

Investigating the Location Pattern of Information and Communication Technology Firms: Case of Vancouver

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Zahra Abedi.

Abstract

Despite the volume of literature examining the role of producer amenities (e.g., highways and airports) in firms' selection of a location, almost no quantitative studies regard the impact of consumer amenities (e.g., theatres and cafes) in attracting firms, as they are hypothesized to attract residents rather than firms or companies. Since the Information and Communication Technology (ICT) sector is regarded as a significant driver and an increasingly important part of the economy in North American and European countries, this research aims to provide insight into the importance of consumer amenities in the location pattern of companies in this sector. Consumer amenities are stated to be important factors in the lifestyle of creative and talented workers such as employees of high-tech industries (Florida, 2003); therefore, this study hypothesizes that ICT firms tend to locate near consumer amenities as they are assumed to be attractive to the talented and highly educated workers that those firms want to employ. ICT firms, because of their size and use, can also be integrated into existing land use, such as downtown where there are lots of amenities. Industrial uses would be more likely to locate near highways because of their land requirements. This thesis looks at a broad pattern as an exploratory study to see if there is a location pattern between consumer amenities and ICT firms' location.

Using census data from Canadian industries, this thesis focuses on exploring a spatial pattern for distribution of ICT companies, both with regards to amenities and the location of firms in other industries. In doing so, information of 66,078 firms that operate in Vancouver

and their associated data were obtained from Statistics Canada and the Canadian Business Database. A walkability index is also developed that represents the amenity variable.

The findings of this study suggest that ICT firms are more likely to be found in areas with a high concentration of consumer amenities. However, the result shows that there is statistically weak relationship between location of ICT firms and existence of consumer amenities, but this relationship is generally not detected for firms in other sectors. Moreover, the most significant finding of this thesis is that there is a tendency for ICT firms to locate close to and concentrated in downtown cores. As a result, the findings demonstrate that the agglomeration factor in ICT firms' location decision is more important than the existence of consumer amenities in the place. This study concludes by suggesting that municipalities and their local economic development specialists wanting to attract regional economic growth to better understand and focus on the determinant elements of location decision by ICT firms.

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Dedication

This thesis is dedicated to my husband, who supported me in all aspects of my life, and to my mother, for her motivation in each step that I have taken.

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Chapter 1

Introduction

Do Information and Communication Technology (ICT) firms prefer to be located close to public service such as universities, producer enities such as highways and airport, or consumer amenities such as restaurants, theaters? Based on statistics Canada and industry Canada (1996) definition the 'ICT' sector includes industries “ primary engaged in producing goods or services, or supplying technologies, used to process, transmit or receive information”. Moreover, OECD defines the 'ICT' sector as the one that is “intended to fulfill the function of information processing and communication by electronic means, including transmission and display, or which use electronic processing to detect, measure and/or record physical phenomena, or to control the physical process”(OECD, 2003). Since ICT firms now conduct knowledge-based activities in most developed countries, the answer to this question can be important to economic development officials, community development specialists, urban planners, urban policymakers, and local governments as they can include incentives in their policies to attract those activities to their regions.

The ICT sector has made a salient contribution to the world economy during the last decades. For example, the ICT sector significantly influences productivity growth in North America and Europe because a small investment in ICT can enormously affect managerial and organizational structures. Litan and Rivlin (2001) argue that new activities using information and communication technology contribute to the much of productivity growth in the new economy:

“Some of the productivity improvement will come from firms using the Internet to manage supply chains more efficiently, improve scheduling, reduce inventories, and bring about more effective collaboration among different business partners. Increasing use of the Internet in rapidly globalizing economy is likely to increase competition by broadening the reach of the market for both buyers and sellers. Increased competition may enhance productivity and may also shave profit margins”(Litan & Rivlin, 2001, p. 5).

Consensus prevails that ICT can bring about productivity growth that leads to the coexistence of low inflation and low unemployment. Consequently, ICT firms can have strong positive effects on the economy of the region where they are located. Therefore, factors that have been identified as important to ICT firms in their decision about location must be examined to determine the extent of influence of these factors. Some known location factors are knowledge spillover generated by competitors and universities; need for ‘face-to-face’ interaction with complementary business activities; “diversification in producer and consumer” function; and “physical and digital accessibility” (Van Oort, Weterings & Verlinde, 2003). Amenities are another important factor in the location selection of both firms and their workers.

However, researchers have overlooked the importance of consumer amenities in attracting firms, because amenities are hypothesized to attract residents rather than firms. ICT firms, because of their size and use, can be integrated into existing land use, such as downtown where there are lots of amenities. Industrial uses would be more likely to locate near highways because of their land requirements. On the one hand, “Amenities have gradually come into the radar scope of public officials as a tool to attract new residents. Governments have spent billions on convention centers, stadiums, malls, light rail, and other facilities they hope will attract people and firms” (Clark, 2004, p. 9). Moreover, Glaeser argues that in the

past 20 years, due to the changes in the “style of government”, enhancement in “law enforcement technology”, and an increase in incomes there has been an increase in the demand for “high-end urban amenities” (Glaeser & Gottlieb, 2006). On the other hand, Florida argues that creative people, as workers in the new economy, do not chose their place of residence based on the density of jobs in that location; “They cluster in places that are centers of creativity and also where they like to live” (Florida, 2002, p. 7). Because amenities are an important factor that influences the decision of where workers of specific industries (e.g., knowledge intensive industry) would like to live, companies in those industries usually tend to locate in area with high density of amenities.

These topics have received some attentions at the inter-urban scale; however less is known about the importance of proximity to amenities at the intra-urban scale. This thesis aims to provide insight on the latter, considering the specific case of Vancouver, British Columbia.

1.1 Research Question

The focus of this study is on specialized firms in information and cultural industries. The aim of this thesis is to explore important urban factors that affect the location decisions of ICT companies to find out how these companies are distributed with respect to those urban factors and to identify their clustering patterns among different sectors of industry. Identifying those amenities desired by ICT firms and exploring their role in location decisions can be important to municipalities that wish to boost the economy of their municipal regions.

Transportation infrastructures, building stocks, and high-quality education and medical services are amenities that might be important for firms considering their work place location. However, as Audirac (2002) argues, face-to-face interaction and access to a highly skilled professional and technical labor pool are factors that are more important than other factors for firms in high-tech industries. Coffee shops, juice bars, and universities are amenities that meet the needs of those firms and their employees.

Therefore, an important unanswered question is whether consumer amenities are significant in the choice of office location in information intensive industries. If they are, do firms that are active in these industries base their location decision on proximity to public services such as universities, producer amenities (e.g., post secondary institutions or highways) or consumer amenities that are defined as local goods and an attractive mix of social patterns that are hard to transport, such as restaurants and theaters (Glaeser, Kolko, & Saiz, 2000)?

1.2 Extended focus/purpose statement

There is a large amount of literature on the geographical characteristics of office locations dealing with a wide variety of themes such as the determinants of office locations (Clapp, 1980; Ihlanfeldt and Raper, 1990; Gottlieb, 1995; Clark, 2004), spatial relationship between location of workplace and place of residence (Glaeser, Kolko, & Saiz, 2000; Shuttleworth & Gould, 2010; Partridge, Rickman, Ali, & Olfert, 2010)). Recently, the spatial pattern of high-

technology firms has gained some attention in the literature (Van Oort *et al.*, 2003; Doeringer, Evans-Klock, & Terkla 2004; Meyer 2006). The purpose of this study is to examine the relationships between consumer amenities and the location of workplaces in the information technology sector. Therefore, this research seeks a broader understanding of how urban factors, in particular amenities, can affect the location choice of firms, specially ICT ones.

Chapter 2 presents a brief literature review to determine the importance of ICT in the “new economy”¹ and also firms’ location choices. A conceptual model, an explanation of methodology employed to test the model, and the analysis of the data are provided in Chapter 3. Using Statistics Canada census tract data to identify the number and location of ICT firms in the metropolitan area of Vancouver, this study will investigate whether there is a significant correlation between amenities and ICT firms’ locations. The independent variable of interest is “amenities”, because as Richard Florida notes, it is an important aspect of the Creative Classes’ lives. Florida exemplifies the “creative class” as educated workers in industries that “create new ideas, new technology and/or new creative content” (Florida, 2002, p.8). Power (1988), defines amenities as qualities and characteristics of a location that make it a desirable “place to live and work” (Power 1988) such as coffee shops, restaurants, swimming pools, and parks. Other independent variables will be introduced in the model, in order to control for possible factors acting on locations including, post-secondary institutions,

¹ The ‘new economy’, according to the OECD (2000), is defined as follows: “aspects or sectors of an economy that are producing or intensely using innovative or new technologies. This relatively new concept applies particularly to industries where people depend more and more on computers, telecommunications and the Internet ... produce, sell and distribute goods and services” (as cited in Bourne et al., 2011, p.325).

distance to highways, and transit facilities. The dependent variables are the concentration of industries in a census tract region compared to the metropolitan average, but the focus is on the ICT industry. The ICT firms will be defined as firms that are active in the field of “processing, storing and disseminating information, by acquisition and collection of applications and technologies” (Cohen-Blankshtain, Nijkamp and Montfort 2004, p.2647).

This thesis concludes in Chapter 4, with a reporting of its research findings and a discussion about their implications for academic research and public policy. This research is of importance to municipal policy makers and city planners because, on the one hand, corporations (in particular high-technology firms) are important drivers of economic growth and considered to be a development tool. On the other hand, high-tech companies tend to cluster in locations where they can draw from the pool of knowledge workers who leverage innovation and economic growth, and these knowledge workers are attracted to locations by amenities (Florida, 2002). If the results show a strong correlation between these amenities and ICT firm location pattern, municipalities can draw those businesses to their communities by implementing policies that improve local amenities, thus improves their regional economy.

Chapter 2

Literature Review

Since the focus of this thesis is on investigating the role of consumer amenities in determining the location of ICT corporations, it is necessary to first review previous research on the role of amenities and on location decisions in general, as well as on the ICT sector specifically. As a result, the main literature and theories about the importance of the ICT sector are first summarized, followed by a review of the relevant theories and elements in the impact of ICT on economic growth and existing urban patterns. The following parts will review theories of location decisions made by industries, including economic and environmental factors influencing firms' location selection.

2.1 Importance of Information and Communication Technology

In the last decades, there has been a significant increased in research on the use of ICT. However, the focus of that research has been more on particular case studies than on the development of fundamental theories and approaches (Conole, 2004). However, the increasing use of the personal computer (PC) as a tool for work, ubiquitous use of the Internet and cellphones, replacement of traditional ways of communication with online communication, and the popularity of social networks is an indication of the importance of ICT. Therefore, ICT has a remarkable influence on society, the economy, and even the urban

pattern of cities. An impact of ICT deployment is the efficient distribution of information among locations without changing the urban patterns through utilizing new telecommunication (Mitchell, 2005). Mitchell also states that through facilitating the exchange of information, ICT reduces the demand for activities to be proximate or adjacent to one another and allows other latent needs for proximity to come into existence. As a result, ICT can help a system to “spatially restructure through fragmentation and recombination” when there is pressure for growth and “accommodation of new demands” (Mitchell, 2005).

The Information and Communication Technology (ICT) sector has been growing in recent years, and investment in this sector has increased in all industries in most parts of the world. This sector provides global society with several conveniences, such as communication measures among countries and/or local areas, online trading of securities, Web systems for business, and distance learning (Kurihara,Takaya, Harui, & Kame, 2008).

Moreover, ICT has brought about a rapid change in economic activity in most part of the industrialized world. Kudyba and Diwan (1963) argue that information technology has had a salient impact on the characteristics of production and consumption structures, and effective communication has enabled businesses to generate consistent output while allocating fewer inputs.

2.2 ICT and economic growth

Agriculture, manufacturing or services have been the dominant activities of traditional economies. Recently, as the economic importance of information and knowledge is increasing, the reliance of advanced economies on information and communication technology is growing as an engine of economic growth (Corey & Wilson, 2006). In fact, the level of ICT infrastructure can determine one economy's competitive advantage (Mack, Anselin, & Grubestic, 2010). Moving from industrial to knowledge-based economy has been accompanied by social, political and spatial changes (Mitchell, 2005)

Sustainable economic growth, which is the goal of policy makers and economic developers, can be achieved through productivity growth. In recent decades, until the recent recession, productivity has been growing sharply. Nordhaus (2001) argues that remarkable productivity growth in the "new economy" sector of information and communication has been a reason for part of this growth. Yuhn and Park (2009) argue that investment in the ICT sector can significantly influence organizational and managerial structure, and as a result, such investment can have long-lasting impacts on productivity growth in an IT-based economy.

On the other hand, Kurihara *et al.*, (2008) suggest two perspectives on ICT: ICT as development infrastructure and ICT as a communication measure. Based on the first perspective, ICT is viewed as an infrastructure of economic development that relates to the supply side of economies and contributes to the diffusion and deepening of knowledge. The

second perspective is related to the demand side of the economy. In this perspective, ICT is linked to transaction cost reduction. In addition, by facilitating the network of information exchange, ICT promotes business and consumption. Therefore, ICT can facilitate economic growth, as an investment in ICT boosts the demand and technological change on the supply side (Kurihara, *et al.*, 2008, Chapter 1).

As advances in information and communication technology increasingly spreads within education, policy, the economic and society, the growth of regional economy becomes more and more associated with concentration of high-tech and knowledge-based industries in a region. Glaeser argues that most innovations that speed up economic growth are made through interaction and existence of individuals, companies and industries within cities (Glaeser, Kallal, Scheinkman, & Shleifer, 1992). The increasing importance of ICT companies' role in the development and growth of cities have made officials and specialist in urban planning and policies pay more attention to the criteria that these companies rely on when making their location decisions and "factors associated with organizations and workplaces that can best motivate and enhance creative work" (Florida, 2003, p.16).

