KNOWLEDGE INTENSIVE BUSINESS SERVICES AND METROPOLITAN ECONOMIC GROWTH: AN EXAMINATION OF THE COMPUTER SERVICE INDUSTRY

by

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ABSTRACT

JONATHAN M. KOZAR. Knowledge intensive business services and metropolitan economic growth: an examination of the computer service industry. (Under the direction of DR. WILLIAM GRAVES)

As the United States economy shifted away from manufacturing industry dominance in the 1970's, business service industries grew in size and complexity to become the dominant driver of knowledge-based metropolitan economies. Knowledge-based modern economic growth is increasingly reliant upon the commoditization or production, dissemination, and consumption of knowledge. Economic competitiveness and growth in knowledge-based economies are influenced by the technical expertise and technological innovations created through the provision of professional knowledge in customized products or services. Knowledge intensive business services (KIBS) are at the forefront of modern economic growth through the use of specialized knowledge and advancements in innovation. This research examines the distribution and growth of a highly relevant KIBS industry that has previously been overlooked. As one of the fastest growing economic sectors, the computer service industry has the ability to promote knowledge production and metropolitan comparative advantages in business processes and innovation. The purpose of this research was to (re)define and clarify the fundamental principles that characterize the growth and development of modern knowledge-based metropolitan economies and to derive an understanding of the future growth and spatial distribution of KIBS, as informed by the computer service industry. The findings provide a greater understanding of the industrial structure of modern knowledge-based economies. The results indicate, in aggregate, a measured diffusion of

KIBS down the urban hierarchy and a continued diffusion to the non-core counties of metropolitan areas. Subsector research reveals details obscured by aggregate groupings, in that the larger subsectors, which define the industry in general, appear predominantly in economic and population centers while other subsectors are developed in specialized service centers rooted in local characteristics.

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CHAPTER 1: INTRODUCTION

The United States economy is undeniably a service-based economy. As the United States economy shifted away from manufacturing industry dominance in the 1970's, service industries grew in size and complexity to become the dominant driver of metropolitan and regional economies (Beyers 2005, Coffey 1996). Business and producer services are at the forefront of modern economic growth (Shearmur and Doloreux 2008). They supply the necessary activities that other businesses (services and manufacturers) rely upon to function, in part, because many businesses shed various components of their operations in an effort to become leaner and more efficient and to focus on core business activities while allowing outside vendors to provide specialized service activities essential to business operations (Coffey and Bailly 1991). In addition to the structural impact related to industry dominance and the changing provision of business activities, this transformation also has an impact on the spatial distribution of economic activity as well.

The location decisions of business and producer services are unlike the patterns formed by manufacturing industries. Manufacturers are concerned with the least cost location in relation to the market for goods and resources and labor availability. Business and producer services are concerned with the availability of high skilled workers and the concentration and connectivity benefits associated with the location of key clients or other industry sectors within innovative agglomeration economies. Mass production manufacturing with cheap labor has been replaced with knowledge production and dissemination with skilled and flexible labor (Wood 2005, Kirn 1987, Noyelle 1983).

These changing industry patterns continue to alter the economic landscape as business and producer service industries become ever more central to regional economies. It is essential to understand the impact that this transformation has had and continues to have on the nature of economic activity and regional/urban economic development policy in the United States, much of which has been lacking in geographic research (Beyers 2002). In addition, it is necessary to (re)define and clarify the fundamental principles that characterize the growth and development of knowledge based metropolitan economies.

Knowledge-based modern economic growth is increasingly reliant upon the commoditization or production, dissemination, and consumption of knowledge. Economic competitiveness and growth in knowledge-based economies are influenced by the technical expertise and technological innovations created through the provision of professional knowledge in customized products or services (Strambach 2008, Wood 2006). The computer service (CS) industry may present the ideal industry to assess modern knowledge-based metropolitan economic growth. As defined by the North American Industrial Classification System (NAICS) the CS industry

> "Comprises establishments primarily engaged in providing expertise in the field of information technologies through one or more of the following activities: (1) writing, modifying, testing, and supporting software to meet the needs of a particular customer; (2) planning and designing computer systems that integrate computer hardware, software, and communication technologies; (3) on-site management and operation of clients computer systems and/or data processing facilities; and (4) other professional and technical computer-related advice and services" (NAICS 2007).

CS industry has the ability to promote knowledge production and the sharing of information through the development of comparative advantages in business processes and innovation, which is precisely the way modern service-based economies function (Nunn et al. 1998, Gillespie and Williams 1988). As a subset of business and producer services intrinsically linked to modern economic activity, knowledge intensive business services (KIBS) are generally defined as advanced service industries involved in the use of specialized knowledge, technical skills, improved communication abilities, and greater business consulting competence. As such, they are at the leading edge of innovation and metropolitan economic growth (Doloreux et al. 2010, Currid and Connolly 2008). A top growth industry among the prominent KIBS industries is the computer service industry (Beyers 2003).

1.1. Why Computer Services?

The CS industry is significant to metropolitan economic growth because of the continual advancement and widespread use of computing technologies in nearly all aspects of economic activity. As an industry, it is significant among KIBS but may have its greatest influence across all industries in support of the technological infrastructure needed by knowledge-based advanced services and manufacturing operations. The CS industry role in innovation and technological change has been posited as having "infrastructure" like qualities, in that they provide needed support to firms in a wide variety of business and production processes and innovation activity (Nunn et al. 1998, Gillespie and Williams 1988). In that sense the CS industry could be viewed as similar to, and the service industry equivalent of, the machine tool industry in manufacturing. Just as manufacturing operations rely upon reliable, precise, and state-of-the-art machine tools for production, the service industry depends on the uninterrupted efficient performance of computing technologies and processes (MacPherson and Kalafsky 2003, Kalafsky and MacPherson 2002).

Additionally, the CS industry extends beyond just the service industry; manufacturing operations (including machine tool industries) all rely on some type of computer or network system to function. Thus, the CS industry not only represents a key industry within the overall service economy but is also integral in all advanced services and manufacturing operations. Because it provides the necessary technical expertise and infrastructure to compete in a knowledge-based economy, the CS industry is becoming foundational to modern economies and is essential to the economic development of regions (Nunn and Warren 2000, Coe 1996, Warf 1995). The ever increasing technological advancements in computing and computing technologies promote the need for CS employment across all geographies, making it one of the fastest growing economic sectors for the last decade or more (Beyers 2003).

Aside from a handful of studies from Europe (Howells 1987, Gentle and Howells 1994, Lundmark 1995, Coe 1996, Coe 1997, Coe 2000) and just two from the United States (Nunn et al. 1998, Nunn and Warren 2000), the CS industry has seen little attention in the geographic literature and none in nearly a decade. That computing technologies are ever changing and hold very little resemblance to what they were twenty, or even ten, years ago, and given their importance to modern knowledge economies, it would seem that a more significant line of research is warranted. Previous studies occurred before computers became essential to business operations and did so before internet and network technologies emerged as accessible tools. All while Google and Microsoft became some of the most successful and profitable companies in the United States amidst the dot com boom, which may be one of the most significant economic turning points in the transformation of a modern knowledge economies (Gordon 2000, Jorgenson 2001).

1.2. Goals of Research

This research presents a comprehensive study that details the growth and spatial distribution of the computer services industry in an attempt to not only provide a detailed examination of a prominent industry in an area of economic geography that sorely lacks a significant research focus, but also to inform and understand the future growth and economic sustainability of knowledge-based regional and metropolitan economies now dependent on KIBS. The larger purpose of this research is twofold: One, to (re)define and clarify the fundamental principles that characterize the growth and development of modern knowledge-based metropolitan economies in terms of KIBS now leading the economic viability of regions and metropolitan areas. Two, derive an understanding of future KIBS growth and spatial distribution based on the past and current geography of KIBS and survey-based primary research, as informed by the computer service industry. The availability of computer service industry expertise provides the necessary technological advancements necessary for metropolitan economies to remain competitive in a service oriented economic landscape. In order to achieve the purpose set forth in this research the following objectives will be considered:

Objective 1: To determine if the fundamental principles on the spatial distribution and behavior of KIBS align with past business and producer service literature by examining the computer service industry.

This objective intends to either confirm or redefine the characteristics of business and producer services/KIBS growth and their geographic distribution. As a high growth industry among KIBS, the computer service industry is used as representative example of KIBS in general. The core understanding of business and producer service/KIBS growth and distribution has not been considered, aside from a few offerings, for more than a decade. In particular, findings related to the initial concentrations of services and the subsequent down filtering of these industries through the urban hierarchy, from larger places to smaller places. Do higher concentrations remain in the largest and core of metropolitan areas? What amount of diffusion to smaller metropolitan and peripheral areas has occurred and is it continuing? Verifying the modern characteristics of business and producer services/KIBS provides an updated basis for future research. This holds particular importance to research pertaining to the innovation and economic development potential of KIBS.

Objective 2: To examine and underscore the relevance of subsector research of KIBS.

This objective intends to highlight the varying nature of business and producer services/KIBS within a single industry. Most past research utilized aggregate groupings of industries which masked the variability of dynamic industries that provide unique and very often differentiated services. Subsector research is beneficial in revealing the various levels of service production, from high to low order services, within an industry to identify distinctive patterns of growth and distribution. This approach to industrial sector research in economic geography has not been widely developed.

Objective 3: To examine firm interaction and innovation in computer services through the use of survey-based research of computer service firms in Charlotte.

This objective intends to expand on an area of research that has seen little attention in United States. More specifically, very little research is available on firm interaction or innovation, partly because detailed data on innovation activity and firm interactions are unavailable, but both have been considered as essential to modern economic development and to the growth of regions. In addition, primary data based research of a significant and expanding industry contributes to the expanding knowledge-base of modern economies.

Objective 4: To examine how the distribution and growth of the computer service industry informs the future growth and development possibilities of KIBS in general.

This objective intends to provide a platform for understanding the growth of modern knowledge-based economies dependent on KIBS. By providing the necessary technical expertise and infrastructure to compete in a knowledge-based economy, the CS industry may be the ideal industry to develop the underlying characteristics that foster the future economic success and development of cities and regions in the 21st century.

In aggregate, the fulfillment of these objectives will inform our understanding of the growth and development of modern knowledge economies, as they are now developed around technological advancement and KIBS industries. The provision of computer services is essential for the economic viability of regions. It will be possible to identify regions or metropolitan areas that are or can be successful in a knowledge-based economy and ones less likely to succeed. Understanding these processes allows for the formation of viable economic development strategies to promote the future growth of metropolitan economies.

1.3. Significance of Research

This research is significant for two reasons. One, in industry terms the CS industry represents a high growth industry among KIBS, the highly relevant subset of business and producer services integral to modern knowledge-based economic activity and growth (Beyers 2003). The CS industry is essential to a healthy functional economy because the need for and use of computers and computing technology extends to nearly all industries. Two, in broader economic terms, KIBS and services in general are the dominant means of regional and metropolitan economic growth. The economic viability of modern economic activity relies on the provision of these services to assure economic growth and health, thus understanding their distribution, concentration, and geography can inform economic development strategies and practices.

If KIBS are an essential part of innovation and innovation is seen as means to support or maintain economic growth, by developing and promoting a balanced provision of KIBS and CS industry employment a local or regional economy can build a comparative advantage to support innovation capacity as a means to grow and maintain the economy (Nunn et al. 1998, Shearmur and Doloreux 2009). Specifically, the presence of CS industries enables the transformation to a knowledge economy in post-industrial society and promotes the sustainability of economic activity by supporting knowledge production, innovation, and dissemination (Aslesen and Isaksen 2007).

The geographic contributions of this research are significant for a number of reasons. Research concerning business and producer services/KIBS has been lacking in the geographic literature with only a few examples over the last decade, particularly sector specific inquiries which not only provide detailed analyses of an economic activity but also a greater understanding of modern economic activity. In addition, since business and producer service research has not been revisited for quite some time, the general assumptions about the location of services across the urban hierarchy utilized in current and related research requires updating and verification. As with business and producer service research in general, CS industry research specifically and KIBS in general has been lacking in the geographic literature as well and should be of high importance considering the influence CS and computing technologies have in relation to economic growth and stability in a knowledge economy.

Other areas of research that have not been explored thoroughly include service level and intra-metropolitan distribution of business and producer services/KIBS. The nature of service activities has evolved into a complex network providing various levels of service activity to include high, medium, and low order services. The overall provision of services across the different levels of service is yet to be explored, let alone sector specific research detailing the nuances within a specific industry. An understanding of the intra-metropolitan distribution of business and producer services was never completely developed and has certainly evolved as service and KIBS activities expanded within metropolitan areas.

1.4. Organization of Dissertation

The remaining dissertation is presented in five sections. First, a literature review details past research focusing on business and producer service growth and change, the computer services industry, theoretical foundations, and expectations derived from the literature. Second, the data and methods utilized to achieve the objectives outlined above are specified. Third, detailed results on the inter- and intra-metropolitan distribution of computer service employment are presented. Fourth, an analysis and discussion details the outcome of the results and expectations. Finally, the conclusion offers a discussion in relation to the research objectives and significance of the results, as well as additional research needed to expand on these results.

CHAPTER 2: LITERATURE REVIEW

The literature review will be organized into four sections. The first section will review business and producer service research since the 1980's, with attention given to the decline of such research beginning in the mid to late 90's and a subsequent lack of geographic literature on business and producer services. The second section will discuss the literature on the computer service industry. The third section will introduce the theoretical framework in which the research will be couched. The fourth section will present the significance and expectations of the research, including specific hypotheses derived from the literature.

2.1. Business and Producer Service Research

Research focusing on business and producer services was initiated by the decline of manufacturing activities and the simultaneous increase of services in the United States economy beginning in the 1970's. The growth of business and producer services was largely generated by two factors. One, a broader structural change of the United States economy were services are the primary employment source rather than manufacturing industries. Two, a change in business structure were industries began to externalize various business functions to become more vertically disintegrated rather than vertically integrated in which most aspects of the business operations are completed in-house (Beyers 1991, O'hUallachain 1989, O'hUallachain and Reid 1991). Research concerning business and producer services was developed in the mid to late 1980's and was enhanced through the early 1990's (Beyers 2005, Desmet and Fafchamps 2005, Illeris 2005).

The structural change of the economy focuses on the development of service industries as the overarching economic driver. For decades, manufacturing dominated employment in the United States. As manufacturing industries relocated to cheaper locations, often outside of the United States, and labor demands decreased with advancements in production technology their dominance began to decline and the nation began transitioning into knowledge based economy. Although not necessarily a direct cause and effect scenario, service industries began to develop as the main economic driver of the United States (Harrington 1995a, Harrington 1995b, Kirn 1987).

The changes in business structure focuses on the restructuring of business organizations were once internal components of business begin to be completed by external sources. Large corporations started shedding various components of their business structure and started to outsource the work so that businesses specializing in a particular service now provide and are ultimately responsible for that aspect of the business. This created an environment where various business (producer or intermediate) services became an integral part of the economic structure of the United States. Businesses then rely on external partners for large portions of various aspects of their operations (Coffey and Bailly 1991).

Understanding externalization and the growth of business and producer services cannot be explained by one factor but rather a set of factors relevant to a firm's decision to rely on outside vendors for particular services. Cost efficiencies, specialized service functions, demand factors, and regulatory factors are all reasons firms would externalize various business functions. Cost efficiencies allow a firm to complete certain tasks at a lower cost by outsourcing the particular task. Firms will also externalize specific functions that require a specialized knowledge base that the firm cannot provide or do not have the capacity to undertake various complex tasks that would be done more effectively by functionally specific professionals. If the firm has very little demand for a specific task they are more likely to externalize the task on an as needed basis. In some cases due to government requirements, firms are obligated to use an outside source for particular tasks or the requirements make it impractical to be done internally (Goe 1991).

Externalization and the rise in business and producer services had an initial focus on manufacturing industry restructuring/realignment but as service industries (knowledge producing, high order services) expanded influence on the economy, similar processes were occurring in service industries as well. As service industries began to grow as an important source of employment and income in the economy their business models resembled and were created in accordance with the horizontal linkages manufacturers developed. As manufacturing industries continued to decline and as service industries became the primary economic driver, research focusing on service industries grew in importance and scope (Coffey and Bailly 1991, Goe 1991).

Spatial clustering, or the agglomeration of industries or firms, recognizes the importance of similar firms choosing to locate in proximity to each other in order to take advantage of input-output linkages and innovative capacity through externalization. By having suppliers, business partners, and other related firms located nearby allows for increased interaction in which the concentration of similar or related industries have the ability to innovate with the brightest minds in the field and improve technologically in product and production techniques (Rigby and Essletzbichler 2002, Storper 1992).

Explaining the prevalence of firm clustering or agglomeration has drawn much attention in understanding the way in which firms in general and specifically business and producer services interact with each other at various spatial scales. By locating in close proximity to suppliers and customers, companies are able to either share or reduce business costs due to various linkages. For example, transaction costs are reduced by sharing the cost of such things as infrastructure and collective goods like education and other social programs. Additionally, the large pool of skilled workers accumulated specifically for the spatially clustered industry reduces costs of job recruitment and retention within each firm. Local firm connections and the limited barrier of distance reduce transaction costs within the firm cluster which reinforces the notion of a vertically disintegrated company (Malmberg and Maskell 2002, Scott 1983, Storper and Christopherson 1988).

Knowledge spillovers and local innovation explains firm clustering or agglomeration through the notion of information sharing and institutional relationships of firms in close proximity to one another. These features increase the profitability of all firms involved. The exchange of information leads to and continues the need for firm clustering. These firm clusters and agglomerations create a regional innovative framework that benefits a multitude of firms in the region (Malmberg et al 1996, Morgan 1997).

Considering the rise in importance of service industries within firm clustering and the overall economy in general, research describing and detailing the rise of business and producer services and the various structural and spatial aspects of this increase garnered much attention from academics and professionals. Structural changes in business and producer service industries focuses on understanding which types of service businesses are increasing in employment and importance and the interactions between these businesses and other industries and services. Also of importance are the spatial pattern and location decisions of business and producer service industries as they determine the most beneficial and practical locality for business operations as determined by business costs, client relations, and workforce development (Harrington 1995a, Harrington 1995b).

As business and producer services grew in importance, initial concentrations of remained in the largest places and large urban areas, although there was some growth in smaller places and mid-sized urban areas. The main characteristic that emerged from the initial concentrations of business and producer services is the down filtering of these industries through the urban hierarchy, from larger places to smaller places. As firms throughout the urban hierarchy began to rely on business and producer services, these services responded to the need by expanding into smaller urban areas away from initial concentrations in the largest urban areas. Although some of these business and producer services remained highly urbanized there was a significant increase in these services outside of what could be considered the "core" of business activity within regions. Business and producer services became somewhat more evenly distributed across the urban hierarchy (Coffey and Bailly 1991, Kirn 1987).

Understanding the impact that the growth of services had on intra-metropolitan growth and development is also important. Just as inter-metropolitan diffusion of producer and business services remains important to the growth of regional economies and economic development. The diffusion within metropolitan areas of producer and business services also has implications for growth and development. Much of this research is based on case studies of specific cities or region and provides mixed results in terms of the type of industries locating in central or suburban locations and the magnitudes of growth associated with the location of services within a city or region (Aji 1995, Gong and Wheeler 2002, OhUallachain and Reid 1992). Research concerning intra-metropolitan diffusion of business and producer services identified that some "multi-nucleated" economies independent from the central city had diffused or developed in suburban areas of metropolitan areas, although these suburban concentrations do not and may not have the capacity to support an agglomerative economy like central city firm concentrations (Esparza and Krmenec 1994, Harrington and Campbell 1997, Schwartz 1992).

Some business and producer services remain agglomerated or clustered in central city locations while others move or diffuse to suburban locations. The business and producer service firms that locate in the suburbs tend to serve only local and/or regional markets when compared with central city firms. Business and producer services remaining in the central city tend to serve not only local and regional markets but also national and international markets. These centrally located firms also tend to be associated with a much larger clustering of firm activity than their suburban counterparts. The inter- and intra-metropolitan diffusion of business and producer services function in very similar fashions. Large metropolitan or central city firm clustering serves larger markets and tends to be linked to a broader array of firms at various geographic and spatial scales. While the smaller metropolitan and suburban area firm clusters serve smaller markets and have linkages to firms in a much smaller geographic and spatial scale (Esparza and Krmenec 1994, Schwartz 1992).

The tremendous growth of business and producer services within the United States economy throughout the last three decades has given continued importance to research detailing this growth and development across various geographic and spatial scales. The broad based level of research that developed the underpinnings of services research was generally followed by sector specific research detailing the growth and development of various business and producer services.

Sector specific research is inherently case study based research that details a specific service sector or industry in a particular geographic location, in many instances an urban or metropolitan area. These studies highlight the clustering of firms and the various agglomerative benefits from the collocation of similar and related firms. Numerous studies have been completed that deal with and detail an individual service industry or sector identified as a leading economic activity or industry. These include detailed analyses of industries such as finance, software development, legal services, and various intermediate services, as well as defined economic activities such as high wage or technology dependent (Beyers 2003, Graves 2003, Pollard and Storper 1996, Warf 2001).

Despite the importance of business and producer services, research involving sector specific service industries waned in the 2000's with only a few exceptions (Currid and Connolly 2008, Kay et al. 2007, Shearmur and Doloreux 2008). Business and producer research in general changed focus and the geographic literature was diverted with various other research endeavors.

Most business and producer service research began focusing specifically on KIBS research with innovation as the primary emphasis. Innovation in this context refers to both the innovative capacity inside KIBS industries with their production and dissemination of knowledge but also the innovative advancements that KIBS are capable of developing in the overall economic landscape to sustain and foster growth in metropolitan economies (Aslesen and Isaksen 2007, Simme and Strambach 2006). This line of research typically was completed in Europe were the urban system is very different than the United States and predominantly has a non-spatial approach. Researchers were less concerned with identifying spatial patterns than they were with the innovative capacity of selected KIBS industries (Muller and Zenker 2001, Strambach 2008). With few exceptions, the only geographic aspect recognized was based on prior research that services generally agglomerate in the largest of metropolitan areas and that, in terms of innovative capacity, other areas were insignificant in overall impact (Shearmur and Doloreux 2009).

Much of this research was completed by non-geographers utilizing an implicit understanding of spatial patterns of business and producer services without proper verification. The current research intends to revitalize the spatial aspects of business and producer services and to make the geography of such services an explicit finding through the computer service industry, while incorporating innovation research as a guiding principle.

As general research on business and producer services changed focus and was completed by non-geographers, spatial location became nearly irrelevant. As a result, the geographic literature shifted to other research areas. The geographic analysis of sector specific service industries was, in a way, superseded by increased interest in individual level economic considerations and new theoretical debates. The significance of this research is not being questioned but rather adds to the discussion explaining why “traditional” economic geography research was missing in the literature for much of the last decade.

Research in the 1990’s moved discussions in economic geography to the individual level and away from sector analysis. This change was partly initiated by the introduction of human capital considerations to economic competitiveness, Richard Florida’s creative class synthesis (Florida 2002), and Allen Scott’s revelations about cultural influences on economic restructuring and inter-industry communication in the development of products or outputs influenced by and developed through local culture (Scott 1997). While Scott’s work did open a new avenue of research previously unexplored to a wide extent in economic geography it played at least a part in the diminishing sector analysis of industries. His contributions led to the recognition that an increased level of firm clustering would result from the increased linkages among industries, firms, and social constructs in a cultural influenced economic environment (Pratt 1997, Scott 1997). However, clustering of this nature is inherently organic and difficult, if not impossible, to develop as a means of economic development if not already deep-rooted in the culture of a region or community, therefore difficult to implement as policy.

As for creative class influences, to some, and as further research has revealed, Florida’s (2002) work seems to have only offered a detour into an area of research that needed explored but remains less significant than originally suggested (Asheim and

Hansen 2009, Peck 2005, Rausch and Negrey 2006). This work may be most influential for opening the eyes of researchers to view the economic structure of cities and the interactions between workers and firms in a different light. His greatest contribution probably was highlighting the fact that people can attract jobs and not just jobs attracting people, as was the case in the 20th century (Storper and Scott 2009).

New theoretical and methodological debates also moved economic geography away from sector analysis. This is not all negative, every discipline should take an introspective look to reexamine focus and determine what it is they have to offer. With work by Krugman (1991) and others gaining attention, economists suddenly "found" geography and recognizing the importance of spatial variation and interaction, tenets of economic geography for decades, the sub-discipline found itself, in a way, being co-opted by economics and had to defend economic geography against the new economic geography or geographical economics (Krugman 1991). This not only led to a debate between geographers and economists but also among geographers attempting to define the discipline. Specifically, geographers needed to provide concrete examples as to why economic geographers offer significant contributions to knowledge creation and the understanding of economic activity.

In the end, economic geographers were left with a clearer understanding of their methodological and theoretical approaches. Leading to building upon and incorporating evolutionary (path dependent) and institutional models and cultural influences in economic geography research (Amin and Thrift 2000, Rodriguez-Pose 2001, Scott 2004). Other research directions moving away from spatial sector analysis research in economic geography include globalization/off-shoring or internationalization of economic activity, cluster studies, and foreign/domestic firm subsidiary research, to name a few (Fifarek and Veloso 2010, Rice 2010, vom Hofe and Chen 2006).

2.2. Computer Service Research

Research focused on computer services has seen scant attention in the geographic literature. Most producer service literature has computer services embedded in larger studies of producer services in general but a few examples do exist. Initial research detailing the computer the service industry was completed in the late 1980's and 1990's and was primarily conducted for the United Kingdom and Sweden (Howells 1987, Gentle and Howells 1994, Lundmark 1995, Coe 1996, Coe 1997, Coe 2000).

Research findings generally mirrored those of business and producer services in general. Initial concentrations of CS industry were found to be located in the largest metropolitan areas with strong forward and backward linkages for information transfers and an educated population (Howells 1987, Gentle and Howells 1994, Lundmark 1995). Further research began to identify exportable linkages between computer services and businesses outside of the regional location of computer service industries. Computer services would tend to agglomerate in regional economies that could provide the necessary skilled labor and information exchange needed but began to export services beyond their regional border (Coe 1996, Coe 1997, Coe 2000).

More recent and relevant are two articles by Nunn et al. and Nunn and Warren in 1998 and 2000 respectively (Nunn et al. 1998, Nunn and Warren 2000). These focus on computer services in the United States. The data utilized in each of them represents the growth of the computer service industry from 1982 to 1993. The age of the data makes the analysis dated considering the tremendous growth in computers and computing technologies since 1993, but the research itself is still highly relevant to the questions at hand.

Findings illustrate the concentration of computer services in metropolitan areas but vary among the levels of the computer service industry. High order programming and software and maintenance, rental and management had highest concentrations in the largest metropolitan areas while low order data processing tended to increasingly concentrate in smaller metropolitan areas, between 1982 to 1993 (Nunn et al. 1998, Nunn and Warren 2000).

Both articles were valuable in their approach to the computer services industry. Instead of relying on aggregate data representing the industry as a whole, computer services were disaggregated into the three component pieces of the industry. This recognized the fact that within computer services the level of service varies. This would otherwise be masked when viewing aggregated data. By disaggregating the computer service industry data it is possible to identify the high, medium, and low order sectors of the computer service industry (Nunn et al. 1998, Nunn and Warren 2000).

Of interest in future research is the utilization of the North American Industrial Classification System (NAICS) as compared to the Standard Industrial Classification (SIC) which was used in previous research and contained data processing within computer services. NAICS listings no longer include data processing within computer services (data processing employment has remained stable with a small increase in employment, primarily due to the decline of mainframe computers and the introduction of microprocessors).

2.3. Theoretical Framework

Innovation and the process of innovation have chiefly been focused on manufacturing in the past. Most innovations in manufacturing consist of improvements or refinements in products or processes, which, as will be shown, are relatively easier to quantify than innovations in services. But, as service industries expanded throughout the economy to become the primary driver of metropolitan growth the notion of innovation in services has garnered increased attention in the last decade, particularly within KIBS. Innovation is viewed as a means to remain economically competitive in an ever expanding global marketplace. If firms or industries are not innovating, they can become obsolescent, and ready to be consumed by the latest idea, improvement, or product (Bathelt et al. 2004, Camacho and Rodriguez 2005).

Over the last decade one of the main concerns expressed in the literature has been to conceptualize or determine how innovation in services aligns, or not, with the innovation characteristics of manufacturing. The means of innovation in services present differently than manufacturing innovations, which makes the measurement of innovations in services problematic. This is particularly difficult when trying to utilize research tools designed for manufacturing and no consensus has been reached on this conceptualization (Shearmur and Doloreux 2009).

Services can be conceptualized as both enablers of innovation that influence the business environment for and within client firms and as innovators themselves. The former is a much more complex interaction between services and client firms, in that the measurement of innovation cannot occur within the service firms themselves but rather by the contributions toward innovation in client firms, while the latter would function similar to manufacturing innovations, an approach to measuring service innovation has been debated because although they are similar processes, service innovations are not manufacturing innovations (Cainelli et al. 2004, Camacho and Rodriguez 2005, den Hertog 2000).

Services are enablers of innovation in three ways. One, they can provide innovations directly to client firms which in turn allows the client to innovate or develop additional innovation capacity. Two, they facilitate innovation activity within client firms by supporting them in innovation activities and processes. Three, they can be seen as a delivery mechanism transferring innovation and knowledge within client firms and across industries and regions in general (Aslesen and Isaksen 2007, Shearmur and Doloreux 2009).

To determine the proper way to measure innovation in services as innovation providers there has been three general approaches have been considered. The first approach is the “assimilation approach”, which views innovation in services as identical to manufacturing, thus the measurement and analyses of service innovations should be similarly approached. The second approach is the “demarcation approach”, which views innovation in services as fundamentally different than manufacturing, thus the measurement and analyses of service innovations would require new theoretical constructs and tools. The third approach is the “synthesis approach”, which views innovation in services and manufacturing as similar but not identical, thus the measurement and analyses of service innovations would require tweaking of existing theories and tools to align with the distinctiveness of service innovations (Shearmur and Doloreux 2009, Tether 2005).

