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Research, Science and Technology Parks: A Global Comparison of Best Practices

Hugo Danilo Ruiz Villacres
Purdue University

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By Hugo Danilo Ruiz Villacres

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Dr. Nathan Hartman
Co-chair

Dr. James Mohler
Co-chair

Dr. Mark French

Dr. Jenny Daugherty

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Approved by: Dr. Kathryne Newton 12/7/2015
Head of the Departmental Graduate Program Date

RESEARCH, SCIENCE AND TECHNOLOGY PARKS: A GLOBAL COMPARISON OF BEST PRACTICES

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of

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by

Hugo D. Ruiz Villacres

In Partial Fulfillment of the

Requirements for the Degree

of

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West Lafayette, Indiana

In memory of my parents.

To my wife and children,

For your love, support and encouragement.

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LIST OF ABBREVIATIONS

ANOVA - Analysis of Variance

ASPA - Asian Science Park Association

AUTM - Association of University Technology Managers

AURP - Association of University Research Parks

DEA - Data Envelopment Analysis

IASP - International Association of Science Parks and Areas of Innovation

MANOVA - Multivariate Analysis of Variance

NIS - National Innovation System

NRP - NASA Research Park

OECD - Organization for Economic Cooperation and Development

PRP - Purdue Research Park

RPs - Research, Science or Technology Parks

SBIR - Small Business Innovation Research

TT - Technology Transfer

TTO - Technology Transfer Office

UKSPA - United Kingdom Science Parks Association

UNESCO - United Nations Educational, Scientific and Cultural Organization

ABSTRACT

Ruiz Villacres, Hugo D., Ph.D., Purdue University, December 2015. Research, Science and Technology Parks: A Global Comparison of the Best Practices. Major Professor: Dr. Nathan Hartman.

The purpose of this study was to determine if significant differences exist in the evaluation of effectiveness and efficiency between North American, European, and Asian research parks (RPs). Park directors and staff responded to 25 questions from the Survey for Research, Science and Technology Parks. Effectiveness was measured by director's perception of the RP's contribution to economic growth and job creation. Efficiency was evaluated by the interactions between local universities and research parks, assessment of the ecosystem's basic characteristics, and the culture of innovation in the ecosystem. A stratified sampling procedure from a population of 793 parks was used; analysis of variance (ANOVA) and multivariate analysis of variance (MANOVA) were used to test for significance. 130 RPs from three continents participated in this study. No significant differences were found in the evaluation of RPs' directors on effectiveness and efficiency of RPs.

CHAPTER 1. INTRODUCTION

The research literature available on Technology Transfer (TT), Innovation Systems and related topics in this field is extensive. Although the authors of this research have diverse scientific backgrounds and perspectives, they believe that technological innovation capacity is an important way to improve the living standards of society and has unquestionable impact on the economic growth of nations (e.g., Solow, 1957; Nelson, 2005; Jorgensen, 2005). Because of these benefits, there is an ongoing race among nations competing for markets with high-technology products, with new countries wanting to enter the competition.

These countries; regardless of geographic location, culture, ideology, or beliefs, and, in some cases, with a tradition of a high economic dependency on non-renewable natural resources like oil or agricultural wealth; invest substantial public funds to develop or improve their productive structures and have adopted the RP strategy to boost economic growth.

Among others, many countries from Asia, have invested in RPs with the hope that this initiative will help them to increase the level of sophistication in local industries, attract foreign investments and establish the foundation for a knowledge-based economy (e.g., Koh, Koh & Tschang, 2005, p.219). These governments continue to devote efforts to: upgrade government research institutions, improve university-industry collaboration, establish intellectual property rights and related legal frameworks, create complex institutional structures and interfaces to become competitive in globalized markets.

