MEASURING REGIONAL AND LOCAL INNOVATIVE OPPORTUNITY

By

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LIST OF ABBREVIATIONS

A&E	Architecture and Engineering
AHP	Analytic Hierarchy Process
CBD	Central business district
CPT	Central Place Theory
EAF	Educational attained factor
ECF	Education conferred factor
GDP	Gross domestic product
HC	Horizontal clustering
HHI	Herfindahl-Hirchman Index
LBIO	Literature based innovative output
LIN	Local innovative network
LGC	Locational Gini Coefficient
LQ	Location quotient
LUCIS	Land Use Conflict Identification Strategy
LUCIS^{plus}	Land Use Conflict Identification Strategy Planning Land Use Scenario (Plus)
MSA	Metropolitan Statistical Area
NAICS	North American Industrial Classification System
OECD	Organisation for Economic Co-operation and Development
PCA	Principal component analysis
RIF	Regional innovation factor
R&D	Research and development
SME	Small to medium-sized enterprises
TREO	Tucson Regional Economic Opportunities Inc.
USPTO	United States Patent and Trademark Office

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While some progress has been made in identifying cities that stimulate creativity to explain patterns of economic growth in knowledge based industries, no existing research has used land use suitability to justify similar growth patterns. This study establishes the role and contribution of innovative agents, innovative inputs, and innovative outputs on the regional potential to attract architecture and engineering (A&E) firms as well as the ability to create innovative networks at the local scale using land use suitability. Using longitudinal interactions and the Land Use Conflict Identification Strategy to measure suitability and spatial interactions two factors were created that identified the potential of Pima County, Arizona to create similar innovative networks found in Washington, DC. The results of this analysis indicates that by using longitudinal data and spatial data to measure innovative potential, you can assess local and regional performance in achieving innovative networks.

CHAPTER 1
INTRODUCTION

Cities that have the potential to attract companies with the greatest capacity to expand and attract employees whose sole role is to innovate experience greater economic expansion than those cities whose economic base is composed of more manufacturing or agricultural related activities. Innovative industries derive their value from the networks created by the specific use and arrangement of land uses that support their activities. In agriculture, this productive value is measured by the fertility of land. In manufacturing, productive value is measured by consumer demand for a specific good. In innovative or knowledge based industries, productive value is measured by the spatial arrangement of knowledge networks.

Innovative labor influences which imported goods are substituted through local, more advanced activities. Jane Jacobs believed that innovative labor is a part of companies that expand and develop economies. She states that, “Economies that do not add new kinds of goods and services, but continue only to repeat old work, do not expand much nor do they, by definition, develop” (Jacobs 1970, 49). Current examples of this phenomenon are exhibited in cities like Detroit or Cleveland, where local economies have faltered due to a continuation of business practices that encourage producing goods that are known to sell rather than producing new goods that encourage efficiency and forward-thinking. Furthermore, these cities also exhibit land use patterns that challenge the creation of innovative networks. As national and global markets become more unstable, cities supported primarily by non-innovative or manufacturing related industries seek alternative market economies that serve as substitutes to mitigate negative economic impacts (DeVol et al. 2008).

> Economic growth or development is a structural transformation of the economy in respect of both inter-sectoral and intrasectoral employment and income. The process of growth is associated with the emergence of those sectors, institutions and basic attitudes as well as with such changes in structure and organization [sic] of the economy which would not only prevent the economy from slipping back but would ensure continuous long run development. (Husain 1967, 40; 241)

These additional sectors indicate a shift in the role of the city; in an industrial society, physical growth and land use are slaves to the instruments of production whereas in a post-industrial society where knowledge rules and economic activity relies heavily upon information, people care where they live and lifestyle quality has replaced many of the traditional determinants of location choice (Kotkin 1999; Hearn 2008).

Innovative industries create greater economic efficiency as a result of the "cumulative processes of interaction where different organizations and individuals combine efforts in creating, diffusing, and using knowledge" (Lundvall et al. 2007, 214). Innovation is analogous to ecological succession. An urban economy, like a natural community, is constantly seeking to achieve an optimal range with low environmental stress. Change occurs unpredictably and several different patchworks of ecosystems work together to form a community. According to Jacobs, "in an ecosystem, the essential contributions made within the conduit are created by diverse biological activities" (Jacobs 2000, 59). Therefore cities that fail to replace imports or diversify its activities are environments that do not seek optimal efficiency.

There are two general schools of thought regarding the criteria and development patterns of knowledge based industries and employees. First, unique resources such as density, access to capital, or sufficient labor pool places a premium on land in specific locations. These resources illustrate the first school of thought which is more focused on the actual production of new ideas and the importance of space in economics. This theory “encourages spatially concentrated capital formation (buildings) and accentuates the need to produce at discrete points in space because of increasing returns to scale in production (Anas et al. 1998, 1427-28). Secondly, amenity based characteristics like open space, diverse populations, openness and acceptance, and culture influence how we value our communities. These amenities illustrate the second school of thought which is characterized by “place”. The greater a sense of place we have, the more creative stimulation we exhibit. Richard Florida believes that “creative activities put us in a state of ‘flow’, or intense, unfettered focus and concentration (Florida 2008, 158). Unfortunately, local economic development strategies have used either school of thought to validate the other. Yet relying upon resources (natural resources availability, local, labor, capital investment, entrepreneurial climate, transport, communication, industrial composition, technology, size, export market, international economic situation, and national and state government spending) or capacity (economic, social, technological, and political activity) (Blakely and Bradshaw 2002) independently create weak economies that fail to attract businesses or yield an overabundance of low paying jobs.

While some progress has been made in innovation geography (Ratanawaraha and Polenske 2007; Prosperi 2005) and proximity analysis (Gottlieb 1995; McHarg 1969; Carr and Zwick 2005; Collins et al. 2001) no existing research has used spatial land use conflict to justify growth patterns of knowledge based firms and land use opportunity that facilitates innovative networks. The available body of research that identifies amenities as a significant influence on the location decisions of people and industries focuses on sociological factors as a means of determining regional advantages in the creative economy (Florida 2005; Krupka 2004; Clark 2002). Other research identifies business factors that serve as an attractor of creative networks (Gottlieb 1995; Husain 1967). This paper points out methodological inefficiencies that could significantly influence spatial behavior. Explaining the relationship between economic and non-economic factors of production in a knowledge based economy requires much greater emphasis on the role of land use suitability in the development of networks that stimulate innovation and creativity. Accordingly, by customizing the Land Use Conflict Identification Strategy (LUCIS) (Carr & Zwick 2005), a geographic information system (GIS) model, to examine the causal relationship between business factors, amenity factors, and the intrinsic value of land a relative comparison of regions can be developed that reflects the attractiveness of cities for knowledge based firms based upon the creation of environments conducive to economic advantages for innovative industries.

CHAPTER 2
LITERATURE REVIEW

In the history of economics, none is more unique than the creative economy; its industries and entire economy bridges factors of production with factors of consumption. Cunningham describes the difference between creative industries and the creative economy, as a move away from "sector-specific arguments to creative skill sets as occupational inputs into the broader economy, and creative outputs as intermediate inputs into other sectors…we need to think of creativity as an enabler, in the same way [internet communication technology] are argued enablers of overall productivity" (Hearn 2008, 71). It is this intricate relationship that demands a systems-based approach to understanding and determining economic opportunity.

A systems-based approach in regional economics is not new. The role of cities has traditionally been explained by the competitive positioning and wealth generation in subareas (Blakely and Bradshaw 2002). Innovation systems, commonly defined as environments that facilitate "the creation, diffusion, and use of knowledge" (Carlsson et al. 2002, 233; Ratanawaraha and Polenske 2008), play a similar role to that of cities and are particularly sensitive to spatial and locational attributes (Scott 2006). This review of literature will highlight research that addresses the structure of environments conducive to innovation creation and its importance in the economic structure of jurisdictions.

Theoretical Perspectives of Traditional Economic Theory

The Australian economist Colin Clark (1940) divided the pre-industrial era economy into three sectors: primary (agriculture and mining), secondary (manufacturing), and tertiary (services). Essentially, primary industries supplied raw materials to be turned into finished goods by secondary industries, which are assisted in the tasks of distribution, finance and so on by tertiary industries (Hearn 2008). During this time “the progress of an economy was measured by the degree of productivity (output per capita) in each sector. As productivity rose in each sector (i.e., fewer people were needed to achieve particular levels of output), labor could be transferred from one sector to another. Economic progress, thus, was defined as a function of the differential productivity among the sectors” (Bell 1973, xiv). Clark’s definition of economic progress was derived from the thinking of classical economists and from Clark’s perspective that services were “unproductive”. His view shared that of Marx; only manufacturing produced value by labor. Marx’s view was likely shaped by a “notion of capitalism as a turbulent scene of production and exchange” (Scott 2006, 1). Yet Marx’s, and later Schumpeter’s, view of production and exchange was really innovation in action. Productivity gains during the pre-industrial period was described by Schumpeter as “’creative destruction,’ i.e. the periodic abandonment of old equipment, production methods, and product designs in favor of newer and more economically performative assets” (Scott 2006, 1).

The post industrial economy can no longer be categorized into three sectors as Clark suggested, but additional sectors of the economy are needed and, depending upon the theorist, the additional sectors differ. For example, Bell (1973) suggests adding tertiary (transportation and utilities), quaternary (trade and finance), and quinary (health and education) sectors that fuse theoretical knowledge with science and technology (Bell 1973, xiv). Barry Jones (1982) proposed a quaternary sector covering employment in information processing and related activities (Hearn 2008, 176). This difference in additional sectors illustrates the new economic paradigm. The new economy springs from the shift in natural resource based activities to human resource based activities. In a human resource based economy economic advantage is based upon the ability to transform an import into a new exporting enterprise through innovation; the core of Schumpeter's creative destruction theory. Industrial performance in the new economy can be predicted by three key factors: geography, the entrepreneur/innovator, and rates of productivity. Through systems of innovation, the productivity of the new economy is optimized.

Industrial Performance in the New Economy: Geography

Anas et al. (1998, 1426) stated that "understanding the organization of cities yields insights into economy-wide growth processes and sheds light on economic concepts of long-standing interest: returns to scale, monopolistic competition, vertical integration, technological innovation, innovation diffusion, and international specialization." "Two broad classes of theories help us understand the process of local economic development: location theories, which focus on geographical factors, and economic base theories, which look at the flow of economic activity into and out of the local economy to identify and explain which firms and industries have the greatest capacity to expand" (Blakely and Bradshaw 2002, 57). Economic base theories prescribe a "balance of industrial types and sectors that a community needs to develop for economic stability" (Blakely and Bradshaw 2002, 59). Location theory helps communities understand "the relative value of their locational attributes in relation to other resources that the area possesses" (Blakely and Bradshaw 2002, 64) as a means to optimize their economic base. Both are needed to optimize the economic potential of a region.

Prior to 1840, the shape of cities was tied directly to the location of natural features such as waterways or rivers which provided a means to transport goods over long distances. This created substantial scale economies at these transport access points and the average cost of processing freight fell sharply with the quantity produced at a particular port. A similar phenomenon occurred with the advent of the railroad for smaller quantity goods and the telegraph for transferring information between cities (Anas et al. 1998). For the first half of the twentieth century technological improvements and advanced methods of transport were credited with increased complexity of urban structure. Technology favored decentralization within metropolitan areas, with the automobile contributing the most to this out-migration. Land use patterns shifted with improvements in technology; retailers could follow their customers and manufacturers could follow the labor force. Spatial theory also evolved during this period. For example, Burgess developed his Concentric Zone Model in 1925, during the time when the segregation of work and residence was normal and considered acceptable urban form. In 1939 Hoyt determined that land use patterns were not randomly distributed, nor were they a series of neat concentric circles. Instead, land use in North America could be defined as sectors dependent upon access to transportation and communication (Figure 1-2). Following this realization by Hoyt, Harris and Ullman "introduced a more effective generalization of urban land uses. [They concluded] that many towns and nearly all large cities do not grow around one [central business district] (CBD), but are formed by the progressive integration of a number of separate nuclei in the urban pattern". These nodes become specialized and differentiated in the growth process and were not located in relation to any distance attribute, but were bound by accessibility, land use compatibility, land use incompatibility, and location suitability. This was the first example of a polynuclear structure of urban activity. Yet this structure was not a reflection of technological and transportation improvements rather it was a reflection of a shift in the economic relationships between firms as well as a shift in the organization of work.

The role of manufacturing is central to the process of economic growth and its role changes significantly as economies develop. Chapman and Walker use the analogy of a motor car to illustrate the changing role of manufacturing in a growing economy. "Manufacturing seems to function as an engine of varying efficiency and size relative to the economic vehicle which it drives, but there is no sign of revolutionary change which will lead to a new form of propulsion" (Chapman and Walker 1987, 8). "Economic growth or development is a structural transformation of the economy in respect of both inter-sectoral and intrasectoral employment and income" (Husain 1967, 40). Historically, the essence of growth has been calculated from the relative decline of agriculture in the economy both as a source of employment and income. More recently, economic growth has been calculated from the relative decline or reshuffling of manufacturing in the economy. Over the past forty years manufacturing has been in a state of transition. "Between 1965 and 2000, net job creation in non-manufacturing sectors of the economy was more rapid than for manufacturing, giving rise to the notion that the United States was becoming a service-oriented economy. This is all true, but until 2000 the phenomenon was more about growth in the service sectors, and not about the decline in manufacturing" (Peters 2006). "The process of growth is associated with the emergence of those sectors, institutions and basic attitudes as well as with such changes in structure and organization [sic] of the economy which would not only prevent the economy from slipping back but would ensure continuous long run development" (Husain 1967, 241). The growth in economic sectors since Clark indicate a shift in the role of the city; in an industrial society, physical growth and land use are slaves to the instruments of production whereas in a post-industrial society where knowledge rules and economic activity relies heavily upon information, people care where they live and lifestyle quality has replaced many of the traditional determinants of location choice (Kotkin 1999; Hearn 2008)

Although the polycentric model isn't a revolution, it does remind even the most contemporary urban planner that economic growth influences spatial structure. This model is shaped by location al requirements of specific industries, often traced to eras of economic growth, and reflects the post industrial expansion of economic sectors beyond primary, secondary and tertiary. Parr believes that the agglomeration of activities caused by certain economic industries make a polycentric center "attractive for a range of new economic activity that is emerging within the nation or some section of it" (Parr 2003, 11). The evolution of spatial structure during the twentieth century indicated the point at which economic theory and the physical structure of cities caught up with each other.

Within a polycentric structure "firms could be expected to benefit from such intangibles as reciprocity, exchange, and unexpected creativity" (Parr 2003, 9). It is these "intangibles" that have had such a profound spatial effect during the transition from an industrial to a post-industrial economy. Adam Smith believed that economic growth and these intangibles were realized by increases in productivity yet limited by the size of the market. Smith wrote, “As it is the power of exchanging that gives occasion to the division of labour, so the extent of the division of labour must always be limited by the extent of the market” (Madrick 2002, 27).

The departure from spatial theory in understanding the new economy is due to the relationship between markets and productivity. This relationship is not perfect, partly because location is affected not only by costs of production but also by demand and the location of the market. The method of production sets the “ground rules for the factors of production and, in doing so, controls also the factors of location” (Chapman and Walker 1987, 8). This conflict is addressed by location-production theory, “which attempts to set orthodox microeconomic production theory within an explicitly spatial framework. These analyses then attempt to explain how changes in spatial economic costs themselves affect the optimum location of the firm” (McCann 2002, 3). These models demonstrate that the optimum location of the firm and the optimum production relationships are interdependent and co-determined (McCann 2002).

The problem with most early location-production models is that they are one-dimensional, just like early spatial theory. In these cases, modes of transportation and quantities shipped are fixed. Other assumptions include the fact that location does not impact the availability of labor and capital. “Space is homogeneous” (McCann 2002, 12). Given a profit-maximizing rationale for the firm, as in Weber’s (1909) optimum location model, market failure is inevitable. This is explained by neoclassical economic theory. Neoclassical theories revolve around utility and profit maximization. Two major concepts underlie neoclassical economic theory: equilibrium of economic systems and mobility of capital. Neoclassical economics assumes that “demand and supply will become equal at an equilibrium that leads to an optimal allocation of resources" (Buitelaar 2007, 4). Since markets are rarely fully competitive, the allocation of resources is sub-optimal, since a competitive equilibrium cannot be achieved. The result of a non-equilibrium system is market failure (Buitelaar 2007). Viewing the firm as a rational maximizer is a psychologically unrealistic behavioral assumption (Buitelaar 2007; McCann 2002; Chapman and Walker 1987).

Weber's model implies that the firm's optimum location is where costs are minimized, with emphasis given to the transport costs involved in assembling materials at the manufacturing site and in delivering the finished product to the market. This is probably the most significant limitation of the Weber model seeing that typically transport costs tend to be only a very small percentage of total costs for most firms (McCann 2002, 27). According to Chapman and Walker, Weber also "recognized the influence of labour costs and the possibility that economies may be achieved as a result of the agglomeration of several plants in close proximity to one another" (Chapman and Walker 1987, 19). This problem can be overcome through substitution, which is not accommodated in Weber's model. Production barriers caused by labor shortages or privately controlled infrastructure, if the existing infrastructure is poor, can diminish the impact of poor mobility. The problem with most substitutions is that they are often more expensive or less satisfactory.

Many economists acknowledge that Weber was the most influential early contributor to normative location theory (Chapman and Walker 1987). Normative theory considers basic objectives for industrial location in hopes of determining the best or optimal location at a particular time. Weber's model was deductive, whereas other models that have greatly contributed to urban spatial structure have been inductive. Walter Christaller's Central Place Theory is such an inductive model, based not so much on analysis as "on careful observation and intuition" (McCann 2002, 41). In 1966 Christaller proposed the Central Place Theory that described the distribution of development in terms of a hierarchy of centers, each with a hexagonal market area (Anas et al. 1998). "The Central Place Theory (CPT) shows how the location patterns of different industries are merged to form a regional system of cities. The [CPT] is a model of market-oriented firms, as firms that base their location decisions exclusively on access to their customers" (O'Sullivan 2000, 119-20). The model is not oriented to the location of inputs, energy sources, or labor. "The basic function of the model is the efficient spatial allocation of production and housing in the presence of economies of scale and transport costs. Economies of scale encourage the concentration of production at a relatively few locations, each of which achieves an efficient level of output. Transport costs encourage the adjacent location of production and population (residential housing) to minimize shipping and commuting costs. Production (especially agricultural production) and housing require contiguous space, so they are concentrated in any one location only up to the point at which space requirements increase transport costs enough to exhaust the benefits of scale economies" (Puryear 1975, 307). Collectively, this model introduces the concept of urban systems in location theory.

Shortly after Christaller described the CPT, the German economist August Losch proposed that forces more fundamental than local resource-based differences were at work, which accounted for the concentration of economic activity. "Losch recognized that the goal of the rational entrepreneur should be to select the location at which profits are maximized and that, in reality, neither demand nor costs are spatial constants as assumed by the least-cost and locational interdependence schools respectively" (Chapman and Walker 1987, 19). This is seen in contemporary Chicago. Fyfe and Kenny believe that "the primary factor explaining Chicago is the productivity of the Middle West; location at the southern end of Lake Michigan is a secondary factor. If there were no Lake Michigan, the urban population of the Middle West would in all probability be just as large as it is now" (Fyfe and Kenny 2005, 39).

Although fundamentally important, the CPT is flawed in that it is customer driven, spatially limited, and restricts economic growth. Christaller and Losch both assumed a homogenous geographical landscape with a uniform geographical population distribution; assumptions that encourage spatial inefficiencies. Consider this, from 2000 to 2006, emerging suburbs and exurbs grew nearly three times as fast as the U.S. population, as Americans moved further out in search of more affordable or bigger homes (NJ Report 2008). Developers saw cheap land and rising home prices and residents saw a slew of federal and private loan programs that would help them achieve the American Dream. To fulfill this dream, national investors invested in areas open to outsiders flooding the local market with capital. For investors, the costs and barriers associated with risky deals across regions in locations too far away to benefit from regional economic development and distributive equity increased spatial inefficiencies. For homeowners, costs associated with commuting were underestimated. When the price of gasoline rose to record levels during the summer of 2008 the ability to reduce transaction costs in many areas was impossible. "When population dispersion is combined with a lack of adequate transportation infrastructure, what could be perceived as a large market is only a set of isolated unconnected small communities" (Rios and Romo 2008, 2-3). Therefore to create a truly polycentric structure that encourages economic growth and optimizes the intangibles created through efficient geography, it is not simply a reorganization of firms that needs to occur, but an efficient reorganization of labor as that is what helps to support strong markets.

The CPT also represents a "stationary model of a closed urban system" (Parr 1999a, 1258) and unidirectional interurban trade (Puryear 1975, 308). The model's sole concern is with the flow of goods and services between the central place and market. Parr (1999a) states that "in the production of goods and services …, the supply of inputs from urban [centers] is from those of higher levels, while … the outputs are exported to lower levels, so that upward trade flows from urban [centers] are wholly absent from the system" (Parr 1999a, 1259). When understanding the relationship of firms and spatial economics in a service sector environment or outside of manufacturing, the urban system is dynamic, requires backward and forward linkages, and is independent of fixed transportation routes to define its market.

An additional flaw is that the CPT assumes decreasing costs. "Economic theory holds the view that efficient pricing of public facilities alone will make land use patterns more efficient – thereby saving resource lands for resource uses and facilitating efficient urban development" (Nelson and Duncan 1995, 113). Yet in reality, public facilities use an average cost pricing structure, where everyone is charged equally for the same service, regardless of the real cost to provide that service to a particular customer. This pricing structure encourages sprawled development patterns where higher density developments subsidize the cost of services for outlying low density developments. In a spatial context, by measuring the conflict between land uses or development goals (i.e., what is to be accomplished) all costs are considered, including transaction costs.

Although flawed, Christaller's Central Place Theory plays a significant role in urban spatial theory, especially with regard to the systems-based approach for understanding the spatial relationship between employment sectors and markets. According to McCann, from this theory we can glean two distinct components of functional urban systems: 1) the use of centrality to determine the locational patterns of economic activity and 2) the impact of a diverse set of influences on specialized function activity (McCann 2002).

Industrial Performance in the New Economy: Geography

Jacobs, Blakely and Bradshaw, and others use economic base models to support the need for an economic class whose sole role is to create a stable economy and quickly adapt to any disturbances. This economic class has a national or international market presence and takes advantage of economic opportunity zones that contribute to the expansion of economic activity or expands the markets for goods. Modern economic base theories concentrate on the transactions within an economic system as the engine behind wealth and regional growth. Innovation and the new economy rely upon reducing the failures and inadequacies of those transactions maximizing internal institutional linkages in the public and private sector (Blakely and Bradshaw 2002).

Since the time of Adam Smith, productivity has been used to measure economic performance. One of the primary indicators used to measure economic health is the gross domestic product (GDP). The GDP illustrates the size of the economy and "it represents the total dollar value of all goods and services produced over a specific time period" (Investopedia 2009). As stated in the Organisation for Economic Co-operation and Development (OECD) Science, Technology, and Industry Scoreboard 2007 "investment in new knowledge, notably in R&D, is now growing in line with GDP. This contrasts with the late 1990s when investment in knowledge outpaced growth of GDP" (OECD 2007). This trend is projected to continue, especially in sectors that fuse theoretical knowledge with science and technology (Table 2-1). According to employment projections by the Bureau of Labor Statistics, almost all of the fastest growing industries between 2006 and 2016 are in high-tech or knowledge intensive industries. Such industries require a high share of high advanced skills (Figure 2-1). To support future industry growth in these sectors additional investment of knowledge is required and firms often spend more on knowledge-based workers as a percentage of their total wages expenditure than other sectors (Hearn 2008, 72). The OECD defines investment in knowledge "as the sum of R&D expenditure, expenditure for higher education (public and private) and investment in software" (OECD 2007, 1). As Morrisson and Potts note, "firms understand that innovation, and the knowledge required to catalyze it, is the primary determinant of competitive advantage in the current economic landscape, and that this can involve the re-definition of industry boundaries and positions of market dominance" (Hearn 2008, 168). In this post-industrial society innovation and globalization are the new sources of job creation and have led to major developments in all sectors of the economy.

Unlike the traditional industrial sectors, the success of information based industries is not directly based on monetary returns and relies heavily upon largely undirected, spontaneous, and unmotivated collaboration (Hearn 2008, 179). As Hearn notes, the information economy is premised "on the assumption that economic activity in such an economy will be dominated by the sale or licensing of intellectual property, either directly or embodied in proprietary goods and services" (Hearn 2008, 180). These are not goods or services that can be "manufactured" in an industrial facility. For example, Silicon Valley is regarded as a region that has successfully executed the complex process of knowledge transfer. The economic base in this region is an innovative network of high-value products and services based on its proximity to an excellent source of research, principally at Stanford University, and the clustering of high-technology companies (Brown 2007, 1). To achieve a technological revolution, which is the product of an innovative network and of which productive value is gained, the importance of space must be realized. Lundvall et al. (2007, 216) conclude that "learning processes combined with stationary technology might, in the long run, suppress the importance of space, while radical innovation makes face-to-face interaction necessary." The impact of location on a technological revolution is dichotomous: "on the one hand, it makes it less difficult to operate activities long distance; on the other hand, the radical change taking place within the technology itself gives a privilege to agents interacting face-to-face and with opportunities for hands-on experience" (Lundvall et al. 2007, 216). In Silicon Valley, the focus from a traditional input-output supply-chain linkage to a wide range of collaborative relationships, and the capacity to maintain considerable knowledge flows and innovation between organizations represents a shift in industry spatial organization from the individual firm to a productive system (Fingleton et al. 2007, 62).

Morrison and Potts acknowledge that "innovation is a ubiquitous process that affects significantly [a firm's] choice of investment and strategy, the skills and capital they require, and the competitive pressures that they face. Firms understand that innovation, and the knowledge required to catalyze it, is the primary determinant of competitive advantage in the current economic landscape, and that this can involve the re-definition of industry boundaries and positions of market dominance on, historically speaking, rapid timescales. The wealth of information made available at low cost by the Internet and through increased exposure to international trade should guarantee that those involved in enterprise (who are able to effectively compete) accept and understand the importance of innovation as it relates to their own opportunities, risks, and competitive threats." (Hearn 2008, 168)

Innovation is a market-based activity. As Hearn states (2008), innovation "may be catay[z]ed by science and other non-market forms of knowledge production … but the test of innovation is whether market selection has acted to generate a new source of economic value (usually understood as a new source of profitability). Another way of saying this is that science [and information] produces knowledge that does not necessarily lead to innovation. It is only when demand for a solution based on new knowledge has been realized or created that innovation can be said to have occurred" (Hearn 2008, 166). Furthermore, innovation and creativity are analogous terms. Given the definition of innovation stated above, creativity is defined by Robinson (2001) as "'imaginative processes with outcomes that are original and of value', which requires that 'creative ideas are more than novel; they are valuable'" (Hearn 2008, 60). The Creative Task Force in Britain adds to this definition that creative industries possess activities that "have the potential for wealth and job creation through the generation and exploitation of intellectual property" (Fingleton et al. 2008, 60). For this paper, innovation is the extension of knowledge in creating something new and of value. Creativity is the intersection of science and innovation. Creativity applies that new knowledge in a manner that is understood and valued by a wider audience.

The Urban System

As described above, industrial location has become more complex as technology has improved. The transition from an industrial to a knowledge economy has been "pushed" by the economic value gained from the generation of "new ideas, concepts, products and services, rather than deriving greater efficiency and economies of scale from existing production process" (Hearn and Rooney 2008, 59). The most significant spatial aspect of this "push" magnifies the region versus locality problem; what is in the interests of a region are often not in the interests of a given locality within that region, and vice versa. Economic strategies are often localized and the spatial distribution of benefits bear little resemblance to the spatial distribution of costs (Parr 1999a, 1262). This explains why although regions such as Silicon Valley in California and Research Triangle Park in North Carolina are centers of rapid economic growth, not every community in peripheral areas benefit. Perroux's growth pole theory explains the spatial distribution of key industries but Gunnar Myrdal's theory of cumulative causation helps to explain why some areas are increasingly advantaged while others are disproportionately disadvantaged.

The cumulative causation theory regards economic change as an endogenous phenomenon in the market system (Fujita 2007). This logic follows positive feedback. Blakely and Bradshaw (2002) state that "market forces, by their nature, pull capital, skill and expertise to certain areas. These areas accumulate a large-scale competitive advantage over the rest of the system" (Blakely and Bradshaw 2002, 63). Furthermore, Schumpeter (1934) states that economic development cannot solely be described by the narrow view provided in traditional economic theory.

> Economic development is not a phenomenon to be explained economically, but that the economy, in itself without development, is dragged along by the changes in the surrounding world, that the causes and hence the explanation of the development must be sought outside the group of facts which are described by economic theory. (Schumpeter 1934, 63)

Helen Brown (2007) describes innovation in terms of three stages: research, development, and innovation. Brown states, “Sometimes the word innovation is used to refer to the culmination of all three stages, from knowledge creation to diffusion of innovation into new technological process services or products” (Brown 2007, 2). Collectively, these three stages are an innovation system.

“Systems consist of components, relationships among these, and their characteristics or attributes” (Carlsson et al. 2002, 233). Innovation systems can be viewed in terms of the physical or geographical dimension and in terms of time. The spatial and traditional economic system necessary to support an innovative economy goes against the existing tradition of scientific practice; or normal science. Innovative economies support scientific revolutions. Thomas Kuhn (1996) states that innovation is about “the extraordinary investigations that lead the profession at last to a new set of commitments, a new basis for the practice of science… They are the tradition-shattering complements to the tradition-bound activity of normal science” (Kuhn 1996, 6).

The geographic or physical dimension of innovation systems is an important dimension. Sometimes the most important dimension in economic development is the industry which then determines the geographic boundary but the physical dimension of innovative economic opportunity gains value through finding a location where innovation can thrive and products can easily diffuse into the local market. In Raymond Vernon's product cycle theory he "showed how product development must take place in areas with greater wealth and capital to invest in the process of inventing and developing new products, supported by local markets that can pay higher prices for products that have not yet become standardized" (Blakely and Bradshaw 2002, 59). It's all about location.

Ratanawaraha and Polenske (2007) indicate that three primary issues affect innovation geography analysts.

> The first issue concerns the question of whether innovation, however defined, is spatially concentrated or dispersed in certain areas. Once analysts confirm that an innovation is spatially concentrated/dispersed, the second issue they investigate concerns the various mechanisms and factors that underlie such a distribution and concentration/dispersion, such as regional resource endowments, knowledge spillovers, and industrial organization. The third issue is how the spatial concentration/dispersion affects other variables, such as regional and national economic growth (Ratanawaraha and Polenske 2007, 44).

Through December 2007 the United States continued to steadily produce jobs but geographic inequalities remained. Across the nation a spatial mismatch exists between the people seeking work, the location of work, and the resources needed to stimulate job creation (Blakely and Bradshaw 2002, 10). Blakely and Bradshaw believe that global market demands, obsolete plants, uncompetitive industries, locational disadvantages, inferior skills, and racial discrimination further contribute to spatial inequities. Even in a free market system reducing spatial economic inequality requires intervention. Litvak and Daniels state that,

> Regardless of how it manifests itself, the existence of relatively depressed communities in substate regions means a certain segment of the population is cut off from the fruits of national economic development. People in these localities will not simply migrate to healthier areas. On the contrary, better-educated people with more promising job prospects are likely to move from place to place looking for employment. Moves by poor people tend to be within the same county or city. Clearly there is a need to try to bring jobs to people rather than counting on people to move to jobs (Blakely and Bradshaw 2002, 11).

Martin and Feldman argue that a unique jurisdictional advantage is available in cities that provide positive economic value through knowledge spillovers, clustering, and localized knowledge externalities (Feldman and Martin 2004). I don't disagree, but I believe that true jurisdictional advantage is achieved at the regional level. "The future of regional economic growth lies in increasing 'inter-place competition' by developing "cities and regions that are 'more attractive to highly mobile capital'" (Eflin 2008, 66). Transit and transportation corridors, recreation facilities, crime, and land values are all affected by aggregate county level decisions and events. Furthermore, counties facilitate polycentric spatial patterns that provide a more organized structure for idea exchange and knowledge absorption.

An urban economy, like a natural community, is constantly seeking to achieve an optimal range with low environmental stress. Change occurs unpredictably and several different patchworks of ecosystems work together to form a community. In Richard Florida's book "Rise of the Creative Class" he suggests that in a creative economy it isn't technology that powers long term economic growth. Just like a natural environment, long term growth "requires a series of gradually accumulating changes in the organizational and institutional fabric of society" (Florida 2004, 16). Thus temporally, a snapshot of the system at a particular point in time may differ substantially from another snapshot of the same system at a different time. A comparison of two distinct time periods offers insight into system performance.

One argument against innovative firms is that although the result yields a more efficient or productive good, the length of time associated with creating that new good can be lengthy. But as Schumpeter points out, the length of production is irrelevant. In an industrial-based economy consumption drives production and profit and changes in production is driven by incremental changes. In an innovation-based economy consumption adapts itself to run at the rate of production (Schumpeter 1934, 36-37) and that is why, as Kuhn (1996) points out, “a new theory, however special its range of application, is seldom or never just an increment to what is already known. Its assimilation requires the reconstruction of prior theory and re-evaluation of prior fact, an intrinsically revolutionary process that is seldom completed by a single man and never overnight” (Kuhn 1996, 7).

Carlsson et al. define the elements of the innovation system as follows:

> “Systems are made up of components, relationships, and attributes. Components are the operating parts of a system. Relationships are the links between the components. Attributes are the properties of the components and the relationships between them, they characterize the system” (Carlsson et al. 2002, 234).

In describing the process of innovation, there are four perspectives. Van de Ven’s chaos perspective focuses on the emerging product, Nonaka’s knowledge creation perspective focuses on emerging capability, and Engestrom’s learning perspective concentrates on the object of activity. These perspectives are summarized in four stages. The first stage involves the formulation of the problem or idea. The second stage involves modeling a publicly transmittable representation of this. In the third stage, the model is tested in simulation or real life. Finally, in the fourth stage, the model is consolidated and stabilized in the acquisition of new practices (Brown 2007, 8).

From the perspectives summarized above, four general components of the innovative production process can be defined: innovative networks, innovative agents, innovative inputs, and innovative outputs (Ratanawaraha and Polenske 2007). These components are activities due to labor. The first concept, innovative networks, is what differentiates innovative activities from any other production activity (i.e. manufacturing or agriculture). Innovative networks describe the entire system and add value to not only the production process but through the specific use [and arrangement] of land productive value is achieved. In agriculture this productive value is measured by fertility. In manufacturing productive value is measured by consumer demand for a specific good. In innovation, productive value is measured by the spatial arrangement of knowledge networks. Innovative economies support a research agenda rooted in economies of agglomeration. The knowledge networks create a premium on land in certain locations because of the "need to produce at discrete points in space because of increasing returns to scale in production" (Anas et al. 1998, 1427-1428).

An innovative system is simply a reformulation of the four components of economic development: locality, business and economic base, employment resources, and community resources (Table 2-2). Myrdal's theory of cumulative causation, and new growth theory, relies upon endogenous factors to measure economic growth through technological progress. Very few sectors of the economy continue to base land use theory upon the relationship of markets to proximity of fixed physical transportation routes. Location, by itself, is no longer a "pull" factor (Blakely and Bradshaw 2002). For many people and industries, digital connections seem to trump geography as a gauge of economic viability. The Washington Post columnist Marc Fisher said "Electronic ties alone don't fulfill all our needs. Where we live still matters" (Fisher 2009, C01).

In attraction theory, communities are products. As communities improve their quality of life they tend to attract new populations, which may improve their level of human capital or infrastructure that support "knowledge networks" to act as incubators for innovation (Blakely and Bradshaw 2002, 66). The linkages between locational advantage and the built environment derive from the planning theory of Jane Jacobs. She asserts that creativity originates from the built environment, which encourages the arrangement of unique economic dynamics. More specifically, Jacobs states that "Building the creative city is an illusion, but creativity can certainly benefit from buildings" (Hospers and van Dalm 2005, 12).

Economic development occurs when a community's standard of living can be preserved and increased through a process of human physical development that is based on principles of equity and sustainability" (Blakely and Leigh 2009, 141). In the history of economics, none is more unique than the creative economy; its industries and entire economy bridges factors of production with factors of consumption. "Communities must not only build jobs to fit the existing populace but also build institutions that expand the capability of the populace" (Blakely and Bradshaw 2002, 69). It is this complexity that challenges the economic development professional with creating a plan that integrates the concepts of innovation and the needs of a community.

Institutional factors are inherent to an innovation system. These include "the way publicly financed research is organized in a given country, or the nation's system of schooling, training and financial institutions. Production of economically useful new technological knowledge results from collective actions of different actors of the system connected by various linkages ranging from informal to formalized network relationships" (Acs et al. 2002, 1070).

Components

Husain states that

> The phenomenon of growth, though defined in measureable terms requires a set of tangible and intangible forces making for change. The former are usually the material forces of production and the latter consist of the environment causing and facilitating such a change. These two forces are, however, not independent of each other. They mutually act and react in such a manner that the process becomes cumulative. But the distinction between material forces and the environment of production is not necessarily the same as between economic and non-economic factors. It is not easy to classify the factors of growth into economic and non-economic since the former include the material agents of production as well as a part of environment in which economic decisions are made. (Husain 1967, 67)

Development is caused by economic factors of production as well as facts described outside of traditional economic theory (Schumpeter 1934, 63). The economic forces provide order in the larger environment. This order is formed by credit institutions, fiscal and monetary policy, and price levels. The non-economic forces effects economic decisions indirectly. These forces are defined by the culture, values, customs, institutions, social structure, status system, etc. of the people (Husain 19641967, 72).