2.3 Role of firms in cities: the affect of ICT on city patterns

Cities and urban centers are the major center of administrative activities. On one hand, Glaeser believes that "locations are chosen and that those choices are not entirely irrational" so understanding location choices requires understanding the characteristic of different

locations (Glaeser, 2008). On the other hand, firms are sources of regional and national economic growth; therefore, from a policy perspective it is important how those firms make location decisions. Community development specialists and urban planners thus focus on attracting employers to their area. In this respect, public goods and amenities, human capital and consumption have received a great amount of attention from some researchers such as Paul Gottlieb, Terry Clark, and Edward Glaeser, while other scholars such as Ennis and Clapp have focused on transportation and communication.

Various researchers distinguish ICT as an important determinant of business growth and the development of regional economies (Abler, 1977; Richardson, & Gillespie 1996; Premkumar, 2000). Glaeser states that “the most successful cities of today seem to be particularly concentrated in idea-producing industries, like finance, new technology and the media” (Glaeser, 2008, p.8). The idea that knowledge sharing and innovation is associated with urban proximity is not new and has been implied by some scholars such as Marshall (1890) and Jane Jacobs (1969) (Glaeser, 2008).

Several factors determine the spatial configuration of economic activities, factors such as cost location, agglomeration economies, and external economies. Agglomeration economies as an explanation for why some places are of more interest to some industries will be discussed in more detail in the next section.

2.4 Agglomeration Economies

Economic activities tend to be concentrated in a limited number of geographic areas, and certain key factors affect the location of industries. Natural features such as rivers and harbors and natural resources like mines can be influential in attracting businesses in certain sectors (e.g., manufacturing) to a certain geographic area. For instance, in order to reduce production costs, companies tend to be located near raw materials and transportation infrastructure. “Agglomeration economies” are another important factor in the formation of clusters in small business cores and “describe the economies or cost reductions possible if a group of firms locate near one another” in order to benefit from factors such as large market size and a pool of skilled labor (Evans, 1985, p.40). Glaeser (2008) argues that agglomeration is driven by the tendency of industries to locate near one another in order to minimize “transport cost for goods” through buying and selling to one another. The notion of agglomeration economies, first explicitly introduced by Weber (1928), implies the outcome of a “snowball effect” that collects a growing number of agents who want to benefit from the presence of a great variety of activities and high specialization. According to Matsuyama (1995), this process, which leads to growth of output, is a result of combining declining average cost and increasing returns (as cited in Fujita & Thisse, 2002, p.8).

Agglomeration economies are a concept usually used in economics to discuss the formation of cities: “Agglomeration economies are so central to urban economics because they provide an economic rationale for the existence of cities” (Glaeser, 2008, p.116). Duranton and Puga (2004) state that different sources of agglomeration economies and their

interaction with other aspects of individuals' behavior can shape the composition of cities. Moreover, Duranton and Puga (2003) discuss three types of micro-foundation that generate increasing returns at a regional level: "sharing", "matching", and "learning or knowledge spillover". Each is discussed in detail below.

"Sharing" refers to the contribution of clustered firms to externalities that are generated because of economic activities concentrated in that cluster. Marshall (1923) refers to externalities as a situation in which firms in the same sector of activity tend to agglomerate spatially to take advantage of this agglomeration. He recognizes knowledge spillover (technological spillover), industrial linkage, and skilled worker pools as the three factors that create externalities and encourage firms in a section to concentrate spatially. According to Duranton and Puga (2003), sharing happens in four different areas: sharing the gain from a wider variety of suppliers, such as a highly specialized labor force; sharing indivisible facilities; sharing the gains from narrower specialization that leads to mass production; and sharing risks.

Helsley and Strange (1989) illustrate "matching" as the way that workers and firms match up to increase their productivity. They introduce a model that formulizes "matching", which is to them is the ease by which a can of larger labor market in matching up jobs and skills, as a commonly cited source of agglomeration economies. Glaeser (2008) mentions, "labor market pooling" as an important source of agglomeration, in the sense that industries that use the same type of workers are likely to form a "conglomerate" with each other.

“Learning” or “Diffusion” of knowledge and information occur through labor markets, service markets, and product markets. “Face-to-face communication” is an important means of knowledge sharing (Salis & Williams, 2010; Lambooy, 2010). Engaging individuals in a “mutual exchange of verbal information forms the face-to-face communication”, which can result in the “sharing of tacit knowledge” through interaction among employees. Learning mechanism is facilitated through face-to-face interaction of people in the clusters, as cities provide a knowledgeable labor market, and offer advantages of knowledge spillover (Salis & Williams, 2010). Therefore, one can infer that cities are powerful tools for spreading ideas. Compatibly, connection between skills and city growth suggest that spreading ideas is a reason for cities’ success, as “ cities promote productivity by connecting people to smart people with good ideas” (Glaeser , 2008, p. 149).

As a result, agglomeration affects determine the extent of urban congestion’s attractiveness. Therefore, cities can be regarded as the result of agglomeration economies and the costs of urban density, because the increasing returns encourage firms to cluster together (Helsley & Strange, 1989).

However, using the advanced system of ICT might reduce the need for clustering among knowledge intensive corporations (Evans, 1985). Instead there are some other factors that are of more importance for high-tech companies such as need for “face-to face interaction”, knowledge spillovers, and the existence of amenities. In fact, “knowledge-based agglomeration economies are increasingly important in the world’s most successful cities” (Glaeser, 2008, P. 157). Services and “high human capital sectors” tend to locate near urban cores in order to reduce the cost of moving people caused by face-to-face travel (Glaeser,

2008). Glaeser (2008) argues, on one hand, reduction in goods' transportation costs made possible by agglomeration economies leads to increase in the size of the market and reduction in delivery costs. On the other hand, urban density facilitates the process of matching and connecting smart people. Glaeser continues to argue that these two latent effects made by agglomeration economies may increase the returns for innovation that can explain the location pattern of firms in knowledge-based industries within cities.

2.5 Amenities

2.5.1 What are amenities?

Many factors interact in choosing a business's location. Beside agglomeration economies, amenities are increasingly recognized as a major determinant that makes cities more attractive for workers, and more suitable for industries. Glaeser, Kolko, and Saiz(2000) argue that the future of cities depends on how attractive and livable they are for consumers and companies. Amenities are location characteristics that can both influence the level of individuals' satisfaction and companies' profit (Tolley & Diamond, JR., 1982). Thus, amenities are important elements in policy and planning as individual and private firms consider their access to amenities in making their initial location or periodic relocation decision

The concept of amenity emerged at the beginning of the nineteenth century when modern town planning originated (Smith, 1974). Tolley and Diamond, JR (1982) describe amenities

as a “location-specified good” that are “components of the social, physical, or legal environment”. Gyourko and Tracy (1991) define “amenity” as follow:

“A pure amenity is a non-produced public good such as weather quality that has no explicit price. In practice, previous empirical studies include some government services such as education and public safety” (p. 775).

On the one hand, amenities are a potential location factor for firms, if firms can pay lower wages to their employees because of the existence of such amenities in a location (Gottlieb, 1995). On the other hand, it has been stated in literature that ICT companies tend to locate in area with high density of amenities because creative workers prefer to live in a high-amenity environment (Sivitanidou, 1999; cf. Kotkin, 2000; Florida, 2002). Therefore, providing residential amenities could be a useful and politically attractive strategy in economic development (Florida, 2002).

Tolley and Diamond JR. (1982) define “amenity as a location-specific good”. This definition “encompasses all aspects of the consumption or production decision that influence the location of the household or firm”(p.4). Clark (2004) classifies amenities in two general categories: “ natural amenities” and “constructed amenities”. Examples of the former are moderate temperature, hills, and nearby water; and latter one’s examples are opera, libraries, bookstores, juice bars, and coffee shops.

Glaeser *et al* (2000) classify urban amenities into four groups: services and consumer goods, such as restaurants, theaters; aesthetic and physical setting like moderate temperature; good public services, such as good schools and universities; transport speed. Clark (2004) suggests that individuals are all driven into the cities by private goods concerns (job, income)

as well as by urban amenities. An empirical model developed by Rappaport (2008) illustrates how amenities in intra-urban scale are strongly positively correlated with population growth. This model suggests that quality of life is a key determinant factor of where people choose to live. Thus, existence of amenities in a metropolitan area can affect its quality of life and consequently affect the population growth and density of labor pool in a metro-area.

Researchers often ignore the importance of residential amenities (e.g., Theatres, cafes) in attracting firms, as they are hypothesized to attract residents not firms. However, some authors such as Gottlieb (1995), Van Oort *et al* (2003) have conducted research on a relationship between residential amenities and firm location.

Gottlieb (1995) argues that amenities can influence the firms' location through compensating wage differentials. Gottlieb (1995) has conducted a research on a firms' location in municipalities in New Jersey. He tests a reduced form model of the impact of amenities on corporate location that suggests firms respond directly only to the preexisting labor force. By omitting the population (labor force) aggregates from the standard model, Gottlieb attempts to identify the relationship between traditional business factors, residential amenities, and employment location. The focus of Gottlieb's model is on violent crime as an amenity or disamenity that affects firms' location when evaluated at the worksite itself. Gottlieb's model suggests some result such as:

In the engineering and manufacturing employment sector amenity orientation is better to describe as avoidance of disamenities than as attraction to amenities; agglomeration is still most important factor in location decision of professional service firms; amenities in adjacent

municipalities are significant in the aggregation of elite firms, such as rush-hour trains, property crime, toxic wastes, and teacher per pupil.

Gottlieb argues that residential amenities are most likely to be considered in the location decisions of high-technology firms. He states that attributes of work location, nearby residential amenities, and the length of the commute that connects these two factors are factors that skilled professionals include in their negotiation about their employment.

Furthermore, Van Oort *et al* (2003) conducted empirical research on the importance of residential amenities in order to determine the locational choice of both ICT firms and their employees (knowledge workers). By using the data from the National Information System on Employment (LISA), they conducted both explorative empirical research among knowledge workers and research among ICT firms in Netherland. They interviewed 260 employees of ICT firms to test their three hypotheses. First, knowledge workers appreciate urban and residential amenities in their preferences more than proximity to their work; Second if the residential location of knowledge worker plays more important role in locational decision of ICT firms compared to other locational attributes; third, the importance of attractive residential areas in the locational decision of firms differ from region to region in Netherland.

For the first hypothesis, the results of questionnaires among knowledge workers, and ICT firms demonstrate that knowledge workers have a high commuting tolerance that make them footloose about their choice of residential area, thus they do not have to live near their workplace. Moreover, in terms of testing the importance of residential location of knowledge workers, the results of explorative interviews suggest that the residential preferences of

knowledge workers do not influence the location choice of ICT firms. Ultimately, in terms of third hypothesis, the results illustrate a difference in behaviors of firms and employees with respect to the location of firms in different region. For instance, in the more peripheral and intermediate regions, the presence of residential amenities has the more importance than in the core economic and polycentric area (Van Oort *et al.*, 2003).

Chapter 3

Methodology

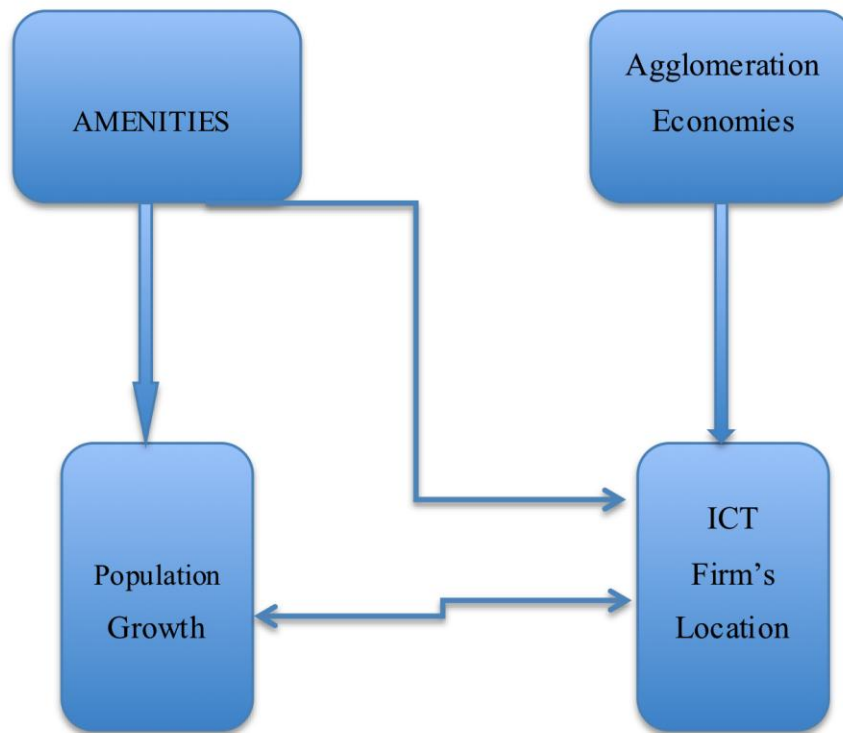
3.1 Conceptual Model

Despite the fair amount of literature afforded location choice of industry and effect of different factors on this choice, studies on the location of information and communication technology firms are relatively rare. Among this literature very few of them are devoted to the role of amenities in the location decision of high technology firms.

Review of literatures in location choice of firms and companies gave an overview of what factors and elements firms consider in making decision about their location. As discussed in Section 1.1, this study aims at investigating the role of amenities in location choice of high-technology companies. Therefore, the purpose of this research is to test whether amenities are an important location factor in location decision of knowledge intensive companies. A conceptual model is developed to analyze the impact of consumer amenities on location pattern of elite corporations. Gottlieb's model (1995) formed the foundation of this structure.

