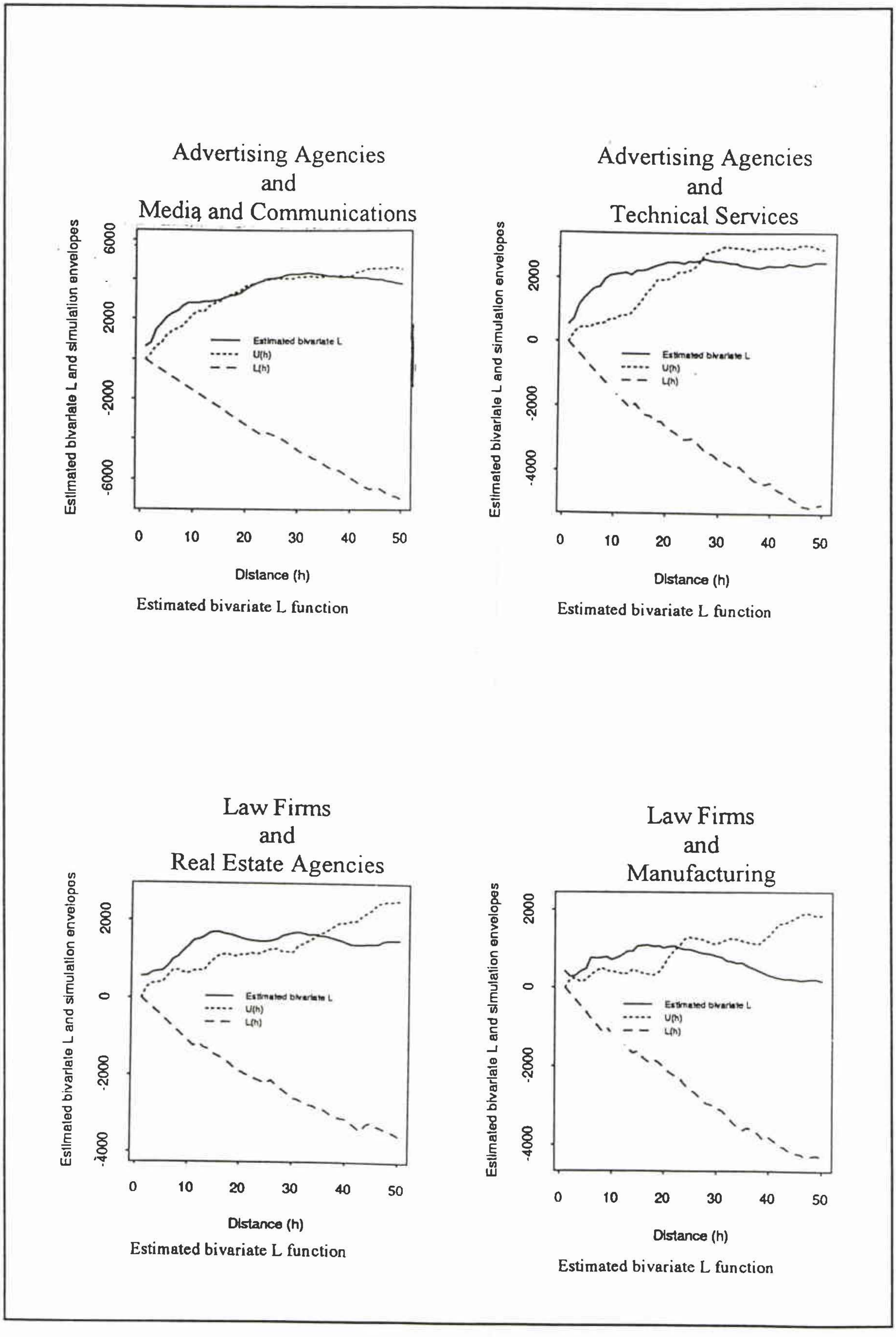


Figure 4.22 Bivariate K Function Estimates for Advertising Agencies and Media; Advertising Agencies and Technical Services; Law Firms and Real Estate Agencies; Law Firms and Manufacturing

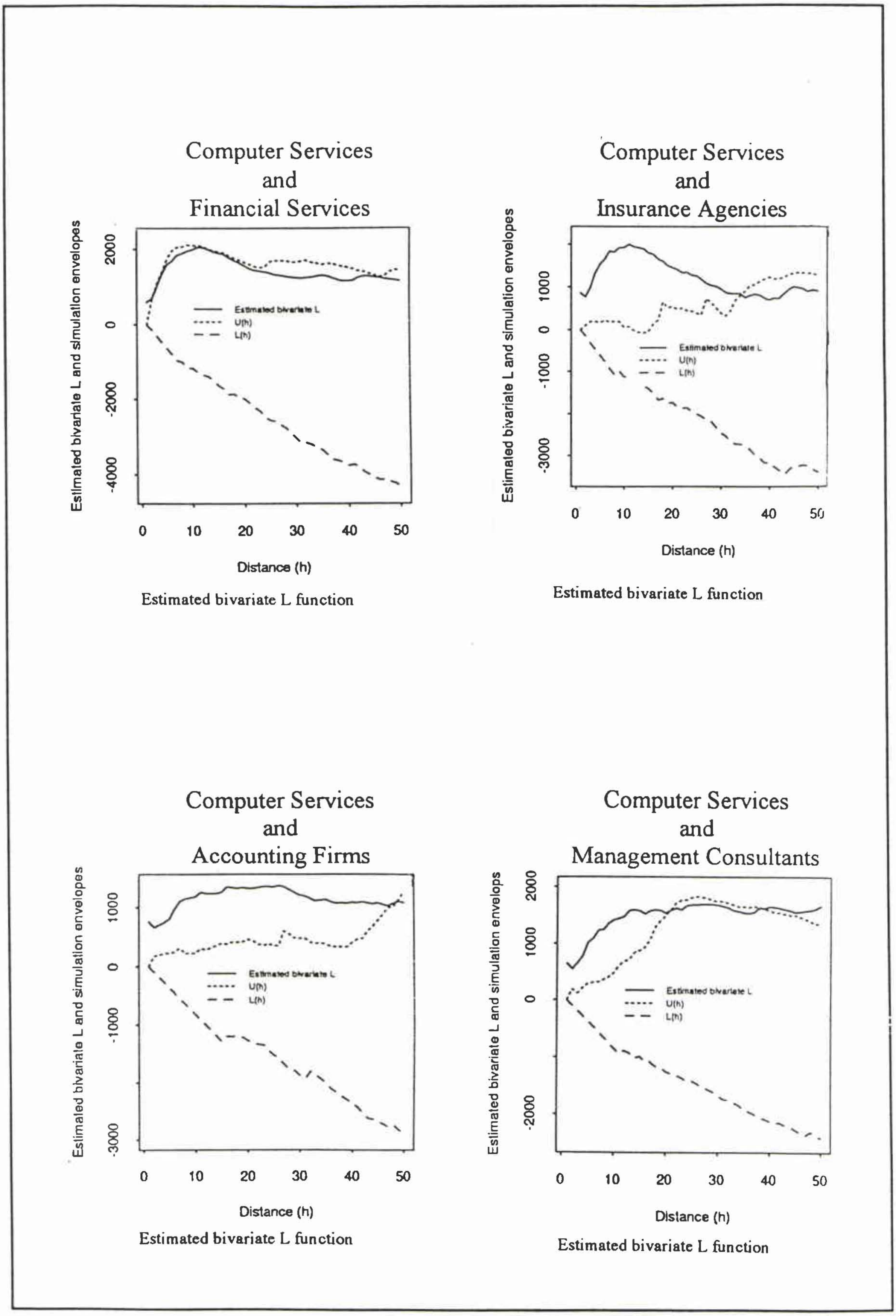


Figure 4.23 Bivariate K Function Estimates for Computer Services and Financial Services; Computer Services and Insurance Agencies; Computer Services and Accounting Firms; Computer Services and Management Consultants

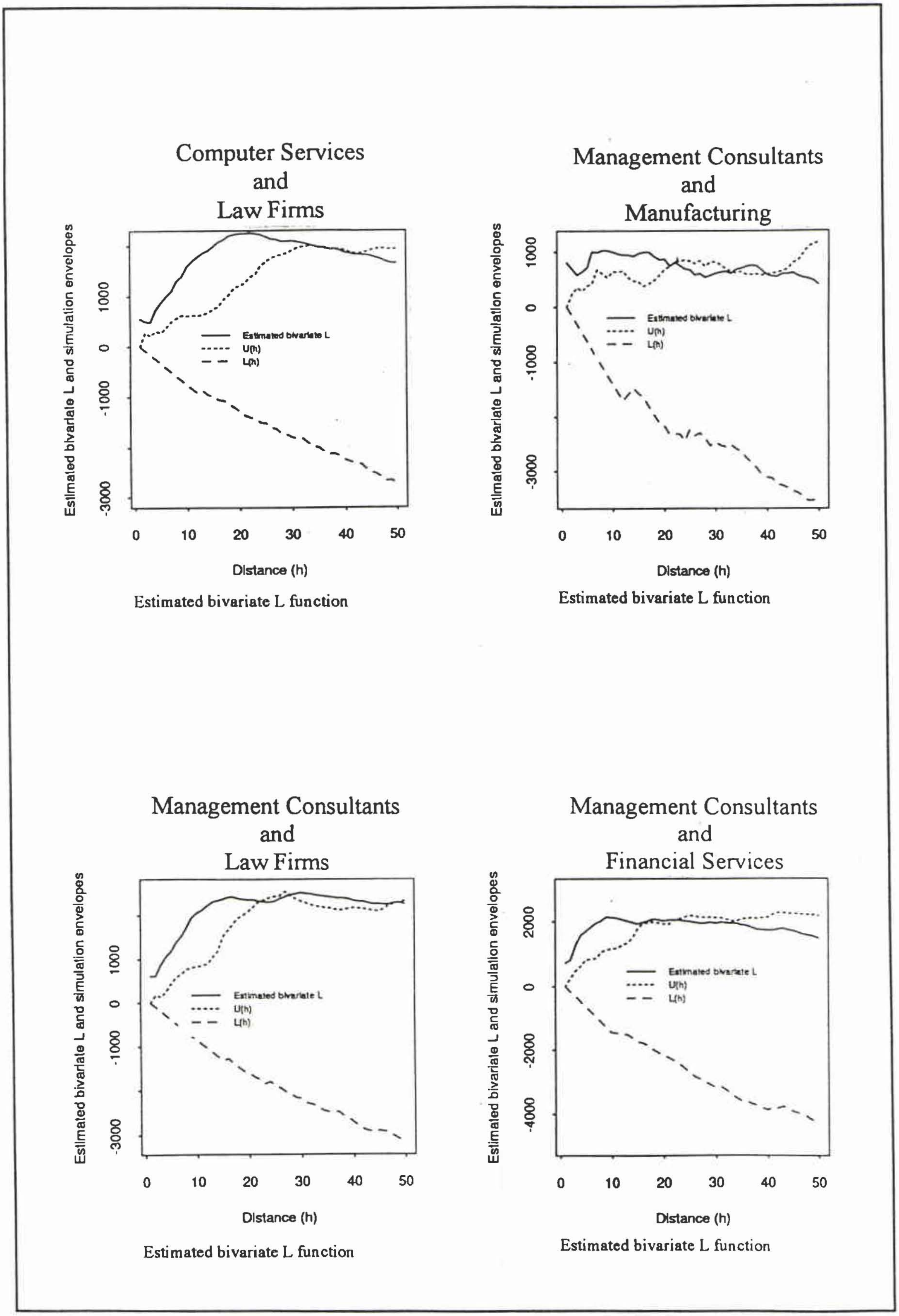


Figure 4.24 Bivariate K Function Estimates for Computer Services and Law Firms; Management Consultants and Manufacturing; Management Consultants and Law Firms; Management Consultants and Financial Services

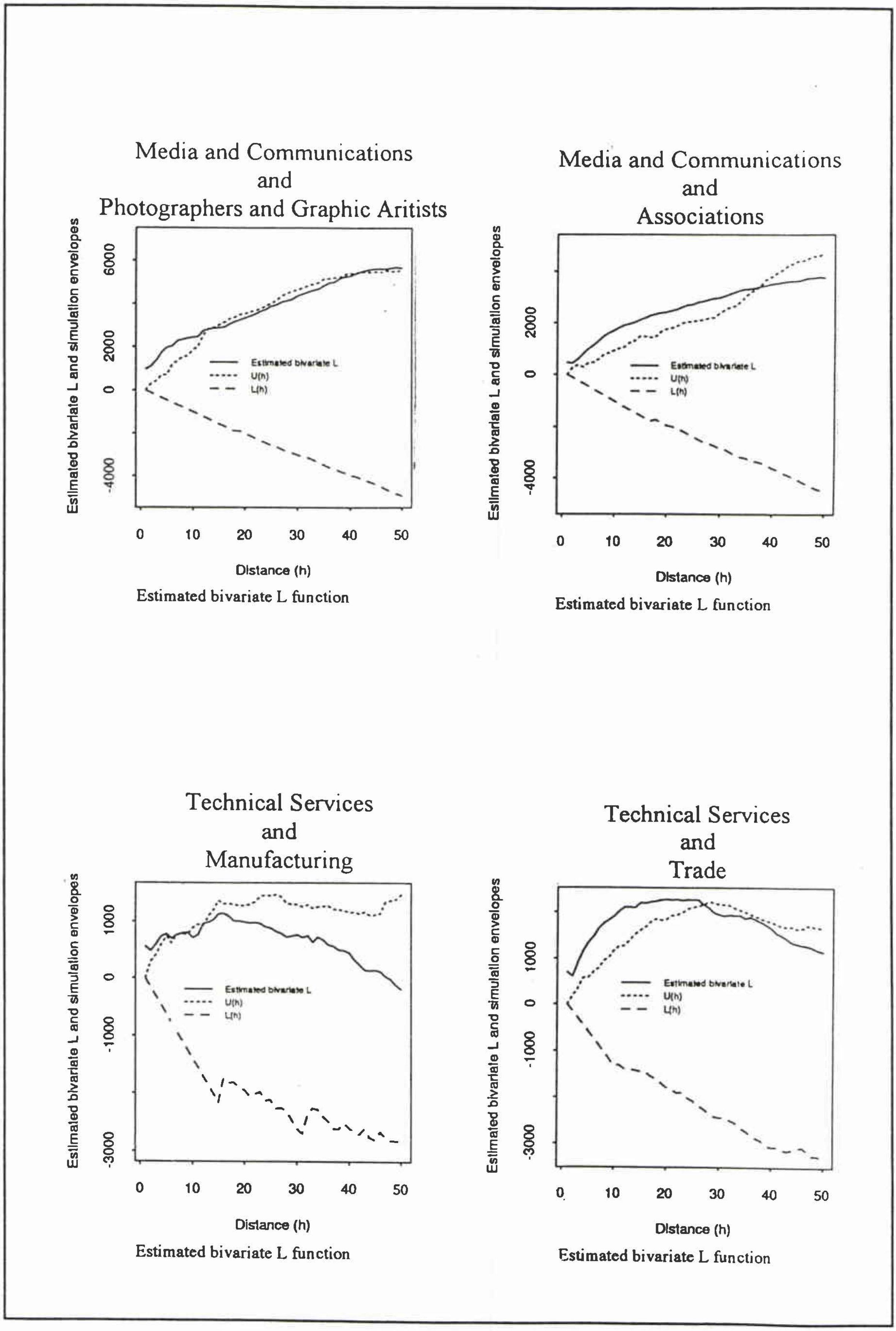


Figure 4.25 Bivariate K Function Estimates for Media and Photographers and Graphic Artists; Media and Associations; Technical Services and Manufacturing; Technical Services and Trade

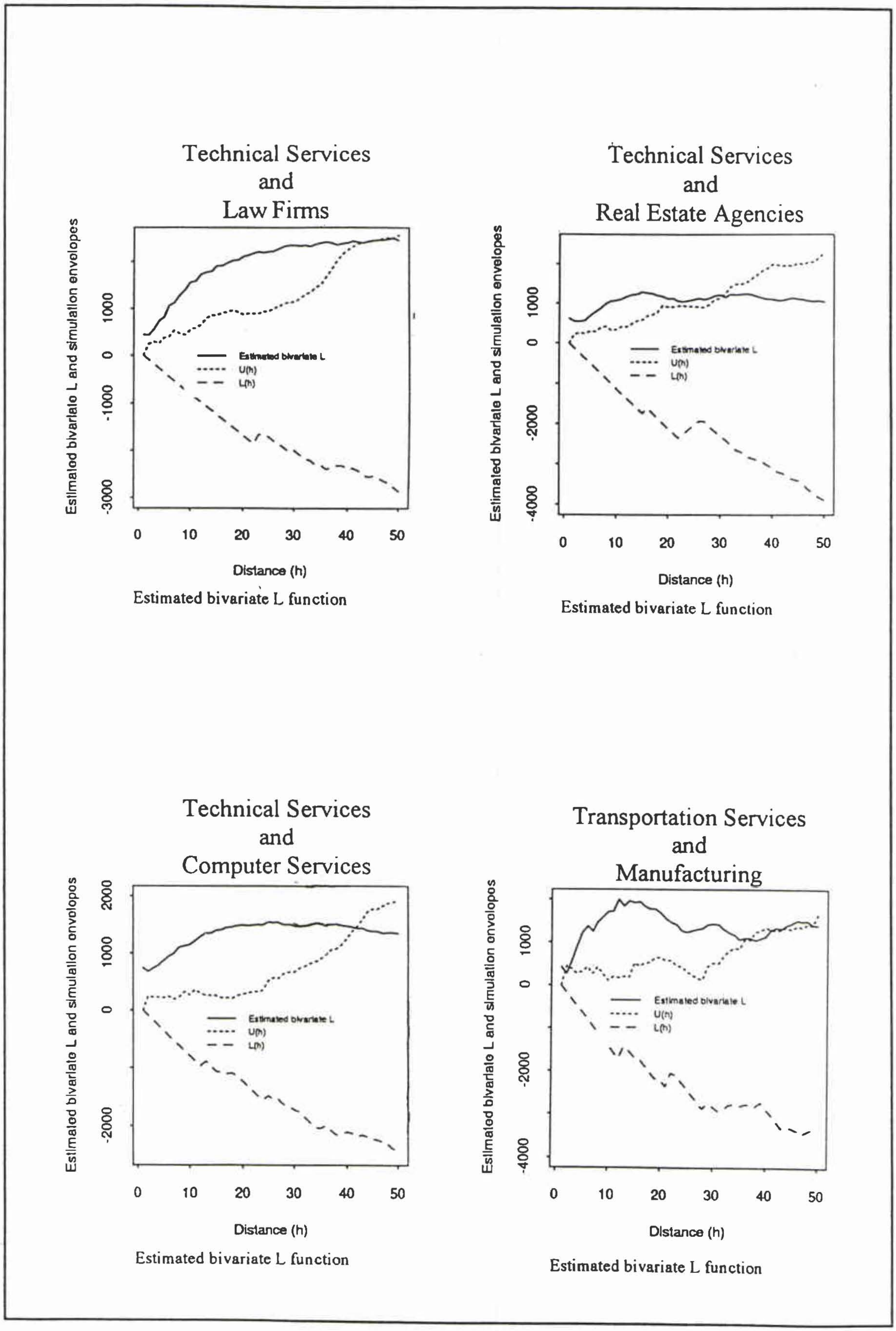


Figure 4.26 Bivariate K Function Estimates for Technical Services and Law Firms; Technical Services and Real Estate Agencies; Technical Services and Computer Services; Transportation Services and Trade