When comparing two companies in the same field in two different cities from the outside the companies may seem similar or even identical, but they aren’t. Economically, the two companies seek the same thing to survive in their respective economic environment, access to capital, purchasing power to support research and development activities, and access to a customer base. In reality the differences between these two firms and their eventual success or failure can be traced to the causal relation that exists between the economic and non-economic factor. Economic factors are based upon logic. Non-economic factors explain the nuances generated by the uniqueness of isolated communities. For example, Schumpeter (1934) uses the example of ground rent and explains that the variations across a given space are due to the differences in the qualities of land. “If I can trace particular price movements to political regulations of commerce, then I have done what I can as an economic theorist, because political regulations of commerce do not aim immediately at the acquisition of goods through exchange or production, and hence do not fall within our concept of purely economic facts” (Schumpeter 1934, 5).

In 2006 two rural Virginia cities, Lebanon and Rose Hill, in desperate need of an economic boost were given access to high-speed Internet (Kang 2009). One town attracted two large companies, creating 700 jobs with average salaries of $50,000 for residents. The other town was unable to attract any large companies and Internet access resulted in the creation of only a few home-based businesses. The difference between these two towns was the additional investment one city undertook to educate its residents and prepare them for positions which utilize the Internet and technology to do business. The willingness of the local government in Lebanon to train its workers and voluntarily increase the educational level of its workers is what attracted Northrop Grumman and software maker CGI to this rural community. According to the Washington Post, about 71% of Lebanon’s residents have a high school diploma, compared with Rose Hill, where only 29% do. In Rose Hill the education gap and lack of training of its residents have presented challenges in attracting new industry. At face value locating in either of these rural areas would present an opportunity to offer lower wages for skilled workers, “highly competitive firms recognize that the firm and the community must continuously invest in assuring a highly skilled workforce” (Blakely and Bradshaw 2002, 69). Furthermore, regardless of the industry, a strong human resource base is a major attractor and “if the local human resource base is substantial, either new firms will be created by it regardless of location or existing firms will migrate there” (Blakely and Bradshaw 2002, 69).

As in the case of Lebanon and Rose Hill an initial investment by government was needed to create a desirable environment for commerce thus stimulating the economy. This form of government intervention is a type of institutional cost. “Governance is about adjusting, influencing, and regulating the action of other owners of user rights. Institutions are the rules of the game in a society or, more formally, the humanly devised constraints that shape human interaction” (Buitelaar 2007, 45 48). In Lebanon, then-Virginia Governor Mark Warner helped in getting $2.3 million in grants to bring fiber optic-pipes to homes and business parks. In Rose Hill, the costs of laying the fiber lines and building cell towers was funded from a state tobacco settlement fund for broadband projects and a rural telecommunications program run through the Department of Agriculture (Kang 2009). Both of these funding efforts facilitate increased human interaction and increase the productive value of land. Although, the production costs in each of these towns don’t guarantee a successful economy, knowledge-based or otherwise.

A review of literature by Acs et al. indicates that “innovation activities are not equally distributed in space. Production of new scientific and technological knowledge has a predominant tendency to cluster spatially” (Acs 2002, 1070). Francois Perroux’s growth pole strategy model proposes a shift in the relationship between firms and geography. The growth pole strategy focuses “investment at a limited number of locations (usually as part of a deliberate effort to modify regional spatial structure), in an attempt to encourage economic activity and thereby raise levels of welfare within a region" (Parr 1999b, 1195). In a growth pole strategy, innovative industries serve as the engine to development that subsequently attracts a complex set of industries needed for production. The degree of polarization is "measured with respect to the intensity of interfirm or interindustry transactions" (Parr 1999b, 1197) and the development of linked industries would cause growth to diffuse throughout a specific zone of influence (Parr 1999b, 1198). The principles behind a natural growth pole strategy support the fundamental arguments for a creative economy: when the intrinsic value of land supports exploiting the potential advantages of a location for innovative, highly competitive industries there will be a cumulative buildup of the various types of agglomeration economy that create beneficial inter-sectoral and inter-industry externalities (Parr 1999a; Parr 1999b; Perroux 1955).

Although the Christaller approach represented the first comprehensive outline of a hierarchical urban system (McCann 2002), the difference between historical perceptions of market area and the growth pole strategy is that Perroux represents an open urban system with spatially flexible supply areas. A market area represents the territory served by a particular urban center (McCann 2002); suggesting an equilibrium environment where "demand is awaiting every supply, and nowhere in the system are there commodities without complements. The sellers of all commodities appear again as buyers in sufficient measure to acquire those goods which will maintain their consumption and their productive equipment in the next economic period at the level so far attained and vice versa" (Schumpeter 1934, 9). The household or firm will respond to changes in the market empirically but, as Schumpeter states, "everyone will cling as tightly as possible to habitual economic methods and only submit to the pressure of circumstances as it becomes necessary. Thus the economic system will not change capriciously on its own initiative but will be at all times connected with the preceding state of affairs" (Schumpeter 1934, 8-9).

Conversely, a supply area is a territory that serves a particular urban center. Within a supply area ideas and new products are generated that improve efficiency by employing "tools and techniques that spare resources and improve outcomes" (The Economist 2008, 67). Innovative economies within a supply area don't rely upon demand side economics and have the benefit of quickly adjusting to negative feedback or emergency adaptations thus reducing market instabilities created by realistic behaviors exhibited by firms and individuals.

Components: Innovative Agents

In McClelland's theory of achievement motivation, psychological and sociological requirements for development are founded upon the idea that "Economic development depends on 'vigorous activities of a number of individuals who behave in an entrepreneurial fashion'" (Husain 1967, 70). Taken a step further, innovative agents are those who produce innovations that expand development. Economic progress is achieved because of individuals who understand where inefficiencies exist and have the capability to synthesize existing practice and expertise and relate them to the need for new technologies that will survive in to the future. "Innovating entrepreneurs are daring in spirit and are ready for experimentation and putting hitherto untried technique into practice" (Husain 1967, 236). These are innovative agents.

"The basic idea is that innovation comes neither out of the blue nor out of the mind of the individual entrepreneur. Innovation reflects cumulative processes of interaction where different organizations and individuals combine efforts in creating, diffusing, and using knowledge" (Lundvall et al. 2007, 214). Madric believes that with each major period of growth the same sorts of factors contribute to economic expansion. Recently, in addition to a reduced cost of computer power and an expansion in how products are used, the suppression of wages and new attitudes toward business and entrepreneurialism contributed to the expansion during the 1990s (Madric 2002).

Human capital, or people as economic agents, affects the geography and population composition of the system. People with marketable skills highlight the connection between investment in education and economic productivity. "An economy or a cluster cannot function without labor and history has shown that the availability of a young and growing population us a prerequisite for economic development" (Power and Lundmark 2003, 57). Gottlieb points out that "college-educated young people, in particular, are more likely to have mastered newer technologies and ideas. Many view these younger workers, who typically have fewer family responsibilities, to be more entrepreneurial and risk-taking than older workers" (Gottlieb 2004, 2).

According to Hall "measures of human capacity range from general to specific. The percentage of college graduates reflect general human capital. Such broad measures accept that innovation is not restricted to laboratories and research centers; a workforce with general skills is better prepared to provide the flexibility necessary to meet opportunities with which they are presented" (Hall 2007, 109-110). More precise measures evaluate the number of bachelor's, master's, or PhD degrees in specific fields as a percentage of the population. Due to the mobility of highly educated human capital, states that are unable to retain or recruit such skilled workers never reap the full benefit of their economic value.

Regions with significant levels of human capital reinforce the importance of a supply area in determining the spatial geography of an innovative system. Husain (1967) and Hearn (2008) indicate that investment in human capital creates more progressive and affluent consumers in stimulating innovation on the part of the producers and services providers and facilitating the adoption of invention. “Economic development requires a change in the composition of skills and attitudes of the people. There arises the need for a transformation of illiterate, backward and ill-fed people to illiterate, skilled, healthy, efficient and trained workers; from the attitude of asceticism and empty spirituality to that of achievement and success; and from resistance to acceptance of innovation” (Husain 1967, 80). Creativity is about knowing what to do when the rules run out or when there are no rules in the first place” (Levy 2006). Having a concentration of intelligent people is important, but in terms of our economic future creativity is about more.

Components: Innovative Inputs

Innovative inputs are the process or efforts used in creating knowledge. There is a lack of understanding in the study of innovation, which involves innovation diffusion and knowledge dispersal, and how to measure it. “To study the question of innovation diffusion, analysts must not consider something after it has been innovated, but where, i.e. – geographical place – the innovation occurs, and under what conditions. If all innovators and people using the innovation were clustered in the same location, those who write about tacit versus codified knowledge would blend with the transmission of codified knowledge” (Polenske 2007, 5). The rate of knowledge transmission is reflected in the mobility of labor. “Mobility functions as a lubricant for structural transformation between declining sectors and companies and expanding ones. Above all perhaps, mobility can greatly effect an area’s supply of tacit or non-standardised knowledge and the social capital based on people’s network positions” (Power and Lundmark 2003, 56). The central role of tacit knowledge is the process of learning-through-interacting, and this method overextends the tools whose use neoclassical economists regard as the most fundamental criterion for remaining scientific (Lundvall et al. 2007). The meeting and interaction of people in the workplace through which ideas can be negotiated, transferred or developed is crucial for development. More specifically, knowledge and innovation is developed through interaction in the workplace itself (Power and Lundmark 2003). This interaction is evident in the cluster.

Feser et al. define the cluster, in their ideal form, as “essentially the empirical manifestation of the mutually reinforcing influences of first-mover effects, conventional business agglomeration economies, localized technology spillovers, and geographical path dependence. More than simply picking ‘winners,’ cluster policies attempt to marshal diverse resources and programs behind groups of related industries that have demonstrated some evidence of local competitive success” (Feser et al. 2001, 1). With respect to ‘creative cities’, Hearn describes the relationship to ‘cluster theories’ as the “correlation between agglomerations of related firms and industries and sectors, and the economic success of particular cities and regions” (Hearn 2008, 64). The economic implications of this relationship are evident in the “successful geographical clusters [that] generate sustained competitive advantage for the firms and institutions within them by: increasing productivity through innovation by making information about new opportunities more widely available; and promoting new business formation in related sectors, through capital" (Hearn 2008, 65). Location-based clustering can be explained using five indicators:

1. The importance of specific forms of labor [sic] input, and the quality of each specialized labor [sic] and associated forms of tacit knowledge;

2. The organization of production in dense networks of small to medium-sized enterprises (SMEs) that are strongly dependent upon each other for the provision of specialized inputs and services;

3. The employment relation in creative industries, which is frequently characterized by intermittent, project-based work, meaning that recurring job-search costs can be minimized through co-location in particular areas;

4. The indirect, synergistic benefits that result from the interaction of individual creativity with collective learning, tacit knowledge and historical memory, through the co-existence of people and enterprises engaged in inter-related activities; and

5. The development of associated services and institutional infrastructure, and the priority that the relevant industry sectors have in the thinking of local and regional governments.
(Hearn 2008, 65)

"A fundamental idea of the 'cluster' literature is a shift in focus from the firm to productive systems and an understanding of the phenomena of competitiveness as a collective result rather than the outcome of individual processes" (Fingleton et al. 2007, 62).

In a knowledge economy, less tangible variables, such as the quality of life overshadow advantages in market area or natural resources (Blakely and Bradshaw 2002). Although the exportable commodity plays an important role in supporting an economy, its more vital role is to "act as the 'carrier' in diffusing changes in the level of income from other regions to the subject region" (North 1955, 250). Previous research (Arora et al. 2000; Hall 2007) indicate a clear association between knowledge workers (individuals with high levels of human capital) and location preferences; particularly with those places that have a higher than average quality of place.

Financial resources are indisputably an essential component in the process of creating knowledge. Particular geographical areas demonstrate higher than average performance in research and development due to access to primary sources of government investment. Financial capacity for innovative activities is typically measured by research and development (R&D) investment. In the science and engineering fields this information is available from several sources, yet for other industries this information may be more difficult to measure. Therefore, Hall mentions that financial capacity of private knowledge can be measured by industry R&D spending and public knowledge sources are often measured in terms of university R&D expenditures (Hall 2007).

Unlike science, which generates ideas but does not guarantee the creation of new economic value (Hearn 2008, 164), economic value is applied to information through innovation. Information, like science, is a building block “that underpins the future development of further scientific knowledge” (Hearn 2008, 165); Kuhn referred to this as “normal science” (Kuhn 1996, 10). Innovation exceeds convention; the inadequacy of tradition drives the development of new practices (Brown 2007). Yet even the best intentions surrounding plans to maximize economic conditions through technological advances aren’t realistic and can create an imperfect situation. The economic best and the technologically perfect may diverge because “methods which are technologically inferior may still best fit the given economic conditions” (Schumpeter 1934, 15). Schumpeter states, “The objective of technological production is indeed determined by the economic system; technology only develops productive methods for goods demanded" (Schumpeter 1934, 14). Information and science are non-market institutions; they both contribute to the growth of knowledge and act as mechanisms that further innovation. Research and development activities possess potential economic value.

As mentioned previously, human capital is an integral part of innovation and in many cases the innovator is an individual who can use a process or service in a more economically efficient manner, but that does not make the innovator an entrepreneur. Often the entrepreneur leads production into new channels (Schumpeter 1934, 89). The entrepreneur's role in innovation is to provide economic leadership, to find funding to pursue R&D goals. Aside from traditional government investment, another means of funding is through venture capital sources. Venture capital investment is often used to gauge innovation capacity but this is a misplaced indicator. Hall states that "venture capital does not represent capacity to innovate but, rather, capacity to commercialize. Economic growth follows commercialization, which supports the distinction between commercialization capacity and innovation capacity" (Hall 2007, 111).

Components: Innovative Outputs

Innovative output is evidence of what is produced by knowledge-based activity. Polenske believes that innovative outputs "range from those for intermediate outputs, such as patented inventions" (Polenske 2007, 36), to those that indicate the end of the innovation process: the commercialization of technical ideas as tangible products (Polenske 2007, Acs et al. 2002). Previous research by Ratanawaraha and Polenske (2007) indicates that patent data is the most widely used data in innovation geography measurement (2007, 36). This is due to the ease of access to such data, the ability of researchers to conduct both longitudinal and cross-sectional analyses with this data, and because patent data extends beyond just the actual count but it identifies locational specialization. According to Acs et al. (2002), indicators such as patents may misrepresent true output because firm size may influence the need to announce new products. But Acs et al. does admit that there is some evidence that patents “provide a fairly reasonable measure of innovative activity at the industry level, and some evidence that patents and innovations behave similarly at the state level however, this has not been tested at the substate level” (Acs et al. 2002, 1071).

Other methods of determining innovation counts are through literature based innovative output (LBIO) data. “These are compiled by screening specialist trade journals for new-product announcements” (van der Panne 2007, 495). Advantages of this method over patents include that they document the commercialization of every innovation but these types of counts are very expensive to produce and typically only represent select years across select geographies.

Relationships

Initiative, creativity, problem solving, and openness to change are increasingly important skills in a knowledge economy (Houghton and Sheehan 2000, 9). The market and physical environment contribute to creating an atmosphere where innovation can thrive. This is why cities like New York, San Francisco or Chicago have advantages in production and consumption that other cities like Tampa or Charlotte can’t replicate (Florida 2008, 135). Knowledge workers seek high returns socially and financially for their specialized education and skills. Richard Florida believes that “money and capital flow to where the returns are greatest, and people move where opportunity lies. Both capital and talent concentrate where opportunities for productivity and returns are highest" (Florida 2008, 46).

The criteria and development patterns of knowledge based industries and employees are based upon two principles. First, unique resources such as density, access to capital, or a sufficient labor pool places a premium on land in certain places. These resources illustrate the first principle, which is more focused on the actual production of new ideas and the importance of space in economics. Secondly, amenity based characteristics like open space, diverse populations, openness and acceptance, and culture influence how we value our communities. These amenities illustrate the second principle which is characterized by "place". The greater a sense of place we have, the more creative stimulation we exhibit. Richard Florida believes that "creative activities put us in a state of 'flow', or intense, unfettered focus and concentration" (Florida 2008, 158). Unfortunately, local economic development strategies have used either principle to validate the other. Yet relying upon resources (natural resource availability, location, labor, capital investment, entrepreneurial climate, transport, communication, industrial composition, technology, size, export market, international economic situation, and national and state government spending) or capacity (economic, social, technological, and political capacity) (Blakely and Bradshaw 2002, 55) independently create weak economies that fail to attract businesses or yield an overabundance of low paying jobs.

Within a system relationships are the "links between components" (Carlsson et al. 2002, 234). A review of literature by Gottlieb indicated that "executives consistently rank[ed] both labour supply and quality of life as top location factors, raising the possibility that amenities are viewed as a separate factor, possibly even a 'non-economic' one" (Gottlieb 1995, 1414). Amenities contribute to the attractiveness of a commuter-shed for a firm, where employees live (Gottlieb 1995; Gottlieb 2004; Florida 2005). Although Gottlieb was among the first to recognize the relationship between amenities and business location, Richard Florida's (1999) research was considered progressive from previous scholars, particularly with general audiences, who chose to ignore the relationship of residential amenities in the attraction of the firm. Employees of high technology firms demand more of residential amenities when considering where to locate. Therefore high technology firms within metropolitan areas are more likely to consider residential amenities in their firm location (Gottlieb 1995).

Traditional economic factors of production represent endogenous causes of business growth. According to Morrison and Potts, "innovative enterprises, in order to grow and stay competitive – and therefore create high-value jobs – need:

1. cost-effective access to reliable transport, energy, and telecommunications infrastructure;
2. to operate in a competitive environment in terms of input markets;
3. access to finance on terms and conditions appropriate to their needs;
4. a stable macroeconomic environment, appropriate company, commercial and intellectual property law, and minimum (by the standards of global best practice) business regulation, and red-tape; and
5. Access to an appropriately skilled and experienced labor [sic] force (or human capital base).
   (Morrison and Potts 2007, 169)

Items 1, 2, 3, and 4 above relate to the inputs necessary to create an appropriate environment and affects the acceptance of outputs created by innovative firms and agents outside of the immediate market area. Item 5 is necessary to incite the flow of knowledge. Furthermore, to strengthen metropolitan economies Bruce Katz of the Brookings Institution suggests that the above factors with quality places can have significant implications on the form and functions of a region by creating a strong and diverse middle class with the potential to grow in more environmentally sustainable ways (Katz 2008).

Companies that innovate provide the functional environment in which new ideas can flow but without the people to manipulate these inputs, ideas are simply free advice. Individuals that possess the education or acumen to fully develop a new product from an idea are a scarce resource, and as such must make tradeoffs when choosing a community that satisfies their intellectual needs. Innovative companies realize this, as do the communities in which they locate. Charles Tiebout outlined a powerful framework for identifying the tradeoffs involved in choosing a place, rooted in the local value of public goods. Therefore if innovative agents, who place a high value on amenities, are presented with several employment choices Tiebout argued that their final decision will reflect a more localized fitness advantage: aesthetic appreciation (Jacobs 2000; Florida 2008).

Gottlieb defines amenities as “place-based goods or services that enter the utility functions” (Gottlieb 1995, 1413) of individual choice. Gottlieb believes that the firm is an amenity-maximizing agent, thus cities and firms use amenities as an economic development strategy for three reasons:

1. Executives consistently rank both labor supply and quality of life as top location factors, raising the possibility that amenities are viewed as a separate factor, possible even a ‘non-economic’ one.

2. Firms may locate in high-amenity areas, not only to tap an existing labor force, but also to recruit a new one. The elite firm may act as an amenity-maximizing

agent, blurring the distinction between residential and non-residential location behavior.

3. Amenities presumably affect firm location through compensating wage differentials. If the price rather than the quantity of skilled labor is key, then a focus on migration or labor supply could be misleading (Gottlieb 1995, 1414).

Gottlieb developed a method for spatially weighting amenity variables for high tech employment concentrations. His research concluded that at the municipal scale corporations are agglomerative and there was evidence of amenity optimization over hypothetical commuter-sheds, supporting the hypothesis of the firm as an amenity-maximizing agent. In his research only the most distressing disamenities matter at the place of work, while surrounding residential locations must pass a higher amenity standard.

Gottlieb developed the relational illustration in Figure 2-2 for the location of an amenity-oriented firm. Typical location theory, illustrated by the solid lines, considers the existing labor force as the primary attractor. Business factors contribute to firm location and amenities draw population to a region. New residents appeal to firms looking to relocate and with the addition of employment opportunities and the expansion of business sectors employees possessing specific skills are drawn to the area. This model also indicates that the relationship between the firm and quality of life is ignored, the dashed arrows. After developing this model, Gottlieb realized that amenities had to be considered in firm location since amenities are a priority to the quality and type of employee high tech innovative firms seek.

Gottlieb studied a region in northern New Jersey connected by mass transit, highways, and a diverse economy. The area had an abundance of skilled professionals with the highest per capita income and housing costs (Gottlieb 1995, 1416). Gottlieb acknowledged the polycentricity of the region and the region's autonomy in land-use regulation and the provision of services. He used six business variables that highlighted the locational concerns of the high tech or professional service sector and several amenity variables. The Gottlieb study excluded tax rates, utility rates, and land costs because he believed that the high tech sector was less sensitive to these variables than manufacturing firms. These variables were excluded because he believed that these costs were influenced by the attributes (i.e. amenities) of that municipality and since these attributes have been included as individual factors, to include tax rates and land values would be redundant. Gottlieb's research focused on agglomerative and infrastructure factors such as the number of college graduates, municipal employment density, and access to transportation. Generally, Gottlieb used proximity analysis, reflected in the positive or negative coefficients on the independent variables represented in his firm location function. Spatially, Gottlieb included variables like distance away from minority residential neighborhoods (to measure where employees are less likely to live), distance away from congested roads, proximity to recreational opportunities, and proximity to local public services and public education as values that influence an employee's decision to live in a particular place and a firm's choice to locate.

To measure the response of high-tech firms to amenities and agglomeration in their location decisions, Gottlieb used a combination of a gravity formula to determine the weighting of business variables to explain consumption behavior and the negative exponential formula in conjunction with questionnaires to determine the weight of amenities and density gradient of high-tech workers around the facility where they worked (Gottlieb 1995). To measure the spatial effects of amenities Gottlieb uses distance decay parameters to determine the coefficients of his empirical model. The more significant problems with this model include imprecision in determining the distance decay properties of consumption or physical geography without collecting massive amounts of data or conducting a large detailed study.

Measurement

Polenske (2007) identified three main issues in current literature about innovation. First, there seems to be a bit of difficulty in defining innovation. Secondly, there is a lack of consensus on a framework both to define the theory of innovation and the ways to measure it, and by the vast number of empirical studies that are done, but using relatively simplistic measures. Lastly, as mentioned previously, there is a lack of understanding in the study and measure of innovation, The experimental design of innovative geography projects involve determining two primary factors: geographic unit and measuring relational innovative activity.

Apiwat Ratanawaraha and Karen R. Polenske completed an extensive literature review of the spatial measurement of innovation. In their research, they concluded that the three primary obstacles in the study of innovation geography are limited data availability, inadequate theoretical models, and conceptual precision (Ratanawaraha and Polenske 2007, 30). Together these hindrances prevent the development of "robust empirical indicators, indices, tests, and analysis of innovation" (Ratanawaraha and Polenske 2007, 30). These obstacles are created due to the lack of existing innovation geography research that details data and underlying mechanisms for attracting innovation. Additionally, Ratanawaraha and Polenske note that previous research is ineffective in identifying and measuring the indicators that explain the spatial distribution of innovation. Although traditional location theory is used to measure the agglomeration/dispersion of innovation it is insufficient. Geographers, planners, and researchers should consider the tradeoffs in measurement that result from separating the product that is created from the people and process needed to develop a new idea.

It is relatively easy to understand the theoretical framework behind innovation and the four general components of the innovative production process (innovative agents, innovative inputs, innovative outputs, and innovative networks). What is more difficult is designing an equivalent framework for temporal and spatial measurement. Ratanawaraha and Polenske developed a comprehensive survey of data and sources for each step of the production process (Appendix A).

As mentioned previously, the value of land is determined by unique resources in certain places and amenity based characteristics dictate how we value our communities. From Table 3 we see that the study of innovation geography to this point has occurred at a very gross scale, the census tract or larger. Yet within an innovative system microclimates exist that may transcend standard political or geographical boundaries. The dilemma is attempting to measure value gained from inputs, outputs or agents beyond a predetermined scale. A greater difficulty lies in obtaining comparable empirical data that illustrates a discrete measurement of economic or social value. Land use suitability analysis is a method that merges the temporal and spatial aspect of measurement and provides a value reflective of localized and global actors.

Anas et al. provided a review of various techniques used to measure urban structure at finer resolutions. One approach uses fractals, or geometric figures which display ever-finer structure when viewed at finer resolutions. “Geographers have used fractals to examine the irregularity of the line marking the outer edge of urban development in a particular urban region. The fractal approach highlights the inadequacy of a deterministic view of development in accounting for the irregularities in urban structure" (Anas et al. 1998, 1433). A more intuitive approach used by urban economists identifies employment centers as "a cluster of contiguous zones, all with employment density exceeding some minimum D [density], and together containing total employment exceeding some minimum $\bar{E}$ [employment]" (Anas et al. 1998, 1434). This method does not consider irregularity and scale dependency of employment patterns and agglomeration clustering.

Jane Jacobs discusses what the approaches ignore. She states that "cities cannot be 'explained' by their locations or other given resources. Their existence as cities and the sources of their economic growth lie within themselves, in the processes and growth systems that go on within them. Cities are not ordained; they are wholly existential. To say that a city grew 'because' it was located at a good site for trading is, in view of what we can see in the real world, absurd" (Jacobs 1970, 141). Jacobs suggests that cities are the result of a gestalt approach; there is an intrinsic suitability of land uses that dictate urban form.

Growth responds to natural processes, which are clearly visible in the pattern and distribution of development in its density (McHarg, 1969, p. 160). Using scenario modeling and suitability surfaces, Ian McHarg developed methods that relied upon the land to dictate its best sites for development (McHarg, 1969, 197). The core of McHarg's methods was social values and utility. He postulated that intrinsic characteristics lend to maximizing future utility and optimal use. Conflicts between the values of multiple uses was resolved either through a decision made by an actor or co-existence of multiple uses. His suitability model also deviated from more absolute models of land use assessments and value analysis. It is easy to understand the importance of a tangible good if a monetary value is assigned but McHarg's method establishes a method to understand the relative importance and value of systems and processes. The original McHargian process was rational and explicit – meaning that the process and results were reproducible.

Land use suitability analysis is an analytical process that combines inventory information to determine the fitness of a given unit of land. The result is either tabular data, a single map or a series of composite maps that display the relative suitability [or appropriateness] for a specific use (in siting studies) or a number of uses (in comprehensive planning) (Randolph 2004, 591). As landscape architects in the late 1800s, Charles Eliot and Warren Manning used suitability analysis in their environmental planning pursuits to measure the relative degree lands in Boston were fit for integration into the Boston Metropolitan Park System. Central to this process was developing a systematic approach to inventory site resources and, through the use of overlay mapping, analyze the natural fitness of the land. The various approaches to suitability analysis "offer alternative perspectives in understanding the interactions between human and natural processes. Some are innovative and sensitive to the future, while others are the repackaging of the same approaches under different names or refinements of tools and techniques" (Ndubisi 2002, 138).

An extension of traditional suitability analysis is land use conflict. An example of a land use conflict method is the Land Use Conflict Identification Strategy (LUCIS), developed by Professors Paul Zwick and Peggy Carr at the University of Florida. According to Carr and Zwick, LUCIS illustrates “where land use suitabilities are in conflict or where one land-use type is clearly more suitable than another” (Carr and Zwick 2007a, 26) LUCIS stops short of representing alternative futures, but instead focuses on the comparison of the results of three suitability analysis purposefully designed to capture biases inherent in the motivations of three stakeholder groups: conservationists, developers, and farmers and ranchers dedicated to an agricultural future (Carr and Zwick 2005).

The evolution of suitability analysis has required that current methods be “more accurate, legally defensible, technically and ecologically sound, and open to public scrutiny” (Ndubisi 2002, 142). In determining locations for creative employment this is even more important because determining the optimal use of the landscape for innovative industries implies “a shift from using ecological considerations solely to embracing an understanding of changing economic circumstances: the supply and demand of land, varying human needs and values, political realities, and new technologies. Acting together, these forces drive the evolution of the landscape” (Ndubisi 2002, 142). Planners, economists, and decision makers can be so deeply involved in maximizing their economic base that trade-offs of that performance goal are not considered, even when these trade-offs are highly relevant to social well-being, as is the increasing possibility of gentrification. A broader perspective – supported by appropriate data and decision-support tools – is needed in order to have livability given a serious consideration in planning and to have it viewed as a legitimate part of the set of goals to be served by creative employment decision making (National Research

Council 2002, p11). Suitability analysis is a spatial measurement of the intrinsic suitability of land. It provides a method of allocation that recognizes the social, economic, and political values people place on specific land uses (e.g. creative employment or commercial/service employment). According to the National Research Council this effort can be hampered by several factors:

1. Addressing the complex issue of liveability requires access to a wider variety of information than is traditionally used by the various planning organizations.
2. Communities need to be able to measure whether their actions are improving liveability, but they often lack necessary data and face challenges in developing sound methodologies.
3. Organizations and stakeholders often do not have consistent or comparable data, making the analysis of options and decisions more difficult.
4. The information needed to make good decisions may not be available in useable forms.

Land use suitability analysis provides a quantitative and qualitative medium to measure innovative economic potential and accounts for structural, residential, and non-residential location behavior (i.e. quality of life). LUCIS specifically, and suitability analysis in general, resolves the complex association in measuring the relationship between markets and productivity. Geographers, planners, and researchers should consider the trade offstradeoffs in measurement that result from separating the product that is created from the people and process needed to develop a new idea.

Measurement: The LUCIS Approach: The LUCIS Strategy is a six step suitability analysis process. The first step is the development of a hierarchical set of goals and objectives for each stakeholder group that become suitability criteria or indicators of measurement (Figure 2-3). The stakeholder groups are identified as land use types or categories integral to the development process. Generally, the grossest scale for measurement and group categorization is agriculture, conservation, urban. The hierarchical procedural tree, developed by Alexander and Mannheim in 1962, was used as a method for combining factors. This is an important aspect of suitability analysis as it helps to organize the components of the environment that are important.

Generally, a systematic assessment of the environment involves a three tiered framework:

- IMPACT VARIABLES. Identifying components of the environment that are important (e.g., water quality)
- IMPACT INDICATORS. Measures that indicate change in an impact variable (e.g. dissolved oxygen)
- IMPACT THRESHOLDS OR STANDARDS. Values of impact indicators above or below which there is a problem; used to evaluate the impact (e.g., 6 ppm minimum of dissolved oxygen)
(Randolph 2004, 613)

The first tier, Impact Variables, is analogous with the LUCIS hierarchical goals, objectives, and sub-objectives. Husain (1967) understood the interrelated nature of economic and non-economic factors of production. LUCIS goals lend to this interaction. By identifying the multiple purposes within each stakeholder, the complexity of production can be measured. For example, amenity-based characteristics influence how we value our communities. Within the LUCIS structure, the values of amenities are listed as parallel goals with productive value. The intent of each goal is dichotomous, economic and non-economic or physical. These are represented by objectives. The variables that contribute to achieving the intent are identified as sub-objectives.

LUCIS goals, objectives, and sub-objectives allows for a clear method to organize indicators of innovation opportunities, reduce uncertainty, and explain the inter-dependence of explanatory factors. The hierarchical structure separates considerations of cost, in terms of real estate prices and costs of production, from value, in terms of desirable local attributes or amenities given cost. The hierarchy provides a relational structure for measuring the transaction costs in determining creative economic opportunity. “Transaction costs refer to all costs other than the costs of physical production. Transaction costs are the costs that are made to increase the information available to us and to reduce uncertainty” (Buitelaar 2007, 30-31). In suitability analysis this is accomplished through the measurement of suitability for each component factor. As uncertainty is reduced a framework is created that illustrates the comparative advantage of knowledge based firms integrating the influence of amenities, as a measure of quality of life, and resources needed to encourage the production of new ideas. The suitability of objectives and sub-objectives contribute to the overall goal productive value. The hierarchical structure lends to concluding that the explanatory factors of economic and non-economic factors of production, as illustrated in terms of distinct goals, are inter-dependent. Conversely, the complexity of many aspects of knowledge based activity creates difficulties in identifying components of the environment that are important.

The second step of the LUCIS strategy is to develop an inventory of available data that best demonstrate the suitability of the feature(s) identified in each objective or subjective. The second step of LUCIS is analogous to the second tier, Impact Indicators, of systematic assessment.

Economic performance is typically measured by discrete numeric indices, as in the case of GDP. According to some, the material well-being measured by GDP is not appropriate in determining the broader quality of life. The biggest difficulty is “assigning monetary values to the various factors and intangibles that comprise a wider measure of socio-economic well-being" (The Economist 2005, 1). Furthermore, other attempts to create non-monetary indices of social and economic well-being "is in the selection bias and arbitrariness in the factors that are chosen to assess quality of life and, even more seriously, in assigning weights to different indicators" (The Economist 2005, 1). In suitability analysis the importance of the factors chosen that contribute to innovative systems can be measured statistically and through existing and historical land use policy. For example, "high real estate prices are assumed to put upward pressure on wages in order to attract labour independent of local amenities. Similarly, with land of a given accessibility in less than perfectly elastic supply, high wage levels boost real estate values. Therefore wages are a function of land rents and amenities" (Stover and Leven 1992, 738). Using suitability analysis you can spatially measure the inter-dependence of land value and the suitability of land for creative employment. Using a historical dataset you compare the location of new creative employment and change in future land value as it relates to the influence of explanatory factors by performing a sensitivity analysis on the appropriate suitability surface.

Returning to the example of GDP, critics suggest that using GDP illustrates a clear and substantive meaning to quality of life and that prices are objective weights for the goods and services that make it up (The Economist 2005, 1). Unfortunately, price isn't often reflective of true value therefore problems arise when using it as an "objective weight". If supply and demand is based upon false prices (value) through subsidies, taxes, tariffs, or speculation local economies can randomly contract. Since suitability is a measure of the intrinsic value of land the data used to measure a feature neglects any artificial influences.

Determining creative employment suitability introduces various difficulties in spatial measurement. As Husain stated above, economic forces are influenced by tangible and intangible economic factors. Examples of such economic forces include taxation and government spending. In spatial suitability, impact indicators are represented by a geographic relational database. The first issue that arises is related to data availability. Determining spatial suitability is not only dependent upon understanding what factors contribute to measuring explanatory factors of fitness but also having access to spatial data to complete the measurement. For example, in the context of fiscal and monetary policy the data used in measurement would include descriptive information about the rate of taxes and associated descriptive and topological information identifying spatial geography. This introduces issues related to scale and data availability. If spatial data is available the scale of fiscal and monetary policy is gross; its spatial extent is larger than a municipality or county. Also, the impact of a fiscal policy over a given area is typically uniform and local sensitivities between the economic (human) or natural processes are difficult or impossible to measure. Additionally, to perform suitability analysis on a factor with such a gross scale would not provide any useable or direct suitability results. Factors unavailable in a geographic or spatial format would be used to facilitate the synthesis and analysis of relationships typical of the gestalt method. The gestalt method is based upon direct observation and views the site as a whole. In contemporary suitability analysis, including LUCIS, this is associated with community values or weighting.

The third step of the LUCIS strategy makes use of methods employed by Carr and Zwick, including proximity and statistical analysis, to measure the suitability of a specific unit of land within the region with respect to the values and bias of each stakeholder. The third step of LUCIS is analogous to the third tier, Impact Thresholds or Standards, of systematic assessment. Depending upon the intent of the objective and/or sub-objective, GIS models are developed, which are a workflow of spatial data and geoprocessing tools that measure suitability in terms of utility value. LUCIS employs a standardized value range of 1 to 9, with 1 representing low suitability and 9 representing high suitability. Once the suitability of each objective and/or sub-objective has been determined, individual layers within a goal are combined using utility values (i.e., weights) that equal 1.0 (100%). The result is a single GIS raster layer that illustrates the final suitability for a specific stakeholder group: agriculture, conservation, or urban. These suitabilities are combined to create land use preference.

The Impact Thresholds or Standards tier of general assessment identifies variables given two general indicators of change (or influence). The first is based upon proximity. This idea is based upon the principle of diminishing or increasing return; either how far away from or closer to you are to a particular impact indicator. The second indicator of change is based upon the idea of with-without. This is similar to "a binary classification of factors in a form like 'suitable or unsuitable', 'good or bad', or 'pass or fail'. This classification reflects only qualitative, not quantitative differences between mutually different levels of suitability. For each factor, criteria are established to identify the minimum acceptable ratings which serve as cut-off points. All sites with a rating below the minimum acceptable rating fail or are unsuitable, while all sites with a rating at or above the minimum rating pass or are suitable for that particular use" (Rainis 1991, 15).

Most variation in the suitability surfaces can be explained either statistically or due to the indicator of change (i.e. proximity or with-without). A significant part of determining creative employment opportunity over a given area employs the inclusion of non-economic factors that are based upon quality-of-life standards, which are often subjective. These standards are reflective of personal and community values and within suitability analysis are best used for deriving weights for various quality-of-life objectives.

The weights are determined using a pair wise comparison method. Carr and Zwick calculate community preference using the analytic hierarchy process (AHP). AHP is a non-general form of pairwise comparison that assists in setting priorities and makes the best decisions when both qualitative and quantitative aspects of a decision need to be considered (Expert Choice 2008).

Combining spatial data is best completed using map overlay. Warren Manning introduced the map overlay concept in 1912 and since then it has been instrumental to the practice of land use suitability. "In land suitability assessment, the map overlay technique is often used in conjunction with a weighting scheme. The weight values are incorporated into the map overlay process to produce land suitability maps" (Xiang 2001, 61). As described in the description of third step of the LUCIS Strategy, individual objective suitabilities within a goal are combined using weights representative of community values and goals are combined using weights reflective of the values from the AHP process. Surveys have also been used to gauge community values. For determining the importance of the future location of growth - exercises such as visioning sessions, which link questions about personal preference for future growth to a solid connection with the landscape through either maps or other visual aids, encourage participants to think realistically about their goals and how to achieve them.

