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The new North: Patents and knowledge economy analysis in Alaska

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THE NEW NORTH: PATENTS AND KNOWLEDGE ECONOMY ANALYSIS IN ALASKA

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ABSTRACT

In the last few years, Alaska's economy suffered as world oil prices plunged to very low levels, and the analysts predicting that Alaska output will continue to dwindle in the years to come. As a result of Alaska's dependence on oil economy, the state now faces a budget deficit. Modern economic development theories suggest searching for ways to manage northern frontiers. Investment in a knowledge –based economy seems to be new one of the appealing alternatives, and investing the human capacities is necessary. There is enough evidence from both central and peripheral regions that geographic proximity between the people and the organizations that creates knowledge is still at the core of region's ability to nurture a successful regional innovation system.

As the Alaska economy recovers from the recent economic crisis, the focus is now shifting towards how the new sources of economic growth can be fostered in order to provide the jobs and prosperity for the coming decades. In the state of Alaska, there have been very few studies of the knowledge and creative economies. The key features of a knowledge economy include a greater reliance on intellectual capabilities than on physical inputs or natural resources, combined with efforts to integrate improvements in every stage of the production process. Patents are usually considered as a representation of the knowledge economy. We provide evidence drawn from patent data to document dynamics in knowledge production. Over thirty-five years (1976-2010) investigation of the spatial distribution of patents and typological characteristics of innovation activities in Alaska had done. The

primary results show that Alaska has considerable patent activity, especially in wells industry sector, that there is strong clustering of innovation in Anchorage, Fairbanks, and Matanuska Boroughs and that there is a relationship between innovation and employment in the top 25 industry sectors in Alaska.

Overall, between 1976 and 2010 AKRIS evolved from a small isolated system dominated by individual (lone-eagle) inventors focused on the innovation in old, low-technology sectors to a relatively diversified (although still over-reliant on the oil sector) intra- and internationally connected system with a considerable presence of company-driven innovation, but yet a strong position of individual inventors, including those from smaller communities. Correlation analysis show that the most significant relationship was observed with population, overall inventor count, and employment in 25 top patent –producing sectors. Further studies need to apply more qualitative and quantitative analysis methods, such as network analysis, to create a full clear image of innovation production over a long-time frame. Including more socio-economic factors that impact innovation activities in Alaska and connecting the dynamics of innovation with other processes in Alaska and global economy would also be important.

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TABLE OF CONTENTS

PAGE

LIST OF TABLES viii

LIST OF FIGURES ix

CHAPTER 1. INTRODUCTION 1

1.1. Research Goals 3

1.2. Research Questions and Objectives 3

CHAPTER 2. LITERATURE REVIEW 5

2.1. The Knowledge Economy and its Role in the Economic Development 5

2.2. What is Innovation? 7

2.3. Regional Innovation Systems 8

2.4. The Impact of Geographical Location on Knowledge Economy 10

2.5. Geographical Analysis of Patents 11

2.6. The Knowledge Economy in the Arctic 12

2.7. A Brief Description of Alaska Economy 14

2.8. Creative Capital and Innovation in the Periphery 17

CHAPTER 3. METHODOLOGY 20

3.1. Study Area 20

3.2. Measures of Knowledge Economy 21

3.3. Inventors' Networks 22

3.4. Inventor Networks Analysis 24

3.5. Inventors' Spatial Networks 26

3.6. Methods and Techniques 26

3.7. Data and Definitions 29

3.8. Measuring Innovation Activity in Alaska Using Patents 31

3.9. Quantitative Analysis 34

CHAPTER 4. RESULTS AND DISCUSSION 35

4.1 History of Patents in Alaska 35

4.1.1 Patents Production in Alaska's Borough: Historical Trends 37

4.2. The Geographical Distribution of Patents and Inventors 39

4.2.1. Overall Patent Production 39

4.3. Descriptive Indicators of Patents and Inventors 44

4.3.1 Patents and Inventors Distribution over the Investigated Time 44

4.3.2. Description of Patents by Industry Sectors 52

4.3.3. Analysis of Applicant Inventor and Organizations by Industry Sectors 60

4.4. Specialization and Sectoral Concentration of Patents 64

4.5. Understanding innovation networks within AKRIS 69

4.5.1 The Regional Innovation System in Alaska 70

4.6. Co-Inventors Networks Analysis 76

4.7. Identifying Potential Factors of Innovation Activities 97

4.7.1. Correlation Analysis 98

CHAPTER 5: CONCLUSIONS 102

5.1. Limitations and Future Directions…………..…….………………………...107

REFERENCES......................... …………………………………………………..109

APPENDIX A: PATENTS AND POPULATION IN ALASKA BOROUGH………120

APPENDIX B: PATENTS COUNTS IN ALASKA CITIES FROM 1976-2010. ...121

APPENDIX C: PATENTS DATASET DEFINITIONS... 122

APPENDIX D: PYTHON SCRIPT OF INVENTORS SPATIAL NETWORKS...... 123

APPENDIX E: PERCENTAGES OF DISTRIBUATION OF THE RESIDENCE OF THE INVENTORS OVER A PERIOD OF 35 YEARS …..…….126

APPENDIX F: ANNUAL OIL PRICES COMPARING WITH PATENTS AND INVENTORS COUNT………………………………………………127

APPENDIX G: CALCULATED LQ VALUES OF RECORDED PATENTS FROM 1976- 2010……………………..………………………130

LIST OF TABLES

TABLE PAGE

1 Major Alaska Economic Sectors.. 15

2 Annual Number of Patents and Inventors 1976-2010... 47

3 Innovations by Industry Sector 53

4 Descriptive Statistics of Company and Individual Inventors of Top 25
Industry Sectors…………………………………………………………………..61

5 Calculated LQ Values of Recorded Patents from 1976-2010 of the Top 25
Industry Sectors…………………………………………………………………..67

6 A Cluster of Patenting in a Certain Industry beyond the Predicted Portions,
over the 35 Years ‘Time.. 69

7 Patent Activity_ Socio-economic Factors.. …………..99

8 Correlation Analysis: Patents and Socio-economic Characteristics of Alaska
Boroughs (2000-2010) 100

LIST OF FIGURES

FIGURE PAGE

1 A Stylized Regional Innovation System 9

2 Study Area: Alaska (Patents in Alaska Boroughs) 21

3 Flow Chart of Research Methodology 27

4 Patents and Inventors Numbers Trends.. 36

5 Patents and Inventors Share per Borough by Five-Year Periods.......................... 38

6 Anchorage, Fairbanks, and Wasilla's' Total Number of Patents Granted
From 1976 to 2010……………………………………………………………….40

7 Utility and Design Patents Total Number in Alaska Cities………..……………..41

8 The Recorded Patents per Alaskan Borough 41

9 Alaskan Patents per 1000 Residents 42

10 Alaskan Inventors per 1000 Residents... 43

11 Distribution of the Residence of the Inventors over a Period of 35 years
under Investigation.. 45

12 Annual Number of Patents and Inventors, and Average Team Size per Patent... 49

13 Oil Prices Trends Comparing with Patent Count 1976-2010…………………....51

14 Wells Industry Patents... ………55

15 Surgery Industry Patents 56

16 Hydraulic Technology Patents 57

17 Land Vehicles Industry Patents.. 58

18 Top 5 Industry Sector over the First Three Decades & Last 5 Years 60

19 A Stylized Regional Innovation System 70

20 Alaskan Regional Innovation System Components 72

21 Percentages of Individuals, Company, Government, and Universities Shares 74

22 Alaskan Inventors Share in Patents 75

23 Non-Alaskan Inventors Share in Patents 75

24 Co-Inventors Spatial Locations 1976-2010 77

25 1976-1980 Alaskan Inventors Network 78

26 1976-1980 Inventors Analysis 80

27 1981-1985 Alaskan Inventors Network 81

28 1981-1985 Inventors Analysis 83

29 1986-1990 Alaskan Inventors Network 84

30 1986-1990 Inventors Analysis 86

31 1991-1995 Alaskan Inventors Network 87

32 1991-1995 Inventors Analysis 89

33 1996- 2000 Alaskan Inventors Network 90

34 1996-2000 Inventors Analysis 91

35 2001- 2005 Alaskan Inventors Network 92

36 2001-2005 Inventors Analysis 94

37 2006-2010 Alaskan Inventors Network 95

38 2006-2010 Inventors Analysis 96

CHAPTER 1

INTRODUCTION

Exploring the role of innovation and creative activities in economic development recently became an important study area among economists around the world (Feldman, 2000). Over the past few decades, the knowledge economy has risen to occupy a key status in economic development and has played an essential role in improving the global economy (Bell, 1973; Clark, Feldman & Gertler, 2000). According to studies, there is a strong relationship between innovation in a region and its economic development, since innovation measures the efficiency of the economic activities in the economic development in a certain region (Feldman, 1994).

Measuring the knowledge economy and innovation activities in a certain location is a difficult task (Feldman, 2000). One can study the development of a knowledge economy based on different elements, such as Research and Development (R&D) spending, technological innovations, and the financial investment in different economic sectors. These factors are used to measure in less developed countries economic development (Irvine & Martin 1989; Braun, Glänzel, & Schubert, 1991). Without any doubt, the economically feasible innovations and creative capital that brings them to existence are the key elements of the economic development (Florida, 2002, 2012; Petrov, 2007, 2008; Petrov & Cavin, 2012).

Many studies indicate the importance of using patents as an indicator of economic development since they are a major component of innovation (Breschi, & Malerba, 2003; Hall, Adam, Jaffe & Manuel Trajtenberg, 2001). For patents to be of economic value, they must be commercially active (Sonn, 2008). Many previous studies have analyzed the impact inventions have had on economic growth by clarifying the relationship between the geographic location and innovative activities (Bathelt & Graft, 2006; Scott, 1993; Storper, 1997). These studies have found that the regions that have experienced economic growth are all geographically correlated to concentrations of creative activities (Sonn, 2008; Florida, 2002, Florida & Mellander, 2014). However, with the advent of the internet, it is possible for cooperation to take place between distant places. This creates economic connections between these places regardless of the geographic location effect (Sonn, 2008). In these studies, the researchers focus on patent analysis in the USA and its relationship with other national innovation systems, discovering the similarities and differences between innovative trends around the world.

Recent research extended the notion of knowledge economy and creativity as drivers of economic development in remote areas. For example, Huskey (2002) discussed ways to attract high-tech firms to Alaska in an attempt to create ’Silicon Tundra’ through low costs and high quality of life. Since remote regions in the north require higher costs while providing only limited economic of scale, the question remains whether the quality of the life overcomes other factors (Huskey, 2002). Other studies emphasized both opportunities (Petrov, 2007, 2008; McGranahan & Wojan, 2007); and challenges for innovation, entrepreneurship, and creativity in rural and remote settings.

This study highlights the role of the knowledge economy in Alaska. Alaska is a peripheral region in the USA and in the world. It is also considered as a part of the Arctic region, which has experienced an economic boom in the last few years (Larsen & Huskey, 2015). A variety of economic sectors outside the traditional "pillars" of the arctic economy (resources, public sector, and subsistence), such as professional and financial services, specialized manufacturing, information technology, have contributed to the Arctic's growth (Petrov, 2016). Thus, understanding the role of creative capital and innovative activities in Alaska could help us to better understand the emergence of the new economies in peripheral areas as they become affected by globalization, urbanization and knowledge-driven development.

1.1. Research Goal.

The goal of this study is to analyze the geography and dynamics of the knowledge economy in Alaska and elucidate linkages to the economic development in the area between 1976 and 2010.

1.2. Research Questions and Objectives

This study will address the following research questions:

1. What are the geographies and typologies of patent production in Alaska?

2. What are the internal and external components and connectivity’s within the Alaska Regional Innovation System?
3. What socio-economic factors influence innovation activity in Alaska?

To answer these questions, we pursue three objectives:

1. To determine the spatial distribution of patents and typological characteristics of innovation in Alaska.
2. To elucidate the external and internal innovation connectivity within the Alaska Regional Innovation Systems (AKRIS).
3. Identify the possible factors that influence innovation activities in Alaska.

CHAPTER 2

LITERATURE REVIEW

2.1. The Knowledge Economy and its Role in the Economic Development

According to the literature, there is an overall acceptance that innovation, knowledge, and education are important for building a strong and healthy economy (Bell, 1973; Clark et al., 2000). Innovation is at the core of economic development connecting previous knowledge and new knowledge. Innovation ensures the continuation of the economic process and that influences all social sectors of development (Kogler, 2010; Feldman, 2000). Also, previous studies suggest that there is a significant connection between creative and artistic capital and scientific technology (Florida, 2002).

Creative Capital provides a power of a region's innovation and knowledge potential (Florida, 2002, 2012; Petrov, 2007, 2008 McGranahan & Wojan, 2007). Also at the level of the economic value creative capital can be represent as the stock of human creativity that has an economic value (Petrov, 2007, 2008; Petrov & Cavin, 2012, Florida, 2002, 2012).

The Knowledge economy is defined as an economy that depends on knowledge and technology as main factors of production and wealth making. Since technology and knowledge convert wealth-creation activities from physically-based functions to knowledge-based activities (Lagendijk, & Lorentzen, 2007; Kogler, 2014; Sonn, 2008).

The presence of creative people in communities leads and motivates individuals to innovate (Florida, Mellander & Stolarick, 2008). Creativity is the core of our daily life and creative work is leads to high economic rewards and a better quality of life in everything (Florida, 2012). Economist Paul Romer noted that “the biggest advances in standards of living –not to mention the biggest competitive advantages in the marketplace –have always come from ‘better recipes, not just more cooking’ (Florida, quoted in 15, 2012). Technological innovation is not the only aspect of creativity, it also includes the differences of the intelligence behavior and special methods of thinking that are cultivated at both individuals and groups (community level). Creativity cannot only be developed by individuals, but can also be generated within organizations (Florida 2002).

Due to the importance of the economic growth, much literature has surfaced to discuss the variables that impact economic growth and development. Some of the most important elements of knowledge-driven economic development are creative activities (Barkely, Henry & Lee, 2006; Feldman, 1994, 2000), and knowledge production, including patents (Audretsch & Keilback, 2006; Bell, 1973; Beyers & Lindahl, 2001; Lagendik & Lorentzen, 2007; Romer, 1990). Many examples have pointed out that patents are clustered (Grabher, 1993; Storper, 1997). Therefore, geographical region plays a significant role in altering creative activities and increasing the strength of knowledge economy (Florida et al., 2008; Petrov, 2010; Porter, 1999).

Modern economic growth is largely built upon models with fixed or increasing returns to crucial factors as a result of the accumulation of knowledge (Blomström, Kokko, &

Sjöholm, 2002). A continuous knowledge expansion leads to years of growth and development (Feldman, 2000). The growth can be based on the new knowledge or the transfer of the existing knowledge resulting in economic competitiveness and success. New knowledge adds to economic production through enhancing the productivity and merging of innovative ideas and technology. The new innovations or applications of the existing knowledge to improve old technologies have brought enormous benefits in many sectors. Taking the knowledge externalities into account, the literature concludes that geographic proximity still a key factor in innovation activities (Storper, 1999; Audrestsch, 2003). Clearly that identifying the paramount importance of geographic space is an essential factor in generating innovative activity (Audretsch & Feldman, 2004).

2.2. What is Innovation?

Innovation can be defined as the implementation of a new product or development process. Its perceived to be novel and involves creativity which is an individual intellectual process (Feldman, 2002). Perhaps uniquely, what is important about the innovation is that the innovation relies on knowledge creation and deployment. For instance, the difference between product innovation and process innovation centered on sharing innovative technology into the methods of production (Feldman, 2000). In general, the process innovation is linked to a firm level of productivity which influences the increase of product quality or the decrease of the cost of productivity. While the product innovation is associated with creative ideas and lead to new products with simply noticeable improvements, the novel data that have an impact in the economic activity, such as patents or some product announcements. Malecki (1988) provides another definition for the innovation describing it as an effect of the creative applications on modern technologies. He highlighted the importance of local conditions that determine innovation potential (Malecki, 1988). Regions with strong technological innovation have experienced a significant increase in economic growth (Frenkel & Shefer, 1996).

2.3. Regional Innovation Systems

The Regional Innovation Systems (RISs) is a well-accepted approach to understanding the geographic encapsulation of the knowledge economy (Asheim & Isaksen, 2002). The concept has two main parts: the first part is innovation research and its characteristics, and the second is regional science (encourage collaborative teaching, learning, and research) since it is interested in explaining the local distribution of regional tech industry, innovation networks industry (Cooke, Uranga & Etxebarria, 1997). The RIS strategy promotes the interactive innovation and systematic learning. The RIS is likely associated with knowledge exchange between knowledge producers and knowledge users. Also, the RIS approved who focusses on supporting institutions, agencies that feed those regional knowledge exchanges. Since there is universal recognition that innovation takes places within regional innovation systems. In the scheme shown in Figure 1 RIS research focuses and its main dimensions on:

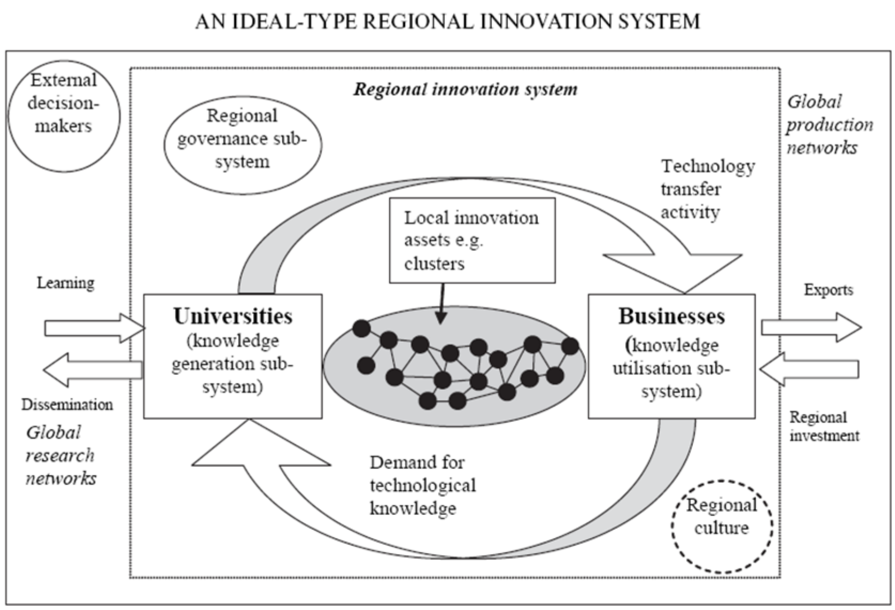

Figure 1: A Stylized Regional Innovation System (Source: Organization for Economic Co-operation and Development [OECD], 1994, Cooke & Piccaluga, 2004)

- The Interaction between the actors of the innovation system that influence the exchange of knowledge.
- The role of institutions to support the knowledge exchange within the local region.
- The key role of RSI in regional innovation policy making. (Lundvall, 1988).

Alaska is one of the regions in need for exploring the structure of the local RIS and the factors that play role in regional innovation and stimulate vibrant knowledge economy. However, Alaska RIS (AKRIS) is yet to be described and mapped, a significant gap and impediment for economic development efforts in the state.

2.4. The Impact of Geographical Location on Knowledge Economy

Location generally has a considerable impact on people’s activities, so when we talk about creative people, we should study the regional influence on creativity. Through history, creative people have gravitated to highly populated areas since cities provide people with the suitable environment to be creative. Economically successful cities benefit from the production scale and the area size (Markusen, 2004; Porter, 1990). Cities have a wide variety of facilities and high possibilities that stimulate people's creativity and encourage them to think about new things. This what happened in the European cities in the past (Florida, 2002).

There is enough evidence that geographic proximity between people and organizations that create knowledge is at the core of their ability to keep innovating (Gertler, 2005). The studies of aerospace, semiconductor, and biotechnology show that the clustering (organizations) is a crucial factor (Bathelt & Graft, 2006; Saxenian, 1994; Scott, 1993). As shown by these studies any knowledge flow is subjected to constraints and depend upon the cost of covering distances (Acs, 2002; Audretsch & Feldman, 1996; Glaeser, 1999; Patel & Pavitt, 1991; Porter, 2000; Storper, 1997; Zucker, Darby & Armstrong, 1998).

The location of innovation, specifically a knowledge-intensive economic activity, can be manifested as a cluster of innovative activity, such as well-known Silicon Valley in California (Saxenian, 1994). Urban-scale economy’s (Feldman, 2000, 2002) stimulate an exchange of complimentary knowledge between several agents within geographic region s (Jacob’s concept of diversity (Jacobs, 1969)). Each of these approaches indicates a benefit of clustering in the economic activity. In this study, we will provide a framework to consider how the spatial distribution of patents may affect the economic developments in the region.

2.5. Geographical Analysis of Patents

Patents represent the main instrument for protecting intellectual property rights for individuals and groups (Merges, 1997). Patents give an inventor an exclusive right to economically exploit the innovation for a certain period. A patent should be a piece of new work (novel) not a part of previous work. In addition, a patent must have an invention and should solve a problem in a field and lead to the possibility of a valuable application. An invention within a patent must be explained in enough details to enable others to take the advantage from this patent. (Merges, 1997). Patents are usually considered as a good indicator of knowledge economy (Feldman, 2000).

Patents are an indicator of innovation and R&D process (Jaffe, Trajtenberg, & Henderson, 1993; Jaffe, & Trajtenberg, 2002; Khan, Dernis, 2006). In the USA, U.S. Patents and Trademarks Office (USPTO) holds the patents statistics for various locations. However, not all patents are useful and not all of inventions are patented (Feldman, 2000).

Another indicator in the R&D processes is the number of scientific publications, which are considered as a very useful source of information on R&D output (Thomas, Sharma & Jain, 2011). But there are many of restrictions in publications, such as the language style (Rousseau S. & Rousseau R., 1997; Leeuwen, Moed, Tijssen, Visser & Raan, 2001), authorship and others. The measure of the contributions for each author becomes a problem. In addition, it is difficult to split multi-author papers among different countries (Thomas et al., 2011). Other publications such as reports, projects, and monographs count as scientific data but there are no certain methods to cover all of them. R&D outputs heavily rely on scientific publications that give the advantage to states that have the higher number of publications. The database provided by USPTO and ISI Web of knowledge Science Citation Index is a valuable source about the knowledge economy (USPTO, 2009).

In the United States patents must be granted by the US Patent and Trademark Office (USPTO) upon the examination of an invention (Kogler, 2014). But that depends on the type of patent since the technological patents are more directly valuable in knowledge economy than other types of patents since they impact the economic development more than other types of patents (Petrov, 2016). The number of patents in a certain area reflects the knowledge economy outcomes.

2.6. The Knowledge Economy in the Arctic

The knowledge economy is shaped by the location of the study area. For example, the Arctic is known for its peripheral, powerless and dependent status with respect to the southern regions (Agranat, 1992; Bone 2009; Rea, 1968; Petrov 2012). With unstable resource economy, finding new economic opportunities is an urgent need to improve economic development in Arctic (Petrov, 2016). However, new economic opportunities in the Arctic are not plentiful since there is a shortage of labor force with limited human capital (Larsen &

Fondahl, 2014). Many economists and economic geographers have demonstrated that human capital has a significant impact on economic growth through innovations. That considered as the driver of the knowledge economy, and many types of research pointed out an important relationship between the economic development and the capability to catch human capital (Desrochers 2001; Florida 2002; Glaeser 2000; Jacobs 1984).

The Arctic economy has been described always as a dynamic, adaptable economy since its early history; however, nowadays the change differs from the past in nature and magnitude, especially in respect to climate change, economic integration with global markets, and increased accessibility. In the North, both small and large urban and industrial centers are experiencing the global change. Northern regions facing limitations, such as resource dependency and socio-economic challenges perhaps have a lower adaptive capacity to the new economic change. Southcott (2010) suggested that the northern regions in Canada influenced by globalization and shifted from simple economy components such as fishing and subsistence-based economy to postindustrial and knowledge-based economy (Southcott, 2010). The base economy in the Arctic is still dominated by resource extraction where the productivity outcomes are affected by the prohibitive cost of productivity, long distances to the central markets. With sparse and scattered population and economic activity, northern economies experience elevated levels of uncertainty and volatility (Larsen & Huskey, 2015).