A consensus on either of these approaches has not been reached, but seems to lie somewhere between the demarcation and synthesis approaches. The assimilation approach is nearly discounted because of its reliance on mostly technological innovations involving product or process. While non-technological innovations play a role in manufacturing, they are not considered the primary source for innovation as they can be in service innovations. Within services and KIBS especially, product and process innovation can be considered a routine firm activity as they are primarily engaged in providing custom materials or results for clients, it is the application of these custom materials to a clients specific needs through knowledge input and dissemination where the innovation can be found (Bettencourt et al 2002).

Although there is some evidence that KIBS may be the most likely to innovate and provide the greatest opportunity for economic growth there is little research and consensus on the types of regions or places that can foster this type of development (Bathelt et al. 2004). Innovation in KIBS as a means to support economic growth through the development of local comparative advantage can be utilized as a tool to facilitate economic growth and stave off decline. With that in mind, by understanding the distribution and growth of the prominent KIBS computer service industry, that not only enables and provides innovation but supports the innovative capacity of all firms, it is possible to identify specific regions and factors associated with them that can contribute to economic success by having and providing greater innovative capacity in services.

2.4. Expectations and Implications

The purpose of this research is to examine the growth and spatial distribution of computer services industry. This examination provides details of a prominent industry in an area of economic geography lacking significant research focus, as well as to inform and understand the future growth and economic sustainability of knowledge based metropolitan economies. This research also seeks to (re)define and clarify the fundamental principles that characterize the growth and development of modern knowledge economies in terms of KIBS. Finally, an understanding of future metropolitan growth in KIBS is derived from the past and present geography KIBS as informed by the computer service industry.

Collectively, the analysis provides a holistic view of the growth and spatial distribution of an industry that has the ability to promote knowledge production and the sharing of information through the development of comparative advantages in business processes and innovation. This is precisely the way that modern service-based economies function. Each section of the analysis offers valuable evidence towards understanding and extending our knowledge about how modern knowledge economies function. The first section provides an overdue assessment of the recent growth and spatial distribution of KIBS through the examination of an industry that is relevant to KIBS growth and to the sustained growth of knowledge based economies. The second section provides a detailed examination of an area within KIBS that has been lacking significant research focus. The intra-metropolitan distribution of KIBS has seen little attention in the literature. The third section provides a case study to not only add validity to secondary source measurements but also to detail the distribution and growth of computer services in a modern knowledge economy such as Charlotte.

From the review of the literature there are a number of expectations that will be tested through this research. CS industry will present significant growth across the urban hierarchy as the need for computer system and technology becomes an integral component to sustained modern economic growth. Both low and high order CS industries will diffuse down the urban hierarchy but high order CS industry will remain concentrated in larger metropolitan areas. Low order CS industry will be distributed across the urban hierarchy more evenly and begin to develop concentrations in smaller metropolitan areas were significant clusters of activity emerge to meet local demand. Also, high order CS industry concentrations will emerge in metropolitan areas with high demand associated with government, universities, and major centers of production for computing technology regardless of metropolitan size. CS industry will develop increased levels of employment and concentrations in non-core metropolitan counties as many business and producer services have. The greatest amount of absolute growth in CS industries will occur in core metropolitan counties, particularly with concentrations in high order CS industry. Low order CS industries will have the greatest increases in the non-core metropolitan counties providing services to expanded business clients as computing resource requirements extend to all levels of business and industry.

The following hypotheses developed from the literature will be tested.

Hypothesis 1: Higher concentrations of CS employment will remain in the largest metropolitan areas and the core of metropolitan areas.

Hypothesis 2: Continued diffusion of CS employment to smaller metropolitan areas and the non-core of metropolitan areas, but without overtaking the largest metropolitan areas and core of metropolitan areas.

Hypothesis 3: Individual CS subsectors will not be characterized as a homogenous sector but rather as unique representations of concentration, growth, and diffusion.

Hypothesis 4: Local economic conditions will provide certain metropolitan areas advantages in growing and maintaining concentrations of CS employment.

This research has implications concerning the growth and development of modern metropolitan economies, and more broadly to the study of economic geography. The implications for geographic research emanate from the lack of sector based industry studies in economic geography. The lack of KIBS based research leaves researchers without a clear understanding of the location and spatial distribution of industries that are building and sustaining metropolitan economies. Furthermore, the complexity of KIBS now providing significant levels of both high and low order services is masked when previously used aggregate industry groupings are employed as a standard. The intra-metropolitan distribution of KIBS has not been fully investigated or completely understood. This research seeks to remedy these shortcomings, as well as provide evidence that sector based industry studies should again be a prominent line of research in economic geography. Sector based CS industry studies are significant because the CS industry provides the necessary technical expertise and infrastructure essential to the development of metropolitan regions and builds the foundation for modern knowledge based economies.

The implications concerning the growth and development of modern metropolitan economies is based on the notion that the CS industry enables knowledge production, innovation, and dissemination which presents it as the ideal industry to assess modern knowledge based metropolitan economic growth. The CS industry is significant not only because it is an innovative high growth industry but also because it supports and builds the technological infrastructure needed by thriving knowledge based metropolitan economies. Metropolitan economies with concentrations of CS industry are then at the forefront in attracting and maintaining economic growth in a service dominated economy. Given the increases in outsourcing of business services and due to the constant innovations and technological advancements in computing technologies, the provision of CS industry expertise by external sources is much more practical and efficient than developing the expertise internally in a firm. Thus, the CS industry can support metropolitan growth and competitiveness, as well as advance a region's economic position.

CHAPTER 3: DATA AND METHODS

3.1. Data

The analysis utilizes U.S. Census Bureau County Business Pattern (CBP) data for metropolitan areas (MSAs) total employment and CS industry employment, including the four North American Industrial Classification (NAICS) systems five-digit subsectors of CS industry. CBP data is the most commonly used source for employment data in industry based economic analysis, including studies of business and producer services/KIBS. The data provide an annual detailed accounting of industrial employment, including industrial subsectors, for counties and metropolitan areas in the United States (Isserman and Westervelt 2006, Nunn and Warren 2000, Nunn et al. 1998). CBP data are utilized in this analysis because of the availability of county level industrial subsector employment over time. The latest available data were for 2008 and prior to 1998 the CBP data were categorized with the Standard Industrial Classification (SIC) system, since replaced by NAICS. The transition from SIC classification to the NAICS classification significantly altered the CS industry by reclassifying data processing as an information processing activity. For consistency in classification, the period of analysis was from 1998 to 2008. Due to data disclosure issues with CBP data, employment for suppressed counties was estimated using employment size class midpoints per establishment size groupings given by the CBP (Clapp et al. 1992, Glaeser et al. 1992, Isserman and Westervelt 2006).

The analysis was completed for the 366 MSAs defined in the U.S Census 2008 MSA classification. Data for the analysis was obtained annually for the 10 year time period from 1998 to 2008 from CBP at the county level and aggregated to the MSA level for comparable analysis across years. Metropolitan areas were aggregated into five metropolitan size categories according to population for the inter-metropolitan analysis and four metropolitan categories according to the number of counties in an MSA (Nunn and Warren 2000, Nunn et al. 1998). For the inter-metropolitan analysis of CS this aggregation allows for an evaluation across the urban hierarchy in the United States, and for the intra-metropolitan analysis of CS this aggregation allows for a comparison of core/non-core concentrations based on the geographic size/scope of a metropolitan area.

Analyzing the disaggregated CS industry data permits for a much more detailed understanding of the complex nature of the CS industry with respect to high and low order service aspects of the industry. CS industry data are classified in NAICS as Computer Systems Design and Related Services (5415) and is broken down into four subsectors. Custom Computer Programming Services (541511), Computer Systems Design Services (541512), Computer Facilities Management Services (541513), and Other Computer Related Services (541519).

Computer programming and systems design represent high order computer services in that they require highly skilled workers and access to information flows related to ever changing technological advancements in computing technology. Facilities management and other related services represent mid- to low-order computer services that do not require as highly skilled workers but rather working knowledge of computer systems and networks. Without data processing considered a subsector of CS industry since the NAICS conversion in 1998 the make-up of the industry has changed. Within CS industry, as they are reported now, the low order computer services have almost become a ubiquitous resource available and needed almost everywhere; therefore metropolitan size may have very little impact on the concentration of these activities.

A final analysis relies on primary source data obtained through a mail survey of all CS industries in the Charlotte Metropolitan Region. Primary source information regarding intra-metropolitan firm characteristics, including firm interaction and innovation, is essential due to the lack of detailed data and research concerned with such characteristics, which severely limits a comprehensive examination of the location characteristics of firms. The case study seeks to fill this void by acquiring data that determines specific firm characteristic information among CS specializations and how they may influence the location of firms in the metropolitan area. The acquisition of detailed data on firm interaction and innovation through survey-based research is seen as the most reliable and effective way of obtaining such data and is becoming more common (Aslesen and Isaksen 2007, Djellal and Gallouj 2007, Tether 2005, Muller and Zenker 2001).

A listing of CS industry firms and addresses was obtained from InfoUSA, a leading business information provider for consumer and survey research. The survey was mailed with a stamped return envelope to 500 identified CS firms with verifiable addresses. In addition, in attempt to bolster participation, a web-based survey was created and firms had the opportunity to complete the survey online. A second postcard mailing was sent encouraging firms to participate if they have not done so already, the web based survey link was referenced on the postcard for participation. A discussion of the survey questions and what is expected from the questions is described below in the methods section.

3.2. Methods

The results of the dissertation are organized into four sections: 1. the inter-metropolitan distribution and growth of computer services, which utilizes a series of geographic research methods and statistical analysis, 2. the intra-metropolitan distribution and growth of computer services, which utilizes a series of geographic research methods, 3. a series of regression models to identify specific characteristics of metropolitan areas where the location of CS industry employment and concentration is prominent, and 4. a case study of computer service firm distribution, interaction, and innovation in the Charlotte Metropolitan Area. The methods for these four sections are presented below.

The inter-metropolitan analysis of computer services utilizes the following methods. Following past studies, the methods utilized for the analysis are some of the most widely used for industry based economic analysis, including studies of business and producer services/KIBS (Gabe 2008). To determine the overall change in concentration of CS employment from 1998 to 2008 the Gini coefficient was utilized. The Gini coefficient represents the percentage departure from an equal distribution. The Gini coefficient ranges from zero (perfectly equal distribution) to one (completely concentrated distribution). The Gini coefficient is represented by the equation: $G = 0.5 \sum \left| Q_i - Y_i \right|$ where Q_i is the percent of CS employment in the ith MSA and Y_i is the the expected percent of employment if a perfectly equal distribution existed (Graves 1998, Griffith and Amrhein 1991). The Gini coefficient identifies CS industry concentrations which deviate from the expected regional and subsector distribution. The Gini coefficient is often used in this context for providing an overall concentration measure of industry employment and giving a basis for the concentration and diffusion of CS industry across the urban hierarchy (Graves 1998, Audretsch and Feldman 1996).

In order to ascertain which individual MSAs contain concentrations of CS employment location quotients were calculated. Location quotients provide a measure of specialization in relation to a reference variable (total employment) and reference area (typically the nation) and can be compared across MSAs. The location quotient is defined as a ratio of ratios and is calculated as: $LQ = (X_r / RV_r) / (X_n / RV_n)$ where X_r is CS employment in the MSA, X_n is CS employment in the nation, RV_r is total employment in the MSA, and RV_n is total employment in the nation (O'hUallachain and Reid 1991). The LQs identify MSAs which deviate from the expected distribution of CS industries and the MSAs with considerable concentrations of CS employment are presented to surmise a cause for the concentration. In addition, the location quotients were examined from year to year utilizing Spearman rank correlations to determine if and to what extent there was change among and across concentrations of CS industries (Rice 2010). To determine the growth of CS employment an analysis was completed by evaluating the percent growth of CS employment across metropolitan areas.

The intra-metropolitan analysis of computer services utilizes similar techniques as the inter-metropolitan analysis of the computer services, which were modified to allow for the intra-metropolitan analysis of computer services. Modified location quotients were calculated for CS industry employment for each subsector in core and non-core metropolitan counties. Also presented as a concentration ratio (Nunn and Warren 2000) the modified location quotient is calculated similar to the traditional location quotient except that metropolitan employment will be utilized as the denominator rather than national employment for a measure of metropolitan concentration. In this instance a value greater than one represents concentrations of employment in core/non-core counties are greater than employment for the metropolitan area and values less than one represent employment concentrations in core/non-core metropolitan counties are less than employment for the metropolitan area. To assess individual metropolitan concentrations the percentage distributions of concentrated versus non-concentrated metropolitan areas were analyzed. Also, to determine the growth of core/non-core CS employment an analysis was completed by evaluating the percent growth of CS employment within metropolitan areas.

A series of regression models were developed to identify specific characteristics of metropolitan areas where the location of CS industry employment and concentration is prominent. A series of ordinary least squares (OLS) regression models were utilized. It should be noted that the use of the regression models is not intended to develop a causal model but rather to identify specific characteristics of MSAs where CS industry employment and concentration is prominent. The analysis included ten regression models utilizing two different dependent variables; one for each of the four CS industry specializations and one for overall CS industry per dependent variable for 2008. The dependent variables in the models were CS industry employment and CS industry concentration as determined by location quotients.

The independent variables for the OLS regression models represent characteristics identified as being fundamentally important in the location and growth of KIBS employment. These include educational attainment, the population size of the MSA, economic growth of a MSA, income, and industry diversity in the MSA.

Educational attainment is defined as the percent of the population 25 years or older with a bachelor's degree or higher. A more or well educated workforce has been identified as a determinant in the sustained growth of metropolitan areas in a service based economy. Many of the high growth, skilled service industries require a highly educated workforce (Green and Howells 1987).

The population size of the MSA is defined by population density and was measured as population per square mile. KIBS, particularly high order services, will locate in large metropolitan areas to facilitate contact with clients and inter-industry partnerships through agglomeration. Also, the location of low versus high order CS industries should be influenced by MSA population size (Nunn et al. 1998, Scott 1986).

The economic strength of an MSA is defined by two measures. Overall employment growth and per capita income is utilized as measures of economic strength. The location of knowledge intensive service industries, such as CS, should have the greatest impact in MSA's that are leading growth centers of knowledge economies which are most amenable to KIBS activity (Coe 1997).

A measure of urban economic concentration of the MSA, the percent of total employment in the MSA located in the core county, is included as an independent variable because the economic density or urbanization of a metropolitan area may have a greater importance to the growth of CS industry and KIBS in general than other characteristics of an MSA (Noyelle 1983, Nunn et al. 1998).

To measure the industry diversity of an MSA an entropy index was calculated for all MSA and included as an independent variable. The diversity of a regional economy has become a prominent theme in discussions around fostering economic growth and security in a successful modern economy, which bolsters a region from employment losses and unpredictable swings in industry volatility (Shearmur and Doloreux 2008).

The data for the independent variables are available from a few sources. Educational attainment data are available from the U.S. Decennial Census for 2000, and since 2005, yearly estimates are available for areas (MSAs) over 65,000 in population from the U.S. Census American Community Survey. Population data is available from the U.S. Census Bureau from the Decennial Census for 2000 and yearly estimates are available from the Population Estimates Division. Yearly per capita income data are available from the U.S. Bureau of Economic Analysis. Economic data detailing employment and growth can be derived from the U.S. Census County Business Patterns data available yearly.

The final section of the analysis utilized a mail survey of CS industry firms in the Charlotte Metropolitan area to collect and examine primary source data on the distribution, interaction, and innovation of the CS industry. Questions included in the survey instrument cover general firm characteristics (location, number of employees, revenue, innovation activity, etc.), firm history (location decision, ownership details, etc.), and clients/export characteristics (geographic markets served, interaction with clients, etc.). The complete survey can be found in the Appendix A.

Questions concerning firm characteristics and history allow for an analysis beyond readily available population demographics to include details of individual firms to describe the distribution of and spatial relationships of CS industry. Additional questions about firm history will be utilized to gain an understanding of firm interaction including corporate linkages and business relationships with other CS and client firms. Measures of innovation are severely lacking in current research and primary source data is the only readily available method of obtaining such data. The ability to and propensity to innovate has been identified as a means for economic revitalization and development and understanding the levels and patterns of innovation activity is essential. The questions pertaining to innovation were adapted from the European Community Innovation Survey which has been utilized in Europe to measure innovation activity of firms since the late 1990's and has subsequently been adapted for use in Canada.

The case study adds to the limited but significant research describing the intra-metropolitan distribution of business and producer services (Harrington and Campbell 1997, Nunn and Warren 2000, O'hUallachain and Reid 1991, Schwartz 1992). Case study research provides a significant source of regionally specific information that is often obscured or unavailable from secondary source data. The survey and case study is important because the role of KIBS varies across and within metropolitan areas and due to the absence of detailed firm characteristic data it provides a more reliable and accurate assessment of the intra-metropolitan distribution of CS industry (Beyers 2002). In addition, it details individual firm characteristics that can be utilized to identify where particular types of firms are located and distributed within a metropolitan area.

CHAPTER 4: RESULTS

To aid the analysis, for the time period in question (1998-2008), it was determined that two distinct periods of activity occurred in the CS industry, which created two logical time periods to center the analysis around. As Figure 4.1 illustrates, there is a distinct period of growth for the CS industry that bookends the dot com boom of the late 1990's and its subsequent bust in the early 2000's. After peaking in 2001, CS industry employment declined for two consecutive years before beginning a rebound that continued through 2008, constituting a second distinct period of growth. Therefore, most of the analysis was conducted for the time periods from 1998 to 2003 and 2003 to 2008, as well as the overall time period 1998 to 2008. The analysis of these time periods reveals details that would otherwise be masked by just looking at the overall time period or muddled by a year-over-year analysis. And, the fast rise of the CS industry during the dot com boom was replaced with a more typical growth pattern that appears to be driven by the natural tendencies of market demand.

Research results are presented in four sections. An overview of CS employment in the United States and metropolitan areas is presented. Next, the inter-metropolitan analysis of computer service employment is detailed; including results pertaining to concentration and growth. The presentation of regression analysis results detailing the factors influencing computer service employment distribution is included. Then, the intra-metropolitan analysis of computer service employment is detailed; including results pertaining to the core/non-core concentration and growth of computer service employment. Finally, an analysis of survey findings from a mail survey of computer service firms in the Charlotte metropolitan area is presented.

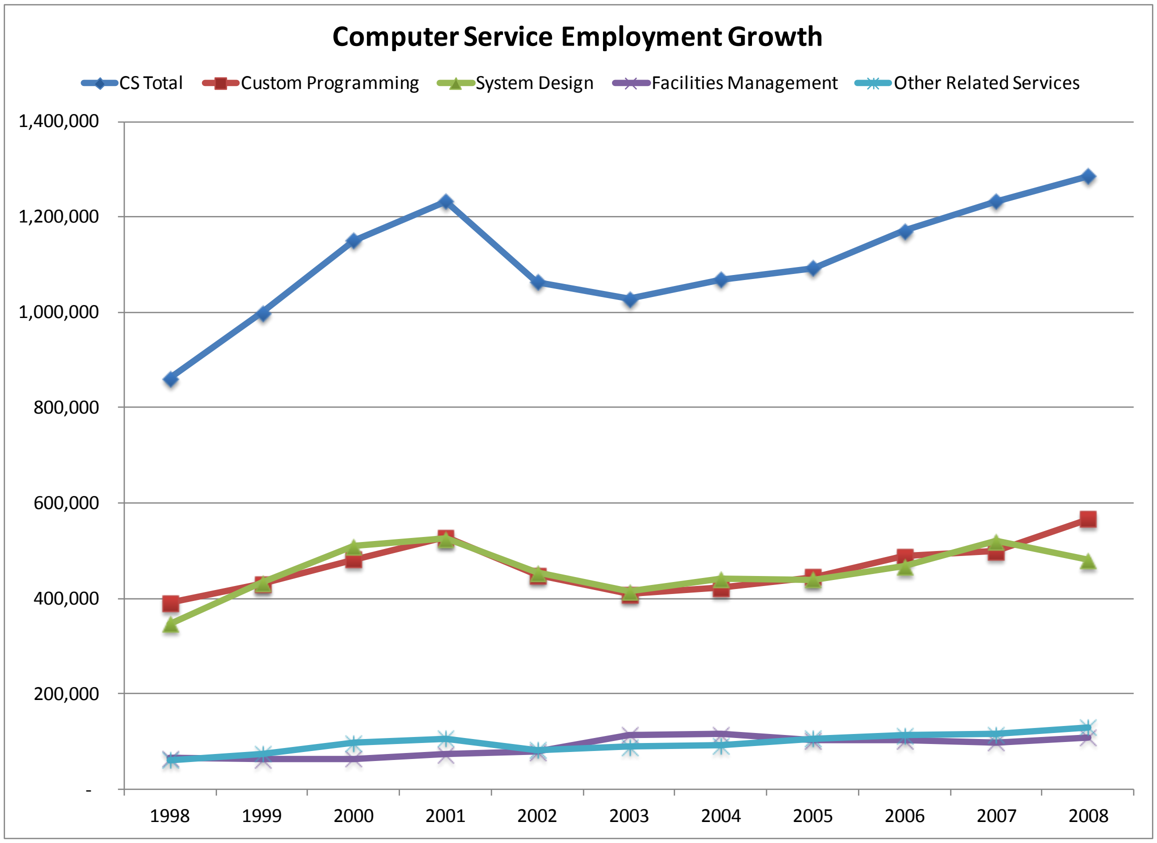


Figure 4.1: Computer Service Employment Growth (Source: County Business Patterns)

4.1. Overview of Computer Service Employment

Table 4.1 and 4.2 presents total and percent of CS industry employment for each subsector by metropolitan size category and the United States. Total CS employment in the United States in 2008 is over 1.3 million and has grown by 50 percent since 1998. In 2008, forty-four percent of metropolitan CS employment is in custom programming, 37 percent in system design, 10 percent in other related services, and 9 percent in facilities

Table 4.1: Employment in CS

Total CS			
Population Size	1998	2003	2008
Less Than 150,000	9,721	14,423	15,008
150,000 to 250,000	15,980	23,578	35,727
250,000 to 500,000	47,267	70,524	82,382
500,000 to 1 million	73,900	78,700	100,201
Greater than 1 million	714,718	840,256	1,052,088
Non Metro	20,240	35,992	34,538
United States	881,825	1,063,472	1,319,942
Custom Programming			
	1998	2003	2008
Less Than 150,000	3,577	4,546	6,449
150,000 to 250,000	5,923	7,379	11,773
250,000 to 500,000	19,116	22,478	35,903
500,000 to 1 million	35,647	34,577	43,471
Greater than 1 million	325,497	340,324	468,636
Non Metro	7,287	9,896	11,237
United States	397,046	419,199	577,468
System Design			
	1998	2003	2008
Less Than 150,000	4,936	5,435	6,951
150,000 to 250,000	8,512	12,091	18,705
250,000 to 500,000	18,089	24,050	30,343
500,000 to 1 million	26,717	31,363	38,166
Greater than 1 million	288,312	341,640	386,344
Non Metro	10,646	13,146	16,155
United States	357,210	427,723	496,663
Facilities Management			
	1998	2003	2008
Less Than 150,000	409	1,359	942
150,000 to 250,000	670	1,440	3,630
250,000 to 500,000	6,800	18,837	9,838
500,000 to 1 million	7,717	7,849	10,589
Greater than 1 million	48,956	84,703	84,178
Non Metro	468	2,613	4,455
United States	65,019	116,800	113,630
Other Related Services			
	1998	2003	2008
Less Than 150,000	800	3,084	667
150,000 to 250,000	875	2,670	1,620
250,000 to 500,000	3,263	5,160	6,299
500,000 to 1 million	3,820	4,911	7,975
Greater than 1 million	51,954	73,590	112,931
Non Metro	1,840	10,338	2,693
United States	62,551	99,751	132,183

Source: County Business Patterns, calculations by author

Table 4.2: Percent Employment in CS			
Total CS			
Population Size	1998	2003	2008
Less Than 150,000	1%	1%	1%
150,000 to 250,000	2%	2%	3%
250,000 to 500,000	5%	7%	6%
500,000 to 1 million	8%	7%	8%
Greater than 1 million	81%	79%	80%
Non Metro	2%	3%	3%
United States	100%	100%	100%
Custom Programming			
	1998	2003	2008
Less Than 150,000	1%	1%	1%
150,000 to 250,000	1%	2%	2%
250,000 to 500,000	5%	5%	6%
500,000 to 1 million	9%	8%	8%
Greater than 1 million	82%	81%	81%
Non Metro	2%	2%	2%
United States	100%	100%	100%
System Design			
	1998	2003	2008
Less Than 150,000	1%	1%	1%
150,000 to 250,000	2%	3%	4%
250,000 to 500,000	5%	6%	6%
500,000 to 1 million	7%	7%	8%
Greater than 1 million	81%	80%	78%
Non Metro	3%	3%	3%
United States	100%	100%	100%
Facilities Management			
	1998	2003	2008
Less Than 150,000	1%	1%	1%
150,000 to 250,000	1%	1%	3%
250,000 to 500,000	10%	16%	9%
500,000 to 1 million	12%	7%	9%
Greater than 1 million	75%	73%	74%
Non Metro	1%	2%	4%
United States	100%	100%	100%
Other Related Services			
	1998	2003	2008
Less Than 150,000	1%	3%	1%
150,000 to 250,000	1%	3%	1%
250,000 to 500,000	5%	5%	5%
500,000 to 1 million	6%	5%	6%
Greater than 1 million	83%	74%	85%
Non Metro	3%	10%	2%
United States	100%	100%	100%
Source: County Business Patterns, calculations by author			

management. Not surprisingly, metropolitan areas with greater than 1 million in population represent the greatest concentrations of CS industry employment across all subsectors. These largest metropolitan areas possess nearly 80 percent of all CS industry employment across all subsectors, with the exception of facilities management, in all three time periods. Facilities management is represented with around 75 percent of employment in the largest metropolitan size category. Little variation exists in terms of employment distribution across years among metropolitan size categories.

The largest amount of employment is concentrated in custom programming, followed closely by system design. Facilities management and other related services maintained similar employment numbers for the three time periods, with facilities management edging out other related services in 2003 but was reversed in 2008 with other related services gaining a significant advantage in employment. When CS employment is compared to total employment in the metropolitan size categories, it is revealed that the largest metropolitan size categories contain a disproportionate share of CS employment. The largest metropolitan size category with greater than 1 million in population contains around 60 percent of total employment but 80 percent of CS employment. For all smaller metropolitan size categories CS employment is represented by a smaller percentage of employment compared to total employment. Also, CS employment is significantly less than the percentage of total employment found in non-metropolitan areas.