Suitabilities related to quality of life create difficulty in determining community values. On the one hand you could conclude that repeated future patterns of development indicate an environment that is amenable to residents. On the other hand you could use Kevin Lynch's (1960) "Image of the City" as a guide for measuring how you feel in an environment. Lynch's "legibility" of the city can be measured using life-satisfaction surveys as a determinant of quality of life; thus can be applied as weights to suitability surfaces reflective of the physical aspects of quality of life. "These surveys ask people the simple question of how satisfied they are with their lives in general. The simple measure of life satisfaction [as opposed to surveys of the related concept of happiness] has been found to correlate highly with more sophisticated tests, ratings by others who know the individual, and behavioral measures" (The Economist 2005, 1). Life satisfaction is seen as a judgment that depends on social and culturally specific frames of reference, which is exactly how community values are formed.

Unfortunately, community values, if existing policy is not used as a guide, can often introduce bias into the larger suitability process. Depending upon who defines the assumptions used for suitability weighting results in achieving different ends. "On one end of the gradient is an approach that looks to citizen stakeholder groups to define internally consistent narrative assumptions about how future land [use] will unfold. The citizen-driven approach produces alternative futures that typically have the advantages of integral citizen involvement, greater political plausibility and increased likelihood of institutional acceptance" (Hulse et al. 2004, 326). The disadvantage of this approach is that it is difficult to statistically aggregate their preferences into a smaller number of values. "At the other end of the gradient is an expert-driven approach, with experts in the bio-physical and social sciences or planning professions defining a set of decision or transition rules, often with input from other groups, that determine future land [use] conditions. The decision rules are generally constructed to optimize for particular endpoints or illustrate focal policy options (e.g., improved water quality, better wildlife habitat, lower infrastructure costs, less highway congestion, etc.). Alternative futures produced using this approach typically have the advantages of quantifiable statistical likelihood and the disadvantages of unclear political plausibility, which may be due to the encoded decision or transition rules lying outside the political processes actually governing land [use] in the study area" (Hulse et al. 2004, 326).

The fourth step of the LUCIS strategy combines goal suitabilities to represent stakeholder preference. Carr and Zwick (2007b: 14) define preference as, "a measure of the degree to which a stakeholder is preferred for any given land unit". The final suitability raster developed in step three for each stakeholder has values that range between 1 and 9, but may not include the value 9. For a value of 9 to result, at least one cell in the study area would have to be optimally suited for every measure of suitability included in the goals, objectives, and sub-objectives for that land-use category. The probability of this occurring is very low. Carr and Zwick (2007b) recommend normalizing final suitability values before comparing preferences. Normalization only occurs on areas with development potential.

“The final suitability layer is often a weighted summation of the scaled data layers for each raster cell. For these multi-attribute problems, the individual cell size of the raster representation of a given geographic region that results in larger raster databases is not a limiting factor for the procedure because raster cells can be processed independently of one another” (Cromley and Hanink 2003, 343). Cromley and Hanink argue that scale is an issue in multi-objective land use allocation because two or more non-complementary activities cannot occupy the same location or raster cell. This isn’t entirely true. Take the case of determining individual suitabilities within a goal. The objectives are aggregated to the goal level and the resultant suitability surface comprises a common extent with unique cell values based upon mathematical calculations. But in land use conflict, the non-complementary activities (i.e. individual stakeholders) are linked together by individual preference value.

The fifth step of the LUCIS strategy reclassifies the preference of each stakeholder into three classes that correspond to high, medium, and low preference. There are several methods available that produce an even distribution of preference values. The distributed values are characterized using a designation of 1, 2, or 3, which describe the level of preference (Table 2-3). This method is called “collapsed preference” and identifies relationships among the three stakeholders.

The sixth and final step to develop a conflict surface compares areas of preference to determine the quantity and spatial distribution of potential land use conflict. As stated above, the collapsed preference surface is characterized using values of 1, 2, or 3.

To compare the preferences of each stakeholder the collapsed preference surface is combined into one GIS raster layer. This GIS raster layer is known as the final conflict surface. The values in the final conflict surface ranges in value from 111 to 333. The first, second and third digit in each number sequence is representative of agricultural, conservation, and urban preference, respectively (Figure 2-4). The LUCIS conflict surface illustrates which lands a single stakeholder has the highest preference value, which lands two stakeholders have the same preference value (i.e., moderate conflict), and which land all three stakeholders have the same preference value (i.e., severe/major conflict) (Table 2-4).

The value in LUCIS is the land use conflict feature which identifies locations for specific land use opportunity. This feature sets LUCIS apart from other suitability models in that other models gain their value in the assumptions used or the role of lay and expert stakeholders in the scenario modeling process. With the LUCIS Conflict table, differences between stakeholder preferences are identified before synthesis products are developed. Land use conflict is a synthesis of the outcomes of the modeling assessment "in terms of potential options for mediating identified conflicts in the interactions between human and natural processes" (Ndubisi 2002, 139). Land use conflict provides spatial context insight into resource competition. The relative conflict values illustrate opportunity costs associated with choosing specific geographic units of land relative to other land uses.

Although this research does not allocate actual creative employment centers, it is important to note that allocating development based upon land use conflict introduces the concept of differential rent. For example, if more land is needed for urban use than is available in urban preference and the assumption is made that agriculturally preferred land can be used to satisfy urban need then the rent of agricultural lands with a higher land use suitability increases.

Conclusion

Creating an environment or system conducive to innovation is about more than developing new products. Innovation and the activities it spurns are a source of growth – economic and physical. The structure of the innovation system is inextricably linked to markets, education, asset value, and land use patterns. Madrick sums it up nicely, "Markets and information are linked. Rapid growth produces more savings, making capital investment easier and less expensive to undertake, just as growing savings helps facilitate growth. A growing economy motivates people to educate themselves and make the public investments in transportation and communications often necessary for further growth, just as more investment in education raises the potential rate of growth" (Madrick 2002, 8). Yet the components and relationships of innovation aren't nearly as multifaceted as the attributes associated with measuring the performance of the system.

Table 2-1. The OECD/EC classification of knowledge-intensive sectors

Styles	Apply to
High Technology	Aerospace (17-2011); Pharmaceuticals (29-1051); Computers, office machinery; Electronics-communications; Scientific instruments
Medium-high technology	Electrical machinery; Motor vehicles; Chemicals –excluding pharmaceuticals; Other transport equipment; Non-electrical machinery
Medium-low technology	Coke, refined petroleum products and nuclear fuel; Rubber and plastic products; Non-metallic mineral products; Shipbuilding; Basic metals; fabricated metal products
Low technology	Other manufacturing and recycling; Wood pulp, paper products, printing and publishing; Food, beverages, and tobacco; Textile and clothing
Knowledge-intensive high-tech services	Post and Telecommunications; Computer and related activities; Research and development
Knowledge-intensive market services (excl. financial intermediation and high-tech services)	Water transport; Air transport; Real estate activities; Renting of machinery and equipment without operator, and of personal and household goods; Other business activities
Knowledge-intensive financial services	Financial intermediation, except insurance and pension funding, except compulsory social security; Activities auxiliary to financial intermediation
Other knowledge-intensive services	Education; Health and social work; Recreational, cultural and sporting activities
Less-knowledge-intensive market services	Sale, maintenance and repair of motor vehicles and motorcycles/retail sale of automotive fuel; Wholesale trade and commission trade, except of motor vehicles and motorcycles; Retail trade, except of motor vehicles and motorcycles/repair of personal and household goods; Hotels and restaurants; Land transport/transport via pipelines; Supporting and auxiliary transport activities/activities of travel agencies

Table 2-1. Continued

Styles	Apply to
Other less-knowledge-intensive services	Public administration and defense/compulsory social security; Sewage and refuse disposal, sanitation and similar activities; Activities of membership organizations n.e.c.; Other service activities; Private households with employed persons; Extra-territorial organizations and bodies

(Source: Miles, I. (2008) Knowledge Services, Knowledge Policy: Challenges for the 21st Century, 14-15)

Table 2-2. A reformulation of the components of local economic development

Component	Old Concept	New Concept
Locality (Innovative Inputs)	Physical location (near natural resources, transportation, markets) enhances economic options.	A quality environment and strong community capacity multiply natural advantages for economic growth.
Business and economic base (Innovative Inputs)	Export base industries and firms create jobs and stimulate increased local business.	Clusters of competitive industries linked in a regional network of all types of firms create new growth and income.
Employment resources (Innovative Agents)	More firms create more jobs, even in many are minimum wage.	Comprehensive skill development and technological innovation lead to quality jobs and higher wages.
Community resources	Single-purpose organizations can enhance economic opportunities in the community.	Collaborative partnerships of many community groups are needed to establish a broad foundation for competitive industries.

Source: Blakely and Bradshaw 2002, 67, Table 3.2

Table 2-3. Preference value descriptions

Cells with a value of	Indicate
1	Low preference
2	Moderate preference
3	High preference

Table 2-4. Three example stakeholder preference value explanations.

Conflict Value	Preference Value	Stakeholder Preference
333	Major Conflict	Agriculture, Conservation, and Urban have the same preference value
113	No Conflict	Urban has the highest preference
122	Minor Conflict	Conservation and Urban have the same preference value

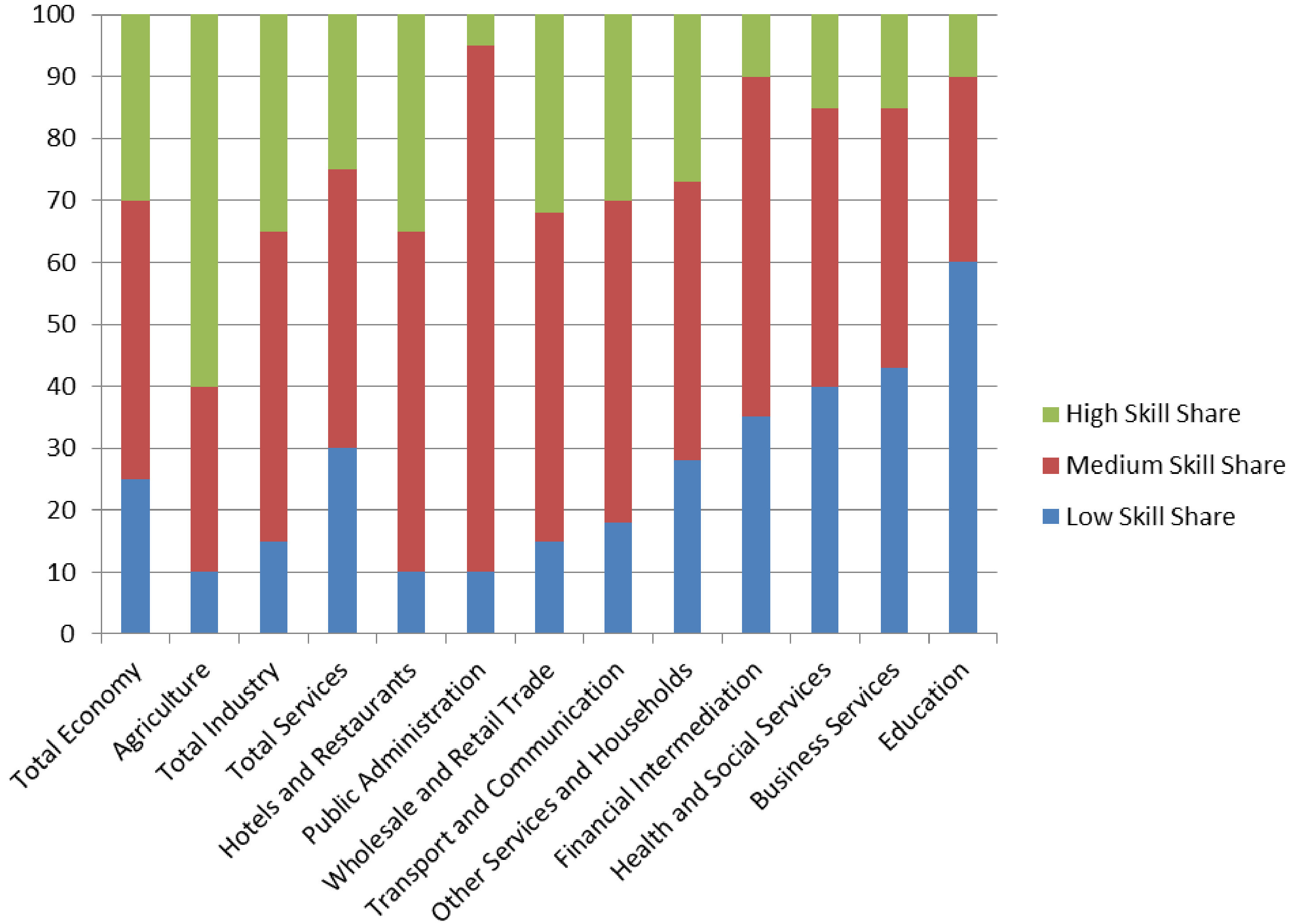


Figure 2-1. Skill composition of economic sectors in the European Union, 2000. (Recreated from Miles, I. (2008) Knowledge Policy: Challenges for the 21st Century, 16)

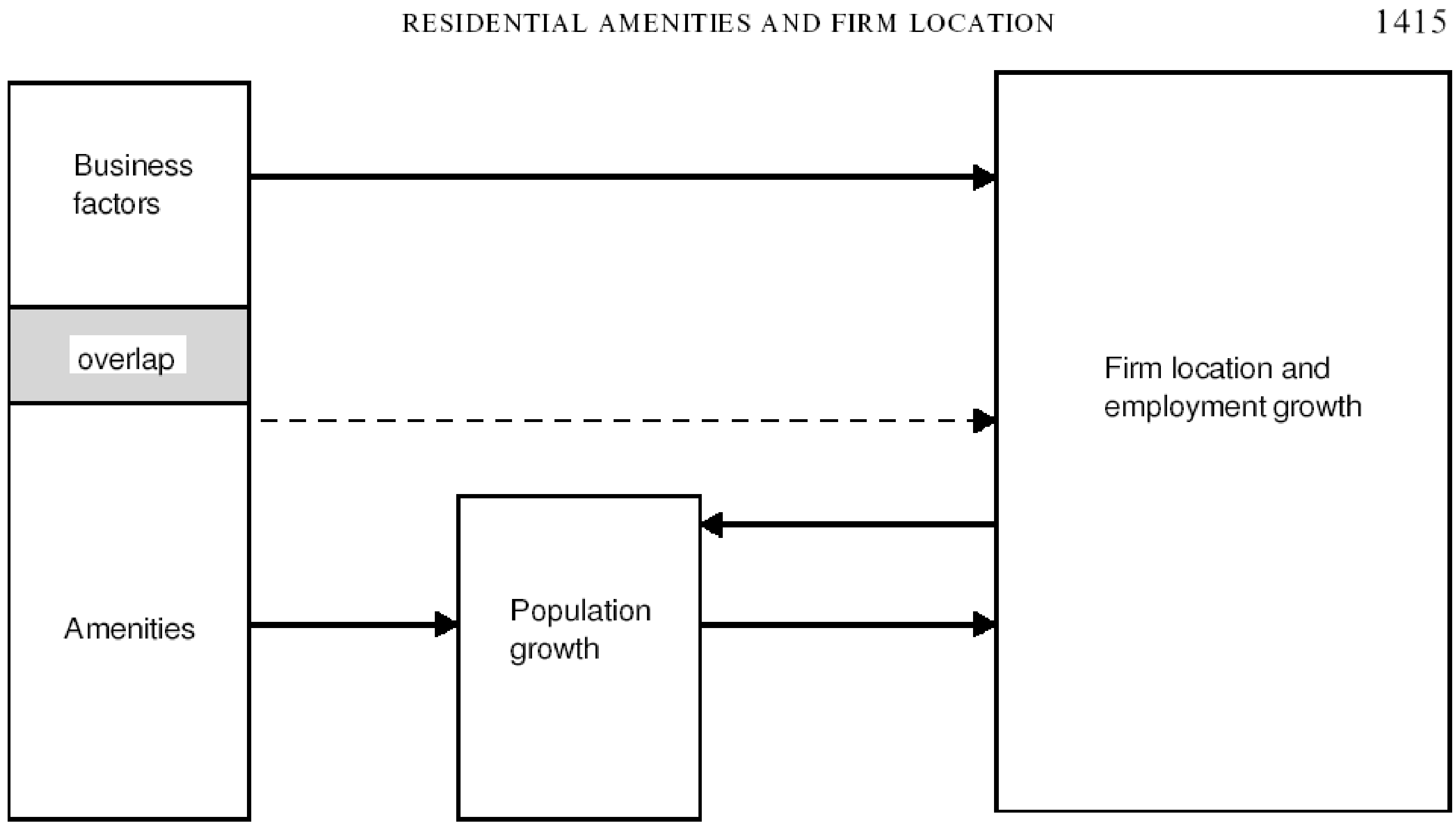


Figure 2-2. Illustrates the relationship between residential traditional business factors, residential amenities, population growth, and firm location and employment growth. (Source: Gottlieb, P.D. (1995))

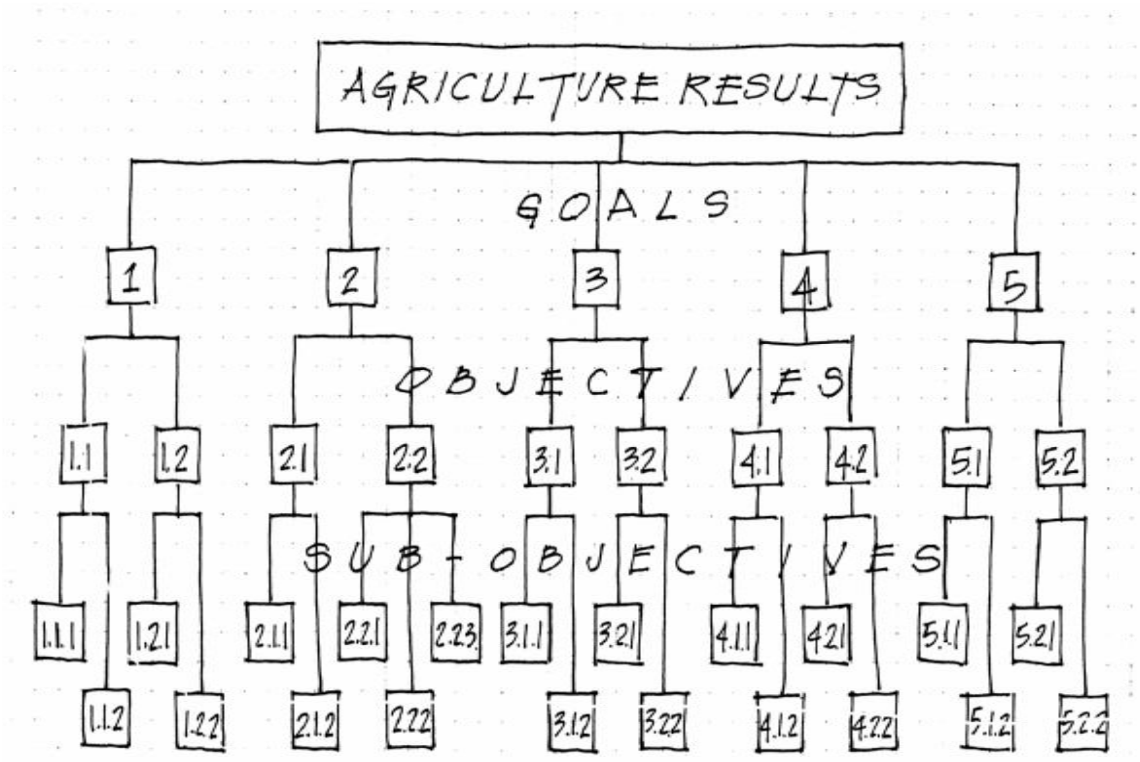


Figure 2-3. LUCIS hierarchical structure

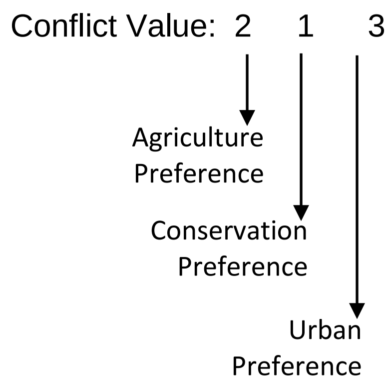


Figure 2-4. LUCIS preference

CHAPTER 3
METHODOLOGY

The ability of a single new idea to seamlessly integrate itself into multiple industrial sectors is the product of a knowledge economy. Houghton and Sheehan characterize the emergence of the knowledge economy in terms of the "increasing role of knowledge as a factor of production and its impact on skills, learning, organization, and innovation" (Houghton and Sheehan 2000, 9). The solution for cities like Detroit or Cleveland isn't as simple as opening up a few engineering firms or research facilities and suddenly an explosion of economic growth occurs. Again, the purpose of this research is to identify physical and economic factors of urban economics that leverage land use suitability in the location of innovative industries. The outcome of this research is to develop two relative measures – one local and one regional – that reflect the opportunity available for innovative agents, in terms of people or industries, to locate to a particular region.

While some progress has been made in identifying cities that stimulate creativity to explain patterns of economic growth in knowledge based industries, no existing research has used land use suitability to justify similar growth patterns. The available body of research that identifies amenities as a significant influence on the location decisions of people and industries focuses on sociological factors as a means of determining regional advantages in the creative economy (Florida 2005, 76). These factors include diversity in local and regional populations, parks and open space, and cultural activities. Robert Putnam's social capital theory supports the idea that "regional economic growth is associated with tight knit communities where people and firms form and share strong ties" (Florida 2005, 30). Richard Florida equates amenities with more traditional factors of production that result in an increase in economies of scale. Florida believes that “resources like technology, knowledge, and human capital differ in a fundamental way from more traditional factors of production like land or raw materials; they are not fixed stocks, but transient flows. Technology and talent are highly mobile factors, flowing into and out of places” (Florida 2005, 5). Nevertheless, explaining the relationship between amenities and neo-classical definitions of economic factors of production in a knowledge based economy requires much greater emphasis on the role land use suitability has played in the development patterns of knowledge based industries.

Earlier research on the determinants of the motivation of innovative firm location and the preferences of their employees provided the framework for subsequent analysis (Donegan et al. 2008, Florida 2008, Florida 2002, Gottlieb 1995, Markusen 2006). Nevertheless, attention was limited to discussing the relationship between traditional economic and spatial theory and the changing spatial relationships needed for firms to thrive in a knowledge economy. As spatial data that more accurately illustrates physical features becomes more readily available, using spatial analysis methods that account for the intrinsic properties of land enable more detailed assessments of land use suitability. Nonetheless, little research has utilized land use suitability analysis to evaluate the determinants of innovative firm location.

Traditionally, the focus of economic growth has been at the national level, however Feldman and Martin point out that “research has shifted the focus to lower geographic units defined as clusters of industrial activities or alternately as regions. The literature suggests that economic growth is a local process and that cities [and counties] are an important, if not most important economic unit, in generating new development, competitiveness and prosperity" (Martin and Feldman 2005, 1). Regional economic development is a slave to the activities that occur within the counties and cities that operate within them.

In Gottlieb's relational model (Figure 2-2) he believed that firms only responded to a pre-existing labor force and quality of life was ignored in the location of an amenity-oriented firm. This study proposes that the pre-existing regional labor force, amenity value, and demographic trends create local environments conducive to the creation of new knowledge (Figure 3-1). Furthermore, understanding the suitability or appropriate opportunities for specific land use types aids in evaluating the tradeoffs associated with the location of employment centers at the local scale and influences more local location decisions.

Theoretical Study Area: Metro Washington, District of Columbia

Defining the scope of a region through urban structure is important in evaluating social and economic performance and provides a framework for policy intervention (Parr 2003, 14). The study area consists of two distinct geographic areas: metro Washington, DC and Pima County, Arizona. The metro Washington, DC region in this study consists of seven counties in Virginia and Maryland (Virginia: Alexandria City, Arlington County, Fairfax County, Fairfax City, Falls Church City; Maryland: Montgomery County, and Prince George's County) plus the District of Columbia. "Greater Washington is home to the most Inc. 500 fastest-growing private businesses in the U.S. – and has been for the past 13 consecutive years" (Greater Washington Initiative 2010). Over the past 15 years the Capitol region has experienced a significant shift from primarily federal employment to high tech industries, occupations, and products. According to the National Science Foundation, the metro Washington region leads the country in academic research and development funding and “ranks number 1 in the world for government research and development spending per capita, beating out Beijing, Shanghai and Berlin, as well as all other major metropolitan areas in the U.S.” (Greater Washington Initiative 2010). Maryland ranks second among U.S. states with regard to federal R&D obligations, ranks sixth in terms of federal R&D expenditures to academic institutions, and ranked fourth in the number of Small Business Innovation Research (SBIR) awards granted between 1995 and 2000 (Feldman 2007, 242).

Comparative Study Area: Pima County, Arizona

Unlike the metro-Washington DC megaregion, Pima County, Arizona has yet to be recognized as a major player in the larger national or western economy. The county seat of Pima County is Tucson and, although unofficially, is part of the Sun Corridor megapolitan region. Recently, more studies have suggested the growing benefit for regional cooperation between Tucson and Phoenix. Even though the Sun Corridor would provide the largest concentration of economic power in the eight states of the Intermountain West (Sonoran Institute 2010), this study considers only Pima County. In addition to providing a basis for comparison for the regional comparison measure being developed, the outcomes of this study will support or reject further discussion concerning the need or benefit of regional economic development.

Also unlike the Washington, DC region the Pima County region is self-contained within one county. Pima County contains four municipalities and an unincorporated area. The municipalities are: Marana, Oro Valley, Sahuarita, South Tucson, and Tucson. The county has experienced a steady rate of population growth for the past 20 years with significant growth in the municipalities of Sahuarita and Marana, primarily due to incorporation. The Town of Sahuarita was incorporated in 1994 and originally covered approximately 9 square miles. Today, the town boundaries encompass more than 29 square miles. The Town of Marana was incorporated in 1977 but after starting out as a town of about 10 square miles and a population of about 1,500 townspeople an aggressive annexation policy and access to water from the Colorado River in 1992 has supported additional growth and burgeoning populations. Today Marana covers almost 120 square miles and has a population of over 34,000 people.

Researchers from the Sonoran Institute (2010) believe that Tucson's role in the larger regional economy is to provide an environment conducive to small- and medium-sized high-waged industries. Tucson offers a lower cost of living that cities such as Phoenix or those within the metro-Washington, DC region and by catering to smaller enterprises local planners believe that fewer infrastructure improvements will be needed. Compared to the Capitol region who ranked 4th, in 2008 Tucson ranked 55th in population with a little more than 1 million residents (Sonoran Institute 2010). Among all the attributes that contribute to an innovative system the current status is not very promising in Tucson. Between December 2006 and December 2008 Tucson experienced a higher job loss rate, 2.8%, than the national average, 1.5%. The average annual pay lags behind the national average and other cities in the West and the percentage of Tucson workers with a college degree continues to be low by comparison to other western cities (Sonoran Institute). In 2007, the Tucson Regional Economic Opportunities Inc. (TREO) released a blueprint identifying five areas needed to develop a more competitive economy: high skilled/high-wage jobs, educational excellence, livable communities, urban renaissance, and collaborative governance and stewardship.

All of these areas are included in this research study as key aspects of developing an innovative system.

As stated previously, the metro-Washington, DC region is the baseline to which Pima County will be compared. Questions may arise concerning the scale of comparison, given that the innovative propensity of eight counties will be compared to the lone county of Pima. First, although Pima County could benefit from joining the Sun Corridor and leveraging the stronger Phoenix economy, there is strong political will against this idea. Locally, Phoenix and Tucson refer to each other as “us” and “them”. Therefore, there will need to be an overwhelming motivation for these two mini-regions to partner. Secondly, locally the “Tucson region” references the larger metropolitan city of Tucson and the suburbs of Oro Valley, Marana, South Tucson, Sahuarita, and Green Valley. Although these geographies are much smaller than a county scale, the relative measure of innovation and methods outlined below really illustrate the interaction between places. Lastly, the following two chapters, Analysis and Discussion, will outline the regional and local effects of innovation in the metro-Washington, DC region and discuss whether similar patterns are visible in Pima County and its suburbs.

Understanding the Innovative System: The Actors

Since growth pressure is directly related to population and employment, given an employment that facilitates new ideas, this study asserts that firms will follow the agents that create these ideas thus enhancing the regional economic climate and subsequently attracting new firms and people to the area. This study analyzes this relationship specifically for architecture and engineering firms.

Architecture and engineering are two sectors of industry as old as the world itself. Creating a seamless connection between the practical functions, the purpose and relationships of its various parts, and structural principles is the nature of building and design. Architecture and engineering are among a short list of industries in which an artistic expression has an infinite benefit across disciplines and applications. Kimball and Edgell state that “Certain expressions are even incompatible with others, and each fusion of expressions in a single building involves the sacrifice of many others, and is a unique creation” (Kimball and Edgell 1960, 6). A&E expands the bounds of rationality. These fields associate practitioners and researchers with specialists of other knowledge and expand the application of traditional measurement (Pinson 2004).

For data collection and standardization purposes, firms included in the architectural and engineering sector are those included in the NAICS category 541300. This level of sectoral data is available at the state, county, and metropolitan statistical area from the U.S. Department of Labor Bureau of Labor Statistics. Nationwide, the average annual salary for these occupations in 2007 is $66,280, which is significantly above the average American income in 2007 of $50,233. According to the Greater Washington Initiative, which includes a larger study area than that discussed in this research, there are over 71,000 employees within architecture and engineering occupations (Appendix B). Among these occupations, which range from landscape architects and cartographers and photogrammetrists to materials and electrical engineers, the average is $77,930. Nationally, the value added (in current dollars) of A&E has grown almost 100% since 1998 (Bureau of Economic Analysis 2010). “Value added is the contribution of each industry’s labor and capital to its gross output and to the overall gross domestic product (GDP) of the United States” (Bureau of Economic Analysis 2010). Over the next ten years the wage and salary growth of architecture and engineering industries will continue to rapidly grow, while industries associated with manufacturing will continue to decline (Appendix C).

A sample of A&E firms in both metro Washington and Arizona were obtained from three different sources: Brian Spivak at Arizona State University, Site to do Business online (www.stdb.com), and Dun and Bradstreet data. Data from the first two sources are based upon information gathered from InfoUSA. For the sake of standardization, unless otherwise noted, total A&E population estimates will be based upon this data. To illustrate the saturation of A&E firms in the metro Washington region, Table 3-1 illustrates the number of A&E firms per capita compared to that of Pima County.

Understanding the Innovative System: Methods

This research project integrates qualitative, quantitative, and spatial methods to accomplish methodological triangulation. This type of mixed method research involves "the use of different methods to analyze a specific situation" (Gaber and Gaber 2008, 136). More specifically, this project is a between-method investigation, which "combines dissimilar methods to examine a particular situation" (Gaber and Gaber 2008, 136). The research methods described below use descriptive, predictive, and evaluative analytics that reduce the complex system of an innovation economy into elementary units. These elements facilitate the development of a detailed analysis to understand the types of interaction between spatial and aspatial determinants.

Additionally, this research examines the innovative network of the metro Washington, DC region and through spatial analysis and descriptive statistics determines the temporal and spatial significance of possible explanatory factors for innovative agents, inputs, and outputs of A&E firms. Once explanatory factors for innovation have been stated, the innovative capacity for Pima County will be determined. Given the factors that encourage innovation in the Capitol region, this treatment will be applied to Pima County to determine whether its impacts the innovation potential of A&E firms across the region and locally.

Geographical dynamics limit the development of a “universally applicable panacea for cities, regions, and nations, to develop a creative economy” (Eflin 2008, 63). Gottlieb cautions the transferability of the results in a model such as the one described in this study. It is easy to find a region with similar characteristics as the New Jersey region Gottlieb studied and transfer his conclusions regarding the relationship of amenities, business factors and firm location to another area but he warns the political climate significantly influences development (Gottlieb 1995, 1416). Economic expansion through innovation can only be achieved by creating activity systems that facilitate the cluster or agglomeration of clusters of particular industries by investing in attributes that make it particularly attractive to firms and talent in those clusters. Not all cities and regions will succeed with similar strategies. The key lies in diversity, not copy-cat strategies to attract the most current vogue industries (Feldman and Martin 2004).

Additionally, the usefulness of data is also determined by the spatial extent of information available. For example, the study area for my research is the Capital Region, which is comprised of the following locales: Washington, DC, Prince George’s County (Maryland), Montgomery County (Maryland), and Fairfax County (Virginia). For data available (e.g. High Tech Manufacturing Employment) available at only the Metropolitan Statistical Area (MSA) scale, the data would not be useful for two reasons: (1) the Washington MSA includes the counties in my study area but is also comprised of three additional counties in Maryland and nine additional counties in Virginia; and (2) the data at such a gross scale would not allow me to understand the sensitivities that exist within my study area due to the influence of the High Tech Manufacturing Employment data.

Data

Independent variables were chosen from readings of the survey literature on amenities based location, econometric literature on intra-metropolitan firm location, literature for high technology firm location, and the literature on the place-based location preferences of scientists and engineers. The goal was to select business and amenity variables studied previously and variables that matter in business geography decisions.

Research results, implications, and conclusions are most directly affected by spatial units. The spatial component in this research project relies heavily upon geo-spatial data at a parcel or smaller scale to capture the complex relationships between dependent and independent variables. Therefore, to take advantage of the micro- and macro-scales of data that measure innovation, during analysis that integrate both economic and amenity based factors data will be summarized up to the smallest common spatial unit. Analysis in this research project will be assessed using a raster-based GIS. In raster GIS, decision problems involving multi-objective or multi-attribute land use allocations “correspond to finding the most suitable raster cell(s) for the siting of a single activity” (Cromley and Hanink 2003, 343), or in the case of my research, to determining the opportunities for creative employment.

Using variable scale data for modeling doesn’t pose problems because of model analysis but is significant in drawing conclusions about the effects of your data on whatever you are testing. For example, land value is a factor that will be represented by a continuous raster surface. Each raster cell in that surface will have a unique land value. Additionally, the geographic location of cultural and entertainment facilities is currently available as a static vector format. In my analysis, land value and cultural and entertainment facilities will be evaluated together creating a common scale is imperative in analysis. This common scale is achieved by using the same raster cell size for all data within my analysis and ensuring that all data represents the same spatial extent. For discrete locations that may not have continuous values over the entire surface, cells outside of those with a value representing a specific feature is given a dummy value so that in the end all datasets used are on the same scale; each dataset has a representative cell over the exact same extent with a unique value. Conversely, scale becomes a significant issue when drawing conclusions over the urban landscape. The smaller the unit of input data, the more likely sensitivities in the pattern of development can be identified. “The urban landscape is highly irregular when viewed at a fine scale, and how one averages these local irregularities determines the look of the resulting pattern” (Anas, et al. 1998, 1440). The number, size, and arrangement of employment densities (sub-centers) are spatial scale and definition.

The temporal and physical dimension will be examined within each innovative component (i.e., innovative agent, innovative input, and innovative output). The temporal dimension examines the relationship and trends of the independent variables over time. More importantly, the temporal dimension is used as a way to analyze the regional impact of each variable. Theoretically, it is an application of putting the horse before the cart; before innovation can blossom from smaller microclimates the larger (regional) environment must be conducive to growth and expansion.

The spatial dimension serves two purposes. First, to validate local responses to regional variables (i.e., the relationship between A&E firms to education, demographics, income, etc.). Once it has been determined that the regional climate can support innovative endeavors the spatial aspect identifies microclimates or more localized networks which offer the greatest opportunity for innovative firms.

Innovative Agents: Temporal

As stated above, the metro Washington, DC region has evolved into a metropolitan area well-known and well-respected for its growth in research and high-skill employment. Using census data for 1990, 2000, and 2008 a correlation between A&E business patterns and demographics is determined. Specifically, residents within the 20-54 age range are compared. Although innovative agents continue to create and explore new ideas past the age of 54, the rate of innovation decreases with age. Younger agents tend to be less focused and may develop many dissimilar processes that further an exponential number of new products, but as the agent gets older time and experience begin to narrow the focus of product creation. The coefficient of determination is then calculated for each age group to determine the percentage of variance in the business pattern variable that is accounted for by the variance in each age range variable.

Although not all agents need formal training to create, a connection with a research institution enables the agent to explore new ideas with financial support. The provision of research funding for post-secondary education is related to level of degree. Therefore, the lower the level of degrees the less funding available for research. Using data provided by the University of Arizona Career Services, the study considered disciplines most associated with architecture and engineering and determined an educational conferred factor (ECF) that considers the influence of degrees awarded in the following fields: agriculture, architecture, engineering technology, engineering, and natural resources and conservation. The degrees included within each discipline vary according to the institution. Table 3-2 summarizes the range of degrees awarded in each discipline for the 26 schools within the metro Washington, DC region and Pima County. Using data from the National Education Administration, a count of conferred degrees at the certificate, associates, bachelors, masters, and doctorate level was recorded. A weight was applied to the total number of degrees awarded at each level (Table 3-3). An average ECF for all schools within each county was calculated. Alexandria City and Fairfax City were aggregated to Arlington County and Falls Church City was aggregated to Fairfax County, since they are consolidated metropolitan areas and not true counties.

Although some of the disciplines listed in Table 8 seem outside the scope of NAICS 5413, when sub-sector products and line of work is examined for existing A&E firms within the study area these fields are deemed appropriate. Example line of business descriptions include Mechanical Engineering Consulting, Building Construction Consultant, Architectural and Interior Design Service, and Engineering Services: Civil.

There are two measures of education used in this study. The first, described above, determines the relationship between degrees conferred and presence of A&E firms using business pattern data from the Economic Census. The second measure is the educational attainment factor (EAF). Educational attainment measures population characteristics whereas degrees conferred measures characteristics of the educational institutions in the region. The EAF and ECF will be compared using basic descriptive statistics to note differences/similarities in the educational level of the general population vs. those of a specific demographic group. Using a regression, the relationship between educational attainment and business patterns was measured temporally for the years 2008, 2000, and 1996.