Migration is a very important factor as well because the migration direction reflects the economic health of the region and community. If the migration towards a region declines, then services and activities will decrease, and the economy will decline. Climate change is the biggest challenge to the growing economy in the arctic. New industries and technologies should be introduced in the North instead of traditional ones. For example, winter transportation has provided problematic transportations infrastructure in Alaska (Huskey & Southcott, 2010, Huskey, 2015). There are other factors should be studied to guarantee the long-term economic development in the Arctic and to design new strategies to promote the economic sustainability.

2.7. A Brief Description of Alaska Economy

The state of Alaska is a typical example of the “three-pillar” Arctic economy (Arctic Human Development Report (AHDR), 2004, see Table 1). These pillars include the resource sector, public /government sector and traditional economy. The petroleum sector has the bulky weight in the economy, alongside with the government sector. The petroleum sector is responsible for 34 percent of jobs in Alaska, according to the Alaska Oil and Gas Association (Goldsmith, 2015). The largest oil field in North America is Prudhoe Bay located in Northern Alaska. Although this sector is a solid supporter to the economy is affected by the low oil process and declining productivity of oil fields (Knapp, 2016). The mining industry is another non-renewable resource sector that provided as many job opportunities. According to the Alaska Miners Association, this sector offered 4,100 jobs in 2010 working in exploration and production. Another primary industry that has declined over the last decades is the timber industry, although this decline, this sector still produces woods (Goldsmith, 2015).

Table 1*: Major Alaska Economic Sectors*

Major Alaska Economic Sectors

Basic or Support	Sectors	Major Industries	Selected Important Economic Drivers
Basic	Resource industries	▸ Oil ▸ Seafood ▸ Mining	▸ Oil prices ▸ Other resource prices ▸ Federal and state regulations ▸ Resource technology
	Federal government	▸ Federal civilian ▸ Federal military	▸ Federal politics
Support	State and local government	▸ State government ▸ Local government *(including K-12 education)*	▸ State oil revenues ▸ State investment revenues ▸ State politics
	Trade, service, transportation, and infrastructure industries*	▸ Retail trade ▸ Wholesale trade ▸ Healthcare Services ▸ Transportation ▸ Construction	▸ Basic sectors' output, employment and income ▸ Extent to which households and businesses spend money in Alaska ▸ State and local government spending ▸ Government transfer payments (including Permanent Fund dividends) ▸ Rate of and expectations for future economic growth

The tourism industry is a second largest employer in Alaska according to the state's Resource Development Center (Robinson, 2015). The fishing industry is also an important sector in the economy of Alaska, the position of the state in long coastline provides a special opportunity for many people to fishing many kinds of fishes which generating so many jobs.

Economic base theory and its staples theory variant (Innis, 1956) in particular, serves as a cornerstone of the regional development policy in Alaska (Huskey 2006; Petrov 2011). However, with dwindling prospects of oil and other staple sectors, there is a need to search for modern ways to develop America's northern frontiers. The idea of a knowledge –based economy in the North seems to be appealing, and building economic prosperity around human capacities rather than non-renewable resources is viewed as more sustainable (Goldsmith 2008; Huskey, 2002; Petrov, 2016).

The recent studies showed that there are a few communities in the periphery which could grow a different economic base by capitalizing on local human capital (Beyers & Lindahl, 2001; Boschma, 2005; Gradus & Lithwick, 1996; Selada, Inês & Elisabete, 2011). Utilization of human capital is one of the essential tools to develop non-staple economic sectors (Petrov, 2007, 2014). The creative capital is based on the relation between its local embeddedness and local knowledge institutions (Aarsaether, 2004; Petrov, 2011). Expanding human capital is an essential part of the economic development in Arctic cities and towns (Petrov & Cavin, 2012) because engaging the human capital in such places helps to diversify the economy and make it less depending on the "pillars" such as petroleum industry. Some cities in Arctic direct significant attention toward educated specialists (Larsen & Fondahl, 2014; Petrov, 2014).

Human organizations in Alaska are an intrinsic factor in the development process. This can be a political institution or private non-governmental organization or individuals (Petrov, 2014). These 'agents of change' either have a prominent level of education or engaged in creativity (technology, artistic, scientific) types of activities and actions (Florida, 2002). In recent studies (Desrochers, 2001; Florida, 2002, 2005; Polese & Tremblay, 2005; Schienstock, 2007) customary to cite the creative human capital is one of the most important drivers of regional development and competitiveness. Moreover, the ability of the region to assemble creative capital is an amendatory condition for the innovative development and knowledge-based economic growth process (Desrochers, 2001; Florida, 2002).

2.8. Creative Capital and Innovation in the Periphery

Existing studies of innovation in peripheral areas indicate that creativity should be linked into social networks and embraced by surrounding communities (Aarsather, 2004; Barnes & Hayter, 1992 and others). For example, Hayter, Barnes and Grass, 1994 and Stohr, 2000 studied the importance of the key local actors in the creative process in certain places and they found that inventors and entrepreneurs who are supported by a community, create connection led to speed up the economic growth. One of the key outcomes from the literature (Verspagen & Schoenmakers, 2004, Verspagen & De Loo, 1999) is that patent concentrations are present between the inventors that have short geographical distance, supporting the theory that knowledge flows are geographically concentrated.

Along with many mechanisms in which Creative Capital (CC) can drive economic growth and development (Boschma &Fritsch, 2009; Bathelt, Feldman & Kogler 2011; Florida, 2002; McGranhan & wojan, 2007), CC is the factor for creating that contain economic value (Florida, 2002). These meaningful new forms are innovations that delivered economic outcome and benefits. Although the importance of the CC in development and growth is difficult to dispute, most studies into these topics neglect regions outside the central metropolitan areas. In addition, other research indicated that CC plays a significant role in the regional modification of distant areas involving Arctic (Petrov, 2007). The importance of creative individuals in an innovative process in distant areas is highlighted in some studies (Aarsaether, 2004; Copus & Skuras, 2006; Doloreux, 2003; Jauhilinen & Suorsa, 2008). Inspired by results of CC analyses in Canadian North, Petrov (2008) suggested that the availability of CC enhances the prospects for future economic modification and development in peripheries.

Measuring economic growth and innovation potential of a region can be done using the creative capital variables, Florida (2002) offered three basic special characteristics that determine the place as an attractive place for the creative class. These elements are principal elements of measuring the creative class; tolerance, technology, and talent or the three T's (Florida, 2002). However, some other scientists disagree with these elements to measure CC in other areas (Asheim & Hasen, 2009; Hoymand & Faricy, 2009). There are more factors which could affect the creative class such as industries types, density of population, universities, and openness to the women role in the leadership (Florida et al., 2008; Lagendik & Lorentzen, 2007; McGranahan & Wojan, 2007; Mellander & Florida, 2006; Petrov, 2007; Stolarick, Denstedt, Donald & Spencer, 2010). In the non-metropolitan context, scientists have focused on the landscape features such as culture, tourism, history and the connections between urban centers (McGranahan & Wojan, 2007: McGranahan, Wojan & Lamber, 2011; Stolarick et al., 2010).

When new knowledge is applied it to new product and process, it is then employed it in the marketplace in the form of innovations. This model represents the core of technological change that leads to economic growth (Dosi, Freeman, Nelson & Soete, 1988). Patents represent a poll of information and process that can give insights about the knowledge creations. (Jaffe & Trajtenberg, 2002). It is found that the patent system had as significant a role in stimulating innovation and process development, and patent output continued to promote economic growth. The previous literature using patent data as the innovation measure has consistently found a strong positive role for innovation. For instance, Scherer, 1965 used the patents output as an indicator of the economic source of innovative activity. Griliches. 1990, Reported that the research and development (R&D) data and patent statistics are widely used in economic studies as innovation proxies. Recently other literature used patent data as the innovation measure has found a solid positive role for innovation (Crosby, 2000, Fisher & Seater, 1993; Yang, 2006).

The study will analyze the contribution of patents and innovations that are lead economic growth varies significantly across Alaska cities and general changes in the period of (1976-2010) in order to fill the research gaps that were the importance of knowledge economy in distant regions since there were few studies about innovation in periphery, particular in Alaska, so this study could be good one to spotlight on innovation in Alaska. The literature review demonstrated that studying and measuring the patents outputs is important to find out the relationships between economic development and innovation process, especially in remote areas that have less attention of studies on other economies. Alaska State is a good example of an area to study the role of creativity activities on the economic since it has lack of other resources.

CHAPTER 3

METHODOLOGY

3.1. Study Area

The study area for this research is the State of Alaska and its boroughs where patents and innovations were issued over the 35- year period time from 1976-2010 (Figure 2). Alaska has the largest area but is the fourth least populated State in the USA with a population of 710,231 in 2010 (United States Census, 2010). Anchorage is the largest city in the state with around 40 % of the state's residents (291,826) living there. The second city is Fairbanks, with a population of 31,535, which is less than 200 miles from the Arctic Circle (United States Census, 2010). Followed by Juneau (31,275), the capital of Alaska and is one of Alaska's oldest cities. The three cities with the largest number of patents in Alaska are Anchorage, Fairbanks, and Wasilla, with 527, 112, 73 patents respectively, see Appendix 1.

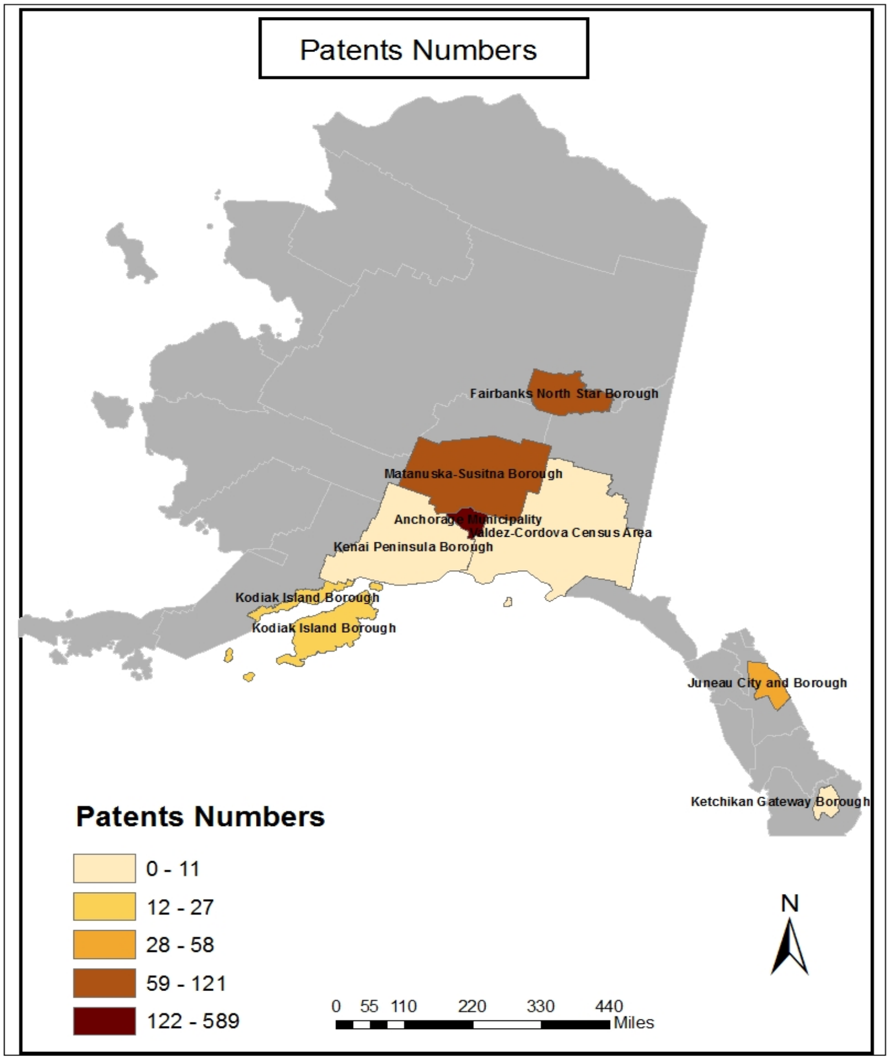

Figure 2: Study Area: Alaska (Patents in Alaska Boroughs, Resource: USPTO,2009)

3.2. <u>Measures of Knowledge Economy</u>

Measures of the knowledge-based economy can be based on new knowledge outputs or knowledge inputs. The main knowledge indicators, as outlined here are: (a) expenditures on research and development (R&D); (b) patents; (c) international balances of payments for technology, (d) employment of engineers and technicians. Indicators of R&D expenditures, the indicator regarding research personnel approximate the volume of problem sorting involved in knowledge production (Feldman, 1994). Patents represent novel ideas, and are the most accepted indicator of knowledge production (Jaffe & Trajtenberg, 2002). There are many methods to analyze patent data, including analysis that depends on the geographic area and industrial product group. Thomas et al., (2011) conducted the analysis of R&D in the USA based on the correlations between R&D outputs and inputs. The data were taken from scientific publications and patents and the output is the R&D process is the total R&D performance by the state in 2004-2008. As a result, only 14 out 51 states and regions of the USA provide modest improvements in the R&D efficiency.

Patent analysis starts with determining the spatial distribution of these patents, to figure out the clustering locations of creative activities and what the trends of their extending over the time (Kogler, 2010). USPTO presents the spatial characteristics of whole patents activities in the USA and allows researchers to follow the historical trends of patents activities since it provides patents data from the 1700s until nowadays. This study, will investigate USPTO dataset to determine the spatial characteristics of Alaskan patents between the periods from 1976 to 2010.

3.3. Inventors' Networks

Inventor networks are very important in understanding the innovative flows that could be done by using a map of the network shows the position of the inventor that determines the knowledge flow. Networks are often considered as main underlying factors for innovation activities (Borgatti & Cross, 2003, Ibarra, 1993, Cicchetti & Toth, 2006). Inventor networks build joint knowledge and a co-operation system through time this synergy enhance the knowledge creativity and produces strong relationships.

Many efforts have been made to quantify knowledge spillovers (Ejermo, 2002). Specifically estimating innovative ways to facilitate the knowledge flows between the economic agents. Many geographers' study patent networks (inventors, co-inventors, positions, and citations) as signs of localized knowledge spillovers (Ejermo, 2002; Griliches, 1979; Feldman & Audretsch, 1999; Kogler, 2010). Recently, more and more scholars have realized that networks are a suitable conceptualization of inter-organizational collaboration and knowledge flows. Hence, keeping the communication with colleagues in the same area can provide a hiring firm with extra access to external knowledge (Boschma & Wal, 2008). Also, it is important to say that previous studies proved that extensive local networks connecting specialized firms were represented as a major feature of clusters that contributed to their economic development (Boschma & Wal, 2008). However, the networks can span not only between the local areas but also across the world (Morrison, 2008), the networks configurations and tools developed over time (Gay & Dousset, 2005; Cowan, Jonard & Özman, 2004).

Not surprisingly the networks theory has become one of the key aspects of economic geography when the modern network theory is applied (Ellison & Glaeser, 1997). Further insights can be obtained through the networks such as the geographic and social features (Morrison, 2008; Giuliani &Bell, 2005), the factors that control the flow of knowledge

(Lucas, 2009), the importance of present economic agencies and universities in the region (Blind & Frietsch, 2006; Geuna & Nesta, 2006). Consequently, since the networks develop over time and space, the evolution networks are related to the evolutions of knowledge spillovers (Boschma & Wal, 2008).

3.4. Inventor Networks Analysis

Patents are key indicators of creativity and knowledge source region. The patent has a significant amount of valuable information about scientific applications in various fields ranging from scientific innovations studies to economic studies. In the common case, the patent contents include detailed descriptions of the technological information's and their procedures. Also, the patents records provide information about the inventors of these patents. Others information includes the people who take the advantage of the patent, the scholars who cite the patents. A network can be constructed, based upon the available patents database, specifically about the patent applicant and the inventors is worth, in both levels, i.e. individual level, or at the level of institutions or companies.

The common method in regional network studies is to assign the inventor as the node in the network. For example, in high tech areas, the social relationships play a vital role to support their innovations and technology activities (Dahl & Pedersen, 2004). For example, the study by Ejermo and Karlsson (2006), examined the interregional inventor networks in Sweden concentrating on co-authorship of patents and examining the residence of inventors and co-inventors contained in Swedish patent applications in the database of European Patent

Office (EPO). They argue that such information is considered an indicator of knowledge exchange. A patent was considered to be Swedish if at least one of the inventors had an address in Sweden. They used fractional method for assigning applications to regions when the contribution is weighted by the number of authors. Given this information, they were able to show the geographical distribution of patent applications per capita. They also discussed the interregional inventor networks in Sweden in a concept called affinity. Affinity refers to the number of networks between two areas. They found that affinities are influenced by travel time and distance. Also, it is extended to regions that have high R&D levels. Additionally, it has highlighted the role of universities: the presence of university can increase the numbers of inventors (see also Kogler, 2010; Audretsch & Feldman, 2004).

In this research, inventors' networks analysis will rely on the first inventor of the patent since it is usually considered as the main inventor of the patent in many studies. And these networks will cover all Alaskan patents that have at least one Alaskan inventor who recorded their patents over the time from 1976-2010. Inventor's network analysis will determine the geographical location for each patent according to the first inventor residency, and build a network between Alaskan co- inventors and the external co-inventors, to figure out both the clustering and inter- and interregional connections of patents. And this analysis will consist of both individual inventors and company inventors to explain the co-authorship between inventors regarding to the patents' spatial and sectoral characteristics (see Appendix B).

3.5. Inventors' Spatial Networks

Innovation activities in Alaska involved many local and external inventors. The patents creation process in Alaska involves a diversity of spatial connections between Alaska, other states, and foreign countries. To examine the spatial characteristics of patents, it is useful to build inventor networks between the co- inventors of these patents inside and outside Alaska. To do so, in this study, we investigate the patents dataset to figure out the patents count that have more than one inventor each, then determine the spatial locations for these inventors by geocoding (longitude, latitude) the cities of inventor's residency, then connect line networks between these locations by writing Python script (see Appendix C).

3.6. Methods and Techniques

A flow chart below arranges and explains the main steps that are carried out throughout the research (Figure 3).

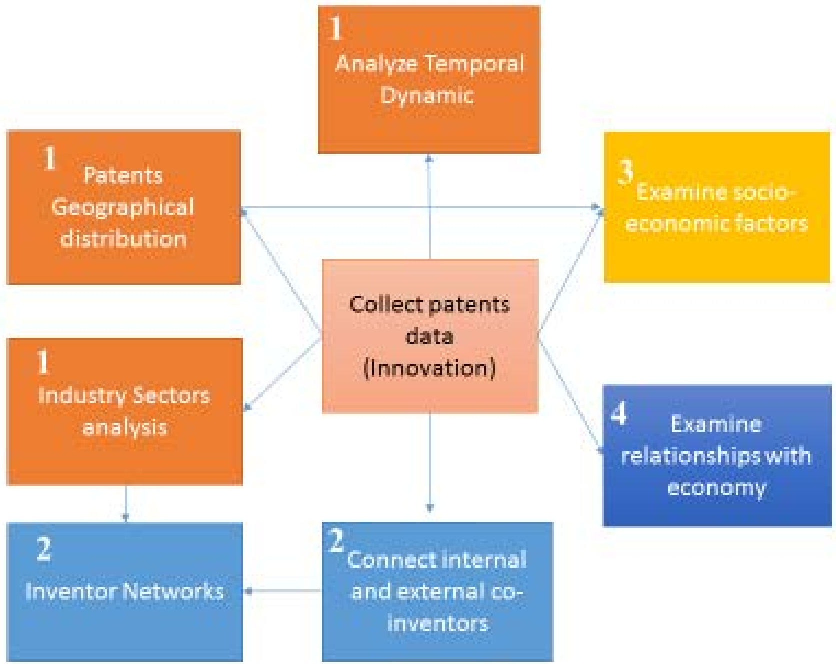

Figure 3: Flow Chart of Research Methodology

To achieve the research objectives, there are some steps that are to be followed as is shown in the Figure 3. First, patent data are obtained from Dr. Dieter F. Kogler database that has been extracted from the USPTO database. This study, groups these patents in 5- year time periods from 1976 to 2010 to make it easier to analyze and compare the results. The inventor database contains any patent that has at least one Alaskan inventor listed over the 35 years. Analyzing patents data starts with examining the temporal dynamic characteristics of patents and identifying the historical trends of patents over the time. Then, the study determines the spatial distribution of patents within the study area and the clustering of patents. Industry sectors that have the largest number of patents are also analyzed to have a deeper understanding of innovations activities.

Identifying and mapping the connections among co-inventors of these patents, give us a full image of the inventors' spatial networks to understand the spatial distribution of inventors and who are involved in the patent production process among local Alaskan inventors and external inventors. In addition, this study examines the socio-economic factors that influence patent activity such as patents per capita, employment per sector and population density to explain the relationships between innovation activities and other economic factors.

The temporal dynamics analysis methods are utilized to assess the historical dynamics of innovation by 5-year periods. The inventor database includes any patents that have at least one Alaskan inventor listed from 1975 to most recent. Most recent years have a truncation problem because not all patents applied for in the past couple of years are granted yet. Thus, the best option seems to be is to run any long-term analysis on the application year range from 1976-2010. It is important to note that this analysis also provides key insights into the idiosyncrasies found in patent data (Kogler, 2010).

3.7. Data and Definitions.

In this study, the first objective is to determine the spatial distribution of patents and typological characteristics of innovation in Alaska. To achieve this goal, we investigate the patents distribution in Alaska. A patent of an invention is the award of a property right to the inventor, and Alaskan patent means any patent that has at least one Alaskan inventor who recorded his patent while his/her residency in Alaska. Patents are allowed for new, beneficial and intelligent inventions for a term of 20 years from the filing date of a patent application, and give the right to prevent others from taking advantage of the invention over that period (Foray, 2002). U.S. patents are published via the USPTO (United States Patent and Trademark Office) (Stopfakes.gov article *What-is-a-Patent*, 2016), the main types of patents are utility patent and design patent; a utility patent protects the structural and functional aspects of a new or improved product or system, and is the most prevalent type of patent. A design patent, on the other hand, covers the unique appearance of an item. A design patent embraces element such as a specific product shape, color arrangement, or surface ornamentation (Stopfakes.gov article *What-is-a-Patent*, 2016, USPTO, 2016*).* In this study, we define an Alaska patent as a patent that has at least one Alaskan inventor listed from 1975 to 2010 according to the United States Patent and Trademark Office.

USPTO data serves as a foundation for the proposed analysis of spatial and sectoral patterns of knowledge formation and spillovers. This patent database constitutes quality of the comprehensive inventory in the American economy from 1976 to 2010. The USPTO patent database ensures strong confidence in the results obtained from the investigations carried out because it itself issued patents and recorded all related information. Furthermore, this database provides a larger dataset of relevant information for American inventors and co-inventors, regardless of their place of residence at the time they worked on a specific invention. Inventors who developed inventions over the extended period are repeatedly represented in the database. This database uses the USPTO classification system for the technologies to which the patented inventions belong

Dr. Dieter F. Kogler, from the School of Geography in University College Dublin, shared an Alaska patent dataset that included all Alaskan patents from 1975-2010 with all inventor's geographical locations. Since we have tables that we can prepared with Python. Although the data in the original database were not organized enough to fit into Python script by determine the patents that have co-inventors, then connect their locations to create an inventor network, this was addressed by determining which variable could be used and adding the missing parts of data by cross referencing with the source of patents data (USPTO).

It is imperative to also examine some of the structural properties that are inherent to knowledge production in the USA as indicated by patent data. This section uses spatial analysis techniques to understand the distribution of patents across Alaska. The best option seems to be to run any long-term analysis on the application year range of 1976-2010.

In this study, the investigated data consist of the inventor file, and includes any patent that has at least one Alaskan inventor listed from 1975 to 2010. So, the appropriate way is to run any long-term analysis on the application year range from 1976-2010 to avoid any missing data of patents. So, it's all Alaskan inventors and their potential Alaskan co-inventors along with other potential US or international collaborators. The data consists of the patent number and then the sequence of inventors as to how they are listed on the patent document in USPTO. There's also a unique inventor ID which is based on the algorithm of first/last names. Also, there are all spatial indicators based on inventor residence, e.g. state, city, and country name. Then comes the organization it is invented for, and if it's blank, the patent is most likely not assigned to a company, but to the inventor directly. This is then followed by date stamps (application/issue date) for each patent and then by the USPTO technology classification codes that are listed in the patent document, the classification that are used here is called the current US Class that is listed in USPTO website (USPTO, 2017).