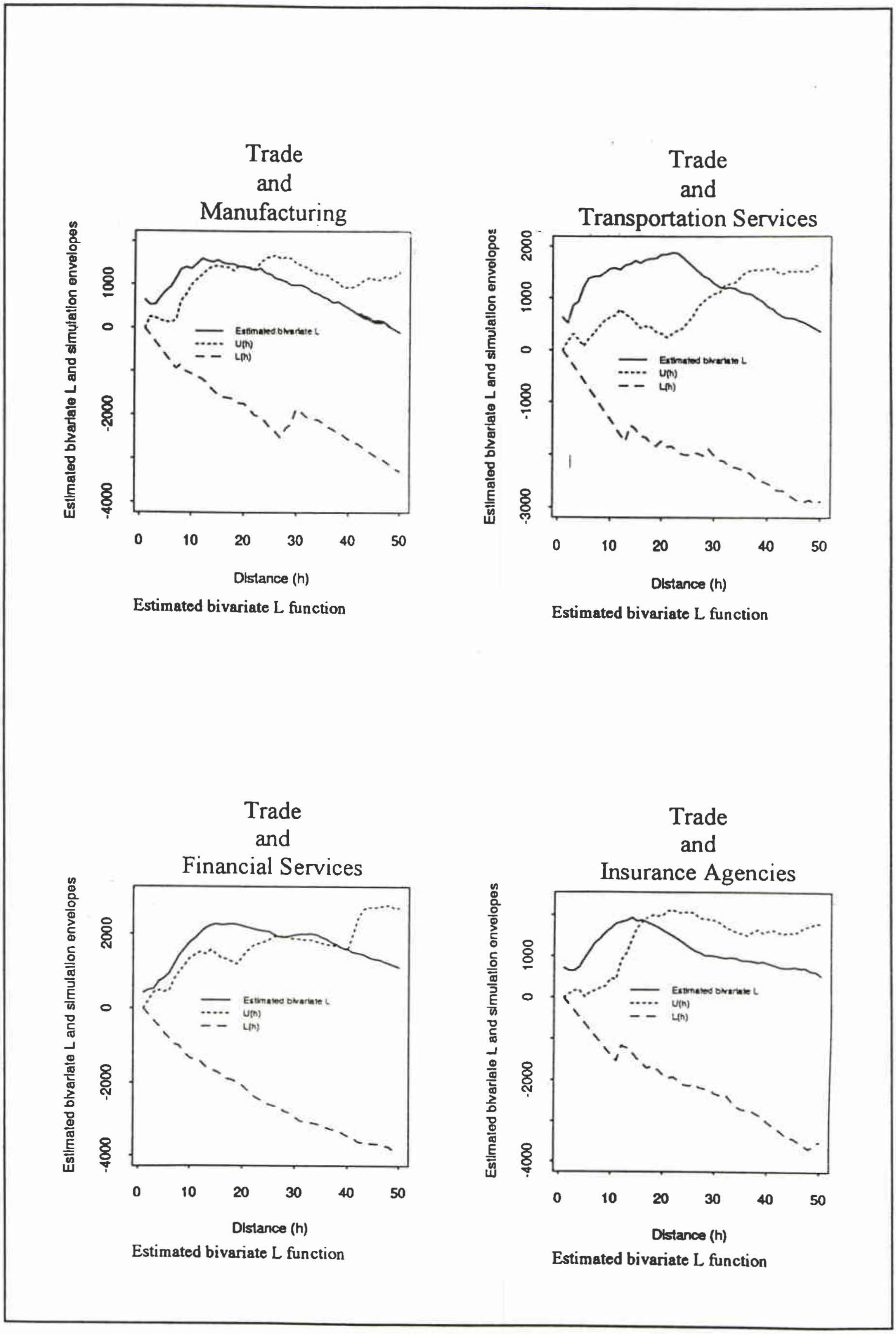


Figure 4.27 Bivariate K Function Estimates for Trade and Manufacturing; Trade and Transportation Services; Trade and Financial Services; Trade and Insurance Agencies

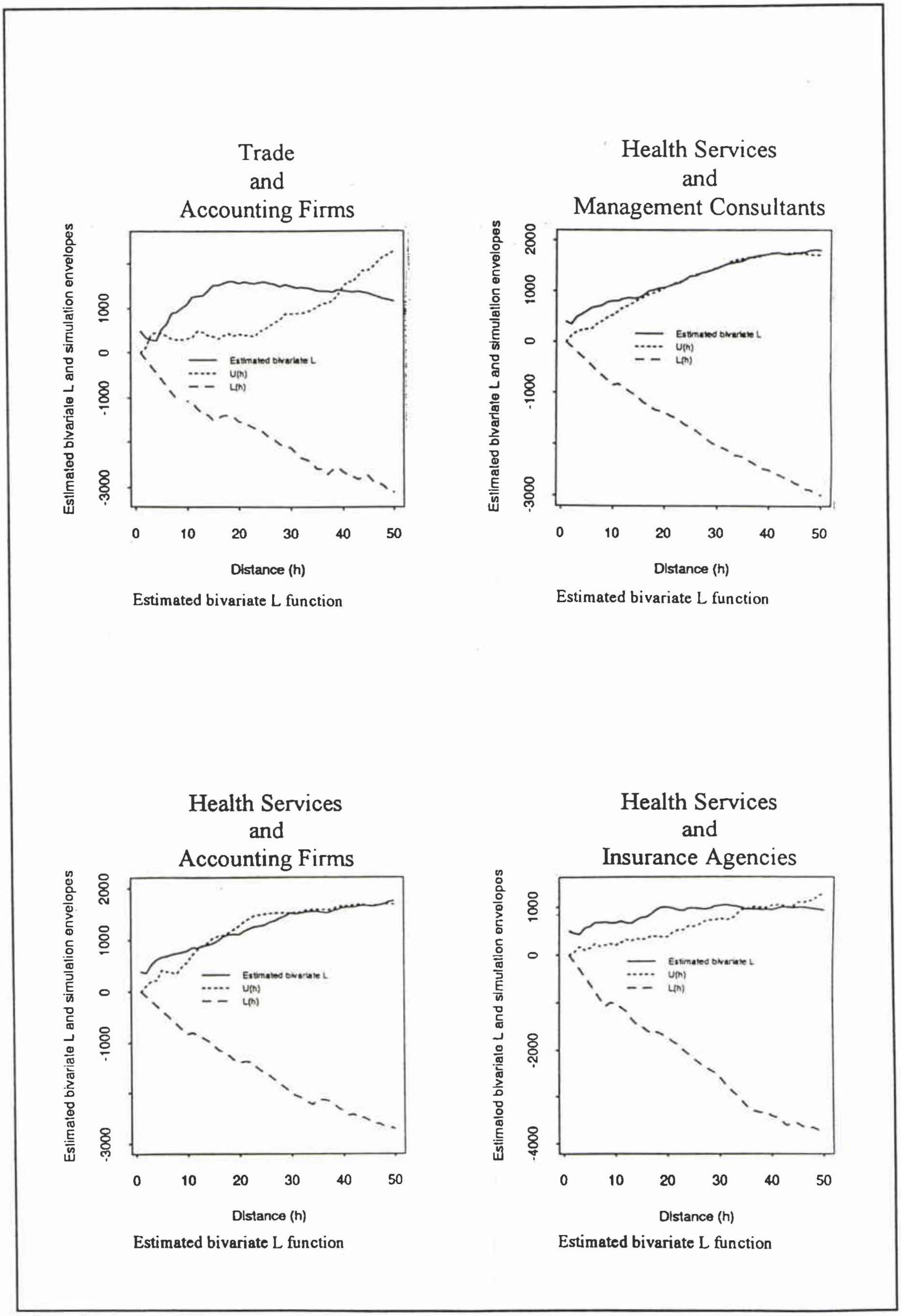


Figure 4.28 Bivariate K Function Estimates for Trade and Accounting Firms; Health Services and Management Consultants; Health Services and Accounting Firms; Health Services and Insurance Agencies

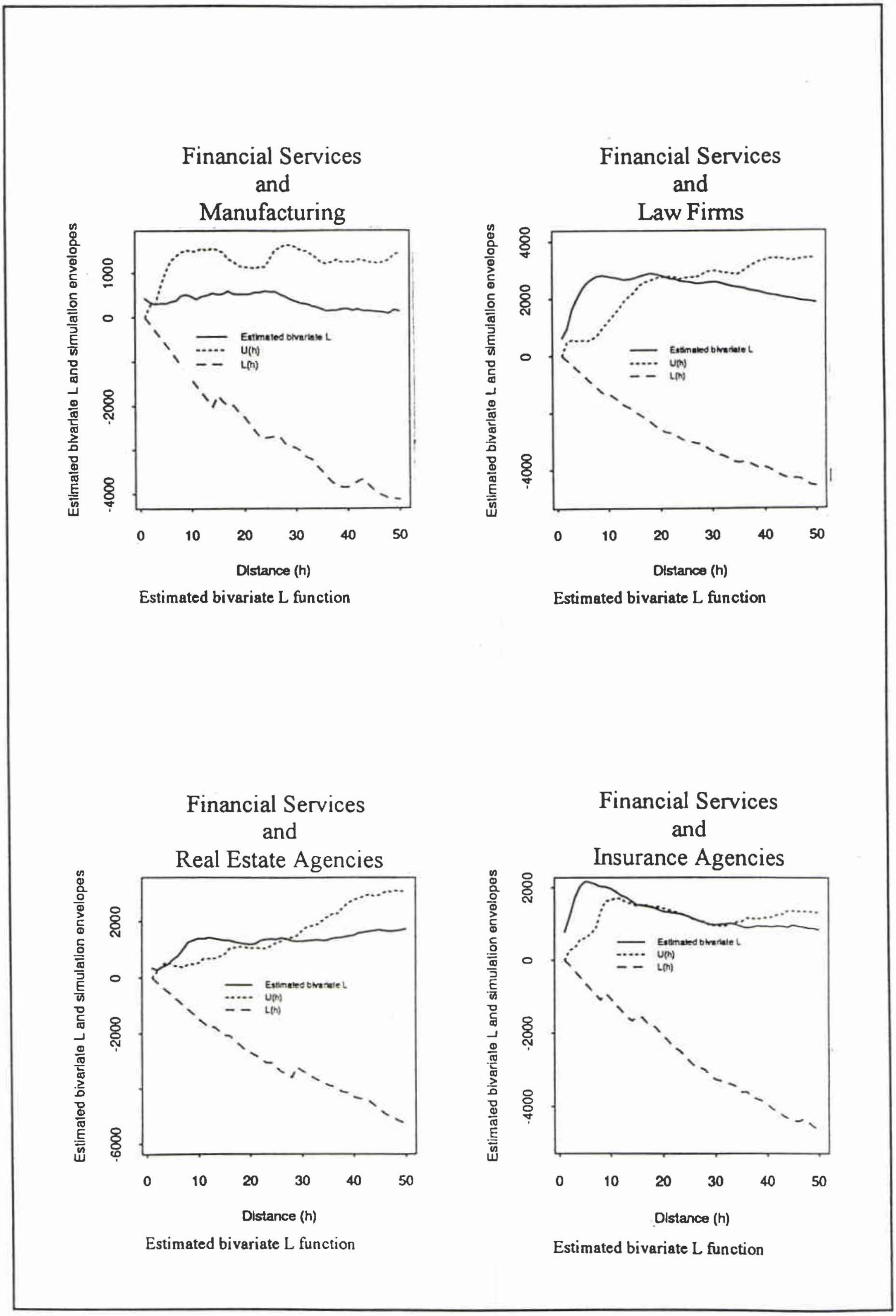


Figure 4.29 Bivariate K Function Estimates for Financial Services and Manufacturing; Financial Services and Law Firms; Financial Services and Real Estate Agencies; Financial Services and Insurance Agencies

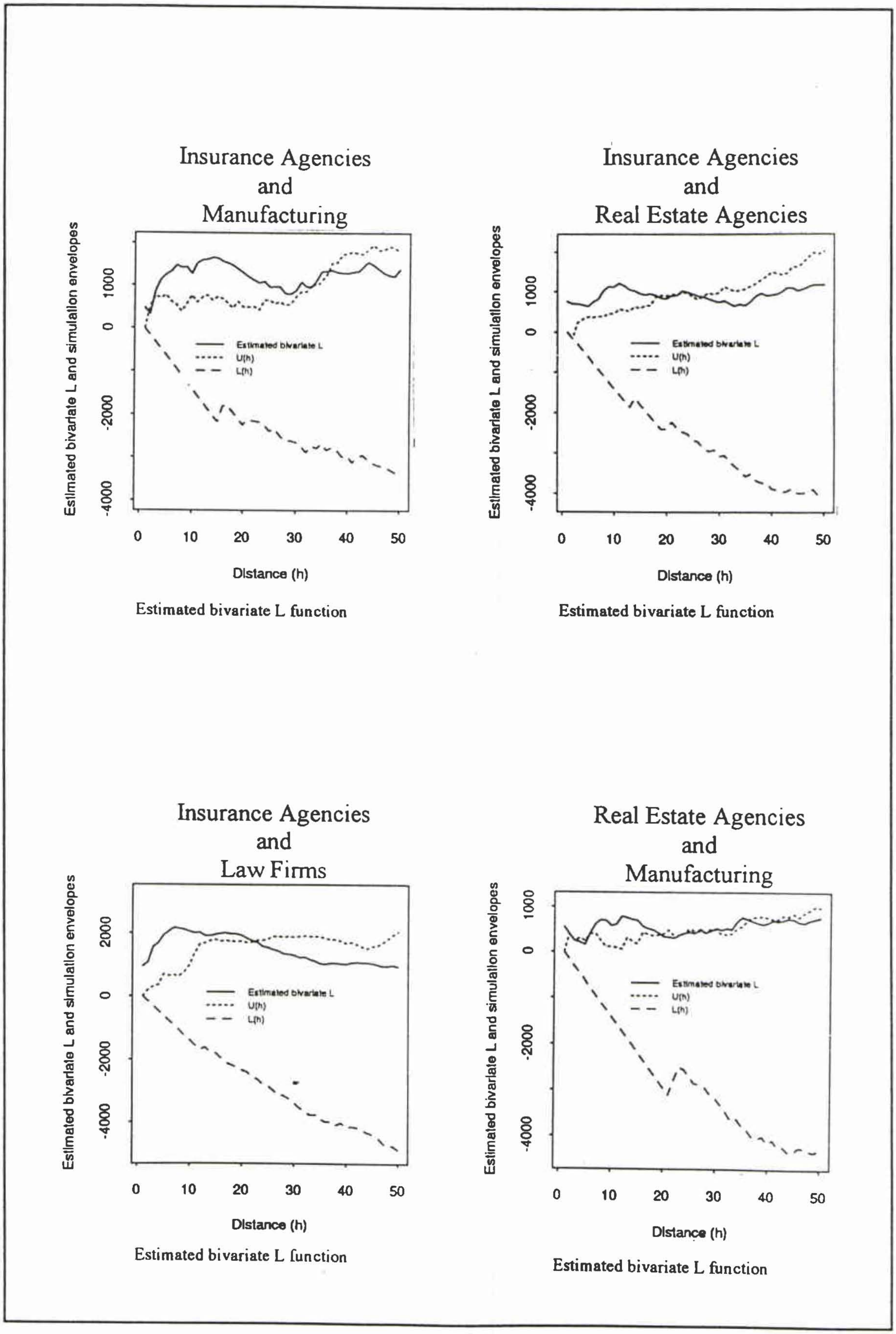


Figure 4.30 Bivariate K Function Estimates for Insurance Agencies and Manufacturing; Insurance Agencies and Real Estate Agencies; Insurance Agencies and Law Firms; Real Estate Agencies and Manufacturing

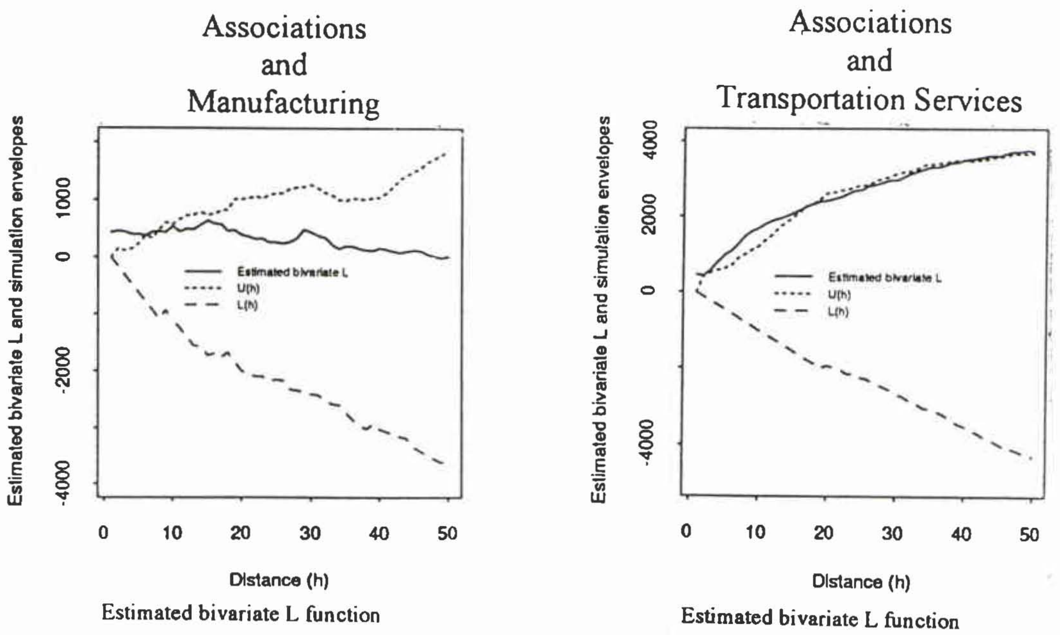


Figure 4.31 Bivariate K Function Estimates for Associations and Manufacturing; Associations and Transportation sServices

Table 4.6 Evidence of Event Interaction among Office Activity Patterns

Office Activity	Office Activity Pairings	Evidence of Spatial Interaction up to distances (h)	Evidence of Spatial Interaction between distances (h)	Evidence of Spatial Interaction beyond distances (h)	No Spatial Interaction up to distances (h)	No Spatial Interaction between distances (h)	No Spatial Interaction beyond distances (h)
Transportation Services	Manufacturing	5.3 km					5.3 km
Financial Services	Manufacturing						0 km
	Law Firms	3 km					3 km
	Real Estate Agencies	4.7 km					4.7 km
	Insurance Agencies	5.2 km					5.2 km
Insurance Agencies	Manufacturing	5.3 km					5.3 km
	Real Estate Agencies	3.7 km					3.7 km
	Law Firms	3.7 km					3.7 km
Real Estate Agents	Manufacturing	2.6 km	2.9 km - 5.3 km			2.6 km - 2.9 km	5.3 km
Law Firms	Real Estate Agencies	4.2 km					4.2 km
	Manufacturing	3.7 km					3.7 km
Accounting Firms	Manufacturing	2.1 km	5.3 km - 6.8 km			2.1 km - 5.3 km	6.8 km
	Law Firms			0 km			
	Finance	7.1 km					7.1 km
Management Consultants	Manufacturing	2.9 km	5.3 km - 6.0 km			2.9 km - 5.3 km	6.0 km
	Law Firms			0 km			
	Financial Services	2.9 k m					2.9 km

Table 4.6 con't Evidence of Event Interaction among Office Activity Patterns

Office Activity	Office Activity Pairings	Evidence of Spatial Interaction up to distances (h)	Evidence of Spatial Interaction between distances (h)	Evidence of Spatial Interaction beyond distances (h)	No Spatial Interaction up to distances (h)	No Spatial Interaction between distances (h)	No Spatial Interaction beyond distances (h)
Advertising Agencies	Manufacturing						0 km
	Media and Communications	7.6 km					7.6 km
	Technical Services	4.1 km					4.1 km
Associations	Manufacturing						0 km
	Transportation Services	0 km					
Technical Services	Manufacturing						0 km
	Trade	4.2 km					4.2 km
	Law Firms	0 km					
	Real Estate Agencies	3.6 km					3.6 km
	Computer Services	3.4 km					3.4 km
Media and Communications	Photographers and Graphic Artists	1.0 km				1.0 km - 4.3 km	4.3 km
	Associations	4.3 km					4.3 km
Health Services	Management Consultants	0 km					
	Accounting Firms	832 m				832m - 3.6 km	3.6 km
	Insurance Agencies	5.2 km					5.2 km
Trade	Manufacturing	3.2 km					3.2 km
	Transportation Services	4.9 km					4.9 km
	Financial Services	6.3 km					6.3 km
	Insurance Agencies	2.1 km					2.1 km
	Accounting Firms	5.7 km					5.7 km
Computer Services	Financial Services						0 km
	Insurance Agencies	5.2 km					5.2 km
	Accounting Firms	0 km					
	Management Consultants	1.7 km				1.7 km - 3.6 km	3.6 km
	Law Firms	0 km					

dependence at large distances indicates that these office pairings are clustered in many areas located across the entire metro area suggesting the evidence of possible localization and urbanization economies. Estimates that lie above the upper simulation envelope but then fall below it at intermediate or large distances (*h*) indicates independence or non-clustering of bivariate events at those distances beyond the intersection of the estimate and the upper simulation envelope. The spatial clustering (dependence) is only significant when the estimate lies above the upper envelope. Significant clustering ceases to exist when the estmate falls below the upper envelope.

The results for accounting firms show that they are significantly attracted to the locations of law firms at all spatial scales. Accounting firms also tend to be significantly attracted to financial services at distances $h \leq 45$ or 6.8 kilometers. These results indicate that accounting firms, law firms and financial services may have similar locational preferences and may also conduct business with one another. Accounting firms tend to be attracted to manufacturing services at distances $h \leq 15$ or 2.3 kilometers and independent at further distances. Advertising agencies tend to be attracted to manufacturing offices at very small distances and tend toward independent locations at larger distances. Advertising agencies and media and communications services are similar in function in that they provide information and communication technologies. As a result advertising agencies tend to be significantly attracted to locations of offices providing media and communications services. Finally, locations of new advertising agencies are significantly attracted to the locations of offices providing technical services at distances $h \leq 25$ or 3.8 kilometers. Law firms are significantly attracted to real estate agents at distances $h \leq 35$ or 5.3 kilometers. They are also significantly attracted to manufacturing services at $h \leq 22$ or 3.3 kilometers. Offices of computer services tend toward being attracted to the locations of financial services. However the $L_{ij}(h)$ estimate lies just below the upper simulation envelope indicating that computer services for the most part locate independently from offices providing financial services at all spatial scales. Computer services are significantly attracted to the locations of insurance agencies and law firms at distances $h \leq 32$ or 4.8 kilometers. These services are attracted to accounting firms at all spatial scales. However computer services are only attracted to the locations of management services at small distances. Management consultants are significantly attracted to the locations of law firms at all spatial scales and to financial services and manufacturing services at $h \leq 20$ or 3 kilometers. Media and communications services are significantly attracted to the offices of photographers and graphical artists at distances $h \leq 15$ or 2.3 kilometers and to associations at distances $h \leq 38$ or 5.7 kilometers. The locations of technical services are significantly independent to locations of manufacturing services beyond 1 kilometer. Technical services are significantly attracted to offices providing trade services and offices of real estate agents at distances $h \leq 25$ or 3.8 kilometers and $h \leq 31$ or 4.7 kilometers respectively. The most significant attractions occur between technical services and the offices of computer services at $h \leq 40$ or 6 kilometers and law firms at $h \leq 50$ or 7.5 kilometers.