Innovative Agents: Spatial

Ideally, this project would include a spatial analysis of the variables examined temporally for innovative agents. Using spatial autocorrelation, two demographic spatial relationships were measured to determine the degree of clustering or dispersion. These measures were 1) the location patterns of county residents between the ages of 20 and 54, and 2) income. Spatial autocorrelation "compares the attribute values between neighboring features to the distribution of values for the dataset as a whole" (Mitchell 2009, 107) given a continuous set of data. In areas indicating clustering spatial descriptive statistics are determined against existing A&E firm locations.

Innovative Inputs: Temporal

Innovative inputs introduces the concept of standardizing the dependent variable, in this study architecture and engineering firms, to control for the size and economic base of each municipality (Gottlieb 1995, 1418). The dependent variable will be standardized in two ways. First, the employment in the architecture and engineering sectors will be measured as a function of density. As in each innovative production phase, temporal and spatial measurements are employed to determine employment density. The second method to standardize the dependent variable calculates professional service employment in architecture and engineering sectors relative to other firms measured using the location quotient. Gottlieb notes the advantage a location quotient yields in a cross sectional analysis stating, "Total employment in any municipality is heavily influenced by a number of factors, including agglomeration economies, competition with residential locators and zoning. The [location quotient] effectively controls for fixed-area effects that influence business location in general, rather than the composition of industry" (Gottlieb 1995, 1418).

Previous research indicates numerous methods to identify employment centers. McDonald (1987) introduced the first formal procedure for identifying sub-centers (McMillen 2001, 17). By estimating a simple employment density function, McDonald creates a linear relationship between the number of employees per acre and distance from the CBD. Sub-centers are then identified as clusters of positive residuals in the estimated function. Giuliano and Small (1991) also propose a method that defines "a sub-center as a set of contiguous tracts that have a minimum employment density of 10 employees per acre each and, together, have at least 10,000 employees" (McMillen 2001, 18; Giuliano et al. 2007, 2939). Both of these approaches suffer from several significant flaws. The definition of 'cluster' or 'sub-center' is subject to interpretation and the results are sensitive to the unit of analysis. In McDonald's model the definition ultimately affects the number of residents that are classified as a sub-center. In Giuliano's model the lack of precision of the definition encourages arbitrary cutoffs for employment density and jobs, leading to the identification of fewer centers. If a sub-center is an area of large employment then the extent of the sub-center may include several contiguous tracts but because of their density are disproportionate in size to tracts in surrounding areas. "The local rise in employment density produced by a sub-center tends to flatten the estimated employment density function, which reduces the probability of identifying sub-centers" (McMillen 2001, 17). For both models McMillen states that “local knowledge must guide the choice of cutoff points, limiting the analysis to familiar metropolitan areas” (McMillen 2001, 18).

Craig and Ng use a nonparametric estimation procedure to obtain smooth employment density estimates, eliminating many of the problems with earlier methods (McMillen 2001, 18). “Using a quantile regression approach, they focus on the 95th percentile of the employment density distribution. The quantile regression approach is attractive in this context because a subcenter is defined using the extremes of the distribution” (McMillen 2001, 18). This method is not as sensitive to the unit of analysis as those mentioned previously and is readily reproducible by other researchers. This method also requires little knowledge of the local area. McMillen states that the arbitrariness caused by the McDonald and Guiliano-Small methods is “eliminated because the local rise that defines a subcenter is subject to tests of statistical significance” (McMillen 2001, 18). For this research project, I will identify employment centers as Craig and Ng describe.

Developing a methodology for measuring the spatial patterns of innovation is often difficult. Traditional methods involve using case studies and in the 1980s quantitative methods were introduced using indicators of geographic concentration. A fundamental argument supporting innovation geography is that spillover and the transfer of knowledge is the catalyst to creativity and economic growth. From the arguments presented previously in the review of literature, spillover is most successfully achieved when relational industries are located in close proximity to one another. From previous innovative geography research measures of concentration can be divided into two categories: concentration indicators that do and do not measure spillover.

From the review of Ratanawaraha and Polenske (2007), they concluded that there is no single indicator or measure that is ideal to measure innovation (Table 3-4) (Ratanawaraha and Polenske 2007, 54). They recommend that “for a concept as complex as innovation, analysts need to consider the multi-dimensional economic, social, and political context within which innovation occurs” (Ratanawaraha and Polenske 2007, 54). For this study, a comparison of location quotients was used to measure spillover in the study region.

“An LQ greater than one indicates that there is an above-average proportion of employment in a given industry in a given area” (Fingleton 2007, 69). The shortcoming of the LQ in measuring clusters is that, according to Fingleton, “it captures whether an area has a higher or lower share of a particular industry than the national share, but does not include any information related to the absolute size of the industry in that area” (Fingleton 2007, 69). This problem can be resolved using a method developed by Fingleton, Igliori, and Moore which takes into account the relative local importance of an industry and the size of the agglomeration in terms of number of jobs. “Cluster intensity is defined as the number of jobs in the local industry that exceeds its expected number. The expected number is then defined by the number of jobs in the industry that would correspond to the area having the national share of the industry and therefore produce a LQ equal to one” (Fingleton 2007, 69). Fingleton calculates cluster intensity, also known as horizontal clustering (HC), by dividing the employment in industry i in area j by the area, A, in each jurisdiction. This is represented by $HC = \left(\frac{E_{ij}}{A}\right)$. Fingleton admits that although “this equation does not take into account the relative employment concentration with regards to the national average it does capture the mass effects, which could be responsible for the generation of positive externalities advocated in cluster literature" (Fingleton 2007, 71).

Innovative Inputs: Spatial

The capacity to innovate is based upon how knowledge is dispersed and the organization of firms in space. As mentioned previously, the dependent variable will be standardized using density. This density is representative of employment centers. Empirically, employment centers are not an appropriate measure or description of the distribution and concentration of employment. Giuliano et al. (2007, 2938) identifies extensive research that larger US cities have become polycentric using definitions of job density and total jobs to define employment concentration. Additionally, Gottlieb believes the use of polycentric regions facilitate the firm location (Gottlieb 1995, 1416). Parr believes that the "economic efficiency of [polycentric regions] spatial structure is superior to alternative spatial structures, or at least no worse" (Parr 2003, 16).

Understanding the distribution and concentration of innovative firms will result in a greater understanding of whether the mechanisms that facilitate clustering are significant. As Giuliano et al. (2007) illustrated in their research, "if, for example, advancements in communication technology and lower transportation costs are indeed reducing the need for clustering then we should see an overall reduction in employment concentration: fewer and less dense employment centers" (Giuliano et al. 2007, 2938). But a static analysis of distribution is "unable to predict the consequences of discontinuous changes in the traditional way of doing things; it can neither explain the occurrence of such productive revolutions nor the phenomena which accompany them" (Schumpeter 1934, 62).

Due to a lack of temporal spatial data, a comparison of the distribution over time was not available. As mentioned previously, firm locations were provided from three different sources: Brian Spivak at Arizona State University, Site to do Business online (www.stdb.com), and Dun and Bradstreet data. Firm location data provided by Site to Do Business included a business inception date but did not indicate when or if the business failed. Therefore, this information was excluded from the analysis to reduce error. This study measures the impacts and transaction costs resulting from the concentration and location of A&E firms in the goals and objectives within the land use conflict model.

Innovative Outputs

In the review of literature two research projects stood out which measured innovation capacity, a similar goal of this research. The first completed by Hall (2007), uses factor analysis to isolate "shared variance among a set of variables and then groups individual variables into new uncorrelated variables referred to as common factors" (2007, 112). In this work, patents are removed from determining capacity since it follows rather than precedes innovation. A similar process is followed in the work of Acs et al. (2002) where patents were used to explain the relationship of regression variables.

This study uses a combination of the two methods. First, this study employs factor analysis to reduce the variables identified as significant for innovative inputs and innovative agents. The principal component analysis (PCA) factor method is used because it gives the original factors in terms of differences and similarities between the factors. Theoretically, the first two production phases of innovation, inputs and agents, should lead to innovative outputs. Therefore, a regression equation that includes innovative inputs and innovative agents will be used to predict the innovative outputs, or patent counts. The differences in the predicted score and the actual number of patent counts for each county and regionally, also known as the error of estimate, will be used to validate how appropriate the use of patent counts is in predicting the outcomes of innovation.

The calculation of innovation outputs in this study is used more as a validation tool than as a true measure of innovation capacity for one primary reason. The patent data that was collected was based upon patents granted during the following year increments: 1989-1990, 1999-2000, and 2007-2008. All data was collected from the United States Patent and Trademark Office (USPTO) through the online search tool (http://www.uspto.gov/patents/process/search/index.jsp). Filings through the USPTO are only published when a patent is granted. Furthermore, patents may not be granted within eighteen months, the typical time period for application processing and new methods could be in use before formal approval is given by the USPTO. Also, patent information is not available by county. Patent information was retrieved according to major cities included in the sample of A&E firms used in this study. Therefore, it is possible the patent counts represent a sample of the total patents available for a county then the error of estimate would be based upon a sample patent count and not an actual count.

Suitability Analysis and Economic Opportunity

The variables introduced to this point describe the relationship of variables that reduce barriers to entry. The variables and statistical values calculated do not indicate where the specific networks or microclimates that offer the greatest opportunity for information exchange and may ultimately yield the greatest productive value. By using key elements of the LUCIS method as factors of innovation, opportunities for innovative networks are identified.

The LUCIS method as applied to economic models uses the first tier of the LUCIS method with a modified second tier. The first tier consists of the process to determine land use conflict. The process includes 1) determining land use suitability based upon the pre-determined goals and objectives; 2) determining land use preference; and 3) identifying conflict. In the standard LUCIS process the second tier consists of the allocation of employment and population in the development of alternative futures. The second tier in this study employs the Combine Grid for allocation but consists of different variables that facilitate the allocation of innovative employment in areas that present the greatest opportunities for innovative networks.

The standard LUCIS^{plus} Combine Grid uses of the following layers in scenario building:

- Transit access layer
- TAZ layer
- Political Areas
- Developments of Regional Impacts (DRI) (if applicable)
- Clustering

These layers describe typical considerations of residential and employment location. For example, priorities may be given to allocating a specific population into DRIs based upon phasing plans approved by the regional planning agency. In the location of innovative employment the rationale of location is a bit different. Although it is easy to allocate employment into particular areas because of directed capital investments or regulatory incentives, these mechanisms ignore the dynamic system created by the natural organization and presence of amenities and innovative system.

The modified Innovation LUCIS^{plus} Combine Grid uses the following layers in scenario building:

Transit access layer. The traditional LUCIS^{plus} model uses the following methodology to determine transit access (Arafat, Zwick, and Patten 2010):

- Calculating the network distance from the upstream nearest stop to job related stops downstream
- Calculating the distance from the downstream stop to the job location
- Calculating the job opportunity associated with downstream stops
- Applying the gravity model to calculate an accessibility index for each stop
- Summarizing the transit scores within walking distance from parcels using an opportunity/distance accessibility model
- For simplicity, this model utilized the determined transit access by calculating Manhattan Distance

TAZ layer. Used for aggregation of final employment

Political areas. The traditional LUCIS^{plus} model uses the Political Areas field to apply a geographic weighting in the prioritization of employment and residential allocation

Firm Density (IP_Density). Describes the A&E firm density by census tract (unit of measurement is # of firms/square mile)

Average values for transit access and service suitability were taken in census tracts with A&E firm densities within one standard deviation of the mean. The PCA is then re-run twice: once using the average values for transit access as the predicted value, by county; and secondly re-run using the average transit access value as the predicted value.

Final Multiple Regression Equation. The first PCA analysis examines the relationship between all of the variables deemed “significant” and measures the degree of contribution to the innovative outputs using longitudinal data. The second and third PCA analysis, which integrates the spatial component, measures the ability for actual on-the-ground innovative networks to be created and describe the microclimates in which innovative firms prefer. To determine innovative economic opportunity a two-step process is employed:

1. A regression equation is formed using the variables included in the first PCA analysis to understand the regional context for innovation. Coefficients of the regression equation are based upon the PCA values in the reference region, the metro-Washington, DC region.
2. A regression equation is formed using the transit access, firm density, and average service suitability values, again, using the values from the PCA as the coefficients for the regression equation.

The following chapter, Results & Analysis, will discuss in detail the outcomes of each step described in this Methodology for the metro-Washington, DC region and Pima County.

Table 3-1. A&E firms per capita

County	A&E Firm Population	2008 Population	A&E Firm (per capita, in thousands)
Alexandria City	224	140,657	1.6
Arlington County	308	204,889	1.5
District of Columbia	733	588,373	1.2
Fairfax County	1,403	1,005,980	1.4
Fairfax City	116	23,281	5.0
Falls Church City	37	11,169	3.3
Montgomery County	1,306	942,747	1.4
Prince George's County	118	825,924	1
TOTAL	**4,245**	**3,743,020**	**1.1**
Pima County	539	1,018,012	0.5

Table 3-2. Degrees and disciplines considered for architectural and engineering industries

Discipline	Degrees Included
Agriculture, Agricultural Operations, and Related Services	Landscaping and groundskeeping
Architecture and related services	Architecture, Landscape Architecture
Engineering Technologies/Technicians	Engineering/Industrial Management; Computer Engineering Technology/Technician; Architectural Drafting and Architectural CAD/CADD; Computer Technology/Computer Systems Technology; Aeronautical/Aerospace Technology/Technician; Civil Engineering Technology/Technician; Construction Engineering Technology/Technician; Electrical/Electronic Engineering Technologies/Technicians, Other; Electromechanical Instrumentation/Maintenance Techs, Other; Water Quality & Wastewater Treatment Mgmt & Recycling Tech
Engineering	Civil Engineering, Other; Computer Engineering, General; Computer Software Engineering; Electrical, Electronics and Communications Engineering; Engineering, Other; Systems Engineering; Aerospace, Aeronautical & Astronautical Engineering; Agricultural/Biological Engineering & Bioengineering; Chemical Engineering; Engineering, General; Engineering, Other; Materials Engineering; Mechanical Engineering; Architectural Engineering;
Natural Resources and Conservation	Environmental Science; Environmental Studies; Natural Resources Management and Policy; Natural Resources/Conservation, General

Table 3-3. Education factor for weight distribution

Degree	Education Factor Weight
Certificate	0.067
Associates	0.134
Bachelors	0.201
Masters	0.268
Doctorate	0.335

Table 3-4. Traditional measures of concentration

Concentration indicators that DO measure spillover	Concentration indicators that DO NOT measure spillover
Location Quotient (LQ)	Ellison-Glaeser Geographic Concentration Index (EGGCI)
Horizontal Clustering Location Quotient (HC)	Geographic Coincidence (Concentration) Index (GCI)
Locational Gini Coefficient (LGC)	Gene-Related
Herfindahl-Hirchman Index (HHI)	

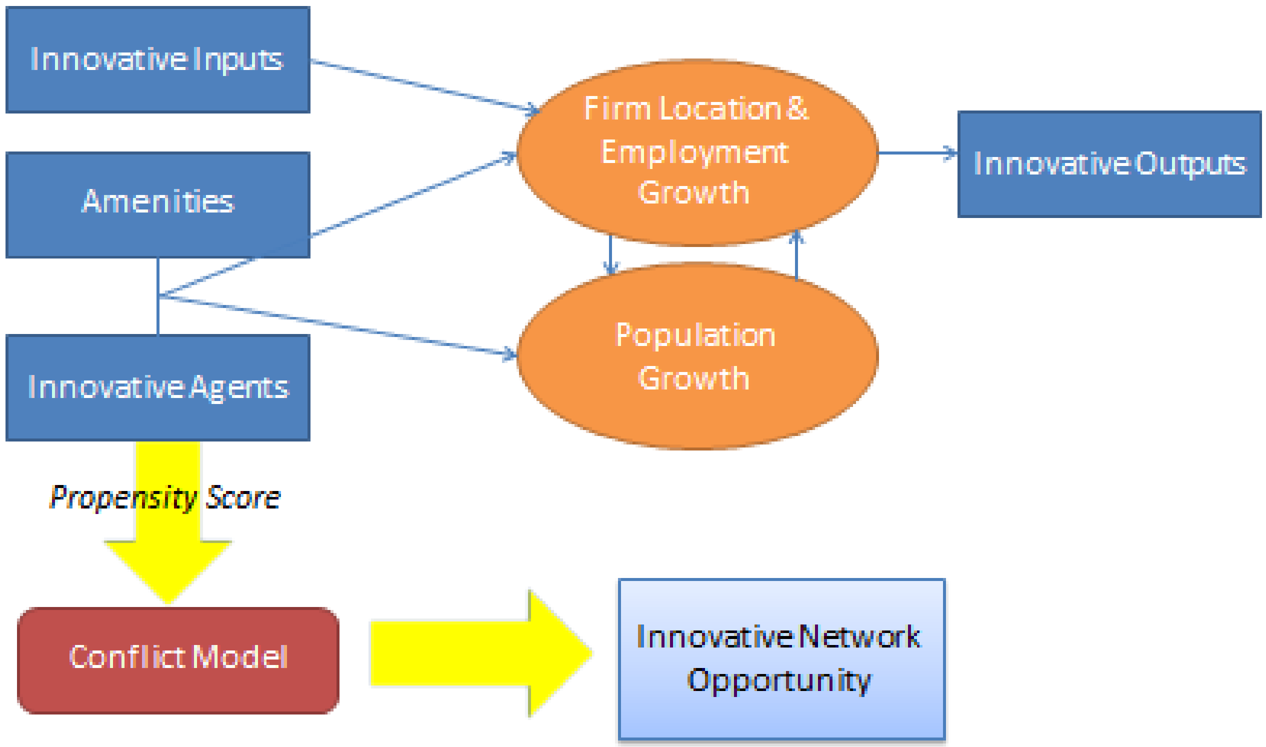


Figure 3-1. Proposed theoretical model

CHAPTER 4
RESULTS AND ANALYSIS

Capitol Region – Innovative Agents

As stated in the literature review, existing human capital is fundamental to Gottlieb's base model of innovation dynamics. More importantly, finding a region with an ample supply of young and growing population provides greater meaning to the dashed lines connecting overlap between business factors and amenities to firm location and employment growth. The null hypothesis for innovative agent's states: There is no relationship between innovative agents and the location of A&E firms.

The Capitol region has experienced a steady rate of population growth for the past 20 years. Table 6 illustrates that between 1990 and 2000 the Capitol region experienced a cumulative growth of about 11% and through 2008 growth was much slower at 5%. Demographically, there was a decline in population of 20 to 24 year olds in all counties within the region from 1990 to 2000. During this same time period there was a decline in population among 25 to 34 year olds except in Alexandria City and Arlington County, among 34 to 44 year olds there was an increase in population in all counties except in the District of Columbia and Falls Church City, and all counties during this decade experienced an increase in population among 45 to 54 year olds.

The following decade offered more promise for all age cohorts. Among 20-24 year olds between 2000 and 2006/2008, all counties experienced an increase in population except Alexandria City, Arlington County, and Fairfax City. Among 25 to 34 year olds all counties declined in population except the District of Columbia and among 35 to 44 year olds the District of Columbia, Fairfax County, Montgomery County, and Prince George's

County all experienced population declines. Among the last age cohort, 45 to 54 year olds, all counties saw an increase in population.

Regionally, from 1990 to 2000 there was a cumulative loss in population only among the 20 to 24 year olds and among the 25 to 34 year olds. During this decade 45 to 54 year olds experienced the largest gain in population and 25 to 34 year olds experienced the largest decline in population with 150,932 people and -69,843, respectively. During 2000 to 2006/08, there was a loss in population among 25 to 34 year olds and 35 to 44 year olds. The greatest population gain was among 45 to 54 year olds and the greatest decline was found among 25 to 34 year olds with 58,913 and -87,278, respectively.

Although the decline in residents during 2000-2006/08 is noteworthy, remember that general Census demographic data reflects the residential location of individuals. Housing opportunities in the Capitol region beyond the counties included in this study were better than those available within the included counties and residents were willing to live further and commute into the metro Washington, DC region. This is evident in data listed in Table 4-1, which illustrates the county of residence for firms located within each study area county.

What's most significant about innovative agents and firm location is the availability of young, educated workers. The relationship between the number of firms and the age composition for each county was calculated using a regression to determine if in fact a relationship existed in the Capitol region. Firm location information was based upon business pattern data provided in the Census Business Statistics for 2008, 2000, and 1998. To measure this statistical relationship the hypothesis is restated and a research hypothesis is given: the regression equation does not account for a significant portion of the variance in the location of A&E firms. Unfortunately, a direct comparison to parallel time periods was unavailable for 1998 so this study used 1990 demographic data in this comparison. First, a scatterplot of business patterns against population quickly illustrated the correlation between both variables. The log of the raw business patterns and population data was taken to normalize the data. For each age cohort the figures used were the cohort population as a percentage of the total county population. Appendix D illustrates the scatterplots for 1990, 2000, and 2008 for each age group. Table 4-2 summarizes the correlation between these two variables and the direction of the relationship.

Given the three time periods this study examines, no strong relationship was evident between any age cohort and business patterns. Although it is important to note that the strength of the relationship increased as time progressed. The greatest increase in strength was noted in the 20 to 24 year old and 35 to 44 year old age cohorts, which illustrated a direct and indirect relationship, respectively.

The foundation of this research is to predict innovation based upon various variables described in the Methodology section. Essentially this study contends that given independent variables that describe innovative agents, innovative inputs, and innovative outputs business patterns in our study region can be predicted. For innovative agents a regression is used to predict the business patterns given the population within each age cohort. The following equation is used in this prediction:

Log (# of businesses) = Log (total population) + % of each age range of total population

This equation describes the contribution of each age range to business firm location, by county, while adjusting for total population.

The resultant regression statistics for the age cohorts (Appendix E) during the three time periods indicates that a high percentage of variation in business patterns is explained by the relationship between the total county population and population of that specific cohort. The adjusted R square more accurately reflects the bivariate relationship of the degree of fit in the population. The adjusted R square values in Table 4-3 indicate that in 1990 and 2000 age described business patterns to a greater degree than in 2008.

A 95% confidence interval was used in the regression analysis. The F-ratio critical ratio for 2008 with n=7 has df =2, 4 and a critical value of 6.94. For all 2008 age groups, the F statistic is less than the critical value therefore we fail to reject the null hypothesis.. The F-ratio critical ratio for 2000 and 1990 with n=8 has df=2, 5 and a critical value of 5.79. The F-ratio critical value in 2000 for the 20 to 24 year old and 35 to 44 year old cohorts in addition to all cohorts in 1990 were greater than the critical value therefore rejecting the null hypothesis. Therefore, as time has progressed the age cohorts examined in this study have explained less of the variation in A&E business patterns.

In space, spatial autocorrelation was used to determine the degree things near each other were more alike than things far apart. Spatial autocorrelation indicates “whether the distribution of values is dependent on the spatial distribution of the features” (Mitchell 2008, 105). Positive autocorrelation results when nearby features are more like each other than they are like more distant features. Negative autocorrelation is when neighboring features are unlike each other. No autocorrelation results when there is a random pattern among features (Mitchell 2008). The advantage to using this statistic is that it can handle continuous data like age although spatial autocorrelation doesn't indicate if clustering is for high values or low values.

Using Census 2000 data the age cohorts in the Washington, DC, Virginia and the Maryland counties the Moran's Index indicated clustering. For Fairfax City, Arlington County, and Alexandria City the Moran's Index indicated a random distribution of age. ArcGIS also produces a z-score when spatial autocorrelation is calculated to indicate confidence of the spatial statistic. The analysis of the age cohorts will demonstrate whether the data is randomly distributed.

Assuming a 95% confidence limit, the z-score for all age cohorts except Fairfax City and Arlington County are outside of the -1.96 to 1.96 range, thus indicating that the null hypothesis cannot be rejected.

An additional argument used to support attracting creative industries to cities is that they provide higher wages than non-knowledge based industries. An example is in the case of A&E firms in which the average salary is higher than the national average for all industries. Once again, Washington, DC and the two Maryland counties indicated a clustered distribution for median income, whereas the three Virginia counties illustrated a dispersed pattern with z-scores within the 95% confidence limit indicating that null hypothesis cannot be rejected.

An educated population is not only beneficial for municipalities in attracting new employment but the educational level attained by a population can influence available services and amenities. As described in the Methodology, the Educational Attainment

Factor (EAF) was calculated reflecting a county's educational attainment for the general population. Greater weight was given to more advanced degrees, thus the higher the factor the more residents with advanced degrees. Similarly, the ECF was calculated based on the actual number of degrees awarded by universities in each county. Unlike the age cohort data, degrees conferred were available for each respective year represented in the longitudinal study. Therefore, for 1998 business patterns degrees conferred were used from the 1997-1998 academic year. Table 16 shows the EAF, ECF, and A&E business patterns count for each county in which there are universities with disciplines related to A&E. During each of the three time periods the educational attainment of the county is greater than that of the average number of degrees awarded by universities in that county.

A scatterplot of business patterns against the educational attainment factor quickly illustrates the correlation between both variables. Appendix E illustrates the scatterplots for 2008, 2000, and 1990 for each time interval. Table 4-4 summarizes the correlation between these two variables and the direction of the relationship, which is weak and indirect.

For the educational attainment factor a regression is used to predict the business patterns for each year. The following equation is used in this prediction:

Log (# of businesses) = Log (total population) + educational attainment factor

This equation describes the contribution of the level of education to business firm location, by county, while adjusting for total population.

The resultant regression statistics for the three time periods (Appendix F) indicates that as time progresses the percentage of variation in business patterns explained by the county educational attainment decreases. The adjusted R square values in Table 4-5 indicate that in 1990 and 2000 the educational attainment of the county in which A&E firms were located accounted for more than half of the variation in firm location.

A 95% confidence interval was used in the regression analysis. The F-ratio critical ratio for all three time periods with n=8 has df=2, 5 and a critical value of 5.79. The F-ratio critical value in 1990 is greater than the critical value which supports a rejection of the null hypothesis. The F-ratio critical value in 2000 and 2008 is less than the critical value, resulting in a failure to reject the null hypothesis. Therefore, as time progressed the linear relationship between educational attainment and business patterns have decreased.

Capitol Region – Innovative

A random sample of A&E firms (Table 4-6), the dependent variable, was used in this study to reflect innovative inputs.

Spatially, the dependent variable was standardized as a function of density in each census tract (Figure 4-1). The magnitude of the z-scores indicate that census tracts with the number of A&E firms furthest away from the mean are located in the District of Columbia or within one mile of the DC boundary. For each county, the average nearest neighbor was calculated to "measure how similar the mean distance is to the expected mean distance for a hypothetical random distribution" (Mitchell 2008, 88). The nearest neighbor index considers the relationship between features and indicates whether features are randomly distributed (i.e., the null hypothesis). In every county examined in this study (Appendix G), the nearest neighbor index indicates clustering and the z-score for each county indicates that the probability is less than 0.05, which translates into a rejection of the null hypothesis and the features are not randomly distributed.

The second method of dependent variable standardization uses the location quotient to determine the influence of A&E firms to determine their influence on the larger economy. Location quotient (LQ) values were collected from 2001, 2005, 2008, and 2009 (Table 4-7). All counties, except Fairfax City and Falls Church City, experienced a relative decline then increase over the course of the eight year time period. No county rebounded to its highest LQ value except Washington, DC. Additionally, in all study area counties there is an above-average proportion of employment in A&E. The highest proportion of employment for each of the four time periods remains within three counties: Arlington County, Fairfax City, and Fairfax County.

In addition to the LQ, Ratanawaraha and Polenske (2007) identify various other methods of concentration that also measure knowledge spillover. This study calculated the horizontal clustering (HC) location quotient for each metro DC county. Horizontal clustering also indicates cluster intensity. Given the total number of A&E firms in a county, Table 4-8 details the HC quotient for each Capitol Region county. The HC quotient measures the cluster intensity of employment per unit area. Although it is easy to translate this value as a measure of concentration/dispersion of innovation this value does possess two weaknesses. First, the accuracy of the results is based upon the disaggregation of the sectors, also known as 'aggregation bias' (Ratanawaraha and Polenske 2007, 47). This study analyzed A&E firms at the 4-digit sector level, which according to research completed by Ratanawaraha and Polenske, may reveal one or two subsectors of innovation. The second potential weakness is the inability to translate the results of the HC quotient to explain the degree of dispersion over the region.

Capitol Region – Innovative Outputs

For each aspect of innovation discussed thus far, innovative agents and innovative inputs, variables were identified that could explain the relationship with firm location. To reduce the variables examined in this study, factor analysis was used to determine which were important.

The hypotheses for innovative agents are:

- H_0: There is no relationship between innovative agents, amenity factors, and the intrinsic value of land in the creation of innovative networks.
- H_1: There is a relationship between innovative agents in the creation of innovative networks.

At the county level, firm location was examined given the following temporal variables:

- Age cohorts
- Education: degrees conferred and educational attainment
- Horizontal clustering quotient

The research hypothesis, H_1, is not specific since this study only focuses on three possible treatment conditions. The principal components analysis (PCA) results provide summary statistics and a correlation matrix (Appendix I). A&E firms have a moderately strong relationship to the 20 to 24 year old age cohort. For all other age ranges there is a weak or negatively correlated relationship. This means that businesses may be moving to the region for reasons aside from the demographics of the general population.

The eigenvalues resulting from the PCA exclude the 25 to 34 year old and 45 to 54 year old cohorts in 2008 because these two variables are negatively correlated. In 2008 the first three eigenvalues, business patterns, total population, and the 20 to 24 year old cohort correspond to more than 87% of the initial variability of the data. The correlation circle of axes F1 and F2 shows a projection of the initial variables in the factors space.

Patent data has been used in the past as a measure of innovative output. The factor scores from PCA for each county was used as the predictor for innovative agents in the regression equation for patent counts, the nearest neighbor ratio reflected the degree of clustering for innovative inputs, and the actual number of patents granted was the predicted value. The adjusted R square value of 0.737 indicates that the variability in patent counts is due in large part to cluster dynamics and innovative agents.

Theoretical Regional Regression Equation

The regression equation that describes the regional context of innovation (RCI) is:

RCI = 0.662 (log total population) + 0.628 (20 to 24 year old %) + 0.059 (25 to 34 year old %) – 0.560 (35 to 44 year old %) – 0.267 (45 to 54 year old %) – 0.122 (educational attainment factor) + 0.071 (educational conferred factor)

When the regression equation is applied to the test site a graph of the expected (predicted) outputs, as a function of patents, and actual outputs is available. The resultant graph demonstrates whether the region underperforms (below the regression line) or over performs (above the regression line) the regional innovative performance of the Capitol region. When applied to the metro DC region, the RCI index is:

RCI = 0.662 (6.572) + 0.628 (0.070) + 0.059 (0.130) – 0.560 (0.31) – 0.267 (0.30) – 0.122 (0.228) + 0.071 (0.067)

The resulting regional innovative value is 4.350 + 0.044 + 0.008 – 0.174 – 0.028, which equals 4.200.

Capitol Region – Innovative Networks

Using the LUCIS hierarchical framework as a guide, suitability was determined for the entire Capitol region. Although this study does not include future employment allocation, a conflict surface was created and a Combine Grid was assembled using the following fields:

- Census Tract
- TAZGrid
- Conflict
- TransAcces
- Jurisdiction
- SvcSuit
- FirmDens

PCA was run on the 668 census tracts with A&E firms in them using the TransAcces, SvcSuit, and FirmDens fields. None of the variables in the resulting correlation matrix are negatively correlated, so all variables affected the result. The firm density (IP_DENSITY) and transit access are different from zero with a significance level alpha=0.05. From the eigenvalue matrix it is evident that the first eigenvalue equals 1.379 and represents almost 46% of the total variability. Although the value is relatively low (i.e., less than 50%), the first two factors represent almost 80% of the variability.

Theoretical Local (Spatial) Regression Equation

The regression equation that describes local innovative networks (LIN) is:

LIN = 0.826 (IP_DENSITY) + 0.817 (TransAcces) + 0.171 (SvcSuit)

When applied to the average density for the Washington, DC region the local innovative network value results in the following:

LIN = 0.826 (38.96) + 0.817 (7) + 0.171 (7)

The resulting local innovative value is LIN = 32.18 + 5.719 + 1.197, which equals 39.096.

Pima County Region – Innovative Agents

Table 4-9 illustrates that between 1990 and 2000 the Pima County region experienced a cumulative residential growth of about 27% and through 2009 growth was slightly slower at 21%. The municipalities within the region that experienced the largest amount of growth was due primarily to a significant influx of retirees and those hoping to take advantage of the growth resulting from the housing boom in the late '90s and early millennium. County-wide there was a cumulative increase in population within all age groups analyzed. Trends between jurisdictions indicate a general increase in populations among all age cohorts with the exception of Tucson. The 35 to 44 and 45 to 54 year old demographics illustrate a decline between 2000 and the 2006-08 estimates. Tucson is home to the University of Arizona, the major university for southern Arizona, and the decline is most likely due to students graduating and moving out of the area or seeking housing after graduation in a Tucson suburb due to the cost of housing within the City of Tucson. Although there are residents who work in Pima County and live in other adjacent counties (Table 4-10), the proportion of these residents is much lower than those found in the Capitol region.

Using Census 2000 data, the Moran's Index for age cohorts in Pima County indicated clustering only in the 45 to 54 cohort. The 35 to 45 cohort indicated randomness and both the 20 to 24 and 25 to 34 cohorts demonstrated dispersed distribution of age. ArcGIS also produces a z-score when spatial autocorrelation is calculated to indicate confidence of the spatial statistic. Assuming a 95% confidence limit, the z-score for the 35 to 44 cohort indicates that the pattern does not appear to be significantly different than random. For the 45 to 54 cohort there is less than 5% likelihood that the clustered pattern could be the result of random chance. This indicates for both these age cohorts that the null hypothesis cannot be rejected and for the cohorts between ages 20 and 34 the null hypothesis can be rejected.

An additional argument used to support attracting creative industries to cities is that they provide higher wages than non-knowledge based industries. An example is in the case of A&E firms in which the average salary is higher than the national average for all industries. Pima County demonstrates a clustered distribution with a z-score within the 95% confidence limit indicating that there is less than 1% likelihood that this clustered pattern could be the result of random chance. Therefore the null hypothesis cannot be rejected.

From the reference Capitol region, the following variables were included in the final regional regression equation:

- Total population, 2008
- 20 to 24 year old %
- 25 to 34 year old %
- 35 to 44 year old %
- Educational attainment factor
- Educational conferred factor

Table 4-11 lists the values for Pima County.

Using the regional regression equation, regional innovation can be measured by:

RI = 0.662 (6.0078) + 0.628 (4.8616) + 0.059 (5.1221) – 0.560 (5.1060) – 0.267 (5.1338) – 0.1222 (0.2324) + 0.071 (0.1117)

The resulting regional innovation measure is 3.977 + 3.053 + 0.3022 + 2.859 – 1.37 - 0.0283 + 0.0079, which equals 8.8008.

A random sample of A&E firms (Table 4-12), the dependent variable, was used in this study to reflect innovative inputs.

Spatially, the dependent variable was standardized as a function of density in each census tract (Figure 4-2). The magnitude of the z-scores indicates that census tracts with the number of A&E firms furthest away from the mean are located in the City of Tucson. For each county, the average nearest neighbor was calculated to "measure how similar the mean distance is to the expected mean distance for a hypothetical random distribution" (Mitchell 2008, 88). The nearest neighbor index indicates clustering and the z-score for Pima County reflects that there is less than 1% likelihood that the clustered pattern could be the result of random chance.

To predict the innovative network potential, the local innovative network equation was applied:

IN = 0.826 (IP_DENSITY) + 0.817 (Trans_Acces) + 0.171 (SvcSuit)

For each of the variables, the averages were applied for all 126 census tracts that contain A&E firms in Pima County.

IN = 0.826 (3.323) + 0.817 (5) + 0.171 (5)

The resulting local innovative network value is 2.745 + 4.085 + 0.855, which equals 7.685.