Many studies only use the top level of classification as an indicator to what technology the invention belongs, but the more sophisticated analysis would use all the codes. Similarly, this study uses only the first USPTO code which yields good results if one wants to know the 'spread' of technology within a state in a certain industry sector. In order to analyze the data, this study regroups the time frame into 5-year aggregate time periods, as following (1976-80, 1981-85, 1986-90, 1991-1995,1996-2000,2001-2005, and 2006-2010) to make the analysis more comparable and easier to follow (see Appendix C).

3.8. Measuring Innovation Activity in Alaska Using Patents.

Patent-based indicators are frequently used for measuring economic growth. Describing these indicators and analyzing their characteristics leads to a better understanding of the economic development and technological change (Kogler, 2010). Aggregating the patents data by firms or by patent subclasses into industry categories provide insights into economic growth and prosperity in either regional or national context (Kogler, 2010). Patent indicators are useful to measure the innovation activity and have become strong motivating forces for economic research (Pavitt, 1985; Grupp & Schmoch, 1999)

This study utilizes the patent based indicators that help to monitor and analyze economic processes. *Patents per capita* (1) is an important indicator in the literature (Lee & Kim, 2009; Carlino, Chatterjee & Hunt, 2007). Although this indicator is well established, there are some limitations, such as misinterpretations due to the assumption of the fact that there is a linear relationship between inventive capacity and the innovativeness that consequently reflect into economic well-being (Kogler, 2010).

$$Patent\ per\ Capita = \frac{\sum Patent}{\sum Population} \times 100{,}000 \qquad (1)$$

To better understand patenting trends, one can start by looking at *categories of patents*. First of all, all patents can be grouped in the 10 top categories; the patents in these categories tend to make more claims compared to smaller technological groups, which may or may not reflect the underlying value. The second indicator one may use is the sectoral distribution and employment rate in each sector, because the varying propensities to patent across industries, definitely will have a direct influence on the output observed. We should measure the actual sectoral per employee rates (ppe_s) by the below formula (2):

$$ppes = \frac{Ps}{es\left(\frac{1}{100{,}000}\right)} \tag{2}$$

Where Ps represents the average number of patents granted in sector *s*, as determined from the 1976-2010 patent cohort, and e_s represents a count of employee in sector *s* over the time period as indicated in the census of population.

Another indicator that can be used to compare the share of patenting in a particular industry sector among more aggregate or national level and help evaluate geographic patterns of concentrations is Location Quotient (LQs). The Location Quotients (LQs) are ratios that conduct an area's distribution of employment by industry sector to be compared to a base area's distribution (Burt, Barber & Rigby, 2009). An LQ can be calculated for any industry where comparable data exist for the area. By the equation below, one can calculate the Location Quotients (LQ) of a specific industry by dividing share of total patent output in the region (*j*) devoted to the sector (*i*) on the total national share of the sector (*i*).

$$LQ_i^j = \frac{A_i^j / \sum_{i=1}^{n} \left(A_i^j\right)}{B_i^j / \sum_{i=1}^{n} \left(B_i\right)} \tag{3}$$

If LQ =1 industry has the same share of activity as it does in the reference area.

If LQ>1 reflects the relative concentration of specific activity in the region compared to the nation.

If LQ<1 reflects that the sector is underrepresented of the region of interest compared to national share.

3.9. Quantitative Analysis

After the spatial and sectoral analysis, the next step is a compare between socio-economic variables and the patenting activities in the study area. Therefore, the last step is to execute correlation analysis to examine the relationships between patents per capita and other innovation indicators and socio-economic conditions in Alaska boroughs. The correlation analysis aims to clarify and test the relationships between patents per capita and socioeconomic indicators (population, change of income, employment per industry sector, inventors count, and patents count), to find out which indicators have a significant correlation with patents per capita, and variables make a significant relationship, to find the differences of variables impacts on patents activities. Due to data limitations this part of the study covers only 1995-2010.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 History of Patents in Alaska

Utilizing the USPTO database, the following study provides a first glance at knowledge creation and its distribution using patents in Alaska over the period of 1976-2010. The indicators described here are mainly descriptive but are highly informative in terms of establishing insight into the diverse evolutionary characteristics of innovation activity in Alaska. The total number of Alaskan patents was 1,077, created by 1,873 inventors during 1976-2010. Here we consider the patent is Alaskan if it has at least one inventor had an address in Alaska when the patent was awarded. The total count of inventors from Alaska (first inventors and co-inventors) is 1,340 (71.5%), while the non-Alaskan-inventors count is 532 (28%). Similarly, the count of patents that has the first inventor (main inventor) from Alaska is 928, compared with 149 patents for the non-Alaskan first author. It is very clear in this analysis, a comparison of a patent granted at USPTO to inventors residing in Alaska reveals that more patents are granted to those individuals in Alaska more than individuals outside AK. That means most patents have Alaskan as a first inventor of the patent. In this study, the first inventor of the patent, as it is listed in USPTO dataset, is considered as the main inventor of the patent.

To analyze the historical trends of the patents process, it is useful to regroup the patent dataset into five years' periods to make the results comparable and easily readable. In the first period between 1976- 1980, the total patent number was 83, created by 120 inventors, 74 patents of the patents had the first inventor from Alaska while nine patents of them have a non- Alaskan as a first inventor. The difference between this period and the next one is significant in both levels of patents and inventors. Same trend is also highlighted in the following time periods from 1981-1985, when71 patents were registered, and 99 inventors in total, with 63 patents having the first inventor from Alaska. In the same period 73 inventors from Alaska, 8 patents have first inventor non- Alaskan and 26 inventors non –Alaskan. Not surprisingly that in the later period the number of patents significantly increased, i.e. 1996-2000 the number of total patents was 235 compares to 114 in 1986-1990 (Figure 4). In the last period from 2006 to 2010, the number of patents and inventors declined. Patents' number was 155, while the inventor number was 330.

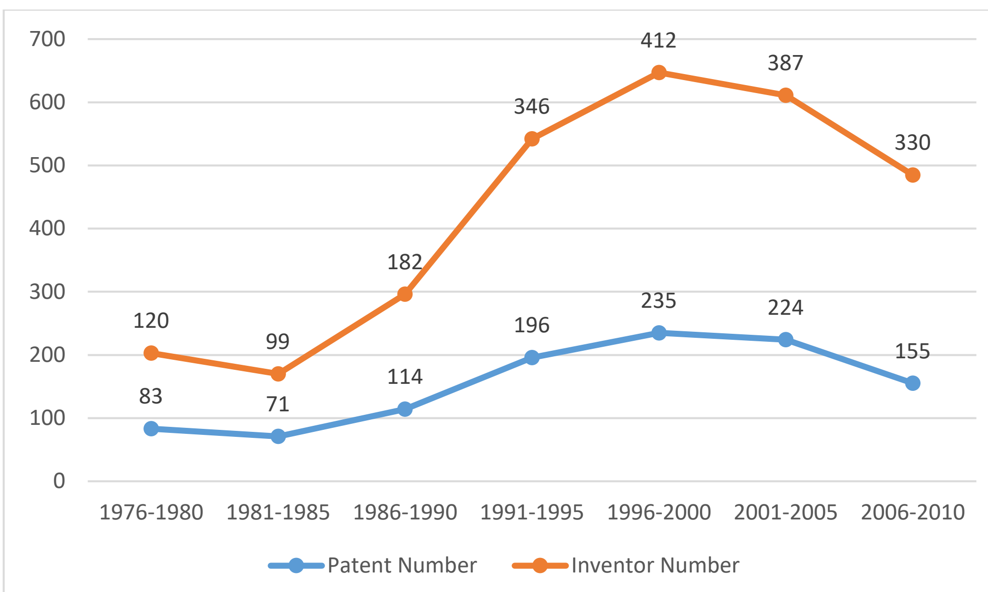

Figure 4: Patents and Inventors Numbers Trends.

4.1.1 Patent Production in Alaska's Boroughs: Historical Trends

Patents production in Alaska is highly concentrated in space. When we considered the patents and inventors residing in Alaska, the clear majority of them, more than 90 percent in each of the five year periods from 1976- 2010, located in eight boroughs. Among the inventors located outside Alaska, the majority of them lived in the USA with few are from overseas.

At the borough level, the Anchorage Municipality had the highest number of patents, larger than the rest of boroughs combined. Fairbanks North Star Borough and Matanuska-Susitna Borough were distant second's in terms of the number of patents. Patents per capita in Anchorage were 23.5, 16.4, 26.51, 49.06, 51.09, 43.29, and 25.01 in period of 1976-1980, 1981-1985, 1986-1990, 1991-1995, 2006-2000, 2001-2005, and 2006-2010 respectively (Figure 5) higher than in any other borough in Alaska. This could be explained by population size, since Anchorage is the biggest city in Alaska, and hosts more technology, engineering and communication industries, as well as oil-related businesses. In addition, the new era of patents enhances the bargaining power of the technology holder, this is inducing firms to offer technology for licensing or technological ability for hire.

In the first time period observed, which refers to patents granted during 1976-1980, patents number was 83 which is a small number compared to the last two periods under study that is 267, and 188 refers to 2001-2005 and 2006-2010 respectively in overall boroughs in Alaska. Consistently with Figure 5, the number of patents in each borough is higher for the same periods. This is probably due to the presence of technology and new communication tools and networks compared with the first period under study that's behind in terms of recent technology. Figure 5 also shows the trend of patents over the period of study 1976-2010. The trend clearly shows that the number of patents was increasing until very recently.

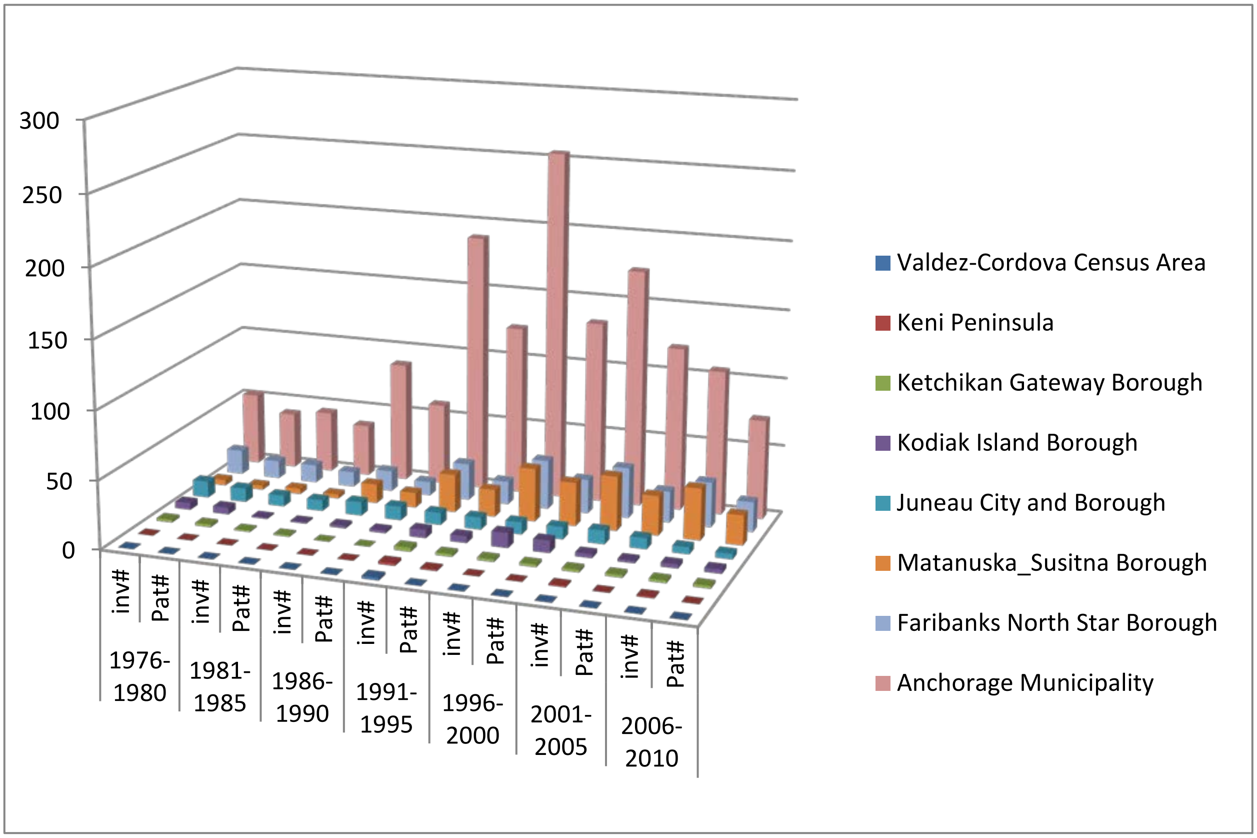

Figure 5: Patents and Inventors Share per Borough by Five-Year Periods

In Anchorage, the number of patents was the largest in 1996-2000 is reached up to 255 patents and 133 inventors. Followed by the period of 1991-1995, the number of patents was 189 and the number of inventors was 124. The next borough was Fairbanks North Star

Borough followed by Matanuska Susitna Borough. Both had a very big gap compared with Anchorage municipality. For example, the number of patents and inventors between 1996 and 2000 in Fairbanks North Star Borough was 36 and 25 respectively. For the same period, Matanuska Susitna Borough had 39 and 32 respectively. The next was Juneau City and Borough where the number in the entire period is low compared with the first boroughs. The maximum number of patents in Juneau City and Borough was 10 patents and 10 inventors from 1986-2000. Interestingly, the number of patents in Anchorage Municipality for the same period was almost 19 as large. The rest of boroughs, including Kodiak Island Borough, Ketchikan Gateway Borough, Kenai Peninsula and Valdez-Cordova Census Area had few patents and inventors. For example, the number of patents in Ketchikan Gateway Borough, Kenai Peninsula, and Valdez-Cordova Census Area from 1986-1990 was 0. Noticeably, the periods of 1991-1995, 1995-2000, and 2001-2005 showed higher produced flow of patents compared with the periods before and after, and this is general trend for all Alaska boroughs.

4.2. The Geographical Distribution of Patents and Inventors

4.2.1. Overall Patent Production

Patent counts is an important indicator of the knowledge economy and their typological, geographical and historical patterns provide a key insight into the Alaska's regional innovation system. Patents could be either normalized by employment or by population to be more comparative across communities and with other states. The total number of patents granted to Alaska residents between 1976 and 2010 was 1,077. The cities of Anchorage, Fairbanks, and Wasilla exhibited the higher number of patents granted between 1976 to present. These cities were granted around 712, more than other cities in Alaska (Figure 6). In addition, Figure 7 shows utility and design patents number distribution among Alaska cities.

In this study, we have eight boroughs that have recorded patents from 1976-2010. As mentioned, Anchorage Municipality borough is the leading borough with 589 granted patents, the second borough is Fairbanks North Star Borough that recorded 121 patents, followed by Matanuska-Susitna Borough with 120 patents. While Ketchikan Gateway Borough, Juneau City and Borough, Valdez-Cordova Census Area, Kenai Peninsula Borough, and Kodiak Island Borough exhibiting the lower number of patents comparing with first three boroughs (Figure 8 and Figure 9) (Appendix B)

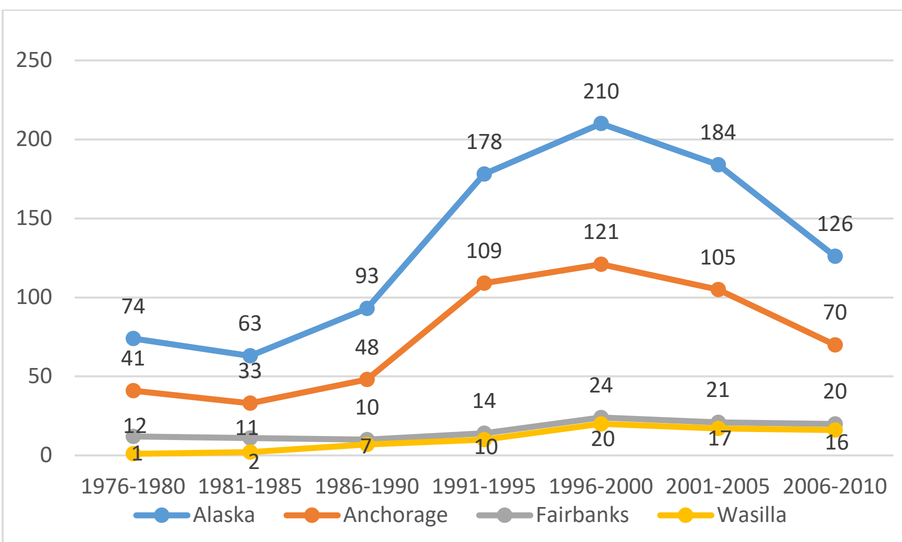

Figure 6: Anchorage, Fairbanks, and Wasilla's' Total number of patents granted from1976 to 2010

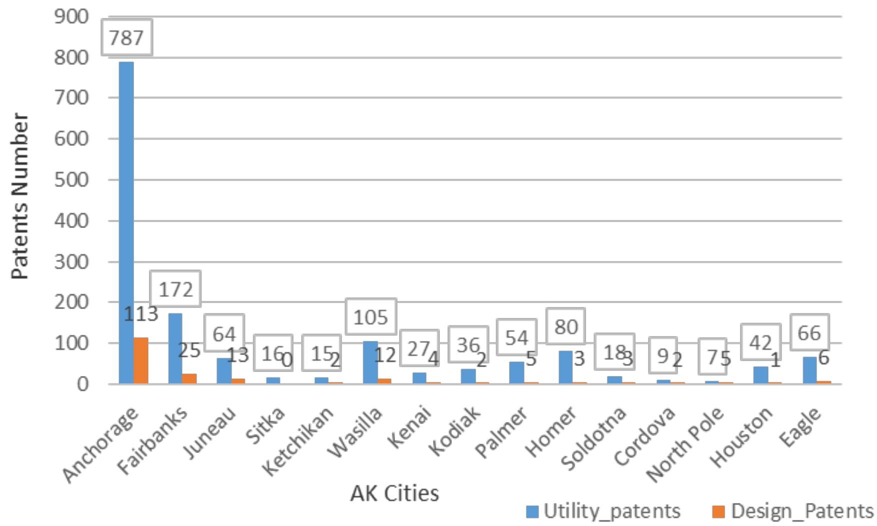

Figure 7: Utility and Design patents Total number in Alaska Cities

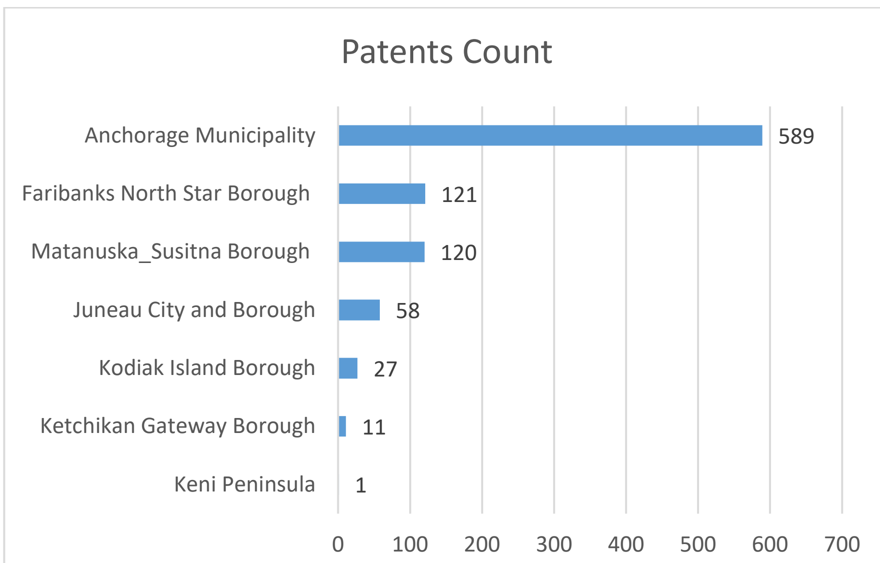

Figure 8: The Recorded Patents per Alaskan Borough

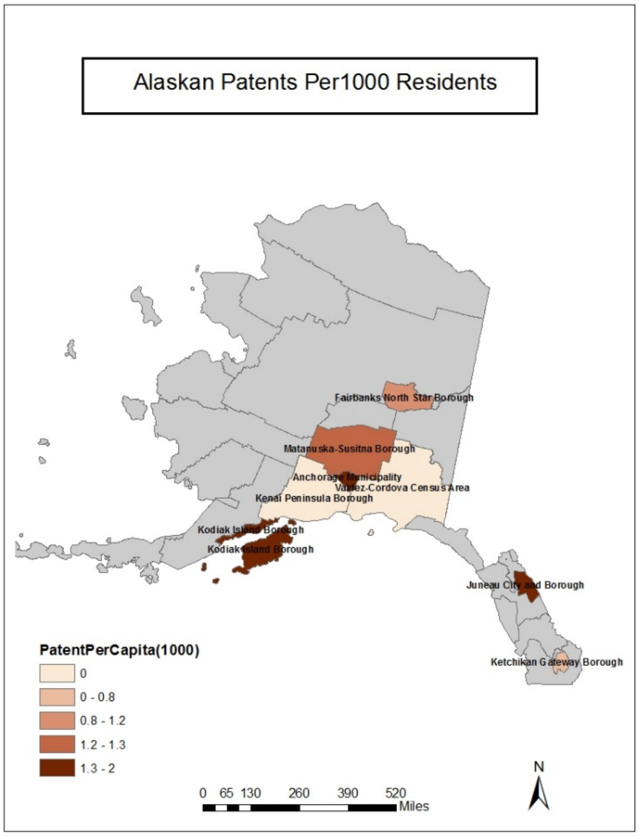

Figure 9: Alaskan Patents per 1000 Residents

Inventors distribution is similar to the patents distribution among Alaskan boroughs since the highest number of inventors exist in Anchorage Municipality borough, Fairbanks North Star Borough, and Matanuska-Susitna Borough with 910, 179, and 167 inventors respectively. However, when we measure inventors per 1,000 residents we find that low population density boroughs have high percent of inventors' share comparing with the population density, e.g. Ketchikan Gateway Borough has 3.1 inventors per 1,000, and Valdez-Cordova Census Area has 1.9 inventors per 1,000 (Figure 10).

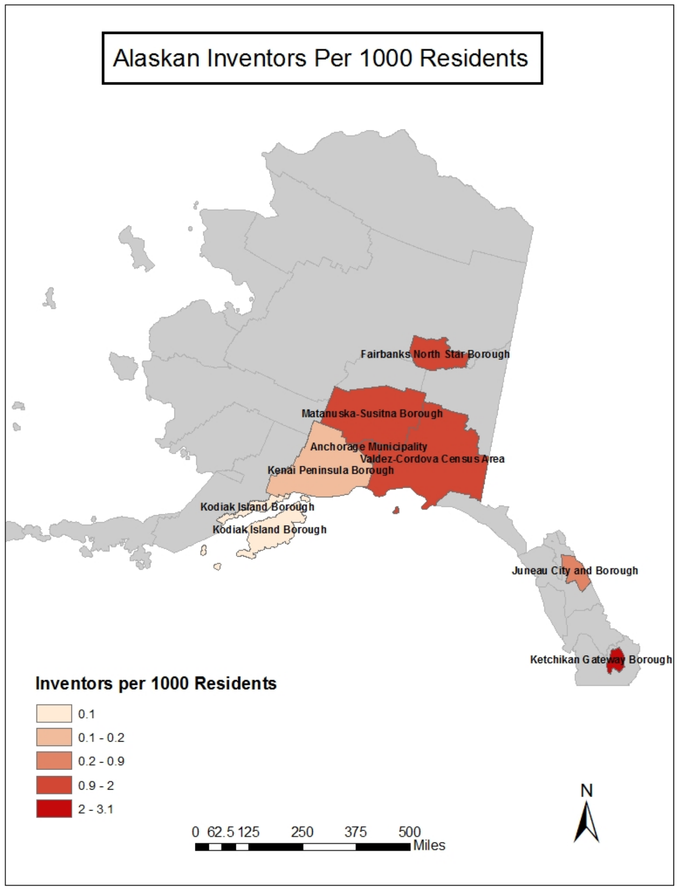

Figure 10: Alaskan Inventors per 1000 Residents.