According to this model, three factors can both directly and indirectly influence the location of businesses. Economic agglomeration is the most important factor in determining the firms' location that can directly affect the firm's location. Agglomeration can generate demand-side, supply-side, and own-industry spillover. Such spillovers can contribute to location decision through affecting the cost (Cohen & Paul, 2005).

Figure 1- Consumer Amenities and ICT Firms Location



Moreover, amenities are the factor that can influence the location choice of businesses both directly and indirectly. Amenities are considered in firms' evaluation of their employees' residential locations. Thus, amenities are regarded as important factor to the location decision of certain firms (particularly, in location choice of high-tech firms) (Gottlieb 1995).

However, Rappaport (2008) has developed an empirical model that also demonstrates a strong positive correlation between population growth and several measures of consumer's amenities. Therefore, amenities can affect the quantity of skilled labor (by attracting more population into the region), and as a result indirectly influence the firm location through compensating wage differentials. The extent to which these factors can be operationalized in this research is discussed below.

3.2 Method

A two-step process is used to identify the variables that affect the location decision of knowledge intensive companies within Vancouver CMA. First, the relationship between amenities and ICT firms' location is illustrated by a very simple, at the same time well-established, model which discovers the variables that impact significantly on the location decision of ICT corporations and observes whether there is any proximity effect conditional on these variables. The methodology is designed such that the independent variable is the density of amenities in each census tract of the CMA, and the dependent variable is the location of businesses in ICT sector of industry. The following model specifically examines the role of amenities through controlling for other variable that might be important in location decision of businesses.

$$Y = \beta_k X_k + \varepsilon$$

Where Y is the location of high-technology firm; X_k is a set of independent variables including amenity variables and other group variables hypothesized to be important to location patterns of information and cultural sector; ε is the error term and β is coefficient to be estimated.

The second step of the analysis tests the significance of amenities' role, while considering the role of other important variable such as educational institution location, downtown core, and transportation infrastructures in location decision of knowledge intensive companies. Reviewing different approaches in spatial location studies, Principal Component Analysis is identified as a useful approach in distinguishing precisely the location pattern of information technology firms from appropriate data sets. This approach is used in different areas of urban studies (Davies & Murdie 1991; Meligrana & Skaburskis 2005; Ley 1998). Therefore an index using principal component analysis is developed that will be presented in analysis section along with the results of analysis.

Lastly, the distribution pattern of ICT firms is mapped to illustrate the correlation between these companies location and amenities and also other independent variables.

3.3 Study area

3.3.1 Vancouver CMA

The Greater Vancouver Regional District now known as Metro Vancouver is located on the western fringe of Canada. Covering an area of 36000 square kilometers and having the largest seaport in Canada, Vancouver is one of the Canada's largest industrial centers (Government of British Columbia's official website). The population of Vancouver is almost 2.6 million people, which comprises 60 percent of the province's population. Region's population has had a growth of 7.6 per cent between 2001 and 2006 (BC check-up 2011 census data from Statistic Canada 2006). The Vancouver Metropolitan area is comprised of seven urban municipalities: Burnaby, Coquitlam, Richmond, North Vancouver, District north Vancouver, Surrey, New Westminster.

Founded in 1886, Vancouver is the “ historic core of one of the fastest-growing region in North America” (Punter 2003, p.9). The central city with 2,700 people by 1900 now has a population of 580,000 (Statistic Canada, 2006). In terms of population and growth, Vancouver is the third leading city in Canada after Toronto and Calgary (Barnes *et al.*, 2011).

Vancouver is a desirable city to live in terms of setting, a temperate climate along with many other attraction and amenity (Leo & Anderson, 2006). High demand of property, profitable development, and competition between developers made this city rich in terms of established infrastructure and amenities (Punter, 2003), consumption and cultural amenities such as markets, café, parks, and streetscape with the view of ocean and mountain that make this city attractive to the creative firm and workers (Barnes *et al.*, 2011).

Vancouver has a service-oriented economy that consists of a highly educated labor force working in professional, scientific, and technical service industries. Thus the economy of this region is gradually influenced by economy of SMEs (small-and medium-sized enterprise), entrepreneurs, technology and scientific workers, and creative workforces (Barnes *et al.*, 2011)

The remarkable quantity of amenities within the city of Vancouver, and the significance of profession, scientific and technical service industries in economy of the CMA were the inspiration of this thesis to find any potential correlation that exist between these two factors.

3.4 The Dataset

3.4.1 Response (Dependent) Variables

The primary dataset, including the information of 66,078 firms that operate in Vancouver and associated data, was obtained from SimplyMap Canada (2011). SimplyMap is a web mapping application developed by Geographical Research Incorporation. The data source available in SimplyMap Canada contains 2006 adjusted Canadian Census data, current and future years estimate for a variety of demographic and socio-economic variables, 2009 household expenditure data, and Dun and Bradstreet Canadian business directory database. The firms' data obtained from SimplyMap is provided as points-of-interest data, including firm's legal name, business name, NAIC code, SIC code, address, telephone number, line of business, and web address. Collecting data on firms that are active in Canada requires the use of four-digit Standard Industrial classification codes (NAICS) - North American Industry Classification System. This system gives comprehensive data across the United States, Canada, and Mexico and categorizes Canadian Economic activities into 19 sectors. Since it would be difficult to identify all industry employment using these data, two-digit industries have to be selected to identify the sectors. Sectors' codes, their names, and examples of companies that are active in each sector are presented in Table 1.

Table 1- Industry Sector's code, name, and examples

Sector's Code	Sector's name	Example of Firms
11	Agriculture, Forestry, Fishing and Hunting	Crop Production, Animal Production, Forestry and Logging
21	Mining and Oil and Gas Extraction	Oil and Gas Extraction, Mining and Quarrying, Support activity for Mining and Extraction
22	Utilities	Electric Power Generation, Transmission and Distribution, Natural Gas distribution
23	Construction	Construction of Buildings, Utility System Construction, Specialty Trade Contractors
31, 33	Manufacturing	Food Manufacturing, Textile Mills, Clothing Manufacturing, Wood Product Manufacturing
41	Wholesale Trade	Farm, Petroleum, Food, Beverage, Tobacco Product Wholesaler- Distributors
44-45	Retail Trade	Motor Vehicle and Parts Dealers, Furniture and Home furnishing, Electronics and Appliance stores
48-49	Transportation and Warehousing	Air Transportation, Rail Transportation, Water Transportation, Truck Transportation
51	Information and Cultural industries	Publishing Industries, Motion Picture and Sound Recording Industries, Telecommunications
52	Finance and Insurance	Monetary Authorities-Central Bank, Credit Intermediation and Related Activities
53	Real estate and Rental and Leasing	Real States, Automotive Equipment Rental and Leasing, Lessors of Non-Financial Intangible Asset
54	Professional, Scientific and Technical Services	Legal Services, Accounting, Tax Preparation, Bookkeeping and Payroll Services
55	Management of Companies and Enterprises	Management of Companies and Enterprises, Holding Companies, Head Offices
56	Administrative and Support, Waste Management and Remediation Services	Administrative and Support Services, Investigation and Security Services
61	Educational Services	Elementary and Secondary School, Universities
62	Health Care and Social assistance	Ambulatory Health Care Services, Hospitals
71	Arts, Entertainment and Recreation	Performing Art Companies, Spectator Sport
72	Accommodation and Food services	Travel Accommodation, Full-Service Restaurant
81	Other Services-except Public Administration	Repair and Maintenance, Personal and Landry Services, Private Households

For the purpose of this research, these 19 sectors, as shown in Table 1, have been collapsed and grouped into ten categories based on similarities in nature of the sector, as summarized in Table 2. For example in Table Utilities (NAICS 22), and Transportation and Warehousing (NAICS 48-49) have been combined together and have been called UTW. Each of these combined categories is shown with an acronym.

Table 2- Industry category acronyms

Category Acronym	Sector Code Included in the Category
AGF	(11)
MOG	(21)
CON	(23)
MNF	(31-33)
UTW	(22,48,49)
RAF	(44,45,72)
ICT	(51)
FIR	(52,53)
MNG	(55)
PAE	(54,56,61,62,71,81)

The focus of this thesis is on the information and communication technology sector. Since in Canadian classification of industry there is no specific NAICS code for ICT sector, the process of collecting statistical data of ICT firms in Vancouver was obstructed by deficiency of official source. Moreover, there is no unity in existed definition of ICT sector between

several authorities. The North American Industry Classification System, for example, include radio and television broadcasting, but exclude manufacturing of electronic components, and wholesaler and lessors of ICT equipment. In the contrary, OECD has opposite choice in its statistics. This research follows broadly Statistics Canada and Industry Canada's definition of ICT sector, which includes industries "primary engaged in producing goods or services, or supplying technologies, used to process, transmit to receive information" (June 1996). This definition comprises the firms that are mostly classified under NAICS codes 51 (Information and Cultural sector); however, other sectors comprise ICT industries as well. Information and Cultural sector in Canadian Industry Statistic (NAICS 51) includes:

"Publishing industries, including software publishing, the motion picture and sound recording industries, the broadcasting industries, the telecommunication and related services industries, data processing industries, and the other information services industries, including Internet publishing and broadcasting and web search portals" (Statistics Canada, 2007).

Because information and cultural sector utilize ICTs in various ways, this category is give the acronym of ICT to be representative of ICT firms. Firms' addresses and zip code area data were extracted for Census Metropolitan Areas of Vancouver². Using 2006 metropolitan area boundary file from Canada Census, location of firms was determined by geographic information system (GIS). They have been converted to the dataset that shows the number of firms based on NAICS categories in each 410-census tract of the Vancouver CMA. Based on Statistics Canada's definition, a census tract is a small geographic unit with relatively stable boundaries that follow easily identifiable physical features like highways, railway lines, and

² Metropolitan area "is a very large urban area (known as the urban core) together with adjacent urban and rural areas that have a high degree of social and economic integration with the urban core. An MA has an urban core population of at least 100,000, based on the previous census" (Statistics Canada)

major streets. Census tracts are located in census metropolitan areas and have population ranges of 2,500 to 8,000 (Statistic Canada 2006).

3.4.2 Explanatory (Independent) Variables

The variables employed in this study were selected based on important factors that have been identified in the literature on firm location. All independent variables are measured using the metropolitan scale for the year 2006. Independent variables have been classified into two categories: distance variables and the amenity variable. The five distance variables were selected to highlight the locational concerns of all industrial sectors such as proximity to transportation infrastructures or proximity to center business district (CBD).

The first set of variables held to be associated with location choice of ICT companies is a distinct set of environmental and cultural amenities. One of the significant features of Vancouver is public life and cultural amenities in city such as Public Square, outdoor patio, and beaches that remain a vivid picture for people who visit this city (Barnes *et al.*, 2011). This research identifies walkability variable as a measure of proximity to amenities by using the walkability scores for each census tract in the Vancouver CMA. Walkability is an element that is defined and measured differently by various researchers. For instance, while Frank and his colleagues (2010) consider “net residential density”, “retail floor area ratio”, “land use mix”, “intersection density” as components of walkability index, Crane (2000) just considers density, land mix, and street pattern as important factors. In this research,

walkability score is measured based on proximity to restaurants, coffee shops, grocery stores, shopping centers, parks, bookstores or libraries, pubs, banks, and place of entertainment. The walkability index that is used for this thesis generated by utilizing data from the “walk score” website. Basically, this score represent how easy it is to live in a certain area without being depended on using car to access amenities³. However, the walk score does not incorporate transit score, or proximity to transportation facilities, into our walkability index. The walk score algorithm gives points to an address based on its’ walking distance to nearby amenities in each category. The data resources that walk score utilize are various including Google, Education.com, Open Street Map, Localeze. The census tract reference map with the 2006 boundaries is used to identify the center of each Vancouver census tract.

Five sites within the Vancouver CMA (Census Metropolitan Area) are selected to be our points of interest. These sites that each represents the important and main feature of different area of the CMA including economic activities, transportations, and higher educations.

Since Metropolitan Vancouver comprises 220,000 workers specialized in production industries and 100,000 office workers in the Central Business District (CBD) (Barnes *et al.*, 2011), the metropolitan core is considered as one point of interest in this thesis. The distance of this point from the centroid of each census tract is the first independent variable of this research. In order to have a specific coordinate (longitude and latitude), the location of the Waterfront transit station is used as the center of the Metropolitan core.

³ Places with walk score 100-90 means residents of those areas do not need car for their daily errands. Walk score 90-70 implies to places that most errands can be accomplished without using car. Area with walk score 69-50 means people who lives in these areas can access to some amenities within walking distance. Walk score 49-25 is used for places with few amenities within walking distance. Walk score 25-0 implies to places that their residents require car almost for all errands. (Www.walkscore.com)

Ports and airports can influence firm's productivity and profitability that leads to the higher wages in urban areas (Glaeser, 2008). Also, as a gateway to global and national markets, access to airport is key for ICT and advanced business workers that means access to travel opportunity. Vancouver International Airport (YVR) is important as a Canada's Asia-Pacific gateway, therefore this site is considered as second point of interest. Vancouver International Airport is located in the City of Richmond and represents the second largest concentration of jobs after the downtown (Barnes *et al.*, 2011). The location of the main terminal is taken to represent the airport.

The University of British Columbia (UBC) and Simon Fraser University (SFU) are the other variables (points of interest) that represent center for higher education. The center of each of the universities' main campus is taken as the precise point for measurement. The mid point of the UBC's campus is location of Sauder School of business and church office middle of is the SFU's campus. The main campus of Simon Fraser University is located on Burnaby Mountain. The main campus of British Columbia University is also in Burnaby close to Discovery Park, and is important institution in forming the technological side of the municipality 's economy.