Table 4-1. Top 10 places of residence for metro-Washington, DC region workers

County of Employment	1990 Census – County of Residence	2000 Census – County of Residence
Arlington County, Virginia	Fairfax County, VA (51,841) Arlington County, VA (34,382) Prince George's County, MD (17,055) District of Columbia (13,393)	Fairfax County, VA (48,670) Arlington County, VA (34,379) Prince George's County, MD (15,912)
District of Columbia	District of Columbia (236,734) Prince George's County, MD (141,590) Montgomery County, MD (103,320) Fairfax County, VA (94,502) Arlington County, VA (43,842) Alexandria City, VA (23,557) Prince William County, VA (13,547) Anne Arundel County, MD (11,964) Charles County, MD (9,976) Howard County, MD (7,917)	District of Columbia (190,566) Prince George's County, MD (126,138) Montgomery County, MD (99,672) Fairfax County, VA (88,908) Arlington County, VA (42,263) Alexandria City, VA (23,292) Anne Arundel County, MD (15,891) Prince William County, VA (15,368) Charles County, MD (10,785) Howard County, MD (8,461)
Fairfax County, Virginia	Fairfax County, VA (238,650) Prince William County, VA (32,934) Loundoun County, VA (18,055) Montgomery County, MD (16,177) Arlington County, VA (15,575) Prince George's County, MD (15,362)	Fairfax County, VA (278,064) Prince William County, VA (44,322) Loundoun County, VA (35,933) Montgomery County, MD (22,148) Arlington County, VA (20,476) Prince George's County, MD (18,258) Alexandria City, VA (14,643)

Table 4-1. Continued

County of Employment	1990 Census – County of Residence	2000 Census – County of Residence
Montgomery County, Maryland	Montgomery County , MD(251,949) Prince George's County, MD (40,560) District of Columbia (20,487) Frederick County, MD (18,887) Fairfax County, VA (15,001)	Montgomery County, MD (267,128) Prince George's County, MD (40,240) Frederick County, MD (22,867) District of Columbia (19,509) Fairfax County, VA (16,943)
Prince George's County, Maryland	Prince George's County, MD (167,418) Montgomery County, MD (26,879) Anne Arundel County, MD (23,758) Howard County, MD (13,202) District of Columbia (12,979)	Prince George's County, MD (155,671) Montgomery County, MD (26,825) Anne Arundel County, MD (26,271) Howard County, MD (14,538) Charles County, MD (13,834)

Source: US Census Bureau Journey to Work and Place of Work
http://www.census.gov/population/www/socdemo/journey.html

Table 4-2. Capitol region R2 values, age

Age Cohort	1990 R^2	2000 R^2	2008 R^2
20 – 24 year old	0.0198 (Positive)	0.1949 (Positive)	0.3947 (Positive)
25 – 34 year old	0.0004 (Positive)	0.0031 (Positive)	0.0035 (Positive)
35 – 44 year old	0.0761 (Negative)	0.2160 (Negative)	0.3140 (Negative)
45 – 54 year old	0.0213 (Negative)	0.2501 (Negative)	0.0711 (Positive)

Table 4-3. R square regression statistic by age cohort

Age Cohort	2008 R^2	2008 R^2 Adj	2000 R^2	2000 R^2 Adj	1990 R^2	1990 R^2 Adj
20 – 24 year old	0.6604	0.4906	0.7266	0.6172	0.7884	0.7038
25 – 34 year old	0.5012	0.2517	0.6737	0.5432	0.7858	0.7002
35 – 44 year old	0.5404	0.3105	0.8430	0.7802	0.8029	0.7240
45 – 54 year old	0.5576	0.3364	0.6923	0.5692	0.7969	0.7156

Table 4-4. Capitol region R^2 values, educational attainment factor

	2008 R^2	2000 R^2	1990 R^2
Regional EAF	0.0621 (Negative)	0.0464 (Negative)	0.0312 (Negative)

Table 4-5. R square regression statistic for educational attainment factor

	2008 R^2	2008 R^2 Adj	2000 R^2	2000 R^2 Adj	1990 R^2	1990 R^2 Adj
Region	0.6390	0.4947	0.6799	0.5503	0.8034	0.7248

Table 4-6. Capitol region architecture and engineering firm study count

County	Population	Study Sample
Alexandria County	224	146
Arlington County	308	140
Washington, DC	733	463
Fairfax County	1,403	86
Fairfax City	116	60
Falls Church City	37	18
Montgomery County	1,306	602
Prince George's County	118	240

Table 4-7. Location quotients for Capitol area study counties

2001	2005	2008	2009
Arlington County (5.82)	Arlington County (5.71)	Arlington County (4.79)	Arlington County (5.07)
Fairfax City (3.42)	Fairfax City (3.92)	Fairfax City (4.17)	Fairfax City (4.47)
Fairfax County (2.59)	Fairfax County (3.21)	Fairfax County (2.67)	Fairfax County (2.62)

Table 4-8. Horizontal clustering quotient for metro Washington, DC region

County	Land Area, 2000 (sq miles)	Persons per sq mile, 2000	Horizontal Clustering (HC) Quotient			
			2001	2005	2008	2009
Arlington County	25.87	7286.7	309.6	288.9	273.6	281.8
District of Columbia	61.4	9378.0	100.9	110.1	134.4	129.7
Fairfax County	395.04	2455.1	36.4	47.7	43.7	40.3
Fairfax City	6.27	N/A	100.5	163.8	159.5	161.6
Falls Church City	2	N/A	57.5	87.0	105.5	104.0
Montgomery County	495.52	1760.8	19.1	16.4	7.6	13.4
Prince George's County	485.43	1652.6	8.3	8.5	14.0	7.7

Table 4-9. Pima County population, 1990 - 2008

	1990 Population	2000 Population	90-00 Population Change	90-00 % Population Change	2008 Population	00-08 Population Change	00-08 % Population Change
Pima County	666,880	843,746	176,866	27%	994,244	150,498	18%

Table 4-10. Places of residence for Pima County, Arizona workers

County of Employment	1990 Census – County of Residence	2000 Census – County of Residence
Pima County, Arizona	Pima County, AZ (282,789) Maricopa County, AZ (1,111) Pinal County, AZ (1,000) Cochise County, AZ (805) Santa Cruz County, AZ (741))	Pima County, AZ (359,296) Pinal County, AZ (2,601) Cochise County, AZ (1,711) Maricopa County, AZ (1,214) Santa Cruz County, AZ (978)

Source: US Census Bureau Journey to Work and Place of Work
http://www.census.gov/population/www/socdemo/journey.html

Table 4-11. Pima County regression values

Regression Variable	Pima County Value
Log total population 2008	6.0078
20 to 24 year old percentage	4.8616
25 to 34 year old percentage	5.1221
35 to 44 year old percentage	5.1060
45 to 54 year old percentage	5.1338
Educational attainment factor	0.2324
Educational conferred factor	0.1117

Table 4-12. Pima County architecture and engineering firm study count

County	Population	Study Sample
Pima County	523	484

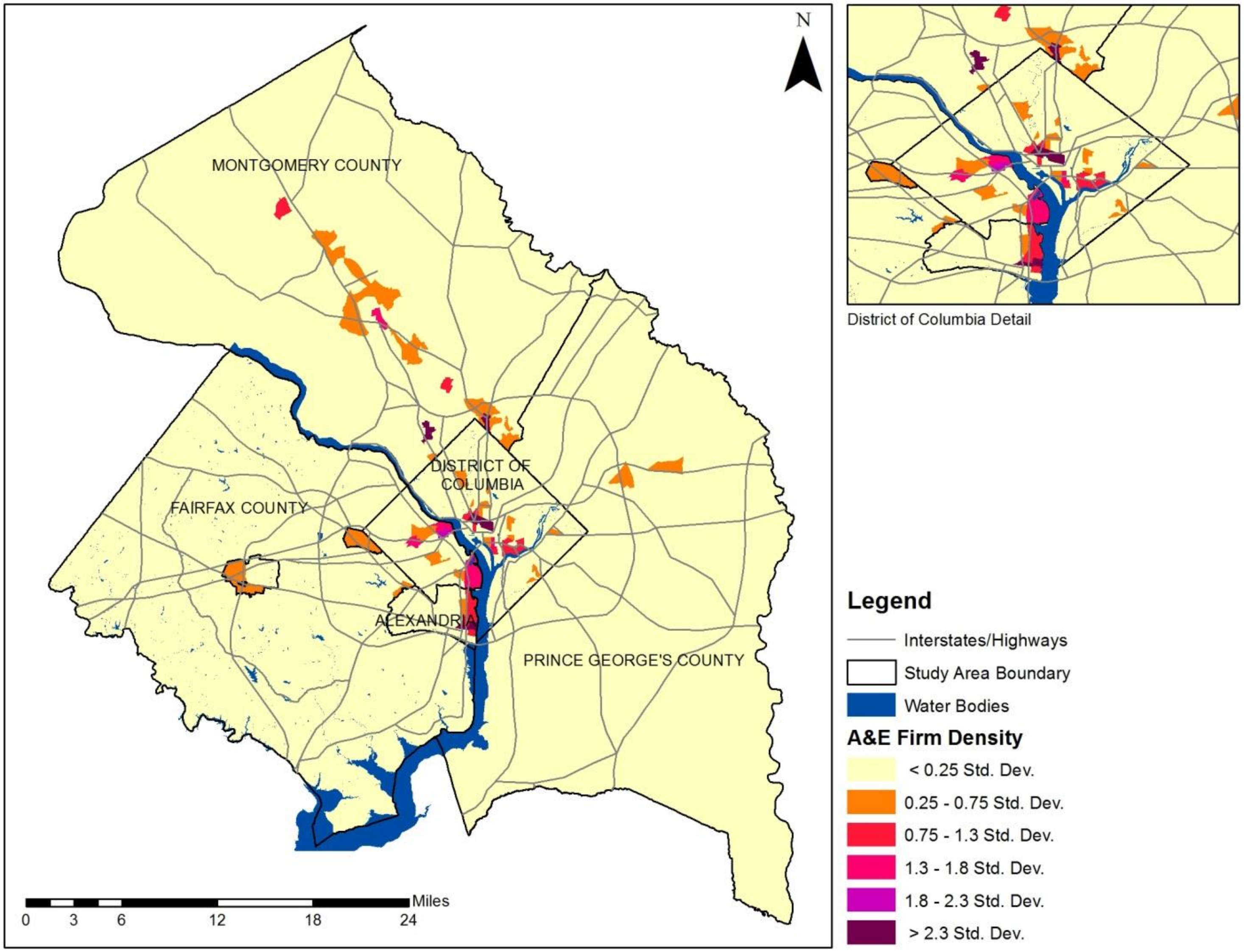


Figure 4-1. Capitol region A&E firm density

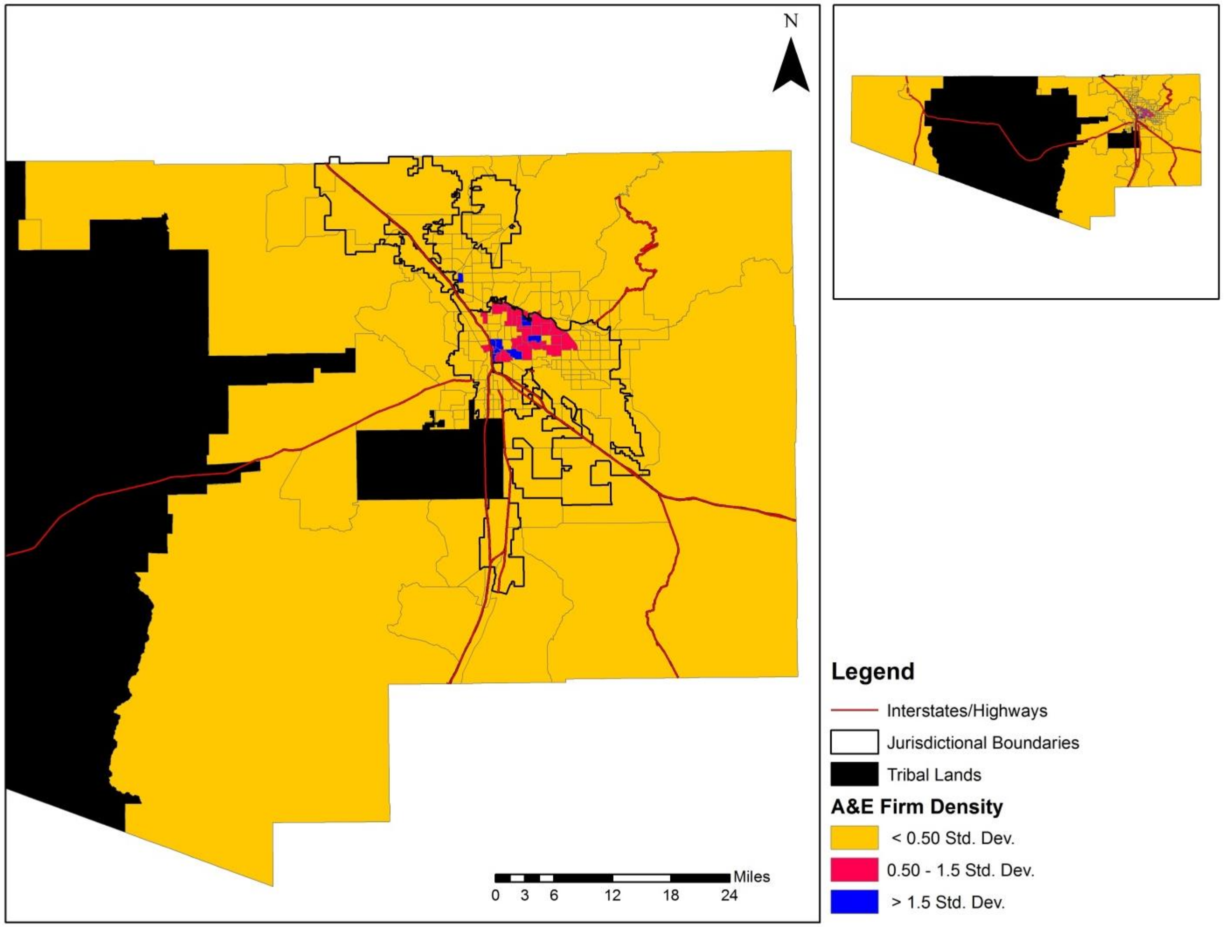


Figure 4-2. Pima County A&E firm density

CHAPTER 5
DISCUSSION

Existing research described in the Literature Review identified several elements that contributed to an innovative environment. Some of these elements included: a young population to serve as a knowledge base for employers (innovative agents), co-location of existing A&E companies and business factors that provide financial benefits for location (innovative inputs), evidence of the productive value of a knowledge network through patents (innovative outputs), and the spatial relationship of existing firms (innovative networks). The Methods section outlined the elements to be examined in this study that would reflect the four elements of innovation: innovative agents, innovative inputs, innovative outputs and innovative networks.

From the reference Washington, DC metro region it was determined that the size of the population, the 20 to 24 year old cohort, the 25 to 34 year old cohort, and the education conferred factor all contributed to the locations of A&E firms. Interestingly, in Pima County the two age cohorts have declined in population since 1990. As mentioned previously, the Pima County region is comprised of five jurisdictions and it would be easy to conclude that the decline is due to the burgeoning senior populations in the large retirement communities of Sahuarita and unincorporated Pima County. Unfortunately, this is not the case. In Tucson, where the greatest densities of A&E firms are located (Figure 4-2), the population is getting older; the higher age cohorts possess a larger share of the total population.

The State of Arizona has three universities and the University of Arizona in Tucson is a land grant university with an enrollment of approximately 37,000 students and is the second largest in the state behind the Arizona State University in Tempe, which has approximately 52,000 students. Although the Capitol region is larger and made of multiple counties, the number of degrees in the disciplines considered in this study are, by number, greater than those of the University of Arizona alone. The other advantage to the Capitol region is that in addition to the major universities in the region (i.e., American University, the University of Maryland, etc.) the region has smaller colleges and community colleges that confer a large number of degrees that contribute to jobs in architecture and engineering fields. In Pima County, there are smaller educational facilities that provide degrees in A&E related fields, but the per capita numbers are much less.

Regionally, when the regional innovation regression equation is applied to the Capitol region the RI value equals 4.200. When applied to test sites larger values indicate an over performance of innovation and values below indicate an underperformance when compared to the Washington, DC region. Locally, the innovative network measure is calculated to be 41.799 and the same rules apply in the determination of over- and underperformance as stated above.

When the same tests were applied to Pima County the regional innovation value equals 8.8008 and the local innovative network value equals 10.3875. For Pima County, on a regional scale it over performs the Capitol region but underperforms on a local level. This can be translated to mean that although when both regions are compared at face value and then considering the methods described in this study it seems as if the Washington, DC region is thriving in creating quality places that A&E firms want to locate even though regionally there may be other industries that may have a comparative advantage. Pima County on the surface doesn’t seem like a county that offers much in terms of attracting A&E firms, but the potential exists to leverage regional resources. Yet on a local level (i.e., within census tracts), Pima County is unable to leverage and translate regional demographic and educational benefits in to sound land use policy that create the networks needed to attract A&E firms. Furthermore, the location quotient for Pima County is 0.78, which indicates that there is underemployment for A&E industries.

CHAPTER 6
CONCLUSION

The purpose of this study was to determine the role and contribution of innovative agents, innovative inputs, and innovative outputs on the regional potential to attract A&E firms as well as the ability to create innovative networks at the local scale. This study has achieved this by examining various measures of innovation at each innovation level and determining a measure or predictor of innovative potential based upon the contribution of various factors. Theoretically, this study resembles the Gottlieb residential amenities and firm location study. The difference is that this study provides a way to measure local and regional firm advantage and provides a way to explain the advantage at various scales. This study also more clearly measures land use suitability using the LUCIS methodology. One aspect of the spatial component not explored in this study but could serve as a basis for future research is to determine if in locations where there is a regional but not local advantage for A&E firms whether by allocating A&E, or more generally service, employment in areas illustrated with a high opportunity or conflict value would change the innovative network potential.

From a practical point of view, this study could aid economic development offices in understanding how to better leverage traditional factors of business location with land use policy to attract firms of particular types. The LUCIS model, and models which employ similar McHargian methods, is important in that in addition to the ability to create a land use conflict value, it provides a common scale to measure land use potential within regional microclimates using values that describe achieving the greatest use of the land.

This paper implicitly re-introduces the region vs. non-region debate in that the baseline “region” is multi-county and successfully achieves regional jurisdictional advantage. The test region, Pima County, is a region defined using municipalities to define its regional context. Again, future research may use the methods employed in this study to determine whether a greater share of innovative networks can be created if the Sun Corridor were used as the region of study. Furthermore, it would be interesting to undertake a comparative study for Maricopa County to determine how it fared against the Capitol region in measure of RI and IN. Due to study funding constraints, data was obtained from various sources and during quality control some discrepancies were documented. Secondly, the land use suitability model built for Pima County was more detailed than that of the Capitol region due to limitations on available data. The District of Columbia has a very thorough and complete GIS database available for free, whereas free spatial data for the other municipalities was limited and the costs associated with many datasets was beyond the budget for this project. The result of these differences could potentially surface in determining the suitability value for service related industries.

My interest in my research topic came from two unique perspectives. After reading a book by Richard Florida on the location characteristics of the creative class I was left thinking that the success of cities and the attraction of specific employees and employment types was more complex than the framework and methodologies that seemed to encourage socially engineering cities with an appropriate mix of beatniks, parks, and removing any evidence of professional sports stadiums. Florida mentioned throughout his book that his results were supported by science but I was curious how the advancement of predictive spatial and statistical models contributed to understanding the dynamics behind thriving cities and communities and how these methods would encourage more proactive planning.

The linkage between location advantage and the built environment derive from the planning theory of Jane Jacobs. She asserts that creativity originates from the built environment, which encourages the arrangement of unique economic dynamics. More specifically, Jane Jacobs states that “Building the creative city is an illusion, but creativity can certainly benefit from buildings” (Hospers and van Dalm 2005, 12). The outcomes of my research would be considered scientific in the planning community because I am not criticizing the conceptual weaknesses in economic theory, but using economic and non-economic factors to explain the casual relationship between creative industries and spatial structure. Kuhn states that, “one of the things a scientific community acquires with a paradigm is a criterion for choosing problems that, while the paradigm is taken for granted, can be assumed to have solutions. To a great extent these are only the problems that the community will admit as scientific or encourage its members to undertake” (Kuhn 1970, 37). In spite of incentives for interdisciplinary research, diverse contributions specifically within economics have been implicit to urban planning (e.g. neoclassical economics, land rent, agglomeration economy, etc.). In the shadow of these contributions, specific knowledge for urban planning has developed through history (Pinson 2004, 506).

For the future of urban planning, “the key question is not to establish if the contributions meet the standards of a science (which differ from a non-science), but to see how a specific contribution adds something to the current knowledge about human settlements, and their production from a specific point of view" (Pinson 2004, 507). Science is called upon to provide an understanding of the complexity of objects and phenomena. Furthermore, "what is important is not the unity but the coherence of knowledge. Coherence is truth's last stronghold" (Ramadier 2004, 425). This study marries science with planning knowledge. This study provides a scientific measure for understanding regional and local potential for architecture and engineering industries.

APPENDIX A
DATA LIST

Table A-1. Data used for spatial concentration/dispersion of innovation measurement

General data		Specific data	Examples of empirical work	Geographical scale and location	Time frame	Industries	Data sources
Innovative inputs	R&D Expenditures	Funding for research projects	Feldman and Lichtenberg (1998)	Country (EU)	1962-1996	All	CORDIS-RTD database
		Laboratory R&D budget	Adams (2002)	Distance from laboratory location (200 miles) (US)	1991-1996	All	Survey of Industrial Laboratory Technologies
	R&D personnel	Number of scientists and engineers engaged in R&D	Porter and Stern (1999)	Country (OECD)	Various years	All	OECD Science and Technology Indicators
		Number of “star” scientists and collaborators	Zucker, Darby, and Brewer (1994)	Zip-code, County, and Functional Economic Area (US)	1975-1989	Biotechnology	GenBank database
	Employment	Employment in “creative sectors”	Fingleton, Igliori, and Moore (2003)	UALAD (UK)	2000	7 “creative industries”	Annual Business Enquiry of the Office for National Statistics

Table A-1. Continued

General data	Specific data	Examples of empirical work	Geographical scale and location	Time frame	Industries	Data sources
	High-tech manufacturing employment	Malecki (1985)	Metropolitan Area (US)	1983, 1993	4 high-tech	Dun & Bradstreet Corporate Market Identifiers File
		Alecke et al., (2003)	County, Labor Market Area, and Planning Region (Germany)	1996	9 high tech	NA
		Maggioni (2002)	State, Census divisions (US), County, Region (UK), Departement, Region (France), Provincia, Regione (Italy)	1991-1995	5 high-tech	County Business Patterns (US), ONS (UK), Institut National de la Statistique et des Etudes Economiques (INSEE) (France), ISTAT (Italy)

Table A-1. Continued

General data		Specific data	Examples of empirical work	Geographical scale and location	Time frame	Industries	Data sources
Innovative outputs	Patent counts	Number of applied patents	Guerrero and Sero (1997)	Province (Spain)	1989-1992	16 productive sectors	RIP data
		Number of granted patents	Thompson (1962)	Standard Metropolitan Area (US)	1947	16 patent classes	Official Gazette of the Patent Office
		Patent families	Criscuolo (2005)	Countries (EU, Japan, US)	1989-2000	All	EPO, USPTO, and Japanese Patent Office (JPO)
	Innovation counts	Number of new products introduced to market	Feldman (1994)	State (US)	1982	All	SBA database
		Innovative outputs (direct innovation surveys)	Hinloopen (2003)	Country (EU)	1992, 1996	All	Eurostat CIS I and II databases
		Publications in R&D	Feldman and Lichtenberg (1998)	Country (EU)	1962-1996	All	CORDIS-RTD database
	Potential innovations	Awards in the SBIR	Wallsten (2001)	State and Metropolitan Statistical Area (US)	1993-1996	7 technology areas	SBIR database

Table A-1. Continued

General data		Specific data	Examples of empirical work	Geographical scale and location	Time frame	Industries	Data sources
Innovative agents	Innovation-related establishments	Universities, R&D institutes, and new firms, Venture capital firms	Zucker, Darby, and Brewer (1994)	Zip-code, County, and Functional Economi Area (US)	1976-1989	Bio-technology	GenBank database
	Formation of new firms	Number of single-location firms	Malecki (1985)	Metropolitan Area, State, Region (US)	1986-1993	4 high tech	Dun & Bradstreet Corporate Market Identifiers File
Innovative networks	Innovation networks	Research and technology	Vonortas (2002)	Country	1980-1998	All	MERIT-CATI database
	Knowledge spillovers	Patent citations	Jaffe, Trajtenberg, and Henderson (1993)	State, Standard Metropolitan Statistical Area (US)	1975, 1980	All industries	USPTO

APPENDIX B
OCCUPATIONAL PROFILES

ARCHITECTURE & ENGINEERING OCCUPATIONS	EMPLOYMENT	AVERAGE ANNUAL WAGE
Architects Except Landscape and Naval	4,400	$81,930
Landscape Architects	650	$64,550
Cartographers and Photogrammetrists	830	$76,920
Surveyors	1,730	$60,240
Aerospace Engineers	2,500	ND
Biomedical Engineers	600	$76,630
Chemical Engineers	480	$90,100
Civil Engineers	7,590	$84,430
Computer Hardware Engineers	3,220	$106,410
Electrical Engineers	5,930	$96,670
Electronics Engineers Except Computer	4,760	$100,130
Environmental Engineers	1,880	$91,190
Health and Safety Engineers Except Mining Safety Engineers and Inspectors	530	$83,430
Industrial Engineers	3,840	$87,770
Marine Engineers and Naval Architects	830	$98,350
Materials Engineers	510	$110,420
Mechanical Engineers	5,430	$103,370
Mining and Geological Engineers Including Mining Safety Engineers	ND	$118,130
Nuclear Engineers	480	$119,310
Petroleum Engineers	70	$105,410
Engineers All Other	7,930	$107,340
Architectural and Civil Drafters	2,490	$48,790
Electrical and Electronics Drafters	680	$57,880
Mechanical Drafters	600	$50,290
Drafters All Other	100	$49,680
Aerospace Engineering and Operations Technicians	ND	$68,660
Civil Engineering Technicians	1,990	$49,960
Electrical and Electronic Engineering Technicians	4,110	$59,240
Electro-Mechanical Technicians	590	$51,660
Environmental Engineering Technicians	430	$49,280
Industrial Engineering Technicians	1,010	$57,550
Mechanical Engineering Technicians	970	$51,400
Engineering Technicians Except Drafters All Other	2,010	$64,630
Surveying and Mapping Technicians	1,580	$42,670
TOTAL	71,090	$85,190

Source: Bureau of Economic Analysis.

Source: Greater Washington Initiative, Occupational Profiles - Architecture and Engineering Profiles. http://www.greaterwashington.org/regional-data/occupational-profiles/architecture-and-engineering-occupations.aspx

Figure B-1. Occupational profiles – architecture and engineering firms (NAICS 5413) in the Greater Washington area.

APPENDIX C
SECTOR INDUSTRY TRENDS

Table C-1. Industries with the fastest growing and most rapidly declining wage and salary employment, 2008 and projected 2018

Industry description	Sector	2007 NAICS	Thousands of jobs		Change	Average annual rate of change
			2008	2018	2008-18	2008-18
Fastest growing						
Management, scientific, and technical consulting services	Professional and business services	5416	1,008.9	1,844.1	835.2	6.2
Other educational services	Educational services	6114-7	578.9	894.9	316.0	4.5
Individual and family services	Health care and social asistance	6241	1,108.6	1,638.8	530.2	4.0
Home health care services	Health care and social asistance	6216	958.0	1,399.4	441.4	3.9
Specialized design services	Professional and business services	5414	143.1	208.7	65.6	3.8
Data processing, hosting, related services, and other information services	Information	518, 519	395.2	574.1	178.9	3.8
Computer systems design and related services	Professional and business services	5415	1,450.3	2,106.7	656.4	3.8
Lessors of nonfinancial intangible assets (except copyrighted works)	Financial activities	533	28.2	37.9	9.7	3.0
Offices of health practitioners	Health care and social asistance	6211, 6212, 6213	3,713.3	4,978.6	1,265.3	3.0
Personal care services	Other services	8121	621.6	819.1	197.5	2.8
Outpatient, laboratory, and other ambulatory care services	Health care and social asistance	6214, 6215, 6219	989.5	1,297.9	308.4	2.8
Facilities support services	Professional and business services	5612	132.7	173.6	40.9	2.7

Table C-1. Continued

Industry description	Sector	2007 NAICS	Thousands of jobs		Change	Average annual rate of change
			2008	2018	2008-18	2008-18
Fastest growing						
Software publishers	Information	5112	263.7	342.8	79.1	2.7
Independent artists, writers, and performers	Leisure and hospitality	7115	50.4	64.8	14.4	2.5
Local government passenger transit	State and local government	NA	268.6	342.6	74.0	2.5
Elementary and secondary schools	Educational services	6111	854.9	1,089.7	234.8	2.5
Scientific research and development services	Professional and business services	5417	621.7	778.9	157.2	2.3
Waste management and remediation services	Professional and business services	562	360.2	451.0	90.8	2.3
Other miscellaneous manufacturing	Manufacturing	3399	321.0	399.4	78.4	2.2
Community and vocational rehabilitation services	Health care and social asistance	6242, 6243	540.9	672.0	131.1	2.2
Most rapidly declining						
Cut and sew apparel manufacturing	Manufacturing	3152	155.2	66.7	-88.5	-8.1
Apparel knitting mills	Manufacturing	3151	26.2	12.5	-13.7	-7.1
Textile and fabric finishing and fabric coating mills	Manufacturing	3133	48.3	23.5	-24.8	-7.0
Fabric mills	Manufacturing	3132	65.4	35.0	-30.4	-6.1
Audio and video equipment manufacturing	Manufacturing	3343	27.0	14.6	-12.4	-6.0
Apparel accessories and other apparel manufacturing	Manufacturing	3159	17.0	9.2	-7.8	-6.0
Fiber, yarn, and thread mills	Manufacturing	3131	37.4	20.7	-16.7	-5.7
Textile furnishings mills	Manufacturing	3141	75.4	41.9	-33.5	-5.7
Railroad rolling stock manufacturing	Manufacturing	3365	28.4	17.5	-10.9	-4.7
Footwear manufacturing	Manufacturing	3162	15.8	10.0	-5.8	-4.5
Pulp, paper, and paperboard mills	Manufacturing	3221	126.1	81.9	-44.2	-4.2
Basic chemical manufacturing	Manufacturing	3251	152.1	99.9	-52.2	-4.1

Table C-1. Continued

Industry description	Sector	2007 NAICS	Thousands of jobs		Change	Average annual rate of change
			2008	2018	2008-18	2008-18
Most rapidly declining						
Semiconductor and other electronic component manufacturing	Manufacturing	3344	432.4	286.8	-145.6	-4.0
Computer and peripheral equipment manufacturing	Manufacturing	3341	182.8	124.7	-58.1	-3.8
Other textile product mills	Manufacturing	3149	72.2	49.4	-22.8	-3.7
Federal enterprises except the Postal Service and electric utilities	Federal government	NA	63.5	44.9	-18.6	-3.4
Leather and hide tanning and finishing, and other leather and allied product manufacturing	Manufacturing	3161, 3169	17.8	13.0	-4.8	-3.1
Cutlery and handtool manufacturing	Manufacturing	3322	49.1	35.9	-13.2	-3.1
Manufacturing and reproducing magnetic and optical media	Manufacturing	3346	34.9	26.0	-8.9	-2.9
Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing	Manufacturing	3334	149.5	112.8	-36.7	-2.8

Source: Employment Projections Program, U.S. Department of Labor, U.S. Bureau of Labor Statistics (2010)