The distribution of CS employment by subsector within each metropolitan size category for 1998, 2003, and 2008 is presented in Figures 4.2 to 4.4. Each value represents each subsectors percentage of total CS employment for each metropolitan size

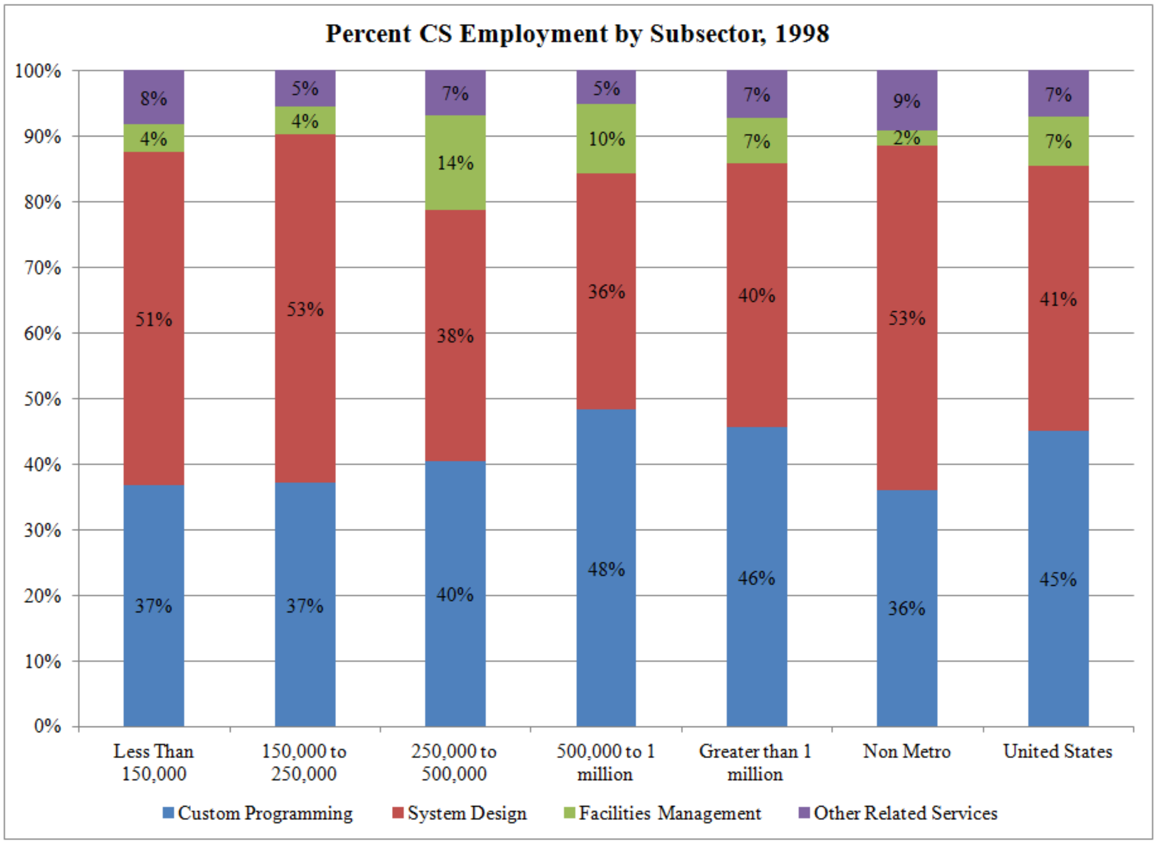


Figure 4.2: Percent CS Employment by Subsector, 1998 (Source: County Business Patterns, calculations by author)

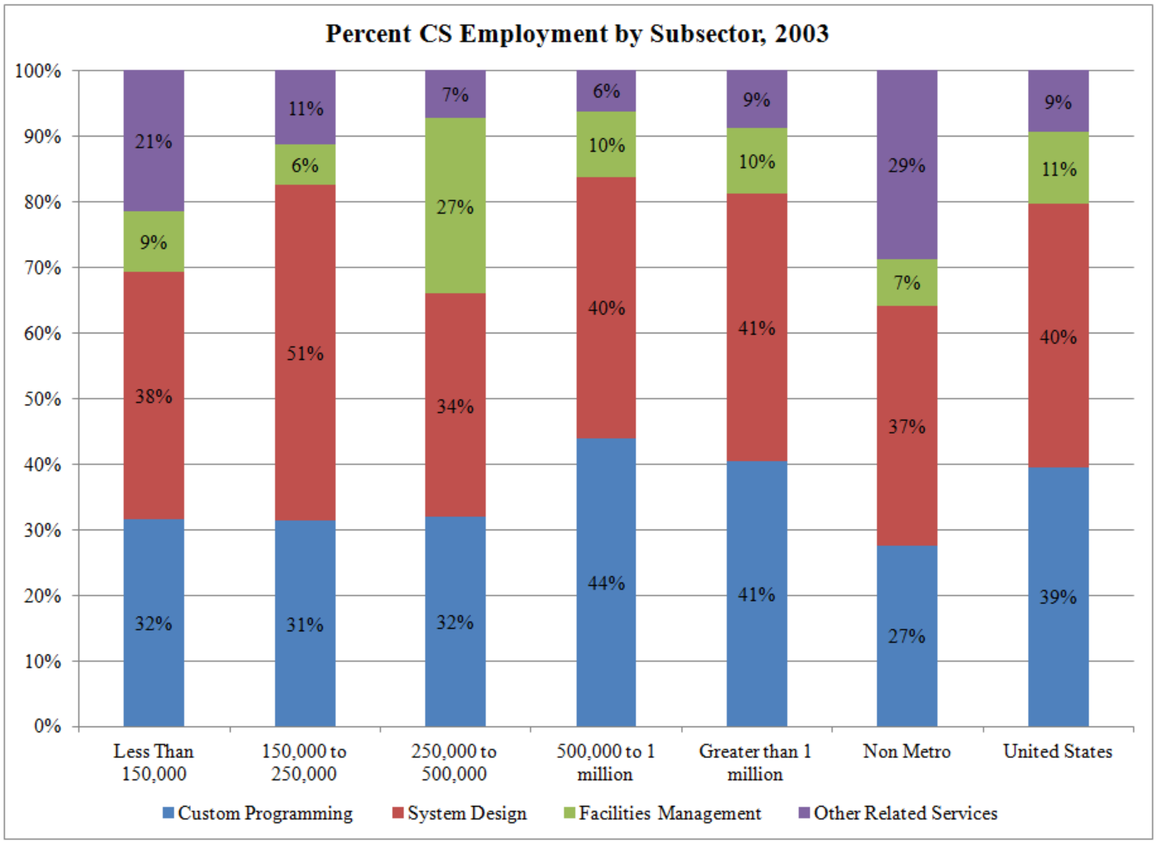


Figure 4.3: Percent CS Employment by Subsector 2003 (Source: County Business Patterns, calculations by author)

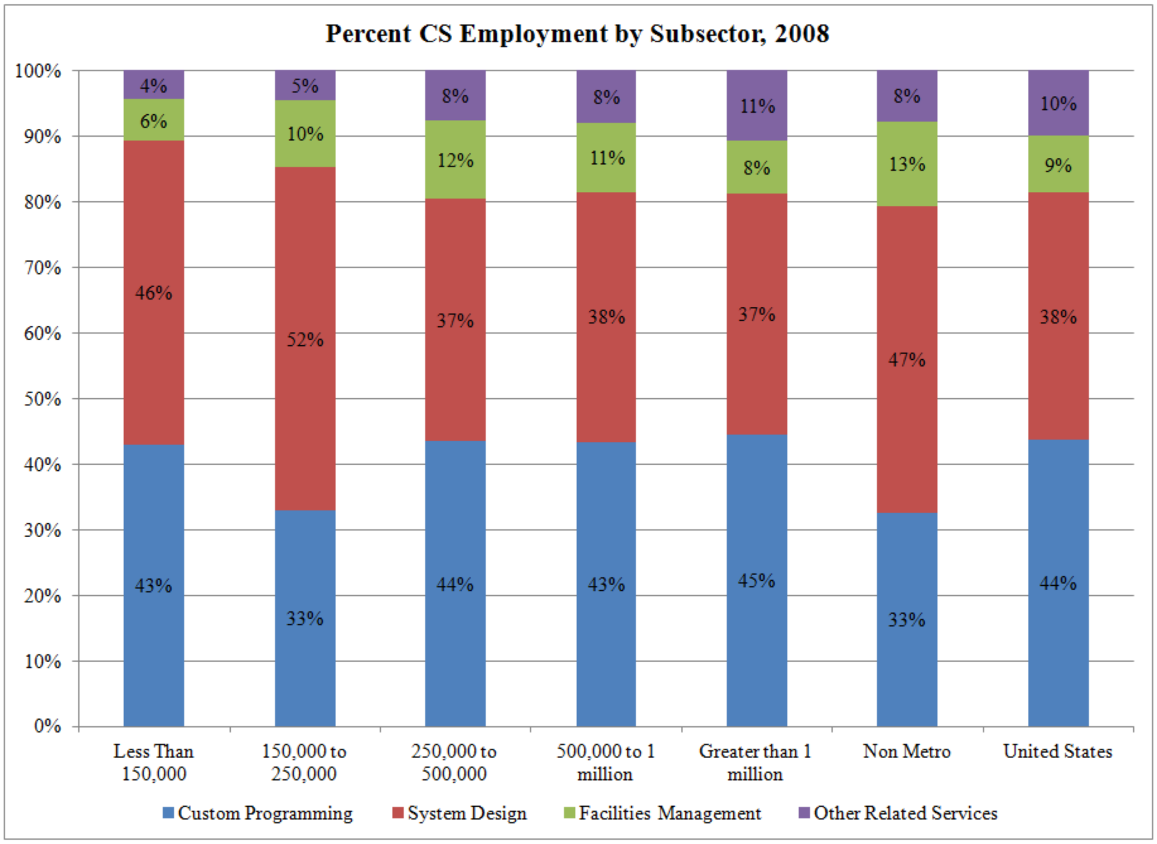


Figure 4.4: Percent CS Employment by Subsector, 2008 (Source: County Business Patterns, calculations by author)

category. As recognized from the literature and previous CS industry research, the high order custom programming and system design industries should have higher concentrations in the largest metropolitan size categories, while facilities management and other related services could have concentrations among any metropolitan size category. In 1998, the two largest metropolitan size categories have the highest concentration of high order custom programming but not system design, which has higher concentrations in the smallest metropolitan size categories. For facilities management in 1998, the highest concentrations were found in the 250,000 to 500,000 and 500,000 to 1 million metropolitan size categories. Other related services were more evenly distributed among all metropolitan size categories but was highest in the smallest size category.

In 2003, the highest concentrations of custom programming are still represented in the largest metropolitan size categories but the percentage of CS employment in custom programming declined across all metropolitan size categories. System design shifted its highest concentration to the 150,000 to 250,000 population metropolitan size category from the smallest metropolitan size category, and the system design percentage of CS employment remained relatively consistent. Facilities management concentrations remained in the middle metropolitan size categories but increased significantly in the 250,000 to 500,000 population metropolitan size category. Other related services shifted from an even distribution to having large concentrations in the two smallest metropolitan size categories.

In 2008, custom programming is now represented evenly across metropolitan size categories and the percentage of CS employment in custom programming increased across the metropolitan size categories. System design gained concentrations in the smallest metropolitan size categories. Facilities management concentrations shifted down toward having greater concentrations in smaller metropolitan size categories. Other related services returned to a more even distribution after declining in concentration in the smallest metropolitan size categories.

In terms of the distribution of high and low order employment and diffusion of business services it appears that the CS industry aligns with previous research in some aspects but not all. High order custom programming had initial concentrations in the largest metropolitan size categories with growth and diffusion to smaller metropolitan size categories form 1998 to 2008. High order system design, which should follow a similar pattern to that of custom programming, had higher concentrations in the smallest metropolitan categories and maintained that distribution from 1998 to 2008, opposite of what would be expected. Low order facilities management maintained concentrations in the mid-size metropolitan categories and had a relative consistent level of employment in all metropolitan size categories from 1998 to 2008. Low order, other related services had an evenly distributed employment base across metropolitan size categories but did see a disproportionate share develop in the smallest metropolitan size categories in 2003.

4.2. Inter-metropolitan Analysis of Computer Services

To analyze the inter-metropolitan distribution and growth of computer services a series of geographic research methods and statistical analysis were utilized. To determine the distribution and concentration of CS employment an analysis was completed by using the Gini coefficient to determine changes in the overall concentration of CS employment over time, a location quotient analysis to determine concentration across metropolitan areas, and a series of Spearman rank correlations to determine how much the concentration across metropolitan areas changed over time. To determine the growth of CS employment an analysis was completed by analyzing changes in the percent growth of CS employment across metropolitan areas.

Data for the analysis was obtained annually for a 10 year time period from 1998 to 2008 from County Business Patterns at the county level and aggregated to the MSA level for comparable analysis across years. The analysis was completed for the 366 MSAs defined in the 2008 MSA classification. Total CS employment and the four CS subsectors (Custom Computer Programming, Computer Systems Design, Computer

Facilities Management, and Other Related Services) are represented in the analysis to reveal the importance of disaggregated high and low order industry concentrations, as discussed earlier. Also, the data were aggregated into five metropolitan size categories based on population to explore the distribution and growth of CS across the urban hierarchy. Metropolitan categories utilized in the analysis and the counts of MSAs in each category are listed in Table 4.3.

Table 4.3: Metropolitan Size Categories

	Count of MSAs
Less Than 150,000	109
150,000 to 250,000	81
250,000 to 500,000	75
500,000 to 1 million	49
Greater than 1 million	52

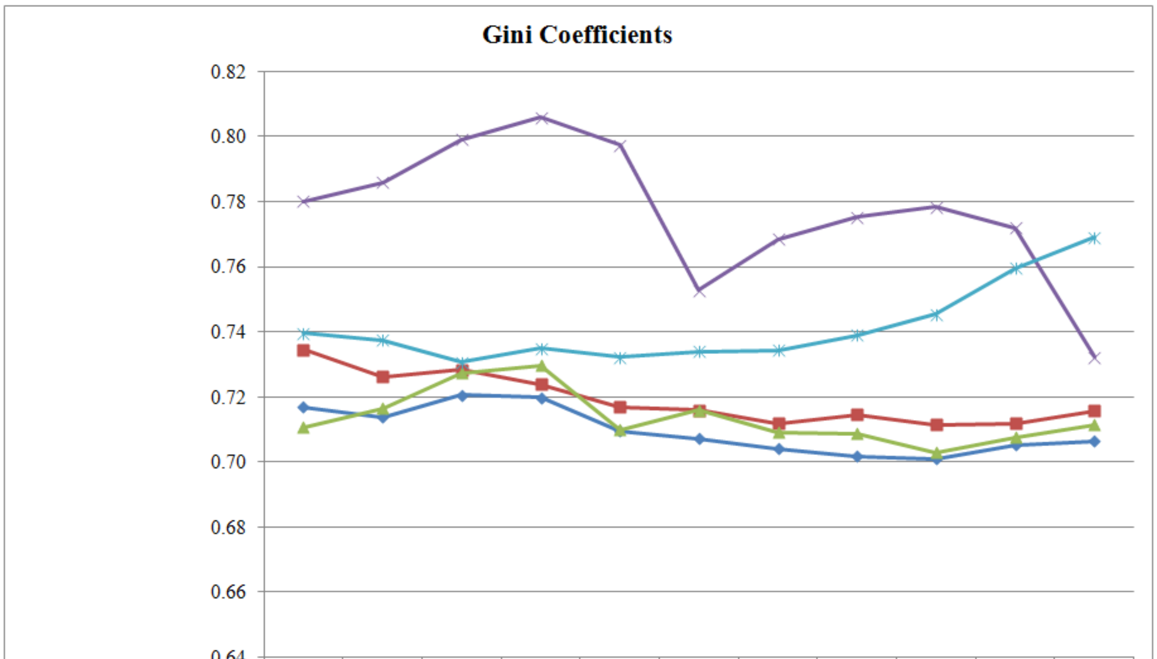
Source: U.S. Census Bureau, calculations by author

4.2.1. Inter-metropolitan Concentration of Computer Service Employment

4.2.1.1. Computer Service Metropolitan Concentration

To determine the overall change in concentration of CS employment for the study period the Gini coefficient was utilized. The Gini coefficient represents the percentage departure from an equal distribution. The Gini coefficient ranges from zero (perfectly equal distribution) to one (completely concentrated distribution). The Gini coefficient is utilized to quantify the level of concentration of CS employment within and across all MSAs. In other words, it is to illustrate how CS employment is distributed among MSAs. The coefficients were calculated annually from 1998 to 2008 for total CS employment and the four CS subsectors and are presented in Figure 4.5.

Overall, the Gini coefficients indicate a level of concentration in total and subsector CS employment for the study period. Total CS employment concentration exhibits little change in the years from 1998 to 2008, with a high of 0.72 in 1998 and 2000-2001 and a low of 0.70 in 2004-2006, ending with a coefficient of 0.71 in 2008, representing an increased level of concentration.



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
CS Total	0.72	0.71	0.72	0.72	0.71	0.71	0.70	0.70	0.70	0.71	0.71
Custom Programming	0.73	0.73	0.73	0.72	0.72	0.72	0.71	0.71	0.71	0.71	0.72
System Design	0.71	0.72	0.73	0.73	0.71	0.72	0.71	0.71	0.70	0.71	0.71
Facilities Management	0.78	0.79	0.80	0.81	0.80	0.75	0.77	0.78	0.78	0.77	0.73
Other Related Services	0.74	0.74	0.73	0.73	0.73	0.73	0.73	0.74	0.75	0.76	0.77

Figure 4.5: CS Employment Gini Coefficients, 1998-2008 (Source: County Business Patterns, calculations by author)

The concentration of high order industries custom programming and system design also exhibits little change from 1998 to 2008, with only slight variability of coefficients in intervening years. Facilities management exhibits the greatest change and volatility in concentration over the study period. The coefficient for facilities management declined from 0.78 in 1998 to 0.73 in 2008 but had two intervals of rising values followed by a decline, corresponding to the two distinct periods of activity identified for periods of analysis (1998-2003 and 2003-2008). The overall decline of the facilities management coefficient represents a decrease in the level of concentration or more pointedly a diffusion of facilities management employment across MSAs. Other related services exhibited some variability over the study period but overall the coefficient increased from 0.74 in 1998 to 0.77 in 2008, representing an increase in the level of concentration of other related services among MSAs.

The variability in the observed levels of concentrations with the Gini coefficient between the high and low order subsectors in CS offers credence to the use of disaggregated industry groupings in sector specific economic research because if total CS employment was just analyzed the differences offered by a subsector analysis would be obscured. High order CS employment tends to follow the distribution of overall CS employment over time by remaining quite concentrated among MSAs. Low order CS employment presents unique results that disagree with the general sentiment that business services remain relatively concentrated but with some diffusion to other areas. Other related services employment is increasingly concentrated over time and at greater levels than total and high order CS employment. The distribution of facilities management employment is volatile with a general trend toward diffusion but has maintained concentrations over the study period higher than total and high order CS employment.

In examining the overall concentration of the CS industry across metropolitan areas the Gini coefficient reveals a high level of concentration among MSAs and the data further support concentrations in the largest MSAs, which aligns with previous research findings. Total CS employment remains concentrated with little diffusion over the entire study period. The literature suggests that some diffusion away from the top of urban hierarchy should be expected but is largely not present in total CS employment. The subsector analysis of CS employment uncovers some interesting patterns involving diffusion. The largest CS subsectors, custom programming and system design, follow a similar pattern as total CS employment and thus driving the pattern of continued concentration of CS employment with little diffusion.

Facilities management and other related services do not follow the general pattern of total CS and the largest subsectors and reveal differences within the CS industry. Facilities management had an overall downward trend in concentration based on the Gini coefficient showing a diffusion of facilities management employment across MSAs. But, the concentration coefficient for facilities management are consistently higher than total CS and larger CS subsectors, so, although facilities management is diffusing to other MSAs employment concentration levels remain elevated compared to other CS employment. Other related services employment concentration across MSAs has become increasingly concentrated over the study period to become the most heavily concentrated of the CS subsectors. Increased concentration is not what is expected and would have been obscured if only looking at total CS employment. Subsector research reveals the varying patterns of concentration and diffusion within the CS industry and the complexities of KIBS that are masked when viewing aggregated industry codes.

4.2.1.2. Location Quotient Analysis

To determine individual MSA concentrations of CS employment, location quotients were calculated for each MSA and compared for 1998, 2003, and 2008.

Location quotients provide a measure of CS employment specialization in relation to total employment and the nation and can be compared across MSAs. A value greater than one indicates an MSA contained a greater level or concentration of CS employment relative to the nation and a value less than one indicates an MSA contained less CS employment relative to the nation, a value of one indicates an identical proportion of CS employment in the MSA and nation.

Individual MSA concentrations are presented for location quotients for total CS and CS subsector employment for 1998, 2003, and 2008 in Figures 4.6-4.20 and the top ten location quotients are highlighted in the analysis. Considerable change and variation exists in MSAs in the top ten between time periods and across CS subsectors. Washington DC is the only MSA represented in all years across all CS subsectors, while Boulder, San Jose, and Huntsville exhibit concentrations of CS employment in no less than nine of the 15 listings.

Total CS employment concentration is relatively consistent across the three time periods, which is, as will be shown, mainly a function of the large employment concentrations of high order services in custom programming and system design. Total CS employment had just five of the 1998 top ten CS concentrations repeat in 2003 and six of the 2003 top ten concentrations remained the same in 2008. Over the ten year time period, five of the top ten CS concentrations remained the same in 2008 when compared to 1998. Washington DC, Boulder, San Jose, and Huntsville appear in each year’s top ten concentration listing, with Olympia represented in 1998 and 2008 after falling out in 2003.

Custom programming employment concentration is the most consistent of the CS subsectors in terms of MSA representation in the top ten listing of location quotients. In addition, the top ten concentrations are dominated by MSAs associated with government operations, universities, or major centers of production for computing technologies.

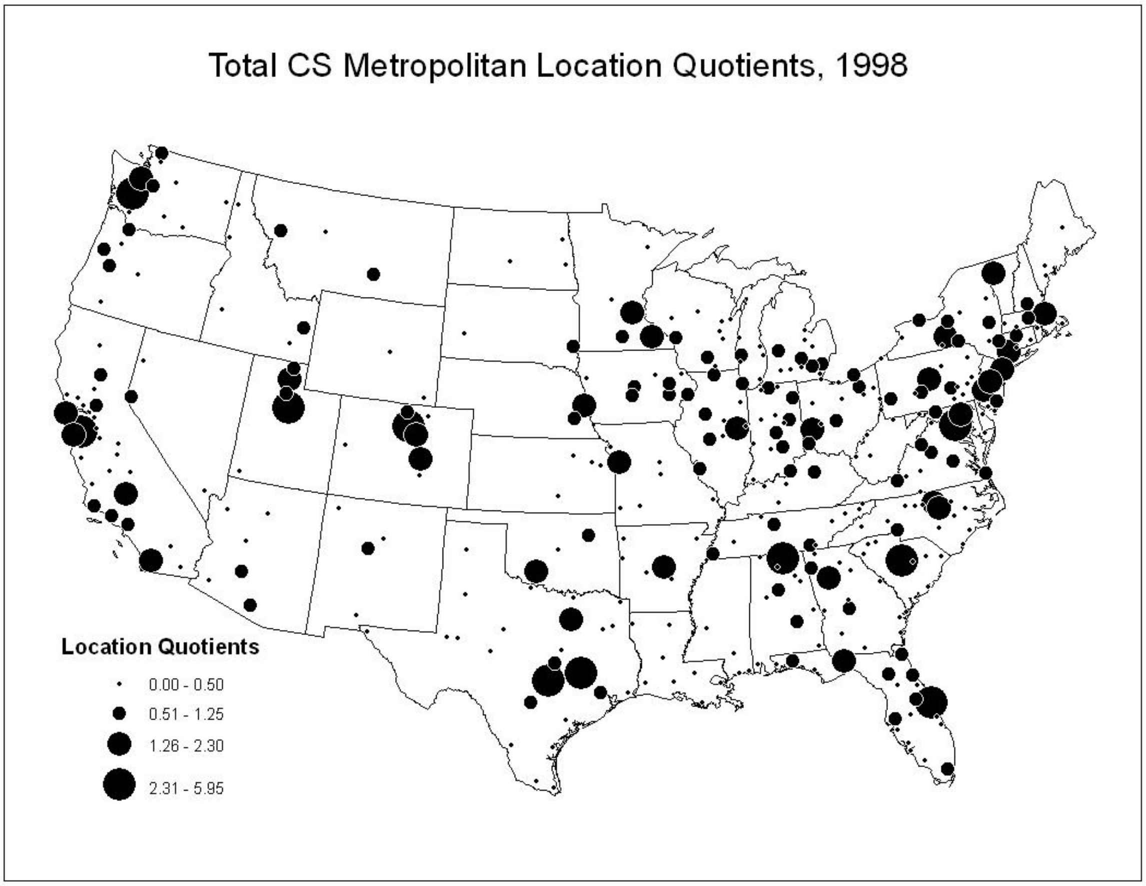


Figure 4.6: Total CS Metropolitan Location Quotients, 1998 (Source: County Business Patterns, calculations by author)

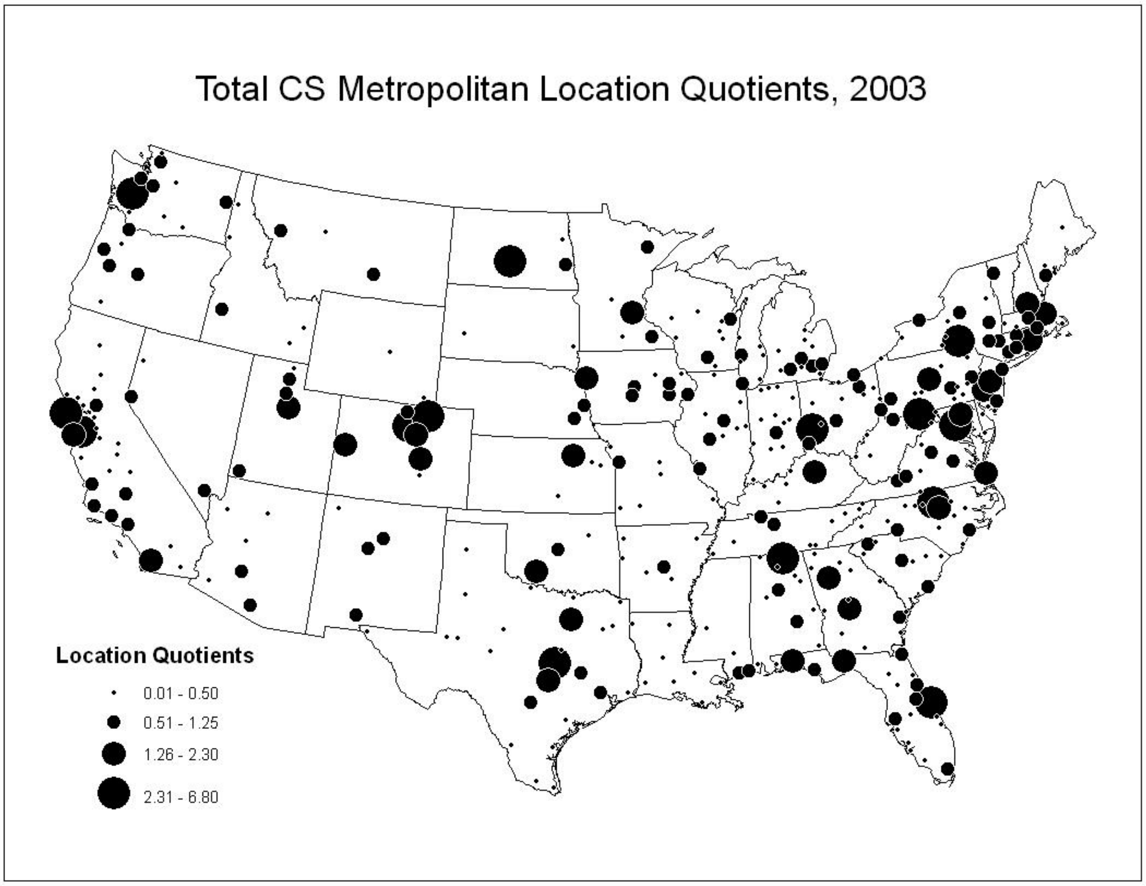


Figure 4.7: Total CS Metropolitan Location Quotients, 2003 (Source: County Business Patterns, calculations by author)

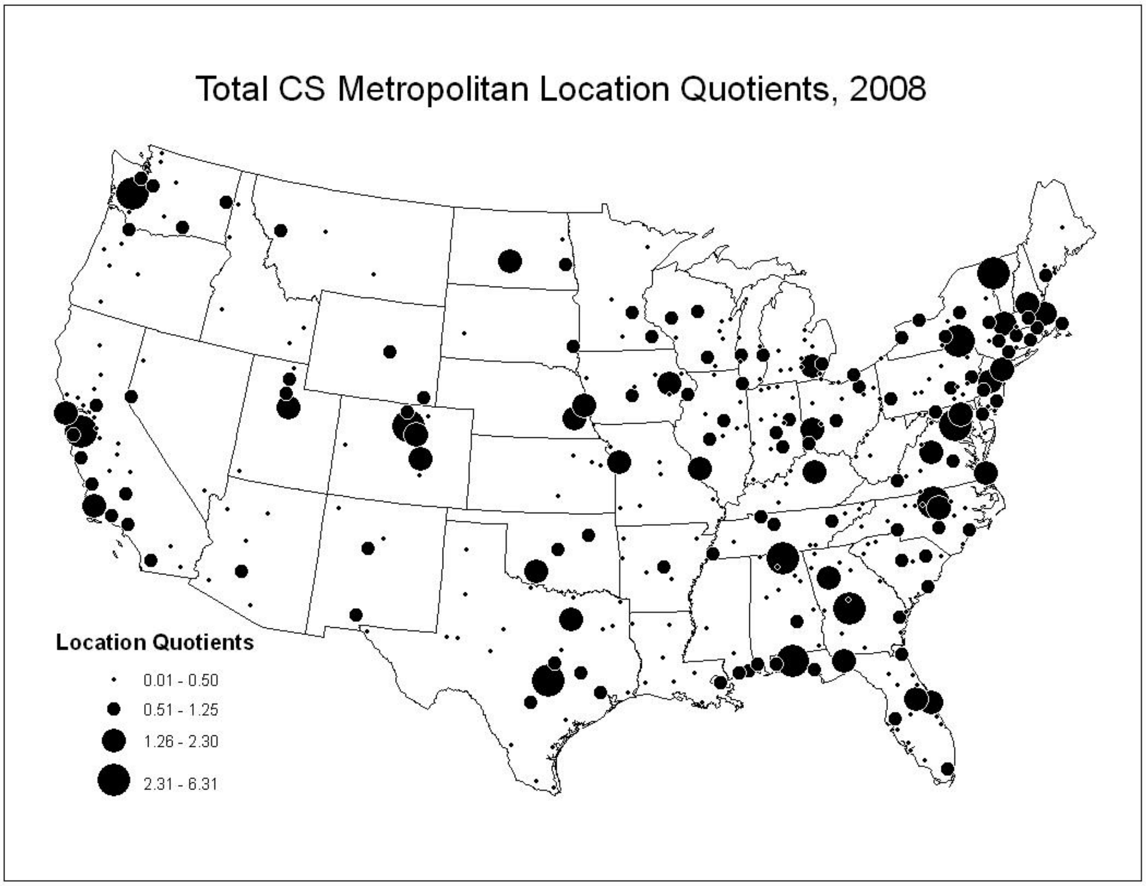


Figure 4.8: Total CS Metropolitan Location Quotients, 2008 (Source: County Business Patterns, calculations by author)