In addition to these distance points, the distances of the centroid of the census tracts to the closest highway ramps have been measured. Knowing the precise location of each of these points of interest through their geographic coordinates (longitude and latitude) helped to minimize the margin of error in distance measurement. At last, one index comprise of calculated distances of a set of six point to the geographic center of each census tracts (polygon) is generated using ESRI's ArcGIS desktop software. Due to the irregular shape of

census tract area polygons, an intersection approach in a desktop GIS is used to measure the distance between selected site to centroid of each census tract. Six independent variables (explanatory variables) are listed in Table 3, along with their acronyms that are used in identifying them in further analysis.

Table 3- Independent variables and their acronyms

Variable (Point's name)	Variable's Acronym
Downtown Core- Metropolitan	CBD
University of British Columbia	UBC
Simon Fraser University	SFU
Highway Ramps (exits)	HWY
Vancouver International Airport	YVR
Amenities (Walkability index)	AME

3.5 Location Quotient

The density of occupations in all 20 sectors of industry within Vancouver CMA is detected through an index representing the composite of Location Quotient (LQ) for all sectors of Canada's industry. LQ is a way of comparing the regional economy to the national economy

or any reference economy. LQ demonstrates the share of the local economy of a particular industry. In general, the location quotient can be used as a measurement of relative concentration (Hayter, 1997; Kuncoro, 2003; Isserman, 2007). Here LQ is utilized as a measurement of establishments' concentration. This index measures the concentration of an industry within the district of a census tract and it is represented as follows:

$$LQ_{ir} = \frac{E_{ir}/E_r}{E_{in}/E_n} = \frac{E_{ir}/E_{in}}{E_r/E_n}$$

The subscript *i* refer to a specific industry. The subscript *n* is an indication of any reference area (here it refers to Vancouver CMA) and *r* indicates the region under study (here each census tract). Lastly, *E* denotes a measure of economic activity such as employment (in this study, number of company or firms from each sector of industry).

Therefore, if this equation is less than one for a particular sector of the industry (*i*), this reflects the fact that the census tract *r* hosted fewer numbers of companies in industry *i* compare to the entire CMA. The equation greater than one indicates the census tract compare has increasing specialization of that industry. Accordingly, equation equal to one implies the census tract *r* has same growth speed of that industry as the entire CMA.

For the purpose of my research, the LQ has been calculated that express the share of each industry in each census tract over the share of that industry in the entire CMA (Vancouver). Thus, this index demonstrates geographic concentration of different companies.

Chapter 4

Data Analysis

4.1 Regression Test

4.1.1 Simple Linear Regression

This study considers 16 variables (independent and dependent), creating the possibility of 60 pairs. It is helpful to do simple regression in order to see the relation between each pair of variables. However, in order to support the analysis graphically, box plots for all of the variables for ICT category are drawn and can be found in appendix A.

The regression tests for the Category ICT (Information and Cultural-NAICS 51) are presented in Table 4. At this stage, only one variable at a time is taken into account to observe the changes in the response variables associated with the changes in each corresponding independent (explanatory) variable. The Pearson correlation between each pair of variables, their associated \mathcal{R}^2 values, which shows “ the proportion of variability of the response variable accounted for by the explanatory variables”, and their level of statistical significance are reported in Table 4 (Landau & Everitt 2003).

Table 4- Simple Regression Results

Distances	AGF			MOG			CON			MNF			ICT			MNG			PAE			UTW			RAF			FIR		
	β	<i>P Value</i>	SEE	β	<i>P Value</i>	SEE	β	<i>P Value</i>	SEE	β	<i>P Value</i>	SEE	β	<i>P Value</i>	SEE	β	<i>P Value</i>	SEE	β	<i>P Value</i>	SEE	β	<i>P Value</i>	SEE	β	<i>P Value</i>	SEE	β	<i>P Value</i>	SEE
CBD	.266	.000	3.90	-.047	.347	.651	.427	.000	.930	-.107	.030	1.01	-.218	.000	.772	-.068	.167	1.11	-.213	.000	.241	.344	.000	1.35	-.189	.000	.514	-.199	.000	.518
UBC	.258	.000	3.91	-.064	.198	.650	.463	.000	.912	-.081	.102	1.01	-.173	.000	.779	-.101	.040	1.11	-.249	.000	.239	.332	.000	1.36	-.168	.001	.516	-.218	.000	.516
SFU	.231	.000	3.94	.128	.010	.646	.087	.080	1.02	-.074	.137	1.01	-.162	.001	.780	.055	.244	1.12	-.059	.235	.247	.135	.006	1.42	-.063	.205	.522	-.092	.068	.527
YVR	.271	.000	3.89	-.034	.490	.651	.452	.000	.918	-.081	.102	1.01	-.136	.006	.784	-.058	.003	1.11	-.231	.000	.240	.262	.000	1.39	-.151	.002	.517	-.242	.000	.513
HWY	.129	.009	4.01	.050	.317	.651	.097	.050	1.02	-.099	.044	1.01	-.106	.032	.786	-.014	.778	1.12	.051	.305	.247	.031	.537	1.44	-.065	.187	.522	-.109	.028	.526
AME	-.302	.000	3.86	.043	.388	.651	-.595	.000	.827	.075	.130	1.01	.165	.001	.780	-.213	.000	1.09	.216	.000	.241	-.400	.000	1.32	.471	.000	.461	.310	.000	.503

The significance codes listed in the footnote have been assigned based on the P values, most significant to least significant.

As it is displayed in Table 4, the result of simple regression, considering one variable at a time, shows that the ICT category is to some degree correlated with all the variables. The results show that the Information and Cultural section (NAICS 51) is positively correlated with walkability of the location ($r = 0.027$, $P < 0.001$). Although, the value of r is low here (indicating low correlation), but diffuse pattern of ICT businesses across Vancouver and large number of firms used in this study make it easy to get statistically significant result even with low correlation. Therefore, the result suggests that the number of ICT companies increases with increasing the concentration of amenities in a location. The coefficient table also demonstrates that there are negative strong correlations between the ICT category and the location of downtown ($r = -0.047$, $P < 0.001$), the location of University of British Columbia ($r = -0.030$), the and location of Simon Fraser University ($r = -0.026$). These results indicate that the number of ICT companies increase by becoming closer to the location of downtown, UBC, and SFU. This result corresponds to Sparkes and Guild's finding, indicating that companies in companies in Information and Technology sector tend to locate close to educational institutions because they perceive this proximity as an assist for their competitive advantage (Sparkes & Guild, 2007).

However, the result for ICT category shows largest \mathcal{R}^2 value ($r = -0.047$) with regard to downtown location (CBD), meaning that the concentration of companies in ICT sector of industry is more correlated to the proximity with location of the Vancouver's downtown rather than other locations (independent variables). This can be because of the response of

ICT firms to their employees' need regarding living within reach of city centers with high "urban cultural and social amenities", or simply the effect of clustering of production reasons (Evans, 1985; Glaeser *et al.*, 2000, Florida, 2002; Van Oort *et al.*, 2003).

The correlation between Vancouver International Airport and the ICT category implies that the locations of the firms in Section 51 industry are to some extent correlated with the location of the airport (YVR) ($r = 0.018$, $P < 0.006$). However, the positive relation with Highway ramps ($r = 0.011$) does not reach statistical significance ($P = 0.035$).

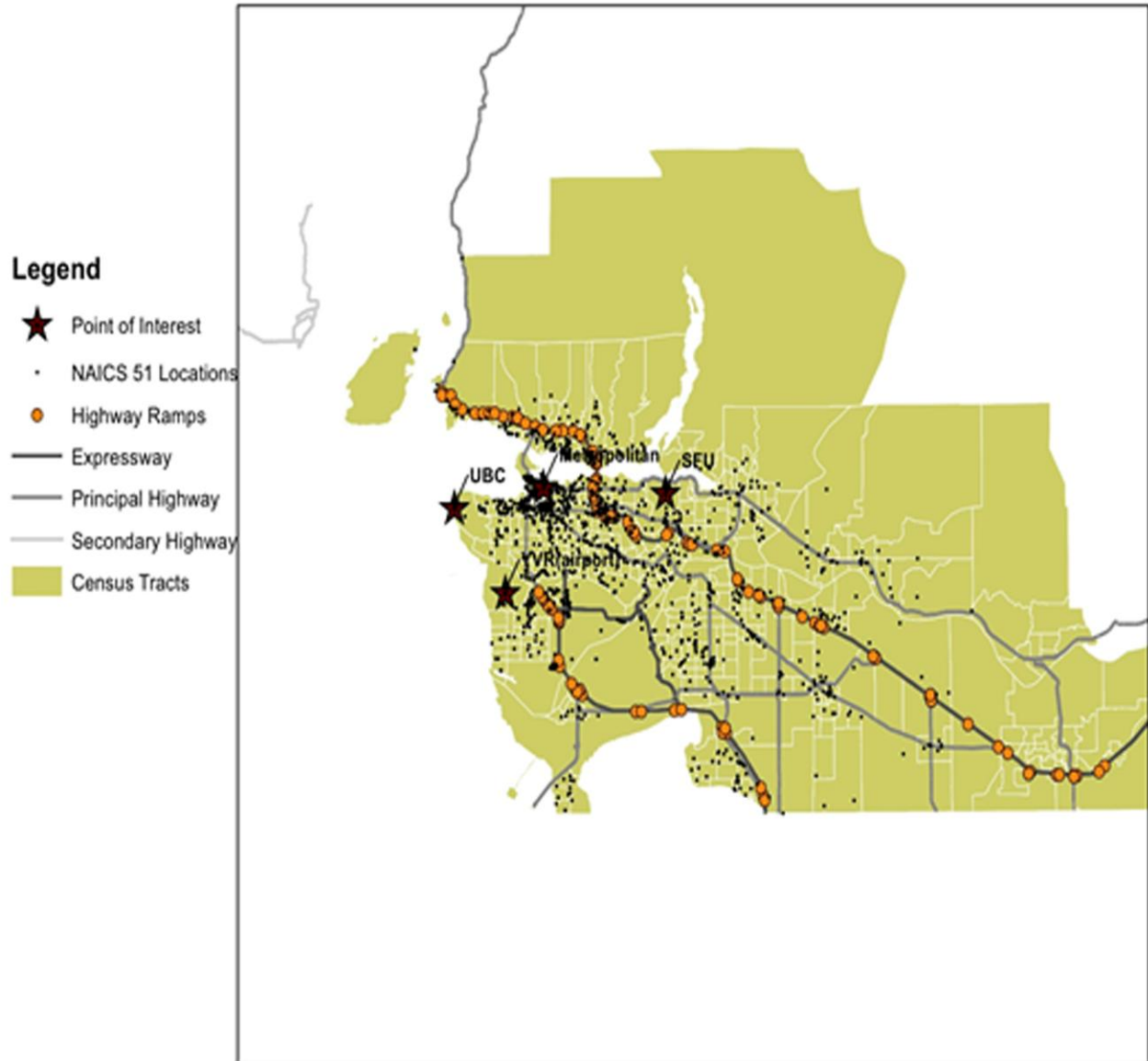
These coefficients presents the measure standard deviation change in the dependent variable in response to increase of one standard deviation in corresponding explanatory variable, without taking to account other independent variables that act on location while all the variables are correlated to some extent. Therefore, it is difficult to attribute the changes in one dependent variable to the changes in a particular independent variable. For instance, if there is strong correlation between the location of construction corporations and location of University of British Columbia, it might initially arise form the negative relation that location of UBC has with concentration of amenities in the place, or proximity of downtown combined with negative correlation of construction corporations with each of the latter two variables. It is helpful to conduct principal components analysis in order to unravel this kind of relationships involved in a set of variables.

Next, two more regression tests are done for each pair of variables to see which model is the best fit for each explanatory variable. Thus, three different regression tests are run for each set of variables overall. The first test is done on the original explanatory variables; the

second test response variable is regressed on the square of each independent variable; and the last test is done on natural logarithm (LN) of explanatory variables. The coefficient table of the latter two tests can be found in Appendix B. A correlation matrix of the data is also included in the Appendix B. The results of the three-regression tests are compared, and the best models that explain the correlation between variables are chosen for each separate explanatory variable. Accordingly, the model with a natural logarithm is a better model for explaining the relation between four of the explanatory variables (distance to downtown (CBD), distance to University of British Columbia, distance to Highway ramps, and walkability) and the response variables. For distance variable to Simon Fraser University (SFU) and Vancouver International airport (YVR), the models that best fits the data is the regression model that is run on the explanatory variables raised to the second power.

As a result, based on the three correlation matrixes, the location of companies in the Information and Cultural industry have a strong negative relation when increasing the distance to downtown, Simon Fraser University, and the Vancouver International Airport. Figure 2 that shows how firms in the Information Technology sector distributed within the CMA supports these results. As the map displays, ICT companies are more concentrated toward downtown core (Metropolitan), however some of them are located close to Vancouver international airport and highway exits (Figure 2).

Figure 2 - Distribution Pattern of ICT Firms with regards to Points of Interest



Source: Created by the author from Census Canada
boundaries are for 2006

Furthermore, there is a weak negative relation between the location of ICT firms and distance to highway ramps, indicating that the location of firms in Information to a lower degree compare to other factor is affected by proximity to highways and transportation. It can be an indication of knowledge workers' "high commuting tolerance" that makes them "footloose" with regard to their work location (Van Oort *et al.*, 2003). The model also shows that the locations of ICT companies are to some extent positively correlated with the walkability variable. Since the walkability variable in this study stands for the density of amenities, not for transit access as walkability index does not measure how accessible is a place to public transit, it can be concluded that information intensive services have a tendency to be located in places with high density in terms of amenities.