APPENDIX D
CAPITOL REGION SCATTERPLOTS – BY AGE COHORT

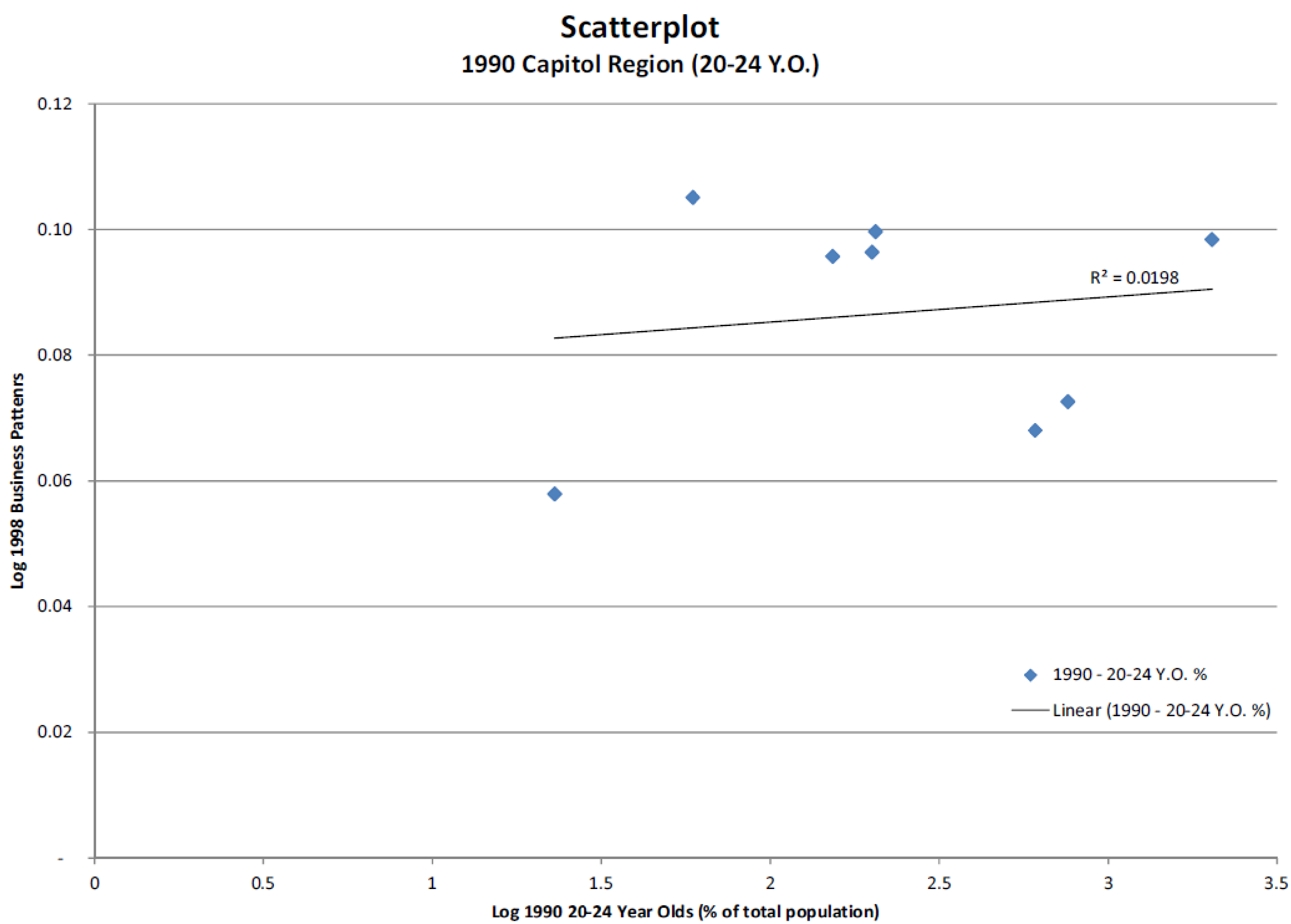


Figure D-1. Business patterns for 20 to 24 year olds in the Capitol Region, 1990

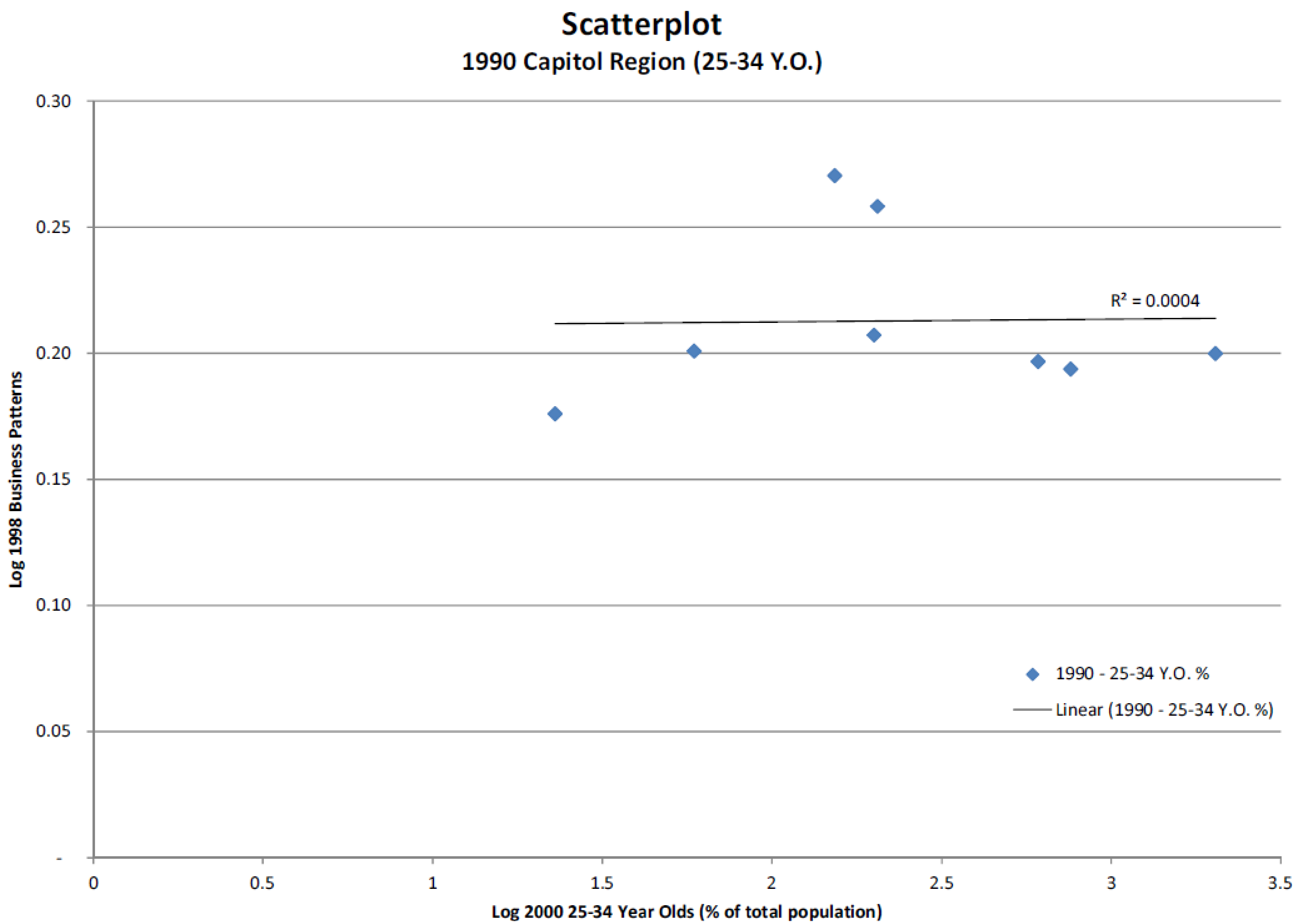


Figure D-2. Business patterns for 25 to 34 year olds in the Capitol Region, 1990

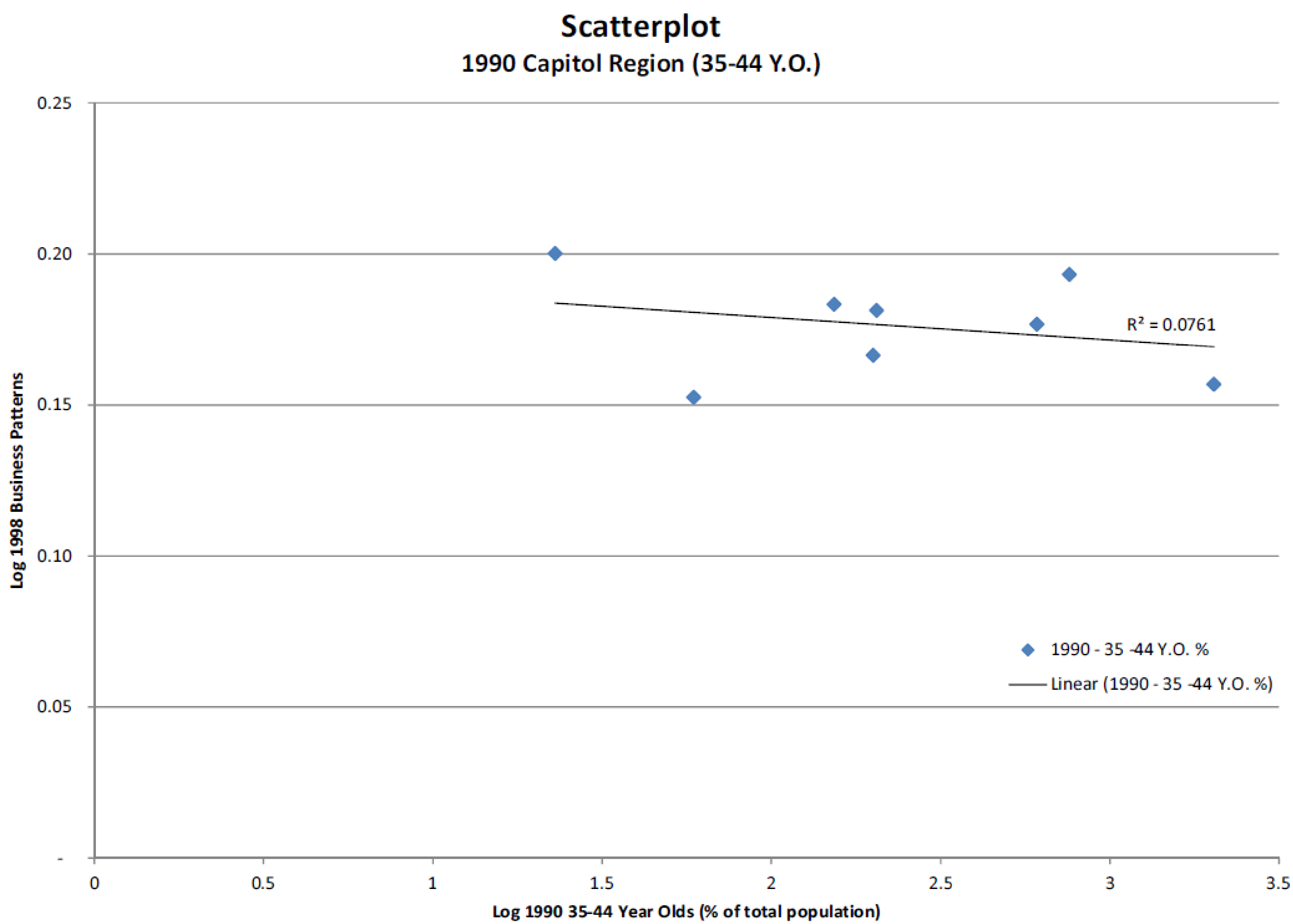


Figure D-3. Business patterns for 35 to 44 year olds in the Capitol Region, 1990

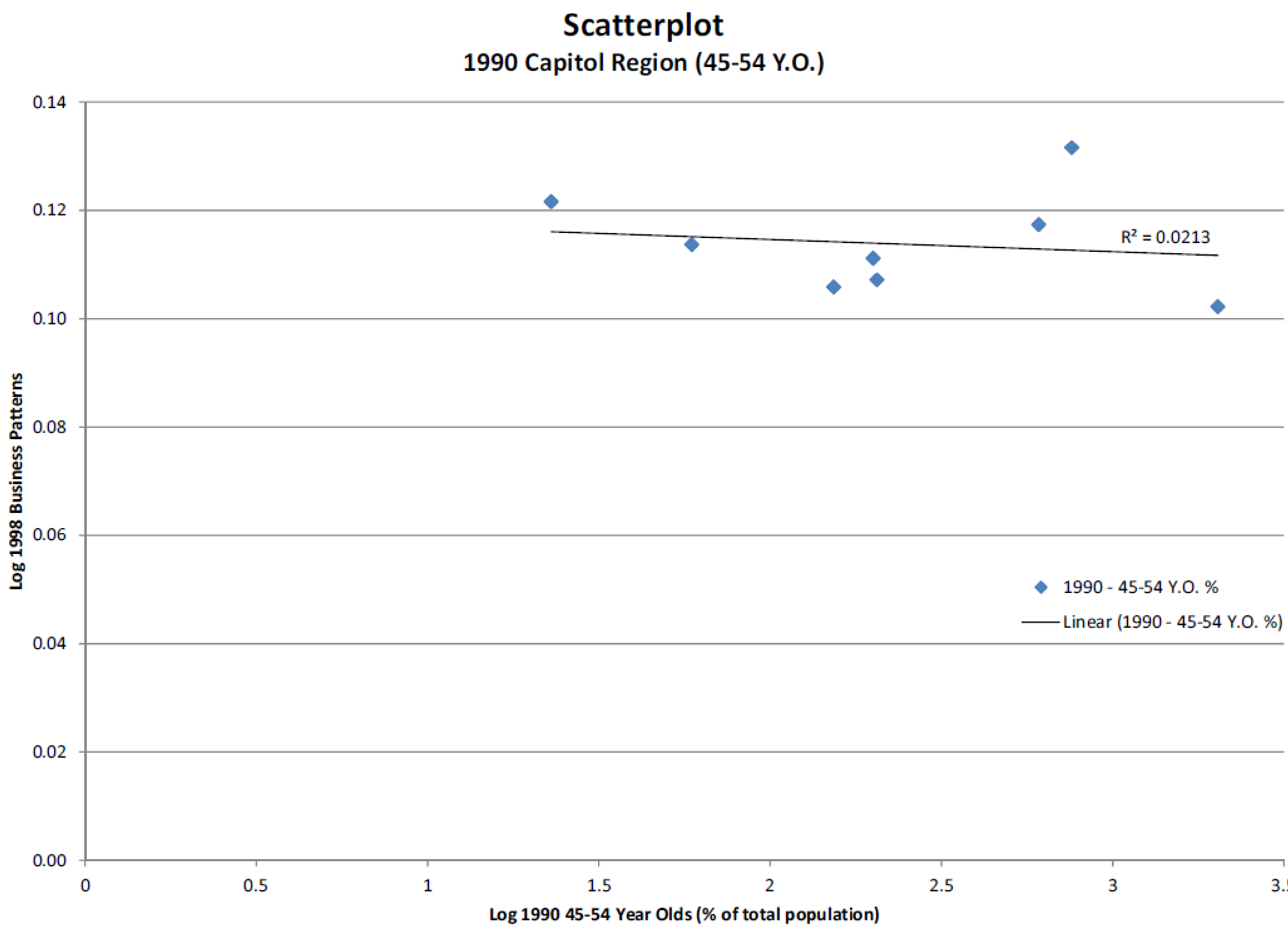


Figure D-4. Business patterns for 45 to 54 year olds in the Capitol Region, 1990

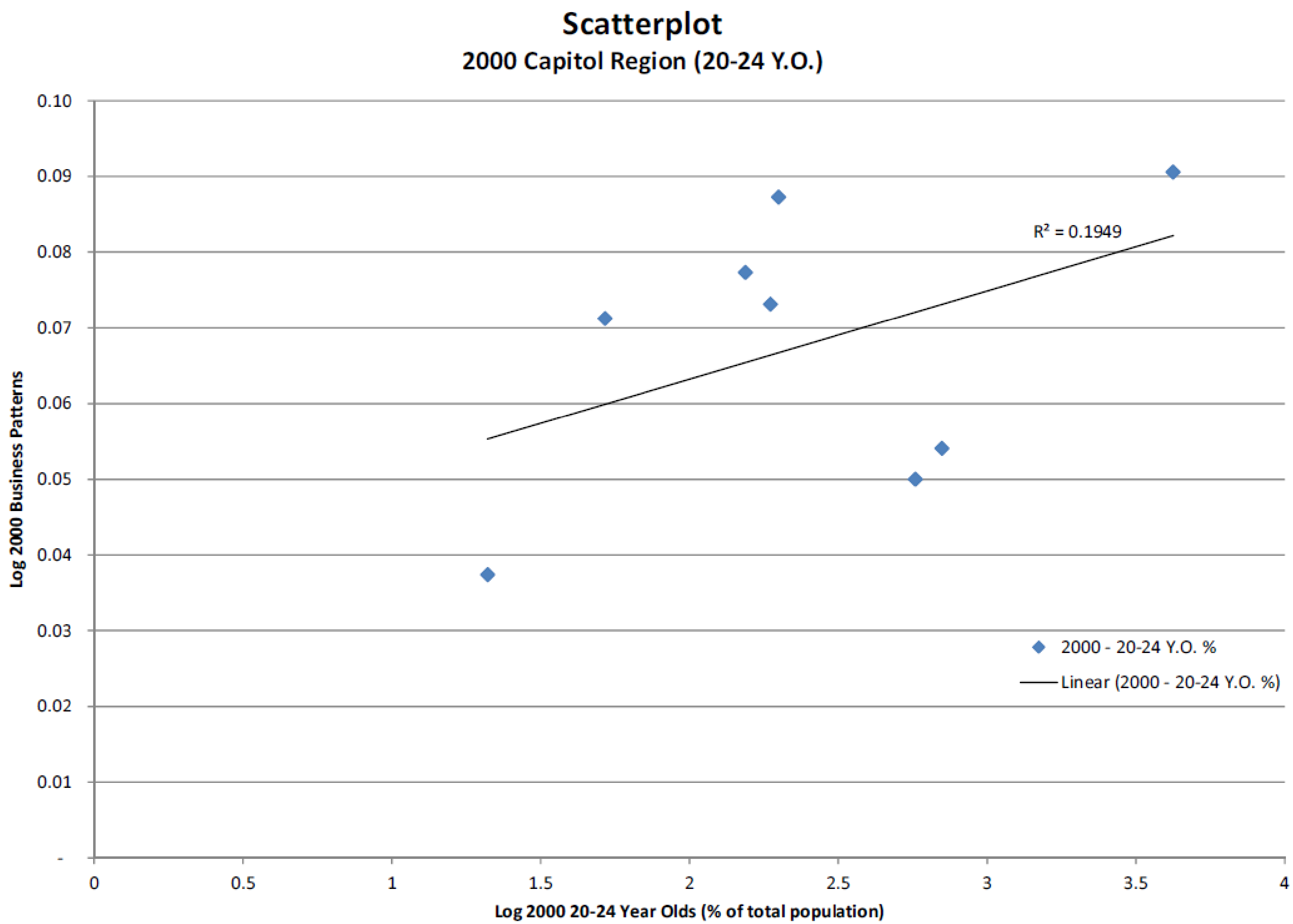


Figure D-5. Business patterns for 20 to 24 year olds in the Capitol Region, 2000

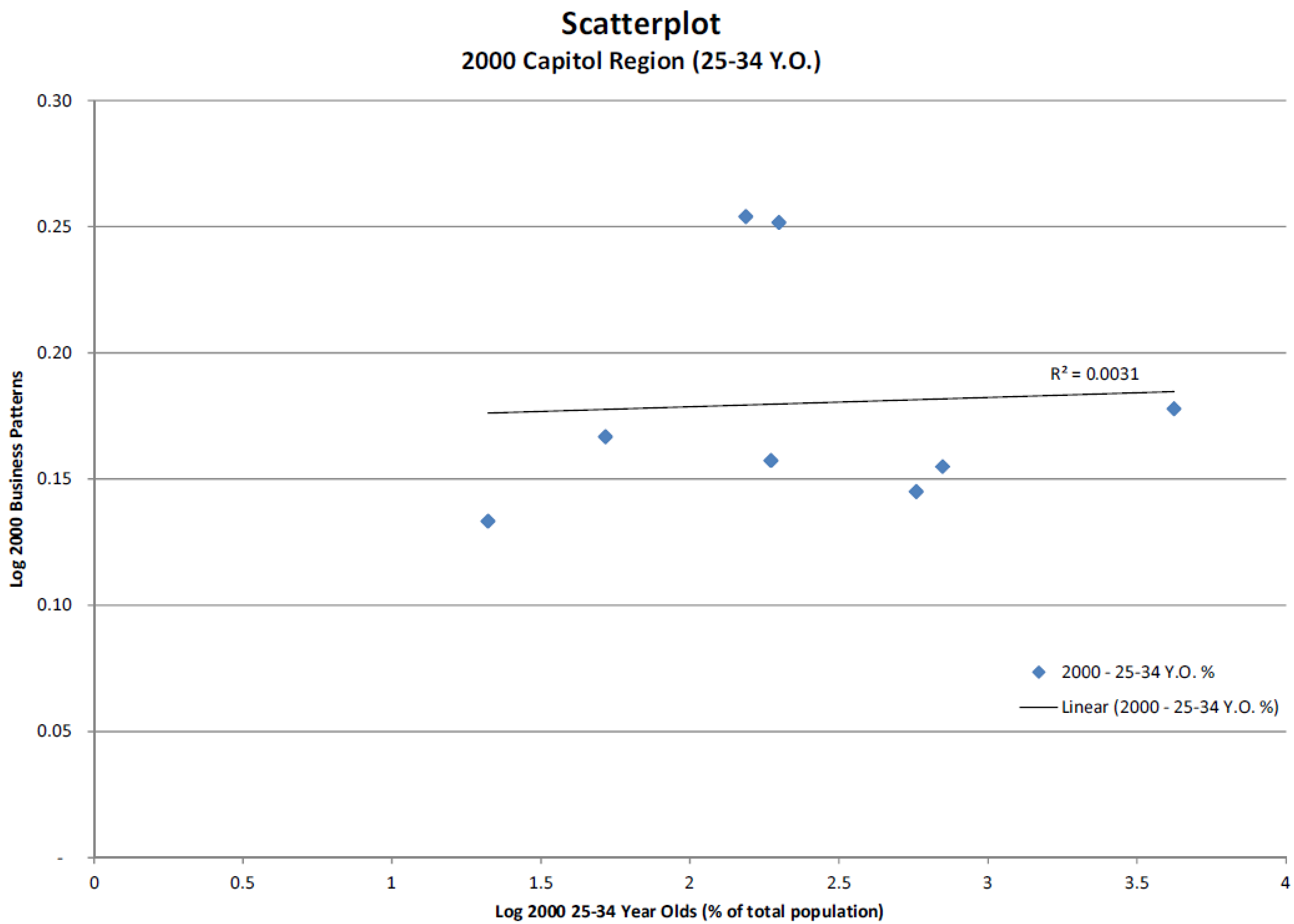


Figure D-6. Business patterns for 25 to 34 year olds in the Capitol Region, 2000

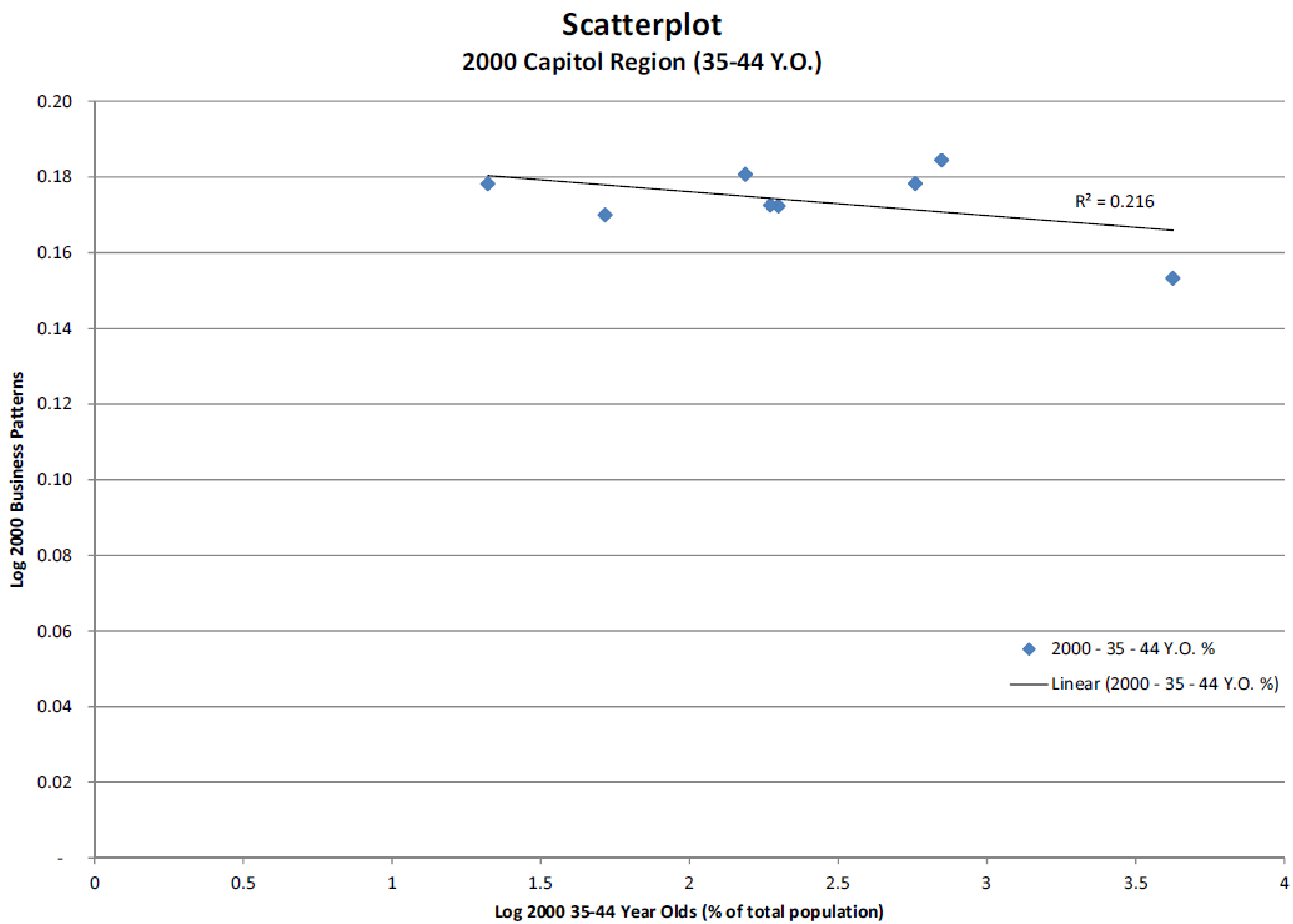


Figure D-7. Business patterns for 35 to 44 year olds in the Capitol Region, 2000

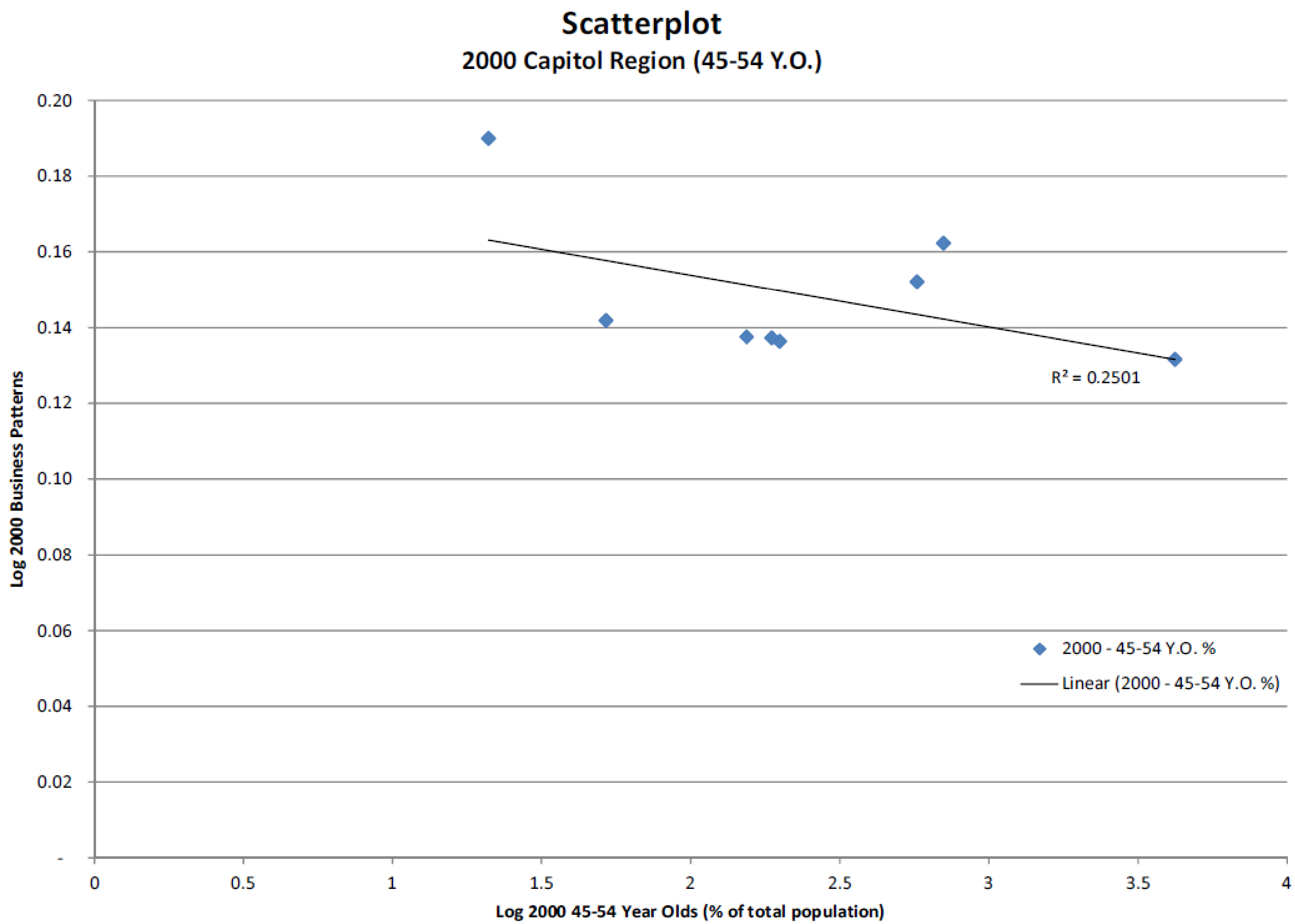


Figure D-8. Business patterns for 45 to 54 year olds in the Capitol Region, 2000

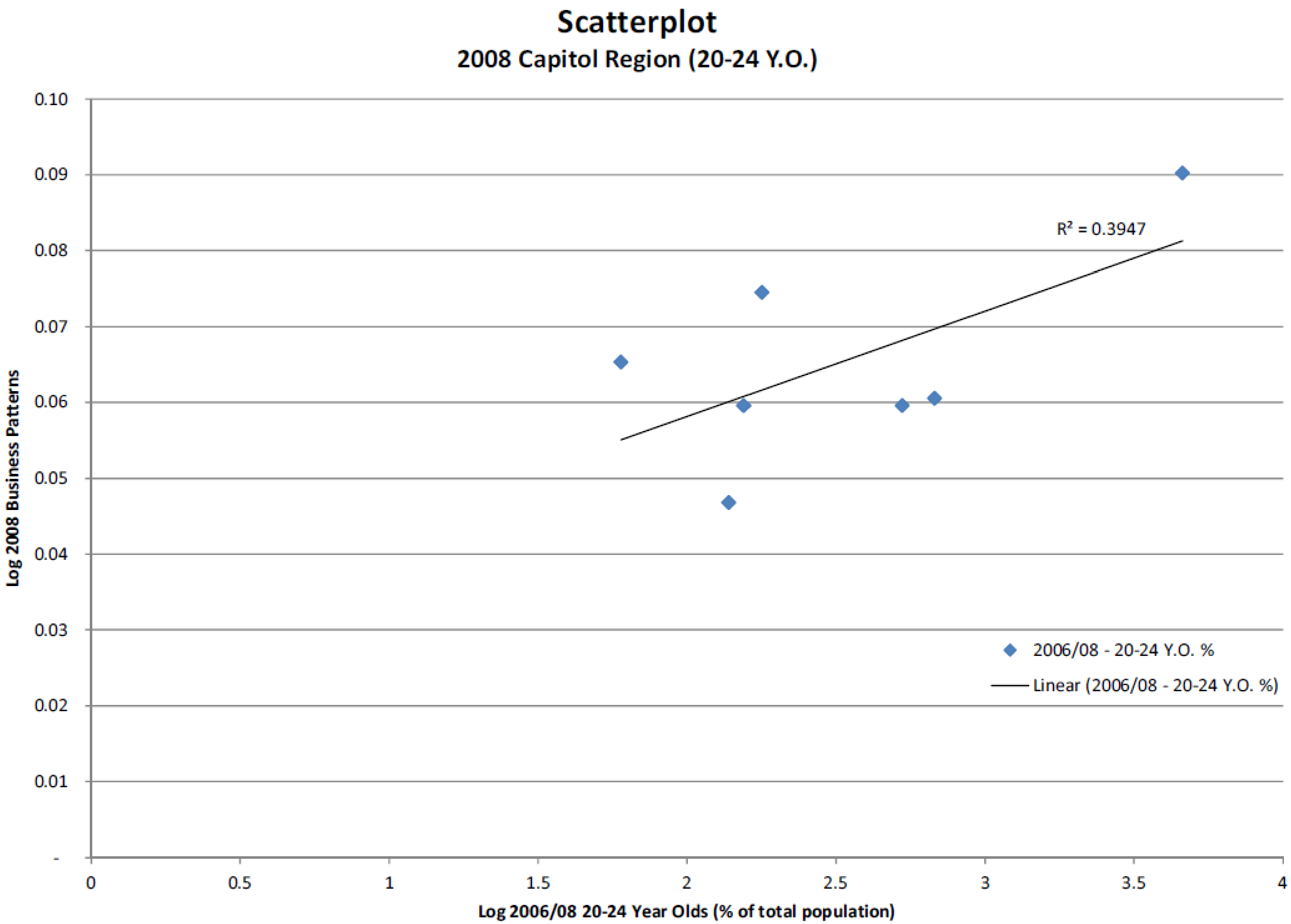


Figure D-9. Business patterns for 20 to 24 year olds in the Capitol Region, 2008

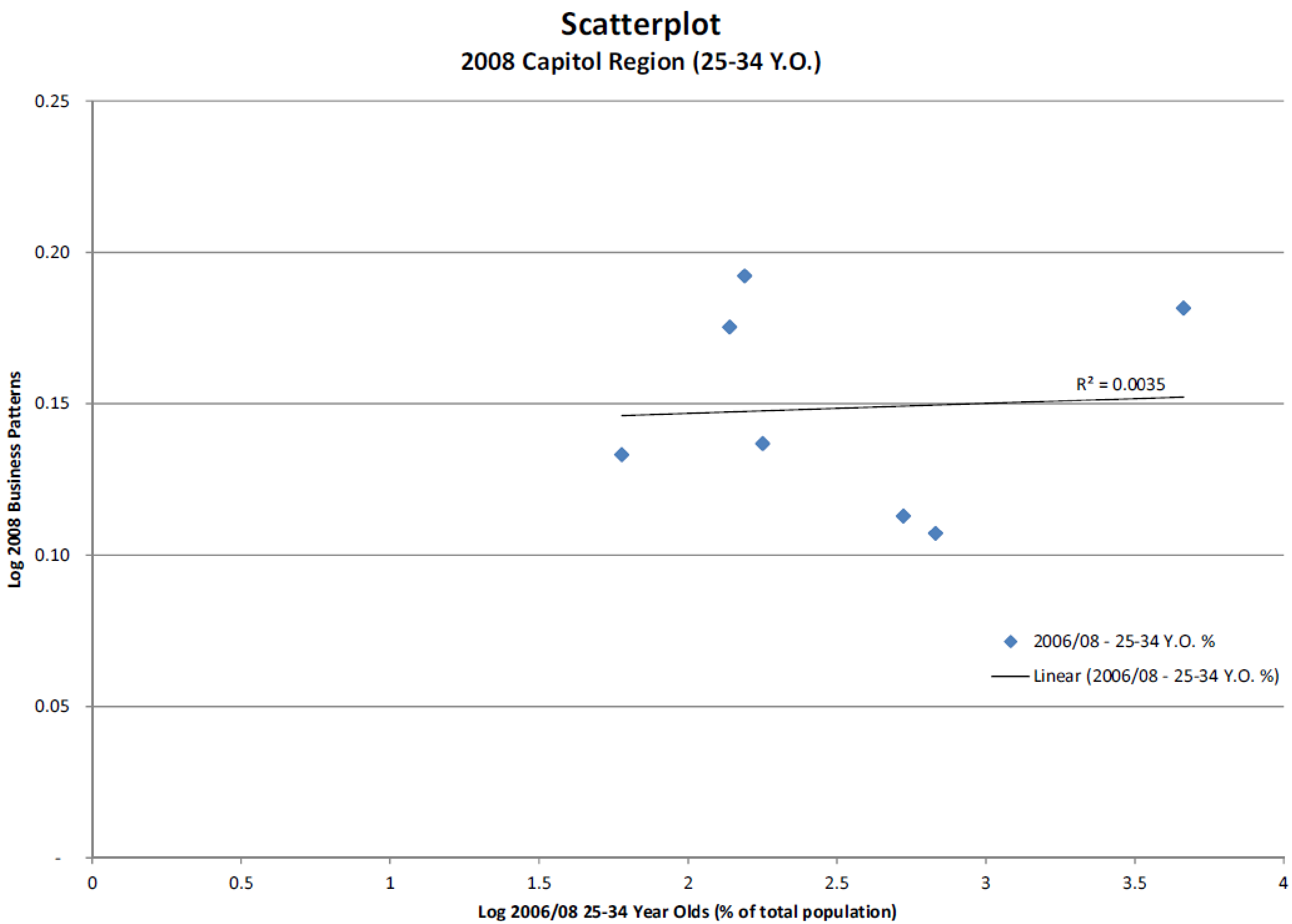


Figure D-10. Business patterns for 25 to 34 year olds in the Capitol Region, 2008

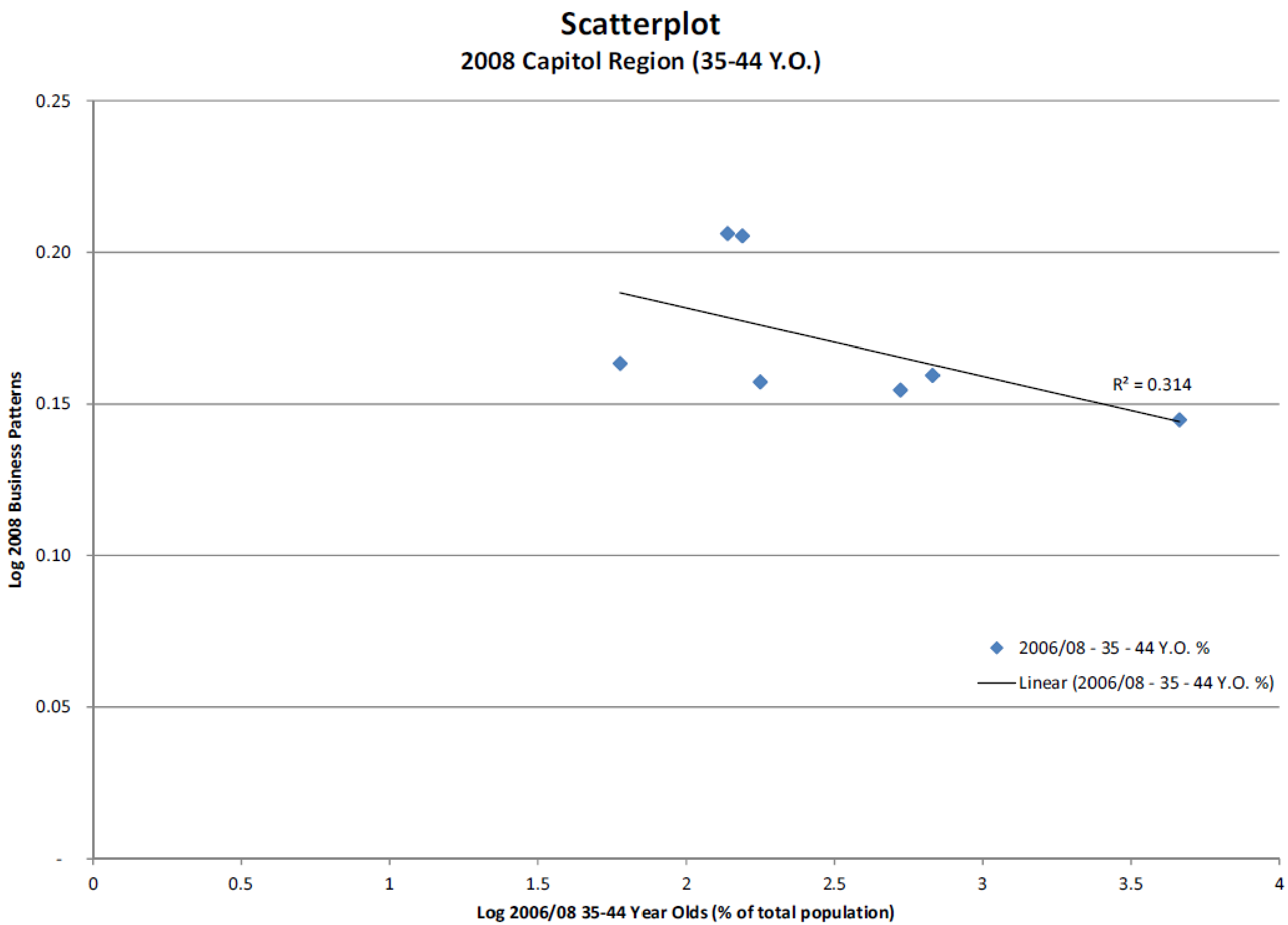


Figure D-11. Business patterns for 35 to 44 year olds in the Capitol Region, 2008

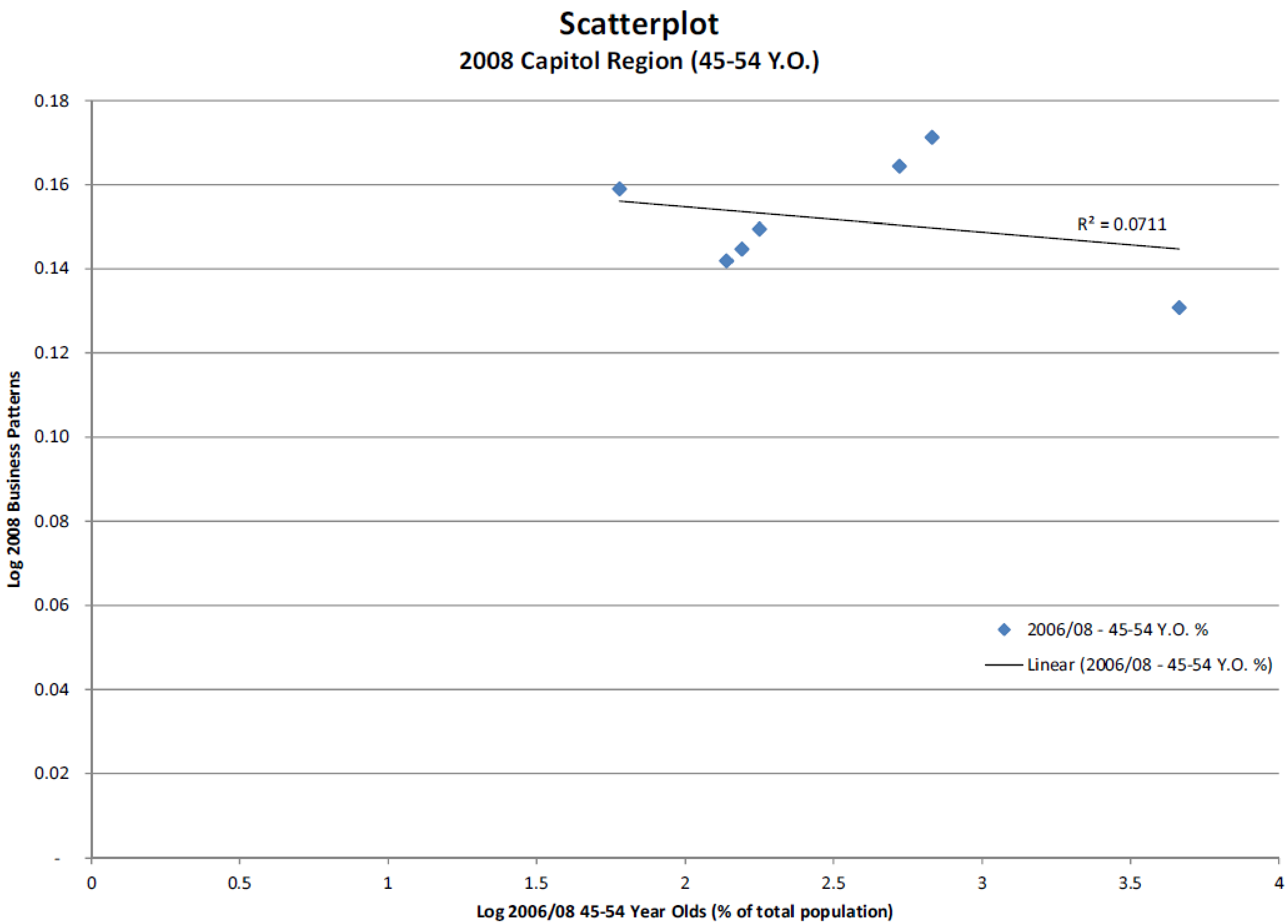


Figure D-12. Business patterns for 45 to 54 year olds in the Capitol Region, 2008

APPENDIX E
REGRESSION RESULTS – BY AGE COHORT

Table E-1. Regression summary output – 1990, 20 to 24 year old

Regression Statistics	
Multiple R	0.887944998
R Square	0.788446319
Adjusted R Square	0.703824847
Standard Error	0.339765802
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.151200431	1.075600216	9.317331616	0.020585028
Residual	5	0.577204	0.1154408		
Total	7	2.728404431			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-1.627557887	1.052570514	-1.546269695	0.182706808	-4.33327653	1.078160756	-4.33327653	1.078160756
log total pop 1990	0.720940328	0.169144801	4.262267148	0.007997541	0.286139775	1.155740881	0.286139775	1.155740881
1990 - 20-24 Y.O. %	2.377452531	7.280057476	0.326570572	0.757219655	-16.33653098	21.09143604	-16.33653098	21.09143604