Transportation services and manufacturing services are significantly attracted at distances $h \leq 38$ or 5.7 kilometers. Trade services are only significantly attracted to offices of manufacturing services and insurance agencies at distances $h \leq 20$ or 3 kilometers and $h \leq 12$ or 1.8 kilometers. Trade and transportation services are significantly attracted at distances $h \leq 30$ or 4.5 kilometers. Finally, trade services are significantly attracted to financial services and accounting firms at distances $h \leq 40$ or 6 kilometers.

The locations of financial services are significant independent to locations of manufacturing services at all spatial scales. Financial services are significantly attracted to the locations of law firms at distances $h \leq 20$ or 3 kilometers. Financial services also interact with offices of insurance agencies, trade services and real estate agencies at distances $h \leq 35$ or 5.3 kilometers, $h \leq 20$ or 3 kilometers and $h \leq 25$ or 3.8 kilometers respectively. Both insurance agencies and real estate agencies are significantly attracted to manufacturing offices at distance $h \leq 35$ or 5.3 kilometers. Insurance agencies are significantly attracted to the locations of law firms and real estate agents at distances $h \leq 22$ or 3.3 kilometers and $h \leq 25$ or 3.8 kilometers.

Health services and management consultants are significantly attracted at all spatial scales. Health and insurance agencies are significantly attracted to accounting firms and insurance agencies at distances $h \leq 10$ or 1.5 kilometers and $h \leq 35$ or 5.3 kilometers respectively. The locations of associations are significantly independent of the locations of offices providing manufacturing services beyond distances $h \leq 8$ or 1.2 kilometers. Associations and offices providing transportation services are significantly attracted at distances $h \leq 15$ or 2.3 kilometers.

Finally an informal descriptive comparison is made using the results from Table 4.6 and the general findings of Gad (1975) summarised in Table 4.2. The rationale for this type of comparison is simply to observe whether statistically tested event interactions found in

Table 4.6 are consistent with linkage intensities of the same pairings found in Table 4.1. A comparison is made in Table 4.7.

Table 4.7
Summary of Comparison: Evidence and Degree of Consistency

Strong Consistencies	Intensity Rank	Strong Inconsistencies	Intensity Rank
Accounting Firms and Law Firms	2	Manufacturing and Trade	1
Accounting Firms and Financial Services	5	Financial Services and Manufacturing	1
Management Consultants and Law Firms	2	Advertising Agencies and Manufacturing	1
Advertising Agencies and Media	2	Technical Services and Manufacturing	1
Technical Services and Law Firms	3	Associations and Manufacturing	1
Associations and Transportation Services	2		

From Table 4.7 it is evident that strong inconsistencies exist among office pairings that involve manufacturing services. Gad (1975) found that manufacturing services had the highest levels of functional linkage intensities with most other individual office activities. The statistical results of the bivariate *K* function provide evidence to the contrary. However it is extremely important to note that Gad (1975) did not investigate statistical independence among pairs of office establishments nor did he imply that functional linkages are directly comparable or inferential to statistical locational attraction. Furthermore his data set did not consist of new office establishment but previously established office activities. Finally Gad's results are based on a study area that cannot and should not be statistically compared to the study area of this thesis. Consequently, no inferences should be made to suggest that linkage intensities imply any type of significant statistical locational attraction between two event processes.

4.9 Conclusions

In this chapter several important findings have been identified and, in the context of this research, merit further investigation in order to fully understand the reasons behind the locational patterns of the office activities in question. The use of advanced statistical techniques revealed that all office activities displayed tendencies to cluster across all distances. The kernel estimates as well as the point patterns themselves provided a visual inspection of the general locations of clustered patterns found within metropolitan Toronto. Furthermore by using the bivariate *K* function techniques it was determined that locational patterns of certain office activities displayed high levels of event interaction with the locations of other distinct office activities further supporting the findings of Pivo (1993). Pivo found that office activities will be attracted to clusters of other activities with locational or physical properties that are most suited to their requirements. These results provide valuable information and will be used congruently with the results of other econometric techniques used in the fifth chapter for the purposes of obtaining a comprehensive understanding of office location patterns.

Thus far the analyses have allowed us to observe where new office establishments locate. However knowing where an establishment locates provides partial knowledge of the locational behaviour of that establishment. To fully grasp the locational behaviour displayed by the results found in this chapter requires the understanding of the motives behind a particular location decision. This topic is examined in the following chapter.

CHAPTER FIVE

INTRAMETROPOLITAN LOCATION OF NEW OFFICE FIRMS: A MULTINOMIAL LOGIT ANALYSIS

5.1 Introduction

The purpose of this chapter is to present and test a model to explain the intrametropolitan location of new office firms. The chapter begins with an explanation of random utility theory. The discussion of the random utility framework leads into the development of a multinomial logit model. The chapter then proceeds with the development of a theoretical office location model that makes location choice a function of the spatial variation of variables that affects profits. The chapter continues with a description of the variables used in the logit analysis. Next, the results of the various logit models are presented and discussed in detail. The results contain the estimates for individually specified logit models, each representing a distinct office activity type. The final section summarizes the general finding of the logit analysis.

5.2 Random Utility Theory

The general framework of random utility begins with a decision maker who is faced with a set of choices. A decision maker can be an individual person, a household or an organization such as a firm or a government agency. With respect to this analysis we refer to the firm as the definition of a single actor in a decision making process. The choice is made from a subset of a broader universal set of alternatives. The subset, termed the choice set, includes all the alternatives that are known during the decision process. Alternatives are selected based on their attractiveness at the time of selection. The attractiveness of an alternative is evaluated in terms of a set of attribute values. In this analysis the alternatives are heterogeneous real estate zones, therefore the attribute values vary across these zones. Upon evaluating the attributes of two or more alternatives a decision must be made. The decision requires a decision rule. Many firm location studies have used an index of attractiveness termed *utility*. In this context utility is specifically defined as profit and is a measure that the firm attempts to maximize through its choice. The decision maker uses the concept of utility when comparing different attributes. It is assumed that decisions are made with *consistent* and *transitive* preferences. This means, everything else being equal, a decision maker who chooses alternative one over alternative two will always choose alternative one over alternative two. This is termed *consistency*. If alternative one is preferred to alternative two and alternative two is preferred to alternative three, then alternative one is also preferred to alternative three. This is known as *transitivity*.

The basis of random utility, as formulated by Manski (1977), is that an individual is always assumed to select the alternative with the highest utility. Utilities are not known to the analyst with certainty and are treated as random variables. Ben-Akiva and Lerman (1985) define observational deficiencies as:

1. Unobserved attributes. The analyst does not have complete information about the attributes affecting the decision.
2. Unobserved taste variations among decision makers.
3. Measurement errors of attributes.
4. Instrumental errors. The analyst does not have complete information about the variables related to actual attributes.

Utility takes on the functional form:

$$U_{in} = U(Z_{in}, S_n) \tag{5.1}$$

where:
U = utility
i = alternative
n = decision maker
U() = utility scale that maps attribute values and socioeconomic characteristics that explain variations in taste
Z_{in} = set of attribute values for alternative i as viewed by decision maker n
S_n = set of socioeconomic characteristics of decision maker n such as income, age and education

Given the above, the probability of alternative i being chosen by decision maker n is equal to the probability that the utility of alternative i, U_{in}, is greater than or equal to the utilities of all other alternatives j in the choice set C_n. This can be written as follows:

$$P_n(i) = Pr(U_{in} \geq U_{jn}\text{ , all } j \in C_n) \tag{5.2}$$

When error and uncertainty is introduced, random utility of an alternative can be expressed as the sum of observable and unobservable components of the total utilities as shown by Ben-Akiva and Lerman (1985):

$$U_{in} = V(Z_{in}, S_{in}) + \epsilon(Z_{in}, S_{in}) \tag{5.3}$$

$$= V_{in} + \epsilon_{in}, \tag{5.4}$$

and equation 5.4 can be rewritten as:

$$P(_i | C_j) = Pr[V_{in} + \epsilon_{in} \geq V_{jn} + \epsilon_{jn}, \text{ all } j \in C_n] \quad (5.5)$$

where:

V_{in}, V_{jn} = systematic (representative) observable components of utility i and j.
ϵ_{ij} = unobservable random disturbances

For computational convenience the function V_{in} is linear in parameters (Ben-Akiva and Lerman, 1985). The sources of randomness listed above are captured in the unobservable error component ϵ_{in}. Probabilities are derived by assuming a joint probability distribution for the set of random variables (disturbances).

A multinomial choice model can be derived given specific assumptions on the joint distributions of the disturbances. Researchers often view the disturbances as normally distributed resulting in a probit model. Under the normal distribution we assume that errors are i) dependent ii) normal distributed and iii) have non-equal variances resulting in correlations across the errors. The equation of the normal distribution is complex and makes estimation using maximum liklihood difficult. Due to its non linear distributional form, the probit model is computationally time consuming and analytically inconvenient.

A more analytically convenient model is the logit model. The logit model assumes that the differences in errors are independently, identically and Gumbel distributed (IID) with a location parameter η and a scale parameter $\mu \succ 0$. The functional form of the distribution is as follows:

$$F(\varepsilon_n) = \frac{1}{1 + e^{-\mu\varepsilon_n}} \qquad \mu > 0, -\infty < \epsilon_n < \infty, \quad (5.6)$$

$$f(\varepsilon_n) = \frac{\mu e^{-\mu\varepsilon_n}}{(1 + e^{-\mu\varepsilon_n})^2} \tag{5.7}$$

where μ is a positive scale parameter which is inversely related to the variance. The distribution approximates the normal distribution but has fatter tails. The distribution can also be linearized which demonstrates its convenience as the function V_{in} is also linear in parameters. A major difference in assumptions between the normal and IID distribution is that errors are independent under IID. This assumption constrains all the disturbances to have the same scale parameter μ. Variances are not assumed equal under the probit assumption. Under the assumption that ϵ_{in} is Gumbel distributed, the choice probability for alternative *i* is given by:

$$P_n(i) = Pr\ [V_{in} + \varepsilon_{in} \geq \underset{j=2.....,J_n}{MAX} (V_{jn} + \varepsilon_{jn})] \tag{5.8}$$

$$P_n\ (i) = \frac{1}{1 + e^{\mu(V_{in} - V_{jn})}} \tag{5.9}$$

$$= \frac{e^{\mu V_{in}}}{\Sigma_{i=1}^{Jn}\ e^{\mu V_{jn}}} \tag{5.10}$$

if $\mu = 1$,

$$\frac{e^{V_{in}}}{\Sigma_{j=1}^{Jn}\ e^{V_{jn}}} \tag{5.11}$$

In the past, studies of firm location have utilized the tobit model (Ihlenfeldt and Raper, 1990). The tobit model is also known as the censored normal regression model. In this model some observations of the dependent variable are censored or omitted. This occurs because of the nature of the dependent variable. In the case of office location studies, the dependent variable may be the number of office firms selecting a census tract from a set of many census tracts for its location. A problem may arise in that some on the census tracts may never be chosen by any of the firms. Hence the dependent variable for those zones has no observations. A truncated normal distribution results as the error term does not have a zero mean since some of the observations have omitted dependent variables.

The logit model was chosen for this study because of its analytical convenience. The logit model was chosen over the tobit model because in this analysis the dependent variable is a set of individual observations of a particular office activity which selects one of twenty-two real estate zones in metropolitan Toronto. Thus, unlike the tobit model the dependent variable is not a count of the number of activities choosing a zone. The logit model is more representative of the real world. Each office activity faces a locational choice among a set of alternative zones. An office activity maximizes its utility by choosing a zone based on that zone's attributes.

The Independence form Irrelevant Alternatives (IIA)Assumption

The basic property of the logit model is the Independence from Irrelevant Alternatives (IIA) property. It is a principle of selection probability developed to assist in the formulation of a choice model (Hensher and Johnson, 1981). The principle states that the ratio of probabilities of choosing one alternative over another is unaffected by the presence or absence of any additional alternative in the choice set. The IIA property assumes that the random elements in utility are independent across alternatives. This condition is both a strength and weakness of the model. It is a strength in that it provides a computationally convenient choice model, and permits the introduction and/or elimination of alternatives in the choice set without re-estimation. The assumption is a weakness if the observed and unobserved attributes of random utility are not independent of one another and/or if there is correlation of the unobserved components of utility among alternatives (Hensher and Johnson, 1981). In a case where two alternatives are identical or very similar in terms of their characteristics, their disturbances (ϵ_{jn}) are assumed to be correlated and may lead to biased estimates of model parameters. Thus, an inherent weakness of the multinomial logit model is that it tends to overpredict the choice probabilities for alternatives which are perceived by an individual to be similar.

5.3 A Model of Intrametropolitan Location for New Office Firms

New office firms are defined as new profit seeking, private establishments that locate in office buildings. The basic assumption underlying the model presented is that new office firms search the metropolitan area for the location that maximizes profit. Location affects profit because the level of new demand for office services is assumed to vary spatially. The model developed in this thesis is similar in structure to that used by Shukla and Waddell (1991). The production function of new offices of a particular type can be expressed as:

$$Q = f(OS, L, A, FFM) \tag{5.12}$$

where:

Q = output of office services
OS = office space characteristics
L = labour
A = amenity and prestige characteristics
FFM = face to face meetings with clients and suppliers

The values of these inputs vary across alternatives and differ in their relative importance between firms. Furthermore, firms may substitute higher quantities of one input for lower quantities of others. Therefore, different types of office firms will have production functions where the inputs will vary in quantity. A firm will choose to locate in a zone in which it can achieve a combination of inputs that represents the highest utility (i.e. profits for the firm). Profit is assumed to vary spatially because of inter-area differences in the level of new demand for office services. Given equation (5.12) the cost and profit functions for office services can be expressed as:

$$C = rOS + sL + tA + uFFM \tag{5.13}$$

$$\pi = PQ - C \tag{5.14}$$

where:

P = price of office services
r = price of office space
s = price of labour
t = price of amenities
u = distance between the office location and suppliers and clients

The firms location decision is motivated by the outcome of the following profit maximization problem over possible locations i:

$$\text{MAX} \quad P(OS_i, L_i, A_i, FFM_i) - rOS_i - sL_i - tA_i - uFFM_i \tag{5.15}$$

The firm chooses the zone which is characterized by an optimal combination of OS_i, L_i, A_i and FFM_i so that an indirect profit function of location *i* can be specified:

$$V_i = V_i\,(P, r_i, s_i, t_i, u_i) \tag{5.16}$$

Under random utility the industry specific formulation of the maximum profit attainable by a firm in industry *n* at location *i*:

$$U_{in} = V_{in}\,(P, r_i, si, ti, u_i\ ) + \epsilon_{in} \tag{5.17}$$

A type *n* firm locates in *i* provided that profits there are the highest. This profit maximizing selection can be cast as a random utility process subject to a random error if assumed to have IID distribution. As discussed in the previous section, this results in the following multinomial logit specification with the probability of a firm in each industry *n* locating in *i* as:

$$P_n(i) = \frac{e^{V_{in}}}{\sum_{j=1}^{Jn} e^{V_{jn}}} \tag{5.18}$$

Other intangible factors or 'unobservable' attributes of a particular location such as the quality of the surrounding environment and perceived elements of prestige, that may be considered in location decision making, are captured by the error term found within the model.

5.4 Explanatory Variables and Hypotheses

In this section the hypotheses behind each of the independent variables are explained. Table 5.1 lists all the independent variables and their definitions. As outlined in the description of the model, theoretical factors which affect profitability in a location are the

Table 5.1
Explanatory Variables

Distance Variables	
MALLDIS	linear distance from zone centroid to nearest shopping mall
HWYDIS	linear distance from zone centroid to nearest highway/expressway interchange
FINDIS	linear distance from zone centroid to center of zone containing the financial district
AIRDIS	linear distance from zone centroid to center of zone containing Pearson Int'l Airport
Dummy Variables	
METWEST	dummy variable for zone chosen, yes=1
METNORTH	dummy variable for zone chosen, yes=1
MIDTOWN	dummy variable for zone chosen, yes=1
DOWNTOWN	dummy variable for zone chosen, yes=1
SHOP	dummy variable for local shopping center in zone, yes=1
TRANS	dummy variable for TTC or GO rapid transit rail stations in zone, yes=1
OFFPARK	dummy variable for office park in zone, yes=1
Building Space Characteristics	
RENT	gross average asking rental rate
PARKING	average parking fees for buildings in zone
INVENT	amount of total office floor space in each zone (square foot)
ABSORP	absorption of office floor space in each zone (square foot)
VSPACE	amount of vacant office floor space in each zone (square foot)
VRATE	vacancy rate in each zone

Employment Variables (gravity variables)
defined as:

$$A_i = \sum_{j}^{n} E_j / d_{ij}$$

MANAGE	accessibility to workers employed in managerial and professional occupations living in zones i,j
CLERICAL	accessibility to workers employed in administrative support occupations living in zones i,j
SERVICE	accessibility to workers employed in financial, legal, business and miscellaneous services living in zones i,j
EMPLOY	accessibility to workers employed in a given office activity working in zone i,j (varies according to model being tested, ie 20 different EMPLOY variables)
AMENITY	accessibility to workers employed in eating, drinking and entertainment establishments working in zone i,j
Income Variables	
POOR	number of households in zone below $10,000 income level
WEALTHY	number of households in zone above $70,000 income level
Landuse Variable	
INDUSE	proportion of zones land in industrial landuse

prices of factor inputs. The factor inputs considered include the prices of office space, the prices of face-to-face meetings and labour costs.

The price of office space (or rent) varies spatially as a function of general site characteristics such as distance to the financial core, proximity to suburban employment and proximity to office parks. The rental price may also be dependent on the amount of vacancies and building space supplied. Office firms employ three types of labour i) managerial, ii) service and iii) clerical. The cost of either type of labour increases with distance from workers' homes. This means workers are willing to trade lower commuting costs or positive attributes of the work location for lower wages (Ihlanfeldt and Raper, 1990). Previous studies have shown that workers prefer safe work environments which offer plenty of amenities including parking facilities (Gottlieb, 1995). New independent firms may rely heavily on outside suppliers for support services such as consulting advice, accounting, and bookkeeping needs, legal services and financial services. Face-to-face meetings with customers may be required throughout the production process to obtain pertinent information that only the customer can provide. More importantly, these meetings are carried out to cultivate and maintain firm-customer relationships. The rate for transporting employees to meetings will depend on the transportation infrastructure that is available. Firms locating near rapid rail transit stations or expressways will experience lower transportation rates. Empirical measures used to estimate the logit model can be grouped under the price factors making up the profit function. Individual variables within each group are described below.

5.4.1 *Real Estate Market Variables*

Assuming that the prime motivator of a new establishment is to maximize its profit it will therefore be attracted to locations with lower rental prices. A set of variables were constructed to reflect office space characteristics.

RENT is defined as the gross average asking rental rate which includes taxes and operating costs by real estate zone. The data is for the year 1995 and were obtained from Colliers International Real Estate Group. The hypothesized sign on rent for all activities other than Law Firms and Financial Services. This variable will distinguish between the centralization/decentralization tendencies among different activity types.

ABSORP is the absorbtion for a specific real estate zone in 1995. It is defined as occupied office space in 1994 minus occupied office space in 1995; where occupancy is equal to inventory minus vacant space. The data were obtained from Colliers International Real Estate Group. This variable indicates which real estate zones are growing in terms of office space leased and is therefore an indirect indicator of demand. It is used to determine whether certain offices prefer high growth areas which may provide access to other newly locating offices. The hypothesized sign is positive for most activity types.

VRATE is the vacancy rate for a specific real estate zone in 1995. It is defined as the percentage of a building's unrented space during a given period. It is sometimes figured as the gross income that a building loses due to vacancies (Gross, 1978). This data were obtained from Colliers International. This variable is considered an indirect indicator of office supply in that it provides a percentage of space available meaning that the decision maker may have more units to choose from. The hypothesized sign is positive.

VSPACE is the amount of vacant space (in square feet) in each zone. The data were obtained from Colliers International. The expected sign is hypothesized to be positive in that office activities prefer areas with high growth potential.