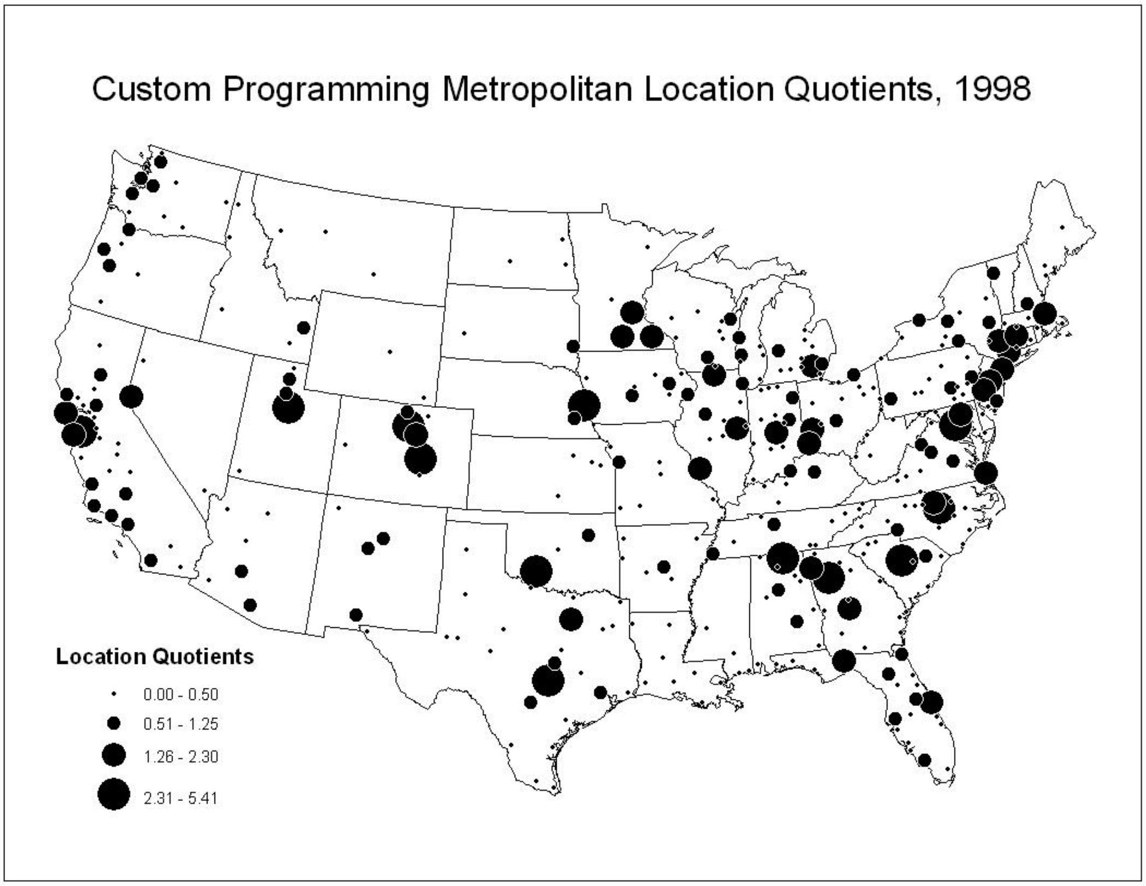


Figure 4.9: Custom Programming Metropolitan Location Quotients, 1998 (Source: County Business Patterns, calculations by author)

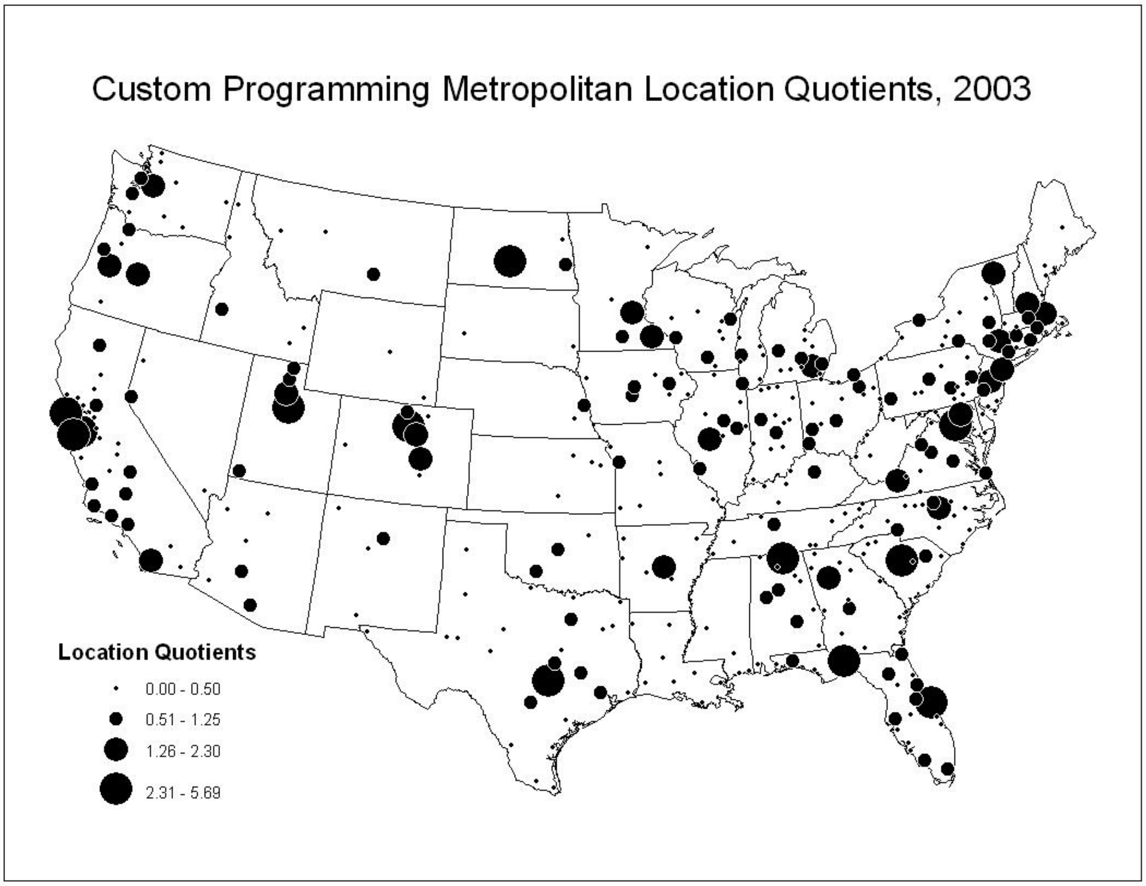


Figure 4.10: Custom Programming Metropolitan Location Quotients, 2003 (Source: County Business Patterns, calculations by author)

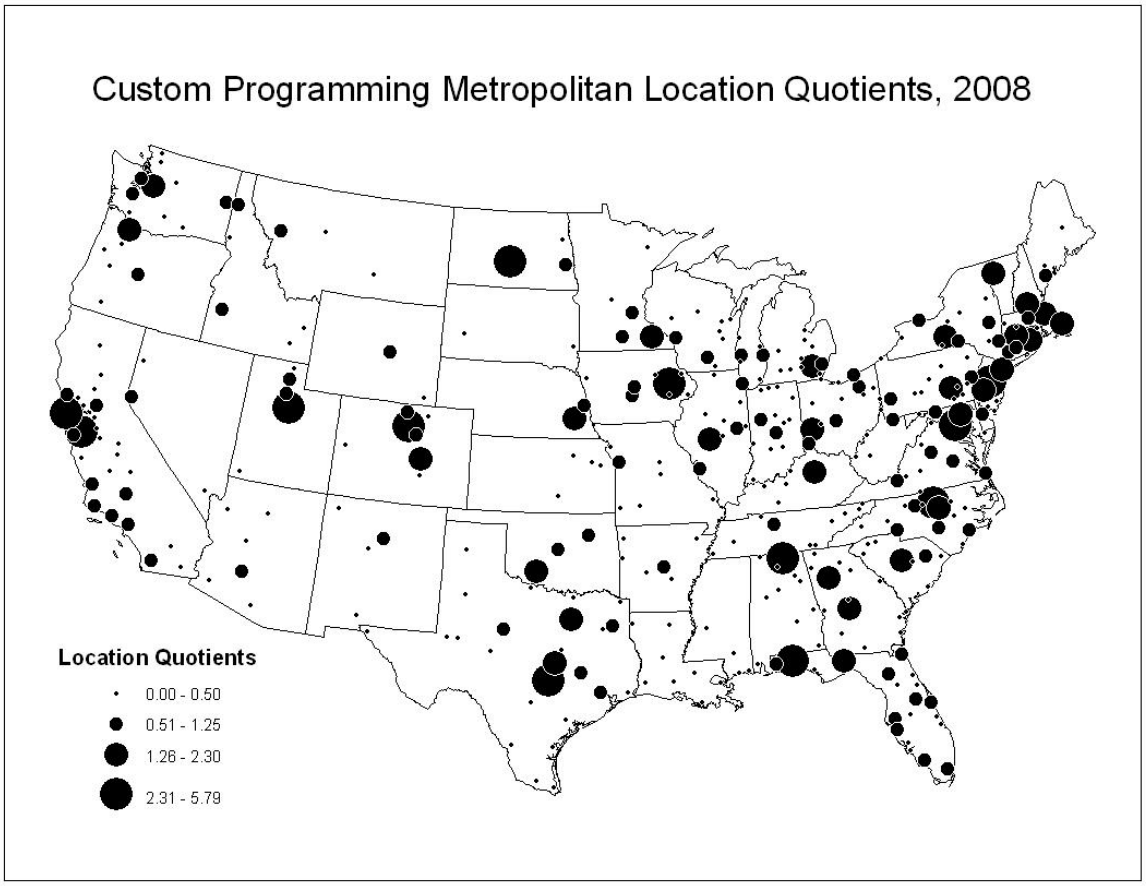


Figure 4.11: Custom Programming Metropolitan Location Quotients, 2008 (Source: County Business Patterns, calculations by author)

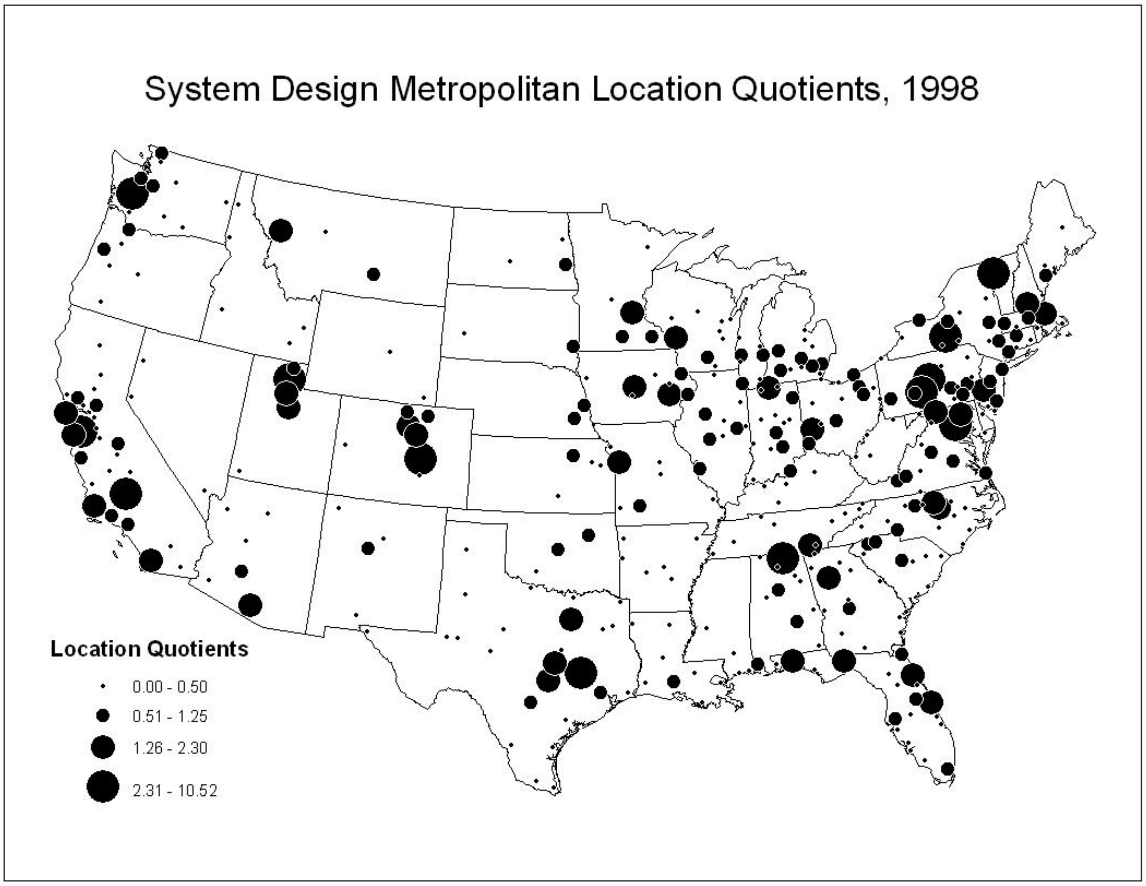


Figure 4.12: System Design Metropolitan Location Quotients, 1998 (Source: County Business Patterns, calculations by author)

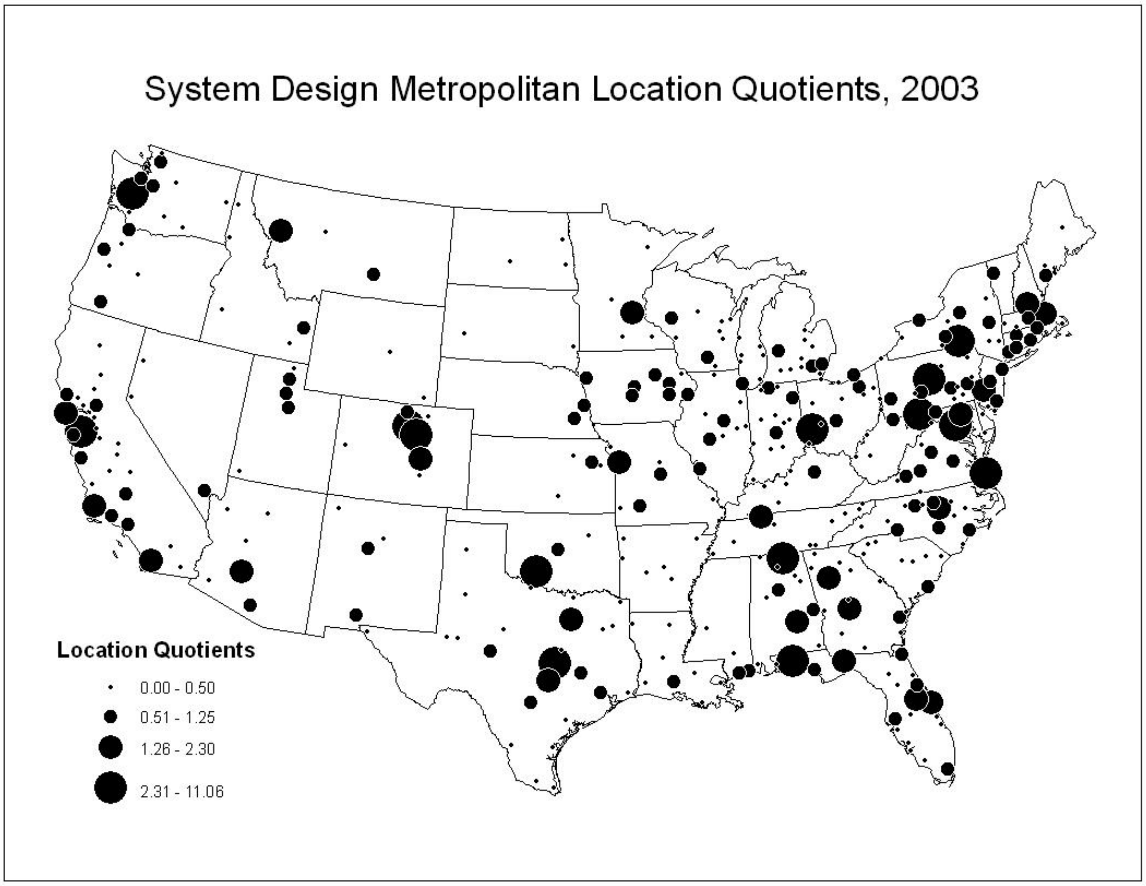


Figure 4.13: System Design Metropolitan Location Quotients, 2003 (Source: County Business Patterns, calculations by author)

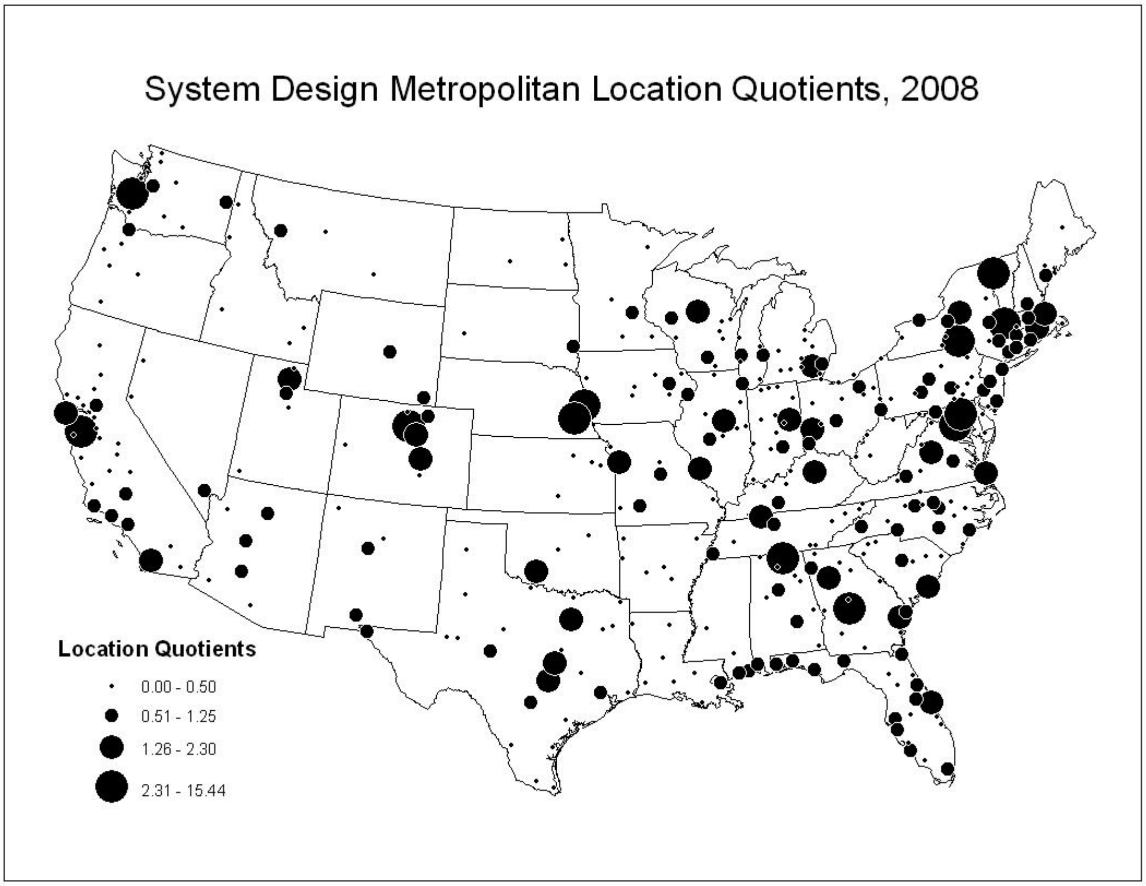


Figure 4.14: System Design Metropolitan Location Quotients, 2008 (Source: County Business Patterns, calculations by author)

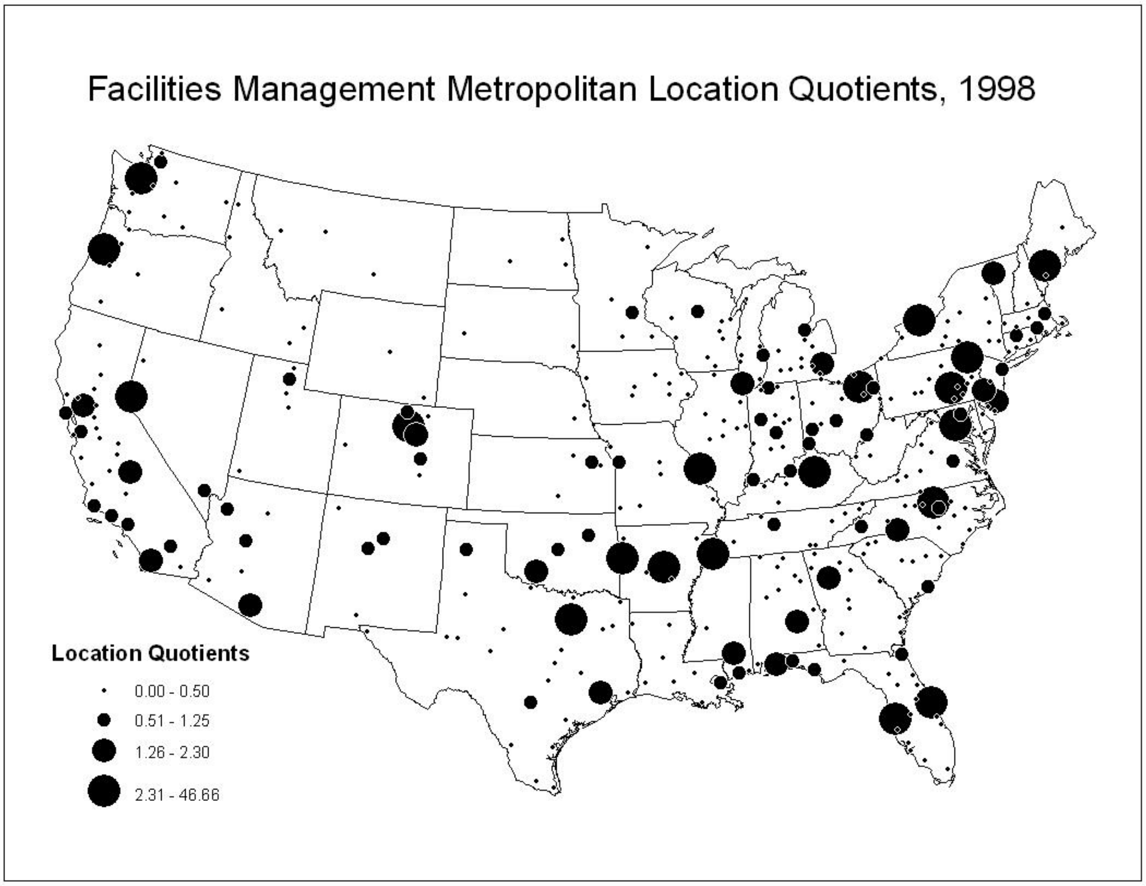


Figure 4.15: Facilities Management Metropolitan Location Quotients, 1998 (Source: County Business Patterns, calculations by author)

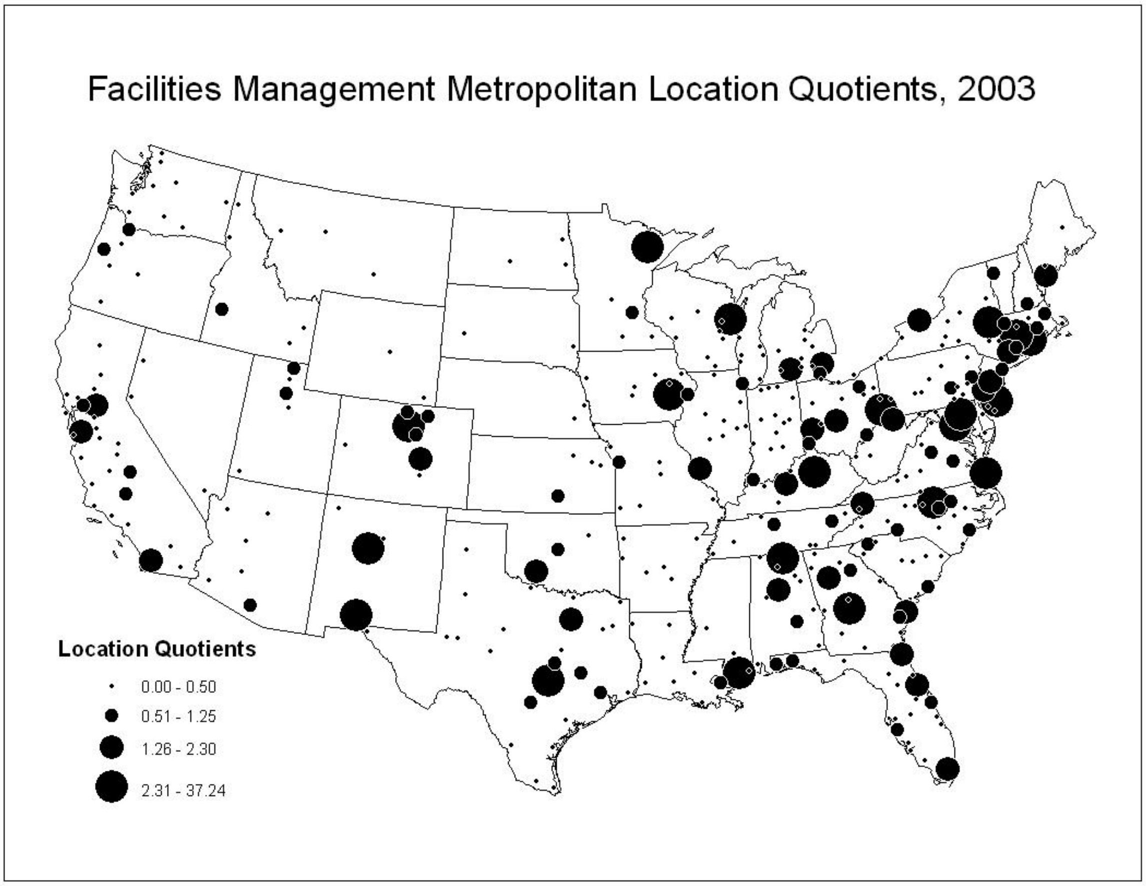


Figure 4.16: Facilities Management Metropolitan Location Quotients, 2003 (Source: County Business Patterns, calculations by author)

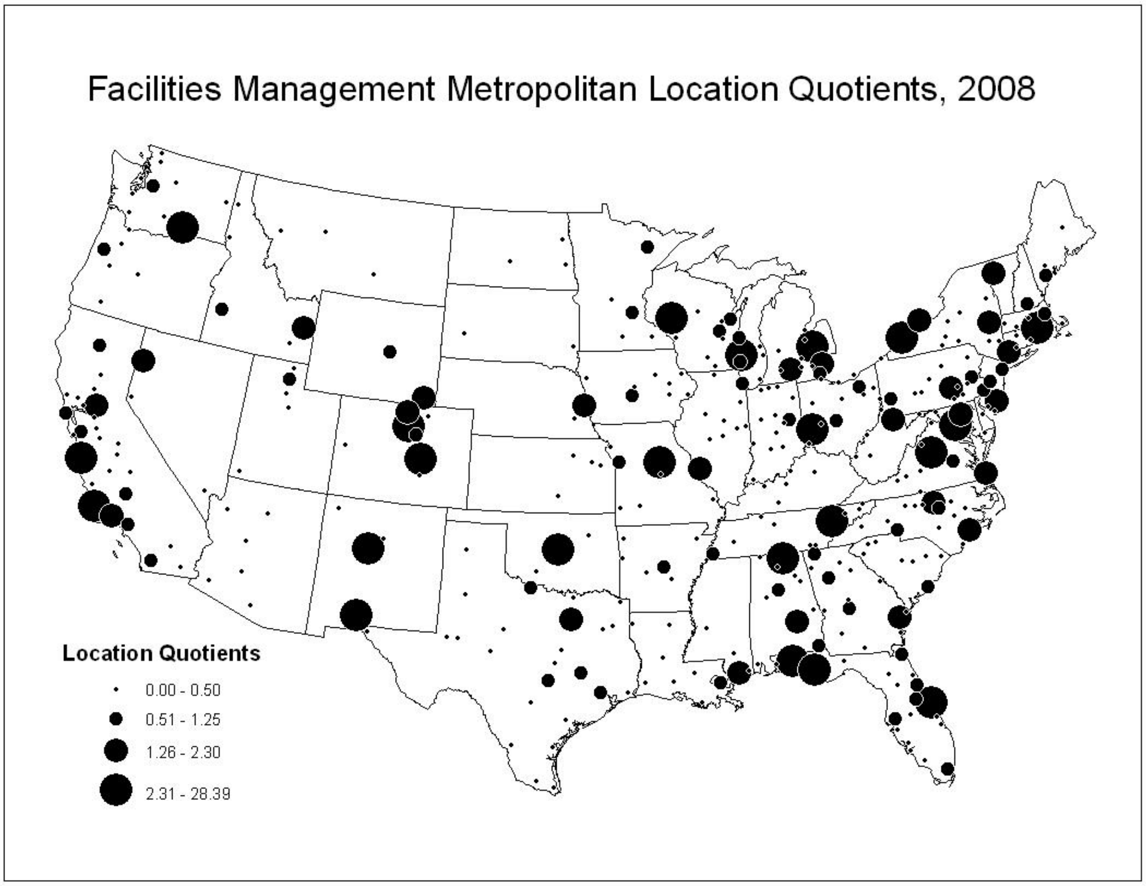


Figure 4.17: Facilities Management Metropolitan Location Quotients, 2008 (Source: County Business Patterns, calculations by author)