4.1.2 Multiple Linear Regression

As a first step of analysis, multiple linear regressions have been run to assess the strength of the relationship between independent variables (explanatory variables) and dependent variables (or response). The following regression model has been tested to provide statistical evidence about the hypotheses:

$$Y_i = \beta_0 + \beta_1 \text{CBD} + \beta_2 \text{UBC} + \beta_3 \text{SFU} + \beta_4 \text{YVR} + \beta_5 \text{HWY} + \beta_6 \text{WALK}$$

Where i can be any of the sectors in category of 10 such as AGF, MOG, *etc.* The results of correlation and regression analysis provide insight into the location choice of different industries. Although, this method is not recommended for making an ultimate inference since some of the independent variables are highly correlated. After applying multiple regression analysis, a set of data result in the form of *standardized regression coefficient* has been obtained that is reported in Table 5. The main correlations between variables are also bolded in Table 1 of appendix A.

Table 5- Standardized Beta Coefficients of Variables and their Significance

Explanatory Variables	AGF		MOG		CON		MNF		ICT		MNG		PAE		UTW		RAF		FIR	
	β	Sign	β	Sign	β	Sign	β	Sign	β	Sign	β	Sign	β	Sign	β	Sign	β	Sign	β	Sign
CBD	-.912	**	-.631	.	-1.00	***	-1.41	***	-.864	**	.123	-	1.26	***	-.215	-	-.030	-	.915	**
UBC	.902	*	.267	-	1.43	***	1.59	***	.488	-	-.786	*	-1.65	***	1.08	*	-.170	-	-.824	*
SFU	.331	***	.322	**	.063	-	.282	**	.109	-	.074	-	-.255	**	.027	-	.069	-	-.175	.
YVR	-.036	-	.164	-	-.339	*	-.442	*	.956	-	.395	*	.389	*	-.769	***	.305	.	-.035	-
HWY	.043	-	.008	-	.054	-	-.051	-	-.055	-	-.057	-	.0676	**	.000	-	-.047	-	-.068	-
AME	-.263	***	.005	-	-.563	***	-.044	-	.920	-	-.334	***	.207	***	-.353	***	.538	***	.315	***

Standardized beta coefficients are used, since they measure the change in dependent variable associated with in explanatory variables and allows comparison across regressions. Based on the result presented in Table 4, location of knowledge intensive companies appears unrelated to most of the explanatory variables expect the number of these firms increase by becoming closer to the downtown core (CBD). The results show a strong negative relationship ($\beta = -0.864$) between distance to downtown and location of ICT firms, meaning companies in the Information and Technology sector in Vancouver prefer to locate within reach of the downtown (CBD). As the result in Table 4 shows, when the model tests the effect of variable separately on the location choice of ICT firms all variables seems to be important in ICT firms' location selection, however by considering all the variables together only the effect of proximity to the downtown remains important (Table 5).

4.2 Principal Component Analysis (PCA)

The main aim of this research is to uncover any existing location patterns for industry sectors to determine which factors are important when considering location selection. In order to facilitate the analysis, a variable reduction technique has been used to help explain the maximum amount of variance in the data, while reducing the number of observed variables. The technique that is used is called Principle Components Analysis (PCA), a “variable reduction technique” that reduces the number of data to the smaller number of components that account for most of the variance of the observed variables (Jolliffe, 2002). This

“multivariate technique” transforms “a set of related (correlated) variables into a set of uncorrelated variables that accounts for the decreasing number of the variables in the original observations” (p.328). Essentially, the aim of this approach is to summarize and uncover “any patterns in a set of multivariate” data through “reducing the complexity of the data” (Landau & Everitt, 2003, p.328). The statistical software that are used for analyzing the data are SPSS and R, which are integrated sets of software that manipulate and calculate data, and display them graphically.

A correlation matrix of the data shows that the correlations between variables are substantial; thus, it is possible to simplify the data to certain degree by using principal component analysis. The correlation matrix can be found in Appendix B Table 1. A series of equations is solved in order to find the coefficients that define the principal components. These coefficients are obtained from the eigenvectors of the sample covariance matrix. Sixteen components that correspond to the number of total variables are created.

Table 6 shows the amount of the total variance of the observed variables that each of the principal components explains. Each principal component explains an additive proportion of total variance; hence, the contribution of each new component in explaining the variance is less than that of the preceding components. Table 6 presents the components in decreasing order of importance.

Table 6- Principal Component Analysis Outputs

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
	1	4.589	28.683	28.683	4.589	28.683	28.683	3.652	22.826
2	1.735	10.844	39.527	1.735	10.844	39.527	2.075	12.968	35.795
3	1.468	9.173	48.699	1.468	9.173	48.699	1.515	9.466	45.261
4	1.286	8.040	56.739	1.286	8.040	56.739	1.488	9.300	54.561
5	1.123	7.020	63.759	1.123	7.020	63.759	1.381	8.631	63.192
6	1.034	6.462	70.221	1.034	6.462	70.221	1.125	7.028	70.221
7	.911	5.695	75.916						
8	.822	5.138	81.054						
9	.789	4.933	85.987						
10	.707	4.416	90.403						
11	.652	4.076	94.479						
12	.449	2.809	97.287						
13	.362	2.262	99.550						
14	.065	.408	99.958						
15	.007	.042	100.000						
16	2.320E-16	1.450E-15	100.000						

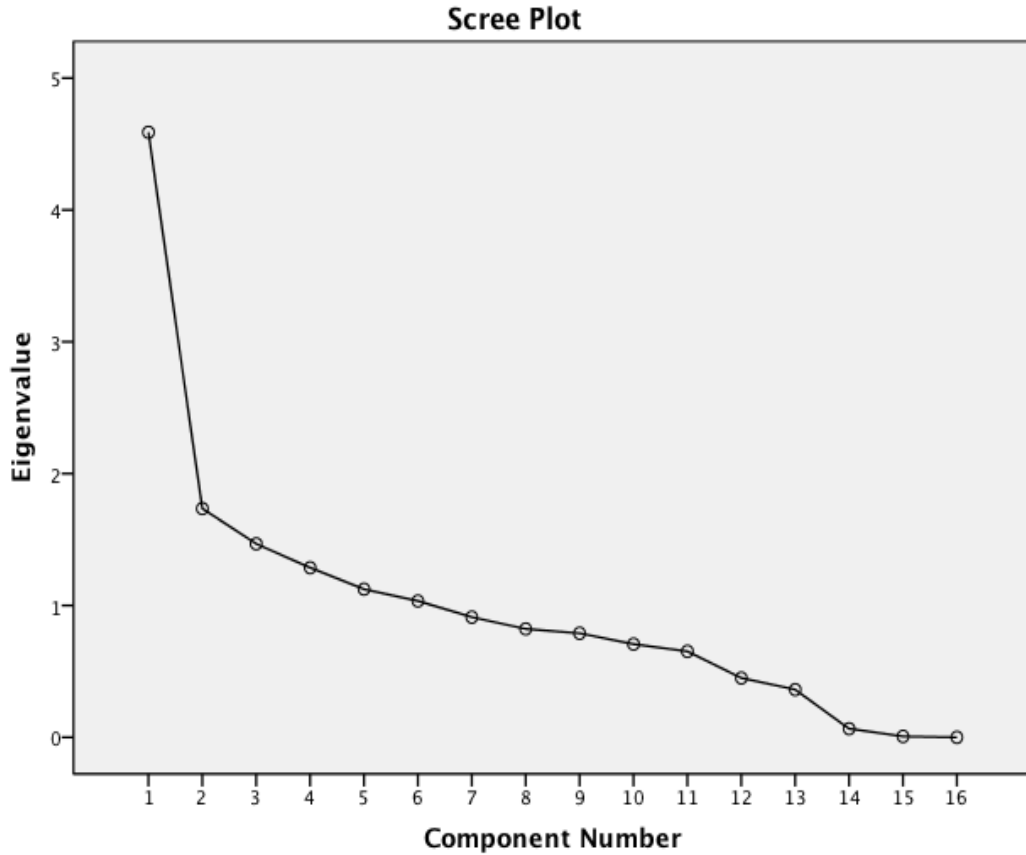
The first component (scaled eigenvector) has a variance (eigenvalue) of 4.6 and is the one that explains the largest part of the total variance; in fact, this component explains 28% of the total variance. The second principal component has a variance of 1.7 that accounts for a further 11% of the variance, and so on. The fourth column that is labeled “ cumulative %”

demonstrates the amount of the total variance that can be accounted for by the first n components. For instance, the first four principal components account for 57% of the total variance, and the first five principal components account for 64% of the total.

The decision regarding the number of components that should be retained is made based on the proportion of the total variation of the original variables that can be explained by the number of different components (Landau and Everitt, 2000). Usually, the value that is suggested for the explanation is between 70% and 90%. The popular approach for extracting the valuable components is to observe the initial eigenvalues and exclude a number of principal components based on the number of eigenvalues below a threshold, which is usually less than one (Kaiser's criterion). Based on the correlation matrix, this approach normally keeps the components whose variances are higher than the average.

Moreover, the screen plot (Figure 2) that graphically demonstrates the distribution of variance among the components displays a sharp "elbow" that is a complementary approach used to make the decision about the number of components to keep. In this screen diagram, the y-axis is a plot of eigenvalue for each corresponding principal component. The elbow of the curve indicates that higher order principal components might not be needed as they account for a declining amount of additional variance. Based on the results of the covariance matrix and the shape of curve displayed by the screen plot, the first 6 components should be retained for further analysis.

Figure 3- Screen Plot of Components



Having decided on the six-component solution, the next step is to interpret the six components by observing the “component matrix”. The interpretation can be done from the initial component matrix, but, since more than one component is retained, the interpretation of unrotated factors is quite difficult. Therefore, factor rotation that is a linear transformation of a component matrix is identified as an aid for interpretation. The initial component matrix,

which contains the loadings of each component, can illustrate how each factor (component) is correlated with each of the variables.

Table 7- Six Extracted Component Matrix

	Component					
	1	2	3	4	5	6
AME	-.761	.320	.130	.013	.025	.052
HWY	.302	.320	-.333	.235	.218	-.065
CBD	.902	.326	.062	-.036	-.145	.020
SFU	.501	.388	-.158	.393	.135	-.062
UBC	.885	.281	.149	-.134	-.173	.062
YVR	.864	.272	.116	-.104	-.155	.091
AGF	.404	.042	.008	.144	.445	.174
MOG	-.016	.001	-.063	.646	.349	.279
CON	.669	-.502	-.024	-.086	-.160	.079
MNF	-.083	-.169	.571	-.007	.305	-.467
UTW	.501	-.248	.231	-.123	.315	-.099
RAF	-.401	.559	.501	.112	-.001	-.099
ICT	-.214	-.190	.182	-.213	.186	.754
FIR	-.374	.211	.134	.304	-.560	.202
MNG	.083	-.557	-.185	.538	-.282	-.181
PAE	-.320	.272	-.745	-.382	.132	-.134

Rotation of the factors does not change the overall structure of the solution; it only alters the way the solution is described. A varimax rotation facilitates the interpretation of each component by sorting out the loadings and subsequent relationships among variables within the same components without changing their original mathematical properties.

Table 8- Rotated Components; Rotation Method: Varimax with Kaiser Normalization

Rotated Component Matrix^a

Variables	Component					
	1	2	3	4	5	6
AME	-.486	.598	-.302	-.064	-.070	-.093
HWY	.233	.013	.078	-.281	.468	.229
CBD	.943	-.108	.105	.018	.136	.128
SFU	.448	.020	.016	-.069	.560	.288
UBC	.951	-.096	.124	.066	.027	.042
YVR	.919	-.111	.110	.047	.066	.023
AGF	.240	-.047	.350	.038	.457	-.146
MOG	-.182	-.042	-.079	.156	.737	-.112
CON	.413	-.689	.212	.179	-.099	-.081
MNF	-.199	.254	.454	.534	-.149	.233
UTW	.274	-.188	.560	.253	.031	-.033
RAF	-.064	.789	-.220	.252	-.007	.088
ICT	-.143	.032	-.005	.049	.000	-.860
FIR	-.084	.174	-.762	.163	-.055	-.021
MNG	-.227	-.663	-.231	.287	.153	.321
PAE	-.249	.110	.046	-.901	-.092	.127

4.2.1 Interpretation of the statistical analysis

In order to interpret the rotated principal components, the component loadings have to be examined considering their relationship to the original variables. To do so, the correlation

between the variables and the components is reviewed; this involves determining the variables measured by each of the retained components. In other words, variables that demonstrate high loading for each component are taken into consideration when interpreting components. Essentially, those components loadings (correlation coefficients) that have absolute values higher than 0.40 have the most important influence in the interpretation. Meaningful loadings in each component are bolded to help track the common themes.

The first component represents areas such as the location of downtown, the University of British Columbia and Vancouver International airport, with strong positive correlation (0.94, 0.95, and 0.92) combined with a moderate positive correlation with the location of Simon Fraser University (0.45). Amenities factor with a negative correlation (-0.48), Construction sector with a moderate correlation of (0.41), and ICT with a negative correlation (-0.14) are other factors that are of interest component one. The inference that can be drawn from this component is that the number of companies in ICT sectors is relatively higher in locations with more amenities rather than places with low concentration of amenities.

The second component, which represents accessibility, demonstrates relatively high positive loading on walkability (0.60) and 'RAF' (0.79), combined with negative loading on 'MNG' (-0.66) and 'CON' (-0.69). These loadings suggest that the location of companies in the retail trade sector and in the accommodation and food services sector are positively correlated with the density of amenities that exist close to their location, while the companies in the management of companies and enterprises sector tend to be located far from places with a high concentration of amenities. These data also support the results of the previous

component, emphasizing that construction companies decrease in number in places where the number of amenities is high.