4.3. Descriptive Indicators of patents and Inventors

4.3.1 Patents and Inventors Distribution over the Investigated Time

Between 1976 and 2010 the USPTO awarded 928 patents that were just created by inventors residing in Alaska at the time the patent was created. In total, there were 1340 individuals participated in the creation of these patents. In the first five years of patenting in Alaska, patents recorded in the years1976-1980, none of the inventors in the USPTO database were from foreign origin, whereas in the final time period, patents recorded from 2006-2010, almost 1.5 percent of Alaskan co-inventors resided abroad. While patents recorded in the years 1976-1980, the percent of inventors from the rest of the United State was 20.8%, whereas in the final time period 41.2%.These shares are based on the first inventor count of inventors. The vast majority of external co- inventors reside in the United States, which has not changed over 35years period, and the remaining co- inventors are of international origin. Figure (11) illustrates the distribution of USPTO inventors' location of residence for each of the 5 time periods investigated, (See Appendix E)

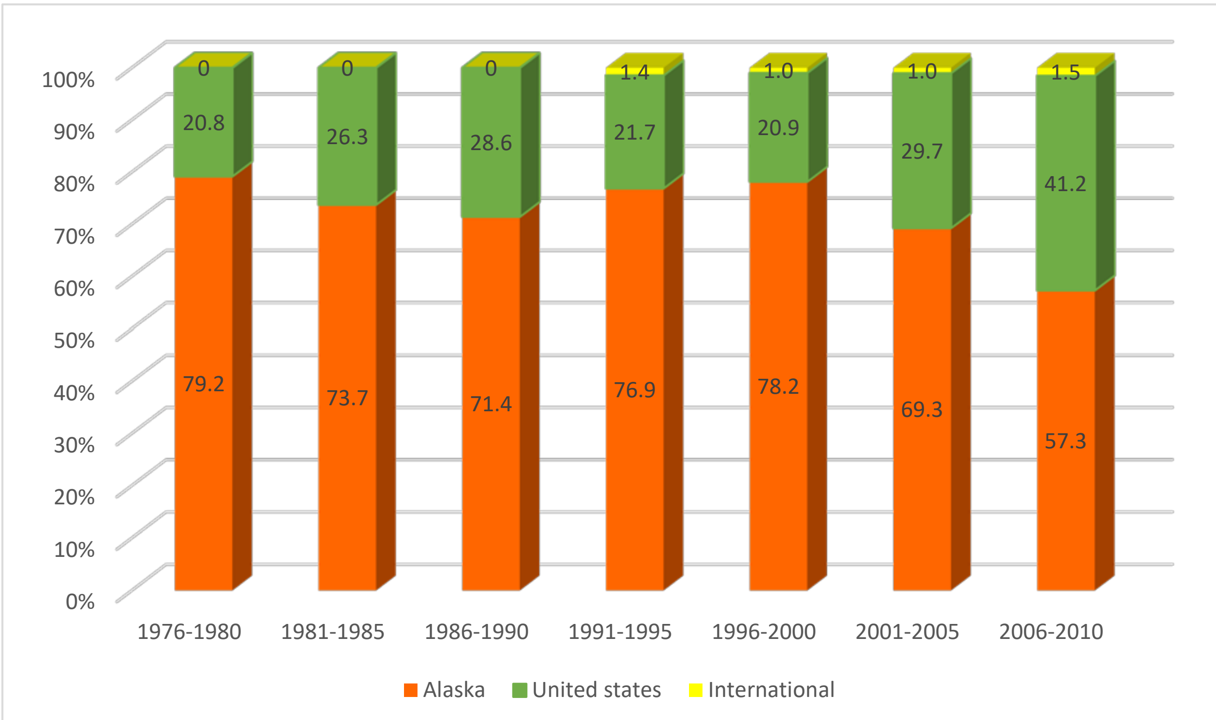

Figure 11: Distribution of the residence of the inventors over a period of 35 years under investigation.

From these results, there are some significant effects according to the aggregate analysis of patent creation and spillovers that follow. First, the noticeable rise in the portion of foreign co-inventors of Alaskan indicates the significance of looking beyond the national regions to gain a full realization of how external co-authorship spatial patterns vary from national innovations activities. Second, any patent test that only examines main inventors ignore the results of the International role in the growth of patents, which is obviously apparent. Third, a constant examination of invention process surely not enough to make a fully understanding of the innovation dynamic processes. Similarly, U.S. co-inventors share increased over the time, starting with 20% in 1976-1980 and ending with 41% in 2006-2010.

Table 2: *Annual Number of Patents and Inventors 1976-2010*

Grant Year	Patents		Inventors		Team Size	Distribution of Inventors by place of Residence		
	Total	Annual-growth	Total	Annual-growth	Avg.# of Inventors per Patent	AK	Other USA States	Foreign Co-Inventors
1976	19		34		1.79	23	11	0
1977	17	-11%	24	-29%	1.41	20	4	0
1978	15	-12%	21	-13%	1.40	16	5	0
1979	14	-7%	22	5%	1.57	18	4	0
1980	18	29%	19	-14%	1.06	18	1	0
1981	16	-11%	24	26%	1.50	16	8	0
1982	13	-19%	17	-29%	1.31	13	4	0
1983	9	-31%	13	-24%	1.44	9	4	0
1984	8	-11%	10	-23%	1.25	8	2	0
1985	25	213%	35	250%	1.40	27	8	0
1986	21	-16%	38	9%	1.81	28	10	0
1987	22	5%	41	8%	1.86	24	17	0
1988	16	-27%	22	-46%	1.38	16	6	0
1989	28	75%	39	77%	1.39	31	8	0
1990	27	-4%	42	8%	1.56	31	11	0
1991	39	44%	62	48%	1.59	45	17	0
1992	28	-28%	47	-24%	1.68	36	9	2
1993	44	57%	73	55%	1.66	60	13	0
1994	50	14%	85	16%	1.70	67	15	3
1995	35	-30%	79	-7%	2.26	58	21	0
1996	37	6%	64	-19%	1.73	49	12	3
1997	44	19%	71	11%	1.61	63	8	0
1998	53	20%	79	11%	1.49	65	13	1
1999	55	4%	104	32%	1.89	78	26	0
2000	46	-16%	94	-10%	2.04	67	27	0
2001	50	9%	83	-12%	1.66	62	21	0
2002	50	0%	80	-4%	1.60	59	20	1
2003	42	-16%	82	3%	1.95	54	24	4
2004	44	5%	71	-13%	1.61	47	24	0
2005	38	-14%	71	0%	1.87	46	22	3
2006	38	0%	77	8%	2.03	47	28	2
2007	20	-47%	37	-52%	1.85	23	13	1
2008	22	10%	63	70%	2.86	27	35	1
2009	43	95%	70	11%	1.63	49	20	1
2010	32	-26%	83	19%	2.59	42	39	2

The Table 2 shows the number of patents and the rate growth in patents and inventors in Alaska and in the USA over the entire 35-year timeframe. It is giving an exact number of patents as well as the corresponding growth rates that occurred between the subsequent periods. The number of patents experienced growth, although to a varying degree. It is very clear that the patents rate in 1990's and 2000's is higher than the 1980's. A closer look at the table content clearly see that 1998, 1999, 2000, 2001 and 2002 have a high number of patents compared with previous years and the later years.

The national and cumulative share of each of these jurisdictions provides further insight into the overall distribution of invention within the national economy. If we consider the next column in Table (2), i.e. the cumulative share of national patent output as measured by inventors 'place of residency, it is apparent that the rate increases substantially in 1990's and 2000's compared with 80's, the share in the USA national economy had increased in 1900's and 2000's.

In addition, the other column in the table provides insights about the patents inventors within Alaska and the country overall. Some inventors in specific years came from overseas. The geographic units seem very crucial, the connections between the inventors in Alaska higher than the connections in the country in terms the number of inventors.

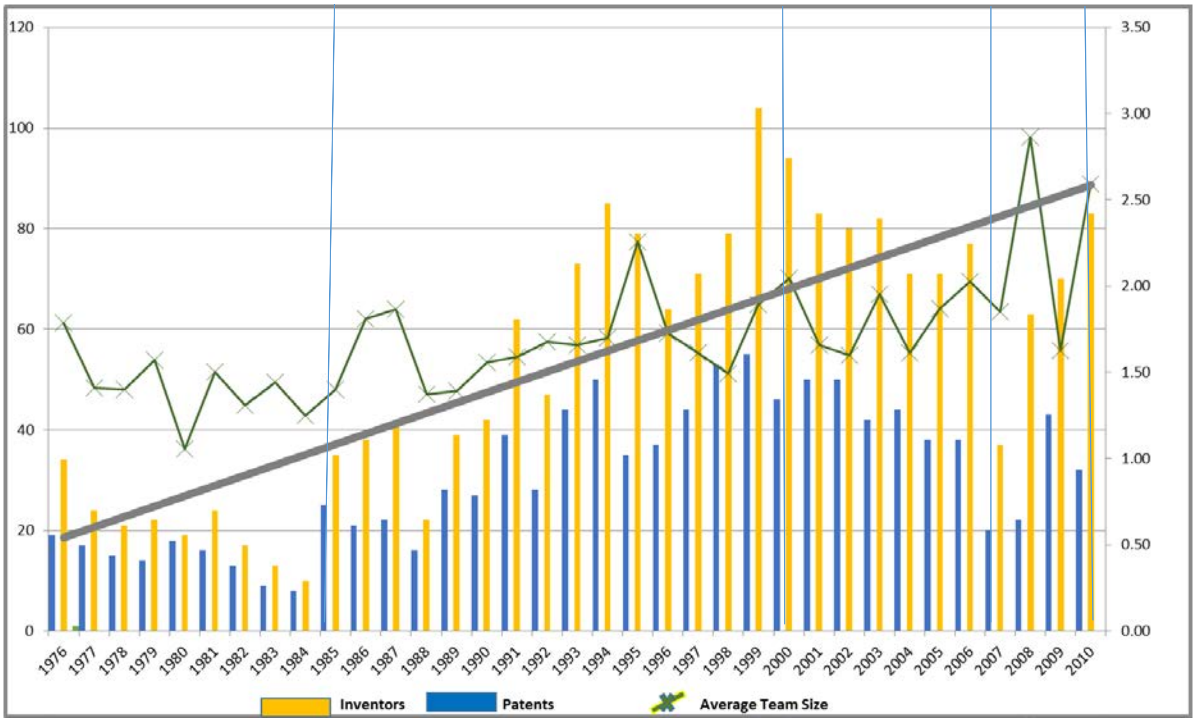

Figure 12: Annual Number of Patents and Inventors, and Average Team Size per Patent

To have a clear image of patents and inventors share over the investigated time, Figure (12) shows the annual growth of patents and inventors and the team size per patents, from 1976-2010 in Alaska. If we divide this chart into four times periods, will find that:

From 1976-1985 the number of patents and inventors are low, with 219 inventors and 154 patents and the team size less than 2 inventors, that means most of the patents were created by individuals. The largest industry sectors were Wells with 13 inventors, then Hydraulic- earth engineering with 10 inventors and fishing with 9 inventors.

The second part from 1986-2000 notice significant increase of patents and inventors' numbers, which consider as Alaska boom with 940 inventors and 545 patents, also the team size increased up to 3 inventors per patent, many inventors involved on patenting from other states, the largest industry sectors were Wells with 215 inventors, followed by Surgery with 39 inventors and Hydraulic earth engineering with 10 inventors. In the third-time period from 2000-2005, the numbers of patents and inventors decrease again with 478 inventors and 269, 87 in wells industry sector followed by Liquid purification or separation, then Hydraulic earth engineering. The last time period from 2006-2010 with 330 inventors and 155 patents shows fluctuate of numbers of patents and inventors, in general, the patents number decrease while inventors number was higher than patents, that means more inventors are involved in producing one patent, because many companies in recently involved in patenting process and involved their employees to be creative, in details, this period has 85 for wells, then Hydraulic earth engineering 15, and measuring and testing sector with 9 inventors.

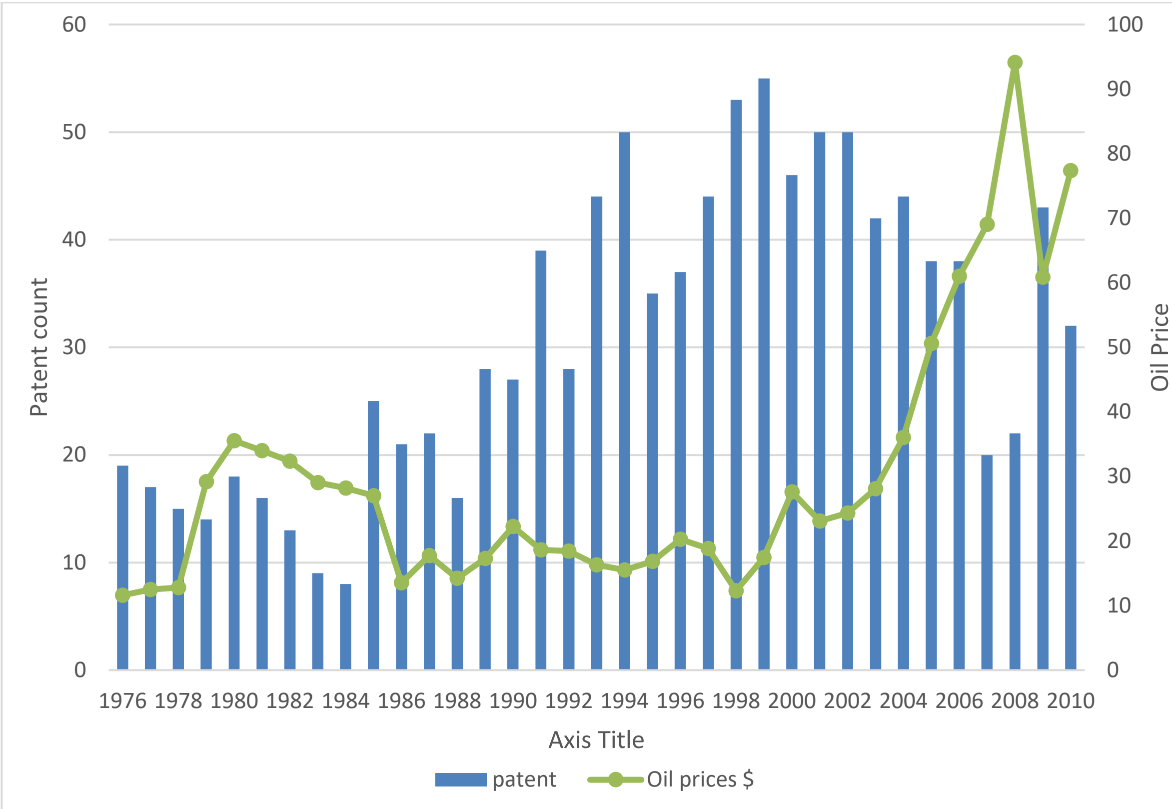

Figure 13: Oil Prices Trends Comparing with Patent Counts 1976-2010

In this Figure 13 compares the oil price trends with the count of patents from 1976-2010. Although the chart did not clearly show any direct relation between the patents vs the prices but the period from 1986 to 2006 shows a huge jump in patents production, in the same period the oil prices declined from 1986 to 2002. While highly increased from 2002 to 2010. In general, the one can claim that the years under- investigate in 1976-2010, its trend shows there was no clear pattern. Although a negative (See Appendix F).

4.3.2. Description of Patents by Industry Sectors

Table 3 shows the top 25 industry sectors that have the most number of patents during the period time from 1976- 2010. In this table, the industry sector with the most patents is wells industry with 117 patents created by 339 inventors, 221 inventors of them from Alaska while 118 inventors from other states. While the lowest industry sectors were material or article handling, fluid handling, and refrigeration with 9 patents for each and inventors count from11 to 13 inventors.

Some of industry sectors have high share of Alaskan inventors, while others show less percent of Alaskan inventors. The industry sectors that had a significant non-Alaskan share were multiplex communication, data processing, marine propulsion, measuring and testing, wells, and liquid purification with 59%, 48%, 45%, 44%, 34%, and 33% respectively. And most of these industries are considered as “new” industry sectors except wells and marine industries. Several industry sectors had 100% of Alaskan inventors including amusement devices: games, material handling, and geometrical instruments. All patents in these industry sectors created by Alaskan inventors, and the majority of them are individuals’ inventors.

Table 3: *Innovations by Industry Sector*

Industry Sector	Total-Patents	Total-Inventor	Alaskan-inventor	Non-Alaskan-inventor	Non-Alaskan-inventors Share (%)	Alaskan inventors per patent
Wells	117	339	221	118	34.81	1.9
Hydraulic-Earth Engineering	43	65	53	12	18.46	1.2
Surgery	30	55	38	17	30.91	1.3
Liquid Purification or Separation	24	45	30	15	33.33	1.3
Land-Vehicles	24	30	29	1	3.33	1.2
Boring or Penetrating the Earth	21	49	34	15	30.61	1.6
Fishing, Trapping, Vermin Destroying	21	22	21	1	4.55	1.0
Data processing Measuring, Calibrating or Testing	17	39	20	19	48.72	1.2
Drug, Bio-affecting And Body Treating Compositions	16	29	19	10	34.48	1.2
Measuring and Testing	15	36	20	16	44.44	1.3
Ships	14	21	18	3	14.29	1.3
Animal Husbandry	14	17	15	2	11.76	1.1
Supports	14	18	15	3	16.66	0.8
Static Structure(Buildings)	13	20	14	6	30.00	1.1
Geometrical Instruments	13	14	14	0	0.00	1.1
Exercise devices	12	18	15	3	16.67	1.3
Package and article carriers	11	13	13	0	0	1.9
Multiplex communications	11	27	11	16	59.26	1.0
Communications: Electrical	11	22	18	4	18.18	1.6
Marine propulsion	10	22	12	10	45.45	1.2
Internal- combustion engines	10	13	12	1	7.69	1.2
Amusement devices: games	10	10	10	0	0.00	1.0
Material or article handling	9	12	12	0	0.00	1.3
Fluid handling	9	13	11	2	15.38	1.2
Refrigeration	9	11	9	2	18.18	1.0

Between 1976 and 2010, most patents in the State of Alaska were granted in wells, hydraulic and earth engineering, surgery, liquid purification and land vehicles. These five industries account for about 60 % of all patents granted in this period. This pattern could be caused by numerous factors. One likely reason is that these sectors might have entered a level of maturity in their technological life cycle. But the most likely explanation is the prominence of oil-based and transportation constructions in Alaska. Figures 14, 15, 16 and 17 present the top four industrial sectors: wells, surgery, hydraulic technology and land vehicles industry, which had recorded the highest number of patents. Anchorage had the highest number of patents in all these industrial sectors.

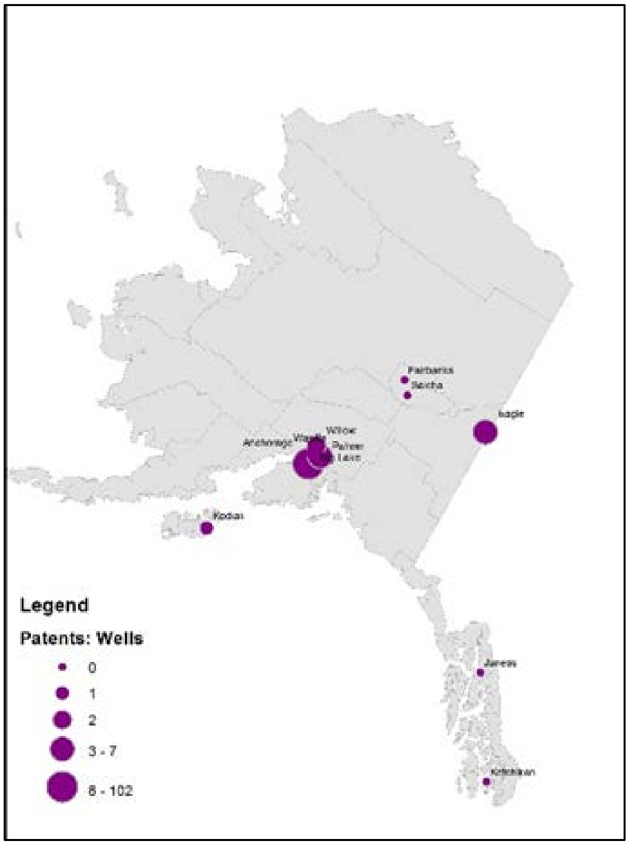

Figure 14: Wells Industry Patents

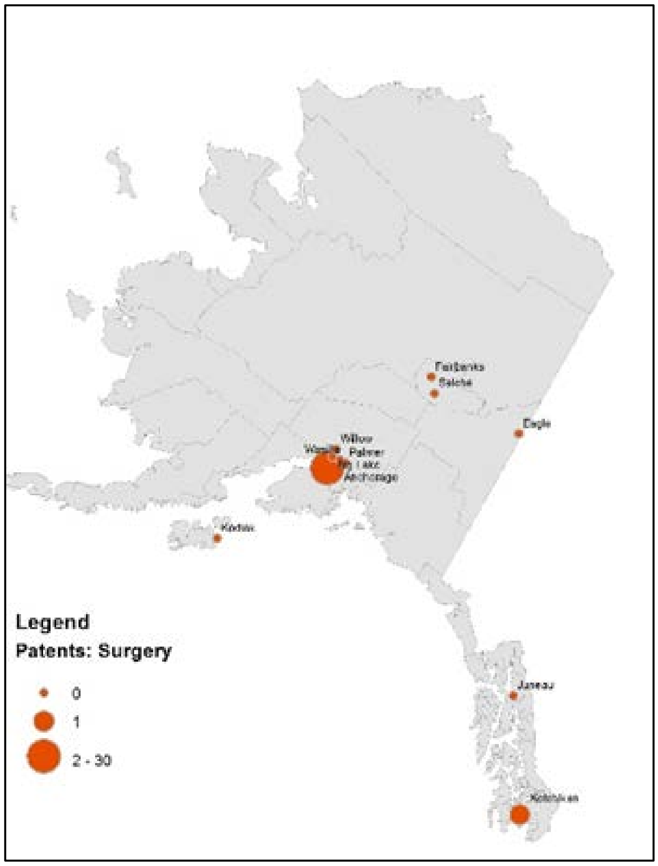

Figure15: Surgery Industry Patents

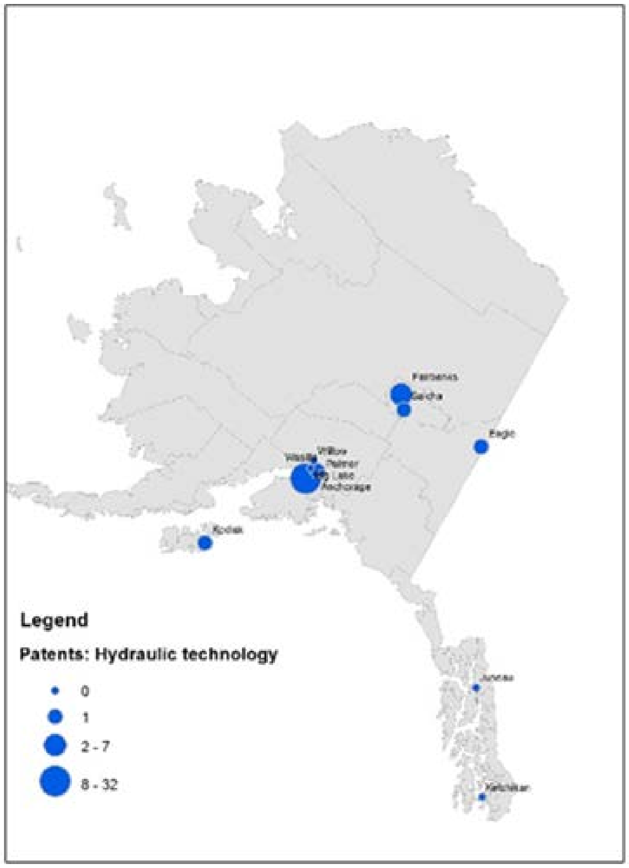

Figure 16: Hydraulic Technology Patents

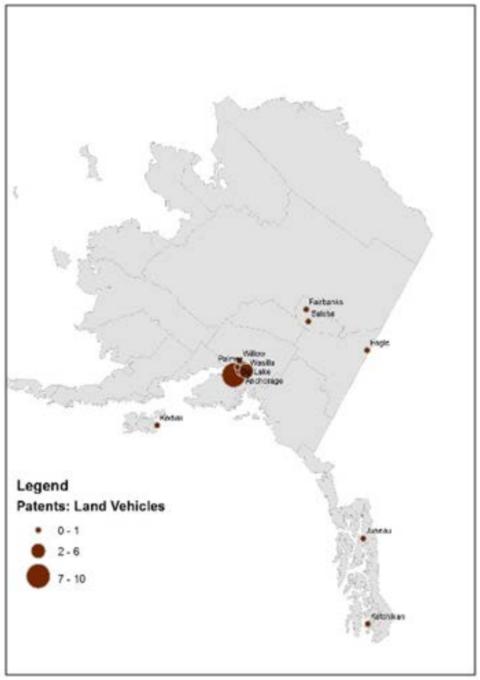

Figure 17: Land Vehicles Industry Patents

In terms of patents classifications, we assigned each patent under specific category according to their own technology, as previously outlined, these industry sectors were mostly represented in six categories, and Figure (18) summarizes the total number of patents granted in each sector in Alaska. Leading sectors changed over time. For example, in Hydraulic and Earth Engineering there were nine patents from 1976-1985. In the following decades, it significantly increased the number of 42 patents for the consecutive decades. However, the number declined again in the following decade. The same trend was noticed in the Fishing, trapping, and vermin destruction. The number was nine in 1976-1985, and it was in the top industry. This number again declined in the following decades and they are no longer among the top five most patented industries.