INVENT, an abbreviation for inventory, is defined as the total office floor space (in square feet) in each zone. The data were obtained from Colliers International. It is used in this study to caputure a zone's size from the sizes of all the other zones in terms of floor space. In this way each zone is considered heterogeneous in terms of floor space by different office activities, therefore a decision can be made by a particular activity according to its utility for a designated number of units. This variable can also be an indicator of agglomeration economies in that large amounts of total office floor space indicates the possible presence of other related office activities. The hypothesized sign is positive.

OFFPARK is a dummy variable indicating whether a real estate zone has an office park within its boundaries. An office park is defined as any suburban office development with campus-like corporate settings that are oriented to expressways that provide direct access to the central area. Varying signs are hypothesized for this variable. It is hypothesized that activities in the financial and business services sector will have a disutility for locating in office parks.

5.4.2 *Labour Cost and Prestige Variables*

The variables used to describe labour costs are similar to the variables constructed by Ihlanfeldt and Raper (1990). They assumed that wage rates were directly related to workers' commuting costs. Given that data on wage rates by location were not available, they used the proximity of sites within a zone to residential locations of office workers to measure spatial variation in labour costs. The same reasoning is used in this analysis. *MANAGE, SERVICE* and *CLERICAL* are gravity variables defined as accessibility to workers employed in managerial and professional occupations living in zones *i, j*; accessibility to workers employed in financial, legal and business services living in zones *i, j* and accessibility to workers employed in administrative support occupations living in zones *i, j*. The data were obtained from Statistics Canada. The data were aggregated up to conform to the real estate boundary definitions. Distances were calculated using ARC/INFO GIS. The construction of these variables make proximity to office workers a direct function of the number of workers living within a certain distance and an inverse function of distance. Mathematically the variables are defined as:

$$A_i = \Sigma_j^n E_j / d_{ij} \tag{5.19}$$

where:

A_i = accessibility within zone i
E_j = employment in zone j
d_{ij} = the interzonal distance matrix

The hypothesized signs on these variables is positive.

Other factors that may cause spatial variation in the cost of labour and at the same time function as indicators of location prestige are attributes of the work location. *INDUSE* is defined as the proportion of a zone's land zoned for industrial land use. In this context industrial land use includes traditional industrial land use (i.e. stock yards, warehouse yards). Land use maps obtained from Metro Planning were used to digitize industrial land use onto pre-existing digital boundary files. The expected sign is hypothesized to be positive for manufacturing, transportation and trade services and negative for all other services.

POOR is defined as the number of households in a particular zone below $10,000 income level. This data were obtained from Statistics Canada and were aggregated up to the real estate zone boundaries. The hypothesized sign is negative for professional, financial and legal business services. *INDUSE* and *POOR* were constructed to measure neighbourhood characteristics. These variables negatively affect worker utility and increase labour costs. Workers may be paid more to work in industrial areas and dislike places that threaten personal safety. As well, negative neighbourhood attributes are also associated with low income households. Studies have shown that reducing labour costs and attracting potential clients can be achieved by locating in wealthy prestigious areas with many employee amenities such as restaurants, shopping malls and parking facilities (George et al., 1980, Clapp 1980, Matthew 1993).

*WEALTH*is defined as the number of households in a particular zone above $70,000 income level. This variable defines zones with wealthy high income households that will attract various office activities and services. The data were collected from Statistics Canada and aggregated up to the real estate zone boundaries. The hypothesized sign is positive for professional, financial and legal business services since wealthier households frequently require the services of financial advisors, accountants and lawyers.

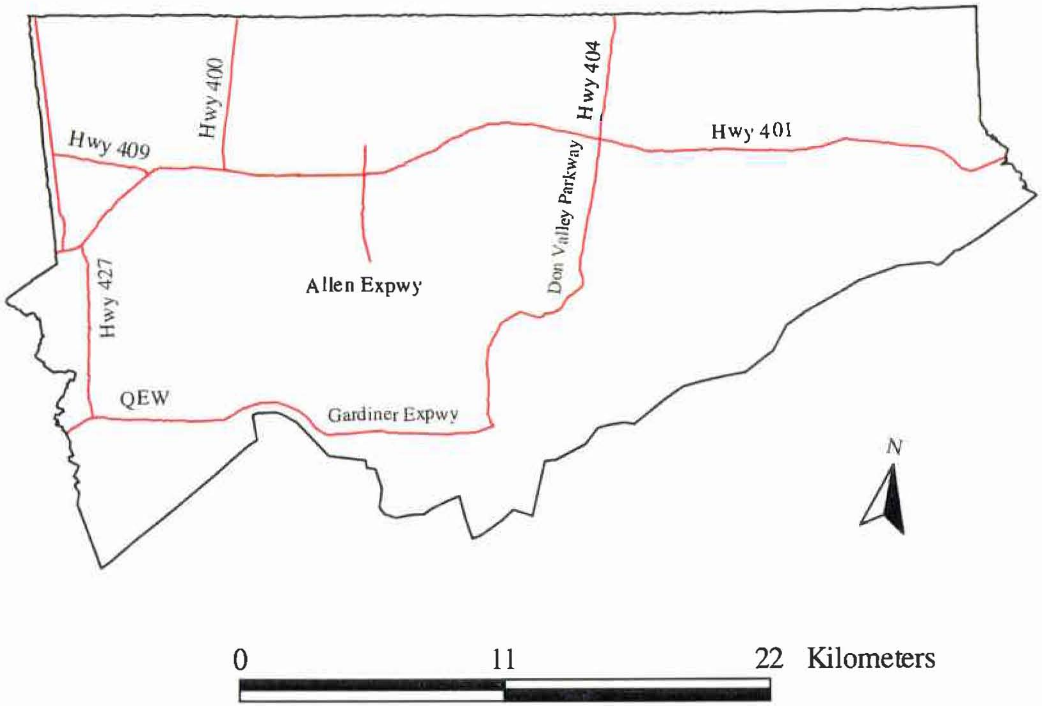
SHOP is a dummy variable indicating whether a zone contains one of the twenty-three major shopping centers found within metropolitan Toronto. *MALLDIS* is defined as the linear distance from a zone centroid to the nearest shopping mall. The distances were calculated using ARC/INFO GIS. The hypothesized sign for both *SHOP* and *MALLDIS* will vary according to the office activity being modelled. *AMENITY* was constructed as a gravity variable that measures accessibility to restaurants and entertainment facilities which may provide a more attractive environment for employees and may also attract potential clients. It is formally defined as accessibility to workers employed in eating and drinking establishments working in zones *i*, *j*. Mathematically the variable has the same form as equation (5.19). The data were obtained from Metro Planning. Distances were calculated using ARC/INFO GIS. The hypothesized sign is positive. *PARKING* measures the average monthly parking fees (in $) in each zone. The data were obtained from CB Commercial Real Estate Group. The hypothesized sign is positive.

5.4.3 *Transportation rates and Distance Variables*

According to the theory proposed by Ihlanfeldt and Raper (1990), the prices of face-to-face meetings depend on the transportation rate and distances between the new office firm and the location of suppliers and customers. Indeed many other studies of office location have documented the importance of transportation facilities. Shukla and Waddell (1991), found access to the airport and highways in Dallas-FortWorth to be statistically significant. Clapp (1980), Gad (1985) and Se-il Mun and Yoshikawa (1993), found distance to transportation facilities to be significant in order to sustain face-to-face contact. Four variables were used to measure differences across locations in transportation rates. *TRANS* is a dummy variable constructed to indicat whether a zone contains a subway (TTC) or commuter rail (GO) station. The data were obtained from Metro Planning. The hypothesized sign is positive. *HWYDIS* is defined as the linear distance from a zone centroid to the nearest highway interchange. Metropolitan Toronto highways and expressways are shown in Figure 5.1. The data were derived from skeletal street network files and digital boundary files obtained from Statistics Canada. The distances were calculated using ARC/INFO. The hypothesized sign is negative. The cost (in travel time) of transporting employees by air to meetings held outside the metropolitan area will be lower at offices located closer to the airport. To measure this cost, the variable *AIRDIS* was constructed. It is defined as the linear distance from a zone centroid to the center of the zone containing Pearson International Airport. The data were obtained from Statistics Canada. The hypothesized sign is negative for trade manufacturing and transportation related services. *FINDIS* is defined as the linear distance from a zone centroid to the centroid of the zone containing the financial district. The raw data were obtained from Statistics Canada as a digital boundary file of the Greater Toronto Area (GTA). The file was edited and re-digitized to resemble the study area (see Figure 3.2 in Chapter 3). Centroids and distances were calculated using ARC/INFO GIS. This variable will distinguish firms that prefer downtown locations from those that require suburban locations. Since the price of land as well as rents decrease with distance from the financial district the expected sign on *FINDIS* , when controlling for rent, for most business related activities is negative.

The variable *EMPLOY* is generic in name but not in the data it represents. The variable name and hence its data will vary from model to model according to the activity type being tested. It is a gravity variable defined as the accessibility to workers employed in the given office activity working in zones *i, j*. The data were obtained from the Employment

Figure 5.1
Highways and Expressways



Land use and Assessment (ELA) database collected by the Metropolitan Toronto Planning Department. The data is for the year 1995 and were disaggregated by minor planning district. The data consisted of the total number of employees of a particular activity type working in a given minor planning district. The data were aggregated up to conform to the previously defined real estate zones within the study area. The zone to zone distances were calculated using ARC/INFO GIS. Mathematically the variable is defined exactly as in equation (5.19). The expected sign on this variable could be either positive or negative depending on the activity being tested.

The variables *METWEST*, *METNORTH*, *MIDTOWN* and *DOWNTOWN* are constructed as dummy variables and indicate which sub-region of metropolitan Toronto the particular office activity has the highest utility for in terms of location. These variables also capture the factors not represented by the other independent variables. Referring to Figure 3.2 in Chapter 3, the zones HC, BI, TO, and AP aggregate to define the sub-region *METWEST*. The zones KH, DF, NY, and YO define the sub-region *METNORTH*. The sub-region *MIDTOWN* is the combination of zones YE, YS, and YB. The zones DN, DS, DE, DW and FC make up the *DOWNTOWN* sub-region variable. These variables indicate which parts of metro are the most prevalent locations for the particular activity being tested. Positive signs are hypothesized on *METNORTH* and *METWEST* for offices in manufacturing and transportation related activities. These activities require large amounts of industrial land and therefore are suburb orientated. Positive signs are hypothesized on *DOWNTOWN* for offices involved in financial and legal services.

Table 5.2
Office Industry Groupings

Professional Services Group
Accounting Firms
Advertising Agencies
Computer Services
Law Firms
Management Consultants
Media and Communication
Technical Services

Finance and Insurance and Real Estate Group
Financial Services
Insurance Agencies
Real Estate Agencies
Other Business Services

Industrial Services Group
Manufacturing
Trade
Transportation Services

Health Services Group
Doctors, Physicians and Dentists
Other Health Services
Health Services

Personal Services Group
Photographers and Graphic Artists
Travel Agencies
Personnel Services

Miscellaneous Group
Government Agencies
Associations

Each office activity is modelled separately. The activities are grouped according to the general office industry classification shown in Table 5.2.

5.5 Results

The logit results are presented in Table 5.3 (on pages 159 and 160) for each industry. Beta coefficients are obtained by the maximum liklihood method using LIMDEP software (for a description of the software see section 3.5). Coefficients without brackets are significant at the 1 - 2 percent level. Coefficients in brackets are significant at the 3 - 5 percent level. The modelling procedure was conducted as follows. A series of models were specified and tested for each individual office activity type. Specifications were designed to capture the main hypothesized effects described in the previous section. Each specification tried to include the effects of at least two of three variables including: *RENT*, *FINDIS* and *INVENT* - the variable capturing a zones size in terms of total office floorspace. These variables were chosen because of their theoretical significance in office location studies. Results for *RENT* and/or *FINDIS* will determine a downtown or suburban location. The results for *INVENT* will determine the particular office activity's utility for a zones size in terms of total office floorspace. Other explanatory variables were individually added to the specification and tested. Uncorrelated variables were kept in the specifications and the procedure continued. Each model provided a correlation matrix which was consulted to observe if possible correlations existed between variables. In other words, if a variable was found to be correlated with another then that variable was discarded and the model respecified. The threshold value of the correlation coefficient was 0.8. Other variables were tested and some

	CONSTANT	MALLDIS	HWYDIS	FINDIS	AIRDIS	METWEST	METNORTH	MIDTOWN	DOWNTOWN	SHOP	TRANS	OFFPARK	RENT
Professional Services Group													
Accounting	-4.9296			1.42E-04		1.4439							
Advertising Agencies	-3.5882			(-1.12E-04)				1.2701					
Computer Services	-16.225			2.56E-04					1.5773				(-0.13357)
Law Firms	-7.1298								0.89763	-0.62796			(0.072238)
Management Consultants	-2.7725	(-1.98E-04)							-0.76155				
Media and Communication	-1.3657	2.66E-04		-1.924E-05		(0.70562)							-0.11327
Technical Services	(1.0124)			(9.661E-05)							(-83944)		
Finance and Insurance Group													
Financial Services	5.6129			-2.15E-04	-1.91E-04	-1.8754							
Insurance Agencies	-10.113			1.31E-04			2.0458			1.5528			
Other Business Services	(.27766)			-1.26E-04								-0.7361	
Industrial Services Group													
Manufacturing	-8.3807				(-7.15E-04)		1.6355						0.3672
Trade	3.1515				-5.449E-05		1.3982						(-0.094438)
Transportation Services	(-0.44642)				-9.664E-05								
Health Services Group													
Doctors, Physicians & Dentists	-6.7478		2.78E-04	8.93E-05									-9.12E-02
Health Services	-7.1797										2.624		-6.05E-02
Other Health Services	-4.3194							(-0.86709)					-9.96E-02
Personal Services Group													
Photographers and Graphic Artists	4.2946			-1.37E-04	3.44E-05								-0.26572
Travel Agencies	4.8273			-3.04E-04	-6.58E-05								
Personnel Services	-3.3933			-1.25E-04									
Miscellaneous Group													
Associations	-3.2114			-9.25E-05		0.99271					1.8855		(-6.17E-02)
Government Agencies	(1.4388)			-4.58E-04			(1.5421)						-0.26714

Coefficients in ( ) 3 - 5 percent significance level
Coefficients with no brackets 1 - 2 percent significance level

Table 5.3 Logit Estimation Results of New Office Firm Location

	PARKING	INVENT	ABSORP	VSPACE	VRATE	MANAGE	CLERICAL	SERVICE	*EMPLOY*	AMENITY	POOR	WEALTH	INDUSE	CHI-SQUARED	RHO-SQUARED
Professional Services Group															
Accounting		1.2967E-07	-1.25E-05	1.5095E-06	-9.2284									51.43811	0.117
Advertising Agencies		5.9842E-08										6.41E-05		19.94248	0.0743
Computer Services		1.3635E-07	-4.08E-06		10.574			0.26832				4.47E-05	5.6447	65.16966	0.0915
Law Firms		7.1272E-08		1.7759E-07	8.5009							5.66E-05		66.50463	0.0699
Management Consultants		(3.3715E-08)												13.52181	0.0168
Media and Communication		(2.9036E-08)	1.59E-06									5.07E-05		88.76085	0.1125
Technical Services				2.9114E-07	6.6332	-0.1728								34.65083	0.0806
Finance and Insurance Group															
Financial Services		1.07E-07							0.07201	0.55202		8.65E-04		88.02139	0.0962
Insurance Agencies		1.25E-07			16.62									38.64083	0.1584
Other Business Services		6.44E-08	1.56E-06			-5.63E-02			(-0.24704)			4.11E-05		98.00297	0.0955
Industrial Services Group															
Manufacturing	-0.031166		4.96E-06										10.085	50.97503	0.2021
Trade	0.016472							-0.47325	-1.8911	0.89705	1.73E-04			100.3587	0.1294
Transportation Services				3.9117E-07					-0.96525			(-1.03E-04)	3.5467	49.17581	0.1611
Health Services Group															
Doctors, Physicians & Dentists								0.20431	0.27097			4.14E-05		62.56672	0.0926
Health Services		(-.318E-07)	(.624E-06)		3.904				0.29385			4.85E-05		133.3341	0.0552
Other Health Services				1.82E-07					1.7108	0.22409		5.71E-05		78.5745	0.0939
Personal Services Group															
Photographers and Graphic Artists		2.86E-07	-5.21E-06						4.7262	0.79029			-5.8779	251.1944	0.1759
Travel Agencies		1.89E-07							(6.3695)	1.4535		7.01E-05		61.19016	0.163
Personnel Services		4.73E-08		(1.549E-06)								5.43E-05		39.78228	0.1254
Miscellaneous Group															
Associations														26.48358	0.0628
Government Agencies		3.51E-07			16.096					-0.68511		-13.057		41.14141	0.1632

Coefficients in ( ) 3 - 5 percent significance level
Coefficients with no brackets 1 - 2 percent significance level
rho squared = 1 - (L(β) / L(0))

Table 5.3 con't Logit Estimation Results of New Office Firm Location

proved to be statistically significant when either *RENT*, *FINDIS* or *INVENT* were not included in the specification. Therefore it is important to note that results not appearing for some variables in Table 5.3 are not necessarily insignificant determinants of office location. These variables are probably correlated with either *RENT*, *FINDIS* or *INVENT* or any combination of the three and when tested separately may prove to be statistically significant. Specifications were experimented with for individual office industries until the most significant fit was achieved. A constant term was included in each specification to capture any effects not otherwise captured by the independent variables and to increase the fit of the model. Model significance is based on the chi-square statistic, which is provided in the output by LIMDEP, and a calculated rho-squared statistic. Therefore specifications were tested until a combination of variables produced the highest chi-square and rho-square values. Chi-squared values are shown in the second to last column of Table 5.3 and rho-square values are shown in the last column in Table 5.3. The results are discussed by individual activity type beginning with the professional services group.

5.5.1 Professional Services Group

Accounting Firms

For accounting firms, six variables were significant at the 1 - 2 percent level. These variables include *FINDIS*, *METWEST*, *INVENT*, *ABSORP*, *VSPACE* and *VRATE*. Positive signs on *FINDIS* and *METWEST* indicate that new accounting firms have a high utility for locating outside the Financial Core and in Metro West. Map 1 in Appendix One also illustrates locations in Metro North. These locations are consistent with studies conducted by Gad (1985), Matthew (1993), Huang (1989), and Metro Planning (1992). Positive signs for *INVENT* and *VSPACE* indicate a utility for locating in areas with large amounts of office floor space. Negative signs on *ABSORP* and *VRATE* were unexpected. This indicates that accounting firms have a utility for well established areas such as Toronto West. Studies have shown that since 1981 North York's downtown had an above average proportion of establishments in accounting (Huang, 1989, Matthew, 1993, Metro Planning, 1992). Vacancy rates of class A inventory in Metro West fell as a result of improvements in the market, therefore attracting new accounting firms. Furthermore, based on the bivariate K function results of Chapter Four, accounting firms interact with offices of manufacturing and trade services which both have high utilities for locating in Metro North and Metro West. Eleven of Canada's fourteen public accounting head offices are located in the Financial Core or Downtown North (Metro Planning, 1992). Recently however, the location of accounting firms has been occurring in suburban downtowns or office parks rather than the traditional locations of the Financial Core. According to Gad (1985), this activity has a very low intensity of face-to-face contacts with meeting partners which supports its decision for a decentralized location.

Advertising Agencies

Significant locational variables for advertising agencies include *FINDIS*, *MIDTOWN*, *INVENT*, and *WEALTH*. Advertising agencies have high utilities for locating in the financial district and in wealthy areas within midtown Toronto. Vahaly, (1976) and Gad, (1985) explained that advertising agencies have found Midtown convenient for maintaining their production and linkages and for access to clients such as media and communication. As was found in Chapter Four, strong linkages exists between advertising agencies and offices involved in media and communications. These advertising and media networks have also been found in the Downtown West area by Gad (1985) and Huang (1989). These types of activities look for cheaper space in older and smaller buildings. They also desire to occupy buildings whose image they can control. Midtown is prestigious and is surrounded by wealthy residential areas such as Rosedale and Davisville to the east and Foresthill and the Annex to the west.

Computer Services

Coefficients for *FINDIS, DOWNTOWN, INVENT, VRATE, SERVICE, WEALTH* and *INDUSE* are positive at the 1 - 2 percent level. *RENT* negative at the 3 - 5 percent level and *ABSORP* is negative at the 1 - 2 percent level. Computer services have a high utility for locating close to the Financial District. As well, locational utility is high in suburban areas (see Map 5 in Appendix One). The signs on *RENT, ABSORP, VRATE* and *INDUSE* indicate a preference for lower rent costs and perhaps less prestigious areas. In fact, Gad (1985) and others found that these types of activities locate in office parks such as Consumers Road, that have lower rents than the central district sub-areas. The locational choices of these types of firms can be attributed to sizeable land requirements for plants, shipping and receiving of supplies, accessibility to labour markets and close proximity to customers. One of the main functions of computer services is to provide support for other office activities. The positive sign on *SERVICE* indicates a high utility for locating in proximity to staff. A utility for wealthy areas is explained by this activity's central locations. According to the results in Chapter Four, computer services locate near financial services and law firms which are generally located in proximity to the financial core.