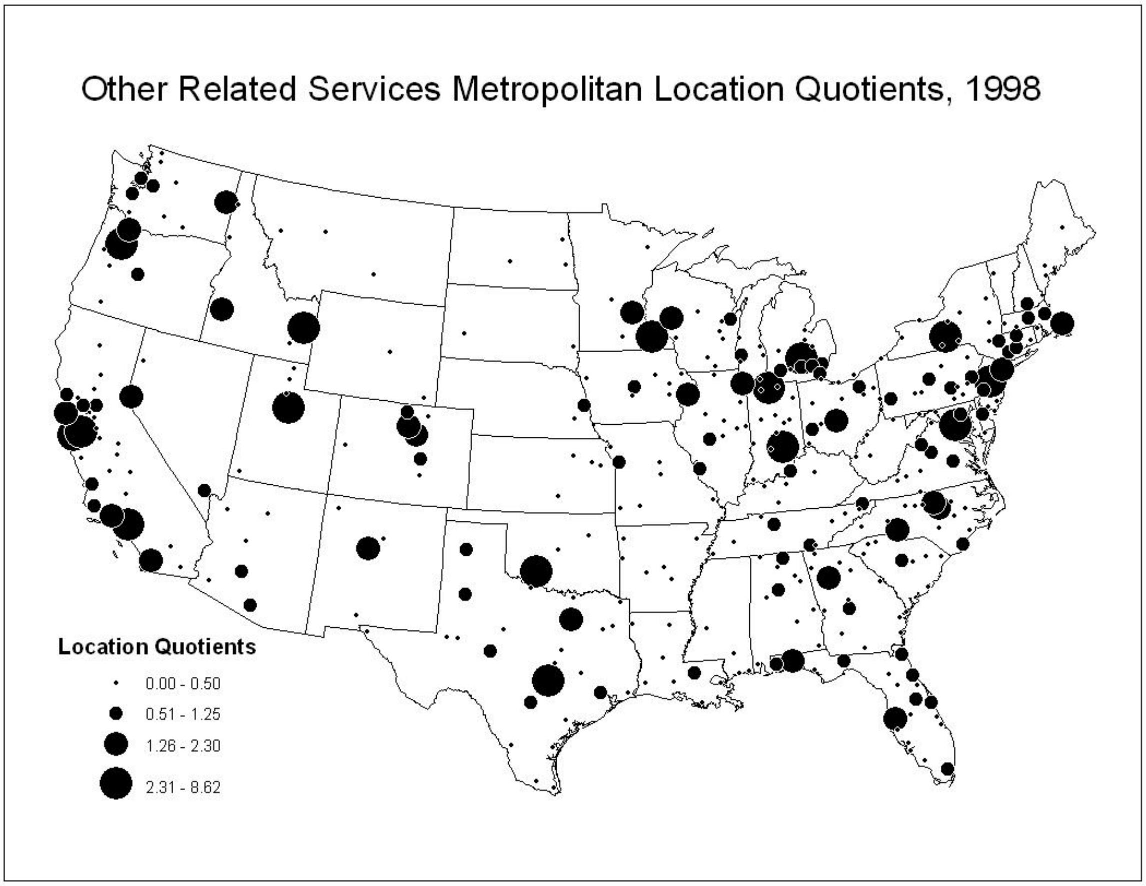


Figure 4.18: Other Related Services Metropolitan Location Quotients, 1998 (Source: County Business Patterns, calculations by author)

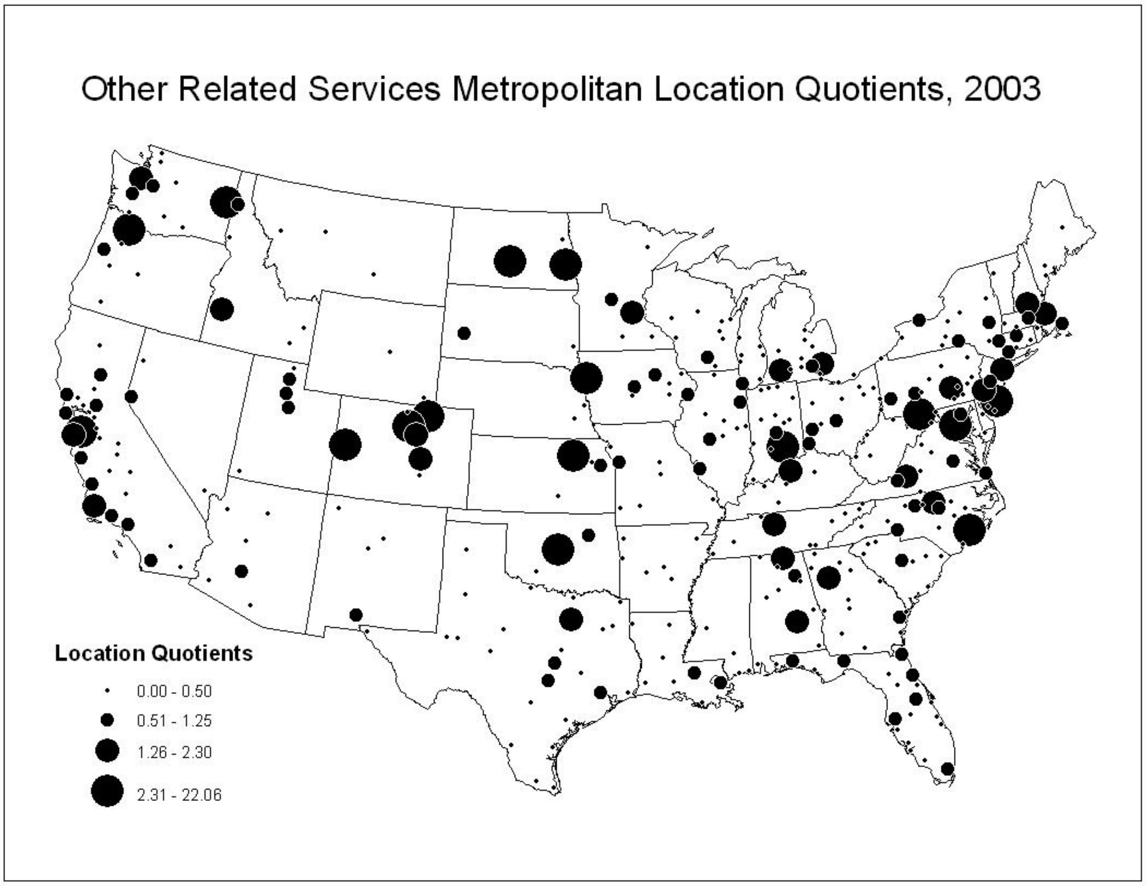


Figure 4.19: Other Related Services Metropolitan Location Quotients, 2003 (Source: County Business Patterns, calculations by author)

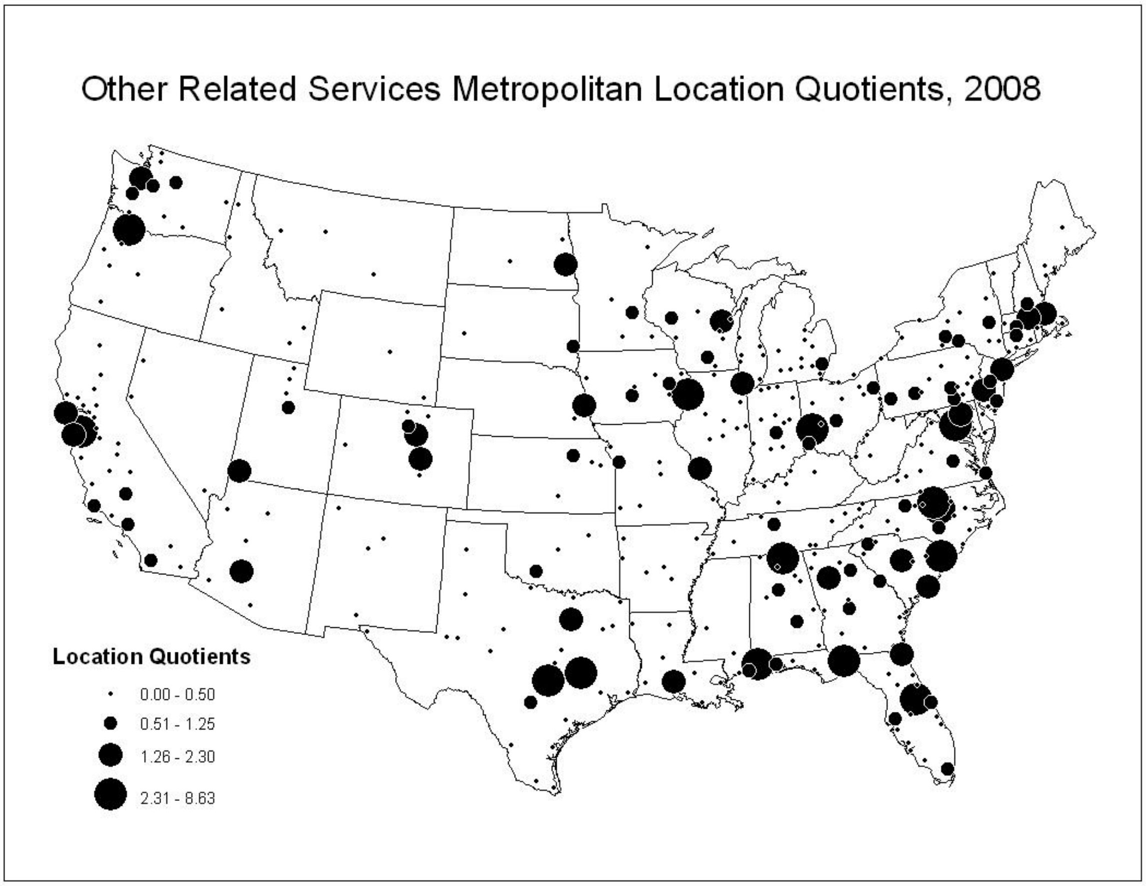


Figure 4.20: Other Related Services Metropolitan Location Quotients, 2008 (Source: County Business Patterns, calculations by author)

Custom programming employment had just five of the 1998 top ten concentrations repeat in 2003 and six of the 2003 top ten concentrations remained the same in 2008. Over the ten year time period, six of the top ten CS concentrations remained the same in 2008 when compared to 1998. Washington DC, Boulder, San Jose, Huntsville, and Provo-Orem appear in each year's top ten concentration listing, with Austin represented in 1998 and 2008 after falling out in 2003.

System design employment concentration is nearly as consistent as custom programming employment in terms of MSA representation in the top ten listing of location quotients. Similar to custom programming, the top ten concentrations are dominated by MSAs associated with government operations, universities, or major centers of production for computing technologies. System design employment had just five of the 1998 top ten concentrations repeat in 2003 and five of the 2003 top ten concentrations remained the same in 2008. Over the ten year time period, five of the top ten CS concentrations remained the same in 2008 when compared to 1998. Washington DC, San Jose, Huntsville, and Olympia appear in each year's top ten concentration listing, with Burlington, VT represented in 1998 and 2008 after falling out in 2003.

Facilities management employment concentration is less consistent than the high order services of custom programming and system design in terms of MSA representation in the top ten listing of location quotients. While facilities management does have significant concentrations in MSAs associated with government and universities it is not as dominant as the high order CS services and presents greater volatility across time periods in smaller MSAs. Facilities management employment had just four of the 1998 top ten concentrations repeat in 2003 and four of the 2003 top ten concentrations remained the same in 2008. Over the ten year time period, three of the top ten CS concentrations remained the same in 2008 when compared to 1998. Washington DC and Boulder appear in each year's top ten concentration listing, with Palm Bay-Melbourne, FL represented in 1998 and 2008 after falling out in 2003.

Other related services employment concentration presents the most volatility among CS subsectors in terms of MSA representation in the top ten listing of location quotients. Employment concentrations in other related services appears scattered among multiple smaller MSAs which vary across time periods, with a discernable concentration pattern associated with colleges or universities. Other related services employment had just one of the 1998 top ten concentrations repeat in 2003 and one of the 2003 top ten concentrations remained the same in 2008. Over the ten year time period, one of the top ten CS concentrations remained the same in 2008 when compared to 1998. Washington DC is the only MSA to appear in each year's top ten concentration listing.

Two patterns emerge after analyzing the top ten highest location quotients for total CS and CS subsector employment. First, high order CS employment appears to concentrate in larger metropolitan areas and low order CS employment appears to concentrate mostly in smaller metropolitan areas. High order computer programming and system design has the greatest stability in the largest metropolitan areas. As evidenced here, higher order services have been shown to concentrate in large metropolitan areas, but concentrations appear to be emerging in smaller metropolitan areas (Bismarck, ND, Warner Robbins, GA, and Fort Walton-Destin, FL). By the nature of employment distributions among CS subsectors, the large employment concentrations of computer programming and system design influence total CS employment concentration analysis so much that it obscures the concentrations and variability of low order CS employment in facilities management and other related services. Low order facilities management and other related services appears to have the greatest volatility in concentration and generally locates in smaller metropolitan areas often associated with universities (Boulder, Charlottesville, College Station, Tallahassee, and Durham-Chapel Hill). But, concentrations are emerging in fast rising larger metropolitan areas (Orlando, Raleigh-Cary, and Portland).

Second, many of the concentrations regardless of CS subsector or metropolitan area size are located in areas associated with government/military, universities, major centers of production for computing technologies, or some combination of the three. Many of these areas could be considered net consumers and net producers of CS industry employment and output, which makes them uniquely tied to computer services compared to other areas. Washington DC is the most prominent of all areas with significant concentrations of employment in all CS subsectors and is heavily associated with government, as well as universities and technological growth. Other government/military associated concentrations include Huntsville, AL, Warner Robbins, GA, and Fort Walton-Destin, FL. CS employment concentrations heavily associated with universities include Boulder, Austin, Burlington, Durham-Chapel Hill, Charlottesville, College Station, and Tallahassee. CS employment concentrations heavily associated with major centers of computing technologies include San Jose, Provo-Orem, and Olympia.

Location quotients were calculated and the top ten MSAs for total CS and each subsector for 1998, 2003, and 2008 were presented to highlight which metropolitan areas had the greatest concentrations of CS employment, as well as to determine if the highest concentrations of CS employment develop in metropolitan areas with specific or unique attributes. There are three key findings from analyzing the top ten MSA concentrations of CS employment. One, the top ten listing for each varies with some consistent representation but the largest CS subsectors (custom programming and system design) have greater consistency than the smallest CS subsectors (facilities management and other related services). Two, the largest and smallest CS subsectors tend to locate in MSAs of contrasting sizes but each have developed concentrations in divergent areas. Three, many of the concentrations regardless of subsector or metropolitan size are associated with local factors (government/military, universities, or centers of computing technologies) which influence the location of CS employment.

The largest CS subsectors tend to concentrate in the largest metropolitan and have the greatest stability among CS subsectors in terms of metropolitan areas that continually have the highest concentrations of CS employment. The smaller CS subsectors tend to concentrate in smaller metropolitan areas and have the greatest variability in terms of metropolitan areas with the highest concentration of CS employment. The largest CS subsectors have emerging concentrations in smaller metropolitan areas associated with government or military operations. The smallest CS subsectors have emerging concentrations in larger metropolitan areas characterized by high growth. The largest CS subsectors appear to be associated with centers of population and economic concentration, while the smallest CS subsectors appear to associated with metropolitan areas with specific local factors influencing the concentration of CS employment. In this instance, many of the concentrations of facilities management and other related services are located in metropolitan areas associated with major universities. With that, the location of CS employment concentrations, regardless of metropolitan size, seem particularly influenced by local factors more so than metropolitan size or economic advantage.

The highest concentrations of CS employment are often located in areas associated with government/military, universities, major centers of production for computing technologies, or some combination of the three. Many of these metropolitan areas are not only consumers of CS industry output but also producers of CS industry employment/talent and input or technological/innovative developments. The convergence of these two factors makes such metropolitan areas leading centers of CS industry employment. Aside from this, the highest concentrations of CS industry employment are particularly influenced by the local character or economic/social make-up of metropolitan areas. These areas provide a consistent source of consumers and/or talent to the industry and have a significant advantage over other metropolitan areas regardless of metropolitan size.

4.2.1.3. Spearman Rank Correlation Analysis

The location quotients were examined from year to year utilizing Spearman rank correlations to determine if and to what extent there was change across metropolitan concentrations of CS industries. The rank correlations measure similarity among location quotient rankings from year to year, allowing a statistical analysis of the variability of metropolitan concentrations. A value of one would equal a perfect correlation and thus no change in the location quotients rankings of metropolitan areas. Year over year correlations and correlations for 2008 in relation to 1998 and 2003 are presented in Table 4.4.

Table 4.4: CS Location Quotient Spearman Rank Correlations

	CS Total	Custom Programming	System Design	Facilities Management	Other Related Services
1999	0.940	0.928	0.917	0.878	0.855
2000	0.962	0.952	0.944	0.940	0.864
2001	0.961	0.935	0.959	0.458	0.875
2002	0.937	0.908	0.922	0.459	0.692
2003	0.895	0.846	0.802	0.664	0.607
2004	0.945	0.941	0.914	0.920	0.891
2005	0.961	0.952	0.936	0.951	0.852
2006	0.970	0.965	0.939	0.951	0.906
2007	0.952	0.948	0.922	0.867	0.851
2008	0.876	0.870	0.858	0.622	0.661
2003-2008	0.825	0.820	0.731	0.605	0.530
1998-2008	0.789	0.719	0.636	0.393	0.536

Source: County Business Patterns, calculations by author

The location quotient rankings for total CS employment had little variation from year to year with strong and significant rank correlations exceeding 0.87 for all years. Slightly lower but still strong and significant, the rank correlations between 2003 and 2008 (0.825) and 1998 and 2008 (0.789) show little variation over the whole study period. The location quotient rankings for custom programming employment had little variation from year to year with strong and significant rank correlations exceeding 0.84 for all years. Slightly lower but still strong and significant, the rank correlations between 2003 and 2008 (0.820) and 1998 and 2008 (0.719) show little variation over the whole study period. The location quotient rankings for system design employment had little variation from year to year with strong and significant rank correlations exceeding 0.80 for all years. Slightly lower but still strong and significant, the rank correlation between 2003 and 2008 (0.731) shows little variation over the second half of the study period. Over the whole study period the rank correlation presents a moderate and significant correlation (0.636), indicating at least some change in the location quotient concentration rankings of system design employment from 1998 to 2008.

The location quotient rankings for facilities management presents strong and significant rank correlations for most years in the study period but a few years do have differing results. Moderate and significant rank correlations are seen in 2008 (0.622), 2003 (0.664), 2002 (0.459), and 2001 (0.458), which indicates at least some change in the location quotient concentration rankings and corresponds to periods of overall decline in facilities management concentration as shown with the Gini coefficient results. Over the second half of the study period the rank correlation presents a moderate and significant correlation, indicating at least some change in the location quotient concentration rankings of facilities management from 2003 to 2008. More significantly, over the whole study period the rank correlation presents a weak but significant correlation (0.393), indicating considerable change in the location quotient concentration rankings of facilities management from 1998 to 2008.

The location quotient rankings for other related services presents strong and significant rank correlations for most years in the study period but a few years do have differing results. Moderate and significant rank correlations are seen in 2008 (0.661), 2003 (0.607), and 2002 (0.692), which indicates at least some change in the location quotient concentration rankings. The rank correlations between 2003 and 2008 (0.530) and 1998 and 2008 (0.536) show moderate and significant correlation, indicating at least some change in the location quotient concentration rankings of other related services over the whole study period.

There is very little variability in the total CS employment metropolitan location quotient concentration rankings, but CS subsector analysis reveals a level of variance not seen in aggregate. Higher rank correlations in total CS employment are at least partially explained by the much larger employment numbers in custom programming and system design, which also showed little variation in location quotient rankings. The highest variability among CS subsectors occurred in facilities management. Several year over year rank correlations exhibit variability that is consistent with the Gini coefficient results indicating overall declined in facility management concentration. From 1998 to 2008, facilities management had the greatest variability of all CS subsectors, representing significant change in the rank correlations of metropolitan areas. Other related services also had year over year rank correlations exhibit moderate variability among metropolitan rank correlations and had some variability in the location quotient concentration rankings which exceeded those from custom programming and system design employment. By disaggregating CS employment by subsector it was possible to reveal the variability in the metropolitan concentration rankings of detailed CS employment, which would have been concealed if total CS employment was only analyzed.

Spearman rank correlations were calculated to assess whether any variability exists among MSA CS employment concentration.   The analysis was used to determine a level of change between CS concentrations across MSAs by using a hierarchical ranking of CS employment location quotients. The results reveal that overall CS employment concentration varies little over the entire study, which means that MSA concentrations of CS employment have not shifted or rearranged much at all among MSAs and signals little change in CS employment concentrations across the urban hierarchy. The largest CS subsectors, custom programming and system design, also showed little variation in CS employment concentration rankings and follows the pattern seen in total CS employment. These dominant subsectors are the main influence for the continued concentration patterns of total CS across MSAs. Although, facilities management and other related services differ considerably from this pattern.

Facilities management has the highest variability of CS concentrations among all CS subsectors across MSAs from 1998 to 2008, which signifies a highly volatile rank distribution of facilities management concentration over the study period. Year of year variability in facilities management concentration coincides with the Gini coefficient results indicating an overall decline in facilities management concentration. The combination of these results points to a redistribution of facilities management employment across MSAs which results in the diffusion and therefore lower concentrations of facilities management employment. Other related services did not have variability as extreme as facilities management but the rank correlations reveal some level of employment concentration change of other related services across MSAs. The Gini coefficient results point to an increased concentration of other related services and with the variability exhibited in the rank correlations the changing concentration patterns of other related services appear to be a redistribution of employment to specific MSAs and thus higher concentrations.

4.2.2. Inter-metropolitan Growth of Computer Service Employment

The percent growth of CS employment was calculated and was used to examine the level of growth in CS employment. To examine growth, percent change in metropolitan CS employment is presented for the five metropolitan size categories and for the three time periods from 1998 to 2003, 2003 to 2008, and 1998 to 2008 in Table 4.5. Overall, CS employment in the United States increased 50 percent from 1998 to 2008, with a 21 percent and 24 percent growth from 1998 to 2003 and 2003 to 2008, respectively. All of which, far exceeds total employment growth in the United States in each of the observed time periods, 1998 to 2008 (10%), 1998 to 2003 (4%), and 2003 to 2008 (10%). From 1998 to 2008, the largest increase in U.S. CS employment was in other related services at 111 percent, followed by facilities management at 75 percent. The high order subsectors had the lowest percentage growth in the time period, computer programming at 45 percent and system design at 39 percent. From 1998 to 2003, low order facilities management (80%) and other related services (59%) experienced the greatest amount of growth. Custom programming grew by just six percent in this time period and system design grew by 20 percent. From 2003 to 2008, facilities management declined with a growth rate of minus three percent and other related services growth rate slowed to 33 percent. Custom programming had the highest growth in this time period at 38 percent and system design growth rate slowed to 16 percent.

Custom programming, from 1998 to 2008, exhibited growth in all metropolitan size categories and had the greatest growth in the three metropolitan sized categories with less than 500,000 in population at no less than 80 percent. When the two periods of growth (1998 to 2003 and 2003 to 2008) are compared, custom programming had the greatest amount of growth during the 2003 to 2008 time period, and for both time periods growth was the highest in the metropolitan size categories with less than 500,000 in population. System design, from 1998 to 2008, exhibited growth in all metropolitan size categories and had the greatest growth in the 150,000 to 250,000 (120%) and 250,000 to

Table 4.5: Percent Growth of CS Employment

	Custom Computer Programming		
Population Size	1998-2003	2003-2008	1998-2008
Less Than 150,000	27%	42%	80%
150,000 to 250,000	25%	60%	99%
250,000 to 500,000	18%	60%	88%
500,000 to 1 million	-3%	26%	22%
Greater than 1 million	5%	38%	44%
Non Metro	36%	14%	54%
United States	6%	38%	45%
Metro	5%	38%	45%
	Computer System Design		
	1998-2003	2003-2008	1998-2008
Less Than 150,000	10%	28%	41%
150,000 to 250,000	42%	55%	120%
250,000 to 500,000	33%	26%	68%
500,000 to 1 million	17%	22%	43%
Greater than 1 million	18%	13%	34%
Non Metro	23%	23%	52%
United States	20%	16%	39%
Metro	20%	16%	39%
	Computer Facilities Management		
	1998-2003	2003-2008	1998-2008
Less Than 150,000	233%	-31%	130%
150,000 to 250,000	115%	152%	442%
250,000 to 500,000	177%	-48%	45%
500,000 to 1 million	2%	35%	37%
Greater than 1 million	73%	-1%	72%
Non Metro	459%	70%	853%
United States	80%	-3%	75%
Metro	77%	-4%	69%
	Other Computer Related Services		
	1998-2003	2003-2008	1998-2008
Less Than 150,000	285%	-78%	-17%
150,000 to 250,000	205%	-39%	85%
250,000 to 500,000	58%	22%	93%
500,000 to 1 million	29%	62%	109%
Greater than 1 million	42%	53%	117%
Non Metro	462%	-74%	46%
United States	59%	33%	111%
Metro	47%	45%	113%
	Total CS		
	1998-2003	2003-2008	1998-2008
Less Than 150,000	48%	4%	54%
150,000 to 250,000	48%	52%	124%
250,000 to 500,000	49%	17%	74%
500,000 to 1 million	6%	27%	36%
Greater than 1 million	18%	25%	47%
Non Metro	78%	-4%	71%
United States	21%	24%	50%
Metro	19%	25%	49%

Source: County Business Patterns, calculations by author

500,000 (68%) metropolitan size categories. When the two periods of growth (1998 to 2003 and 2003 to 2008) are compared, system design had relatively similar growth rates during the each time period and had the highest growth in the 150,000 to 250,000 and 250,000 to 500,000 metropolitan size categories.

Facilities management, from 1998 to 2008, exhibited growth in all metropolitan size categories and had the greatest growth in the two smallest metropolitan size categories with less than 250,000 in population. When the two periods of growth (1998 to 2003 and 2003 to 2008) are compared, facilities management had the greatest amount of growth during the 1998 to 2003 time period and experienced declines in three of the five metropolitan size categories during the 2003 to 2008 time period. Other related services, from 1998 to 2003, exhibited growth in all but the smallest metropolitan size category and had the greatest growth in the two largest metropolitan size categories with greater than 500,000 in population. When the two periods of growth (1998 to 2003 and 2003 to 2008) are compared, other related services had the greatest amount of growth from 1998 to 2003 in the smallest metropolitan size categories but experiences declines in those same categories from 2003 to 2008.

Computer services are undoubtedly a fast growing industry easily outpacing overall growth in the United States and metropolitan areas, as mentioned earlier, with the greatest growth in metropolitan areas with a population of 150,000 to 500,000. The differences in growth between the time periods and metropolitan size categories present varying results. Custom programming had the greatest growth from 2003 to 2008 and in the smallest metropolitan size categories. Custom programming seemed to grow more important as the need for and use of computer and computer systems increased. System design had relatively consistent growth between the two time periods and experienced the greatest amount of growth in mid-size metropolitan categories. System design remained steady but when coupled with custom programming the high order CS employment tends to locate, as was seen with the location quotient analysis, with the availability of talent and not necessarily with population or economic centers of activity.

Facilities management had the greatest growth from 1998 to 2003 and in the smallest metropolitan size categories, but experienced significant decline from 2003 to 2008 in most metropolitan categories with the exception of those with a population of 150,000 to 250,000 and 500,000 to 1 million. Facilities management seemed to decline in importance over time, likely a situation where greater technological advancements in computing depressed the need for management of computer systems. Other related services had consistent overall growth between the two time periods but had tremendous growth in the smallest metropolitan categories from 1998 to 2003 followed by declines from 2003 to 2008. Other related services, after initial growth in smaller areas, appear to have the highest levels of growth associated with larger population centers.

Growth rates were analyzed to not only determine the overall upward growth of computer services but to characterize the growth in terms of CS subsector and geographic distribution across the urban hierarchy. Aside from the fact that the CS industry far outpaces overall economic growth, there are two key takeaways from the growth of CS. One, the growth of CS subsectors was not consistent over the entire study period, and two, there were considerable growth differentials between metropolitan size categories.

Custom programming experienced the greatest growth in the second half of the study period coinciding with a rise in the use of and need for custom computer applications to serve a broader audience of users as computerized systems in business gained prominence. The greatest growth of custom programming occurred in the smallest metropolitan areas, which seems counter to earlier findings about concentration and diffusion. Custom programming held such large employment in the largest metropolitan areas and small amounts in the smallest metropolitan areas that the growth rates reflect gains achieved from small bases were it is hard to overcome the dominance the subsector has maintained in the largest metropolitan areas. Nevertheless, custom programming has been expanding in the smallest metropolitan areas. System design was the most consistent of the CS subsectors by having steady growth throughout the study period. In addition, system design had the greatest growth in the mid-size metropolitan areas. When combined with prior analyses the growth in mid-size metropolitan areas highlights the importance of location specific attributes (talent, universities, etc.) of metropolitan areas to the growth of system design employment as opposed to population or economic influence.

Facilities management had the greatest growth in the first half of the study period and then experienced a significant decline in employment during the second half from 2003 to 2008 across most metropolitan size categories. The decline of facilities management employment coincides with the diffusion of and concentration variability in facilities management. Also, confirming the diffusion of facilities management, the greatest growth occurred in the smallest metropolitan areas while other areas declined. Facilities management appears to have declined in importance over time and future analysis is needed to determine if this trend will continue or if facilities management has reached a balance in terms of the need for the management of computer systems. Other related services experienced consistent growth over the entire study period, with growth in both the smallest and largest metropolitan areas. But, the growth in the smallest metropolitan areas was overshadowed by subsequent declines, whereas the largest metropolitan areas had consistent and sustained growth in other related services. In addition, the growth in the largest metropolitan areas aligns with prior finding that other related services have become increasingly concentrated over the study period.

4.2.3. Location Factors of Computer Service Employment and Concentrations

In addition, a series of regression models were developed to identify specific characteristics of MSAs where the location of CS industry employment and concentration is prominent. As described previously, two models were developed utilizing two dependent variables for each subsector of CS industry, as well as total CS. CS employment and CS concentration as represented by location quotients were utilized as dependent variables. And, there were six independent variables included in the model. Percent of the population with a bachelor's degree or higher as a measure of educational attainment and is expected to have a positive correlation with CS employment and concentration. Population density as a measure of population MSA size and is expected to have a positive correlation with CS employment and concentration. Employment growth and per capita income as measures of economic strength and are expected to have a positive correlation with CS employment and concentration. Employment in core MSA County as a measure of urban economic concentration is expected to have a positive correlation with CS industry employment and concentration. Entropy index was developed as a measure of economic diversity in the MSA and is expected to have a positive correlation with CS industry employment and concentration.