Table E-2. Regression summary output – 1990, 25 to 34 year old

Regression Statistics	
Multiple R	0.886476598
R Square	0.785840758
Adjusted R Square	0.700177062
Standard Error	0.341851729
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.144091407	1.072045704	9.17355647	0.021224724
Residual	5	0.584313024	0.116862605		
Total	7	2.728404431			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-1.283672176	1.181279234	-1.086679711	0.326766795	-4.320247119	1.752902766	-4.320247119	1.752902766
log total pop 1990	0.728108461	0.170028131	4.282282331	0.007846448	0.291037236	1.165179687	0.291037236	1.165179687
1990 - 25-34 Y.O. %	-0.823584981	3.903356738	-0.210994033	0.841221706	-10.85748291	9.210312948	-10.85748291	9.210312948

Observation	*Predicted log 1998 business patterns*	*Residuals*	*Standard Residuals*
1	2.167685419	0.017006012	0.058861146
2	2.313679539	-0.001925678	-0.006665148
3	2.76248848	0.544793567	1.885637504
4	2.862108262	0.018705331	0.064742822
5	1.676496782	0.09435523	0.326581977
6	1.470239358	-0.108511522	-0.375579685
7	2.834916104	-0.051012525	-0.176564364
8	2.81444041	-0.513410414	-1.777014251

Table E-3. Regression Summary Output – 1990, 35 to 44 year old

Regression Statistics	
Multiple R	0.896028544
R Square	0.802867151
Adjusted R Square	0.724014012
Standard Error	0.327981139
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.190546293	1.095273147	10.18180325	0.017254306
Residual	5	0.537858138	0.107571628		
Total	7	2.728404431			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.437296077	1.691050127	-0.25859439	0.806255936	-4.784278816	3.909686663	-4.784278816	3.909686663
log total pop 1990	0.707495303	0.164781434	4.293537733	0.007762934	0.283911143	1.131079462	0.283911143	1.131079462
1990 - 35 -44 Y.O. %	-5.181371716	7.476997133	-0.69297495	0.519188848	-24.40160473	14.0388613	-24.40160473	14.0388613

RESIDUAL OUTPUT

Observation	*Predicted log 1998 business patterns*	*Residuals*	*Standard Residuals*
1	2.183092874	0.001598557	0.005766911
2	2.325668746	-0.013914885	-0.050198966
3	2.841502091	0.465779956	1.680335271
4	2.745326316	0.135487276	0.488780262
5	1.809470118	-0.038618106	-0.139317644
6	1.341864504	0.019863332	0.071658423
7	2.806412168	-0.022508588	-0.08120138
8	2.848717537	-0.547687541	-1.975822877

Table E-4. Regression summary output – 1990, 45 to 54 year old

Regression Statistics	
Multiple R	0.892684033
R Square	0.796884783
Adjusted R Square	0.715638697
Standard Error	0.332920548
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.174223974	1.087111987	9.808285133	0.018593286
Residual	5	0.554180457	0.110836091		
Total	7	2.728404431			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.580321293	1.76449572	-0.328887901	0.755568985	-5.11610194	3.955459354	-5.11610194	3.955459354
log total pop 1990	0.722132921	0.165271512	4.369373235	0.007226317	0.297288974	1.146976868	0.297288974	1.146976868
1990 - 45-54 Y.O. %	-7.44330785	13.18266885	-0.564628296	0.596715724	-41.33043693	26.44382123	-41.33043693	26.44382123

RESIDUAL OUTPUT

Observation	*Predicted log 1998 business patterns*	*Residuals*	*Standard Residuals*
1	2.275696304	-0.091004874	-0.323435784
2	2.400789966	-0.089036105	-0.316438683
3	2.835080537	0.47220151	1.678227325
4	2.71030847	0.170505123	0.605983568
5	1.67331396	0.097538051	0.346655018
6	1.389337147	-0.027609311	-0.098124846
7	2.791530581	-0.007627002	-0.027106739
8	2.825997388	-0.524967392	-1.865759859

Table E-5. Regression summary output – 2000, 20 to 24 year old

Regression Statistics	
Multiple R	0.852398722
R Square	0.726583582
Adjusted R Square	0.617217015
Standard Error	0.439092351
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.561785357	1.280892679	6.643562113	0.039089622
Residual	5	0.964010464	0.192802093		
Total	7	3.525795821			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-1.961657445	1.200901351	-1.633487583	0.163294596	-5.048672644	1.125357755	-5.048672644	1.125357755
log total pop 2000	0.702621429	0.225330507	3.118181554	0.026306243	0.123390922	1.281851936	0.123390922	1.281851936
2000 - 20-24 Y.O. %	9.211217101	9.176285062	1.003806773	0.361548107	-14.3771746	32.7996088	-14.3771746	32.7996088

RESIDUAL OUTPUT

Observation	*Predicted log 2000 business patterns*	*Residuals*	*Standard Residuals*
1	2.339674316	-0.152153595	-0.410006144
2	2.55036096	-0.251507883	-0.677734741
3	2.918090831	0.70629441	1.903241571
4	2.742659598	0.104913061	0.282707744
5	1.738363635	-0.022360292	-0.060253962
6	1.204531605	0.117687689	0.317131354
7	2.67348527	0.085426623	0.230197914
8	2.860141619	-0.588300013	-1.585283735

Table E-6. Regression summary output – 2000, 25 to 34 year old

Regression Statistics	
Multiple R	0.820784457
R Square	0.673687126
Adjusted R Square	0.543161976
Standard Error	0.479690018
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.375283252	1.187641626	5.161358764	0.060825477
Residual	5	1.150512569	0.230102514		
Total	7	3.525795821			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-1.778427148	1.44102792	-1.234137884	0.271991002	-5.482707344	1.925853047	-5.482707344	1.925853047
log total pop 2000	0.761486591	0.237557481	3.205483524	0.023848663	0.150825646	1.372147536	0.150825646	1.372147536
2000 - 25-34 Y.O. %	0.712151714	3.875283076	0.183767663	0.861415881	-9.249580569	10.673884	-9.249580569	10.673884

RESIDUAL OUTPUT

Observation	*Predicted log 2000 business patterns*	*Residuals*	*Standard Residuals*
1	2.292190153	-0.104669433	-0.258180362
2	2.419529261	-0.120676184	-0.297663035
3	2.732469543	0.891915698	2.20002261
4	2.890677454	-0.043104795	-0.106323415
5	1.639427211	0.076576132	0.188884692
6	1.374670073	-0.052450779	-0.129376464
7	2.848911689	-0.089999796	-0.221995853
8	2.829432451	-0.557590844	-1.375368173

Table E-7. Regression summary output – 2000, 35 to 44 year old

Regression Statistics	
Multiple R	0.918131524
R Square	0.842965495
Adjusted R Square	0.780151694
Standard Error	0.332767667
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.972124221	1.48606211	13.42006805	0.009772096
Residual	5	0.5536716	0.11073432		
Total	7	3.525795821			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	3.824828878	2.50376725	1.527629566	0.187139887	-2.611309735	10.26096749	-2.611309735	10.26096749
log total pop 2000	0.737700352	0.165114056	4.467822856	0.006592529	0.31326116	1.162139545	0.31326116	1.162139545
2000 - 35 - 44 Y.O. %	-30.78807144	13.17605347	-2.336668677	0.066655805	-64.65819516	3.082052283	-64.65819516	3.082052283

RESIDUAL OUTPUT

Observation	*Predicted log 2000 business patterns*	*Residuals*	*Standard Residuals*
1	2.028459657	0.159061063	0.565570538
2	2.409805839	-0.110952763	-0.394512727
3	3.353340923	0.271044319	0.963747368
4	2.562304504	0.285268155	1.014322805
5	1.786381381	-0.070378038	-0.250241912
6	1.301590347	0.020628948	0.073349975
7	2.718435873	0.04047602	0.143919849
8	2.866989311	-0.595147704	-2.116155896

Table E-8. Regression summary output – 2000, 45 to 54 year old

Regression Statistics	
Multiple R	0.832037026
R Square	0.692285613
Adjusted R Square	0.569199858
Standard Error	0.4658193
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.440857721	1.220428861	5.62441701	0.052525416
Residual	5	1.0849381	0.21698762		
Total	7	3.525795821			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.412894725	2.462415971	-0.167678707	0.873407143	-6.742736493	5.916947043	-6.742736493	5.916947043
log total pop 2000	0.693733883	0.258804614	2.68053136	0.043792249	0.028455444	1.359012321	0.028455444	1.359012321
2000 - 45-54 Y.O. %	-5.91294299	10.17033935	-0.581390924	0.586200046	-32.05663258	20.2307466	-32.05663258	20.2307466

RESIDUAL OUTPUT

Observation	*Predicted log 2000 business patterns*	*Residuals*	*Standard Residuals*
1	2.317689384	-0.130168663	-0.330638166
2	2.441773596	-0.14292052	-0.363028839
3	2.802814308	0.821570934	2.086851788
4	2.780828554	0.066744105	0.169535031
5	1.754020769	-0.038017425	-0.096567112
6	1.250090184	0.072129111	0.183213352
7	2.809111344	-0.050199451	-0.127510371
8	2.870979697	-0.59913809	-1.521855683

Table E-9. Regression summary output – 2008, 20 to 24 year old

Regression Statistics	
Multiple R	0.812657215
R Square	0.660411748
Adjusted R Square	0.490617623
Standard Error	0.443892199
Observations	7

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1.532770563	0.766385282	3.889485253	0.115320181
Residual	4	0.788161139	0.197040285		
Total	6	2.320931702			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-1.967116657	1.723422523	-1.14140127	0.317394024	-6.752104685	2.817871371	-6.752104685	2.817871371
log total pop 2008	0.552721331	0.312441522	1.769039302	0.151609372	-0.314755402	1.420198065	-0.314755402	1.420198065
2006/08 - 20-24 Y.O. %	22.0572137	13.63655341	1.617506493	0.181077599	-15.80392828	59.91835567	-15.80392828	59.91835567

RESIDUAL OUTPUT

Observation	*Predicted log 2008 business patterns*	*Residuals*	*Standard Residuals*
1	1.911012751	0.228866335	0.631466087
2	2.282703281	-0.092371583	-0.25486283
3	3.212607133	0.450811079	1.243834781
4	2.685744408	0.145485285	0.401409075
5	1.887665592	-0.109514341	-0.302161489
6	2.649160721	0.073473202	0.202720227
7	2.947169979	-0.696749977	-1.922405851

Table E-10. Regression summary output – 2008, 25 to 34 year old

Regression Statistics	
Multiple R	0.707928936
R Square	0.501163378
Adjusted R Square	0.251745067
Standard Error	0.537997614
Observations	7

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1.163165972	0.581582986	2.00932873	0.248837975
Residual	4	1.15776573	0.289441432		
Total	6	2.320931702			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-2.36540616	2.553293789	-0.926413627	0.406666309	-9.454486203	4.723673883	-9.454486203	4.723673883
log total pop 2008	0.759211039	0.380060283	1.997606889	0.116434283	-0.296005473	1.81442755	-0.296005473	1.81442755
2006/08 - 25-34 Y.O. %	4.725537461	6.655461915	0.710023965	0.516890551	-13.7529872	23.20406212	-13.7529872	23.20406212

RESIDUAL OUTPUT

Observation	*Predicted log 2008 business patterns*	*Residuals*	*Standard Residuals*
1	2.37195245	-0.232073364	-0.528312124
2	2.575390369	-0.385058671	-0.876581271
3	2.873066924	0.790351288	1.79922487
4	2.698248268	0.132981426	0.30273056
5	1.579708324	0.198442926	0.451752851
6	2.704228828	0.018405095	0.041898969
7	2.773468703	-0.5230487	-1.190713856

Table E-11. Regression summary output – 2008, 35 to 44 year old

Regression Statistics	
Multiple R	0.73508728
R Square	0.54035331
Adjusted R Square	0.310529965
Standard Error	0.516432129
Observations	7

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1.254123127	0.627061564	2.351168067	0.21127508
Residual	4	1.066808575	0.266702144		
Total	6	2.320931702			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1.028329319	3.104164641	0.331274091	0.757065912	-7.590213403	9.646872041	-7.590213403	9.646872041
log total pop 2008	0.538546806	0.383734517	1.403435922	0.233151635	-0.526871016	1.603964628	-0.526871016	1.603964628
2006/08 - 35 - 44 Y.O. %	-8.689702316	9.220597401	-0.942422919	0.399337002	-34.29018484	16.91078021	-34.29018484	16.91078021

RESIDUAL OUTPUT

Observation	*Predicted log 2008 business patterns*	*Residuals*	*Standard Residuals*
1	2.008882462	0.130996625	0.310665111
2	2.103847136	0.086484562	0.205102507
3	2.877442227	0.785975985	1.863981737
4	2.875366915	-0.044137221	-0.104673648
5	1.960683067	-0.182531816	-0.43288342
6	2.901929008	-0.179295085	-0.425207348
7	2.847913052	-0.59749305	-1.416984939

Table E-12. Regression summary output – 2008, 45 to 54 year old

Regression Statistics	
Multiple R	0.746724713
R Square	0.557597797
Adjusted R Square	0.336396695
Standard Error	0.506652075
Observations	7

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1.294146403	0.647073202	2.520773145	0.19571971
Residual	4	1.026785299	0.256696325		
Total	6	2.320931702			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.851766106	2.781676377	0.306206039	0.774723784	-6.871405656	8.574937867	-6.871405656	8.574937867
log total pop 2008	0.72663181	0.346474377	2.097216584	0.103979539	-0.235335279	1.688598898	-0.235335279	1.688598898
2006/08 - 45-54 Y.O. %	-15.40626259	14.83362997	-1.038603674	0.35764563	-56.59102191	25.77849673	-56.59102191	25.77849673

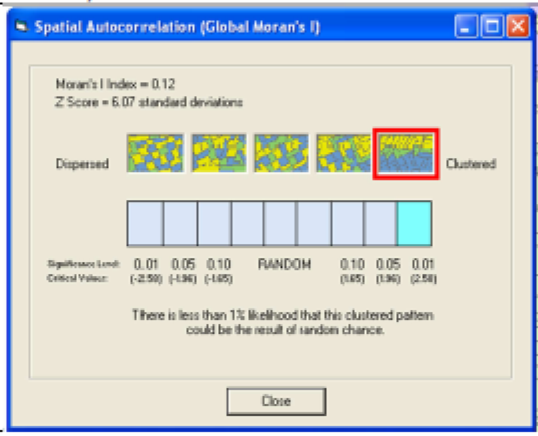
RESIDUAL OUTPUT

Observation	*Predicted log 2008 business patterns*	*Residuals*	*Standard Residuals*
1	2.406898371	-0.267019285	-0.645473524
2	2.481504917	-0.291173219	-0.703861534
3	3.028626148	0.634792064	1.534501415
4	2.575484698	0.255744996	0.618219855
5	1.575821982	0.202329269	0.489096456
6	2.659469317	0.063164605	0.152689647
7	2.848258432	-0.59783843	-1.445172314

APPENDIX F
SPATIAL STATISTICS – METRO WASHINGTON, DC REGION

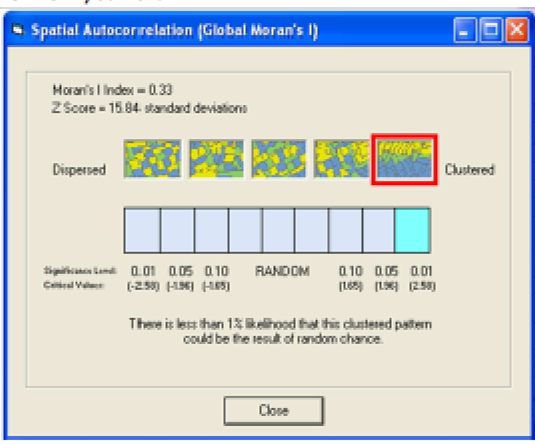
DISTRICT OF COLUMBIA

20 – 24 year old



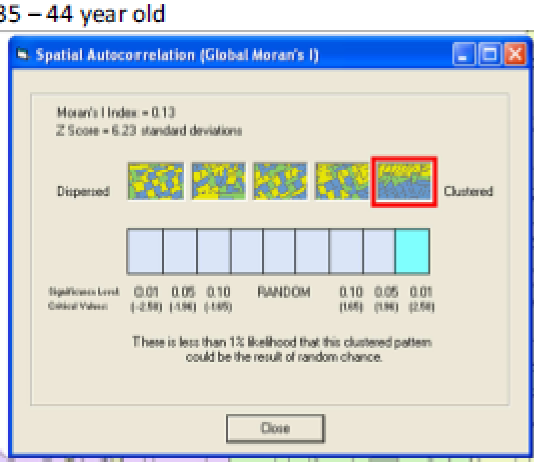
Global Moran's I Summary
Moran's Index: 0.121349
Expected Index: -0.005348
Variance: 0.000435
Z Score: 6.073780
p-value: 0.000000

25 – 34 year old



Global Moran's I Summary
Moran's Index: 0.333893
Expected Index: -0.005348
Variance: 0.000458
Z Score: 15.844238
p-value: 0.000000

35 – 44 year old



Global Moran's I Summary
Moran's Index: 0.128665
Expected Index: -0.005348
Variance: 0.000463
Z Score: 6.225628
p-value: 0.000000

Figure F-1. District of Columbia spatial statistics summary

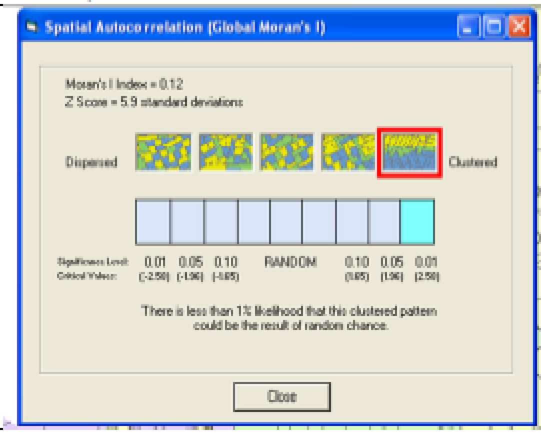
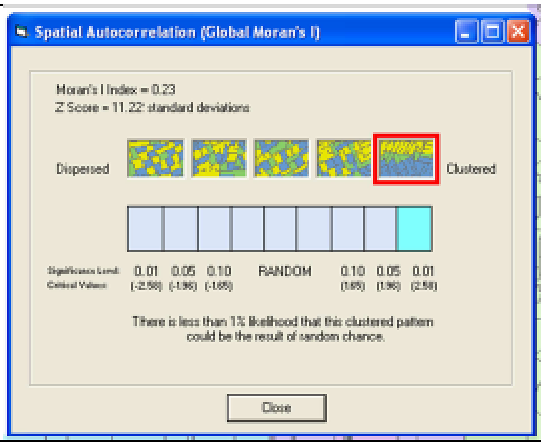
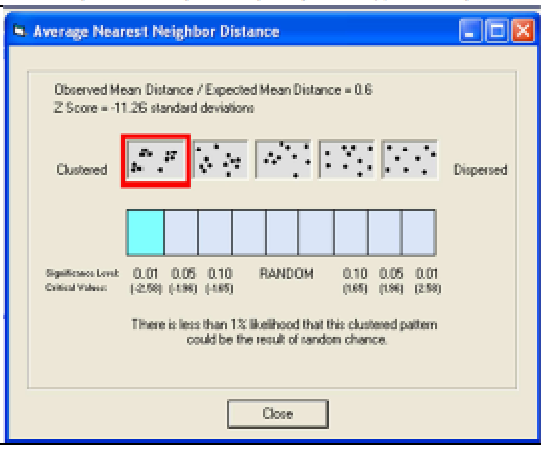
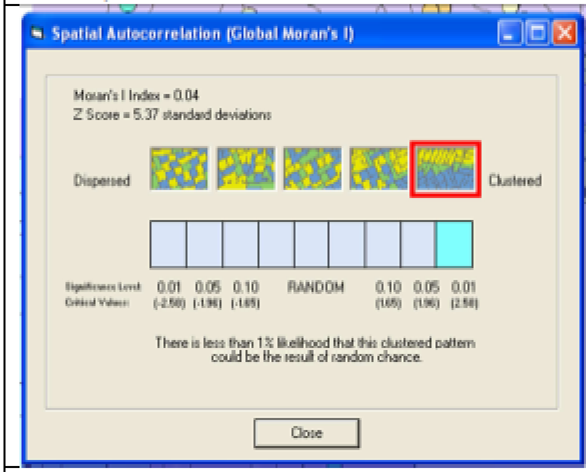
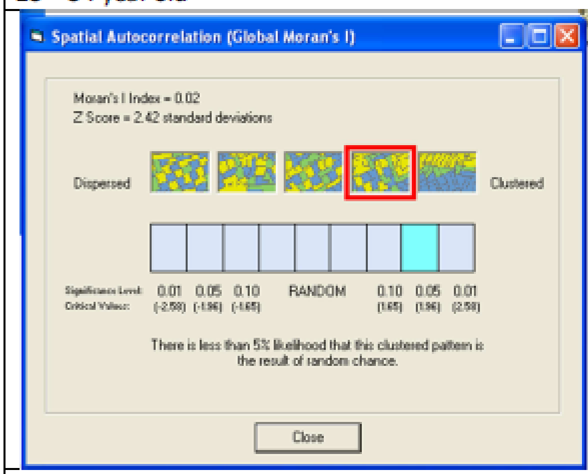
DISTRICT OF COLUMBIA	
45 – 54 year old	
	Global Moran's I Summary Moran's Index: 0.121642 Expected Index: -0.005348 Variance: 0.000464 Z Score: 5.896224 p-value: 0.000000
MEDIAN INCOME	
	Global Moran's I Summary Moran's Index: 0.234653 Expected Index: -0.005348 Variance: 0.000458 Z Score: 11.218478 p-value: 0.000000
AVERAGE NEAREST NEIGHBOR – A&E FIRMS	
	Average Nearest Neighbor Summary Observed Mean Distance: 0.002678 Expected Mean Distance: 0.004446 Nearest Neighbor Ratio: 0.602375 Z Score: -11.257106 p-value: 0.000000

Figure F-1. Continued

<table>
<tr><td colspan="2">PRINCE GEORGE'S COUNTY, MARYLAND</td></tr>
<tr><td>20 – 24 year old</td><td></td></tr>
<tr><td>
</td><td>Global Moran's I Summary
Moran's Index: 0.038428
Expected Index: -0.005495
Variance: 0.000067
Z Score: 5.372673
p-value: 0.000000</td></tr>
<tr><td>25 – 34 year old</td><td></td></tr>
<tr><td>
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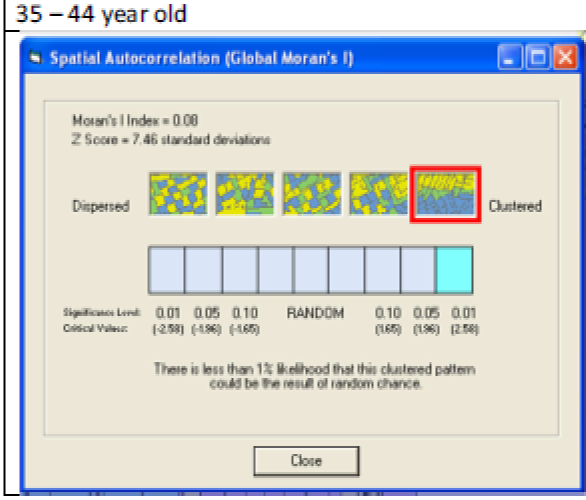
Moran's Index: 0.022813
Expected Index: -0.005495
Variance: 0.000137
Z Score: 2.420927
p-value: 0.015481</td></tr>
<tr><td>35 – 44 year old</td><td></td></tr>
<tr><td>
</td><td>Global Moran's I Summary
Moran's Index: 0.082042
Expected Index: -0.005495
Variance: 0.000138
Z Score: 7.463444
p-value: 0.000000</td></tr>
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Figure F-2. Prince George's County, Maryland spatial statistics summary

<table>
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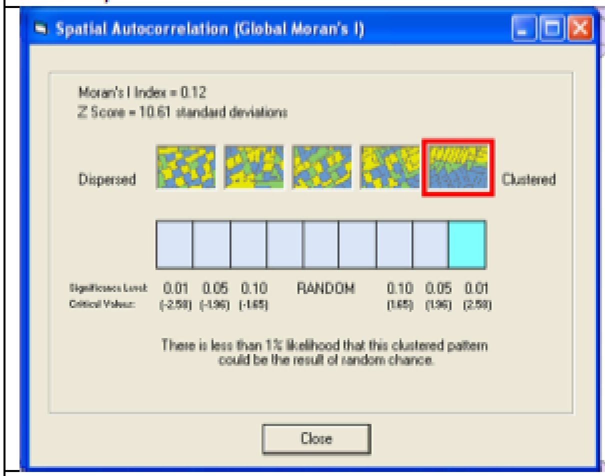
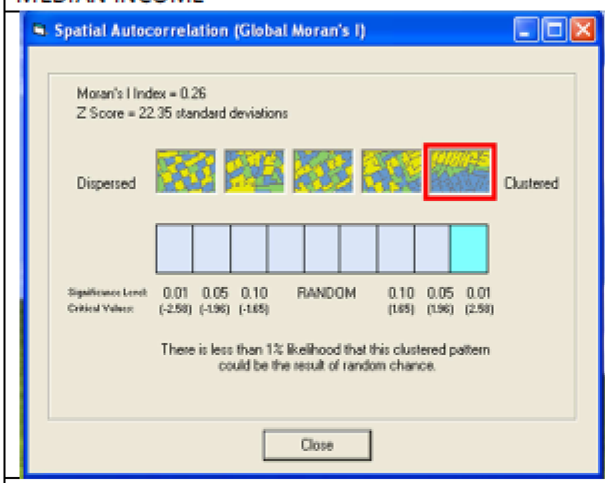
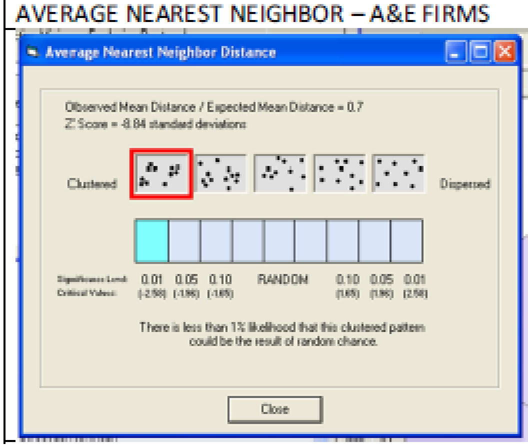
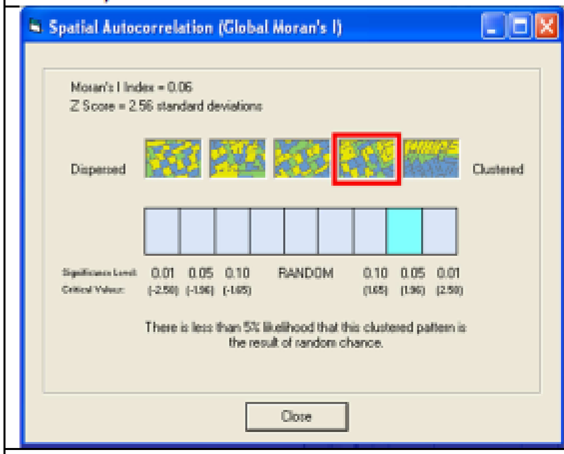
<tr><td>
</td><td>Global Moran's I Summary
Moran's Index: 0.118803
Expected Index: -0.005495
Variance: 0.000137
Z Score: 10.606778
p-value: 0.000000</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">MEDIAN INCOME</td></tr>
<tr><td>
</td><td>Global Moran's I Summary
Moran's Index: 0.257165
Expected Index: -0.005495
Variance: 0.000138
Z Score: 22.345948
p-value: 0.000000</td></tr>
<tr><td></td><td></td></tr>
<tr><td>AVERAGE NEAREST NEIGHBOR – A&E FIRMS</td><td></td></tr>
<tr><td>
</td><td>Average Nearest Neighbor Summary
Observed Mean Distance: 0.007849
Expected Mean Distance: 0.011183
Nearest Neighbor Ratio: 0.701886
Z Score: -8.835254
p-value: 0.000000</td></tr>
</table>

Figure F-2. Continued

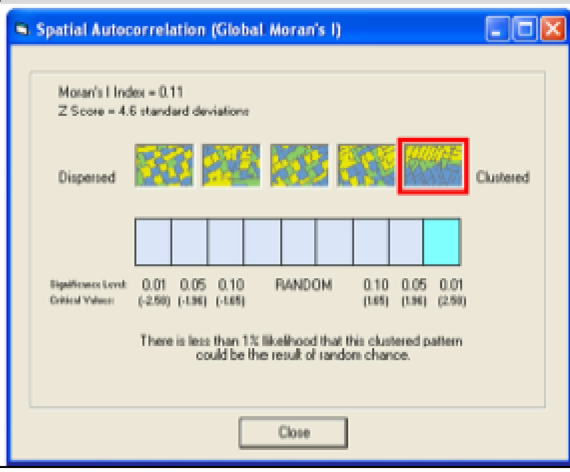
FAIRFAX COUNTY, VIRGINIA

20 – 24 year old



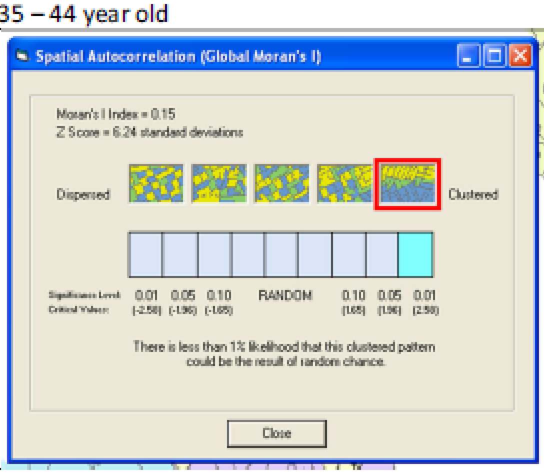
Global Moran's I Summary
Moran's Index: 0.055613
Expected Index: -0.006098
Variance: 0.000582
Z Score: 2.558261
p-value: 0.010520

25 – 34 year old



Global Moran's I Summary
Moran's Index: 0.105496
Expected Index: -0.006098
Variance: 0.000588
Z Score: 4.602919
p-value: 0.000004

35 – 44 year old

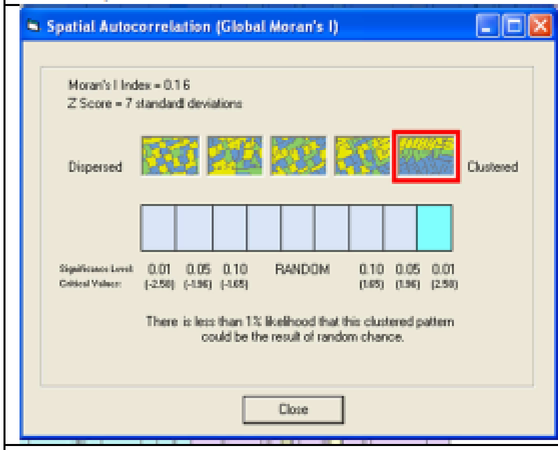


Global Moran's I Summary
Moran's Index: 0.145010
Expected Index: -0.006098
Variance: 0.000586
Z Score: 6.244269
p-value: 0.000000

Figure F-3. Fairfax County, Virginia spatial statistics summary

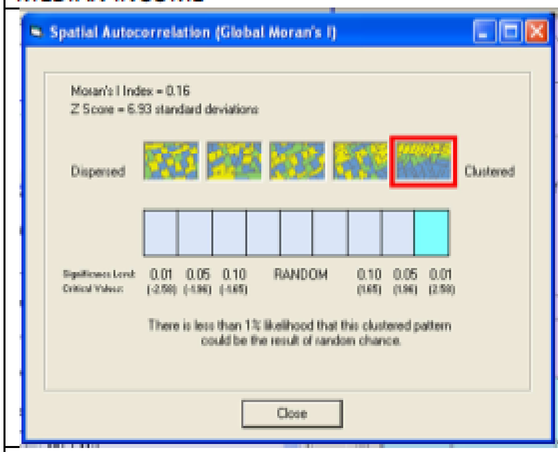
FAIRFAX COUNTY, VIRGINIA

45 – 54 year old



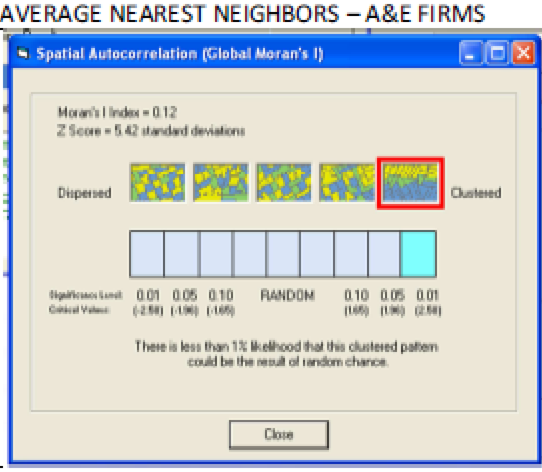
Global Moran's I Summary
Moran's Index: 0.163433
Expected Index: -0.006098
Variance: 0.000586
Z Score: 7.002029
p-value: 0.000000

MEDIAN INCOME



Global Moran's I Summary
Moran's Index: 0.162691
Expected Index: -0.006098
Variance: 0.000593
Z Score: 6.930586
p-value: 0.000000

AVERAGE NEAREST NEIGHBORS – A&E FIRMS

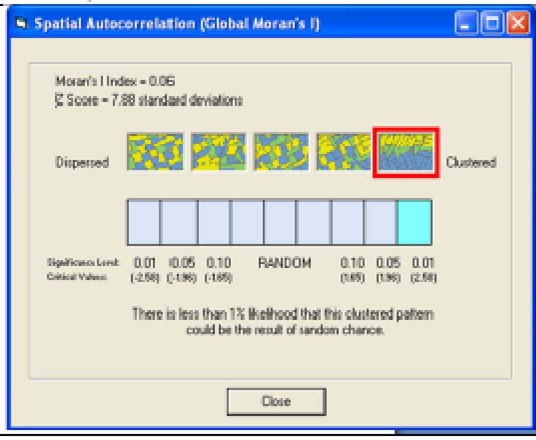


Global Moran's I Summary
Moran's Index: 0.119913
Expected Index: -0.006098
Variance: 0.000541
Z Score: 5.419917
p-value: 0.000000

Figure F-3. Continued

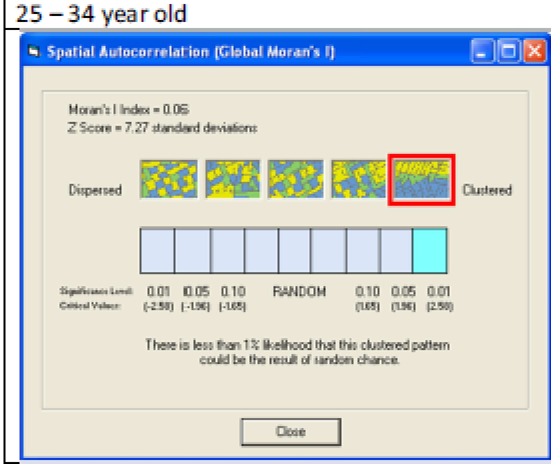
MONTGOMERY COUNTY, MARYLAND

20 – 24 year old



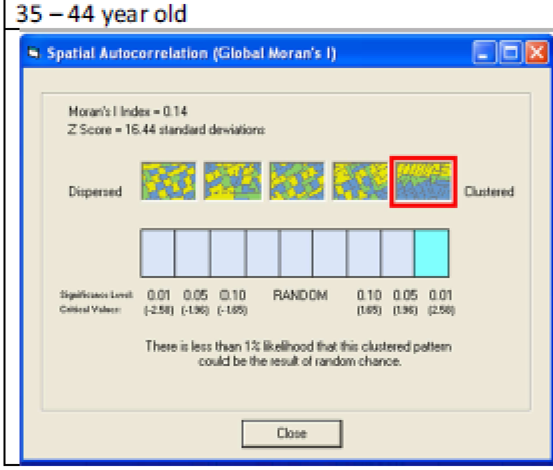
Global Moran's I Summary
Moran's Index: 0.064189
Expected Index: -0.005682
Variance: 0.000079
Z Score: 7.881285
p-value: 0.000000

25 – 34 year old



Global Moran's I Summary
Moran's Index: 0.058975
Expected Index: -0.005682
Variance: 0.000079
Z Score: 7.267577
p-value: 0.000000

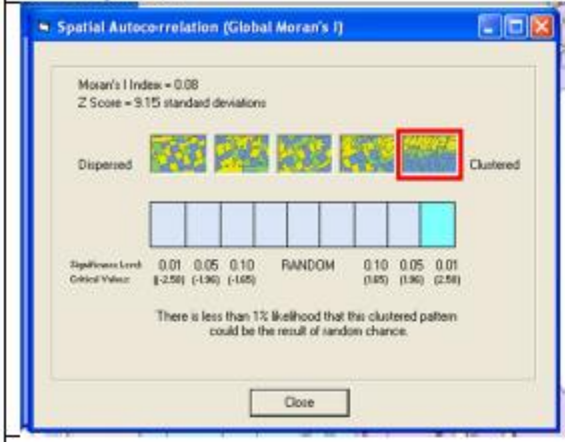
35 – 44 year old



Global Moran's I Summary
Moran's Index: 0.140188
Expected Index: -0.005682
Variance: 0.000079
Z Score: 16.435174
p-value: 0.000000