Law Firms

Variables found positive and significant at the 1 - 2 percent level include *DOWNTOWN*, *INVENT*, *VSPACE*, *VRATE* and *WEALTH*. *RENT* was positive and significant at the 3 - 5 percent level. *SHOP* was negative and significant at the 1 - 2 percent level. Past studies have shown that law firms represent over 25 percent of total employment in downtown zone (Metro Planning, 1992). The positive sign on *DOWNTOWN* is indicative of this. This concentration is due to the presence of many inputs required for the operation of a legal service including access to printing facilities, metropolitan courthouses, law libraries and other downtown facilities. In addition there are important output linkages with business and financial activities, especially banking, which require a downtown location. Bivariate K function results from the previous chapter support these facts. The positive signs on *RENT* and *WEALTH* indicate a utility for prestigious areas such as those found downtown. This makes sense since it is the financial community who largely use legal services. *SHOP* is negative indicating that lawyers have a disutility for locating near congested shopping facilities.

Management Consultants

INVENT is positive and significant at the 1 - 2 percent level. *MALLDIS* is negative at the 3 - 5 percent level and *DOWNTOWN* is negative at the 1 - 2 percent level. Management Consultants have a disutility for locating downtown. This activity has a high utility for locating close to shopping centres and in built-up suburban office centres. A possible explanation for a non-downtown location is that these services prefer sites that are accessible to services such as accounting, advertising agencies, manufacturing and health services. As indicated by the results in Chapter Four, Gad (1985), Huang (1989) and Matthew (1993) found that these services predominantly locate in the Consumers Road and Duncan Mills office parks as well as in the Dufferin/Finch zone. These trends are also evident by the point locations illustrated on Map 10 in Appendix One.

Media and Communication

Significant variables include *MALLDIS*, *FINDIS*, *METWEST*, *RENT*, *INVENT*, *ABSORP* and *WEALTH*. *FINDIS* is negative and statistically significant at the 1 - 2 percent level, and *METWEST* is statistically significant at the 3 - 5 percent level. This variable indicates that media and communication services have a high utility for locations within the Downtown zone, predominantly Downtown West as well as in Metro West. The Metro West locations are predominantly in Toronto West in the entertainment district. These areas are characteristic of radio, television and film studios including the CBC. The negative sign on the *RENT* variable indicates that these services prefer less prestigious lower rent areas for location. The positive signs on *INVENT* and *ABSORP* indicate that these activities have a high utility for pre-established office districts that are undergoing growth periods. As mentioned earlier, media and communications have strong interactions with advertising agencies which are located in wealthy residential areas, hence the positive sign on *WEALTH*. The positive and statistically significant sign on *MALLDIS* indicates a disutility to locating near malls. One reason for this might be that malls are associated with high levels of traffic congestion and are located in areas that are less suitable for the types of services that these activities provide.

Technical Services

The variable *FINDIS* is positive and significant at the 3 - 5 percent level. This indicates that technical services prefer less central locations. Results from the previous chapter indicate that technical services interact with manufacturing, trade and computer services which all have predominantly suburban locations, in the Dufferin/Finch zone, Duncan Mills and Consumers Road zones. The *TRANS* variable is negative and significant at the 3 - 5 percent level. This is understandable in that the suburban locations mentioned above do not have many commuter rail stations. Furthermore, the suburban locations mentioned above are mostly located in close proximity to major highways suggesting that these office nodes are automobile oriented. The positive signs on the *VSPACE* and *VRATE* variables indicate that these activities have a utility for well developed areas that are not as desireable for location as are the downtown zones. *MANAGE* was negative indicating that these activities do not locate near residential areas which is consistent with the above findings.

5.5.2 Finance, Insurance and Real Estate Group

Financial Services

Significant variables for financial services include *FINDIS*, *AIRDIS*, *METWEST*, *INVENT*, *EMPLOY*, *AMENITY* and *WEALTH*. *FINDIS* and *METWEST* are negative and significant at the 3 - 5 percent level indicating the predominantly centralized location. This is consistent with the observations of Vahaly (1976), Gad (1985), Huang (1989), Metro Planning (1992). This is also supported by the findings of Chapter Four where strong interactions were found between financial services and law firms - also centrally located. The negative sign on *AIRDIS* indicates a utility for locating near Pearson International Airport. This is due to the fact that frequent business trips are faced by many employees in this activity. These activities also have utilities for locating in prestigious areas that contain amenities. Amenities include access to restaurants and entertainment that are frequently used for business lunches and customer relations. Added benefits in theory will maximize employee utility thereby minimizing labour costs. A positive sign on *EMPLOY* and *INVENT* indicates the utility of localization economies when locating in an area that has a well established financial infrastructure.

Insurance Agencies

Traditionally, the locations of insurance agencies were more centralized in the Financial Core and Midtown zones. The results for insurance agencies show a disutility for locating near the financial district and imply a general trend in locating in Metro North. This is supported further by the results found in Chapter Four and the point locations on Map 9 in Appendix One. The bivariate K function results show that there is significant interaction among insurance agencies and manufacturing as well as trade services which both have predominant locations in Metro North, particularly the Dufferin/Finch zone. Reasons for this general trend maybe explained by the *INVENT* and *VRATE* variables. Insurance agencies are locating in less prestigious low rent areas where new developments are being proposed, thereby establishing themselves to meet future demand. The *SHOP* variable is positive indicating that shopping malls are important in location decisions. Suburban locations do not offer the level of amenities that are traditionally found in central locations. Therefore to maintain employee satisfaction, locations near malls are considered. As well, insurance agencies mostly conduct business with households which frequently visit shopping centres. Location near these facilities may increase clientele.

Real Estate Agents

The variables tested for this activity were insignificant at all levels. However, observing the point locations on Map 15, it is evident that new real estate agencies predominantly locate in the Midtown, Don Mills, Duncan Mills and Consumers Road zones. Other locations are dispersed throughout western metropolitan Toronto including the Airport zone. The results in Chapter Four further support these findings. The bivariate K function results show that real estate agents interact with technical and manufacturing services which are dominant in Metro North and airport locations. Real estate offices did not locate in Scarborough in 1995. The relatively dispersed nature of this activity is explained by the fact that real estate agents are neighbourhood oriented. It is important that these services have accessibility to the general population. Furthermore, real estate services are provided more frequently to people with higher incomes. This is evident in the predominant Midtown locations illustrated on Map 15 in Appendix One.

Other Business Services

Significant variables for other business services include *FINDIS*, *OFFPARK*, *INVENT*, *ABSORP*, *MANAGE*, *EMPLOY* and *WEALTH*. Negative signs for *FINDIS* and *OFFPARK* indicate that these services have a locational disutility for office parks and a locational utility for areas proximal to the financial district. Positive signs on *INVENT*, *ABSORP* and *WEALTH* also imply locational utility for well developed office infrastructure. Negative signs on *MANAGE* and *EMPLOY* point to non-traditional location patterns. This can be viewed graphically via Map 14 in Appendix One. This point map illustrates the diverse locational patterns of this activity. A main cluster exists in the Midtown and Downtown zones. However, secondary clusters are evident in the Airport and Dufferin/Finch zones. Other sub-clusters are found in the North Yonge, Consumers Road, Don Mills and Bloor\Islington zones. This diversity is the result of a collection of different locational preferences (investigation services, janitorial and maintenance, etc.).

5.5.3 Industrial Services Group

Manufacturing Services

Positive significant variables for manufacturing offices include *METNORTH*, *RENT*, *ABSORP* and *INDUSE*. Negative significant variables include *AIRDIS* and *PARKING*.

Manufacturing offices maximize utility by locating in Metro North and in proximity to Pearson International Airport. Previous studies have shown that these activities have traditionally located in the Don Mills and Scarborough zones (Gad 1985, Metro Planning 1992). The general trend in the mid 1990's has been to locate in growing mixed use areas such as the Dufferin/Finch and Airport zones where proximity to the airport is an advantage. This is illustrated by the point locations on Map 13 in Appendix One. The positive sign on *RENT* reflects the fact that manufacturing land use is space intensive and the supply of land may be limited causing rents to increase. Another explanation may be that the cities in question are increasing property taxes to limit industrial development. Another reason may be that zoning restrictions have been put in place that constrain these industrial areas to certain types of uses. Consequently, these restrictions may drive rent price higher. The negative sign on *PARKING* indicates that parking facilities are an important locating factor for manufacturing offices. This makes sense since this activity is suburban oriented with marginal access to rapid rail transit. The positive and statistically significant result of *INDUSE* further supports the findings of Peddle (1988:1990) in that office firms in light industries are the most likely candidates to locate in industrial parks that have distinct attributes that appeal to those types of firms.

<u>Trade Services</u>

Similar to manufacturing, significant locational variables for trade services include *AIRDIS*, *METNORTH*, *RENT*, *PARKING*, *SERVICE*, *EMPLOY*, *AMENITY* and *POOR*. Earlier studies of office location in Toronto found trade services to be concentrated in the

Financial Core (Gad, 1985). The results here indicate new locational patterns of trade services occurring away from the central area and into the suburbs (see Map 18, Appendix One). The variable *EMPLOY* is evidence of the phenomenon. *EMPLOY* is negative and statistically significant at the 1 - 2 percent level indicating that these activities are beginning to locate away from the central area. Like manufacturing offices, offices involved in trade services maximize utility by locating in Metro North and in proximity to Pearson International Airport. Furthermore, they also enjoy agglomeration economies with manufacturing and transportation services as evidenced by the results in Chapter Four. The negative sign on *RENT* indicates a preference for less prestigious lower rent areas such as those located in Scarborough, South Etobicoke and areas along highway 401 (see Map 18). An explanation for this is that the predominant nature of these services is warehousing which locate in more traditional industrial areas and since these services are space-intensive they need to economize on rent. This rationale is supported by the positive and significant variable *POOR*. Most low income census tracts are located in proximity to traditional industrial land use. Logically, the negative sign on *SERVICE* results from this relationship. Finally the sign on *AMENITY* is positive and significant indicating that it is an important factor for manufacturing worker utility and therefore, in theory, lowering labour costs.

Transportation Services

Traditional locations of transportation services have been in the Don Mills zone. However, they are now attracted to locations that are in proximity to Pearson International Airport. This is supported by the negative sign on *AIRDIS* and *EMPLOY* and the results found in Chapter Four. Transportation services interact with manufacturing and trade and therefore locate in close proximity to these activities. The negative sign on *WEALTH* along with the positive signs on *INDUSE* and *VSPACE* are consistent with the locational patterns of transportation services. Vacant space is the result of new developments under construction in the Airport zone.

5.5.4 Health Services Group

Doctors, Physicians, and Dentists

The spatial distribution of new physicians and doctors offices is shown on Map 1 in Appendix Two. Significant variables determining location decisions include *HWYDIS*, *FINDIS*, *RENT*, *EMPLOY*, *SERVICE* and *WEALTH*. Positive significant signs on *HWYDIS* and *FINDIS* indicate locations away from the downtown and away from major highways. Explanations for these patterns are provided by Mattingly (1991). He found that the exodus of physicians from traditional central areas was occurring due to inadequate access for patients resulting from the growing dependance on automobiles. Offices in current clusters provide on-site parking and are specifically erected for the use of medical personnel. The negative sign on *RENT* also indicates utility for non-downtown locations and therefore in areas where rents are lower. Positive signs on *WEALTH* and *SERVICE* indicate locations in proximity to wealthy residential areas. Previous studies have also found similar trends (Vahaly, 1970). Finally, the positive sign on *EMPLOY* indicates a utility to locate in proximity to services involved in the same activity. This is justified by the fact that specialization in medicine is increasing the need for consultations with other physicians and dentists.

Other Health Services

This activity includes the services of opticians, optometrists, chiropractors, radiologists and medical lab technicians. The distribution of Other Health Service offices is shown on Map 2 of Appendix Two. These services also have less centralized location patterns. The negative sign on *MIDTOWN* and *RENT* indicates the utility for peripheral locations with lower rental prices. These services are predominantly a business type, whose clients are not represented in the downtown core. Positive signs on *AMENITY* and *WEALTH* imply that these activities are not core oriented and locate near wealthy worker residences which by nature contain high levels of amenities. Positive signs on *VSPACE* and *EMPLOY* indicate that these services have a high utility for locating in well developed areas which are also in proximity to offices involved in the same activities. These locational patterns promote consultation activity.

Health Services

Health services, an aggregate category formed by combining doctors, physicians and dentists with other health services as described above. The distribution of all health services is shown on Map 8 in Appendix One. The negative sign on *INVENT* was not expected. This indicates a utility for a more population oriented location pattern attained by locating near densly populated residential areas which is consistent with this activity. The positive sign on

WEALTH supports the fact that these services prefer locations in wealthy residential areas. The positive sign on *TRANS* indicates a utility for access to subway stations. This locational factor is important when considering elderly clientele that do not have access to automobiles. In general, health services have utility for less centralized areas where rent is considerably lower. This is supported by the results in Chapter Four. Health services interact and locate in proximity to less centralized activities such as management consultants, accounting firms and insurance offices. The positive sign on *EMPLOY*, *ABSORP* and *VRATE* indicate utility for locating and developing areas which are in close proximity to other health services-a trend observed throughout this industry.

5.5.5 Personal Services Group

Photographers and Graphic Artists

The significance of the variables *FINDIS*, *RENT*, *INVENT* and *ABSORP* indicate a utility for a more established centralized location that is not as prestigious as areas found within the financial district. Map 3 in Appendix One illustrates the distribution patterns of these activities. The significance of *EMPLOY* indicates that these activities cluster in the entertainment and media district located at the southern end of TorontoWest and Downtown West where rents are not as high. Smaller clusters are beginning to locate at the Airport, Consumers Road, Highway 404 and Don Mills zones. Access to the airport and locations within industrial areas are not significant factors for location for this industry. These services generally require access to potential high-end customers such as advertising agencies and the media which do not locate in traditional industrial areas. The significance of the variables

AMENITY and *INDUSE* indicate that they prefer areas that are rich in amenities such as those found in the entertainment and media district.

Travel Agencies

Travel agencies locate in proximity to the Financial Core as evidenced by the negative sign on *FINDIS*. These activities also prefer locations in proximity to the airport as evidenced by the negative sign on *AIRDIS*. Map 20 in Appendix One illustrates these locational patterns are evident along Yonge Street running north and Bloor Street running west. The positive signs on *INVENT*, *EMPLOY*, *AMENITY* and *WEALTH* indicate a utility for locating in wealthy well-developed areas which contain other travel agencies. These locations offer an abundant supply of wealthy business persons and families who take frequent trips and vacations.

Personnel Services

The negative significant sign on *FINDIS* indicates employment services have a high utility for locating in proximity to the financial district. Map 16 illustrates this fact. These services prefer locating in a well developed office infrastructure as evidenced by the positive signs on *INVENT* and *VSPACE*. The positive sign on *WEALTH* makes sense because it is the wealthy that will use these particular services.

5.5.6 Miscellaneous Group

Government Services

A study of employment trends conducted by Metro Planning found that the government related office activities made up 46 percent of total office employment in the central area outside the financial district (Metro Planning, 1992). As well, government employment was the largest single activity in North York accounting for between 25 percent and 36 percent of all office workers (Metro Planning 1992). This study also illustrated that government employees made up a large share of office employment at the Yonge/St. Clair zone. Similar conclusions can be made from the results of this study. The negative significant sign on *FINDIS* and positive significant sign on *METNORTH* indicates utilities for locations in mid-town and North Yonge zones. This may be due to the fact that various regional and municipal governments are found where incomes are high and locate at sites close to the residences of government workers. As well, metropolitan governments locate where they are relatively more accessible to the city's population. These zones are established office nodes whose rents are not as high as those found in the financial district. The negative sign on *AMENITY* indicates that this variable has a disutility among government offices. The distribution of new government offices is illustrated on Map 7 in Appendix One. New offices are also locating in peripheral areas such as the Highway 427 corridor in Etobicoke, the Don Mills office node adjacent to the Don Valley Parkway and other locations scattered in close proximity to highways. Locating near highways provides accessibility to Pearson International Airport. Federal and provincial government offices need access to the airport to maintain contacts with other areas of the country including the national capital.

Associations

Estimates for associations indicate a utility for location in proximity to the financial district as well as in Metro West where rents are not as high. The types of associations that might locate in the financial district may include business and professional associations. These types of associations require access to lawyers, real estate agents and various lending institutions. General civic associations, religious associations as well as labour associations may locate in areas outside of the central area near churches or factories employing union workers. Other associations such as the Royal Canadian Legion might locate in residential areas. Associations also have a high utility for locating near subway stations.

5.6 Summary and Conclusion

This chapter attempted to model the outcomes of firm location decisions in a discrete choice framework where spatial alternatives are real estate zones in metropolitan Toronto. The alternative zones are described by a set of distance, employment, land and accessibility attributes. The random utility theory guided the specification of a logit model, which was estimated separately for each new office activity type using data from metropolitan Toronto.

The results confirm that professional services are decentralizing. Offices are locating in suburban centers where new developments are being constructed. Predominant locational zones for these services include Dufferin/Finch , Consumers Road, Duncan Mills, North Yonge and the Highway 427 corridor. Activities such as law firms, computer services, technical services, management consultants and communications and media do locate in the downtown area but are now beginning to locate in suburban areas as well. The finance, insurance, and real estate services group have similar locational patterns. These groups have traditionally preferred locations in proximity to the financial district. However, these services are now beginning to locate in growing suburban areas which still maintain good accessibility to the financial district. As the city begins to expand to the north, these services will also locate in areas such as Metro North to meet the new demand. The industrial services group has high utility for access to the industrial lands to the north which also enjoy proximal locations to the airport. Dominant locational areas for these activities include Dufferin/Finch and Airport zones. Health services are neighbourhood oriented and therefore have a more dispersed locational pattern. These services tend to locate in wealthier areas that maintain a high level of amenities as well as access to public transit and other health oriented services. Personal services generally locate in central areas to take advantage of localization economies. However, as with the professional services group, these activities are beginning to locate in suburban areas such as Consumers Road, North Yonge and Toronto West. Government agencies and associations generally prefer central locations. Again, as with other activities, these services are locating in suburban locations.

The overall importance of the *RENT* variable indicates that new office firms are sensitive to rental rates. This variable partially determines the locational patterns of computer services, law firms, media and communications offices, manufacturing and trade offices, health services group, photographers and graphic artists and personal services group. With the exception of manufacturing offices and law firms, all other offices listed above displayed negative coefficients for rent indicating a utility for less central locations.

The variable *FINDIS* and the dummy variables *DOWNTOWN*, *MIDTOWN*, *METNORTH* and *METWEST* also helped partially explain location patterns in Toronto. Offices of advertising agents, media and communications, financial services, other business services, artists, travel agents, personal services, associations and government services all displayed an affinity for central locations mainly because these industries prefer the benefits of urbanization and localization economies.

The variables *AIRDIS* and *METWEST* were significant location variables for the industrial services group indicating that these industries prefer locations with ample supplies of land in less central locations.

The current pattern of offices in metropolitan Toronto indicate that they are locating in suburban centres to take advantage of the attributes that these centres provide. These centres have an ability to attract offices because of their good highway and public transit access to a variety of specific destinations such as the financial district, the airport and other research facilities. Finally, these centres provide the availability of appropriate office space, plentiful parking, moderate leasing costs, good client access, easy access to executives homes, convenient access to the homes of staff and a variety of good hospitality and amenity services.

CHAPTER SIX

CONCLUSION

6.1 Thesis Conclusions

This thesis sought to contribute to the office location literature by developing and testing a model to explain the intrametropolitan location of new office firms in metropolitan Toronto. The thesis began with a review of the recent studies that attempted to test the significance of office location factors. The results indicated that office firms depend on the availability of transportation infrastructure for contact with their clients and suppliers as well as providing efficient commuting for staff. Office firms prefer locating in clusters to take advantage of agglomeration economies. Amenities including the presence of shopping, restaurant, cultural and recreation facilities, prestige, good schools, avialability of research universities and quality of life are important attractors of firms. Firms are significantly deterred by high property taxes and prefer locations that command less rent. Finally, offices were found to locate in areas providing good local amenities, strong public transit systems, and in areas close to employees homes thereby lowering labour costs.

The primary interest of this thesis is concerned with identifying the patterns of office location in metropolitan Toronto and identifying the most significant factors contributing to a particular industry location. Chapter Four was designed to identify the locations of office clusters and test the significance of own-industry and inter-industry interaction. Methodology involved the use of spatial statistics on twenty different point patterns each representing a specific office indusry. The chapter introduced several methodologies each providing powerful graphical outputs. The kernel estimates illustrated the locational patterns and intensities of office activites. The K function modelled the significance of own-industry interaction. The bivariate K function modelled the significance of inter-industry interaction. The results for these techniques indicated a multi-nodal locational pattern scattered throughout distinct employment nodes in metropolitan Toronto. Own-industry clustering was significant for all industries suggesting the need for localization economies. Inter-industry clustering was significant for many groups of industries. In particular its was found that accounting firms are significantly attracted to the locations of law firms and financial services; computer services to accounting firms and law firms; amangement consultants and technical services to law firms. These results suggest that a prime locational factor for these industries may be the presence of agglomeration econeomies. This factor along with others was specifically tested for in Chapter Five.