Additional independent variables were considered for the model but the six mentioned above created the most parsimonious model while maintaining the theoretical expectations of the location of CS employment and concentration. A five and ten year lag of CS employment were considered but not surprisingly the existing presence of CS employment accounted for more than 90 percent of the variation in employment and concentration of CS industry. If a region is already set apart by CS industry there is a high likelihood that dominance would continue. This finding is significant on its own and should be recognized but takes away from the goal of developing the models. Therefore, in order to determine specific characteristics of MSAs that promote CS industry employment and concentration the lag employment variable were omitted from the model. In addition, eight aggregated industry employment sector percentages were considered in the model but added very little predictive power to the model and only professional, scientific, and technical services were significant. Without the addition of much explanatory and significant value these variables were omitted from the model. Standard measures for multicollinearity, dispersion, and distribution were within acceptable ranges. Descriptive statistics for model variables are presented in Table 4.6.

The two regression analyses results for total CS with employment and location quotients as dependent variables are presented in Table 4.7. In the model with total CS employment as the dependent variable, four independent variables are significant. Percent population with a bachelor's degree or higher, population per square mile, and employment growth are all significant in the expected direction, while percent employment in the core county is significant but in not in the expected direction. Population per square mile has the largest impact on total CS employment, with a beta-

Table 4.6: Descriptive Statistics of Model Variables		
N=366	Mean	Std. Deviation
Dependent Variables		
Total CS Employment	3512.290	12903.006
Custom Programming Employment	1547.250	5512.671
System Design Employment	1313.040	5053.676
Facilities Management Employment	298.490	1242.589
Other Related Services Employment	354.000	1612.070
Total CS Location Quotient (LQ)	0.596	0.797
Custom Programming LQ	0.569	0.736
System Design LQ	0.648	1.226
Facilities Management LQ	0.692	1.960
Other Related Services LQ	0.441	0.814
Independent Variables		
Per Capita Income, 2008	36787.880	6870.576
% Population with Bachelor's or Higher	25.338	7.777
Population per Square Mile	242.805	253.896
% Change in Employment	6.571	8.409
% Employment in Core County	84.361	20.164
Entropy Index, 2008	0.828	0.038
Source: County Business Patterns and U.S. Census, calculations by author		

coefficient of 0.492. This means that a one standard deviation increase of population per square mile generates a 0.492 standard deviation increase in total CS employment.

In the model with total CS location quotients as the dependent variable, two independent variables are significant. Percent population with a bachelor's degree or higher and population per square mile are significant in the expected direction. Percent population with a bachelor's degree or higher has the largest impact on total CS concentration, with a beta-coefficient of 0.445. This means that a one standard deviation increase of percent population with a bachelor's degree or higher generates a 0.445 standard deviation increase in total CS concentration.

In terms of model fit, using total CS employment as the dependent variable produces a model with an adjusted R-square of 0.474, which means that the variables in

Table 4.7: Total Computer Services Model Results

	Employment		Location Quotient	
	Coefficient (Std. Error)	Beta	Coefficient (Std. Error)	Beta
Constant	11750 (12860.216)		-0.456 (0.900)	
Per Capita Income	0.155 (0.097)	0.083	0.00001095 (0.000)	0.094
% Population with Bachelor's or Higher	156.2 (77.924)	0.094*	0.046 (0.005)	0.445**
Population per Square Mile	25.009 (2.321)	0.492**	0.000 (0.000)	0.130*
% Change in Employment	188.405 (60.833)	0.123**	0.004 (0.004)	0.041
% Employment in Core County	-176.749 (27.251)	-0.276 **	-0.003 (0.002)	-0.074
Entropy Index	-12452.606 (15421.967)	-0.036	-0.462 (1.079)	-0.022
R-square	0.483		0.337	
Adjusted R-square	0.474		0.325	
*Significant at 0.05, **Significant at 0.01				
Source: County Business Patterns and U.S. Census, calculations by author				

the model account for 47.4 percent of the variation in total CS employment. Using total CS concentration as the dependent variable produces a model with an adjusted R-square of 0.325, which means that the variables in the model account for 32.5 percent of the variation in total CS concentration.

The two regression analyses results for custom programming with employment and location quotients as dependent variables are presented in Table 4.8. In the model with custom programming employment as the dependent variable, the same four independent variables significant in the total CS employment model are found to be significant. Percent population with a bachelor's degree or higher, population per square

Table 4.8: Custom Programming Model Results				
	Employment		Location Quotient	
	Coefficient (Std. Error)	Beta	Coefficient (Std. Error)	Beta
Constant	1958.498 (5137.082)		-1.131 (0.758)	
Per Capita Income, 2008	0.058 (0.039)	0.073	0.00001079 (0.000)	0.101
% Population with Bachelor's or Higher	61.926 (31.127)	0.087*	0.048 (0.005)	0.512**
Population per Square Mile	12.225 (0.927)	0.563**	0.000 (0.000)	0.171**
% Change in Employment	82.532 (24.300)	0.126**	0.005 (0.004)	0.058
% Employment in Core County	-67.598 (10.886)	-0.247**	-0.001 (0.002)	-0.037
Entropy Index, 2008	-2344.402 (6160.386)	-0.016	0.044 (0.909)	0.002
R-square	0.548		0.449	
Adjusted R-square	0.541		0.44	
*Significant at 0.05, **Significant at 0.01				
Source: County Business Patterns and U.S. Census, calculations by author				

mile, and employment growth are all significant in the expected direction, while percent employment in the core county is significant but in not in the expected direction. Population per square mile has the largest impact on custom programming employment, with a beta-coefficient of 0.563. This means that a one standard deviation increase of population per square mile generates a 0.563 standard deviation increase in custom programming employment.

In the model with custom programming location quotients as the dependent variable, the same two independent variables significant in the total CS employment model are found to be significant. Percent population with a bachelor's degree or higher and population per square mile are significant in the expected direction. Percent population with a bachelor's degree or higher has the largest impact on custom programming concentration, with a beta-coefficient of 0.512. This means that a one standard deviation increase of percent population with a bachelor's degree or higher generates a 0.512 standard deviation increase in custom programming concentration.

In terms of model fit, using custom programming employment as the dependent variable produces a model with an adjusted R-square of 0.541, which means that the variables in the model account for 54.1 percent of the variation in custom programming employment. Using custom programming concentration as the dependent variable produces a model with an adjusted R-square of 0.44, which means that the variables in the model account for 44.0 percent of the variation in custom programming concentration.

The two regression analyses results for system design with employment and location quotients as dependent variables are presented in Table 4.9. In the model with system design employment as the dependent variable, three independent variables are significant. Population per square mile and employment growth are significant in the expected direction, while percent employment in the core county is significant but in not in the expected direction. Population per square mile has the largest impact on system design employment, with a beta-coefficient of 0.429. This means that a one standard deviation increase of population per square mile generates a 0.429 standard deviation increase in system design employment.

In the model with system design location quotients as the dependent variable, just one independent variable is significant. Percent population with a bachelor's degree or

Table 4.9: System Design Model Results				
	Employment		Location Quotient	
	Coefficient (Std. Error)	Beta	Coefficient (Std. Error)	Beta
Constant	5835.379 (5375.548)		0.241 (1.595)	
Per Capita Income, 2008	0.066 (0.040)	0.089	0.0000105 (0.000)	0.059
% Population with Bachelor's or Higher	60.364 (32.572)	0.093	0.042 (0.010)	0.265**
Population per Square Mile	8.545 (0.970)	0.429**	0.000 (0.000)	0.073
% Change in Employment	69.743 (25.428)	0.116**	0.002 (0.008)	0.017
% Employment in Core County	-69.99 (11.391)	-0.279**	-0.004 (0.003)	-0.065
Entropy Index, 2008	-6161.756 (6446.355)	-0.046	-0.972 (1.913)	-0.03
R-square	0.411		0.12	
Adjusted R-square	0.401		0.105	
*Significant at 0.05, **Significant at 0.01				
Source: County Business Patterns and U.S. Census, calculations by author				

higher is significant in the expected direction. As the only significant variable, percent population with a bachelor's degree or higher has the largest impact on system design concentration, with a beta-coefficient of 0.265. This means that a one standard deviation increase of percent population with a bachelor's degree or higher generates a 0.265 standard deviation increase in system design concentration.

In terms of model fit, using system design employment as the dependent variable produces a model with an adjusted R-square of 0.401, which means that the variables in the model account for 40.1 percent of the variation in system design employment. Using system design concentration as the dependent variable produces a model with an adjusted

R-square of 0.105, which means that the variables in the model account for only 10.5 percent of the variation in system design concentration.

The two regression analyses results for facilities management with employment and location quotients as dependent variables are presented in Table 4.10. In the model with facilities management employment as the dependent variable, three independent variables are significant. Percent population with a bachelor's degree or higher and population per square mile are significant in the expected direction, while percent employment in the core county is significant but in not in the expected direction. Population per square mile has the largest impact on facilities management employment, with a beta-coefficient of 0.332. This means that a one standard deviation increase of population per square mile generates a 0.332 standard deviation increase in facilities management employment.

In the model with facilities management location quotients as the dependent variable, just one independent variable is significant. Percent population with a bachelor's degree or higher is significant in the expected direction. As the only significant variable, percent population with a bachelor's degree or higher has the largest impact on facilities management concentration, with a beta-coefficient of 0.263. This means that a one standard deviation increase of percent population with a bachelor's degree or higher generates a 0.263 standard deviation increase in facilities management concentration.

In terms of model fit, using facilities management employment as the dependent variable produces a model with an adjusted R-square of 0.292, which means that the variables in the model account for 29.2 percent of the variation in facilities management

Table 4.10: Facilities Management Model Results				
	Employment		Location Quotient	
	Coefficient (Std. Error)	Beta	Coefficient (Std. Error)	Beta
Constant	1529.455 (1437.740)		0.008 (2.572)	
Per Capita Income, 2008	0.017 (0.011)	0.093	0.0000323 (0.000)	0.113
% Population with Bachelor's or Higher	17.36 (8.712)	0.109*	0.066 (0.016)	0.263**
Population per Square Mile	1.627 (0.260)	0.332**	-0.0000842 (0.000)	-0.011
% Change in Employment	11.675 (6.801)	0.079	-0.007 (0.012)	-0.300
% Employment in Core County	-15.759 (3.047)	-0.256**	0.000 (0.005)	-0.006
Entropy Index, 2008	-1732.515 (1724.137)	-0.052	-2.497 (3.085)	-0.048
R-square	0.303		0.104	
Adjusted R-square	0.292		0.089	
*Significant at 0.05, **Significant at 0.01				
Source: County Business Patterns and U.S. Census, calculations by author				

employment. Using facilities management concentration as the dependent variable produces a model with an adjusted R-square of 0.089, which means that the variables in the model account for only 8.9 percent of the variation in facilities management concentration.

The two regression analyses results for other related services with employment and location quotients as dependent variables are presented in Table 4.11. In the model with other related services employment as the dependent variable, three independent

Table 4.11: Other Related Services Model Results

	Employment		Location Quotient	
	Coefficient (Std. Error)	Beta	Coefficient (Std. Error)	Beta
Constant	2426.71 (1771.427)		-0.527 (0.980)	
Per Capita Income, 2008	0.014 (0.013)	0.06	-0.00000502 (0.000)	-0.042
% Population with Bachelor's or Higher	16.548 (10.734)	0.08	0.029 (0.006)	0.282**
Population per Square Mile	2.613 (0.230)	0.412**	0.001 (0.000)	0.206**
% Change in Employment	24.457 (8.379)	0.128**	0.013 (0.005)	0.137**
% Employment in Core County	-23.41 (3.754)	-0.293**	-0.008 (0.002)	-0.196**
Entropy Index, 2008	-2212.204 (2124.295)	-0.052	0.998 (1.175)	0.046
R-square	0.372		0.246	
Adjusted R-square	0.361		0.234	

*Significant at 0.05, **Significant at 0.01

Source: County Business Patterns and U.S. Census, calculations by author

variables are significant. Population per square mile and employment growth are significant in the expected direction, while percent employment in the core county is significant but in not in the expected direction. Population per square mile has the largest impact on other related services employment, with a beta-coefficient of 0.412. This means that a one standard deviation increase of population per square mile generates a 0.412 standard deviation increase in other related services employment.

In the model with other related services location quotients as the dependent variable, four independent variables are significant. Percent population with a bachelor's degree or higher, population per square mile, and employment growth are all significant in the expected direction, while percent employment in the core county is significant but in not in the expected direction. Percent population with a bachelor's degree or higher has the largest impact on other related services concentration, with a beta-coefficient of 0.282. This means that a one standard deviation increase of percent population with a bachelor's degree or higher generates a 0.282 standard deviation increase in other related services concentration.

In terms of model fit, using other related services employment as the dependent variable produces a model with an adjusted R-square of 0.361, which means that the variables in the model account for 36.1 percent of the variation in other related services employment. Using other related services concentration as the dependent variable produces a model with an adjusted R-square of 0.234, which means that the variables in the model account for 23.4 percent of the variation in other related services concentration.

Overall, the models with CS employment as the dependent variable produce more robust results than the models with CS concentration as the dependent variable. The explanatory power in the employment models far exceeds that for any of the concentration models. In addition, the number of independent variables found to be significant characteristics of CS location is more closely suited for the employment than for concentration. Thus, uncovering characteristics of CS employment location is more apparent than CS concentration, which as presented previously may be due to various location conditions (universities, government/military, and technology production centers) that foster the concentration of CS.

For the employment models, four independent variables were consistently significant characteristics defining CS employment in MSAs. Population density most often provided the greatest explanatory power and as such, CS employment is dependent on population concentration to develop in an MSA. Educational attainment, as expected, is a significant factor in the location of CS employment. Employment growth was also significant in many of the models and seems to support the notion that CS employment exists in areas that are represented by high growth. Percent employment in the MSA core county was significant but not in the expected direction. The models found that as the employment in core MSA counties increased the level of CS employment decreases, but it was expected that as core county employment increased CS employment would increase based on the agglomerative benefits for the CS industry. This finding lends more credence to the diffusion of CS and KIBS employment away from the traditional employment cores of MSAs. Per capita income was not significant any of the employment models, as well as the entropy index measuring industry diversity of the region.

For the concentration models, only one independent variable was consistently a significant characteristic defining CS concentration in MSAs. Although other independent variables were significant in some models, particularly population density, educational attainment was the most consistent and offered the greatest explanatory power. Population density, employment change, and percent employment in MSA core counties appeared significant in some models but in most cases offered little explanatory value. Again, per capita income and the entropy index of industrial diversity were not significant in the concentration models.

Regression analysis was performed to determine specific prominent characteristics of MSAs that are either centers of CS employment or concentration. A series of regression models for CS total and subsector employment were completed with two dependent variables. CS employment was utilized in the first series of models and location quotients as a measure of concentration were used in a second series of models. The six independent variables included in the model were previously identified as prominent characteristics of metropolitan areas that have developed significant economic linkages with KIBS.

Overall, the results are more robust for identifying characteristics of CS employment location rather than CS employment concentration. Additionally, the explanatory variables included in the models are more likely to be associated with CS employment than concentration, which confirms earlier findings that local factors have significant influence in the concentration of CS employment. Most notably, the presence of government/military, universities, or major production centers of technology greatly influences the concentration of CS. Not surprisingly, in terms of absolute numbers of CS employment, the size of the MSA has a significant impact on the level of CS employment as the need for such services is greatest in the largest MSAs and concentration is obscured by the overall level of economic activity.

Population density provided the greatest explanatory power for the location of CS employment, aligning with the notion that absolute employment in CS is most prominent in population centers. Related to population size, overall employment growth is a significant factor in the location of CS employment as well. As expected, and almost universally accepted, educational attainment is a significant factor in the location of CS employment. One finding that was not expected was the directionality of employment in the MSA core county. All of the models produced a significant but negative correlation between CS employment and employment in the MSA core county. It was expected that due to the agglomerative benefits for the CS industry that CS employment would primarily locate in the core economic center of MSAs. The models produced results contradicting this notion and found that as the employment in MSA core counties increased the level of CS employment decreased. In other words, CS employment was more likely to locate in periphery counties than economic cores of MSAs. Thus, there appears to be a diffusion of CS employment away from the core into the periphery of MSA. Per capita income and employment diversity were not found to significant for the location of CS employment.

Educational attainment provided the greatest explanatory power for the location of CS concentration and in most of the models was the only independent variable that offered values of considerable size. As in the employment models and in most discussions of promoting KIBS growth, educational levels of the population are important for the development of KIBS industry growth. The results of the other explanatory variables further supports the notion that concentrations of CS employment regardless of subsector are primarily driven by local factors difficult to replicate in other areas. With that said, any attempt at identifying specific characteristics of metropolitan areas conducive for KIBS must be cognizant of the employment data measure utilized in an analysis.

4.3. Intra-metropolitan Analysis of Computer Services

To analyze the intra-metropolitan distribution and growth of computer services a series of geographic research methods were utilized. To determine the distribution and concentration of CS employment within metropolitan areas, an analysis was completed by using concentration ratios, a modified location quotient analysis. Also, to assess individual MSA concentrations the percentage distributions of concentrated versus non-concentrated MSAs were analyzed. To determine the growth of CS employment an analysis was completed by evaluating the percent growth of CS employment within metropolitan areas.

Data for the analysis was again obtained annually for a 10 year time period from 1998 to 2008 from County Business Patterns at the county level and aggregated to the MSA level for comparable analysis across years. Since the goal is to analyze intra-metropolitan CS employment, single county MSAs were removed from the data set. The analysis was completed for 218 of the 366 MSAs defined in the 2008 MSA classification. To enable an examination of core versus non-core metropolitan counties the core county of each MSA was identified as the county containing the primary city designated by the Census Bureau for each MSA and all remaining counties were classified as non-core counties.

Total CS employment and the four CS subsectors (Custom Computer Programming, Computer Systems Design, Computer Facilities Management, and Other Related Services) are represented in the analysis to reveal the importance of disaggregated high and low order industry concentrations, as discussed earlier. Also, the data were aggregated into four metropolitan size categories based on the number of counties in the MSA to explore the distribution and growth of CS across the urban hierarchy. Metropolitan size categories in the intra-metropolitan analysis were based on the number of counties in the MSA so that comparisons of core/non-core concentration can be made based on the geographic size/scope of an MSA. Metropolitan categories utilized in the analysis and the counts of MSAs in each category are listed in Table 4.12.

Table 4.12: MSA County Size Categories

	Count of MSAs
2	74
3-4	82
5-9	45
10 or more	17
Total	218

Source: U.S. Census Bureau, calculations by author

4.3.1. Intra-metropolitan Concentration of Computer Service Employment

4.3.1.1. Concentration Ratio Analysis

Concentration ratios were calculated for CS employment for each subsector in core and non-core metropolitan counties across the four metropolitan size categories to identify concentrations of CS employment. This modified location quotient is calculated similar to the traditional location quotient except that total metropolitan employment will be utilized as the reference variable rather than national employment for a measure of metropolitan concentration. In this instance, a value greater than one represents concentrations of employment in core/non-core metropolitan counties are greater than employment for the metropolitan area and values less than one represent employment concentrations in core/non-core metropolitan counties are less than employment for the metropolitan area.

Concentration ratios for core counties in each CS subsector across the four metropolitan size categories for 1998, 2003, and 2008 are presented in Table 4.13. As would be expected, given the ability and propensity for employment to diffuse from the core county based on metropolitan size, overall, concentration ratios for the core counties across all CS subsectors for each year declines as the number of counties in the MSA increase. Little variation exists in this pattern with the exception of some slightly lower concentration ratios in MSAs with 2 counties compared to MSAs with 3-4 counties.

Table 4.13: Core County CS Employment Concentration Ratios

	Core Total 2008	Core Custom Programming 2008	Core System Design 2008	Core Facilities Management 2008	Core Other Related Services 2008
2	1.06	1.11	0.98	1.11	1.15
3-4	1.02	1.02	1.00	1.05	1.07
5-9	0.81	0.83	0.74	1.02	0.75
10 more	0.74	0.89	0.63	0.72	0.58
Total	0.82	0.90	0.75	0.84	0.71
	Core Total 2003	Core Custom Programming 2003	Core System Design 2003	Core Facilities Management 2003	Core Other Related Services 2003
2	1.05	1.09	0.96	1.24	1.15
3-4	0.99	0.97	1.02	1.02	0.84
5-9	0.74	0.72	0.68	1.07	0.72
10 more	0.76	0.83	0.66	0.79	0.89
Total	0.81	0.86	0.74	0.88	0.79
	Core Total 1998	Core Custom Programming 1998	Core System Design 1998	Core Facilities Management 1998	Core Other Related Services 1998
2	1.02	1.08	1.05	1.14	0.62
3-4	1.08	1.10	1.04	1.23	1.07
5-9	0.82	0.91	0.66	1.13	0.86
10 more	0.75	0.82	0.60	1.06	0.79
Total	0.81	0.87	0.72	0.98	0.77

Source: County Business Patterns, calculations by author

In 2008, the greatest concentration ratios of total CS employment in core counties existed in the smallest MSAs and the concentration ratio for total CS employment in all MSA core counties indicates that CS employment is not concentrated in MSA core counties. Total CS employment concentration in core counties increased from 2003 to 2008 across all MSA sizes, with the exception of the largest MSA size category. Although, no MSA size categories changed from concentrated or not concentrated. From 1998 to 2008, total CS employment concentration in core counties increased in only the smallest MSA size category and decreased in all others.

Custom programming employment in core counties also had the greatest concentrations in the smallest MSA size categories in 2008, while core counties in the larger MSA size categories were not concentrated. Also, the concentration ratio for custom programming employment in all MSA core counties represents the highest concentration ratio, albeit still not concentrated, among all CS subsectors. Custom programming employment concentration in core counties increased from 2003 to 2008 across all MSA size categories. In addition, MSAs with 3-4 counties moved from not being concentrated to being concentrated in employment. From 1998 to 2008, custom programming employment concentration in core counties increased in the smallest and largest MSA size categories and decreased in MSAs with 3-4 and 5-9 counties.

System design employment in core counties were not concentrated in any MSA size category and presented an even distribution of employment for MSAs with 3-4 counties in 2008. Also, the concentration ratios for system design employment in MSA core counties represent some of the lowest ratios among all CS subsectors. System design employment concentration in core counties increased from 2003 to 2008 in the smallest MSAs and the MSAs with 5-9 counties, and decreased in the largest MSAs and the MSAs with 3-4 counties. In addition, MSAs with 3-4 counties moved from being concentrated to an even distribution in employment. From 1998 to 2008, system design employment concentration in core counties increased in the largest MSA size category and MSAs with 5-9 counties and decreased in the smallest MSA size category and MSAs with 3-4 counties.

Facilities management employment in core counties were concentrated in all MSA size categories with the exception of the largest MSAs in 2008. Also, the concentration ratios for facilities management employment in MSA core counties represent some of the highest ratios among all CS subsectors. Facilities management employment concentration in core counties increased from 2003 to 2008 in just MSAs with 3-4 counties and decreased in all other MSA size categories. From 1998 to 2008, facilities management employment concentration in core counties decreased in all MSA size categories, representing some of the largest decreases in concentration among all CS subsectors. In addition, the largest MSA size category moved from being concentrated to not being concentrated in employment.

Other related services employment in core counties were concentrated in the smallest MSA size categories in 2008, while core counties in the larger MSA size categories were not concentrated. Also, the concentration ratio for other related services employment in all MSA core counties represents the lowest concentration ratio among all CS subsectors. Other related services employment concentration in core counties increased from 2003 to 2008 in all MSA size categories with the exception of the largest MSA size category. In addition, MSAs with 3-4 counties moved from not being concentrated to being concentrated in employment. From 1998 to 2008, other related services employment concentration in core counties increased in the smallest MSA size category and MSAs with 3-4 counties and increased in the largest MSA size category and MSAs with 5-9 counties.

The non-core county concentrations of MSAs across CS subsectors and MSA size categories are presented in Table 4.14. The figures in Table 4.14 represent the mirrored results of Table 4.13 but are presented here as an illustration of the concentration and increased concentration of CS employment in non-core counties of MSAs as employment diffuses away from the core of MSAs regardless of MSA size. Overall, in most non-core counties of MSAs of any size the concentration ratios increased from 1998 to 2008 at a much greater frequency than core county concentrations even if the values remain less than one or not concentrated. In addition, with the exception of facilities management which remains concentrated in core counties, the concentration ratios for non-core counties represent higher levels of concentration than those of core counties, which can also be seen in the low concentration ratios presented in Table 4.13 for core counties.

Total CS employment is more concentrated in non-core counties of all MSAs, as well as the largest MSAs, while the smallest MSAs are more concentrated in CS employment, albeit small, in core counties. While some variation exists based on MSA size, generally over time core counties of MSAs are losing CS employment concentration as it shifts to non-core counties of MSAs. This same general pattern holds true for most CS subsectors. Custom programming and other related services present a very similar pattern, while facilities management was similar the level of concentration between core and non-core counties had the greatest contrast with core counties far exceeding

Table 4.14: Non-core County CS Employment Concentration Ratios

	Non-Core Total 2008	Non-Core Custom Programming 2008	Non-Core System Design 2008	Non-Core Facilities Management 2008	Non-Core Other Related Services 2008
2	0.88	0.78	1.10	0.30	0.77
3-4	0.90	0.84	1.00	0.91	0.79
5-9	1.21	1.15	1.27	1.04	1.37
10 more	1.14	1.06	1.20	1.15	1.21
Total	1.22	1.12	1.30	1.20	1.36

	Non-Core Total 2003	Non-Core Custom Programming 2003	Non-Core System Design 2003	Non-Core Facilities Management 2003	Non-Core Other Related Services 2003
2	0.95	0.85	1.15	0.43	0.84
3-4	0.93	0.88	0.91	0.99	1.18
5-9	1.29	1.28	1.39	0.92	1.29
10 more	1.14	1.10	1.19	1.12	1.07
Total	1.24	1.18	1.32	1.15	1.26

	Non-Core Total 1998	Non-Core Custom Programming 1998	Non-Core System Design 1998	Non-Core Facilities Management 1998	Non-Core Other Related Services 1998
2	1.00	0.76	0.90	0.41	2.67
3-4	0.85	0.79	0.89	0.61	1.17
5-9	1.16	1.05	1.37	0.86	1.05
10 more	1.16	1.11	1.25	0.95	1.12
Total	1.25	1.17	1.37	1.03	1.31

Source: County Business Patterns, calculations by author

employment concentration in non-core counties of the smallest MSAs. System design employment is the outlier among CS subsectors with significant concentrations in non-core counties regardless of MSA size. System design also maintains some of the highest concentration ratios compared to any core and non-core counties.

Concentration ratios were calculated to determine the overall distribution of CS employment within MSAs of particular geographic sizes. Total CS employment was found to be more concentrated in non-core counties of MSA regardless of MSA size, with the exception of the smallest MSAs which maintain concentrations in core-counties. The literature suggests a diffusion of employment away from core counties and is confirmed for total CS employment except for the smallest MSAs which is understandable given their size and limited opportunity to change locations. This finding also aligns with the CS employment regression models where CS employment is negatively correlated with the size of core county employment. Generally over time the core counties of MSAs are losing CS employment concentration to non-core counties. Even if the non-core counties are not considered to have concentrations at this time they have gained employment shares as the core counties declined.

Custom programming and other related services hold a very similar pattern as total CS employment. Facilities management, although, continues to maintain concentrations in core counties of MSA over that of non-core counties. The system design concentration ratios for non-core counties regardless of MSA size exceed that of most other concentration ratio for either core or non-core counties in other subsectors. The variability across CS subsectors, particularly the continued concentration of facilities management in core counties, reveals a more nuanced distribution of CS employment than would otherwise be seen if only viewed aggregated employment totals. The CS industry not only has a variety of service offerings and varying distribution across MSAs but divergent intra-metropolitan location patterns as well.

4.3.1.2. Metropolitan Distribution of Computer Service Concentrations

To assess CS employment concentration across individual MSAs the percentage distribution of MSA core counties are calculated based on whether their concentration ratios are concentrated (greater than 1.10), even (0.90-1.10), or not concentrated (less than 0.90) and presented in Table 4.15. A larger percentage of all MSAs (41%) had core county concentrations of CS employment in 1998 but by 2008 that number declined to 37

Table 4.15: MSA Core Total CS Concentration Ratios Concentrations

2008

Number of Counties in MSA	Not Concentrated (Less than 0.90)	Even (0.90 to 1.10)	Concentrated (Greater than 1.10)
2	16%	55%	28%
3-4	29%	29%	41%
5-9	27%	27%	47%
10 or more	47%	29%	24%
Total	26%	38%	37%

2003

Number of Counties in MSA	Not Concentrated (Less than 0.90)	Even (0.90 to 1.10)	Concentrated (Greater than 1.10)
2	16%	53%	31%
3-4	28%	23%	49%
5-9	24%	20%	56%
10 or more	35%	35%	29%
Total	24%	33%	43%

1998

Number of Counties in MSA	Not Concentrated (Less than 0.90)	Even (0.90 to 1.10)	Concentrated (Greater than 1.10)
2	12%	47%	41%
3-4	23%	37%	40%
5-9	22%	31%	47%
10 or more	47%	18%	35%
Total	21%	38%	41%

Source: County Business Patterns, calculations by author

percent, with the greatest percentage of MSAs having an even distribution of CS employment between core and non-core counties in 2008.

In 1998, MSAs with 3-4 and 5-9 counties were more likely to have core county concentration of CS employment and MSAs with 10 or more counties were more likely to not have core county concentrations of CS employment, while the smallest MSAs with

2 counties were more likely to have an even distribution of CS employment between core and non-core counties. A similar pattern holds true through 2003 and 2008. Although this general pattern stays the same, the percentage distribution among categories has changed over time and represents significant changes in the distribution of CS employment within MSAs.