The other top five industries (wells, land-vehicles, and road structure) cooperation showed the same trend. The number of patents in the wells industry was six in the first decade, but, the number has increased by a magnitude of seven in the following decades up to 42 patents. Similarly, the following decades from 1996-2005 the number also increased to 51, and the last 5-years period, the total number of patents in the same field was 18. It is worth mentioned important role oil plays in Alaska's economy and the lives of all Alaskans. The oil industry announced in 1999 that the production had fallen to about 850,000 barrels a day, while patents production in this time increased.

Development of the surgery industry became visible in the second decade under the study along with development in surgery in the world. The number of surgery patents in the second decade was 11, then increased to 15, and somewhat in last years’ decade declined to 4.

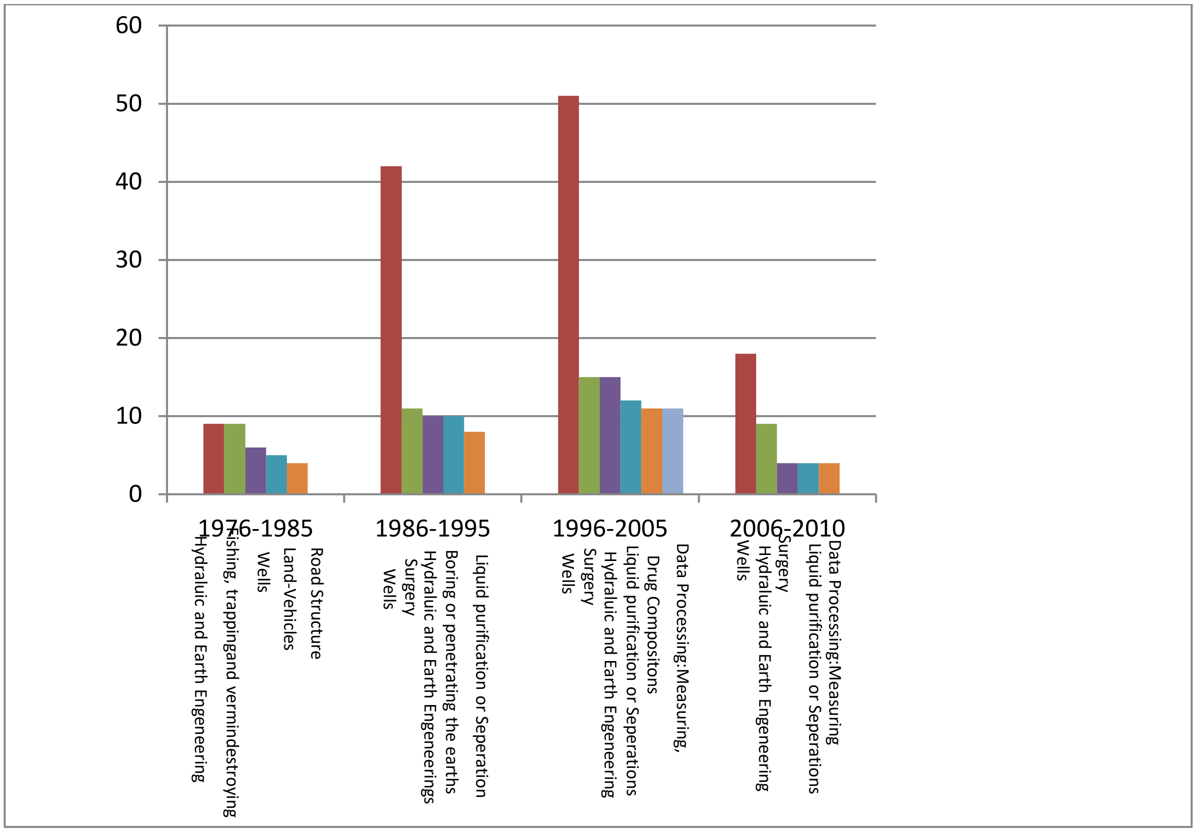

Figure 18: Top 5 Industry Sector Over the First Three Decades & Last 5 Years.

4.3.3. <u>Analysis of Applicant Inventor and Organizations by Industry Sectors</u>

Patenting process is a result of both individual and organizational innovations activities. However, the share of patents is different between individuals and organizations, depending on the industry sector of the patent and the type of patent. Some of patents need a large cooperation to be created, such as patents that are related to petroleum sector. Other types of patents could be done by individuals and require less elective effort to do, for example, fishing patents.

In this section, I analyze organizations and individuals share among applicants for the top 25 industry sectors that recorded the largest count of patents in 1976-2010.

Table 4: *Descriptive Statistics of Company and individual Inventors of Top 25Industry Sectors*

Industry Sector	Total Patents	Total Inventor	Individual Inventors	Company Inventors	AK inventors	Non-AK-inventors
Wells	117	339	17	322	221	118
Hydraulic-Earth Engineering	43	65	15	50	53	12
Surgery	30	55	33	22	38	17
Liquid Purification Or Separation	24	45	14	31	30	15
Land-Vehicles	24	30	27	3	29	1
Boring Or Penetrating The Earth	21	49	10	39	34	15
Fishing, Trapping, Vermin Destroy	21	22	20	2	21	1
Data processing Measuring, Calibr	17	39	9	30	20	19
Drug, Bio-affecting And Body Trea	16	29	11	18	19	10
Measuring And Testing	15	36	5	31	20	16
Ships	14	21	14	0	18	3
Animal Husbandry	14	17	14	3	15	2
Supports	14	18	11	7	18	3
Static Structure(Buildings)	13	20	19	1	14	6
Geometrical Instruments	13	14	11	3	14	0
Exercise devices	12	18	17	1	15	3
Package and article carriers	11	13	13	0	14	2
Multiplex communications	11	27	1	26	11	16
Communications: Electrical	11	22	11	11	18	4
Marine propulsion	10	22	9	13	12	10
Internal- combustion engines	10	13	11	2	12	1
Amusement devices: games	10	10	10	0	10	0
Material or article handling	9	12	7	5	12	0
Fluid handling	9	13	7	6	11	2
Refrigeration	9	11	5	6	9	2

The industry sector that had the largest number of patents in 1976-2010 was the wells sector with 117 patents (11% of total patent) created by 339 inventors ($18 of total inventors). Individual inventors count is 17 inventors who have created just nine patents out of 117 patents, on the other hand, there were 20 organizations and companies that involved in creating 108 patents by 339 inventors. The dominant company was *Atlantic Richfield Company* with 196 affiliated inventors who have created 64 patents, about 129 inventors were from Anchorage alone. The second largest patent applicant was for *Schlumberger Technology Corporation* with 32 inventors who have created seven patents, followed by *Baker Hughes Incorporated* with 23 inventors and seven patents as well.

The second largest industry sector was the hydraulic and earth engineering that had 43 patents (3.9%) created by 65 inventors (3.4%). Individual inventors performed about a fourth of inventions: 15 inventors created ten patents and all of these inventors were Alaskan except one co-inventor from the state of Washington. However, there were 13 companies that registered patents in this sector with total inventors about 50 inventors, who have created 33 patents. The dominant company again was the *Atlantic Richfield Company* with ten inventors who have created six patents, most of them from Anchorage, while three inventors were from Texas and California. The next company is *Gunderboom, Inc.* with nine inventors who have created seven patents, eight inventors from Anchorage city and one inventor from Oregon State. In this industry sector, University of Alaska Fairbanks had involved with one patent made by one inventor. In general, most wells and hydraulic patents have been made by inventors who worked for companies. About 372 company inventors have created 141patents in both industry sectors comparing with 32 individual's inventors who have created 19 patents in both wells and hydraulic and earth engineering sectors.

The third top industry sector was surgery which had about 30 patents (2.7%) made by 55 inventors (2.9%). Two-thirds of inventors were individuals, 33 inventors who have created 22 patents, and the lion share was in Anchorage, with 24 inventors who created 21 patents. The rest of inventors were distributed between Australia, (4 co-inventors), Florida, Idaho (with 2 inventors) each and one inventor from Massachusetts. It is interesting that most of these patents are related to one city, Anchorage, and made by individuals. However, there are six organizations who were involved in the patenting process, but had a small share, the main company was *AutoGenesis Corporation* that registered three patents made by nine inventors.

Similarly, to the surgery sector, there are other industry sectors that have more individual inventors than company inventors, such as land vehicles, fishing, ships, animal husbandry, supports, static structure, geometrical, exercise devices, package, Internal engines, amusement devices, material or article handling, fluid handling and refrigeration industry sectors. The total number of patents for all these sectors was 172 patents (15.9% of total patents), With 183 individual inventors have created 152 patents in the total of these industry sectors while the total of company inventors was 36 inventors have made 20 patents for these sectors. The majority of these individuals' inventors were Alaskan inventors, about 168 inventors of them.

In contrast, there were other industries that had more company inventors than individual inventors, such as liquid purification, boring or penetrating the earth, data processing, drug, bio-effecting, and body treating compositions, measuring and testing, multiplex communications, communications electrical and marine propulsion. All these industries have in total about 199 company inventors who created 79 patents comparing with 70 individual's inventors who made 46 patents in these industry sectors (Table 3).

4.4. Specialization and Sectoral Concentration of Patents

This section aims to describe and examine knowledge formation as specified by the growth of patents in Alaska, by examining the interaction between two aspects over 35 years: the spatial (geographic locations) and the sectoral (industry sectors). Patents and innovations activities vary from place to place, some locations have high concentration of patents while others have less concentration of patents. To measure and compare the portion of patenting in a particular industry sector through different geographic locations with the portion of this same industry at the national level, an appropriate index needs to be produced. The Location Quotient is usually utilized to measure location because it is able to estimate the concentration of geographic patterns. (Burt et al., 2009:124-126).

A Location Quotient (LQ) can be calculated for any industry where comparable data exists for the area. By the equation below, one can calculate LQs for a specific industry by dividing share of total patent output in the region (j) devoted to the sector (i) by the total national share of the sector (i) or

$$LQ_i^j = \frac{A_i^j / \sum_{i=1}^{n} (A_i^j)}{B_i^j \sum_{i=1}^{n} (B_i)} \quad (1)$$

Where ‘A^j_i ‘symbolizes the scale of activity ‘i’ in region ‘j’, i.e. patents in a specific industry awarded to inhabitants of a particular geographic unit, ‘Bi’ symbolizes the scale of activity ‘i’ in the base region, i.e. patents in a certain industry awarded to all inventors who dwell in Alaska, and n indicates the count of innovation activities, i.e. In this study 25 industries in which patents have been awarded to Alaskan inventors.

The six boroughs with the largest patent counts between 1976-2010 were chosen and then LQs for the top 25 industry sectors were computed for them, using data from the United States Patents and Trade Office. In Table 5 uses the following color coding: LQs with a value greater than 2.0 (black), and values below 0.5 (red) are shown to indicate concentration higher or lower than anticipated national sectoral shares. High LQ means specialization of a borough in productivity patents in a certain sector. The gray boxes indicate sectors, in which no patents have been recorded to the residents of the particular borough, and the White boxes include the rest of the values, which are LQs with results between the values 0.5 and 2.0 exclusively. The last column in Table 4 shows the overall count of patents granted in a particular industry over the 35 years time period observed, based on first inventor counts.

Table 6 illustrates location quotients based on patents recorded from1976-2010. Each borough showed patent clustering in at least three industry/technology sectors well beyond the predicted share. Inventors who live in the Matanuska- Susitna Borough, are overrepresented in 14 industry sectors (black boxes). This is the situation in 13 sectors for the Fairbanks North Star Borough, followed by 11 sectors in Anchorage Municipality, and 10 in Kodiak Island Borough. The borough that has the largest number of patents is Anchorage, and the Anchorage -based inventors created new products in every chosen industry sector except for Multiplex Communications industries, abroad specialization of this region. Similarly, Matanuska-Susitna Borough and Fairbanks North Star Borough have high counts of patents almost all in each sector with just one sector under-represented which is Drug, bio-affecting, and body treating compositions in both boroughs.

In contrast, smaller boroughs in terms of total patents output, such as Ketchikan gateway Borough and Juneau City and Borough, have created patterns in relatively few industry sectors, i.e. have very narrow specialization. On the other hand, there are sectors that are only present in a few boroughs, for example, liquid purification or separation, land vehicles, data processing-measuring- calibrating or testing, multiplex communications, internal- composition engines and fluid handling. These tend to be sectors with an overall low count of recorded patents (Table 5).

Table 5: *Calculated LQ Values of Recorded Patents from 1976-2010 of the Top 25 Industry Sectors*

Industry Sector	**Anchorage Municipality**	Faribanks North Star Borough	**Ketchikan Gateway Borough**	**Juneau City and Borough**	**Matanuska _Susitna Borough**	**Kodiak Island Borough**	**Total# of patents (1976-2010**
Wells							117
Hydraulic							43
Surgery							30
Liquid purification or seperation							24
Land Vehicles							24
Boring or penetrating the earth							21
Fishing							21
Data- processing- measuring ,Calibrating or testing							17
Drug, bio-affecting and body treating compositions							16
Measuring and testing							15
Ships							14
Animal husbandry							14
Supports							14
Static Structure							13
Geometrical Instruments							13
Exercise devices							12
package and article carriers							11
MultiplexCommunications							11
Communications: Electrical							11
Marine Propulsion							10
Internal - composition engines							10
Amusement Devices: games							10
Material or article handling							9
Fluid handling							9
Refrigeration							9

The common way is to interpret LQ >2 as a sign of specialization (Table 6). Boroughs showed a cluster of patenting in a certain industry beyond the predicted shares, over the 35 years' time period investigated (Table 6). Black color indicates that a certain geographic place has an LQ value above 1, for a certain industry sector, in time period 1976-2010. The bottom row in Table 6 shows the number of sectors overrepresented per spatial unit, whereas the final column specifies the number of times an industry sector is above the national average share among the boroughs investigated.

It is clear that boroughs that have the largest count of patents, Matanuska, Fairbanks, and Anchorage have by far the most constant knowledge producing clusters with 14, 12 and 11 sectoral concentrations respectively, followed by Kodiak Island, Juneau City, and Ketchikan- Gateway borough. From the sectoral view, fishing is most repeatedly over-represented, accruing in 6 cases, followed by the animal husbandry with 5 cases. In total, fifty-six cases of specializations of patenting, among the 25 industry sectors and 6 geographic units, as specified by LQ values above 1, exist in the Alaskan boroughs over 1976-2010-time period.

Table 6: A Cluster of Patenting in a Certain Industry beyond the Predicted Portions, over the 35 Years' Time.

Industry Sector	Anchorage Municipality	Faribanks North Star Borough	Ketchikan Gateway Borough	Juneau City and Borough	Matanuska _Susitna Borough	Kodiak Island Borough	Number of LQs > 1
Wells	■				■	■	3
Hydraulic	■	■			■	■	4
Surgery	■		■				2
Liquid purification or seperation		■					1
Land Vehicles					■		1
Boring or penetrating the earth	■	■			■		3
Fishing	■	■	■	■	■	■	6
Data- processing- measuring ,Calibrating or testing					■		1
Drug, bio-affecting and body treating compositions							0
Measuring and testing							0
Ships	■			■	■	■	4
Animal husbandry	■	■		■	■	■	5
Supports		■					1
Static Structure					■	■	2
Geometrical Instruments	■	■		■			3
Exercise devices	■				■	■	3
package and article carriers	■	■		■	■		4
MultiplexCommunications					■		1
Communications: Electrical							0
Marine Propulsion	■	■	■			■	4
Internal - composition engines					■		1
Amusement Devices: games		■		■		■	3
Material or article handling							0
Fluid handling		■					1
Refrigeration		■			■	■	3
Number of LQs > 1 over 1976-2010 time period	11	12	3	6	14	10	56

4.5. Understanding Innovation Networks within AKRIS.

The second objective is to identify the external and internal innovation networks within the Alaska Regional Innovation Systems (Cooke & Piccaluge, 2004) (AKRIS, Figure

19). We start by using the stylized model of an "Ideal Type" regional innovation system that is depicted in the scheme below. Figure 19 illustrates the RIS components and the relationships between them.

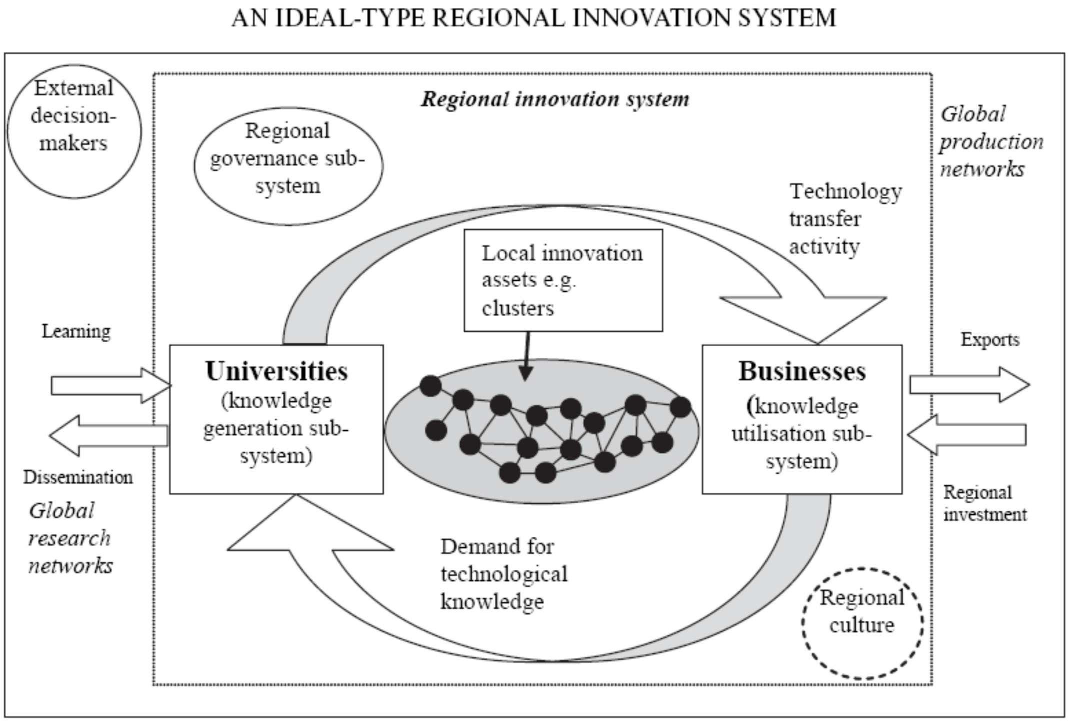

Figure 19: A Stylized Regional Innovation System (Source: in OECD, 1994 and Cooke & Piccaluga, 2004)

4.5.1 <u>The Regional Innovation System in Alaska</u>

To apply the RIS concept to the Alaska innovation system, one needs to quantity different sectors of patent production (Figure 20). System elements in Alaska were classified in two parts: internal and external. And each component was assigned specific share in the innovation process based on patent analysis. This share gives insights about the importance of the components in the overall innovation process. Both levels, internal and external, had different roles in the innovation system. In addition, the internals and externals may interact with each other since the internal be connected outside the region, and at the same time the external components can influence the regional components. In Alaska, the major components (innovation actors) were individual inventors, government, private organizations, and universities. Internally, the individuals had the highest percent among other sources of knowledge production (57%), followed by organizations-private establishments (9%) then universities (1.7%) and lastly the government (0.2%) (Figure 20). However, the external innovation activities exhibited a different pattern. The organization share was the highest (27%), then the next two parts were individuals and government with the same share (1.7 %) of the innovation activities, and finally universities had the smallest percent (0.8%). Clearly the organizations (companies) had the dominant share of external innovation activities (Figure 20).

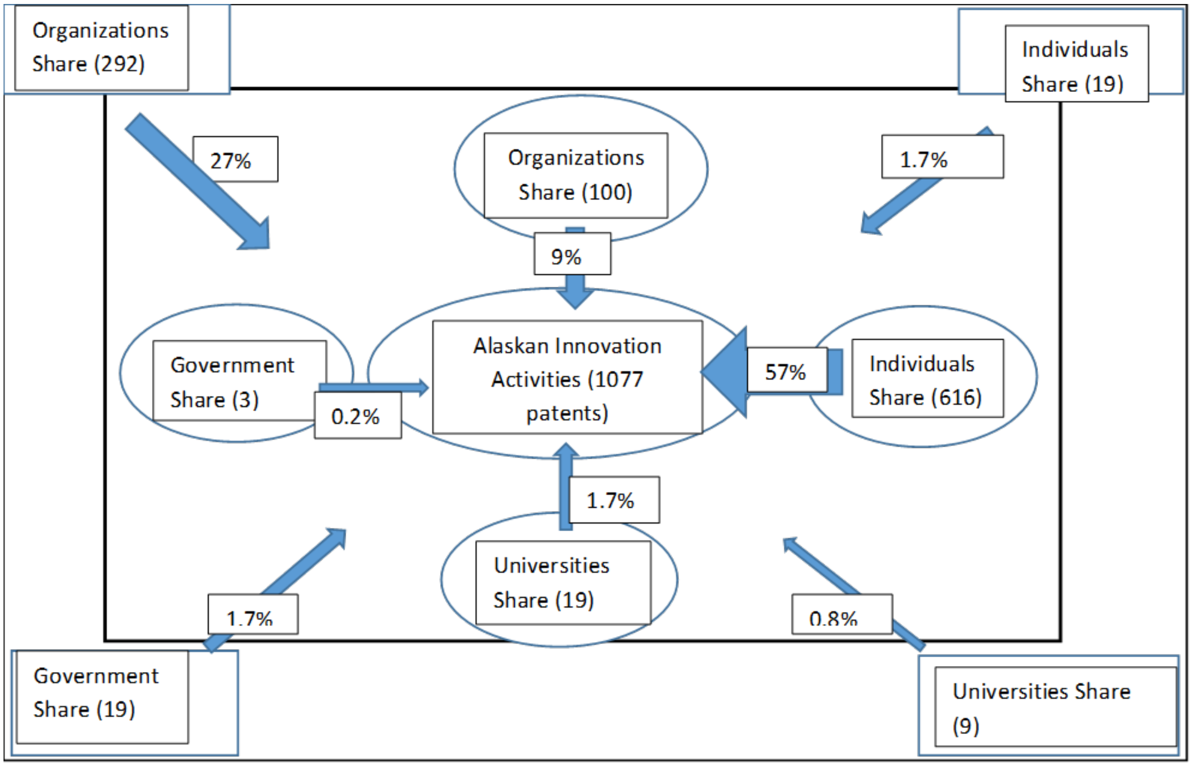

Figure 20: Alaskan Regional Innovation System Components.