Chapter Five presented and tested a model to explain the location of new office firms in Toronto. Secton 5.2 introduced the concepts of random utility theory which outlined the basis of a multinomial logit model. Section 5.3 developed an office location model that tested the significance of specific locational factors and ultimately explained the locational patterns of office activities in Toronto. The model defined a firms' locational decision as being motivated by maximizing its profits. Factors thought to influence a firms location included the price of office space (rent), also its avialability and size; the price of labour determined by a locations' accessibility to the homes of managers, professionals and support staff, the quality of the locations' surroundings affecting employee perceptions of safety, avialability of ample parking space and amenities such as the availability of shopping malls, restaurants and entertainment facilities; and the prices of face-to-face meetings with customers and suppliers determined by the proximity to the CBD, proximity to highways and expressways, proximity to the airport and rapid transit facilities. The prices of face-to-face meetings are also affected by taking advantage of agglomeration economies which decrease travelling distance and hence transportation costs.

The main findings of this thesis provide evidence in support of a polycentric structure common in most North American cities. However the results also support the findings of Huang (1989), Matthew (1993) and Coffey et. al. (1996) in that the locational patterns in Toronto are unlike those in American cities. Canadian cities especially Toronto, Montreal and Vancouver, rely heavily on public transportation which has the effect of continuing the vitality and liveability of the CBD's of these cities. As a result Canadian CBD's will remain strong office centres. New offices in Toronto are locating in the CBD and also in peripheral suburban office centres and nodes indicating that these centres are attracting CBD type offices. The professional services group is beginning to locate in subruban centres and parks. Accounting firms, computer services, technical services, law firms, insurance agencies and financial services do locate in the central area but are now also locating in suburban areas. The results from Chapter Four indicate inter-industry clustering among these activities further supporting a locational trend toward less central locations. The industrial services group have a utility for spacious locations near the airport and locate near other similar activities, as evidenced in the findings of Chapter Four, indicating a utility for localization economies. The health services group have a disutility for central locations that command high rents. These services have an affinity for locations in high income residential areas. The central area still maintains a strong representation of traditional office activities and will continue to attract new businesses. However, as the peripheral centres grow they begin to resemble and demonstrate the qualities possessed by traditional CBD's and hence begin to form suburban downtowns as they attract more professional CBD type activities.

6.2 Planning and Policy Implications

In exploring the factors which induce office establishments to locate in specific suburban or central concentrations, this study's findings seem to support some established planning standards, as well as to indicate some useful guidelines for future attempts to create office centres and parks.

Convenient and fast all-directional access is a critical factor in location decisions of office establishments. One of the routes should lead to the metropolitan CBD, and it may be either a highway or a rapid transit line, provided that the latter's convenience and speed are comparable to automobile travel. Therefore, success in any attempt to create a major mixed-use or office cnetre will depend upon locating it at, or very near to, the intersection of a circumferential or cross-town highway and some major radial route, either a highway or a rapid transit line. If regional plans seek to encourage transit use and discourage auto congestion, they should emphasize densely developed clusters at transit stations. Finally, it is also important to locate office centres so as to capitalize on the advantages of good highway links to other key destinations such as the airport.

The availability of suitable office space and the cost of obtaining that space can influence the final choice between different locations. Therefore it is desirable that an office centre should contain a choice of types of office space, within a suitable range of rental rates, and in a variety of office buildings types and sizes.

Incentives to establish and operate a variety of restaurants, pubs, shopping and entertainment facilities may pay dividends in enhancing sastisfaction levels, and thus the image of office centres. This may be influential in retaining the establishments that locate in the centre initially and may attract new establishments considering that particular centre.

Many small to medium-sized office establishments can be attracted to centres which have convenient access to housing suitable for executives, managers and support staff. This factor may influence the final choice of location for a new office centre, depending on whether its is intended to attract small offices or large branch offices.

6.3 Directions for Future Research

This research was unique for several reasons. First it examined the locations of new profit maximizing firms. Secondly, the thesis studied the locations of offices disaggregated by industry which provided a more accurate description of locational behaviour of certain firms. Thirdly, the study utilized powerful spatial statistical methodologies to determine the presence and significance of office clusters and interactions. Statistical models also analyzed the significance of the factors that influence office location. Finally, the study was unique in that it has never been attempted for metropolitan Toronto or any other Canadian city.

Many issues for further investigation are evident from this thesis. The methodologies used in this thesis may be applied to new office locations in a broader geographical area over a longer period of time. With the recent construction of the new Highway 407, studying new office location in the Toronto (CMA) over a five year period may provide a better understanding of the locational behaviour among industries. It may be of interest to conduct a logit analysis by constructing specific variables to determine their significance. For example, constructing and testing the significance of a richer set of amenity variables may aid researchers, planners, developers and policymakers in developing specialized office centres or improving the quality of existing ones. Conducting a nested logit analysis may provide a more accurate depiction of office location choice. This type of analysis should be attempted by nesting the downtown zones (and/or similar zones) of a metropolitan area to form a one level nest. Furthermore, utilizing a nested logit model remedies possible IIA violations thereby enhancing and strengthening coefficient estimates. Spatial statistical techniques utilized in this study may be applied to office location studies in other North American and European cities. Finally, it may be of interest for other researchers to conduct this type of analysis for specific activities in the high-tech or research and development industries.

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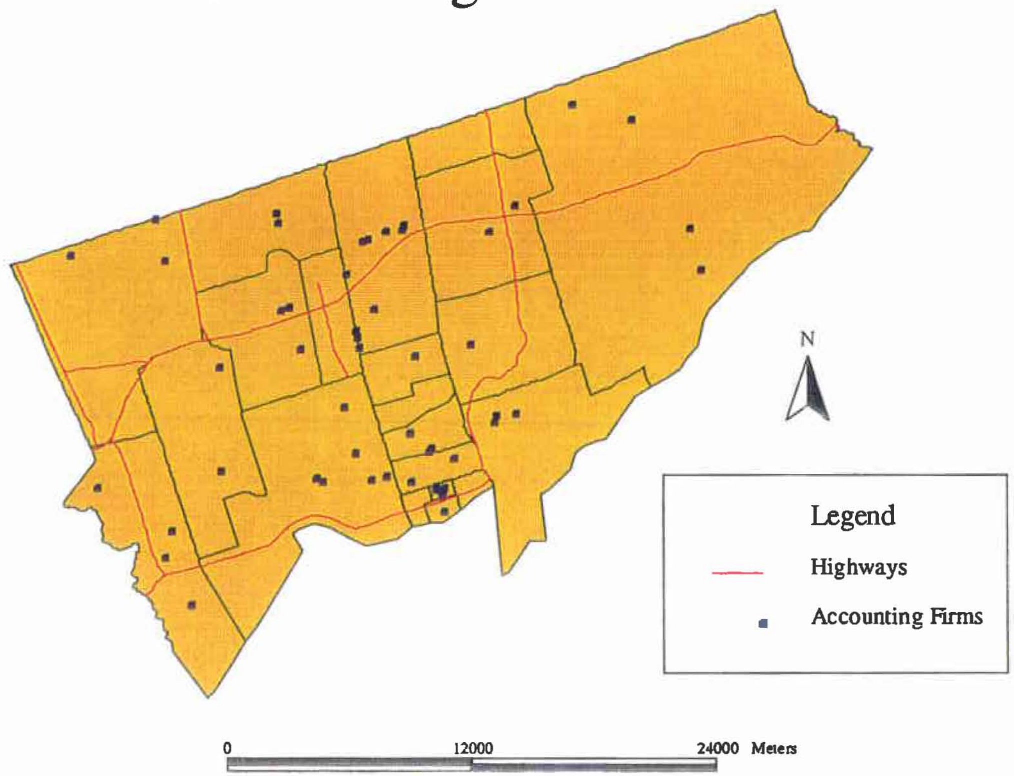
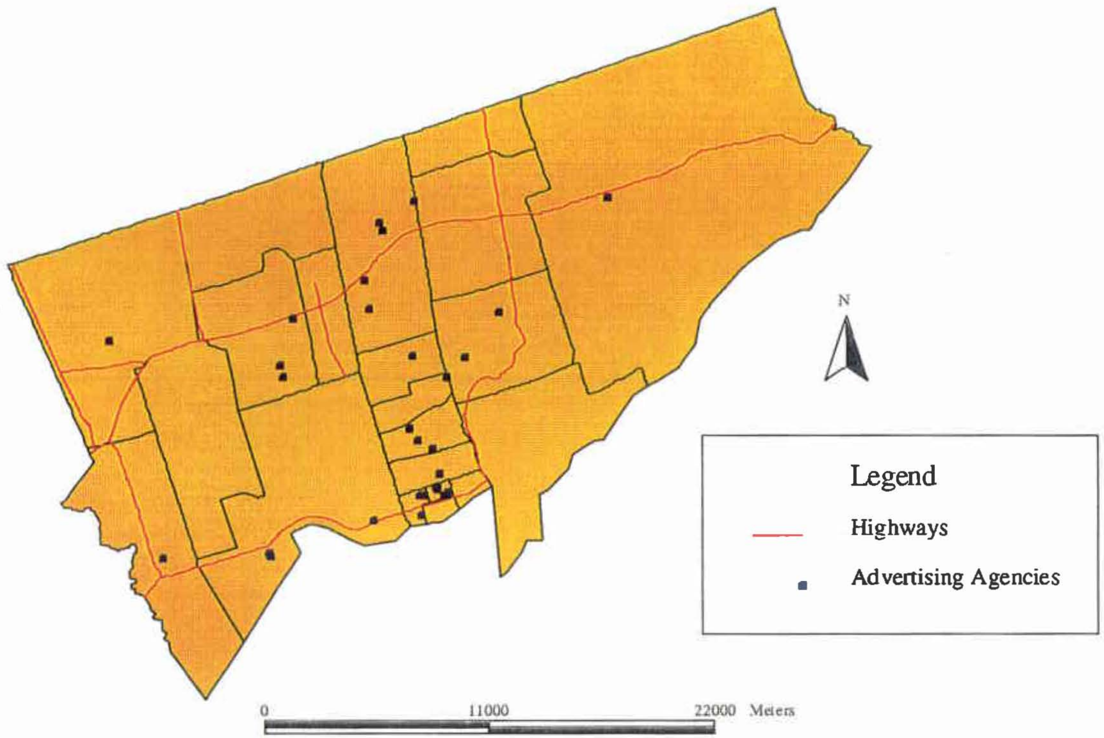
APPENDIX ONE