The noteworthy observations from comparing the 1998 to 2008 changes in Table 4.15 illustrates the diffusion of CS employment through a significant decrease in MSA core counties with concentrations in CS employment, as well as not maintaining an even distribution of CS employment with non-core counties. The percentage of MSAs with 10 or more counties decreased in core county concentration from 35 percent of MSAs to 24 percent, with much of the redistribution classifying more MSAs with an even distribution of CS employment between core and non-core counties. In both 1998 and 2008, nearly half (47%) of MSAs with 10 or more counties had core counties that were not concentrated in CS employment. A similar pattern is also observed among MSAs with 2 counties, signaling a diffusion of CS employment from core counties regardless of MSA size, although, the percentage of MSAs with 2 counties with an even distribution between core and non-core counties is much higher than MSAs with 10 or more counties. The percentage of MSAs with 2 counties decreased in core county concentration from 41 percent of MSAs to 28 percent, with much of the redistribution classifying more MSAs with an even distribution of CS employment between core and non-core counties. In 2008, over half (55%) of MSAs with 2 counties had core counties with an even distribution of CS employment.

From 1998 to 2008, the percentage of MSAs with 3-4 counties and MSAs with 5-9 counties both maintained a similar amount of MSAs classified as concentrated in core county CS employment, 40 percent to 41 percent and 47 percent to 47 percent, respectively. Although the percentage of MSAs with core county concentrations remained the same, there was a redistribution of classification among MSAs with an even distribution and no concentration of CS employment. For both MSA groupings, the percentage of MSAs with an even distribution of CS employment between core and non-core counties declined, while the percentage of MSAs with no core county concentrations in CS employment increased from 23 percent to 29 percent for MSAs with 3-4 counties and from 22 percent to 27 percent for MSAs with 5-9 counties.

This analysis confirms the findings of the concentration ratio analysis. Over the study period the number of MSA core counties which held concentrations in CS employment significantly declined. The smallest and largest MSA core counties declined in concentration to represent a larger number of MSAs that maintain an even distribution of CS employment between core and non-core counties. Mid-size MSAs maintained the level concentrated MSAs but a large number of MSAs that maintained an even distribution of CS employment shifted to non-core county concentrations.

4.3.2. Intra-metropolitan Growth of Computer Service Employment

The growth of CS employment from 1998 to 2008 is examined for core and non-core metropolitan counties. Percent change in core county CS employment is presented for the four MSA categories and for the three time periods from 1998 to 2003, 2003 to 2008, and 1998 to 2008 in Table 4.16. Overall, core county CS employment in the

Table 4.16: Percent Change in Core County CS Employment

98 to 08	Core Total	Core CS Total	Core Custom Programming	Core System Design	Core Facilities Management	Core Other Related Services
2	12%	66%	64%	57%	116%	87%
3-4	6%	52%	56%	27%	66%	169%
5-9	2%	33%	24%	36%	44%	69%
10	3%	34%	35%	33%	2%	77%
Total	6%	46%	44%	39%	42%	96%
03 to 08	Core Total	Core CS Total	Core Custom Programming	Core System Design	Core Facilities Management	Core Other Related Services
2	7%	26%	30%	23%	18%	30%
3-4	4%	29%	62%	10%	-39%	131%
5-9	2%	28%	42%	20%	2%	29%
10	4%	25%	55%	11%	-14%	3%
Total	4%	27%	45%	16%	-11%	34%
98 to 03	Core Total	Core CS Total	Core Custom Programming	Core System Design	Core Facilities Management	Core Other Related Services
2	5%	31%	26%	28%	84%	44%
3-4	2%	18%	-4%	15%	171%	16%
5-9	0%	4%	-12%	14%	41%	32%
10	0%	7%	-13%	20%	18%	73%
Total	2%	15%	-1%	20%	60%	46%

Source: County Business Patterns, calculations by author

United States increased 46 percent from 1998 to 2008, with a 15 percent and 27 percent growth from 1998 to 2003 and 2003 to 2008, respectively. All of which, far exceeds total employment growth in core counties in each of the observed time periods, 1998 to 2008 (6%), 1998 to 2003 (2%), and 2003 to 2008 (4%). From 1998 to 2008, the largest increase in core county CS employment was in other related services at 96 percent, followed by custom programming (44%), facilities management (42%), and system design (39%). From 1998 to 2003, low order facilities management (60%) and other related services (46%) experienced the greatest amount of growth. Custom programming declined one percent in this time period and system design grew 20 percent. From 2003 to 2008, facilities management declined 11 percent and other related services growth slowed to 34%. Custom programming had the highest growth in this time period at 45 percent and system design growth slowed to 16 percent.

Custom programming, from 1998 to 2008, exhibited core county growth in all MSA categories and had the greatest growth in the smallest MSA categories. The core counties of MSAs with 2 counties grew 64 percent, and the core counties of MSAs with 3-4 counties grew 56 percent. When the two periods of growth (1998 to 2003 and 2003 to 2008) are compared, core county custom programming had the greatest amount of growth during the 2003 to 2008 time period, and actually declined in custom programming employment from 1998 to 2003 in all MSA categories with the exception of MSAs with 2 counties. System design, from 1998 to 2008, exhibited core county growth in all MSA categories and had the greatest growth in MSAs with 2 counties at 57 percent. When the two periods of growth (1998 to 2003 and 2003 to 2008) are compared, core county system design had relatively similar growth rates during each time period and had the highest growth in MSAs with 2 counties. In addition, core county system design growth slowed from 20 percent in 1998 to 2003 to 11 percent in 2003 to 2008.

Facilities management, from 1998 to 2008, exhibited core county growth in all MSA categories and had the greatest growth in the smallest MSA categories. The core counties of MSAs with 2 counties grew 116 percent, and the core counties of MSAs with 3-4 counties grew 66 percent. The core counties of MSAs with 10 or more counties grew only 2 percent. When the two periods of growth (1998 to 2003 and 2003 to 2008) are compared, core county facilities management had the greatest amount of growth during the 1998 to 2003 time period, and actually declined in facilities management employment from 2003 to 2008 in MSAs with 3-4 counties and MSAs with 10 or more counties. Other related services, from 1998 to 2008, exhibited core county growth in all MSA categories and had the greatest growth in the smallest MSA categories. The core counties of MSAs with 2 counties grew 87 percent, and the core counties of MSAs with 3-4 counties grew 169 percent. When the two periods of growth (1998 to 2003 and 2003 to 2008) are compared, core county other related services had the greatest overall growth during the 1998 to 2003 time period, but experienced tremendous growth in MSAs with 3-4 counties from 2003 to 2008 with a growth rate of 131 percent.

Percent change in non-core county CS employment is presented for the four MSA categories and for the three time periods from 1998 to 2003, 2003 to 2008, and 1998 to 2008 in Table 4.17 Overall, non-core county CS employment in the United States increased 51 percent from 1998 to 2008, with a 21 percent and 25 percent growth from 1998 to 2003 and 2003 to 2008, respectively. All of which, far exceeds total employment growth in non-core counties in each of the observed time periods, 1998 to 2008 (14%), 1998 to 2003 (7%), and 2003 to 2008 (6%). From 1998 to 2008, the largest increase in non-core county CS employment was in other related services at 136 percent, followed by facilities management (107%), custom programming (43%), and system design (37%). From 1998 to 2003, low order facilities management (110%) and other related services (43%) experienced the greatest amount of growth. Custom programming grew seven percent in this time period and system design grew 18 percent. From 2003 to 2008, facilities management declined one percent and system design declined to 15 percent. Other related services had the highest growth in this time period at 65 percent and custom programming grew 34 percent.

Table 4.17: Percent Change in Non-core County CS Employment

98 to 08	Non-Core Total	Non-Core CS Total	Non-Core Custom Programming	Non-Core System Design	Non-Core Facilities Management	Non-Core Other Related Services
2	15%	44%	69%	110%	68%	-70%
3-4	14%	83%	91%	60%	215%	96%
5-9	11%	53%	64%	21%	109%	175%
10	15%	48%	32%	36%	101%	190%
Total	14%	51%	43%	37%	107%	136%

03 to 08	Non-Core Total	Non-Core CS Total	Non-Core Custom Programming	Non-Core System Design	Non-Core Facilities Management	Non-Core Other Related Services
2	5%	13%	16%	12%	-8%	17%
3-4	7%	23%	50%	26%	-44%	25%
5-9	6%	12%	14%	2%	24%	35%
10	7%	31%	43%	19%	0%	83%
Total	6%	25%	34%	15%	-1%	65%

98 to 03	Non-Core Total	Non-Core CS Total	Non-Core Custom Programming	Non-Core System Design	Non-Core Facilities Management	Non-Core Other Related Services
2	10%	27%	46%	87%	83%	-74%
3-4	7%	49%	28%	27%	459%	57%
5-9	5%	37%	43%	18%	68%	104%
10	8%	13%	-8%	14%	101%	59%
Total	7%	21%	7%	18%	110%	43%

Source: County Business Patterns, calculations by author

Custom programming, from 1998 to 2008, exhibited non-core county growth in all MSA categories and had the greatest growth in the smallest MSA categories. The non-core counties of MSAs with 2 counties grew 69 percent, and the non-core counties of MSAs with 3-4 counties grew 91 percent. When the two periods of growth (1998 to 2003 and 2003 to 2008) are compared, non-core county custom programming growth varied across MSA sizes. MSAs with 3-4 counties and MSAs with 10 or more counties had the greatest growth from 2003 to 2008, and MSAs with 2 counties and MSAs with 5-

9 counties had the greatest growth from 1998 to 2003. Non-core county custom programming actually declined in employment in MSAs with 10 or more counties from 1998 to 2003. System design, from 1998 to 2008, exhibited non-core county growth in all MSA categories and had the greatest growth in MSAs with 2 counties at 110 percent. When the two periods of growth (1998 to 2003 and 2003 to 2008) are compared, non-core county system design had relatively similar growth rates during each time period with the exception of MSAs with 2 counties from 1998 to 2003, which had an 87 percent employment growth rate.

Facilities management, from 1998 to 2008, exhibited non-core county growth in all MSA categories and had the greatest growth in the MSAs with 3-4 counties. The non-core counties of MSAs with 3-4 counties grew 215 percent. With the exception of MSAs with 2 counties, the non-core counties of other MSAs grew over 100 percent. When the two periods of growth (1998 to 2003 and 2003 to 2008) are compared, non-core county facilities management had the greatest amount of growth during the 1998 to 2003 time period, and actually declined in facilities management employment from 2003 to 2008 in MSAs with 2 counties and MSAs with 3-4 counties. Other related services, from 1998 to 2008, exhibited non-core county growth in all MSA categories with the exception of MSAs with 2 counties and had the greatest growth in MSAs with 10 or more counties. The non-core counties of MSAs with 10 or more counties grew 190 percent and MSAs with 5-9 counties grew 175 percent. When the two periods of growth (1998 to 2003 and 2003 to 2008) are compared, non-core county other related services had the greatest overall growth during the 1998 to 2003 time period despite declining in MSAs with 2 counties.

When comparing core and non-core county growth, CS employment growth occurred in MSAs of all sizes regardless of core/non-core county designation but had the greatest growth in non-core counties of MSAs. Custom programming and system design experienced the greatest growth in non-core counties of the smallest MSAs and facilities management and other related services experienced the greatest growth in non-core counties of the largest MSAs. In addition, facilities management and other related services experienced tremendous growth in core counties of the smallest MSAs. Also, facilities management employment growth was the greatest from 1998 to 2003 and actually declined from 2003 to 2008 in a number of MSA categories for both core and non-core counties.

Growth rates were analyzed to not only determine the overall upward growth of computer services but to characterize the growth in terms of CS subsector and geographic distribution within MSAs. As with the inter-metropolitan growth of the CS industry, the CS industry outpaces overall economic growth in both core and non-core counties of MSAs. Though, non-core county growth for most MSA sizes and CS subsectors outpaced the growth of CS employment in core counties. Subsector differences exist when comparing non-core county growth across MSA sizes. Custom programming and system design had the greatest growth in the non-core counties of the smallest MSAs. Facilities management and other related services experienced the greatest growth in the non-core counties of the largest MSAs.

In addition, facilities management and other related services experienced tremendous growth in core counties of MSAs, particularly the smallest MSAs, as well. This aligns with the earlier finding that facilities management maintains core county concentrations of employment over that of non-core counties. The overall decline of facilities management employment is also present as the subsector grew in the first half of the study period but declined in the second half. Previous literature suggests a general pattern of diffusion away from the core of metropolitan areas and, with the exception of facilities management, holds true with the CS industry.

4.4. Computer Service Firms in the Charlotte MSA

A mail survey of CS industry firms in the Charlotte MSA was completed in April and May of 2012. The acquired firm listing produced 500 verified addresses in which a survey and cover letter were sent. Three weeks later a follow-up postcard was sent and directed firms to an online version of the survey if they had not yet completed the survey. The open survey period lasted seven weeks and produced 30 completed survey questionnaires, a response rate of six percent. Although a six percent response rate is often deemed acceptable in many social science applications, the low number of responses for a survey of this type should be used cautiously if attempting to apply the outcomes to other places or at larger scales. With that said, the results presented here should considered exploratory but nonetheless informative in beginning to understand the interactions and innovation activities of knowledge intensive industries in a fast growing knowledge-based city in the 21st century.

The survey elicited responses from three of the four CS subsectors. Of the 30 firms completing the survey one-half (15) were system design firms, thirteen were custom programming firms, and two firms offered other related services. Responding firms typically had small numbers of employees and modest revenues. The highest number of employees reported was 75, with a mean of 10.6 and a median of six.

Fourteen firms had just 1-5 employees, 11 firms had 6-20 employees, and five firms had more than 20 employees. Thirteen firms had annual revenues of less than $1 million, 13 had annual revenues of $1 to $4 million, three firms had annual revenues of $5 to $9 million, and just one firm had annual revenues of $10 to $24 million.

In terms of location, 77 percent of the firms are located in Mecklenburg County. Four firms are located in Union County, two are in Cabarrus County, and one is from York County. Of the firms located in Mecklenburg, respondents were asked to provide their zip code and the resulting geographic pattern is presented in Figure 4.21. The majority of responding firms are located in or near downtown Charlotte and in the affluent southeastern section of Mecklenburg County, where the largest response zip code includes one of the prime suburban job centers in the county (Ballantyne). Based on the pattern of CS firm location from the verified mailing in Figure 4.22, the geographic distribution of respondents appears consistent with firm location patterns. Nearly all of the firms have always been located in their current county. Only four firms have moved and all four moved from within the MSA. Two firms moved from Mecklenburg County to Union and Cabarrus County and two firms moved from Union County to Mecklenburg County. In addition, just three firms were subsidiaries or branches of larger organizations. Of those from larger organizations, they were affiliated with firms from Cincinnati, Cleveland, and Dallas.

Respondents were asked to rate a series of factors on the location decision of their firm utilizing a five point likert scale where five was very important and one was not important. The mean scores for these factor ratings are presented in Table 4.18. Higher mean scores represent a higher level of importance on the location decision of responding

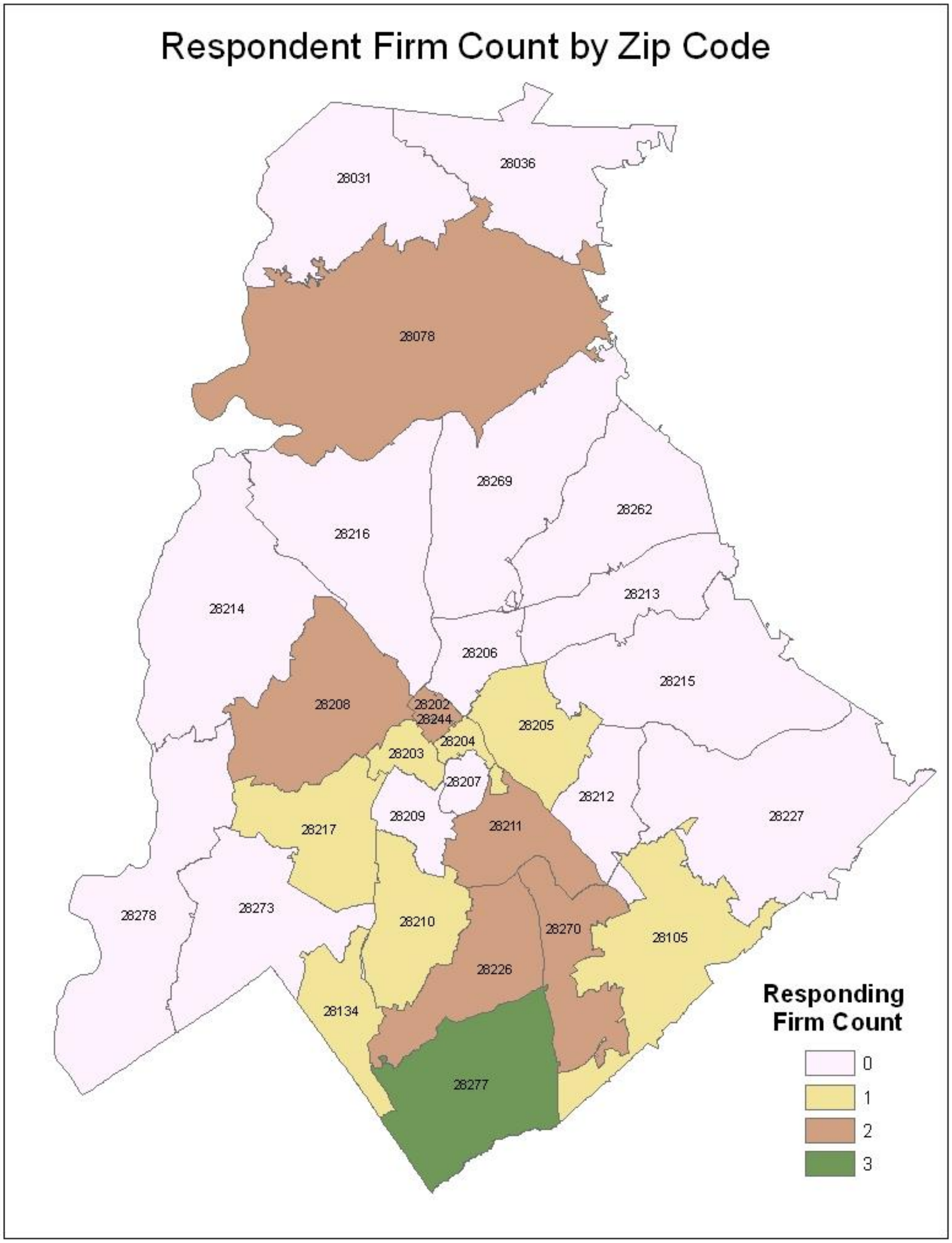


Figure 4.21: Respondent Firm Location by Zip Code in Mecklenburg County (Source: Mail survey by author)

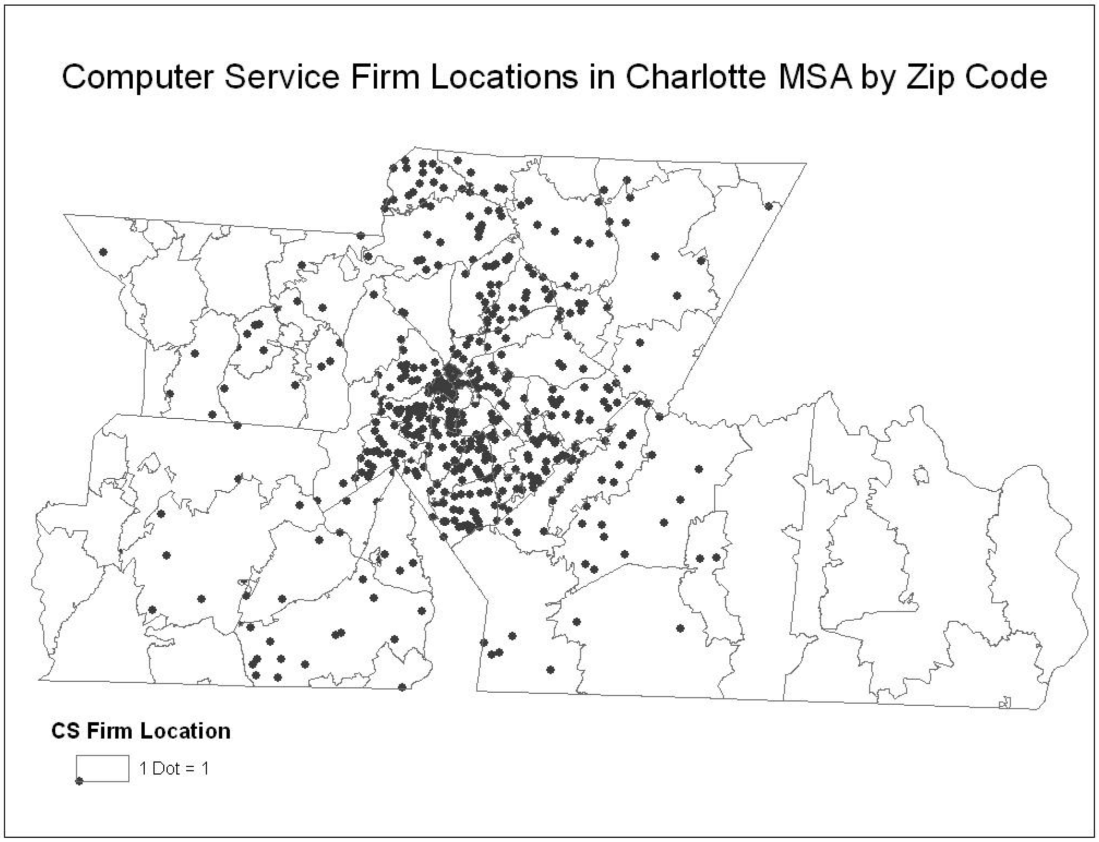


Figure 4.22: Computer Service Firm Locations (Source: InfoUSA)

Table 4.18: Mean Score Factor Ratings on the Decision to Locate the Company	
Factors	Mean Score
Labor Costs	2.80
Land/Building Costs	2.83
Government Incentives	1.70
Employee/talent availability	3.37
Quality of life	4.07
Proximity to clients	3.03
Proximity to suppliers	1.86
Proximity to related firms	1.93
Company founders were located here	4.47
Source: Mail survey by author	

firms. The highest mean score factor rating at 4.47 was that the company's founders were already located in the county. This could be interpreted that many of the firms are local start-ups. The next highest mean score factor ratings were the quality of life (4.07), employee/talent availability (3.37), and proximity to clients (3.03). The lowest mean score factor ratings were government incentives (1.70), proximity to suppliers (1.86), and proximity to related firms (1.93). Labor and land/building costs received a neutral response with mean score factor ratings of 2.80 and 2.83, respectively. Again, the results indicate that these firms are typically local start-ups and both an employee and client base were present in the region that supported the development of the CS industry in the Charlotte MSA.

To determine the geographic markets serviced by CS industry firms, survey respondents were asked to rate the importance of four geographic markets in terms of business sales utilizing a five point likert scale where five was very important and one was not important. The mean scores for these geographic market ratings are presented in Table 4.19. Higher mean scores represent a higher level of importance of geographic markets in terms of sales for responding firms. The most important geographic market was the local market or Charlotte region with a mean geographic market rating of 3.97. Geographic markets in the southeastern United State beyond the Charlotte region and national markets beyond the southeast both had a mean geographic rating of 3.10. Not as significant as the local region but the CS firms responding to the survey do provide some level of service beyond local clientele. The lowest mean geographic rating at 1.83 was for international markets, meaning that CS industry firms in the Charlotte region attract

Table 4.19: Mean Score Geographic Market Ratings in Term of Business Sales	
Geographic Markets	Mean Score
Local/Charlotte region	3.97
Southeast (beyond Charlotte)	3.10
Nationally (beyond Southeast)	3.10
Internationally	1.83
Source: Mail survey by author	

very little business from international clients. The CS industry firms in Charlotte are providing and targeting services primarily to local interests.

Responding firms were also routinely engaged with clients and most often interact with them on project related business almost daily or weekly. Of the 30 firms completing the survey, 18 firms interacted with clients on a daily basis and 11 firms interacted with clients weekly. Only one firm indicated that they interacted with them only periodically. The duration of the working relationship between CS firms and clients varies considerably based on project or contract. Eleven firms typically worked with clients on a project or contract for less than six months, but another ten firms stated they typically worked with clients on a project or contract for more than two years. An additional nine firms typically worked with clients on a project or contract for six months to a year.

Client interaction by various modes was determined by asking respondents to rate the importance of various modes of travel and communication. Utilizing a five point likert scale where five was very important and one was not important, the mean scores for these various travel and communication modes are presented in Table 4.20. Higher mean scores represent a higher level of importance on the use of the various modes of travel and communication of responding firms. The most important modes of communication were email and telephone with mean communication mode ratings of 4.57 and 4.50,

Table 4.20: Mean Score Mode Ratings of Travel and Communication	
Modes	Mean Score
Automobile travel	3.73
Air travel	2.87
Face to face contact	3.97
Email	4.57
Telephone	4.50
Video Conference	3.10
Remote System Management	3.50
Source: Mail survey by author	

respectively. Not as significant as email or telephone but communication through face to face contact (3.97) and remote system management (3.50) are important to responding CS industry firms. Firms responding to the survey still find value in face to face meetings, which bolsters the heavy reliance on local clients. The lowest mean communication mode rating at 3.10 was for video conferencing. The most important mode of transportation was automobile travel with a mean travel mode rating of 3.73. The lowest mean travel mode rating at 2.87 was for air travel. The greater importance on automobile travel again places an emphasis on local clients and routine communications with the CS firms.

A final set of questions in the survey queried survey respondents about their innovation activities. Three types of innovation activities were considered in the survey: product innovation, process innovation, and organizational innovation. A product innovation is the market introduction of a new good or service or significantly improved good or service with respect to its capabilities. Sixteen responding firms introduced a product innovation within the last three years and 14 did so within the last year. In addition, ten of firms indicated that the innovation was new to the market and not just new to their company. Nearly all responding firms provided custom designed products or services to clients but at varying levels. Only one firm reported providing none of their clients received custom designed products or services, while nine firms reported that 100 percent of their clients received custom designed products or services. The mean percent of clients receiving custom designed products or service was 66 percent and the median was 75 percent. Six firms reported that 25 percent or less of their clients received custom designed products or services, five firms each reported that 26-50 percent and 51-75 percent of clients received custom designed products or services, and four reported that 76-99 percent of clients did.

A process innovation is the implementation of a new or significantly improved production process, distribution method, or support activity for goods or services. Fifteen responding firms introduced a process innovation within the last year. An organizational innovation is the implementation of new or significant changes in firm structure or management methods that are intended to improve a company's use of knowledge, the quality of goods, or the efficiency of work flows. Eleven responding firms introduced a process innovation with the last year. The firms that introduced process and organizational innovations have engaged in these innovations recently having done so within the last year and not just in the last three years.

Respondents were asked to rate a series of information sources on the development of all innovation activities of their firm utilizing a five point likert scale where five was very important and one was not important. The mean scores for these information ratings are presented in Table 4.21. The highest mean score information rating at 4.21 was within the company or parent organization. The firms are reliant on internal generation of innovation activity over any other source. The next highest mean

Table 4.21: Mean Score Information Ratings on the Development of Innovation	
Information Source	Mean Score
Within your company or parent organization	4.21
Local Sources	2.14
Suppliers of equipment, components, or software	3.00
Clients and customers	3.86
Competitors	2.75
Consultants or private R&D	2.32
Universities	1.64
Government research institutes	1.44
Source: Mail survey by author	

score information ratings were from clients and customers (3.86) and suppliers of equipment, components, or software (3.00). The lowest mean score information ratings were from universities (1.64) and government research institutes (1.44). Competitors, consultants or private R&D, and other local sources received neutral responses with mean score information ratings of 2.75, 2.32, and 2.14, respectively. Innovation activity within the CS industry in the Charlotte MSA is heavily dependent on internal and partnering agencies/organizations. There appears to be little collaboration between organizations not directly involved with the CS firms that provide any level of innovation support or development.

Additional analysis of response data on interaction and innovation revealed a fairly homogenous sample with little variation from overall results when categorized by CS industry type, employment size, or annual revenue. Overall, CS industry firms in the Charlotte MSA, particularly Mecklenburg County, appear to be local start-ups relying on locally generated employee talent and client bases. The firms are relatively small in terms of the number of employees and revenues. They tend to rely on constant communication with clients and utilize traditional methods of interaction. The duration of firm and client relationships vary based on the project or contract. Finally, the responding CS firms are innovative and routinely provide custom products or services to clients which are derived internally or from organizations with close relationships with the firm.

The survey of the CS industry in the Charlotte MSA was intended to provide primary source data about the distribution, interaction, and innovation of CS firms in a fast growing knowledge-based metropolitan area. Much of the data gleaned from the survey is not available in any other forum and is useful in building a baseline of information about a high growth 21st century service industry. Data on firm interaction and innovation in the United States is lacking while counterparts in Europe and Canada have begun collecting such data by recognizing the importance of tracking and understanding elements of modern economic growth. Charlotte is not a metropolitan area containing a significant concentration of CS employment, therefore not dependent on specific local factors driving growth in the industry. Charlotte's CS employment is driven by general economic need and provides insight into how a "typical" metropolitan area functions in terms of CS employment distribution and interaction. Since such a small number of responses were received, any extrapolation to other metropolitan areas is done with caution.