To get further details about the components of Alaskan innovation systems, this study investigated each component in order to clarify who is behind these patent shares in within and outside Alaska. First, as it mentioned previously, individuals had created more than the half of all patents over the observed time frame, and most of them were Alaskan inventors, while non-Alaskan individuals have a small share of patents (1.7%).

Secondly, organizations had most external patents (292 patents) compared with 100 patents developing to Alaskan organizations. In other words, there were about 51 Alaskan companies that created (9%) of internal patents. Of these, 41 companies are in Anchorage. In contrast, there were about 90 companies from other states that were involved in the patents production of 292 patents by 732 inventors. Among the later group, 412 of them were Alaskan, while 321 inventors were non-Alaskan. Texas had the largest number of companies (29 organizations) that produced 76 patents by 184 inventors. The next state was California that had 17 organizations that have created 144 patents by 384 inventors. However, all the organizations are from US except one company from Canada that had one patent created by 4 inventors.

Thirdly, the government patents share was low, since it had 22 patents created by 70 inventors. In addition, Alaskan state government patented only 3 patents by 9 inventors and all of them were Alaskan. Federal patents were mostly claimed by the military, for example, *United States of America*, *Army* had registered six patents created by 19 inventors.

Last component is the universities that had the least portion of patents activities, since it had limited number of universities that involved in patenting process. In Alaska, the University of Alaska Fairbanks had the lion share of patents among other institutions by creating 19 patens with 33 inventors, 25 of them from Alaska. While there were five other universities (Carnegie Mellon University, University of Kentucky, Montana State University, University of California, and Baylor College of Medicine), they had created nine patents by 23 inventors, 10 of whom were from Alaska.

The number of inventors is another indicator that can be count as a crucial factor in the innovation activities. In Figure 21, shows the counts of patents, inventors, Alaskan inventors and non- Alaskan inventors in the four components of AKRIS. The highest percent was 72% for non-Alaskan company inventors. Individual Alaska inventors recorded the highest percentage with 53%. On the other hand, government and universities recorded the lowest percentages in all variables (patent, inventors, Alaskan inventors, and non-Alaskan inventors)

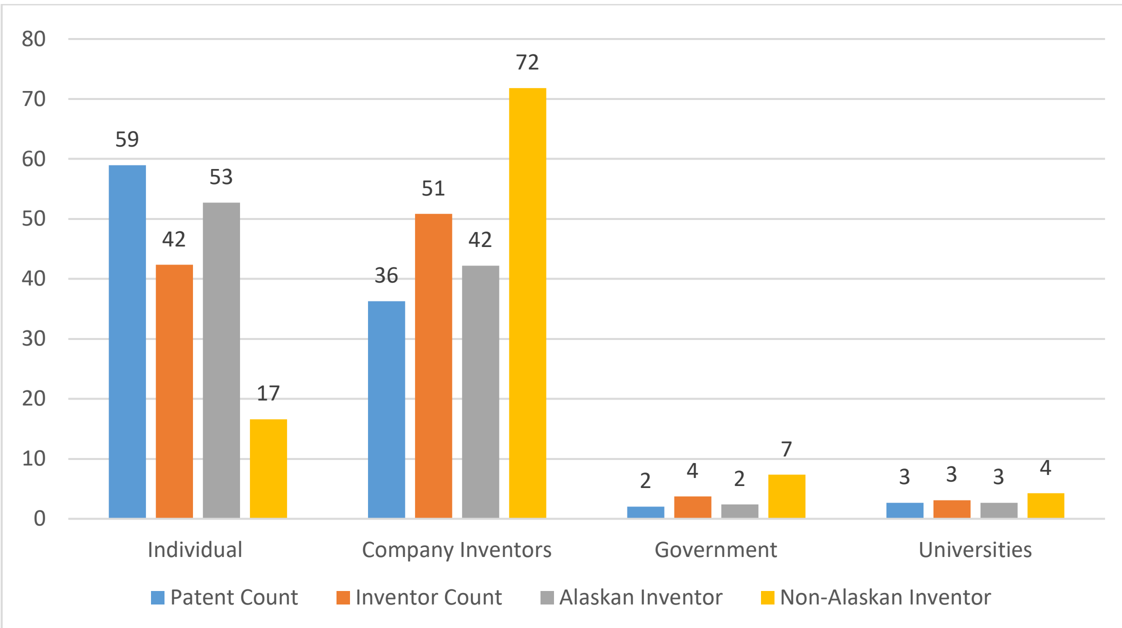

Figure 21: Percentages of individuals, company, government, and universities Shares

To compare between Alaskan and Non-Alaskan inventors share, Figures 22 &23 show that the individuals were still the highest share of Alaskan innovators with 53% of the patent share in innovation activities. The absolute value for both sections leads to conclude that individials take a leading role in patented innovation in Alaska. The second bigger share is the company inventors that was 42%, then universities, lastly are the government inventors. In respect to non-Alaskan inventors (Figure 23), the companies held the dominant share with

72%. Also, the second large portion is an individual portion with 17%. As a result, the share of external components for both patents and inventors has the same trend as internal (Figure 21, 22, & 23).

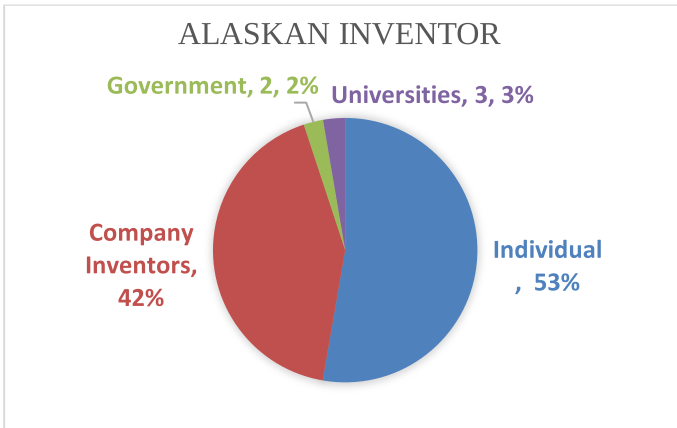

Figure 22: Alaskan Inventors Share in Patents

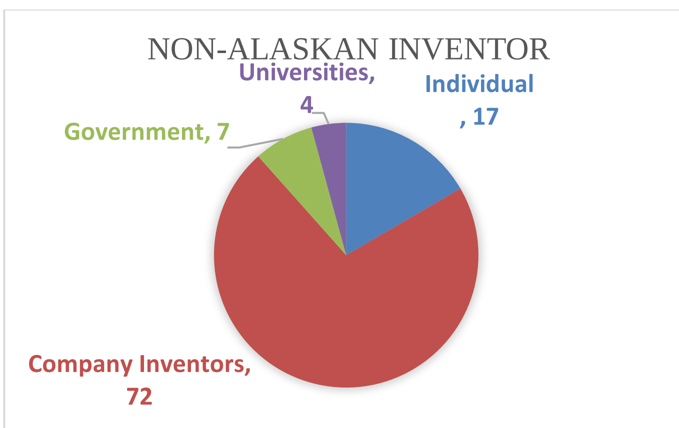

Figure 23: Non-Alaskan Inventors Share in Patents

4.6.Co-Inventor Networks Analysis

This section aims to determine the spatial distribution of co-inventors of Alaska patents and identify the external and internal networks within Alaska and between Alaska and other regions. According to the USPTO patents data, many patents in Alaska have cooperating inventors from inside and outside the state. Thus, we need to go through the dataset to find out the locations of each inventor for each patent. Among 1,077 patents created by 1,873 inventors, there were a lot of patents that had more than one inventor. Original Python scripts were utilized in order to streamline and automate co-inventor spatial information retrieval and build co-inventor networks.

The purpose of Python script (Appendix D) is creating links between all inventors of patents within Alaska and other regions efficiently. This will be needed to achieve one of the objectives of my research, which is clarify the external and internal innovation network within the Alaska Regional Innovation Systems (AKRIS).

The USPTO database allows to investigate patents data by using some of the fields to choose and search for specific patents according to many criteria. There was a need to geocode the locations in the table by using a geocode script tool, since the original data did not have the X, Y coordinates, just city and state name without addresses information. After running the tool, the result was a map of all Alaskan patents with geographical coordinates (Figure 24). Then a new polyline future class was created by using Create Feature Class script tool, and a Python script was developed to connect the inventors.

Co-Inventors Spatial Locations 1976-2010

Figure 24: Co-Inventors Spatial Locations 1976-2010

Since this study covers 35 years (1976-2010) it would be more understandable and useful to regroup patents into five time periods, e.g. (1976-1980, 1981-1985, 1986-1990.…) to analyze the progress of inventors' networks over the time and observe the changes of inventors and patents clustering locations through the time periods.

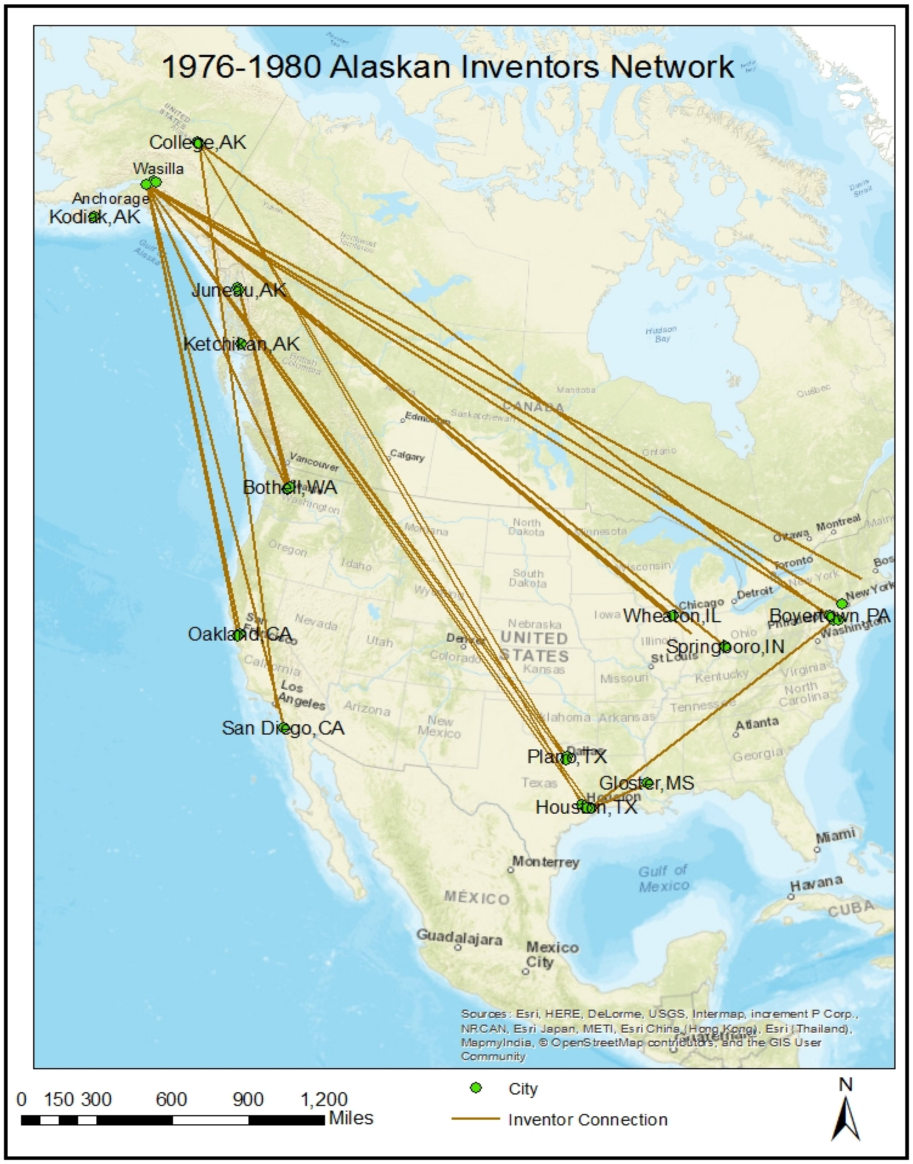

Figure 25: 1976-1980 Alaskan Inventors Network

First, Figure 25 presents the co-inventors network during 1976-1980. The total number of inventors is 120, 74 of them were individuals' inventors i.e. either a single inventor or a group of independent co-inventors with no recorded relationship to any organization or company. On the other hand, there were 46 inventors who involved with their organizations. In this period, all co-inventors were located inside the USA, with most inventors residing in Alaska (Alaska had 95 inventors, about two thirds of them were individuals and one-third belonged to an organization). Most non- Alaskan inventors (60%) were company inventors, while (40 %) were individuals.

Anchorage municipally recorded the largest number of inventors (53 inventors). While among other states Texas had the largest number of inventors (11 inventors: 7 of them as company inventor while 4 as individuals). In general, individual inventors share is larger than company inventors in this time frame and most of the inventors come from Alaska (Figure 26). In other words, the AKRIS in its early days was relatively inward oriented, dominated by individuals and small, localized teams. It has rather limited connectivity within the USA and was isolated from the rest of the world. The time period between 1976 and 1980 reflects the “pre-oil” situation, when the role of large corporations was still insignificant. Referring back to section 4.3, it interesting to point out that the number of patented innovations was small, with a large share fishery, trapping and other “old” sectors. This is the only time when road construction patents made to the top five sectors, a situation reflective of intensive contraction phases of oil development.

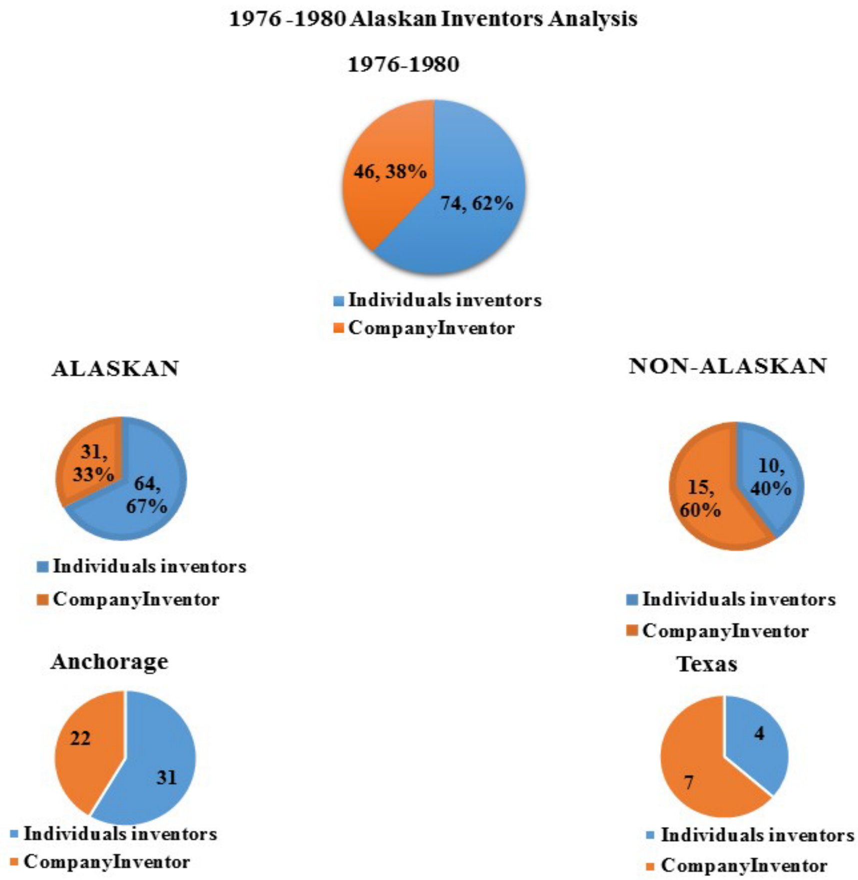

Figure 26: 1976-1980 Inventors Analysis

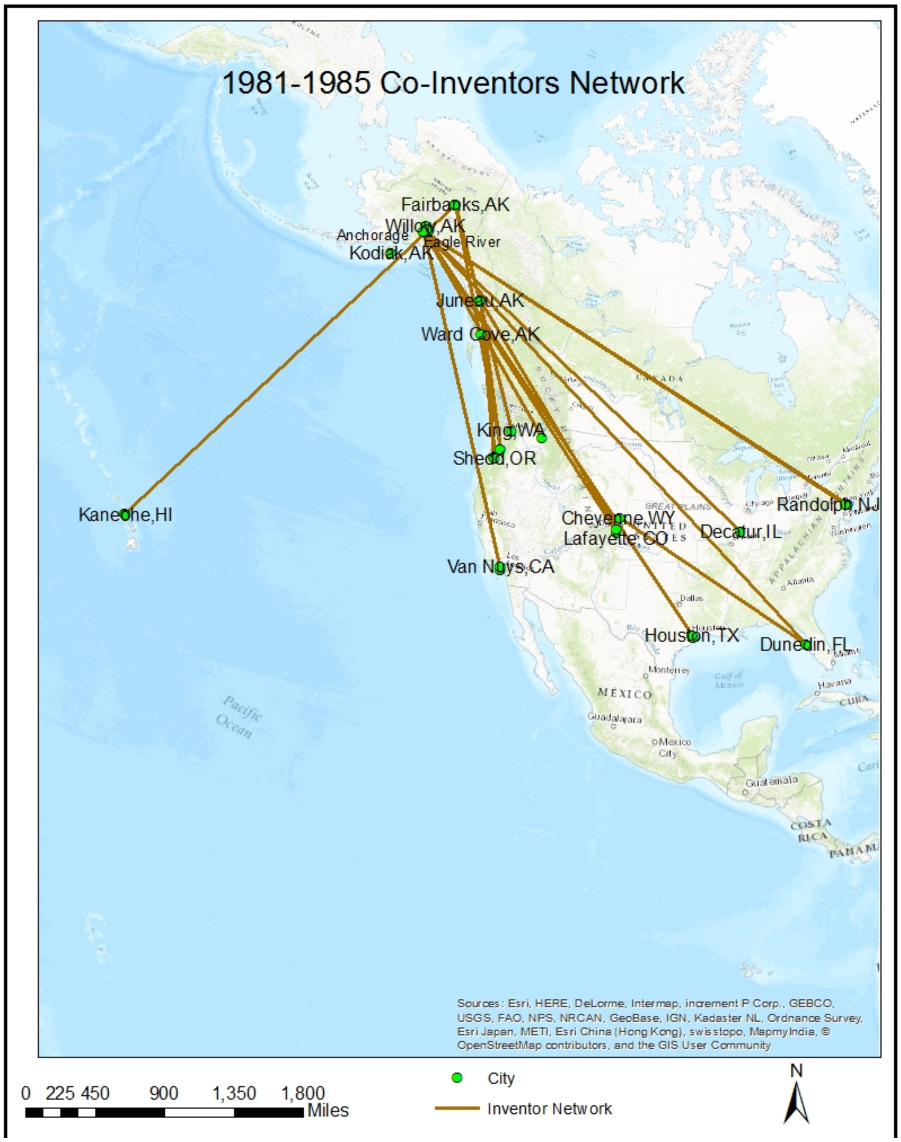

Figure 27: 1981-1985 Alaskan Inventors Network

In the second-time period from 1981-1985 (Figure 27), the total number of inventors was 99, i.e. that are slightly lower than the previous period. But similarly, to the previous period all co-inventors were located inside the USA with no international connections. The number of inventors from Alaska was larger than the number of researchers from other states, (since Alaska had 73 inventors comparing to 26 non-Alaskan inventors). The network structure is similar to 1976-1980 in respect to the percent of individuals and company - based patents, since the percent of individuals' inventors is larger than company inventors (61% and 39% respectively). Most of the individual's inventors came from Alaska, while company inventors were predominantly from other states. Anchorage had the largest number of inventors again (40 inventors), and Oregon State had the largest number of out-of-state collaborators (Figure 28).

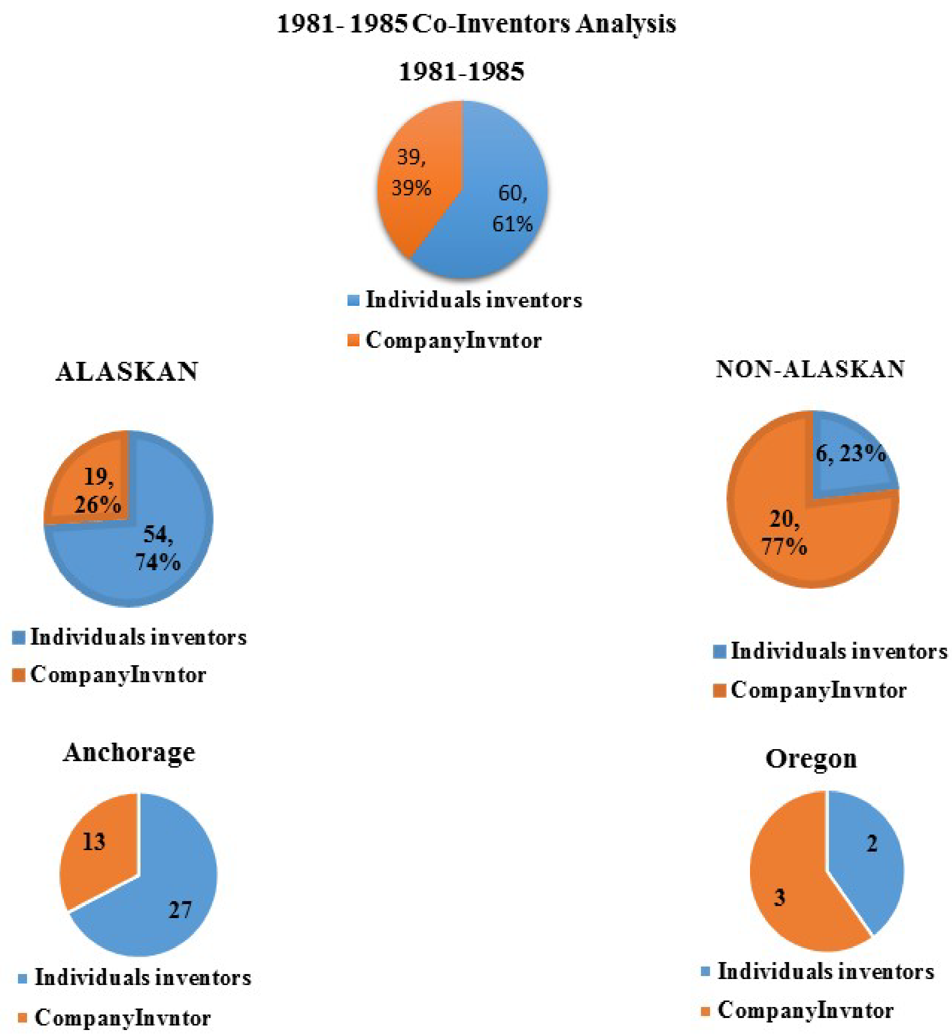

Figure 28: 1981-1985 Inventors Analysis

*Figure 29:*1986-1990 Alaskan Inventors Network

Between 1986 and 1999 the number of inventors increased comparing with previous time periods since the total number of inventors was 182. Most importantly more than half of them were company inventors 57%, while individuals constituted only 43% of the inventor pool. This indicates that, more companies and organizations became involved in creative activities than before. It is clear through the graphs (Figure 30) that Alaskan and non-Alaskan company-based inventors increased by 47% and 83% respectively, whereas individual inventors decreased by 53% among Alaskans and 17% among the rest. At the regional level, Anchorage again was the dominant city with the largest number of inventors among Alaska municipalities with almost the same percent for both individuals and company inventors 51% and 49% respectively. Among other states, Texas had the largest share of collaborators with a total of 37 inventors and 90% of them were company inventors while individuals constitute 10% of them (Figure30). Indeed, this network structure depicts the “oil boom” Alaska situation, characterized by heavy corporate involvement, strong but geographically limited collaborative linkages (mostly Texas) and prevalence of oil-related inventions (wells, hydraulics, etc.).