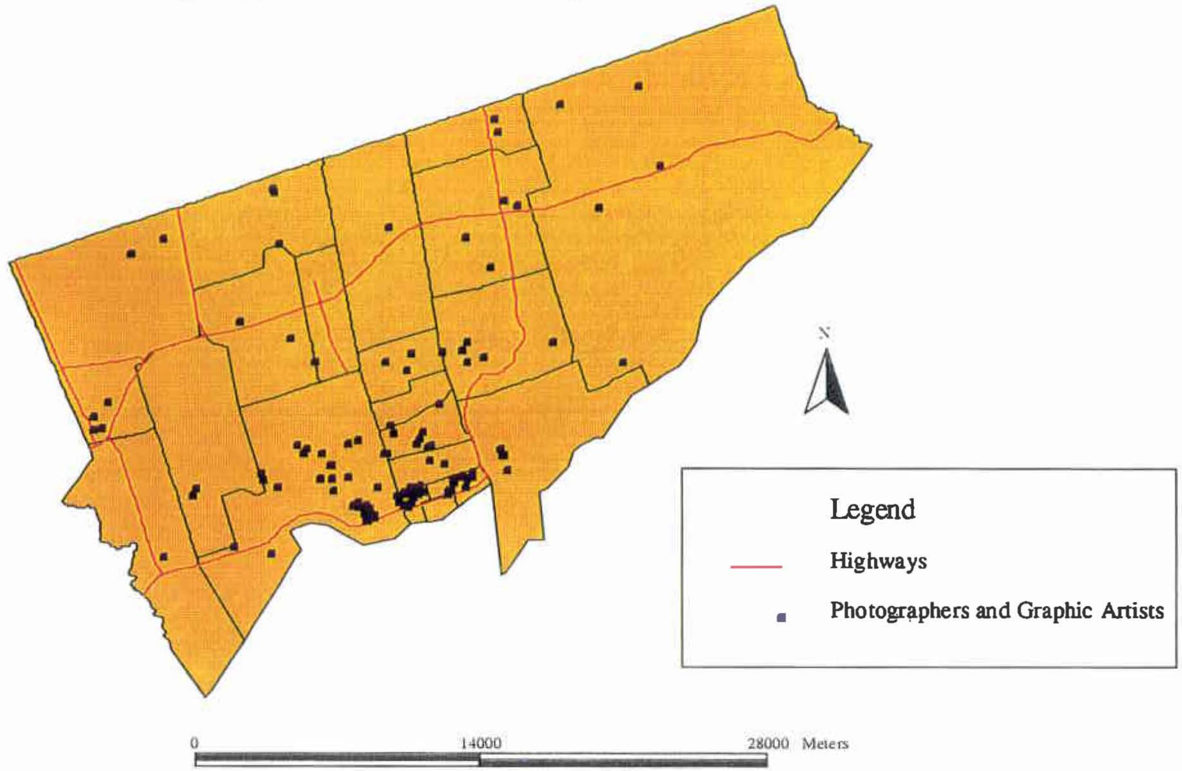
Map 1
Accounting Firms



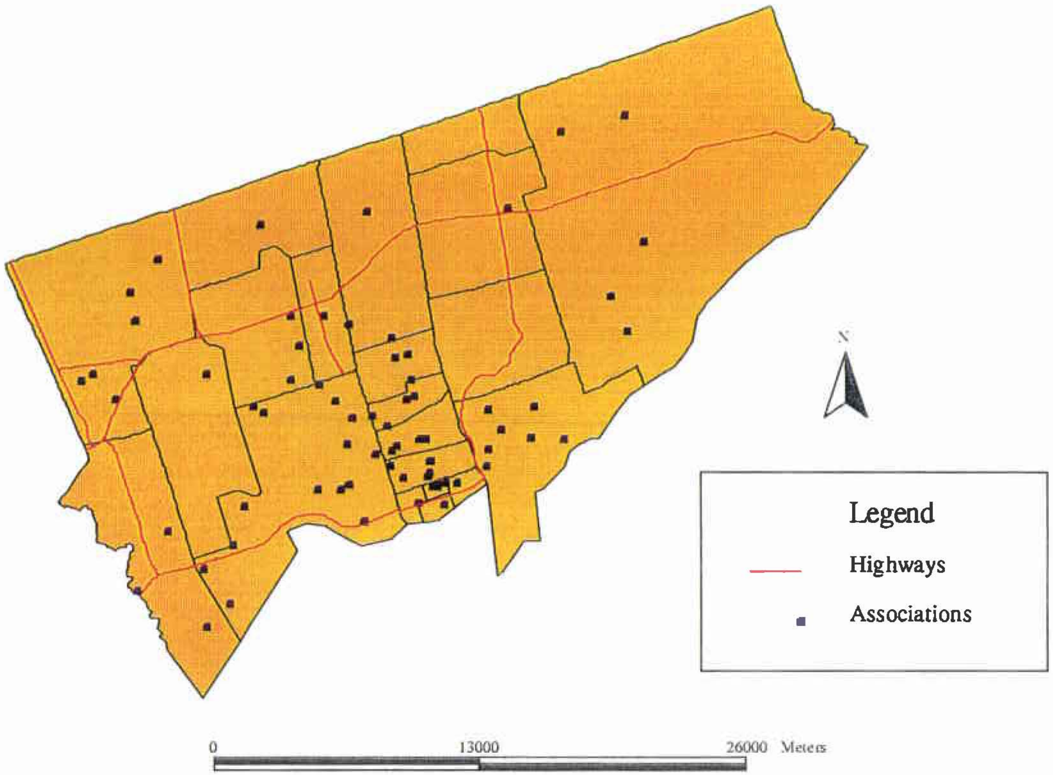
Map 2
Advertising Agencies



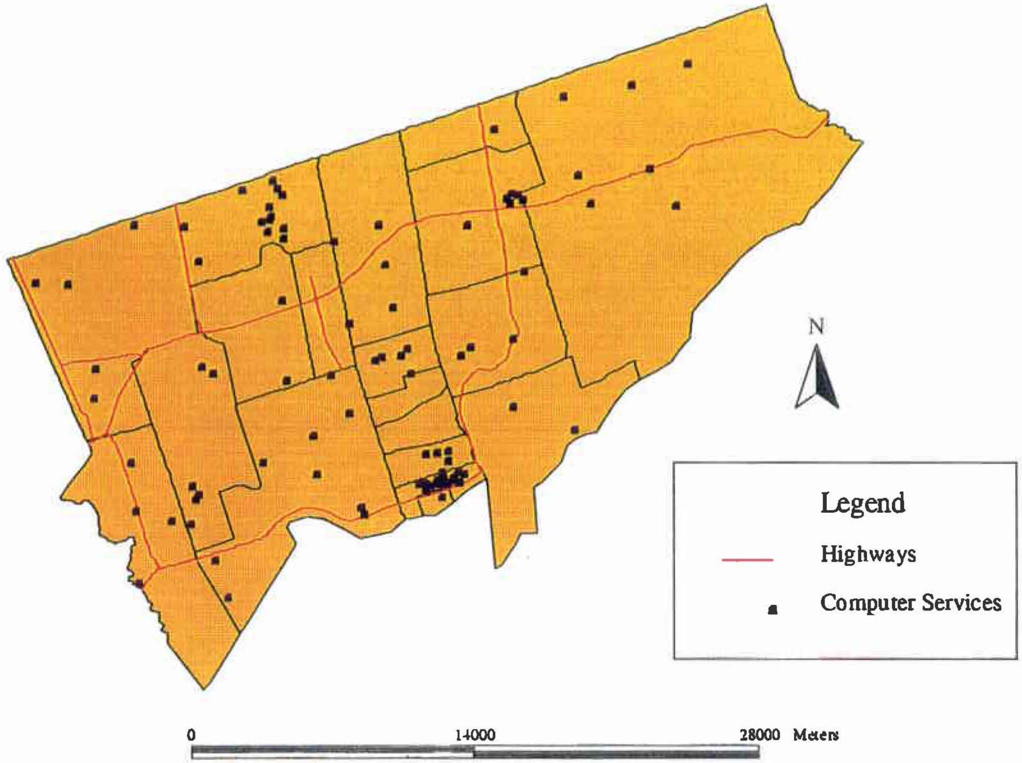
Map 3
Photographers and Graphic Artists



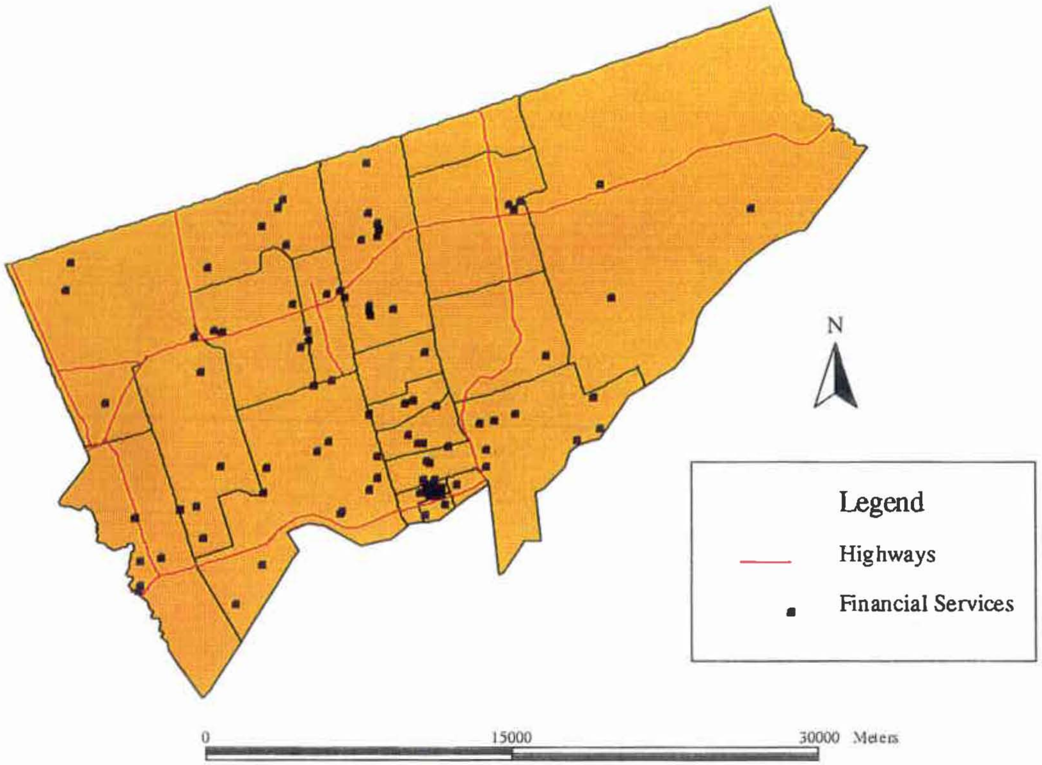
Map 4
Associations



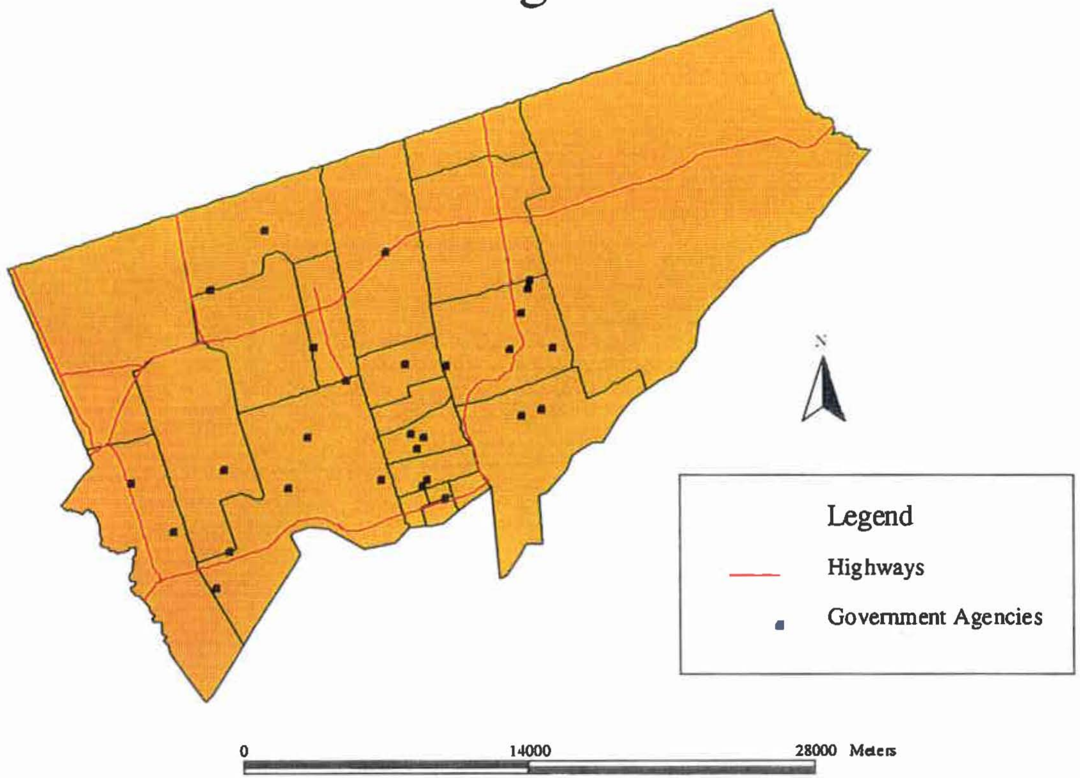
Map 5
Computer Services



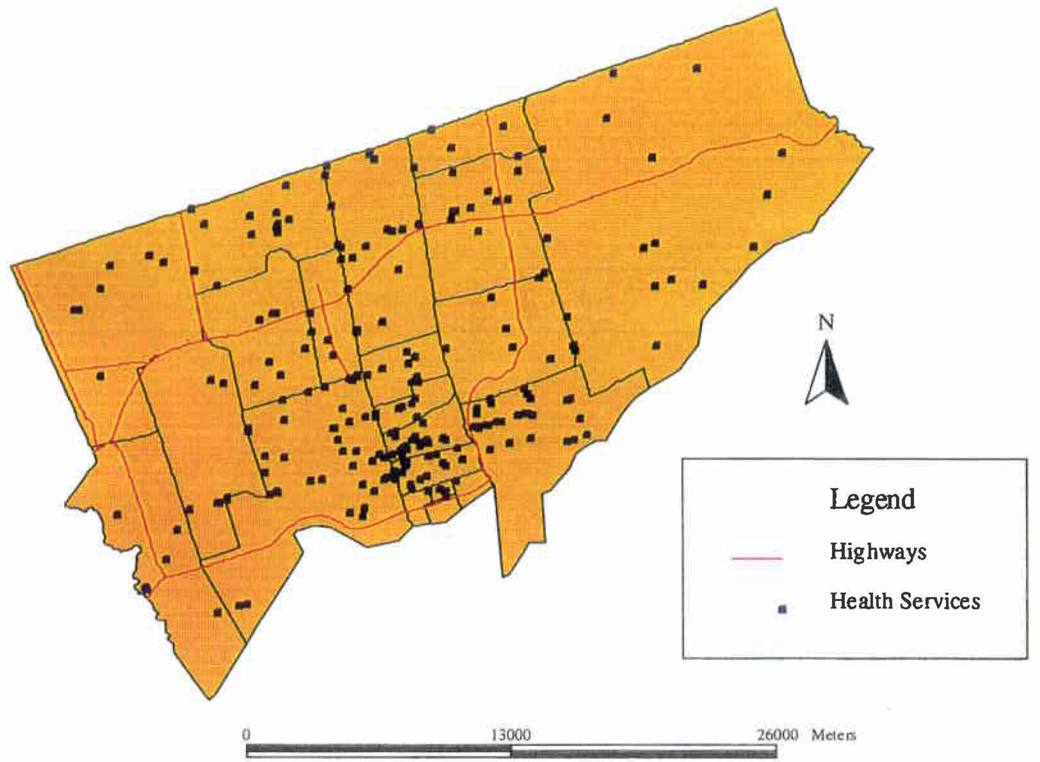
Map 6
Financial Services



Map 7
Government Agencies

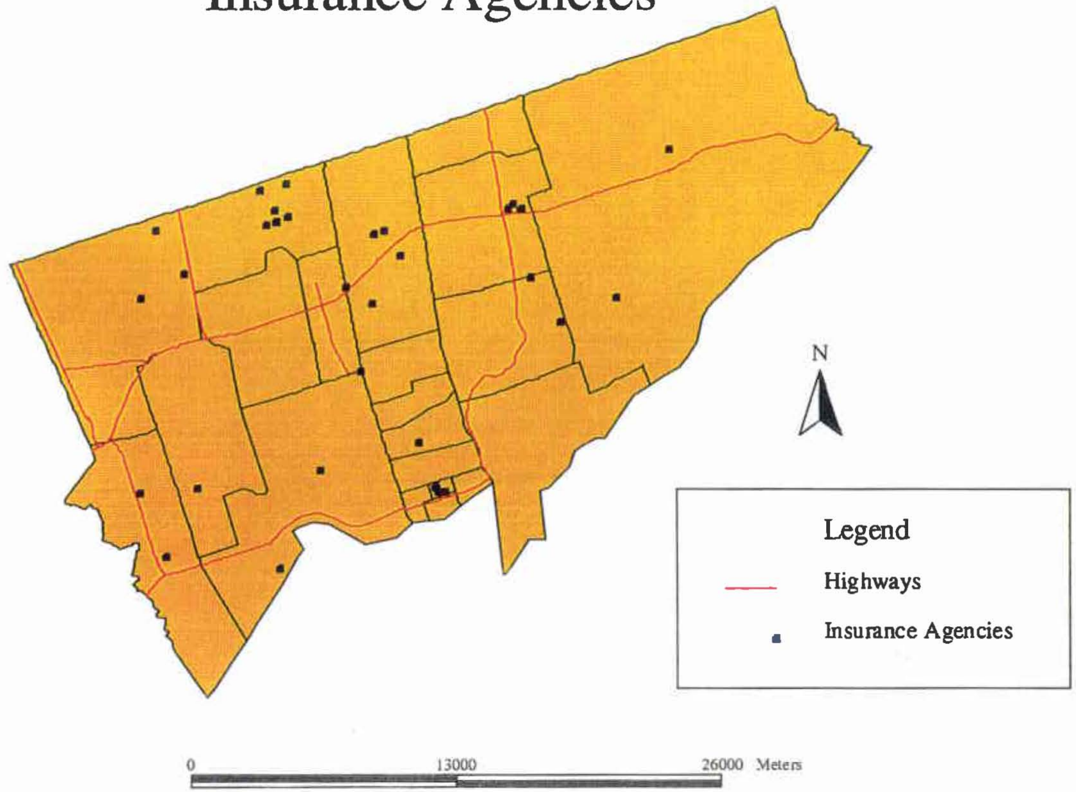


Map 8
Health Services

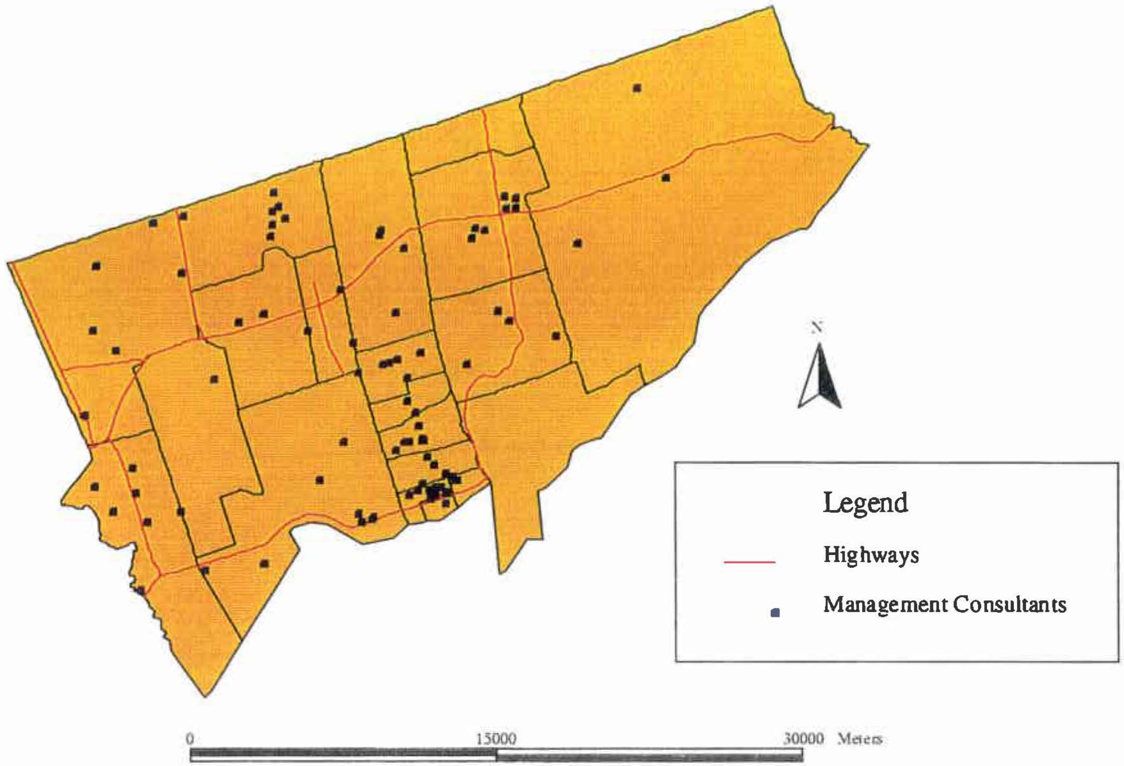


Map 9

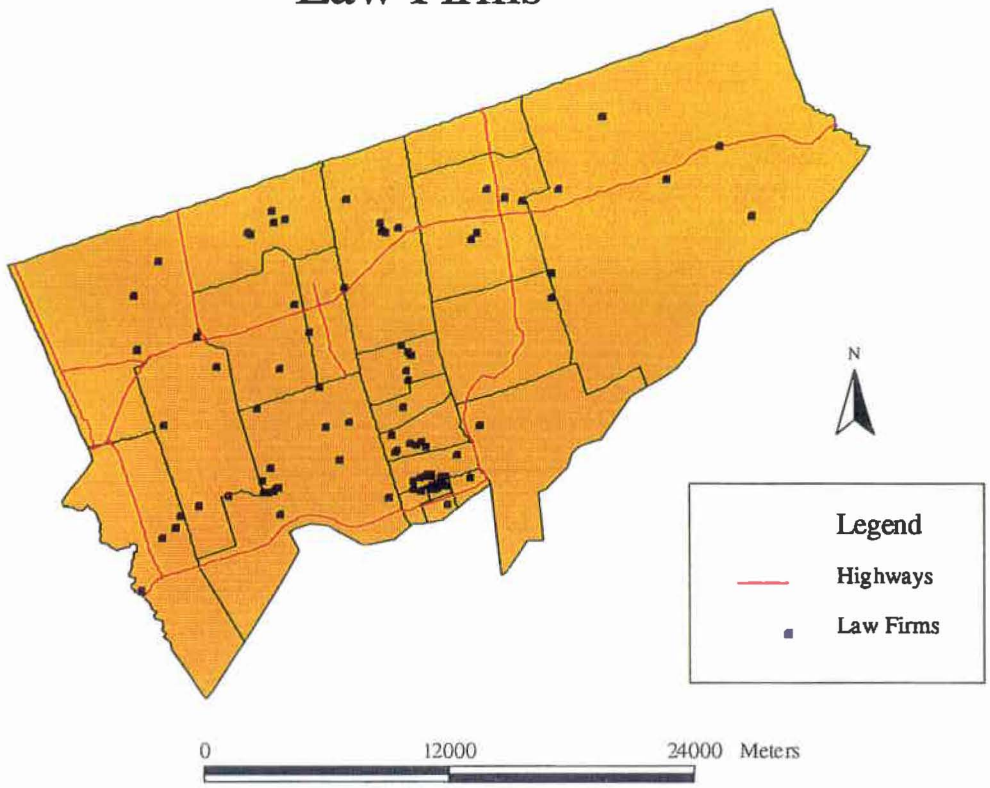
Insurance Agencies



Map 10
Management Consultants

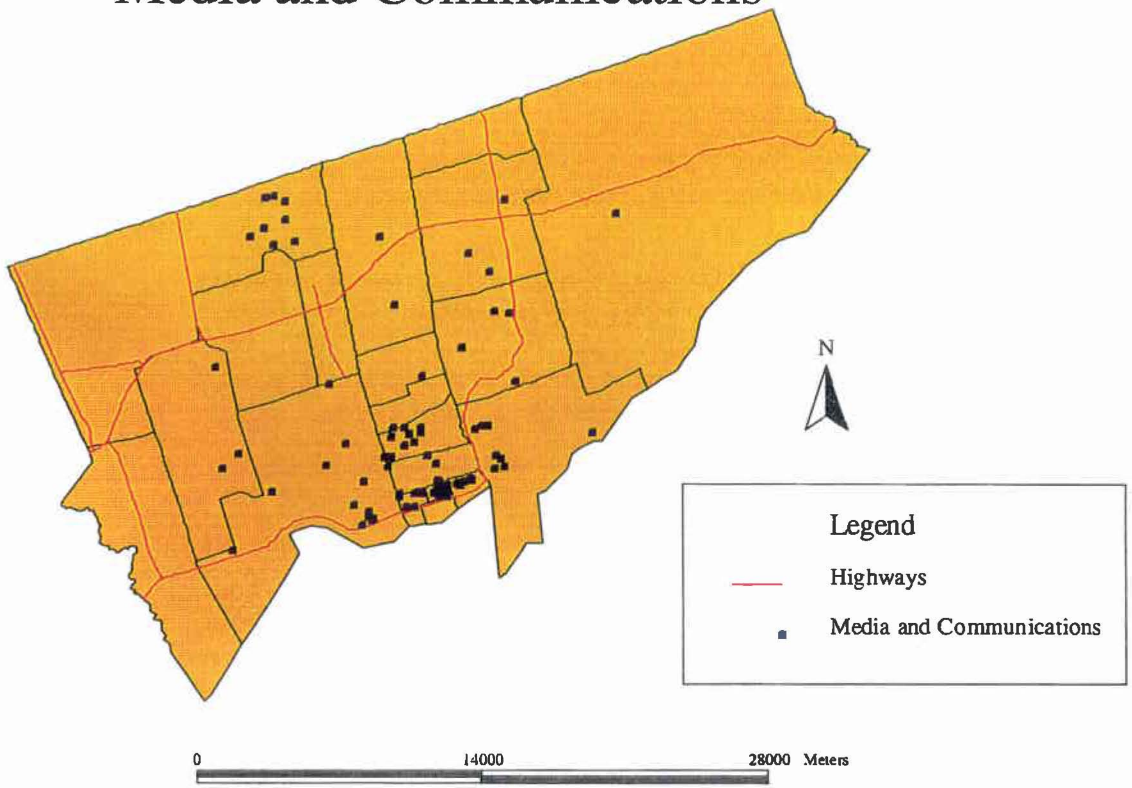


Map 11
Law Firms

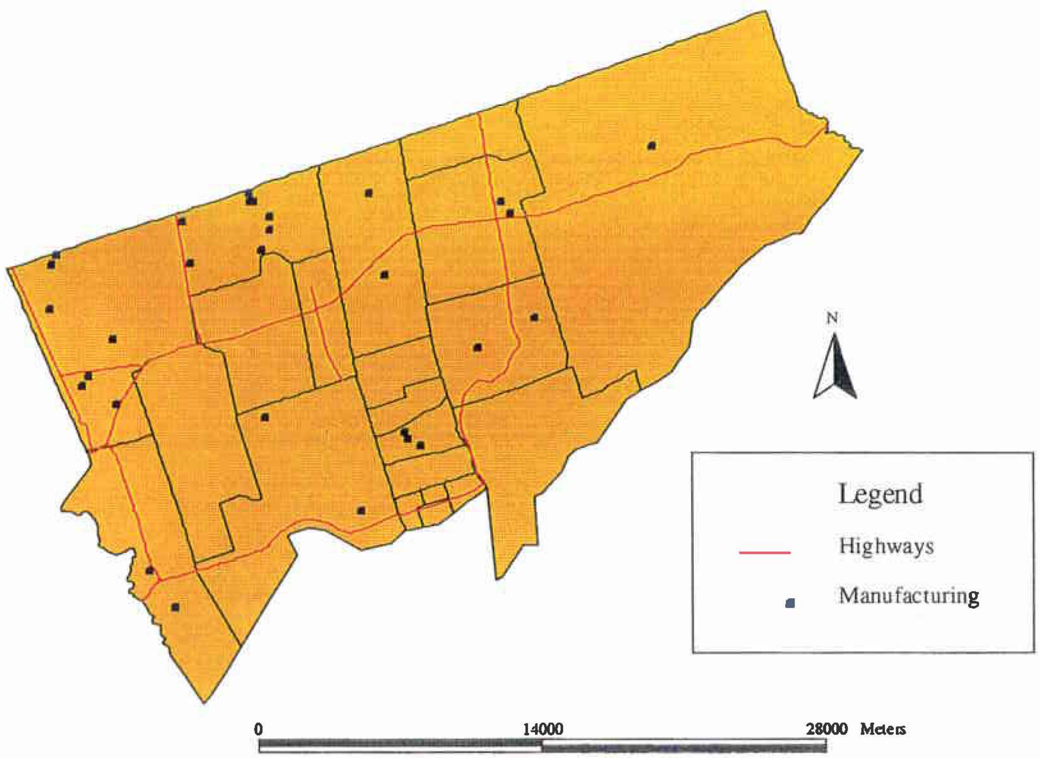