Component three shows negative loading on 'FIR' (-0.76) and positive loading on 'UTW' (0.56), suggesting that companies in the utilities sector and in the transportation and warehousing sector choose their location in parts of the city that are too far from finance and insurance, real state, and rental and leasing companies. The fourth component proposes the same interpretation for 'MNF' and 'PAE' companies by demonstrating high negative loading on 'PAE' (-0.90) and positive loading on 'MNF' (0.53). Companies in the administrative and management businesses sector; educational services sector; art, entertainment and recreation sector; accommodation and food services sector; and health care and social assistance sector; and professional, scientific and technical services sector locate in areas that have features and characteristics different from those of selected area by corporations in manufacturing sector.

The fifth component suggests the location of businesses in the agriculture and forestry sector and in the mining and oil and gas extraction sector have proximity to the highways because there is a positive loading on 'AGF' (0.45) and 'MOG' (0.74), coupled with weaker but positive loading on highway (0.47).

The sixth, and last, component extracted in the six-variable solution demonstrates strong negative loading on ICT firms' locations (-0.86). Interestingly, there is virtually no correlation between this variable and the other 17 variables, suggesting that companies in the Information and Technology sectors are not influenced by location of companies in other

sectors. Moreover, results suggest that there is no dependence of ICT firm locations on any of the independent variables in the model.

4.2.2 Mapping the Distribution of Information and cultural Industry firms

The geographical distribution of the companies in the information and cultural industry sector within Vancouver metropolitan area is illustrated in figure 3. By visually inspecting the map it can be understand how number of ICT companies tend to increase by becoming closer to downtown core (Metropolitan). Moreover, Figure 2 displays the geographic distribution of firms in information and cultural (sector 51) industry with regard to our five distance (independent) variables. Both figures are visual evidence of the undertaken analysis.

Some concentration pattern is found in location of firms toward the downtown core. This concentration of firms around CBD seems significant, however large number of ICT companies are dispersed within the city (see Figure 2). Figure 4 in Appendix C also presents some relationship between location of establishment in Information and Cultural industry and amenities' concentration (walkability score) of census tracts, which again correspond to the result demonstrated in Table 2.

Consequently, both Figures confirm the result of PCA suggesting that ICT firms' location is correlated with concentration of amenities in that location. The PCA results also recommend that firms in Information and Technology sector tend to locate near downtown

core, however when consider all the spatial dimensions this relationship does not seem remarkably strong.

4.3 Investigation a clustering (distribution) pattern between industry sectors

Beside exploring relationship of companies' location to the distance and amenity variables, finding the clustering pattern of ICT businesses among other sectors of industries is part of the research question. Three different steps were taken to uncover any interesting pattern that implies clustering among different companies active in different sector of industry. First, regression test is done for a set of two variables to examine how location of firms in one sector relates to location of another sector's firms. The regression test with one variable at the time is conducted to explore the correlation between locations of each industry sector to that of another sector. The result of this stage suggest that ICT companies might be located in area of the CMA that retail trade and accommodation and food services are located. While, utilities and warehousing companies choose places where are far from the area that ICT firms are located. A multi-linear regression test also is conducted to location pattern of companies in ICT sector with regards to the location of other sector in industry. The result of this test shows how firms in each sector of industry are distributed with regard to the firms in other sectors.

4.3.1 Principal Component Analysis

The same steps have been taken for doing a PCA on industry sectors variables. In order to avoid of redundant explanation, just concise explanation will be brought for each step.

Table 9- Principal Component Analysis Output

Component	Total Variance Explained								
	Initial Eigenvalues			Extraction Sums of Squared			Rotation Sums of Squared		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.183	21.830	21.830	2.183	21.830	21.830	1.700	16.996	16.996
2	1.402	14.019	35.849	1.402	14.019	35.849	1.661	16.615	33.611
3	1.240	12.403	48.252	1.240	12.403	48.252	1.423	14.233	47.844
4	1.084	10.844	59.096	1.084	10.844	59.096	1.117	11.168	59.012
5	1.033	10.327	69.423	1.033	10.327	69.423	1.041	10.411	69.423
6	.939	9.386	78.808						
7	.805	8.053	86.862						
8	.737	7.373	94.235						
9	.577	5.765	100.000						
10	7.517E-15	7.517E-14	100.000						

Having looked at scatter plot and Table 8 (above), five components with eigenvalue greater than one (Kaiser's criterion) are selected to retain. These components account for a large proportion of total variance of observed variables. Pertaining scatter plot and initial component matrix can be found in Appendix F. Rotated component matrix displays the loading of five-extracted component (Table 10).

Table 10- Rotated Components; Rotation Method: Varimax with Kaiser Normalization

Rotated Component Matrix^a

	Component				
	1	2	3	4	5
UTW	.694	.106	.283	.054	-.084
FIR	-.670	-.077	.090	.157	-.009
AGF	.556	-.078	.010	.487	-.042
MNG	-.285	.762	.135	.117	-.193
CON	.465	.702	.142	-.082	.090
RAF	-.377	-.683	.352	.045	-.083
PAE	-.066	-.256	-.867	-.257	-.130
MNF	.071	-.169	.647	-.279	-.069
MOG	-.088	.029	-.022	.828	-.001
ICT	-.062	-.040	.029	-.007	.979

The first component demonstrates positive loading on UTW (0.70), AGF (0.56), and CON (0.465), combined with negative loading on FIR (-0.67). This result reflects the positive correlation between location of firm in Utilities, Agriculture, foresting and fishing, and Construction sectors, while these sectors have negative correlation with location of firms in Finance, Insurance, Real state and Rental services.

The second component, like component one, represents a positive correlation between Management of Companies and Enterprises (MNG = 0.76) and Construction (CON= 0.70), coupled with negative loading on RAF (0.68). This result can be interpreted as clustering of Construction companies with Management of Companies and Enterprises, and their

avoidance of being located close to companies in Retail Trade, Accommodation and Food services sectors.

Component three represents a high negative loading on PAE (-0.87) and moderate positive loading on MNU (0.65), suggesting that Professional, Scientific, Technical, and Educational, Health care services have different criteria in choosing their location to the Manufacturing Companies.

Interestingly, the fourth and fifth components show that Mining, Oil and Gas Extraction companies and Information and Cultural companies are not impacted by location of any other sector. However, based on the previous PCA result, it can be inferred that this pattern of location in MOG is not same as location pattern of ICT sector. It means that due to the nature of Mining, Oil and Gas Extraction industry businesses in this sector tend to be located in certain area that are usually far from cities. Whereas, Information and Cultural companies locate in area with certain features and characteristics different from area that other sectors locate. Therefore ICT firms, in selecting location, even might not be dependent in any other sectors and as a result form an independent cluster in the Vancouver urban area.

Chapter 5

Conclusion

5.1 Summary of Findings

Using census data from Canadian industries, this thesis focused on exploring a spatial pattern for distribution of ICT companies both with regard to amenities and the location of firms in other industries. Analysis of the location pattern of knowledge-intensive firms in Vancouver suggests that the number of businesses in the ICT sector tends to be slightly higher in areas with a high concentration of amenities; however, this relationship while statistically significant is weak for location pattern of ICT businesses. Yet, the existence of a relationship between amenities and location trend of ICT firms, and the absence of this relationship among firms in other sectors, suggests the need for further research as to how exactly amenities are related to location decision of ICT firms. This result supports Florida's argument that talented and knowledge workers are drawn to places that offer them a "social environment" and "opportunity to validate their identities as creative people" rather than to places with traditional attractions. Florida argues that "the physical attraction that most cities focus on – sport stadiums, freeways, urban malls, and tourism, and entertainment districts that resemble theme parks – are irrelevant, insufficient, or actually unattractive to many creative-class people" (2003, p.9). Moreover, Atzema (2001) found that accessibility of a place by car influence the location pattern of ICT firms. He states that "for ICT firms closely linked to what might be called the 'electronic space' and much involved with

telecommunication, accessibility by car emerges as the most important location factor” (2001, p.375). Therefore, the spatial association between concentration of ICT firms and certain amenities, found by this research, does not refer to certain causality, because the decision regarding location of firms is a bundling of factors.

The most significant finding of this thesis that can be inferred from the analysis results and observing the distribution of ICT companies in Figure 2 is that there is a tendency in the location decision of ICT firms to be close to and concentrated in downtown cores. Since firms in the ICT industry are “tightly clustered in one location” then it can be inferred that “there must be strong agglomeration economies in that industry” (Glaeser, 2008, p.125). By comparing this finding to the relationship between the location of ICT firms and concentration of amenities, it appears that the agglomeration factor in ICT firms’ location pattern is more important than the existence of consumer amenities in a place. This result implies that the primary advantage of agglomeration and proximity is the “reduction of transport costs for goods, for people and for ideas” (Glaeser, 2008, p.117). Companies in the Information and Technology sector have a tendency to cluster together in order to “reduce uncertainty” and risk and “maximize face-to face” contact (Evans, 1985). This finding corresponds to Evans’ (1985) finding that even with recent developments in information and technology, the need for face-to-face interaction remains high; therefore, the tendency of offices to cluster in city centers remains unaffected. Atzema (2001) has found that many of firms in Netherlands ICT sector prefer to locate close to central part of cities. Also, the result of study by McNaughton and Brown (2004) shows that ICT firms in Toronto, Montreal, Ottawa, and Calgary have distinct clusters near downtown cores. The tendency of

knowledge-intensive industries to locate in city centers is supporting evidence of “connection between urban density and ideas” (Glaeser, 2008, p.149). This finding is also in accordance with Florida’s argument that “creative-content” and knowledge-based industries tend to cluster together in order to access the source of competitive advantage, which is the concentration of talented people and knowledge workers pool (Florida, 2003). In support of Florida’s argument, Glaeser (2008) claims that clustering of knowledge-intensive industries reduces the transport cost for goods and also facilitates the process of matching and connecting smart people that leads to increases returns for innovation.

Furthermore, Glaeser *et al* (2001) argue that “areas that offer proximity to the CBD have become increasingly valued to consumers who have a high opportunity cost of time” (p.41). Knowledge workers who are part of the creative-class have a high opportunity cost of time and high marginal cash cost (Florida, 2003). Therefore, proximity to a CBD is more valued to talented and knowledge workers rather than other workers who are less restricted in time. As a result, it is justifiable that knowledge-based firms tend to locate close to a CBD because of their employees’ convenience.

However, the result of the principal component analysis shows that location of companies in ICT sectors tend to not be too close to transportation infrastructures that in this thesis were represented by the location of the airport and highway exits. Also, based on the approach that this research examined it, one may suggest that proximity to education centers, the University of British Columbia and Simon Fraser University, which were the representative for them in this research, is not of importance to ICT companies in their location selections. It means that there is no clustering tendency among ICT firms in Vancouver’s urban area near education

and knowledge creating organizations. It is been previously argued by Atzema (2001) that there is limited importance of proximity to education centers for ICT firms in the Dutch ICT sector. In contrary, Saprkes and Guild (2007) argue that proximity to universities and colleges is an important factor that affects the location decisions of ICT firms in Kitchener-Waterloo. Therefore, there might be different factor that determine the relationship between location of ICT firms and location of educational sector, such as influence of zoning regulations and land use, land availability, and orientation of ICT firms in terms of production or service and sales.

The model also attempts to address the clustering pattern of ICT companies among companies in other industries. The result of our analysis does not show any clustering tendency of ICT firms to cluster together with other sectors of industry, indicating that there is no evidence in our analysis that the location decision of ICT companies is impacted by proximity to any other sector. However, spatial analysis results from this study demonstrate that ICT companies are far from the areas where utilities and warehousing businesses are located.

In conclusion, although the empirical analysis does not find any clustering pattern among ICT firms in relation to firms in other industries, the agglomeration effect regarding concentration of companies in Information and Technology firms near the CBD still remains strong. However, the importance of proximity to transportation facilities and educational services is not significant in the location pattern of ICT firms.

5.2 Limitations

A limitation of the methods is use for this study that it might not include all related regional attributes that firms consider in their location choice. In addition, this model does not differentiate between types of ICT firm. Since ICT firms vary in their economic and social benefits and costs, such firms are attracted by different factors. Moreover, it should be noted that the location pattern of product-oriented ICT firms are very different from service-oriented firms; however, the collected data in this research does not allow distinguishing between them in the data. Service oriented ICT firms tend to locate close to their costumers' head offices and, as a result, they might tend to cluster in a CBD, while there is less tendency in product-oriented ICT firms to locate near their clients and they might be found more in suburban areas.

A limitation of the data collection is that it relies on data collected from Census tracts, and includes no case studies or interviews. Therefore, even if the method shows the strong spatial correlation between ICT firms and amenities or the location of a downtown, it does not show whether amenities exist in a region because of ICT firms' demands, or whether ICT firms located in the region because of existence of amenities.

Lastly, this study just uses Vancouver as a study area for the analysis; however, the result of this analysis might differ by adding more study areas from diverse regions, as the distribution pattern of firms might vary from city to city.

5.3 Discussion: Recommendation for Policy and Future Research

Some researchers discussed the importance of consumer amenities as a determinant factor of population growth (Knap & Graves, 1989; Beale & Johnson, 1998; Johnson & Fuguitt, 2000; Clark, 2004; Rappaport, 2008), while others emphasize on the role of amenities in location decisions of firms (Tolley & Diamond, JR., 1982; Gottlieb, 1995; Glaeser, Kolko, & Saiz, 2000). This study shed a new light on the role of amenities in attracting the ICT firms as one driver of new economy. In this study, proximity to a CBD is found to be an important factor in the location selection of ICT firms, and knowledge intensive companies tend to locate their offices close to city centers. ICT firms might locate in a central area of a city with the hope of finding better matches between their “job requirements and skills” for their workers (Helsley & Strange, 1990). Therefore, the model and results stress the need of governments, policy makers, and planners to better understand the determinant elements of the location decisions made by ICT firms in order to improve the economy of their region, as the ICT sector is considered increasingly important in economic growth (Abler, 1977; Richardson, & Gillespie 1996; Premkumar, 2000; Litan & Rivlin, 2001). However, one policy implication or question is how can suburban municipalities attract ICT firms?