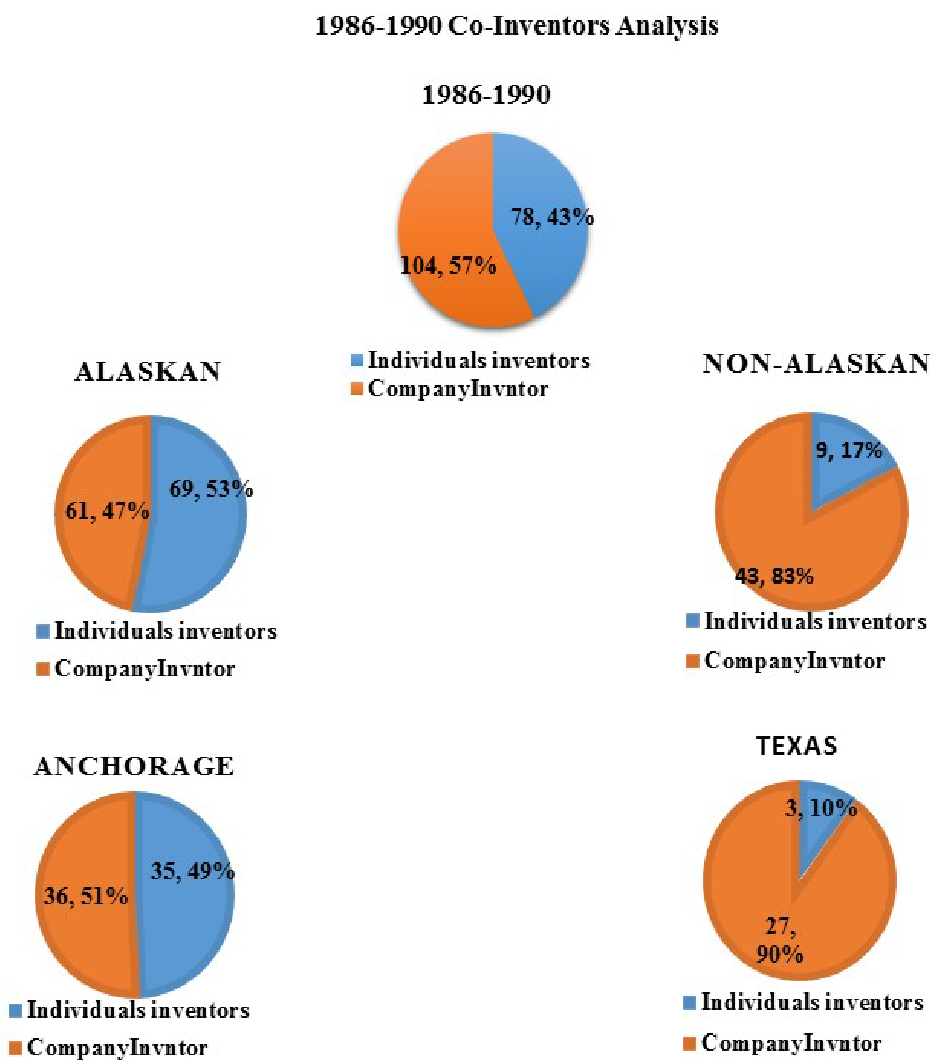

Figure 30: 1986-1990 Inventors Analysis

Figure 31: 1991-1995 Alaskan Inventors Network

During 1991-1995 the inventors count increased rapidly to record the total of 346 inventors who were distributed among Alaska, other states and, for the first time, internationally (Figure 31). The lion share of inventors, however, still resided in Alaska (266 inventors), while non-Alaskan collaborators were in minority 80. The percent of company inventors was higher than individual’s inventors (60% to 40%). There was a difference between Alaskan and non-Alaskan inventors, company inventors increased in both groups with 55% for Alaskan inventors and 76% for non-Alaskan inventors. Anchorage again had the largest number of inventors within Alaska (166), but 60% of them were as company inventors. Within other states, Texas was the residence for 23 inventors, 87% of them were company inventors. In sum, this time period has special characteristics of inventor's count comparing with the previous time frames, since the total of inventors was much higher than before, and also company inventors were dominant co-inventors. In addition, the co-inventors network had extended outside the US since there were two co-inventors from the United Kingdom and three co-inventors from Canada.

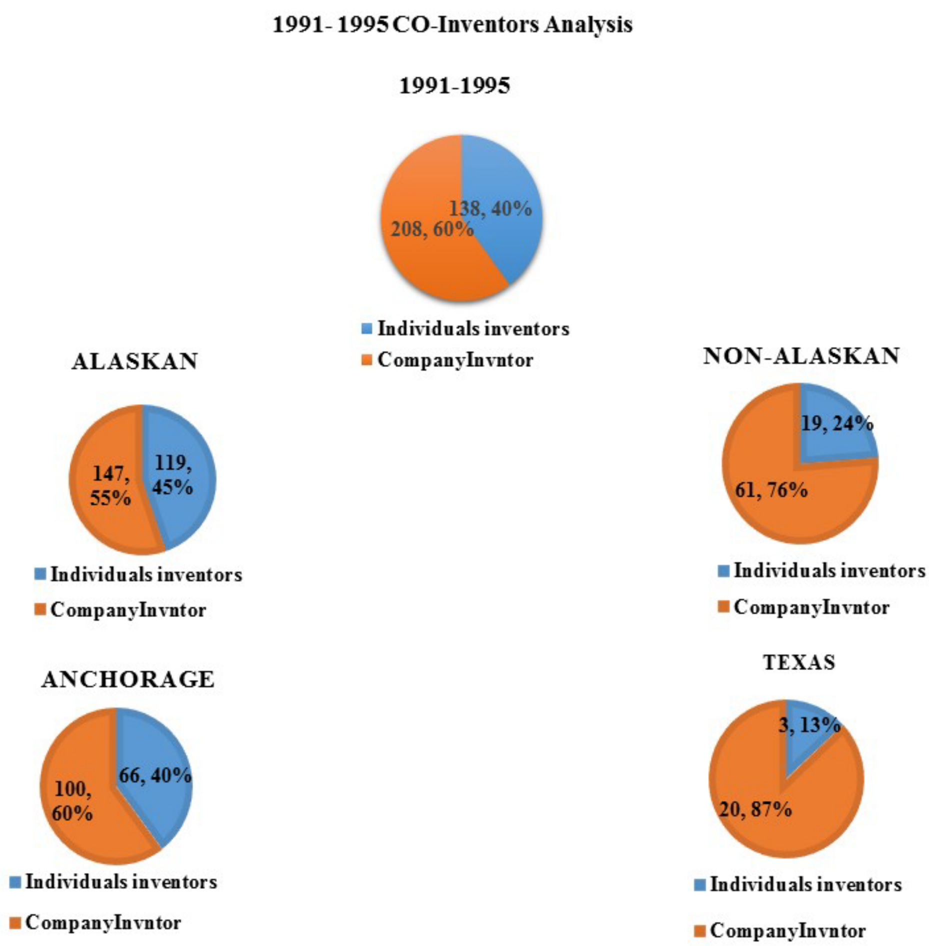

Figure 32: 1991-1995 Inventors Analysis

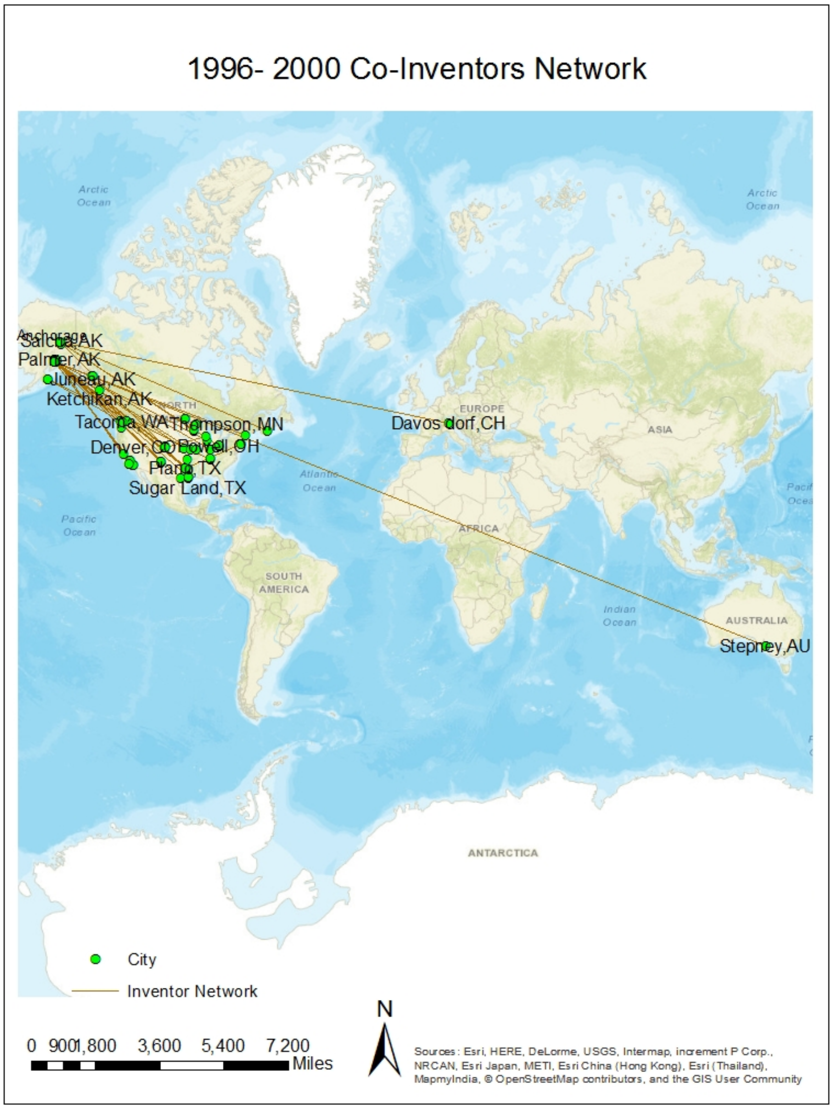

Figure 33: 1996- 2000 Alaskan Inventors Network

During the time frame from 1996 to 2000 (Figure 33) the number of inventors increased to be 412, 58% of them were company inventors while individuals constituted 42%. Similar to the previous period, company inventors increased and were the dominant among

Alaskan and non-Alaskan inventors, while the percent of Alaskan company inventors was 51%, compared with 82% for non-Alaskans. Again in this period Anchorage had the largest number of inventors with 207 inventors, 60% of whom were company inventors, whereas, Texas had the largest number of external collaborators (37 inventors most of whom were company inventors) (Figure 34). In addition, co-inventors network during this time had international co-inventors, about 4 inventors from Canada, Australia, and Switzerland.

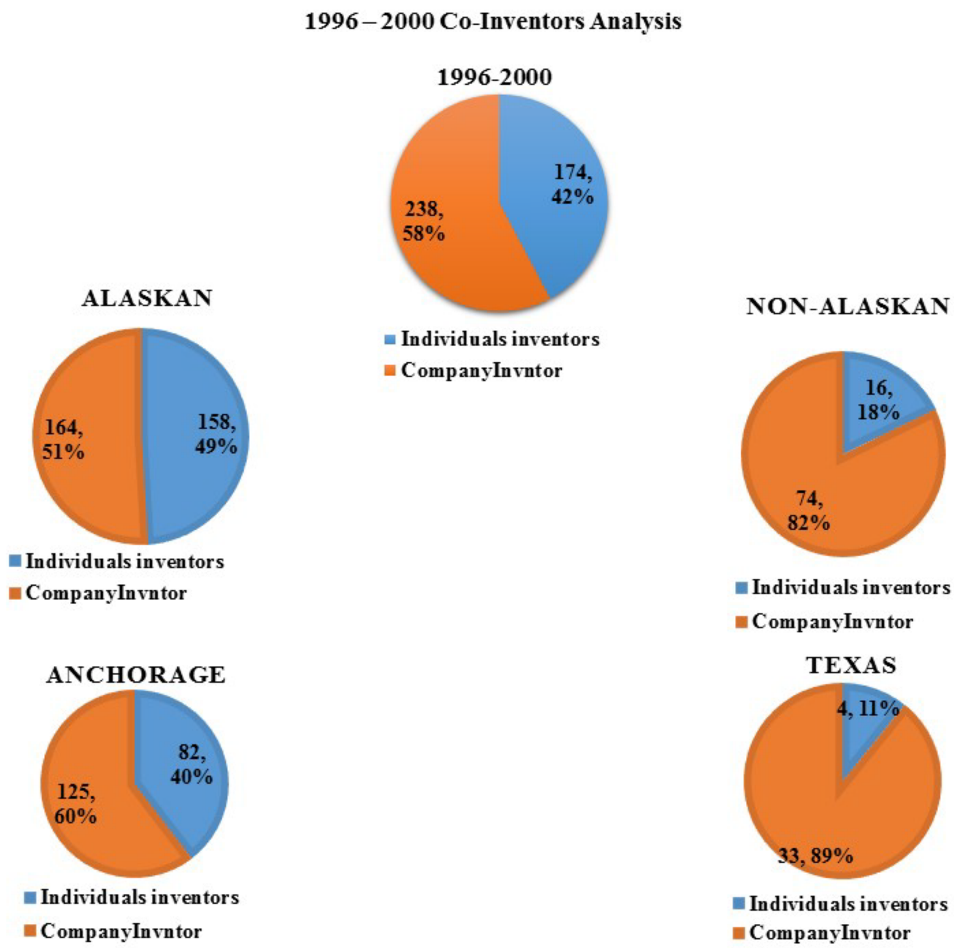

Figure 34: 1996-2000 Inventors Analysis

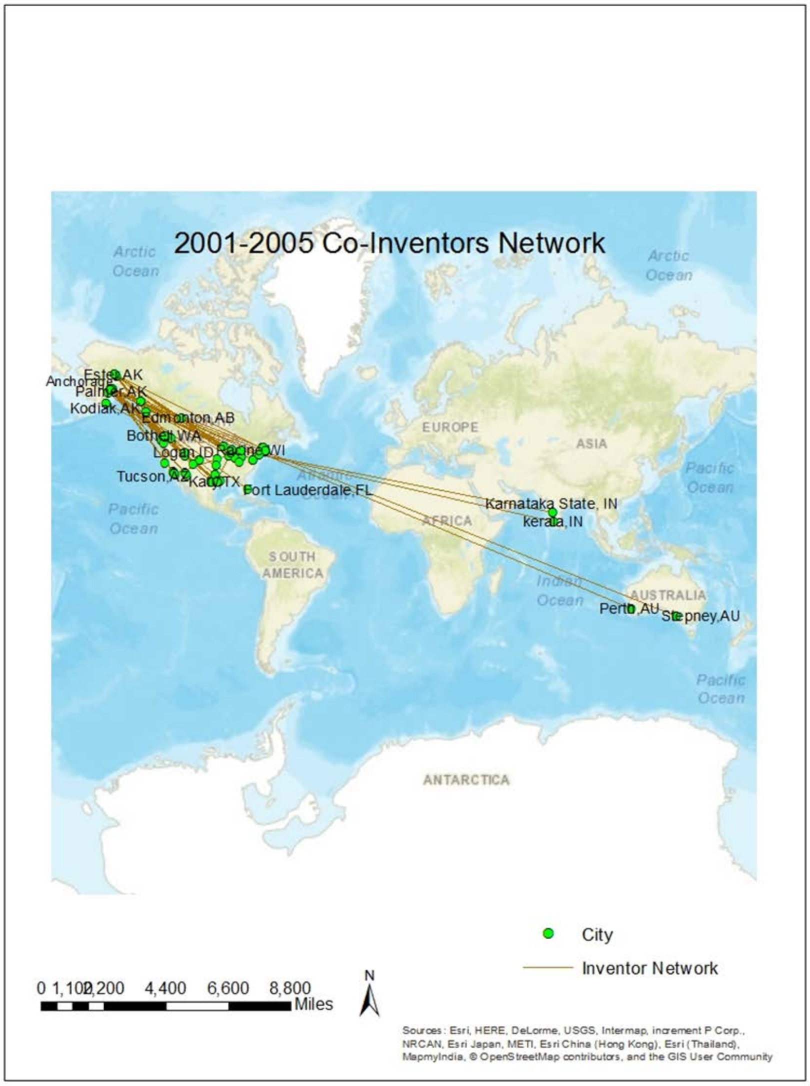

Figure 35: 2001- 2005 Alaskan Inventors Network

During the period from 2001 to 2005, the total number of co-inventors was 387 and this was slightly fewer than the number of inventors during the preceding decade. However, company- based inventors were still a large group during this period constituting 56% of all patent producers, while individual' inventors accounted for 44% of them.

Alaskan co-inventors were more numerous than non-Alaskan co- inventors with 268 and 119 inventors respectively. But the share of company-based inventors in the Alaska inventor pool in this period decreased to 43%, while the non-Alaskan company inventors reached 87% of the total number of all outside patent bearers.

Similarly, to the previous decades, Anchorage remained the dominant concentration of inventors serving as the residence for 153 of them, of which 48% were company and 52% were individual inventors. Yet again, outside Alaska, Texas had the largest number of co-inventors (31) and all of them were company inventors. The share of international co-inventors increased to eight coming from Canada, Australia, and India. (Figure 36).

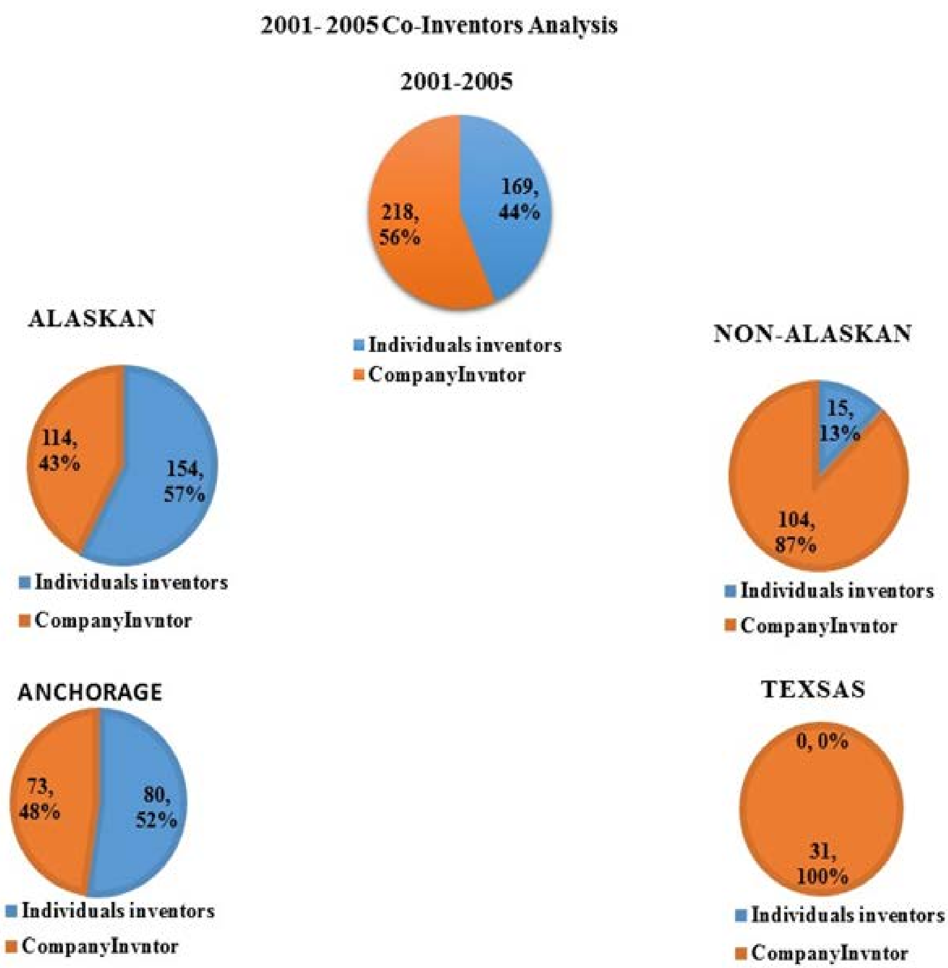

Figure 36: 2001-2005 Inventors Analysis

Figure 37: 2006-2010 Alaskan Inventors Network

In the last time period, 2006-2010, there were 330 inventors, which is slightly fewer than the in the previous period. Among them, 69 % were involved with their organizations to create patents, while 31% (103) were individual' inventors. However, in the early 2000s the share of company inventors became the largest. While similar to the previous years, Alaskan inventors outnumbered non-Alaskan inventors (188 to 142), the percentage of company-based inventors grew to 52% among Alaskans and 91% among outside collaborators. Anchorage still had the largest number of inventors, 54% whom were company inventors. While among other states Texas again had the largest share of inventors and 94% of them were company inventors (Figure 38). On the other hand, the role of inventors in this period came from a diverse group of countries: (Australia, India, United Kingdom, and South Korea).

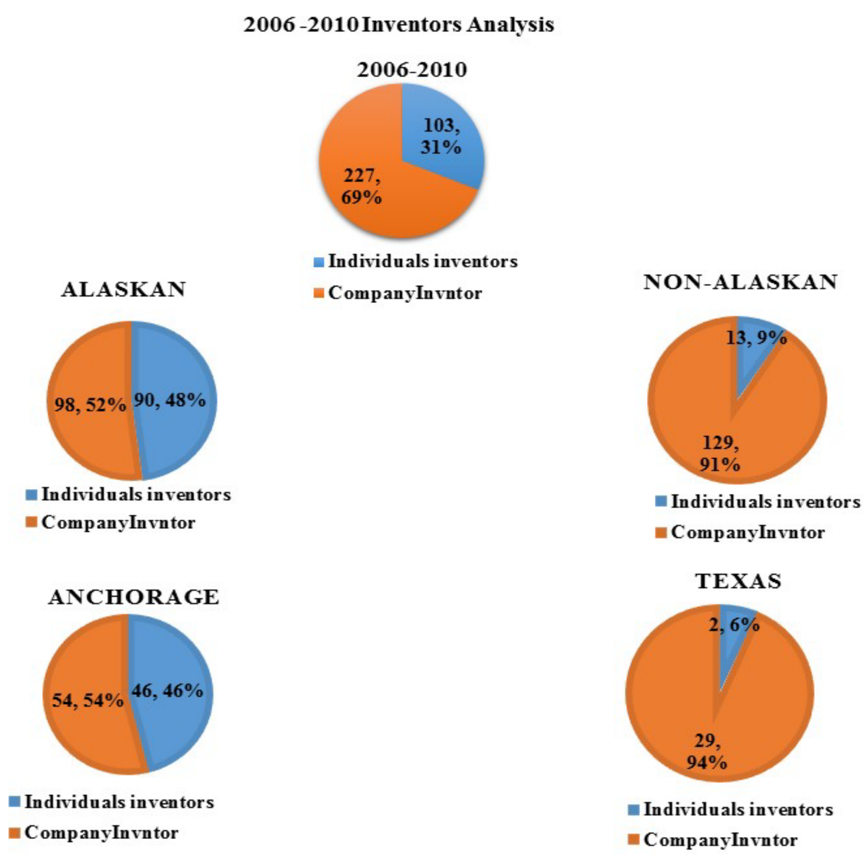

Figure 38: 2006-2010 Inventors Analysis

In summary, between 1976 and 2010 there was an evolutionary trend in respect to the Alaska inventor's connectives with outside collaborators. The co-inventor networks evolved from predominantly internal and dominated by individual (no company affiliation) inventors to externally connected and company-driven. In the early years, the innovation activities started with local co- inventors from Alaska and limited states, and then co- inventor' networks extended to have more states and foreign countries. Between the 1990s'and 2000s', co-inventors network had the largest number of inventors who involved into patenting process not just from the US, but also from Canada, United Kingdom, India, and Australia. On the other hand, until the early 1990s, the patents activities heavily relied on individuals inventors, while after 1990 the number of company inventors increased concurrently with the increase in the expansion of the co-inventors' geography.

4.7. Identifying Potential Factors of Innovation Activities

The third objective of this study was to examine the possible factors that influence innovation activities in Alaska, such as income, employment rates in industry sectors, population density, remoteness, resource-orientation, etc. All indices were developed using census or annual reports of the national and regional statistical agencies. The study used standard statistical analysis (correlation) to determine relationships between socio-economic factors and patent production in Alaska.