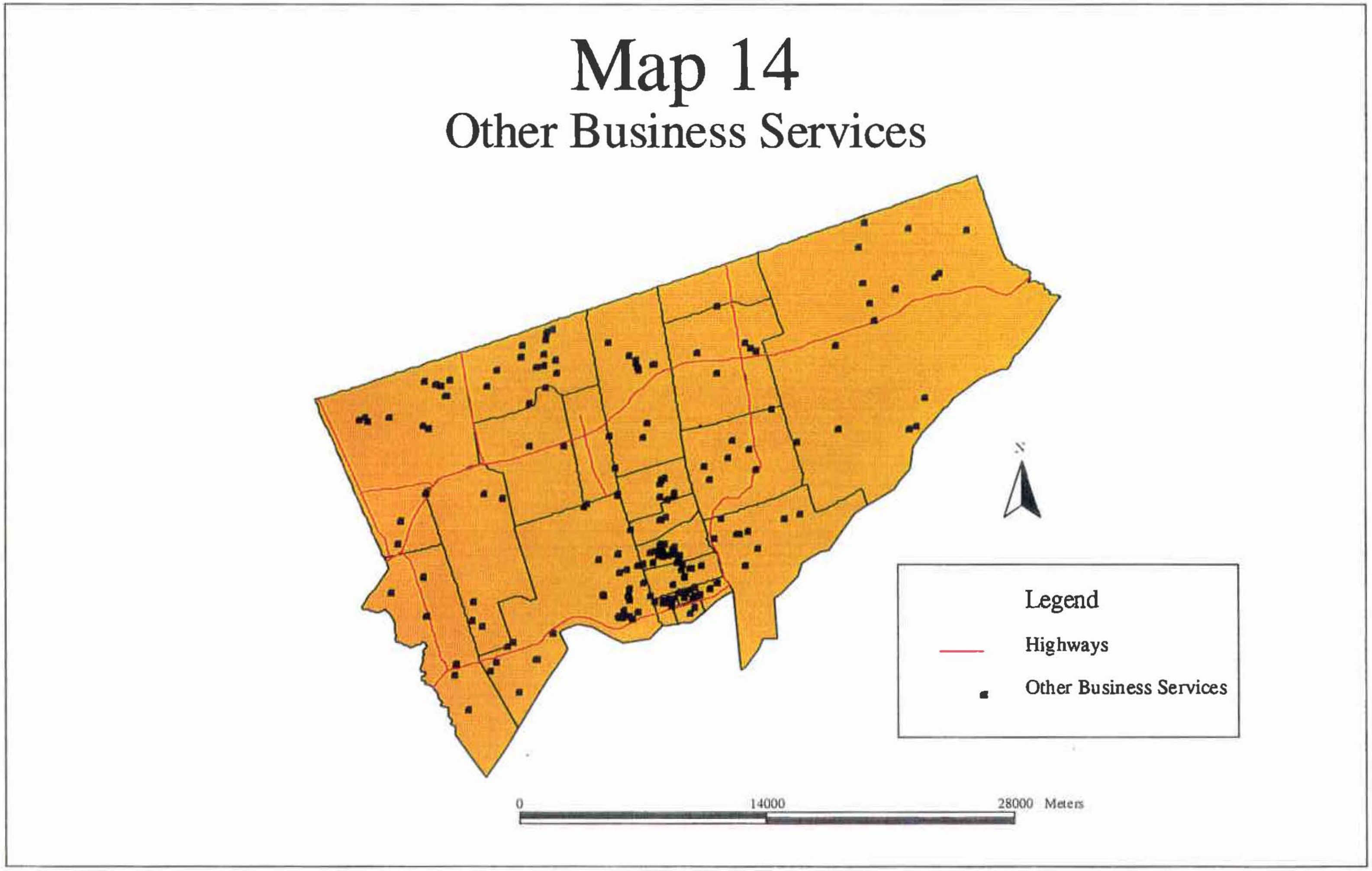
Map 12

Media and Communications

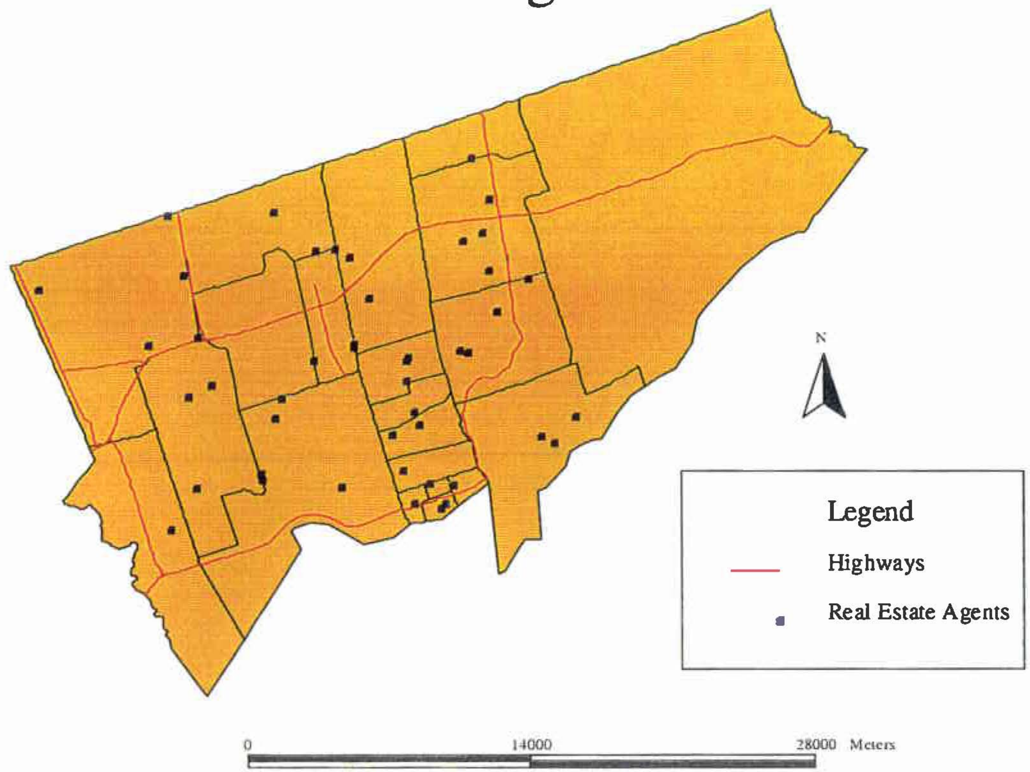


Map 13
Manufacturing

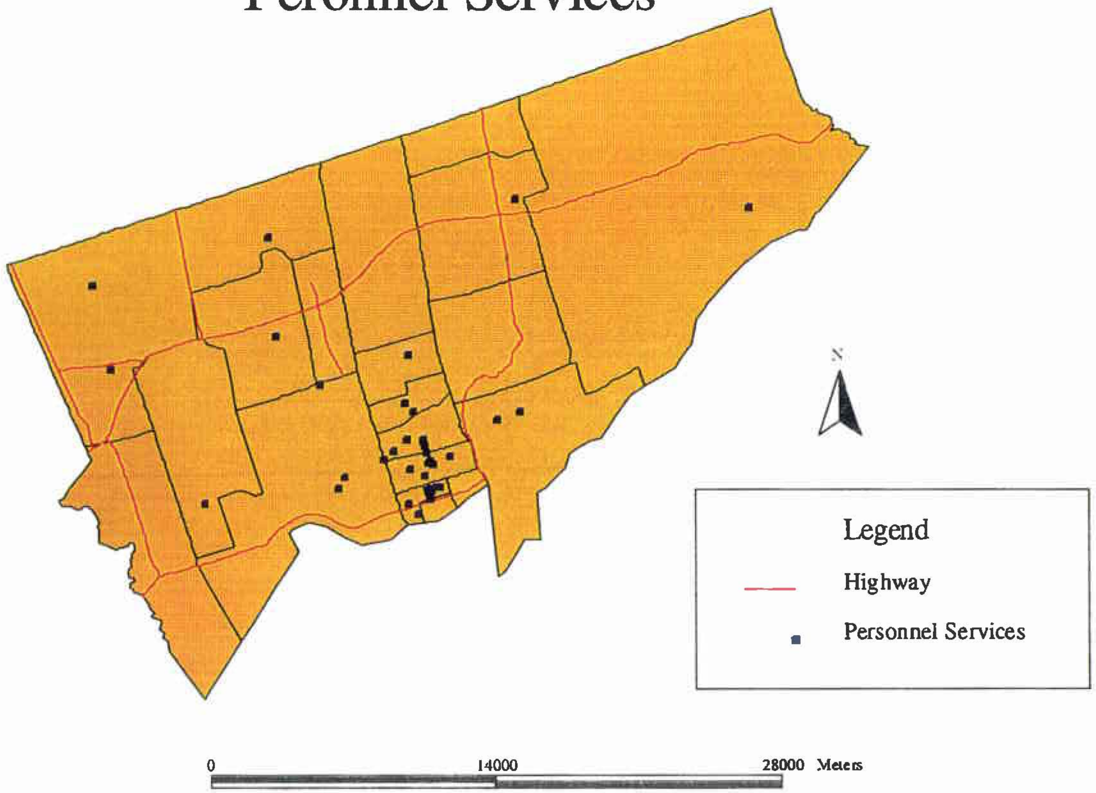



Map 14
Other Business Services
N
Legend
Highways
Other Business Services
0
14000
28000 Meters

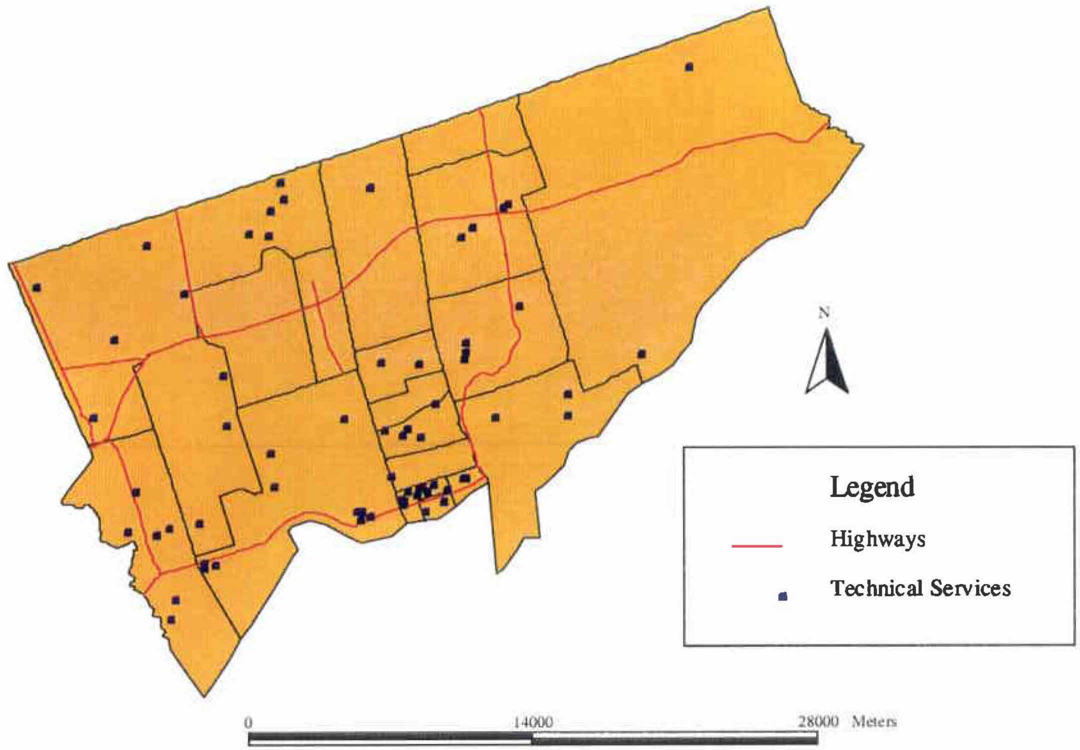
Map 15
Real Estate Agents



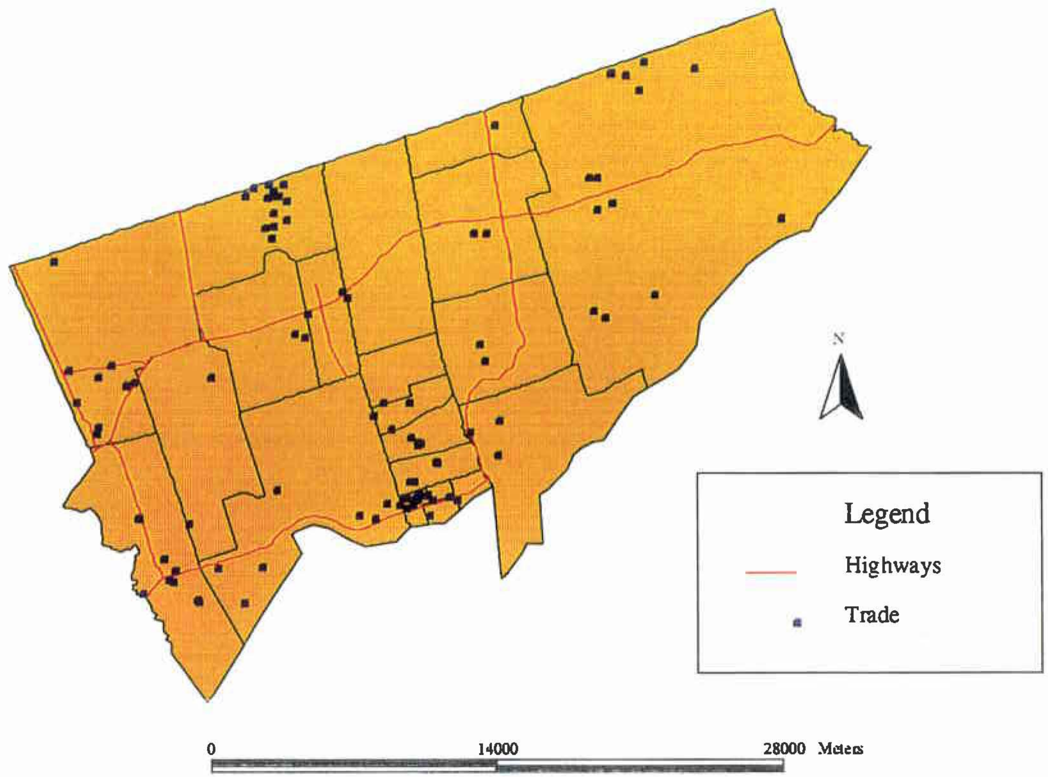
Map 16
Peronnel Services



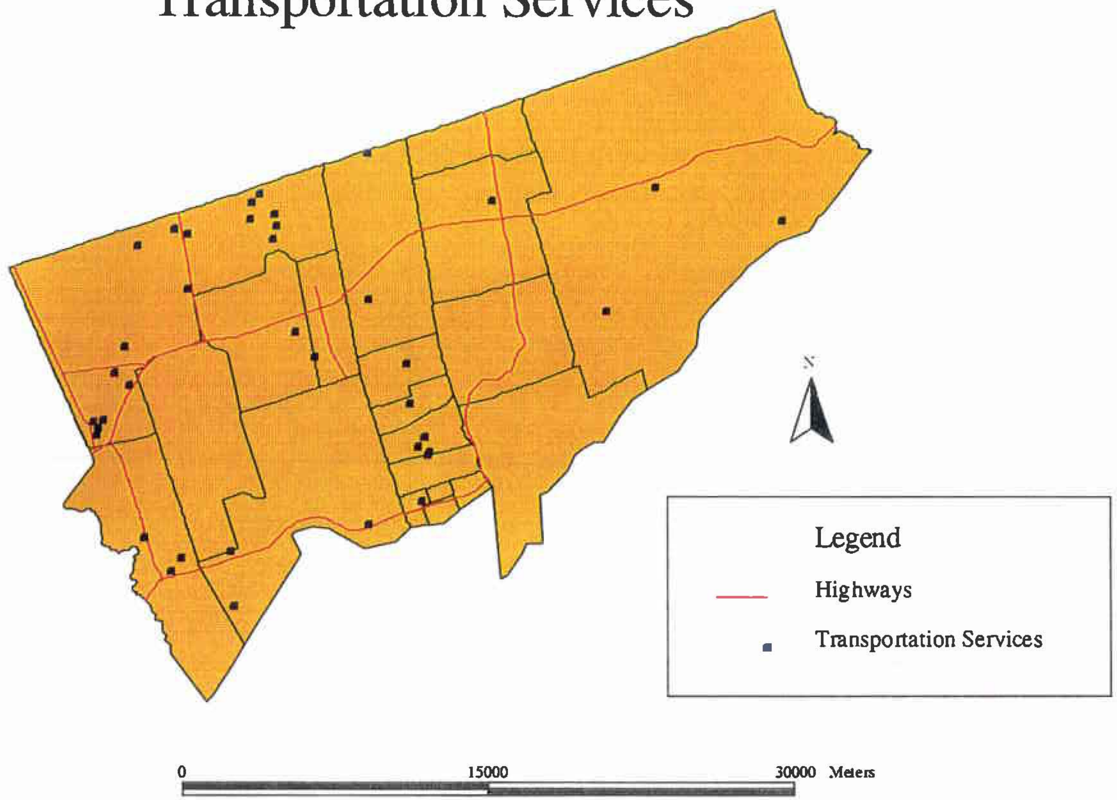
Map 17
Technical Services



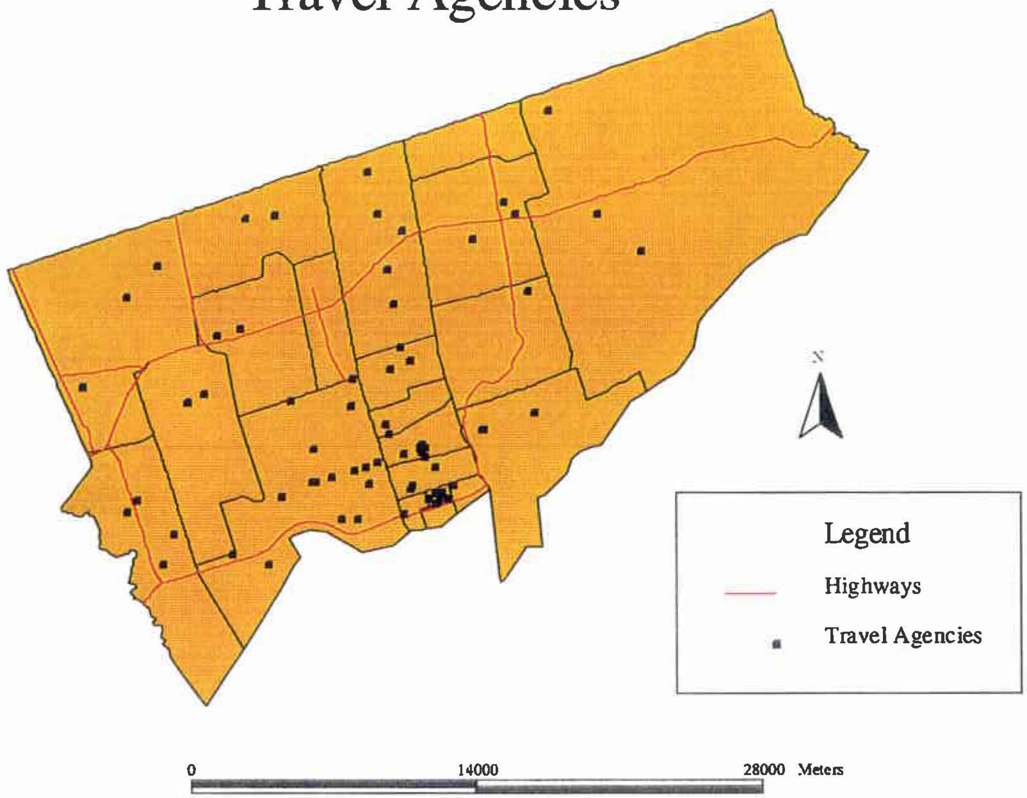
Map 18
Trade



Map 19
Transportation Services



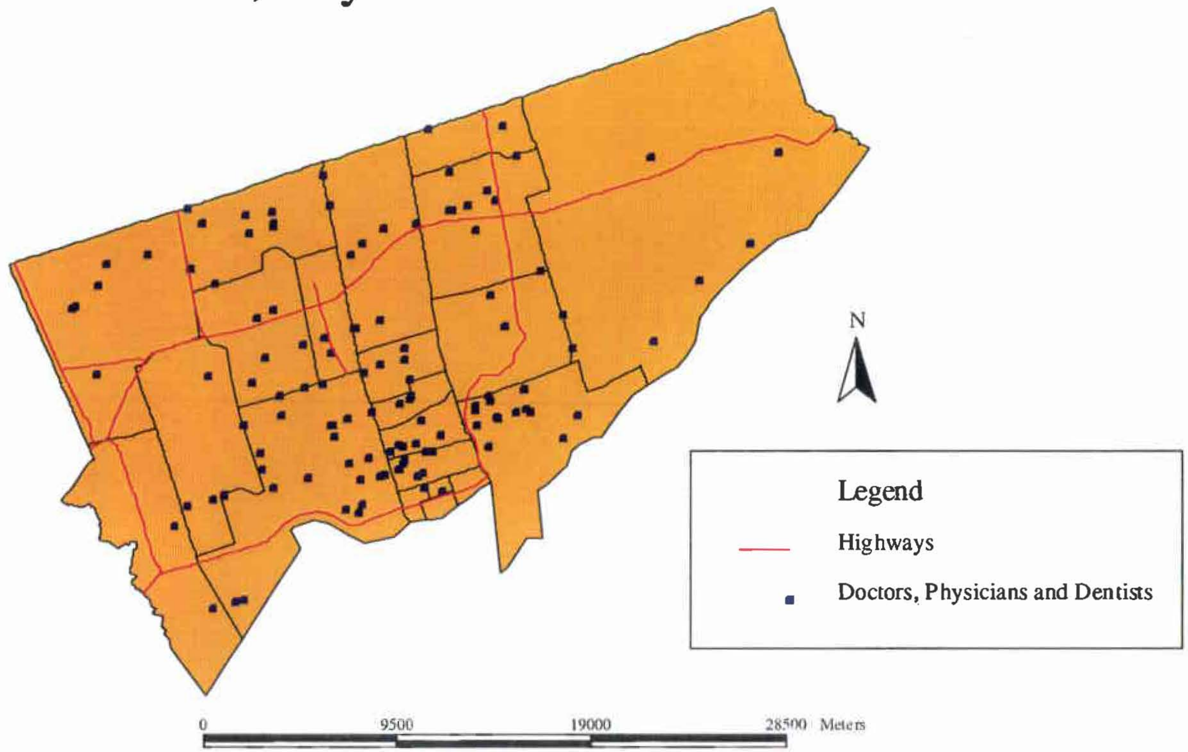
Map 20
Travel Agencies



APPENDIX TWO

Map 1

Doctors, Physicians and Dentists



Map 2
Other Health Services