Moreover, this study does not show any tendency of the ICT sector to be located close to companies of other sectors. Therefore, clustering with other sectors is not found important for the information and communication technology sector. However, the agglomeration factor for firms in the ICT sector appears very strong, as face-to-face interaction is considered

necessary in the production of these types of firms (Evans, 1985; Ihlanfeldt & Raper, 1990; Van Oort, Weterings & Verlinde, 2003)

Furthermore, spatial statistical results produced by this study support the research's hypothesis that consumer amenities are an effective factor in the location decision of information and communication technology companies. Therefore, local governments can attract these types of firm to a region by providing amenities and public goods. Moreover, a potential for future research can be to examine the role of different types of amenities in the location pattern of ICT firms. The study of the behavior of knowledge workers, as a basis of ICT companies, toward different types of amenities should be a fruitful area for additional research.

This study just assessed whether ICT companies tend to cluster together with companies in other sectors. However, it does not analyze the clustering pattern within companies in the ICT sector. Thus, studying agglomeration patterns of Information and Technology companies in relation to companies in other industries is an approach for potential future research.

In conclusion, this study provides many insights into the spatial pattern of ICT companies in Vancouver, as one of the important economic drivers of the region. A recommendation to policy makers, urban planners, and local economic developers is to fully understand and give more attention to factors that attract ICT companies as boosters of a region's economy performance.

Appendix A

Figure 4.A- Normal P-P Plot of Regression of Standardized Residual
(Dependent Variable: AGF category)

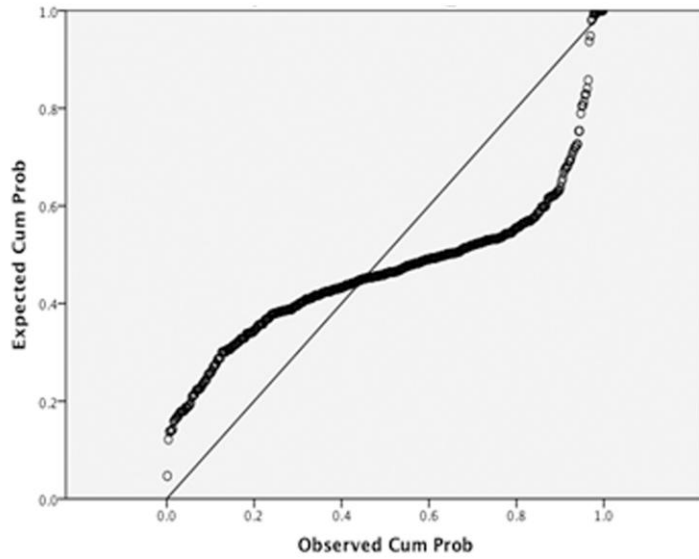


Figure 5.A- Normal P-P Plot of Regression of Standardized Residual
(Dependent Variable: MOG category)

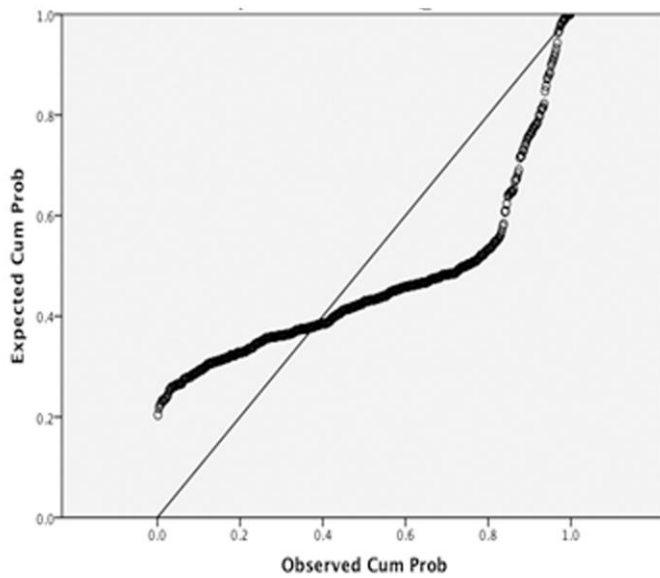


Figure 6.A- Normal P-P Plot of Regression of Standardized Residual
(Dependent Variable: CON category)

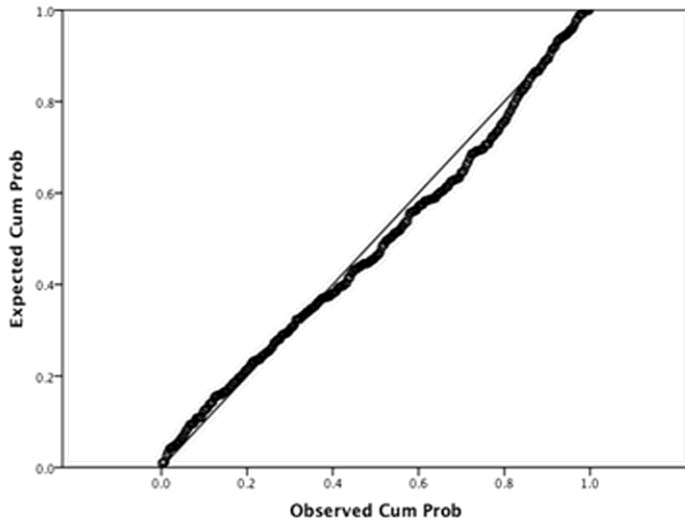


Figure 7.A- Normal P-P Plot of Regression of Standardized Residual
(Dependent Variable: MNF category)

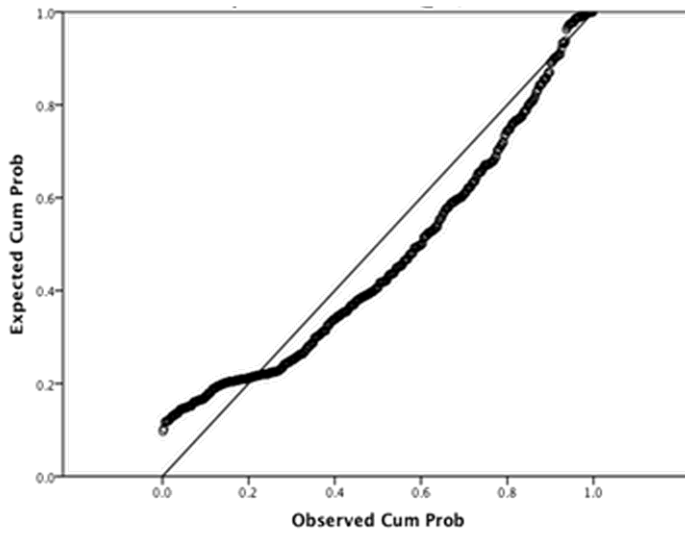


Figure 8.A- Normal P-P Plot of Regression of Standardized Residual
(Dependent Variable: UTW category)

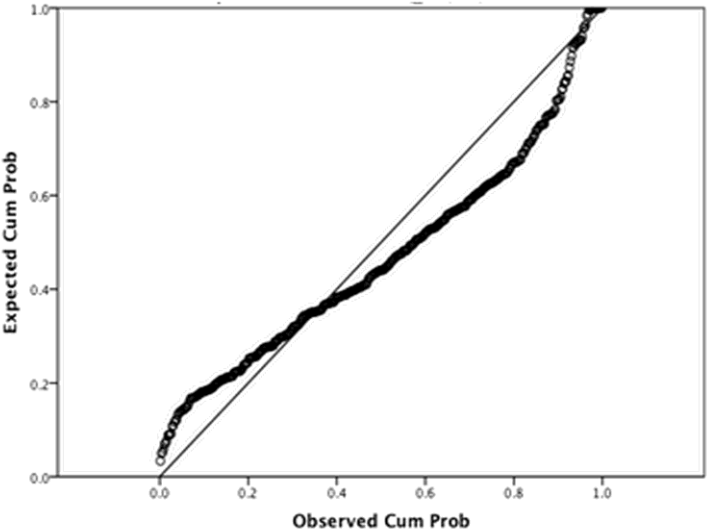


Figure 9.A- Normal P-P Plot of Regression of Standardized Residual
(Dependent Variable: RAF category)

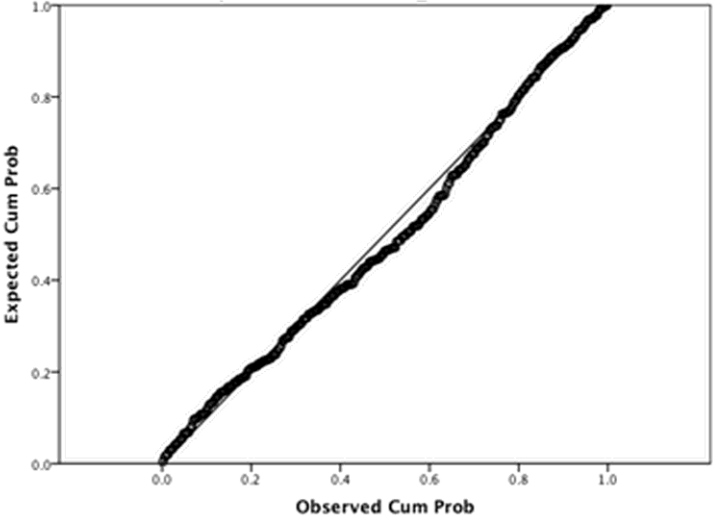


Figure 10.A- Normal P-P Plot of Regression of Standardized Residual
(Dependent Variable: ICT category)

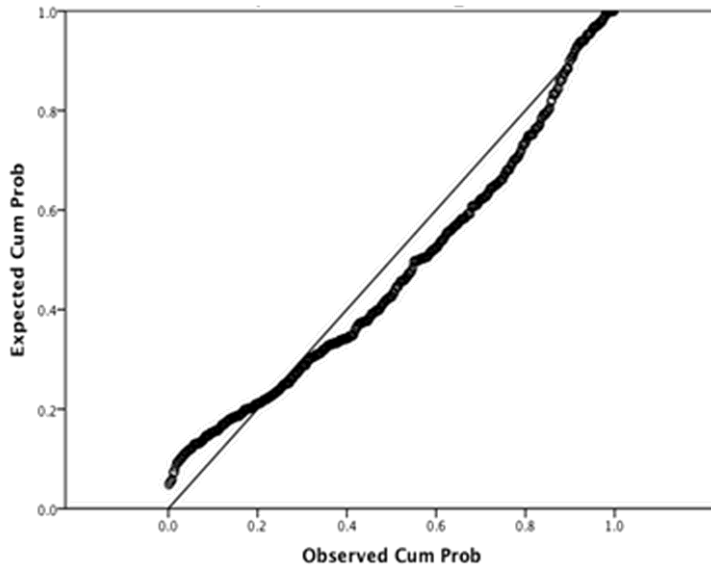


Figure 11.A- Normal P-P Plot of Regression of Standardized Residual
(Dependent Variable: FIR category)

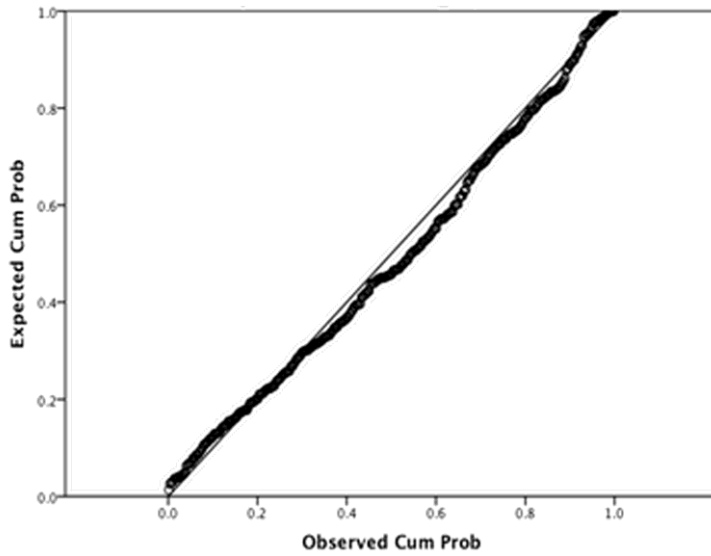


Figure 12.A- Normal P-P Plot of Regression of Standardized Residual
(Dependent Variable: MNG category)

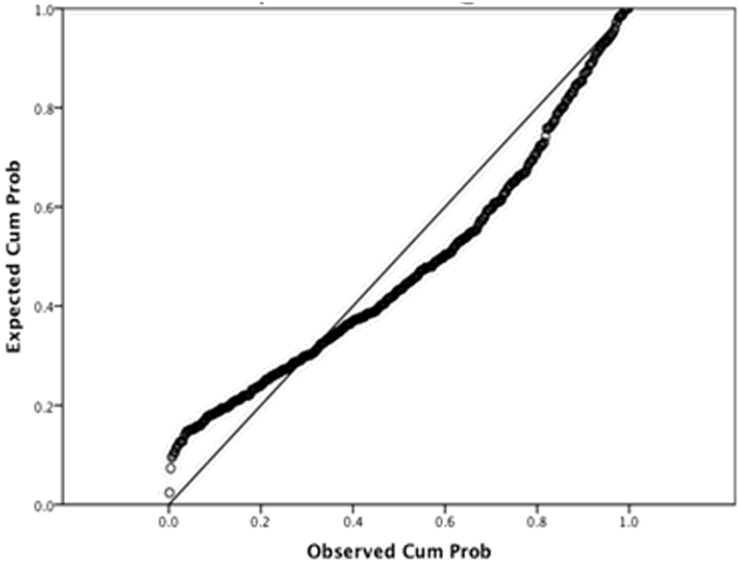
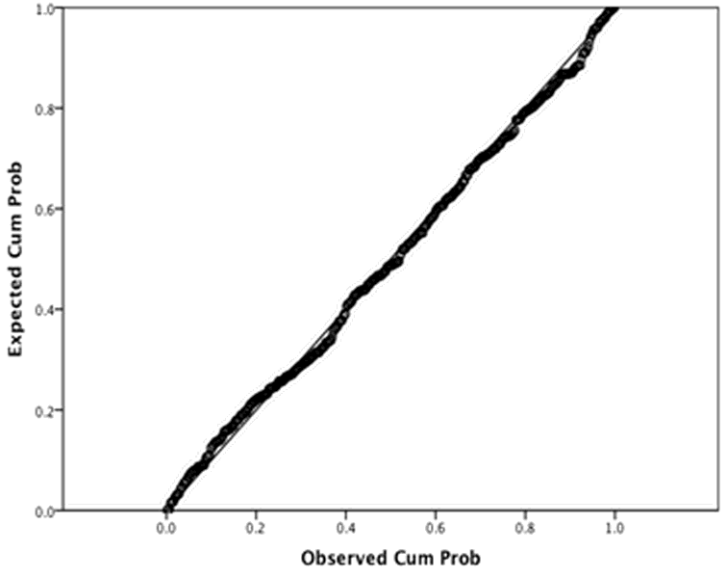