The firm distribution of respondents was primarily the core county of Mecklenburg with some responses from outlying suburban counties contiguous with the core. Firms in the core county located in the downtown core and upscale suburban office environments. Respondents were typically small firms that originated in the metropolitan area, indicating an environment of local start-ups. In addition, much of the interaction of these firms was local with very little employee recruitment or client bases outside of the metropolitan area. National clients are scarce and international interactions are non-existent. The CS industry in Charlotte almost exclusively serves the local region, this dynamic is difficult to generalize but if true for other metropolitan areas, besides those that have significant concentrations, CS firms appear to have small geographic markets, multinationals (IBM, EDS, Dell, etc) aside. Also, given the geographic markets served, the firms rely on constant communication with clients and utilize traditional methods of interactions. Email and phone were frequently cited, as well as face-to-face interaction which is facilitated by local the local client base and ease of automobile travel.

In terms of innovation, CS firms in the Charlotte metropolitan areas are highly innovative and routinely provide custom products to clients. The provision of custom products and innovative activity is a trademark of many of the knowledge intensive business services and is verified by this finding. Similar to client interaction, innovative activity by firms was primarily driven by local sources and most importantly from internal personnel. Product innovations were cited most frequently as the CS firms routinely provide customized products to clients. CS firms in the Charlotte metropolitan area also frequently institute process innovations and some have undertaken organizational innovations within the last three years. CS firms in the Charlotte MSA appear to be representative of knowledge intensive business services in general and CS firms in particular.

CHAPTER 5: DISCUSSION

This research set out to provide a comprehensive study to detail the growth and spatial distribution of the computer service industry. It utilized a prominent high growth knowledge-based industry to inform sector based research in economic geography and provide an understanding of the future growth and economic sustainability of knowledge-based metropolitan economies. The results featured analyses involving inter-metropolitan, intra-metropolitan, regression, and survey data research for the computer service industry in United States metropolitan areas. Following a review of the hypotheses and objectives, the research implications of the results will be discussed in the context of past literature and the significance of the findings presented.

5.1. Hypothesis Testing

Hypothesis 1: Higher concentrations of CS employment will remain in the largest metropolitan areas and the core of metropolitan areas.

From the analysis, concentrations of CS employment have not changed much over time, but patterns of concentration reveal that they are not always in the largest metropolitan areas. In aggregate, higher concentrations of total CS employment remain in the largest metropolitan areas but subsector analysis reveals differing results. The Gini coefficient analysis reveals high levels of concentration among MSAs, with little diffusion over the study period except for facilities management employment, which showed a pattern of diffusion. Some subsectors maintain significant concentrations in smaller metropolitan areas when disaggregated from total CS employment.

The examination of location quotients identified some key findings. The largest CS subsectors (custom programming and system design) have the highest concentrations in larger metropolitan areas and the smallest CS subsectors (facilities management and other related services) have the highest concentrations in smaller metropolitan areas. Concentrations in smaller metropolitan areas are found to be a product of specific local conditions, primarily areas associated with government/military, universities, and major centers of production of computing technologies. The regression analysis also identified population as a significant explanatory variable in determining an areas level of CS employment. In terms of core county concentrations of CS employment, the analysis reveals that this is no longer true as CS employment now has higher concentrations in most subsectors in the non-core periphery of metropolitan areas. The examination of concentration ratios found CS employment to be more concentrated in non-core counties of MSAs regardless of MSA size.

Hypothesis 2: Continued diffusion of CS employment to smaller metropolitan areas and the non-core of metropolitan areas, but without overtaking the largest metropolitan areas and core of metropolitan areas.

Diffusion of total CS employment down the urban hierarchy to smaller metropolitan areas is largely not present but subsector analysis reveals differing results. Some subsectors follow a similar pattern as total CS employment with little diffusion down the urban hierarchy, while facilities management exhibited an increased concentration in the largest metropolitan areas, a trend away from diffusion. There are a number of MSA that maintain significant concentrations of CS employment but diffusion away from the largest metropolitan areas is not the source. Local economic factors are affecting concentrations in smaller metropolitan areas and it is not known if increases in these areas are due to endogenous factors or if they are ultimately attracting a greater share of CS employment. In terms of diffusion to non-core periphery of metropolitan areas, the analysis reveals that total CS employment and all but one subsector (facilities management) exhibit diffusion to the away from the core to the non-core periphery. Over time the core counties of MSAs are losing CS employment to the non-core periphery, and in cases were core counties still maintain concentrations in CS employment, non-core counties have gained CS employment as the core counties decline.

Hypothesis 3: Individual CS subsectors will not be characterized as a homogenous sector but rather as unique representations of concentration, growth, and diffusion.

From the analysis it is quite clear that individual CS subsectors cannot be characterized as a homogenous sector. All levels of the analysis reveal that the individual subsectors of the CS industry present differing results regarding the concentration, distribution, and growth CS employment. The largest subsectors generally follow the pattern of the aggregated industry grouping. The remaining subsectors generate patterns vastly different than the others and in many cases are based on specific local economic conditions of metropolitan areas. The variability across subsectors presents a much more differentiated pattern of CS employment than what is revealed when aggregate groupings are utilized. The analysis of Gini coefficients reveals differences in the concentration of CS subsectors. Facilities management concentration diffused and other related services increased concentration. Location quotient analysis reveals differences in between the distribution of the largest and smallest CS subsectors, with the former tending to locate in larger metropolitan areas and the latter tending to locate in smaller metropolitan areas. Variability across CS subsectors is also evident between core and non-core metropolitan counties. Facilities management continued to maintain concentrations in core counties while other CS subsectors had a pattern of diffusion to non-core counties of metropolitan areas.

Hypothesis 4: Local economic conditions will provide certain metropolitan areas advantage in growing and maintaining concentrations of CS employment.

From the analysis, many of the concentrations of CS employment, regardless of subsector or metropolitan size, are associated with local factors (government/military, universities, or centers of computing technologies) which influence the location of CS employment. The analysis of location quotients reveals many of these differences when examining areas with significant concentrations. Concentrations of the smallest CS subsectors appear to be associated with metropolitan areas with specific local factors more so than the larger CS subsectors. Thus, local economic conditions provide particular metropolitan areas with significant advantages in growing and maintaining concentrations of CS employment. Also, the regression analyses highlight some of the factors evident in metropolitan areas with CS employment and CS employment concentration. The location of CS employment is highly associated with population centers and overall employment growth. Educational attainment was the most significant factor in the location of CS employment and in many cases the only factor in the location of CS employment concentrations. The lack of explanatory power of the other variables, particularly in the analysis of CS employment concentration, included in the model supports the notion that other local factors have a role in the concentration of CS employment.

5.2. Objectives

The larger purpose of this research was to (re)define and clarify the fundamental principles that characterize the growth and development of modern knowledge-based metropolitan economies and to derive an understanding of the future growth and spatial distribution of KIBS, as informed by the computer service industry. In order to realize this purpose, four objectives were considered.

Objective 1: To determine if the fundamental principles on the spatial distribution and behavior of KIBS align with past business and producer service literature by examining the computer service industry.

This objective was to confirm or redefine the characteristics of business producer services growth and geographic distribution. As a high growth industry among KIBS, the computer service industry was used as representative example of KIBS in general. The core understanding of business and producer services/KIBS growth and distribution has seen little attention for at least a decade, with few offerings over that time. Specifically, do higher concentrations remain in the largest metropolitan and core of metropolitan areas? What amount of diffusion to smaller metropolitan and peripheral areas has occurred and is it continuing? In aggregate, higher concentrations of CS employment remain in the largest metropolitan areas. When specific subsectors are included in the analysis this general statement loses some credence as specific subsectors maintain significant concentrations in smaller metropolitan areas with specific local factors driving growth rather than population and economic dominance. Large metropolitan areas are not the only place where a successful knowledge-based economy can thrive. Findings indicate that smaller areas are significantly impacted by the presence of focused industries. In that view, with the right mix of factors, in the future a knowledge-based economy could be sustained in metropolitan areas regardless of size.

Also, core counties of metropolitan areas for most MSA sizes no longer have the largest concentrations of CS employment as it has diffused to the non-core periphery of metropolitan areas. Diffusion down the urban hierarchy has also continued, but when CS subsectors are included it is found that specific subsectors do not follow this general pattern and have instead increased concentration in core counties. In a way, prior understanding of business and producer service/KIBS growth and distribution holds true, but when disaggregated subsectors are added to the analysis a more nuanced pattern emerges were traditional views are disputed.

Objective 2: To examine and underscore the relevance of subsector research of KIBS.

This objective was to highlight the varying nature of KIBS within a single industry. Most research utilized aggregate grouping of industries which masks the variability of such dynamic industries that provide unique and very often differential services. Subsector research is beneficial in revealing the various levels of service production, from high to low order services, within an industry to identify distinctive patterns of growth and distribution. With few exceptions this approach to industrial sector research in economic geography has not been widely developed. The results in this research significantly highlight the importance of utilizing industrial subsectors. All levels of analyses for the concentration, distribution, and growth of CS present differing results across CS industry subsectors, which is typically obscured. In general, the largest or most dominant subsectors of industries follow similar patterns as aggregate industry sectors. Remaining subsectors represent specialized services which may concentrate in particular places based on local factors. These patterns are masked if only viewing aggregate industry groupings and if not recognized may provide an inexact representation of KIBS distribution and concentration.

Objective 3: To examine firm interaction and innovation in computer services through the use of survey based research of computer service firms in Charlotte.

This objective was to expand an area of research that has seen little attention in the United States. Very little research is available on firm interaction or innovation, partly because detailed data innovation activity and firm interactions are unavailable, but both have been considered as essential to modern economic development and to the growth of regions. In addition, primary data research provides detailed information unavailable from secondary sources for expanding knowledge-based industries. Although the findings presented here should be considered exploratory they nonetheless provide a beginning to recognize the importance of firm interaction and innovation in knowledge-based economies. The survey introduced an adapted small part of the European Community Innovation Survey, which to the author’s knowledge has not been broached in the United States, but has begun to be utilized in Canada in recent years. The findings offered information about firm interaction and innovation that was previously unavailable. Findings indicated that CS firms in Charlotte are regionally grounded and extremely innovative, which confirms findings from secondary source research but provides a greater degree of detail.

Objective 4: To examine how the distribution and growth of the computer service industry informs the future growth and development possibilities of KIBS in general.

This objective was to provide a base for understanding the growth of modern knowledge-based economies dependent on KIBS. By providing the necessary technical expertise and infrastructure to compete in a knowledge-based economy, the CS industry represents the ideal industry to develop the underlying characteristics that foster the future economic success and development of regions. By updating our perception of the distribution and growth of the CS industry a redefined understanding of business and producer services can be developed. This new base understanding would recognize the continued diffusion of employment in aggregate down the urban hierarchy and diffusion to the non-core counties of metropolitan areas. In addition, subsector breakdowns of industry reveals details masked by aggregate groupings that counter the general diffusion of services which is essential to recognize. With that, while much of the KIBS industries can be broadly characterized as locating in economic and population centers based on need, by introducing subsector groupings to the analysis reveals the important role that local factors can have in developing employment concentrations in these industries and such local factors are difficult, if not impossible, to replicate.

5.3. Research Implications

This research intended to update or verify sector-based geographic research that has not garnered significant attention since the early 2000s. Much of our underlying assumptions about the location and spatial distribution of business service based metropolitan economic structure utilized to inform current research, particularly KIBS research, is culled from this past research without questioning its applicability to current trends.

The literature suggests that some inter-metropolitan diffusion down the urban hierarchy is expected for business and producer services. This generalization, for the most part, has been reflected in the research articles published in the 1980s and 1990s (Kirn 1987). One exception is the tendency of service sectors which are heavily knowledge intensive to concentrate at greater levels in the largest metropolitan areas. It is thought that the underlying reasons for the relative concentration of these industries compared to other business and producer services is that extremely knowledge-intensive industries have the greatest potential for interregional business transactions, innovation, and export, as well as the associated agglomerative benefits of larger metropolitan areas (Esparza and Krmenec 1994). In addition, some metropolitan areas, largely dependent on size, are driven by local sector specialized economies tailored to local economic conditions (OhUallachain and Reid 1991). The current findings present varied results when compared to previous research efforts.

In aggregate, the CS industry follows a pattern of diffusion to smaller metropolitan areas. Although, this diffusion has not diminished the magnitude of CS employment in the largest metropolitan areas compared to smaller metropolitan areas. Smaller metropolitan areas have outpaced the larger metropolitan areas in terms of employment growth, which is counter to the thought that knowledge intensive services generally concentrate in the largest metropolitan areas. The significance of this is that the CS industry is not restricted as a large metropolitan area phenomenon, but rather an industry that is present in most metropolitan areas regardless of size and in some cases quite heavily concentrated in smaller metropolitan areas.

The concentrations found in smaller metropolitan areas are often associated with local economic structure/conditions that are the basis for CS employment. The CS employment concentrations in these areas have developed to serve a unique localized economic specialization. Much of these variations are revealed when subsector industry groupings are considered in the analysis. In the past, industry groupings were viewed in the aggregate as homogenous sectors. Current subsector analysis reveals differences within the CS industry subsectors that contradict our understanding of KIBS. Industry specializations are masked when analyzing aggregations of industries, which may have distorted earlier findings within business and producer services to show little to no diffusion of services to smaller metropolitan areas. The disaggregation of industrial sectors is able to provide a clearer understanding of spatial distribution and concentration of KIBS.

In terms of the intra-metropolitan distribution of business and producer services, previous findings mirror that of inter-metropolitan diffusion. Diffusion away from the core of metropolitan area to suburban and exurban areas is occurring, but the greatest diffusion is in the largest metropolitan areas (OhUallachain and Reid 1992). Some of the intra-metropolitan diffusion is created by the general movement of businesses, as well as population, to the suburbs of metropolitan areas. In order to properly serve client bases, many of these business services are locating in close proximity to the newly created employment concentrations outside of the metropolitan core. These agglomerations of employment and business outside of core have been terms “edge cities” and function quite like their more heavily developed metropolitan core counterparts (Harrington and Campbell 1997). Any intra-metropolitan diffusion is largely defined by local metropolitan characteristics (metropolitan size, road/transportation network, industrial structure) and is difficult to develop a generalized pattern of diffusion.

The CS industry has shown a pattern of diffusion above and beyond what was previously uncovered in business and producer services. There has been tremendous growth in the non-core periphery of nearly every metropolitan area regardless of size and seems to have no constraints in terms of where this is happening. Growth in the non-core periphery has not been recorded at this pace in the past. Some of the highest growth is occurring in the smaller metropolitan areas, counter to previous findings which found the greatest diffusion with the largest metropolitan areas. The diffusion/growth of the CS industry in the metropolitan periphery appears to not only serve local client bases as in the past but the metropolitan area at large as well. From this research, a generalized pattern of intra-metropolitan diffusion of KIBS should be less concerned with the types of places diffusion is occurring and more focused on the magnitude and extent of diffusion within all metropolitan areas.

Clouding many of these generalizations are the roles that scale and economic structure have in the development and economic growth of specific metropolitan areas. The CS industry is heavily weighted toward larger metropolitan areas in terms of employment but significant concentrations can be found in smaller metropolitan areas. The likelihood of developing a CS industry specialization may have little to do with the size of the metropolitan area, but rather local economic structure, particularly in a service oriented economy. Although some smaller metropolitan areas developed CS industry specializations based on local industrial structure, the size of the metropolitan area appears to have little effect on the spatial distribution of CS employment as the need for the CS industry permeates throughout the entire urban system. Assumptions about the role of metropolitan size in defining an urban hierarchy may need reexamined as the patterns of industry location and distribution have changed since the transformation from a manufacturing to a service dominated economy.

In recent years, most business and producer service research began focusing specifically on KIBS research with innovation as the primary emphasis, but has typically been done Europe and recently in Canada. Particular interest has been given to the innovative advancements that KIBS develop within the overall economic landscape to sustain and foster growth in metropolitan economies (Aslesen and Isaksen 2007). Researchers were less concerned with identifying spatial patterns as they were with the innovative capacity of selected KIBS industries (Muller and Zenker 2001). With few exceptions, the only geographic aspect recognized was based on prior research that services generally agglomerate in the largest of metropolitan areas and that, in terms of innovative capacity, other areas were insignificant in overall impact (Shearmur and Doloreux 2009).

Since much of the research on KIBS and their effect on innovation potential and metropolitan economic growth were developed while using past assumptions of spatial distribution and diffusion the findings for the CS industry would warrant a reassessment of the nature of KIBS and innovation in metropolitan areas. CS has a disproportionate amount of employment in the largest metropolitan areas but significant concentrations are found in smaller metropolitan areas as well and continuing to grow. These small metropolitan areas with concentrations of CS employment have the same likelihood to develop innovative products and services as their counterparts in the largest metropolitan areas. Thus, smaller metropolitan areas should be recognized as having a role in the innovation capacity of an economic system. The spatial patterns of KIBS appear to have moved beyond the largest metropolitan areas and with that so should innovation.

Since subsector research has been nearly nonexistent in sector based geographic research, the patterns that emerged are truly unique in recognizing the differing patterns within an industry. The only United States examples of computer service research previously recognized the uniqueness within, at least, the computer service industry and provided some useful observations on subsector spatial distribution and diffusion patterns. In aggregate the CS industry functioned like other business and producer services but the subsectors presented varying patterns that were contradictory to thoughts about high and low order aspects of the industry. Since the conversion from SIC to NAICS, a direct comparison is not possible but some generalizations can be made. Overall, the low order services remained concentrated in larger and cores of metropolitan areas, while the high order services developed greater concentrations in the non-core or non-central metropolitan areas, the exact opposite of what would be expected of high and low order services.

The general sentiment is that high order services would concentrate in the larger metropolitan areas and the low order services would diffuse and develop concentration in the smaller metropolitan areas. The current CS industry research found the high order services remaining concentrated, with some diffusion, in the largest metropolitan areas, while one of the low order services diffused at greater rates than any other subsector and the other increased in levels of concentration. Findings indicate that the assumptions of high and low order industries do not necessarily align with subsector industry patterns. These patterns may hold true across industries but within an industry the spatial distribution of service levels are not well defined. It may be beneficial to review the defining nature of high and low order services when researching subsector industry groupings by focusing less on the type of service provided (knowledge and technically proficient versus more routine tasks) and more on the type and extent of interactions and innovations between clients and firms.

CHAPTER 6: CONCLUSION

Research concerning business and producer services/KIBS has been lacking in the geographic literature with only a few examples over the last decade, particularly sector specific inquiries which not only provide detailed analyses of an economic activity but also a greater understanding of modern economic activity. The general assumptions about the location of services across the urban hierarchy utilized in current and related research require revisiting in light of the findings for computer services. The computer service industry should be of high importance considering the influence CS and computing technologies have in relation to economic growth and stability in a knowledge economy.

Knowledge intensive business services and services in general are the dominant means of regional and metropolitan economic growth. The viability of modern economic activity relies on the provision of these services to assure economic growth and health. Understanding their distribution, concentration, and geography can inform researchers and policy makers about the future growth and economic structure of metropolitan economies. Innovation is seen as means of supporting economic growth and by maintaining a level of KIBS and CS activity a metropolitan area can build a comparative advantage to support innovative capacity. The patterns of diffusion and concentration for the CS industry presented in the results are important as they inform our understanding of the growth and economic vitality of urban regions. If the CS industry findings are generalized to other KIBS sectors, ideally subsectors, the assumptions about the growth and diffusion of services appear to have become outdated since the 1990s. The results indicate that there is a great deal of information about the diffusion and concentration of KIBS that needs uncovered, therefore a renewed emphasis on KIBS sector-based research in economic geography is warranted. As mentioned earlier, it may also be time to provide some thought to and revisit assumptions concerning high and low order service provision and the location characteristics of economic activity across the urban hierarchy.

The need for services relating to computing technologies is ever present and to fill this need the CS industry is found in nearly all metropolitan areas in the United States. Access to CS industry expertise is a necessary component of business operations and the specialized functions of the CS industry make the outsourcing of these services necessary. The need for CS industry expertise has promoted the growth and development of CS employment in metropolitan areas regardless of size or location. The CS industry is developing significant concentrations of employment in support of localized economic specializations, as well as expanding to new markets in smaller metropolitan areas. Provision of computer services are occurring locally and external access to them from distance metropolitan areas does not appear to be a viable option. The results also point to a movement toward small firm development in the CS industry and are significant if a similar pattern is observed in other KIBS sectors. Strategies to enhance the growth and development of metropolitan areas need to be tailored to support small firms and small firm expansion.

In addition, this growth is occurring endogenously within the metropolitan area and should be properly supported. Metropolitan policymakers should look to provide an underlying economic base that supports the development on KIBS. Included in this is the availability of and access to specialized business services that firms are increasingly outsourcing to focus on core business activities. Chasing and attracting large firms with incentives is not the economic cure-all. Entrepreneurial development needs to be encouraged and supported through the proper mechanisms. A supply of affordable turn-key office space is needed to support local start-ups. Assistance with regulatory and legal processes can accelerate the development of small firms, as well the presence of business incubators and linkages to colleges and universities. Building a strong economic base in support of business development is a high priority if a metropolitan area is to grow and succeed in a knowledge-based economy.

In summary, this research is significant for several reasons. Overall, it presents the distribution and growth of a highly relevant KIBS industry that has previously been overlooked. More specifically, it provides a greater understanding of the industrial structure of modern knowledge-based economies. The detailed CS industry representation presented in the research counters and updates some of the basic notions of business and producer services/KIBS developed over a decade ago. It also revives an area of research that has been largely overlooked in the United States. As the importance of services to economic growth has been increasingly recognized, research has emerged in Europe and Canada but few examples exist in the United States. A renewed and continued analysis of business and producers services is warranted given the results.
If business and producer services and knowledge intensive business services in particular are seen as leading the economic growth of regional economies, an updated and accurate representation of the characteristics that define them is needed. The results presented

here suggest in aggregate a measured diffusion of KIBS down the urban hierarchy and a continued diffusion to the non-core counties of metropolitan areas. Subsector research reveals details obscured by aggregate groupings, in that the larger subsectors, which define the industry in general, appear predominantly in economic and population centers while other subsectors are developed in specialized service centers rooted in local characteristics.

Given the lack of research on the CS industry there are many avenues for future research considerations. Many of these examples can also be applied to other KIBS and business and producer services in general to form a more complete understanding of knowledge-based economies. A greater understanding of the CS industry subsector groupings is warranted. As presented in this research, the CS subsectors present very different patterns of concentration and distribution across metropolitan areas. Focusing detailed research on one or more particular subsector would provide a more in-depth understanding of these unique location characteristics. Similarly, case study research is needed on one or more metropolitan areas containing significant concentrations of CS employment based on local economic factors. A detailed examination of metropolitan areas associated with government/military, universities, or centers of computing technology and how they relate to the growth and proliferation of CS industry is needed to understand the forward and backward linkages between the CS and prominent local industries.

Beyond metropolitan areas, the employment levels and diffusion, or lack thereof, to rural or metropolitan fringe communities has yet to be explored. Do these areas contain levels of CS employment or do they obtain CS services from outside the area.

With that, the export characteristics of the CS industry and KIBS in general, have seen very little attention in the literature. If assumptions about the CS industry becoming foundational to modern economies and essential to the economic development of regions is accurate, the availability of or access to CS is necessary. If metropolitan or other areas lack the necessary CS base they would have to import some level of service. In addition to import/export exchange within the United States, the international export of CS industry is a topic for further exploration as well.

Another dimension of the CS industry that intertwines with many of the considerations just mentioned is that of large multinational CS corporations (IBM, Dell, etc.). If it is generally true that many CS industries operate regionally, as was found in the survey of Charlotte, the role of multinationals is appealing on many levels. What is the scale of operations, where are subsidiaries located? Are they more concerned with international clients than other firms? How does the firm client interaction differ from regionally based firms?

In terms of policy, research needs to be expanded to include the measurement or identification of variables that can act to bolster the underlying economic structure to support the growth of a knowledge-based economy. These variables need to reflect a regions willingness and openness to grow from within by providing the necessary economic enticements that make such growth possible. Such variables would reflect policies that encourage entrepreneurial start-ups, small firm viability, and the availability of firms to perform specialized business functions. Potential variables that should be considered for future research models include office space supply/affordability, tax rate structure, zoning, presence of business incubators, and the entrepreneurial environment of the metropolitan area.

As a final point on CS industry research, a means of measuring the infrastructure qualities of the CS industry needs to be developed if the assumptions presented here and elsewhere are to be evaluated appropriately. This is particularly important in relation to the economic development opportunities provided by the technical expertise and innovative activities the CS industry supplies to compete in a knowledge-based economy. Innovation activities research in general has seen little attention in the United States and to expand on this would be a significant advancement in the geographic literature.

Beyond the CS industry, future research considerations should continue to develop subsector industry groupings, as they are integral in understanding the distribution and growth of KIBS concentrations. A greater knowledge of KIBS must be developed if it is to be brought to the forefront as a means of economic growth and development. In addition, firm interaction and innovation has to be made a significant component of research concerning its contribution to regional economic development in the future.

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APPENDIX A: SURVEY QUESTIONNAIRE

Assessing the Growth and Development of Modern Knowledge-Based Metropolitan Economies

This survey is being conducted for inclusion in a dissertation research project at UNC Charlotte. You will be asked questions about your company and your participation is completely up to you, you may stop at any time. You are not asked to put any identifying information on the survey and all data obtained will be reported in aggregate, no companies can or will be identified. We would appreciate your time in completing the enclosed survey and returning it in the self-addressed stamped envelope provided. Should you have any questions about this survey please contact Jonathan Kozar at jmkozar@uncc.edu or 704-687-2681. You may also contact the University's research compliance office 704-687-3309 if you have any questions about how you are treated as a study participant. Please circle best answer unless instructed otherwise.

1. In which county is your company located? ____
   a. If located in Mecklenburg County, what is your zip code? ____
2. Is your company a subsidiary or branch of a larger organization?
   a. Yes / No If yes, where is your parent organization located?____

If your company is part of a larger organization, please answer all further questions only for your company in your county from Question 1.

3. Has your company always been located in this county
   a. Yes / No If no, where did you last move from and when? __________________________________
4. Please rate the importance of these factors on the decision to locate the company in this county?

	Very Important				Not Important
a. Labor costs………………………………..	5	4	3	2	1
b. Land/building costs……………………….	5	4	3	2	1
c. Government incentives…………………...	5	4	3	2	1
d. Employee/talent availability……………...	5	4	3	2	1
e. Quality of life……………………………..	5	4	3	2	1
f. Proximity to clients……………………….	5	4	3	2	1
g. Proximity to suppliers…………………….	5	4	3	2	1
h. Proximity to related firms………………...	5	4	3	2	1
i. Company founder(s) were located here…...	5	4	3	2	1

5. How many employees are currently working for your company? __________________
6. What is your company's annual revenue?
   a. Less than $1 million
   b. $1 to $4 million
   c. $5 to $9 million
   d. $10 to $24 million
   e. $25 to $100 million
   f. More than $100 million
7. What is the closest description of the primary service you provide to clients?
   a. Custom computer programming (writing, modifying, testing, and supporting software for clients; including custom webpage design services)

b. Computer systems design (planning and designing computer systems that integrate computer hardware, software, and communications; including installation and training and supporting users of the system)
c. Computer facilities management (providing on-site management and operation of clients computer systems and/or data processing facilities; including support services)
d. Computer disaster recovery services and/or software installations
e. Other (please specify ____)

8. Please rate the importance of these geographic markets in terms of business sales?

	Very Important				Not Important
a. Local / Charlotte region…………………………	5	4	3	2	1
b. Southeast (beyond Charlotte region)……………	5	4	3	2	1
c. Nationally (beyond Southeast)…..……………...	5	4	3	2	1
d. Internationally…………………………………..	5	4	3	2	1

9. Please rate the importance of these modes of travel and communication in your interaction with clients?

	Very Important				Not Important
a. Automobile travel……………….	5	4	3	2	1
b. Air travel………………….........	5	4	3	2	1
c. Face to face contact……………...	5	4	3	2	1
d. Email…………………………….	5	4	3	2	1
e. Telephone………………………..	5	4	3	2	1
f. Video conference………………...	5	4	3	2	1
g. Remote system management……..	5	4	3	2	1

10. How often do you typically interact with clients?
    a. Daily
    b. Weekly
    c. Monthly
    d. Periodically

11. How long do you typically work with a client on a single project or contract?
    a. Less than 6 months
    b. 6 months to a year
    c. 1 – 2 years
    d. Longer than 2 years

A product innovation is the market introduction of a new good or service or a significantly improved good or service with respect to its capabilities, such as improved software, user friendliness, components, or subsystems:

12. Did your company introduce a product innovation:
    a. Within the last year? Yes / No
    b. Within the last 3 years? Yes / No

13. Were any of the innovations:
    a. New to the market? Yes / No
    b. Only new to your company? Yes / No

14. What percentage of your clients receives custom designed products or services? _________

A process innovation is the implementation of a new or significantly improved production process, distribution method, or support activity for your goods or services:

15. Did your company introduce a process innovation:
    a. Within the last year? Yes / No
    b. Within the last 3 years? Yes / No

An organizational innovation is the implementation of new or significant changes in firm structure or management methods that are intended to improve your company's use of knowledge, the quality of goods and services, or the efficiency of work flows:

16. Did your company introduce an organizational innovation:
    a. Within the last year? Yes / No
    b. Within the last 3 years? Yes / No

17. During the last 3 years, how important to your company's development of all innovation activities have been each of the following information sources?

Information Source	Very important				Not Important
a. Within your company or parent organization……………..	5	4	3	2	1
b. Local sources……………………………………………	5	4	3	2	1
c. Suppliers of equipment, components, or software………...	5	4	3	2	1
d. Clients and customers…………………………………...	5	4	3	2	1
e. Competitors………………………………………………..	5	4	3	2	1
f. Consultants or private R&D……………………………….	5	4	3	2	1
g. Universities………………………………………………..	5	4	3	2	1
h. Government research institutes……………………………	5	4	3	2	1