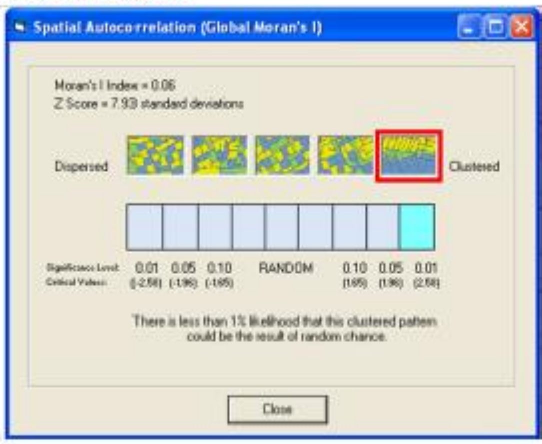
Figure F-4. Montgomery County, Maryland spatial statistics summary

45 – 54 year old



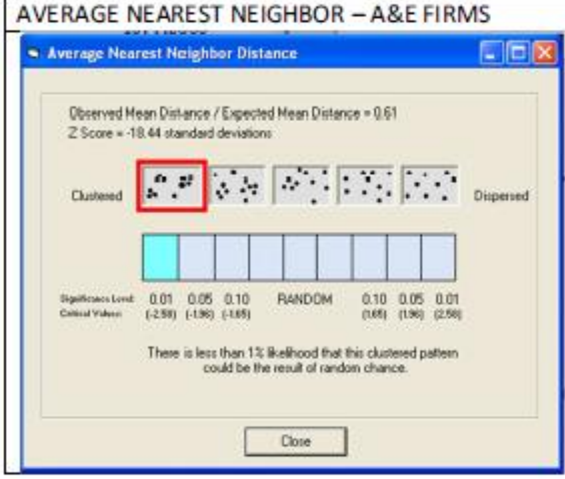
Global Moran's I Summary
Moran's Index: 0.075749
Expected Index: -0.005682
Variance: 0.000079
Z Score: 9.148157
p-value: 0.000000

MEDIAN INCOME



Global Moran's I Summary
Moran's Index: 0.064699
Expected Index: -0.005682
Variance: 0.000079
Z Score: 7.929629
p-value: 0.000000

AVERAGE NEAREST NEIGHBOR – A&E FIRMS



Average Nearest Neighbor Summary
Observed Mean Distance: 0.004603
Expected Mean Distance: 0.007583
Nearest Neighbor Ratio: 0.607095
Z Score: -18.442355
p-value: 0.000000

Figure F-4. Continued

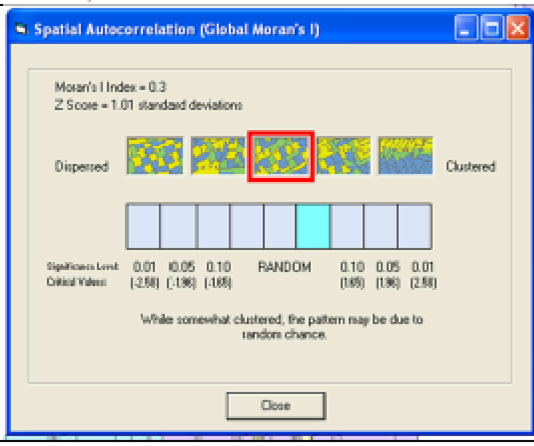
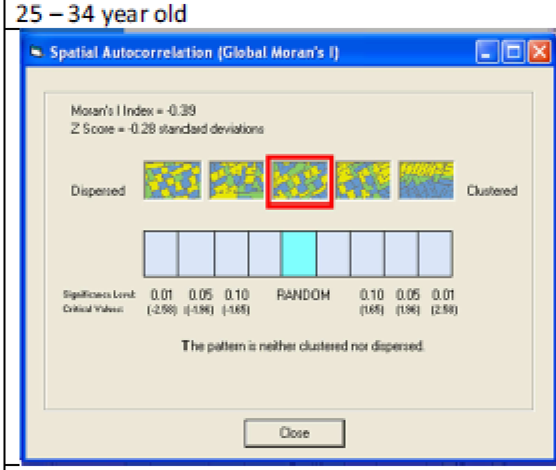
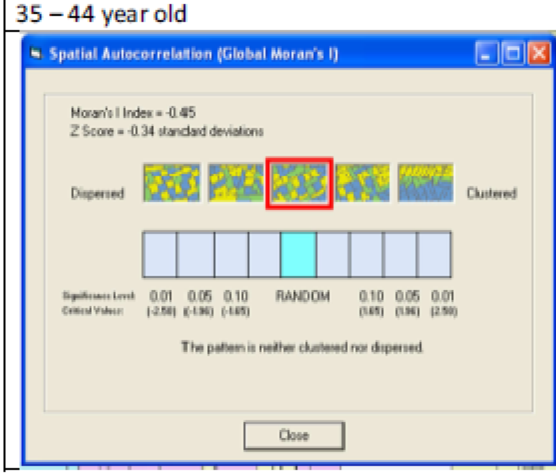
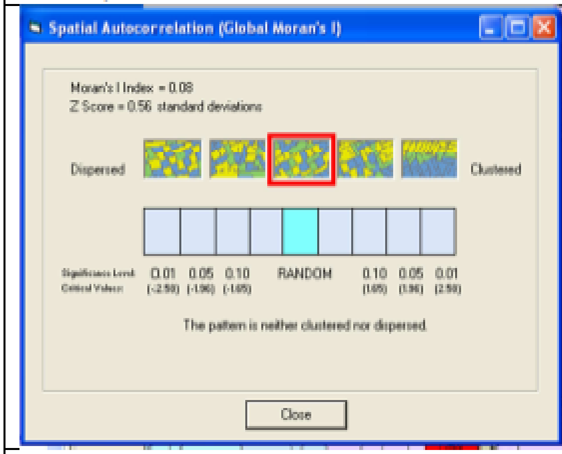
<table>
<tr><td colspan="2">FAIRFAX CITY, VIRGINIA</td></tr>
<tr><td>20 – 24 year old</td><td></td></tr>
<tr><td>
</td><td>Global Moran's I Summary
Moran's Index: 0.304179
Expected Index: -0.250000
Variance: 0.301329
Z Score: 1.009554
p-value: 0.312709</td></tr>
<tr><td>25 – 34 year old</td><td></td></tr>
<tr><td>
</td><td>Global Moran's I Summary
Moran's Index: -0.391478
Expected Index: -0.250000
Variance: 0.259049
Z Score: -0.277970
p-value: 0.781035</td></tr>
<tr><td>35 – 44 year old</td><td></td></tr>
<tr><td>
</td><td>Global Moran's I Summary
Moran's Index: -0.449896
Expected Index: -0.250000
Variance: 0.340068
Z Score: -0.342785
p-value: 0.731760</td></tr>
</table>

Figure F-5. Fairfax City, Virginia spatial statistics summary

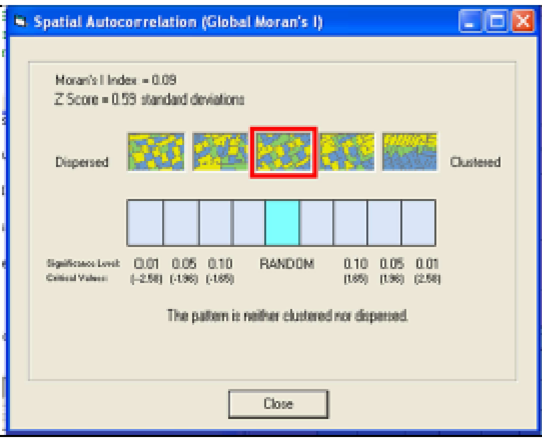
FAIRFAX CITY, VIRGINIA

45 – 54 year old



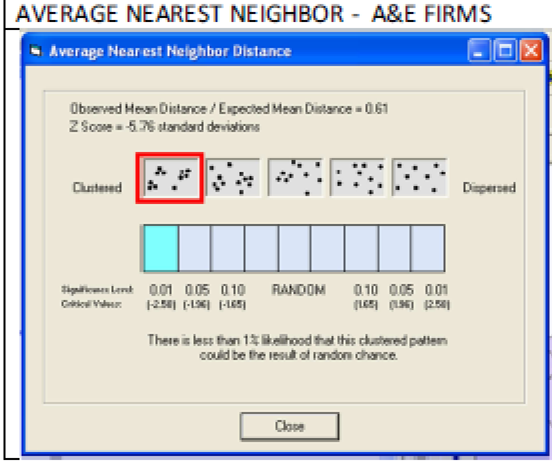
Global Moran's I Summary
Moran's Index: 0.075321
Expected Index: -0.250000
Variance: 0.333206
Z Score: 0.563580
p-value: 0.573040

MEDIAN INCOME



Global Moran's I Summary
Moran's Index: 0.092263
Expected Index: -0.250000
Variance: 0.335655
Z Score: 0.590763
p-value: 0.554679

AVERAGE NEAREST NEIGHBOR - A&E FIRMS



Average Nearest Neighbor Summary
Observed Mean Distance: 0.001380
Expected Mean Distance: 0.002258
Nearest Neighbor Ratio: 0.611037
Z Score: -5.763872
p-value: 0.000000

Figure F-5. Continued

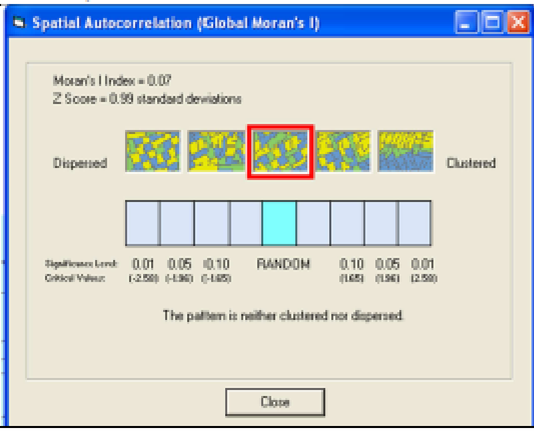
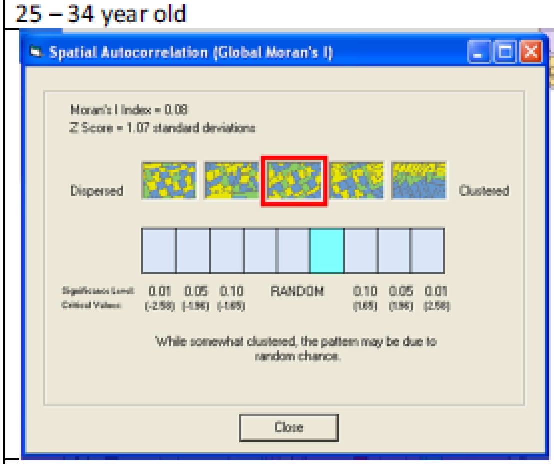
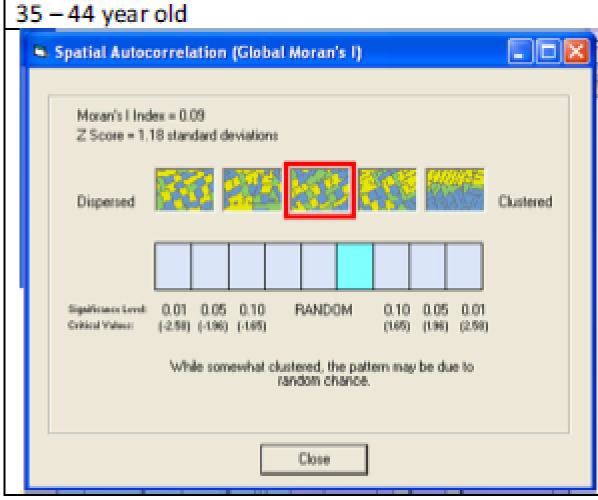
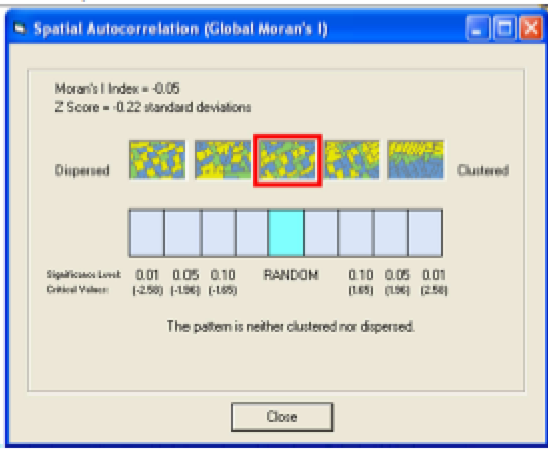
ARLINGTON COUNTY, VIRGINIA	
20 – 24 year old	
	Global Moran's I Summary Moran's Index: 0.068122 Expected Index: -0.026316 Variance: 0.009037 Z Score: 0.993420 p-value: 0.320505
25 – 34 year old	
	Global Moran's I Summary Moran's Index: 0.075035 Expected Index: -0.026316 Variance: 0.009036 Z Score: 1.066217 p-value: 0.286326
35 – 44 year old	
	Global Moran's I Summary Moran's Index: 0.087598 Expected Index: -0.026316 Variance: 0.009320 Z Score: 1.179940 p-value: 0.238024

Figure F-6. Arlington County, Virginia spatial statistics summary

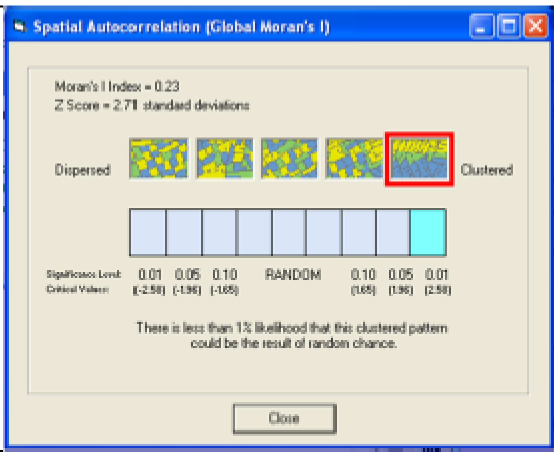
ARLINGTON COUNTY, VIRGINIA

45 – 54 year old



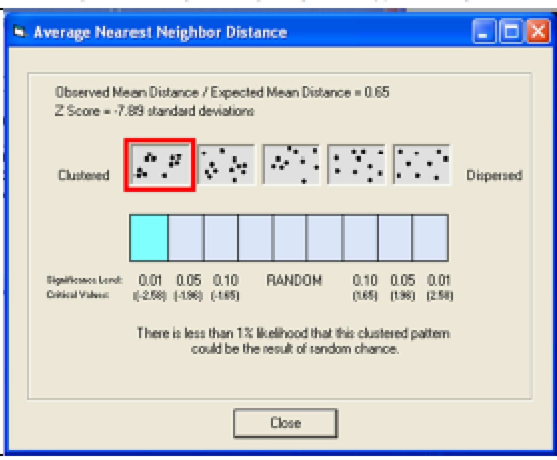
Global Moran's I Summary
Moran's Index: -0.047844
Expected Index: -0.026316
Variance: 0.009283
Z Score: -0.223435
p-value: 0.823197

MEDIAN INCOME



Global Moran's I Summary
Moran's Index: 0.232397
Expected Index: -0.026316
Variance: 0.009123
Z Score: 2.708679
p-value: 0.006755

AVERAGE NEAREST NEIGHBOR – A&E FIRMS



Average Nearest Neighbor Summary
Observed Mean Distance: 0.002225
Expected Mean Distance: 0.003415
Nearest Neighbor Ratio: 0.651580
Z Score: -7.886756
p-value: 0.000000

Figure F-6. Continued

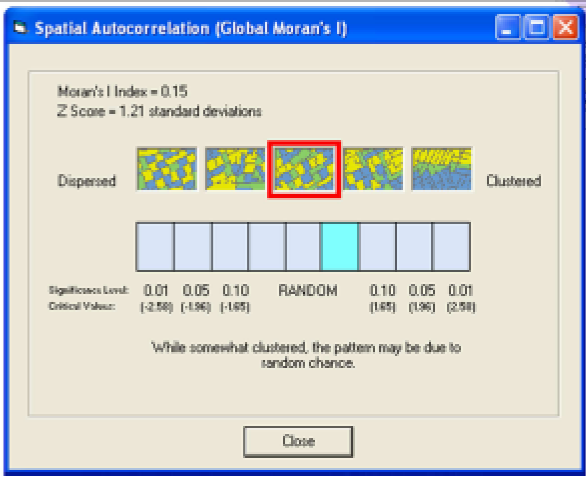
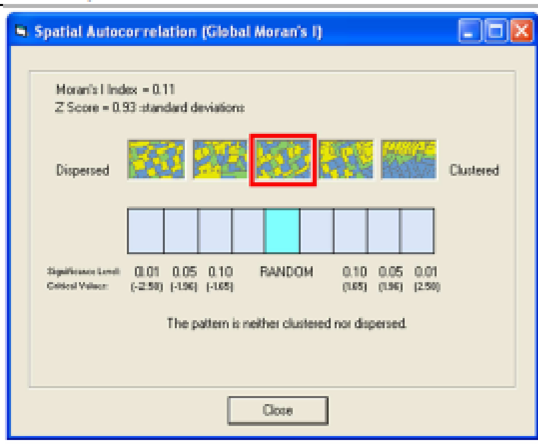
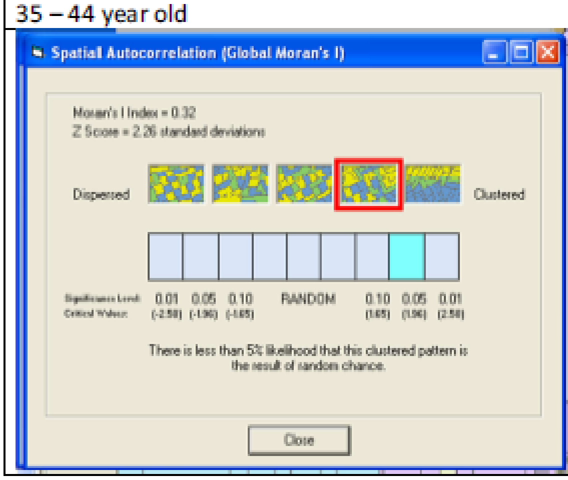
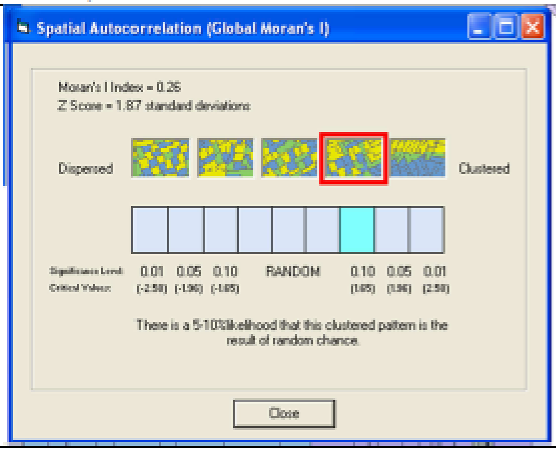
<table>
<tr><td colspan="2">ALEXANDRIA CITY, VIRGINIA</td></tr>
<tr><td>20 – 24 year old</td><td></td></tr>
<tr><td>
</td><td>Global Moran's I Summary
Moran's Index: 0.154813
Expected Index: -0.032258
Variance: 0.024080
Z Score: 1.205538
p-value: 0.227996</td></tr>
<tr><td>25 – 34 year old</td><td></td></tr>
<tr><td>
</td><td>Global Moran's I Summary
Moran's Index: 0.112554
Expected Index: -0.032258
Variance: 0.024332
Z Score: 0.928354
p-value: 0.353224</td></tr>
<tr><td>35 – 44 year old</td><td></td></tr>
<tr><td>
</td><td>Global Moran's I Summary
Moran's Index: 0.321792
Expected Index: -0.032258
Variance: 0.024469
Z Score: 2.263391
p-value: 0.023612</td></tr>
</table>

Figure F-7. Alexandria City, Virginia spatial statistics summary

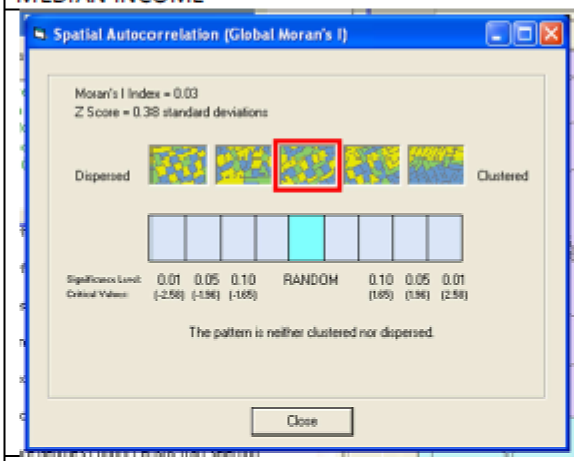
ALEXANDRIA CITY, VIRGINIA

45 – 54 year old



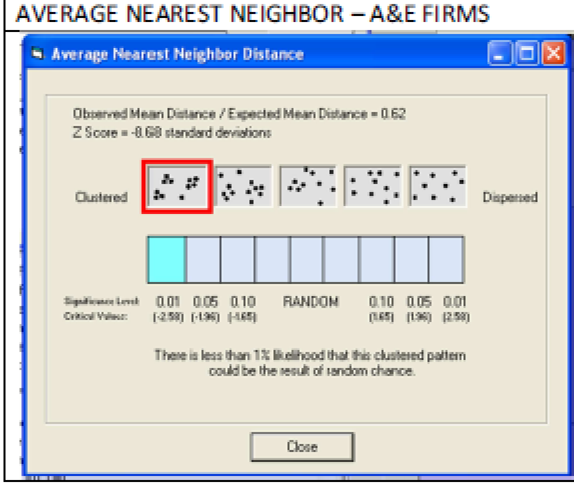
Global Moran's I Summary
Moran's Index: 0.262412
Expected Index: -0.032258
Variance: 0.024774
Z Score: 1.872132
p-value: 0.061188

MEDIAN INCOME



Global Moran's I Summary
Moran's Index: 0.027846
Expected Index: -0.032258
Variance: 0.024442
Z Score: 0.384445
p-value: 0.700648

AVERAGE NEAREST NEIGHBOR – A&E FIRMS



Average Nearest Neighbor Summary
Observed Mean Distance: 0.001522
Expected Mean Distance: 0.002437
Nearest Neighbor Ratio: 0.624452
Z Score: -8.681060
p-value: 0.000000

Figure F-7. Continued

APPENDIX G
CAPTIOL REGION SCATTERPLOTS – EDUCATIONAL ATTAINMENT FACTOR

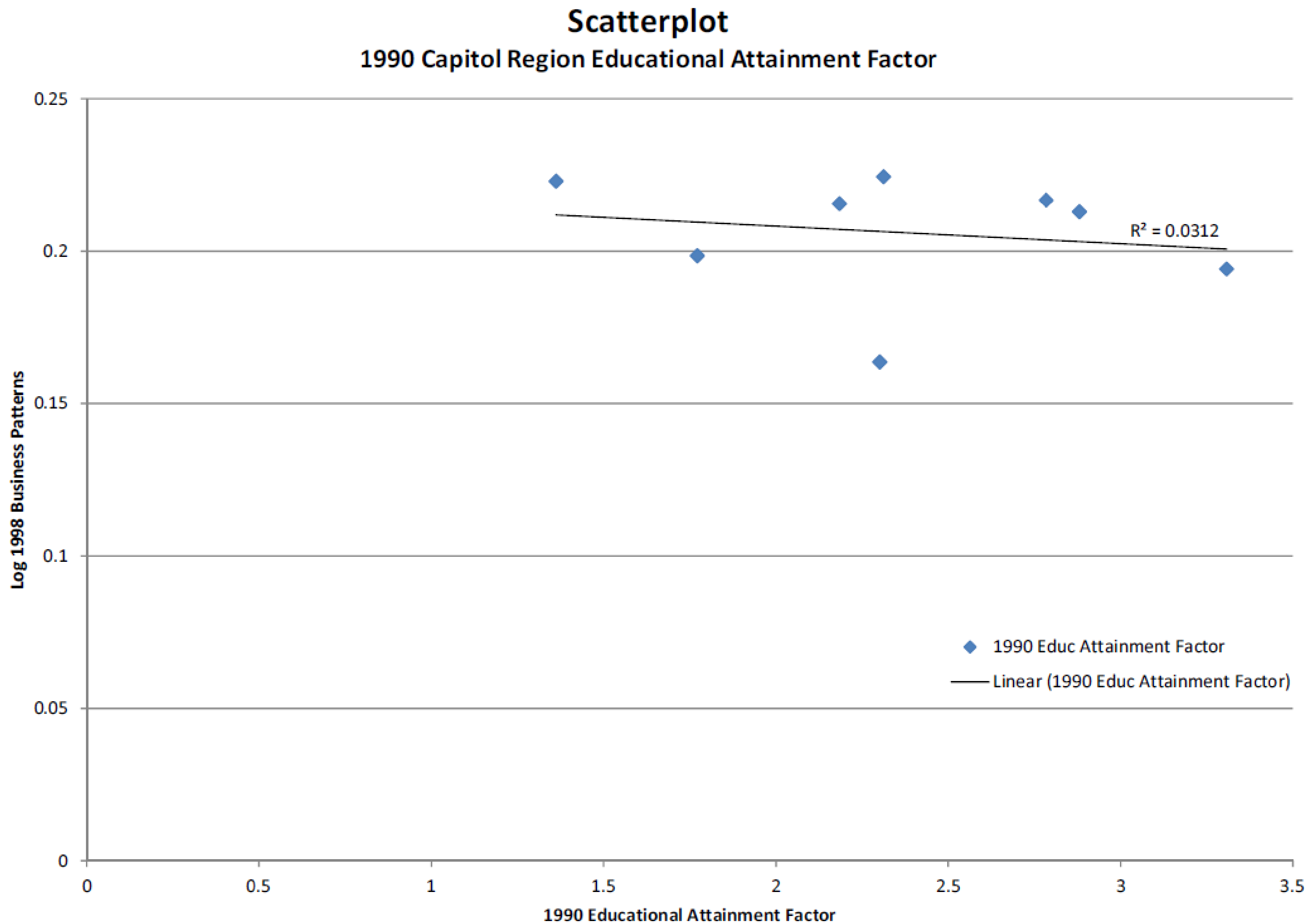


Figure G-1. Business patterns and Educational Attainment Factor in the Capitol Region, 1990

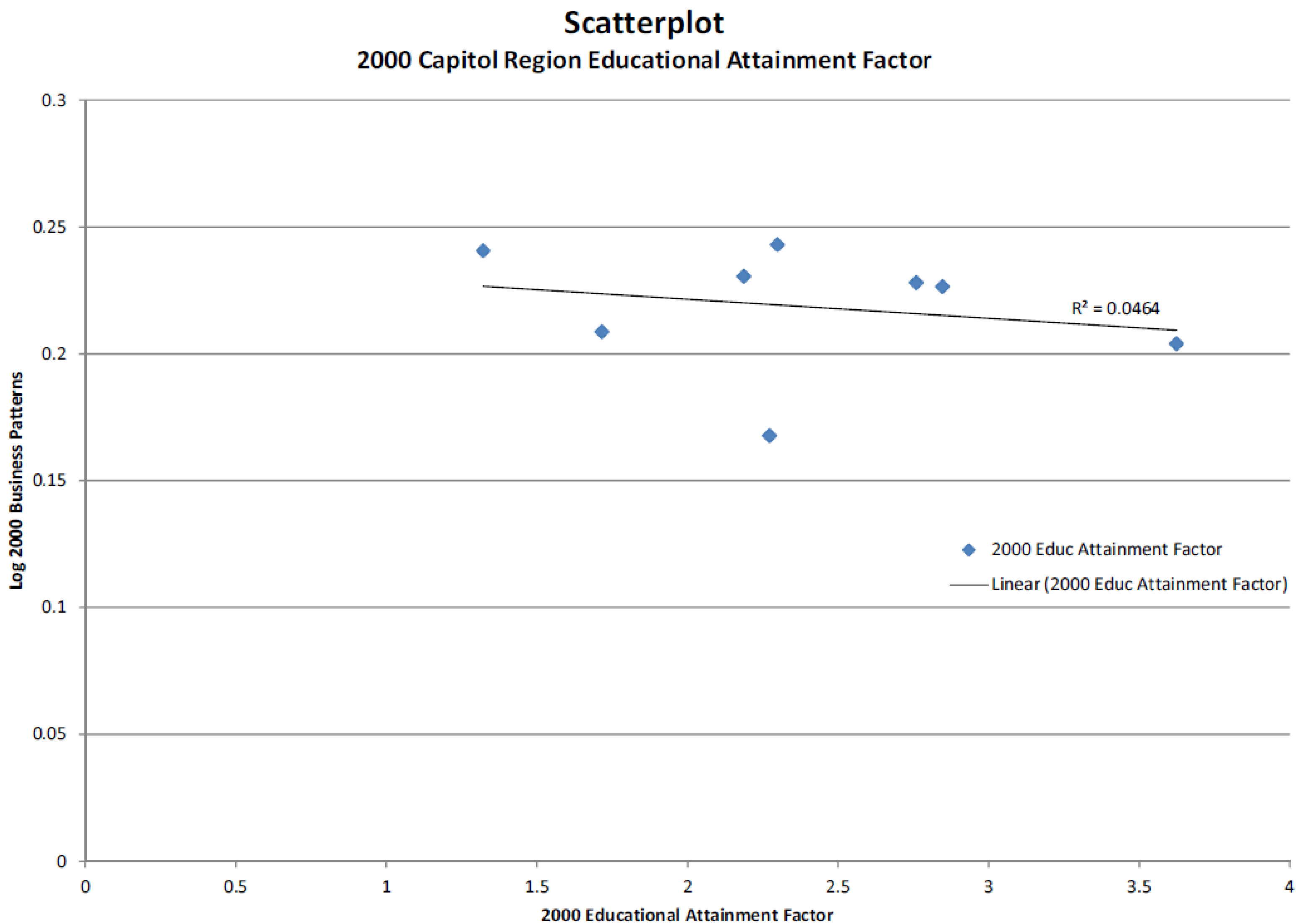


Figure G-2. Business patterns and Educational Attainment Factor in the Capitol Region, 2000

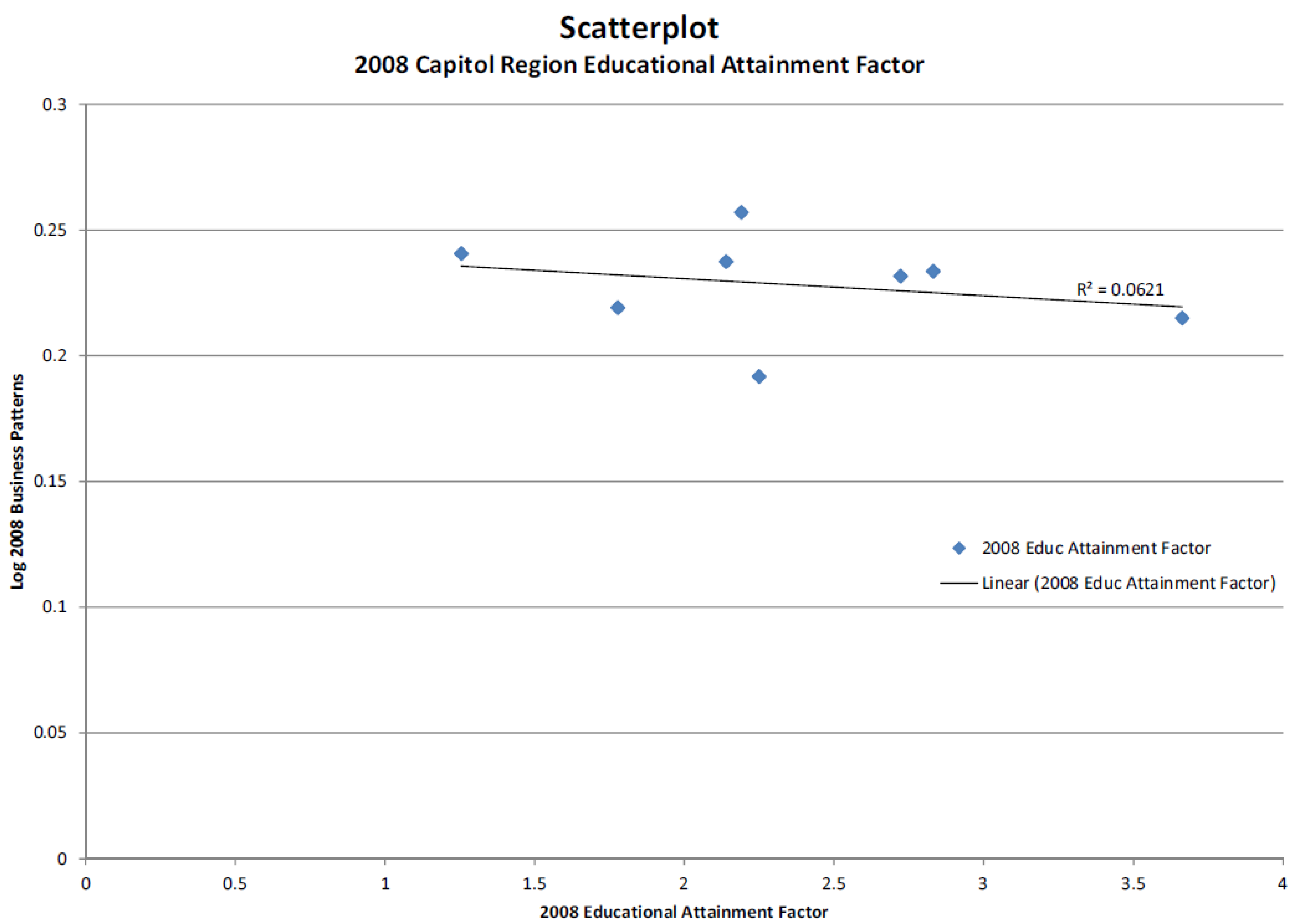


Figure G-3. Business patterns and Educational Attainment Factor in the Capitol Region, 2008

APPENDIX H
REGRESSION RESULTS– EDUCATIONAL ATTAINMENT FACTOR

Table H-1. Regression summary output Educational Attainment Factor– 1990

Regression Statistics	
Multiple R	0.896348649
R Square	0.803440901
Adjusted R Square	0.724817262
Standard Error	0.327503501
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.192111715	1.096055857	10.21882103	0.017129034
Residual	5	0.536292716	0.107258543		
Total	7	2.728404431			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-2.613651036	1.868309055	-1.39893934	0.220702625	-7.416292355	2.188990284	-7.416292355	2.188990284
log total pop 1990	0.76794189	0.173265563	4.432166885	0.006814324	0.322548582	1.213335199	0.322548582	1.213335199
1990 Educ Attainment Factor	4.587321384	6.512174632	0.704422354	0.512616885	-12.15275644	21.3273992	-12.15275644	21.3273992

Table H-2. Regression summary output Educational Attainment Factor– 2000

Regression Statistics	
Multiple R	0.823864554
R Square	0.678752803
Adjusted R Square	0.550253925
Standard Error	0.475952103
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.393143798	1.196571899	5.28216908	0.058492255
Residual	5	1.132652023	0.226530405		
Total	7	3.525795821			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-2.388471868	2.523568471	-0.946466044	0.387371171	-8.875511141	4.098567405	-8.875511141	4.098567405
log total pop 2000	0.792544546	0.25262851	3.137193609	0.025747674	0.143142288	1.441946804	0.143142288	1.441946804
2000 Educ Attainment Factor	2.625400181	7.805019521	0.336373301	0.750247152	-17.43804123	22.68884159	-17.43804123	22.68884159

RESIDUAL OUTPUT

Observation	*Predicted log 2000 business patterns*	*Residuals*	*Standard Residuals*
1	2.265210576	-0.077689855	-0.193136821
2	2.432165897	-0.13331282	-0.331415399
3	2.710114462	0.914270779	2.272875289
4	2.950765214	-0.103192555	-0.256536482
5	1.593083354	0.12291999	0.305578843
6	1.426175614	-0.103956319	-0.258435197
7	2.918793232	-0.15988134	-0.397464684
8	2.730999485	-0.459157879	-1.141465549

Table H-3. Regression summary output Educational Attainment Factor– 2008

Regression Statistics	
Multiple R	0.799426593
R Square	0.639082878
Adjusted R Square	0.494716029
Standard Error	0.516823289
Observations	8

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	2.364851374	1.182425687	4.426797998	0.078256193
Residual	5	1.33553156	0.267106312		
Total	7	3.700382934			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-1.600391267	3.130452381	-0.511233225	0.63095546	-9.647475295	6.446692762	-9.647475295	6.446692762
log total pop 2008	0.76430785	0.270330893	2.827304863	0.036791111	0.069400165	1.459215534	0.069400165	1.459215534
2008 Educ Attainment Factor	-0.480750769	10.43031173	-0.046091697	0.965021428	-27.29272064	26.3312191	-27.29272064	26.3312191

RESIDUAL OUTPUT

Observation	*Predicted log 2008 business patterns*	*Residuals*	*Standard Residuals*
1	2.220268729	-0.080389643	-0.184044159
2	2.335689737	-0.145358039	-0.332782896
3	2.706050694	0.957367518	2.191798528
4	2.875151221	-0.043921528	-0.100554006
5	1.631978618	0.146172633	0.334647828
6	1.37785814	-0.122585635	-0.280647723
7	2.854556473	-0.13192255	-0.30202367
8	2.829782759	-0.579362757	-1.326393902

APPENDIX I

REGRESSION RESULTS– PRINCIPAL COMPONENTS ANALYSIS, CAPITOL REGION

Table I-1. Regression summary output for the PCA of the Washington, DC region

Regression Statistics	
Multiple R	0.890398147
R Square	0.79280886
Adjusted R Square	0.772347993
Standard Error	3.647723296
Observations	61

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	3003.952771	1501.976385	112.8806	1.00873E-20
Residual	59	785.0472295	13.30588525		
Total	61	3789			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
IP_DENSITY	0.029387073	0.023845189	1.232410967	0.222684	-0.018327041	0.077101186	-0.018327041	0.077101186
TranAcces	1.012318841	0.176253759	5.743530517	3.43E-07	0.659635885	1.365001798	0.659635885	1.365001798

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