Figure 13.A- Normal P-P Plot of Regression of Standardized Residual
(Dependent Variable: PAE category)



Appendix B

Table 11.B- Coefficient Matrix

	WALK	HWY	CBD	SFU	UBC	YVR	ACF	MOG	CON	MNU	UTW	RAF	ICT	FIR	MNG	PAE
WALK	1.000	-.136	-.550	-.266	-.516	-.521	-.302	.042	-.595	.075	-.399	.471	.165	.310	-.214	.217
HWY		1.000	.249	.340	.192	.234	.129	.050	.097	-.099	.031	-.065	-.106	-.109	-.014	.051
CBD			1.000	.563	.963	.898	.266	-.047	.427	-.107	.344	-.189	-.218	-.199	-.068	-.213
SFU				1.000	.379	.356	.231	.128	.087	-.074	.135	-.063	-.162	-.092	.055	-.059
UBC					1.000	.954	.258	-.064	.463	-.072	.332	-.168	-.173	-.218	-.101	-.249
YVR						1.000	.271	-.034	.452	-.081	.262	-.151	-.136	-.242	-.058	-.231
ACF							1.000	.081	.154	-.025	.177	-.138	-.051	-.167	-.043	-.149
MOG								1.000	-.080	-.047	-.008	-.015	.000	.001	.101	-.094
CON									1.000	-.054	.240	-.536	-.048	-.351	.212	-.398
MNU										1.000	.057	.097	.004	-.096	-.019	-.244
UTW											1.000	-.312	-.102	-.289	-.072	-.351
RAF												1.000	-.028	.118	-.272	-.186
CT													1.000	-.017	-.108	-.100
FIR														1.000	-.047	-.127
MNG															1.000	-.232
PAE																1.000

Table 12.B- Regression Test of Natural Logarithm of Variables

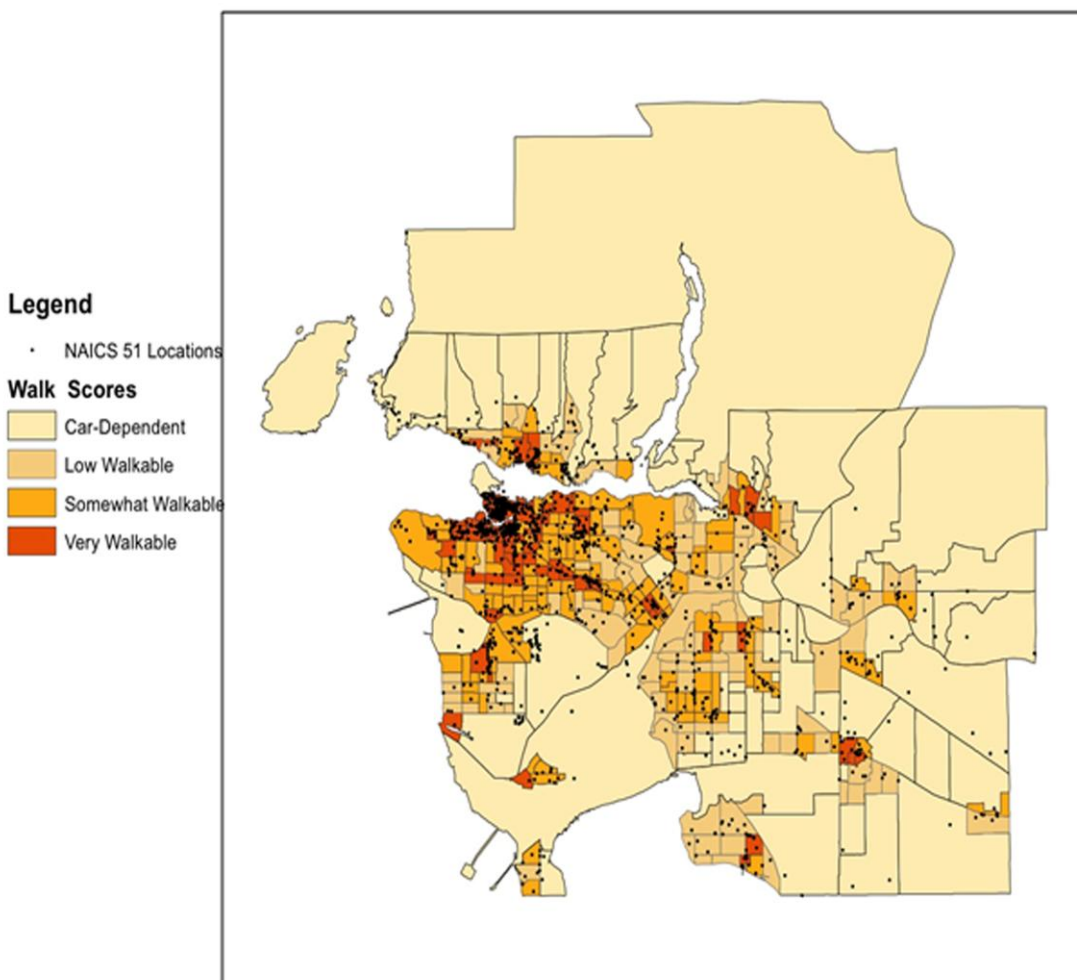
	AGF			MOG			CON			MNF			ICT			MNG			PAE			UTW			RAF			FIR		
	β	R ²	Sig	β	R ²	Sig	β	R ²	Sig	β	R ²	Sig	β	R ²	Sig	β	R ²	Sig	β	R ²	Sig	β	R ²	Sig	β	R ²	Sig			
CBD	.189	.036	***	-.196	.038	***	.427	.182	***	-.126	.016	**	-.234	.055	***	-.057	.003	-	-.156	.024	**	.352	.124	***	-.239	.057	***	-.172	.030	***
UBC	.198	.039	***	-.105	.011	*	.473	.224	***	-.045	.002	-	-.139	.019	**	-.128	.016	**	-.265	.070	***	.338	.114	***	-.171	.029	***	-.191	.036	***
SFU	.167	.028	***	.132	.017	**	.087	.007	-	-.051	.003	-	-.138	.019	**	.052	.003	-	-.046	.002	-	.130	.017	**	-.028	.001	-	-.074	.005	-
YVR	.200	.040	***	-.049	.002	-	.421	.177	***	-.057	.003	-	-.064	.004	-	-.083	.007	-	-.202	.041	***	.207	.043	***	-.121	.015	**	-.239	0.57	***
Hwy	.088	.008	.	.065	.004	-	.097	.009	.	-.120	.014	**	-.127	.016	**	-.032	.001	.	.076	.006	-	.059	.003	-	-.057	.003	-	-.058	.003	-
Walk	-.408	.166	***	-.014	.000	-	-.489	.239	***	.044	.002	-	.110	.012	*	-.225	.065	***	.232	.054	***	-.254	.065	***	.349	.122	***	.272	0.74	***

Table 13.B- Regression Test of Square of Variables

Distances	AGF			MOG			CON			MNF			ICT			MNG			PAE			UTW			RAF			FIR		
	β	R ²	Sig	β	R ²	Sig	β	R ²	Sig	β	R ²	Sig	β	R ²	Sig	β	R ²	Sig	β	R ²	Sig	β	R ²	Sig	β	R ²	Sig			
CBD	.319	.102	***	.000	.000	-	.391	.153	***	-.082	.007	.	-.193	.037	***	-.059	.004	-	-.215	.046	***	.289	.083	***	-.144	.021	**	-.208	.043	***
UBC	.306	.092	***	-.030	.001	-	.433	.188	***	-.075	.006	-	-.180	.033	***	-.075	.006	-	-.238	.057	***	.300	.090	***	-.150	.023	**	-.221	.049	***
SFU	.281	.079	***	.042	.110	*	.130	.017	**	-.083	.007	.	-.163	.027	***	.038	.001	-	-.066	.004	-	.126	.016	*	-.075	.006	-	-.108	.012	*
YVR	.323	.104	***	-.021	.000	-	.435	.189	***	-.077	.006	-	-.159	.025	***	-.043	.002	-	-.229	.053	***	.250	.062	***	-.146	.021	**	-.231	.053	***
Hwy	.114	.013	*	.014	.000	-	.138	.019	**	-.059	.004	-	-.072	.005	-	-.014	.000	-	.004	.000	.	-.006	.000	-	-.052	.003	-	-.111	.012	*
Walk	-.222	.049	***	.082	.007	.	-.581	.337	***	.072	.005	-	.165	.027	***	-.178	.032	***	.175	.031	***	-.403	.163	***	.487	.237	***	.288	0.083	***

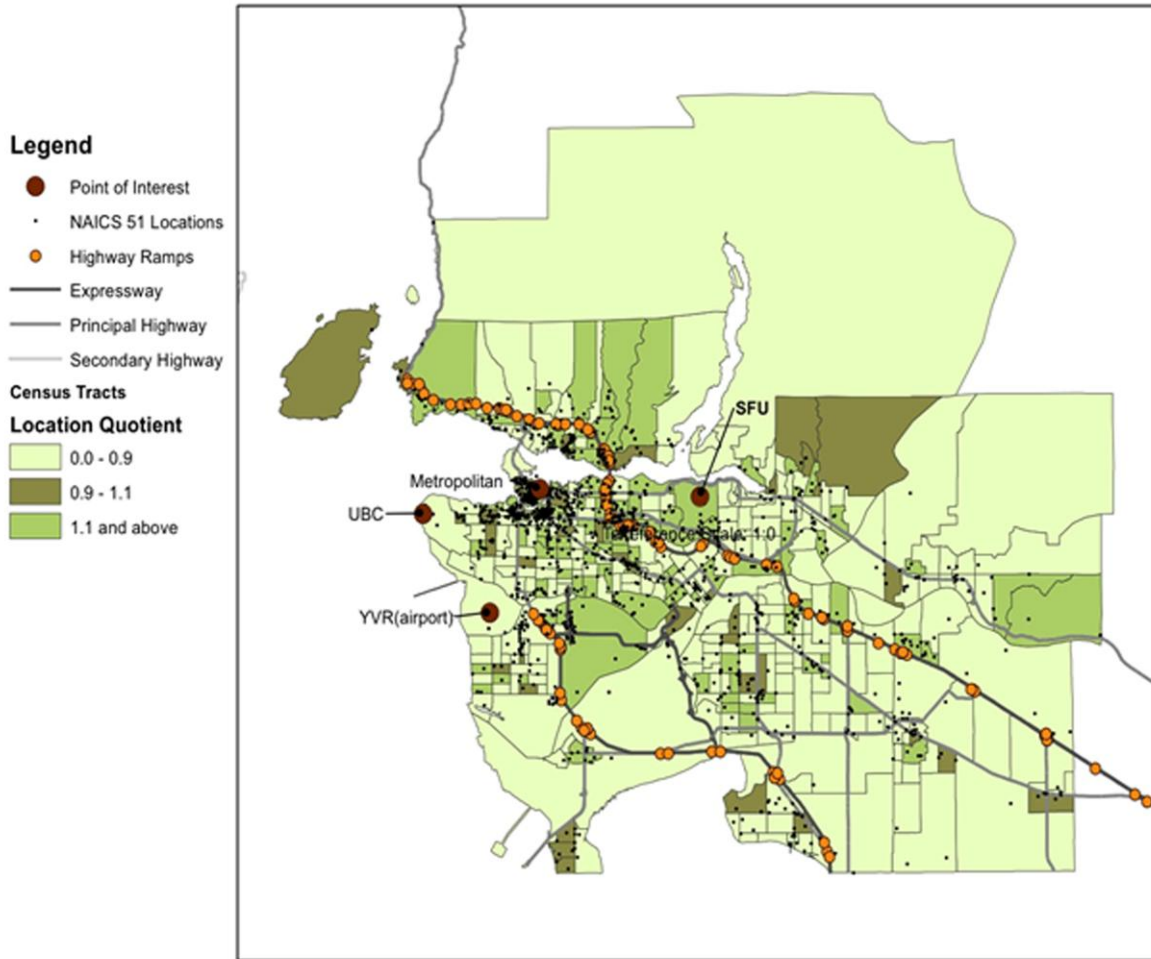
Appendix C

Figure 14.C- Location Pattern of ICT Firms with regards to Loading of Amenities in Census Tracts, Vancouver CMA



Source: Created by the author from Cencuse of Canada
, boundaries are for 2006

Figure 15.C- Location Quotient of Census Tracts along with Location of ICT Companies and Points of Interest, Vancouver CMA



Source: Created by author from Census Canada
boundaries are for 2006

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