4.7.1. Correlation Analysis

Correlation analysis investigated the connection between patents per capita and the socio-economic factors (population, inventors count, the total employment of each borough in the top 25 industry sectors that have the largest recorded patents, patents count, and the change of income over the last time periods (1995-2000,2001-2005,2006-2010) (Table 7). As a result of limited data availability, we only analyzed data for 2000, 2005 and 2010. All variables were measured in five year intervals. Given that there were only eight boroughs with any registered patents, correlations were run for the entire dataset by choosing different years.

The population served as a proxy of potential face-to-face and spillover opportunities, as well as agglomeration and urbanization economies. In a standard scenario, innovative activity will likely be associated with larger places, such as cities. The total employment in the 25-top patent producing sectors is an important supply-side factor of innovation in a LQ format often used as a “Tech Pole Index” (Florida, 2002, Petrov, 2014). Presumably, a large size and elevated specialization in an innovation-producing industry would be conducive of patent creation. The magnitude of change in average per capita income approximates economic growth in a given borough. Finally, the number of patents and inventors were used as supporting variables to tackle the relationship between per capita and absolute innovative activity. Unfortunately, it was impossible to include other important variables, such as occupational and educational statistics due to the lack of data covering the entire time span with a needed frequency.

Table 7: Patent Activity_Socio-economic Factors

2000							
Borough	Inventor Count	Patent Count	Patents Per Capita	Population	Income	Employment per Sector	Change of Income
Faribanks North Star Borough	36	25	30.2	82840	29453	4665	5444
Anchorage Municipality	255	133	51.1	260283	35718	21364	5864
Ketchikan Gateway Borough	2	2	14.2	14059	36963	1010	4902
Juneau City and Borough	9	9	29.3	30711	38	1009	-32569.299
Matanuska_Susitna Borough	39	32	53.9	59322	27	2055	-22997.221
Valdez-Cordova Census Area	0	0	0	10195	32400	757	5067
Keni Peninsula	0	0	0	49691	29724	1972	5364
Kodiak Island Borough	11	9	64.7	13913	29025	568	5183
2005							
Faribanks North Star Borough	37	23	25.4	90381	36579	4980	7180
Anchorage Municipality	174	120	43.3	277157	44255	21546	6659
Ketchikan Gateway Borough	2	2	15	13331	43693	1198	5021
Juneau City and Borough	10	8	25.5	31340	43269	1114	4532
Matanuska_Susitna Borough	40	29	38.7	74871	34680	2779	5375
Valdez-Cordova Census Area	0	0	0	10177	38797	878	6581
Keni Peninsula	1	0	0	51735	34200	1555	4233
Kodiak Island Borough	3	2	14.8	13491	37559	522	6907
2010							
Faribanks North Star Borough	33	22	22.5	97581	45379	3224	5376
Anchorage Municipality	106	73	25	291826	55887	21956	9181
Ketchikan Gateway Borough	2	2	14.8	13477	53595	359	9064
Juneau City and Borough	5	4	12.8	31275	54	692	-45499.022
Matanuska_Susitna Borough	38	22	24.7	88995	39822	2299	4726
Valdez-Cordova Census Area	0	0	0	9636	51544	259	11676
Keni Peninsula	1	0	0	55400	43780	1738	8084
Kodiak Island Borough	3	3	22.1	13592	49729	219	10354

Table 8: Correlation Analysis: Patents and Socio-economic Characteristics of Alaska Boroughs (2000-2010)

Correlations

		InventorCount	Population	EmploymentPerSector	PatentCount	ChangeOfIncome	PatentsPerCapita
InventorCount	Pearson Correlation	1	.897**	.918**	.987**	.112	.547**
	Sig. (2-tailed)		.000	.000	.000	.603	.006
	N	24	24	24	24	24	24
Population	Pearson Correlation	.897**	1	.978**	.929**	.148	.415*
	Sig. (2-tailed)	.000		.000	.000	.490	.044
	N	24	24	24	24	24	24
EmploymentPerSector	Pearson Correlation	.918**	.978**	1	.943**	.174	.402
	Sig. (2-tailed)	.000	.000		.000	.417	.051
	N	24	24	24	24	24	24
PatentCount	Pearson Correlation	.987**	.929**	.943**	1	.094	.578**
	Sig. (2-tailed)	.000	.000	.000		.662	.003
	N	24	24	24	24	24	24
ChangeOfIncome	Pearson Correlation	.112	.148	.174	.094	1	-.149
	Sig. (2-tailed)	.603	.490	.417	.662		.487
	N	24	24	24	24	24	24
PatentsPerCapita	Pearson Correlation	.547**	.415*	.402	.578**	-.149	1
	Sig. (2-tailed)	.006	.044	.051	.003	.487	
	N	24	24	24	24	24	24

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

There was a strong correlation among all socio-economic variables except for the change of income factor that did not have a significant relationship with other factors. All other measures were correlated at the 0.01 significant level except the employment per sector and patents per capita are correlated at the .05 significant level. It is important to note (although not surprising) that patent-generating industries concentrate in places with larger populations. However, this correlation helped to explain that the different socio-economic are connected to one another.

First of all, it is interesting the number of inventors exhibits only moderate correlations with the patents per capita (.55), indicating that the size of the inventor pool is not the overwhelming factor of innovative activity, if it is normalized by population. Among other factors, population size and the total of employment in patent-producing industries has a strong effect on both count of patents and inventors, which means more employment rates lead to more creative activities. Also, employment per industry sectors has a strong connection with the population at the 0.01 level.

Population size had a strong positive relationship with patents and inventor count at the 0.01 level, and at the 0.05 level with patents per capita variable. Since this study measured small communities, population size played a significant role in patenting process, when the population size (and density) increased the probability of producing patents will increase too.

Notably, the income growth did not correlate significantly with neither patent per capita nor any of the factors (Table 8). Not even with population size. In other words, the source of income dynamics is somewhere else, most likely driven by primarily external forces.

Overall, although this analysis does provide a basic understanding of the relationships between patent production and socio-economic variables, more needs to be done. There is a need for more examination of other potential economic factors, for example, the GDP, labor force dynamics, education and occupational characteristics, etc.

CHAPTER 5

CONCLUSIONS

This study explored the dynamics of innovation activity expressed through USPTO patents in order to improve the understanding of knowledge creation and other creative activities in remote areas (using Alaska as a case study). It constitutes a first study of the Alaska knowledge economy which is rising to potentially to occupy a key status in economic development and has played an essential role in improving the economy.

The goal of this study was to determine the geographical and temporal dynamics of the knowledge economy in Alaska by studying the spatial and sectoral characteristics of patents production in Alaska. The study also aimed at identifying networks within the Alaska Regional Innovation System.

In addition, the analysis considered the socio-economic factors that could influence innovation activity in Alaska. In the time period covered by this study (1976-2010) the spatial and temporal dynamics of patent production, as well as the structure of the Alaska RIS has evolved substantially indicating a growing maturity of the regional innovation system. However, it dependency on external factors, such as oil economy.

Patents production is an important indicator of the knowledge economy and their typological, geographical and historical patterns provide a key insight into the Alaska's regional innovation system. Patents count increased over time, so did the count of inventors. The total number of patents granted to Alaska residents between 1976 and 2010 was 1,077 patents that had created by 1,873 inventors. There were clustering of patents on some of

Alaska boroughs, specifically, Anchorage Municipality, Fairbanks -North Star Borough, and Matanuska Borough with total of 830 patents (89% of Alaskan total). At the city level, Anchorage, Fairbanks, and Wasilla exhibited the highest volumes of patent production granted between 1976 to present.

Inventor's distribution is similar to the patents distribution among Alaskan boroughs since the highest number of inventors exist in Anchorage Municipality borough, Fairbanks North Star Borough, and Matanuska-Susitna Borough. The study analyzed the historical trends of the patents and inventors' changes over time, by regrouping the patents into five year periods. The general trend was increasing of the number of patents and inventors from 1976 to 2000, the top number of total patents was 235 and 412 inventors in the time 1995-2000, and then there were decline of the number of patents and inventors between 2001 to 2010.

In addition, the noticeable rise in the portion of local, national, and foreign co-authorships of Alaskan inventors indicates an expansion of co-inventor networks and internationalization of patent activities. In the first six time periods, Alaskan inventors constituted 69 % to 79% of all inventors, but during the last period (2006-2010) the percent declined to 57%. Co- inventors from other U.S. account for 20.8 to 29.7% of authors listed on Alaska patents, but in the last periods this proportion doubled. In the last 20 years Alaskans started to collaborate with international partners as well. Therefore, this study shows that the co-inventor networks evolved from predominantly Alaska-centered and dominated by individual (no company affiliation) inventors to externally connected and company-driven. In the early years, the innovation activities started with local co- inventors from Alaska and limited states (about 4 states), and then co- inventor networks extended to have more states and foreign countries.

The industry sectors had a significant impact on innovation activities in Alaska. Between 1976 and 2010 most patents in the State of Alaska were granted in wells, hydraulic and earth engineering, surgery, liquid purification and land vehicles. These five industries account for about 60 % of all patents granted in the same period. All these industry sectors considered as “old” (and oil-dependent) industry sectors in Alaska (i.e. associated resource specialization) except for the surgery sector. The rest of industries account for about 40 % of all patents granted in the same period. However, new industries, such as surgery, multiplex communications and others, with elevated levels of parent production emerged in the recent decades. The sectoral dynamics of patent activity reflects both economic history of Alaska and technological life cycles within ‘old’ and ‘new’ industries. In the early years, a large share of patents came from fisheries, agricultural and construction equipment sectors, while later the oil-based technologies became predominant. In the latest years their preponderance was somewhat challenged by emerging industries (medicine, communications, etc.).

When LQs for the top 25 industry sectors were computed for Alaska patent-producing boroughs each borough showed patent clustering in at least three industry sectors well beyond the predicted (national) share. Some boroughs showed high specialization in more than 10 industry sectors, among them Anchorage, Matanuska, and Fairbanks. From the sectoral view, over 1976-2010, fishing was the most repeatedly over-represented patent specialization area, accruing in 6 cases, followed by the animal husbandry, i.e. innovation in both of these most traditional sectors was represented broadly across Alaska. Whereas patent production in oil-based sectors was confined to a few spots, such as Anchorage. In total, fifty-six cases of specializations of patenting, among the 25 industry sectors six boroughs,

AKRIS System elements in Alaska were classified in two parts: internal and external. And each component was assigned specific share in the innovation process. And each part has four knowledge producing elements or actors (individuals, organizations, government, and universities). The analysis of the sections of inventors (individuals, company) leads to conclude that the most effective innovation activities in Alaska still come from individuals. Individuals had created more than the half of all patents over the observed time frame, and most of them were Alaskan inventors. While non-Alaskan individuals have a small share of patents (1.7%). The second bigger share is the company inventors that is (42%), then universities inventors, lastly are the government inventors. The same results can be observed in non-Alaskan inventor's share the company inventor still the dominant share for external co-inventors.

According to the spatial networks analysis, co-inventors' connectivities had changed during the observed time period, which started with local co- inventors from Alaska and a few states. Then, between the 1990s'and 2000s', co-inventors networks had the largest number of inventors not just from the U.S., but also from international countries such as Canada, United Kingdom, India, and Australia. On the other hand, the patents activities started with more individuals' inventors than company inventors until early 1990s' when the number of company inventors increased concurrently with the increase in the number of participating countries.

Overall, between 1976 and 2010 AKRIS evolved from a small isolated system dominated by individual (lone-eagle) inventors focused on the innovation in old, low-technology sectors to a relatively diversified (although still over-reliant on the oil sector) intra- and internationally connected system with a considerable presence of company-driven innovation, but yet a strong position of individual inventors, including those from smaller communities.

The last objective in this study, was to identify, the relationships between innovation activities and socio-economic factors. Correlation and regression analysis showed that the most significant relationship was observed with population, overall inventor count, and employment in 25 top patent –producing sectors. However, there was no relationship between patent activity and income growth in Alaska boroughs. These relationships require examination and incorporation of other potential economic factors, for example, GDP, R&D investments, labor force educational attainment and occupational characteristics of Alaska boroughs. Interestingly, the study observed a peculiar relationship between the condition of the oil sector and patent production: period of elevated innovation activity coincided with lower oil prices. While this relationship should not be overemphasized (not least because there is a 2-5 year time lag in patent data), it could be associated with a reduced interest in R&D investments in the oil industry during high oil prices (e.g., no acute need to improve productivity) and/or general divestment in innovation during economic hardships and turmoil (mirrored by high oil process in the 1970s and mid-2000s). Examination of other potential economic factors, for example, the GDP of Alaska boroughs.

5.1. Limitations and Future Directions

There were many limitations that challenge this study. One of the largest was the data availability, since USPTO has a broad dataset that needed be processed and organized to analyze the innovation activities. In this study, we only used the most basic industry classification of patents, did not weight patent contribution per co-inventor, and did not involve other pieces of information available from USPTO. Since this was a first-cut examination of innovation in Alaska, much of analysis was descriptive and exploratory. Although this work successfully identified the structure and spatial characteristics of the Alaska regional innovation system, the co-inventor connectivity analysis presented here was largely descriptive and could have been extended to incorporate more advanced network analysis methods.

Also, the study suffered from data limitations in respect top socio-economic factors that influence the innovation activities. This study also dealt with a small community with low population densities (a potential for a small number problem), and many individuals inventors who created patents without involving organizations and often despite socio-economic conditions. This made factors of measuring innovation activity using statistical tools very challenging.

Another limiting factor of this study was time, since this study had significant statistical analyses needs to apply more qualitative and quantitative analysis methods to create a full clear image of innovation production over a long-time frame. Future studies need to apply more qualitative and quantitative analysis methods to create a full clear image of innovation production over a long time frame. And that will be possible by measuring more socio-economic factors that impact innovation activities in Alaska.

In addition, more studies of patents type could be useful to understand which type of patents has the significant role to improve the economy in Alaska, because patents value determine how much these patents are important in the economy. Industry sectors that have more patents in refers to the importance of this sector and its efficiency in the economy. Therefore, analyzing more industry sectors that have patents probably will help us to explain (or envision) the future of Alaska economy.

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APPENDIX A

PATENTS AND POPULATION IN ALASKA BOROUGH

Bouroghs	Patents Number	Population
Anchorage Municipality	589	291,826
Faribanks North Star Borough	121	97,581
Ketchikan Gateway Borough	11	13,477
Juneau City and Borough	58	31,275
Matanuska_Susitna Borough	120	88,995
Valdez-Cordova Census Area	0	9,636
Keni Peninsula	1	55,400
Kodiak Island Borough	27	13,592

APPENDIX B

PATENTS COUNTS IN ALASKA CITIES FROM 1976-2010

City Name	Patents count	City Name	Patents count
Anchorage	527	Salcha	3
Fairbanks	112	college	2
Wasilla	73	Ester	2
Juneau	52	Girdwood	2
palmer	33	North Pole	2
Eagle River	31	Douglas	1
Kodiak	27	Elmendorf	1
Chugiak	23	Fort Richar	1
Ketchikan	10	Homer	1
Auke Bay	5	Sutton	1
Big Lake	5	Ward Cove	1
Willow	5	Cordova	0
Houston	4	Kenai	0
Indian	4	Total	928

APPENDIX C

PATENTS DATASET DEFINITIONS

Patent ID	Patent number as how it is listed on the patent document in USPTO
Sequence	the sequence of inventors how they are listed on the patent document in USPTO
Inventor ID	a unique inventor ID which is based on the disambiguated algorithm of first/last names
State	The state name of the inventor residency
Country	The country name of the inventor residency
City	The city name of the inventor residency
Fullname	The first and last name of inventor
Organization	The organization name that invented for
gyear	the grant year of patent, that means the date of a recording patent and accept it in USPTO
class	The tecnology classification for each industry sector that patent belongs to
Individual Inventor	An inventor or a group of inventors whose patent do not related to organization
Company Inventor	The inventor who awarded patents with his/her company

APPENDIX D

PYTHON SCRIPT OF INVENTORS SPATIAL NETWORKS

Script1.py - D:\GISProg\Salma_Project\Scripts\Script1.py (2.7.10)

File Edit Format Run Options Window Help

```
#This script made for final project for GIS Programming course Fall 2016.
#The purpose of this script is creating a network between all inventors
#of patents within Alaska and other regions in short time and less effort.
#By using search and insert cursors to create a unique list from the data
#table,(PATENT) field and loop through it to create
# a new line feature class hold the network between the inventors.


#Salma Zbeed

#December 15,2016

#-----------------------------------------------------
# import arcpy module
import arcpy

strFC = r"D:\GISProg\Salma_Project\Output\AKCities2.shp"

theFieldName =  'PATENT'

# create an empty list to hold the patent no. in a unique list
# that means just the patents that are not repatitive
theList = []

#build a search cursor to loop through the table
strSearchCur = arcpy.SearchCursor(strFC)

# create a for loop to go through the rows in the search cursor.
for theRow in strSearchCur:

     #get the value function to get the value from patent field.
    theValue = theRow.getValue(theFieldName)

    # build an if condition to put the patent value
    # in the unique list that we create before
    if theValue not in theList:

         theList.append(theValue)

# call the unique list to the python window
print theList

# call the Length of the unique list (1142)
print len (theList)

#create isert cursor

cursor = arcpy.InsertCursor(r'D:\GISProg\Salma_Project\input\
New File Geodatabase.gdb\PatentNetwork')

# for loop to call out the patents no.

for thePatent in theList:
    #print thePatent
    # build a where clause (fieldname +the varible we
    #create in previos loop(thePatent)
    theWhere = '"PATENT" = ' + str(thePatent)
```

Ln: 26 Col: 0

Continued

```
*Script1.py - D:\GISProg\Salma_Project\Scripts\Script1.py (2.7.10)*
File  Edit  Format  Run  Options  Window  Help

# set search cursor with Where clause.
    strSearchCur = arcpy.SearchCursor(strFC,theWhere)

    theCnt = 0
    latList = []
    lngList = []
    cityList =[]
    stateList =[]
    yearList =[]
    seqList = []

    for theRow in strSearchCur:

        #Use getValue function to get the fields values.

        theSequence = theRow.getValue('sequence')
        seqList.append(theSequence)
        thelat = theRow.getValue('lat')
        thelng = theRow.getValue('lng')
        latList.append(thelat)
        lngList.append(thelng)
        theCityname = theRow.getValue('City_Name')
        cityList.append(theCityname)
        theState = theRow.getValue('state_name')
        stateList.append(theState)
        theyear = theRow.getValue('gyear')
        yearList.append(theyear)


        theCnt = theCnt +1

    theRange = range(1,theCnt +1)

    for x in theRange:
        print x
            #create a line from points in lists
        if x == 1 and len(latList) >1:
            startX = lngList[x-1]
            startY = latList[x-1]

        elif x >1 and len(latList) > 1:
            nextX = lngList[x-1]
            nextY = latList[x-1]
            print nextX
            print nextY
            if startX != nextX:

                writeYear = yearList[x-1]
                writeCity = cityList[x-1]
                writeSequence = seqList[x-1]
                writeState = stateList[x-1]

                lineArray = arcpy.Array([arcpy.Point(startX,startY),arcpy.

                polyLine = arcpy.Polyline(lineArray)

                newRow = cursor.newRow()
Ln: 93 Col: 0
```

Continued

Script1.py - D:\GISProg\Salma_Project\Scripts\Script1.py (2.7.10)

File Edit Format Run Options Window Help

```
    for x in theRange:
        print x
            #create a line from points in lists
        if x == 1 and len(latList) >1:
            startX = lngList[x-1]
            startY = latList[x-1]

        elif x >1 and len(latList) > 1:
            nextX = lngList[x-1]
            nextY = latList[x-1]
            print nextX
            print nextY
            if startX != nextX:

                writeYear = yearList[x-1]
                writeCity = cityList[x-1]
                writeSequence = seqList[x-1]
                writeState = stateList[x-1]

                lineArray = arcpy.Array([arcpy.Point(startX,startY),arcpy.

                polyLine = arcpy.Polyline(lineArray)

                newRow = cursor.newRow()

                newRow.setValue('Shape',polyLine)

                # row.setvalue(theSequence,
                newRow.setValue("PATENT",thePatent)
                newRow.setValue("year",writeYear)
                newRow.setValue("theCityname",writeCity)
                newRow.setValue("SeqEnd",writeSequence)
                newRow.setValue("SeqStart",1)
                newRow.setValue("theState", writeState)

                cursor.insertRow(newRow)
```

Ln: 133 Col: 0

APPENDIX E

PERCENTAGES OF DISTRIBUATION OF THE RESIDENCE OF THE INVENTORS OVER A PERIOD OF 35 YEARS

Year	Alaska%	United states%	International%
1976-1980	79.2	20.8	0
1981-1985	73.7	26.3	0
1986-1990	71.4	28.6	0
1991-1995	76.9	21.7	1.4
1996-2000	78.2	20.9	1.0
2001-2005	69.3	29.7	1.0
2006-2010	57.3	41.2	1.5

APPENDIX F

ANNUAL OIL PRICES COMPARING WITH PATENTS AND INVENTORS COUNT

	patent	Inventor	Oil prices $
1976	19	34	11.6
1977	17	24	12.5
1978	15	21	12.79
1979	14	22	29.19
1980	18	19	35.52
1981	16	24	34
1982	13	17	32.38
1983	9	13	29.04
1984	8	10	28.2
1985	25	35	27.01
1986	21	38	13.53

1987	22	41	17.73
1988	16	22	14.24
1989	28	39	17.31
1990	27	42	22.26
1991	39	62	18.62
1992	28	47	18.44
1993	44	73	16.33
1994	50	85	15.53
1995	35	79	16.86
1996	37	64	20.29
1997	44	71	18.86
1998	53	79	12.28
1999	55	104	17.44
2000	46	94	27.6
2001	50	83	23.12

2002	50	80	24.36
2003	42	82	28.1
2004	44	71	36.05
2005	38	71	50.59
2006	38	77	61
2007	20	37	69.04
2008	22	63	94.1
2009	43	70	60.86
2010	32	83	77.38

APPENDIX G

CALCULATED LQ VALUES OF RECORDED PATENTS FROM 1976-2010

IndustrySector	Anchorage Municipality	Faribanks North Star Borough	Ketchikan Gateway Borough	Juneau City and Borough	Matanuska _Susitna Borough	Kodiak Island Borough	Total# of patents(1976-2010
Wells	17.9	0	0	0	12.1	4.9	117
Hydraulic	12.8	17.2	0	0	2.2	9.6	43
Surgery	3.5	0	7.2	0	0	0	30
Liquid purification or seperation	1.9	2.6	0	1.4	0.7	0	24
Land Vehicles	1.9	0.8	0	1.7	9.1	0	24
Boring or penetrating the earth	7.4	2.4	0	0	2.4	0	21
Fishing	5.1	6.3	34.4	26.1	6.3	56.0	21
Data- processing- measuring ,Calibrating or testing	1.2	1.9	0	0	2.9	0	17
Drug, bio-affecting and body treating compositions	1.2	0.4	0	1.6	0.4	0	16
Measuring and testing	0.7	1.0	0	1.0	0	0	15
Ships	4.4	0	0	9.8	2.4	10.6	14
Animal husbandry	2.8	2.3	0	23.9	2.3	10.3	14
Supports	1.3	2.3	0	0	1.5	0	14
Static Structure	1.0	0.8	0	0	2.5	3.7	13
Geometrical Instruments	2.9	6.0	0	8.3	2	0	13
Exercise devices	2.5	0	0	0	15.4	27.4	12
package and article carriers	2.9	5.6	0	5.9	8.5	0	11
MultiplexCommunications	0.3	0	0	0	2.3	0	11
Communications: Electrical	0.8	0.5	0	0	0.5	0	11
Marine Propulsion	5.2	12.7	69.9	0	0	28.5	10
Internal - composition engines	1.2	0	0	0	4.9	0	10
Amusement Devices: games	1.9	3.8	0	3.9	1.9	8.4	10
Material or article handling	1.7	1.2	0	0	1.2	0	9
Fluid handling	0.8	3.7	0	0	0	0	9
Refrigeration	0.7	2.3	0	0	2.4	5.3	9

Note: LQ outputs are commonly explained in the next method:

LQ > 2, specify a comparative clustering of a particular activity in the region compared to the nation.

LQ = 1, both the region and the nation as a whole show the same portion of activity in a specific sector.

LQ < 1, indicates that a sector is under-attended in the region of interest compared to the national share.