The world is becoming more concerned about technological competition. This concern is evidenced by the implementation in more countries of new public policies to spur innovation, such as capacity building and incentives to Small and Medium Enterprises (SMEs) (Sternberg, 1990), the allocation of larger amounts in national budgets devoted to research and development (e.g., OECD, Research and Development Statistics, 2014) the strengthening of higher education institutions and reshaping public research organizations. Many governments, like France, Japan, The Netherlands and the United Kingdom have encouraged the creation of more technology clusters -- research/science parks (RPs), technopolis or knowledge cities -- with one goal in common: the development and commercialization of new technologies (Westhead, 1997; Hilpert & Ruffieux, 1991; Goldstein & Luger, 1990). As these are long-term projects and the results are only seen after decades, several questions arise pertaining to in what ways technological innovation initiatives should be followed.

Research parks (RPs) through incubation of emerging technology companies and generation of high quality jobs have also proven to be effective agents for economic growth in regional innovation systems (Batelle, 2013). Several studies have been conducted on technological innovation and RPs, and these present different points of view on this complex process as it has been occurring in the United States, United

Kingdom, Germany, Belgium, Spain and other European and Asian countries (e.g., Athreye, 2002; Lofsten & Lindelof, 2002; Storey & Tether, 1998). Most of the data available is for OECD countries (OECD, Science, Technology and Patents, 2014). However, few studies address RPs and technological innovation for developing countries, with the exception of China and India. Except for a very few studies focusing on Brazil, Chile and Mexico, the body of knowledge for the rest of Latin America is still embryonic (Rodriguez-Pose, 2012).

Authors so far have not explored deeper about the implications for a developing nation wanting to invest in and pursue this path. There are uncertainties about the necessary components and resources to have in place so these investments bring about positive results. Lessons from the U.S., and other European and Asian countries with a considerable experience with RPs could be applicable to new projects by starter countries in other parts of the world. Specific characteristics that make these differences significant and influence the efficiency and effectiveness of RPs need to be taken into consideration before replicating or adapting what are known as best practices.

These considerations are important, as they could allow champions of new projects, policy makers and planners in developing nations to understand how technological innovation occurs in its wider context and take the right steps when designing and implementing new or existing projects within the context of RPs.

1.1 Scope

This research proposal centers the analysis on research parks as important agents of innovation ecosystems. These organizations are working hand in hand with universities and private and public research laboratories in the transformation of new discoveries in marketable products in many countries in every continent.

A worldwide comparison of the best practices from the viewpoint of RP directors, regarding their perception of: (a) the RP's contribution to economic growth and job creation, (b) the RPs interaction with neighboring universities, and (c) the ecosystem's innovative culture, provided important insights into the role of the RP in the technological innovation process and differences and similarities across the world.

The information gathered described a cross section of the world's research park population, and provides a common base of elemental building blocks. This common base can be taken into consideration when launching new RPs initiatives or tuning existing ones, regardless of geographic location, culture and other differences.

1.2 Significance

The importance of Innovation and TT for a sustainable economy in the developed world is now more evident to developing countries. For them, the need to understand and implement knowledge-based entrepreneurial activities is not an option but an urgent need. The experience from RPs' directors, as important agents of innovation and catalysts of local and regional economic growth, can point to the Best Practices and the possibility to their applicability to other parts of the world.

More governments are including RPs as part of the regional and national innovation systems to overcome underdevelopment and poverty. In 8 Latin American countries, 60 RPs are now operating; most of them new, started just after year 2000. Another 45 new RPs are in the completion stage, not yet fully operational (Rodriguez-Pose, 2012).

Evidence of higher employment rates based on RP’s initiatives can take years to present tangible results, most likely when parks reach "maturation stage" (Luger & Goldstein, 1991, p.71). Therefore, it is yet unknown the impact these relatively new parks will have in the economic development of these countries.

For example, Ecuador, is implementing the national project, “Yachay” or the “City of Knowledge,” in the north of the country, with an initial investment of 1.041 U.S.$ billions for the 2012-2017 period. “Yachay” is historically the largest national project that the country has embraced to develop scientific areas, including engineering, manufacturing, biotechnology, and nanotechnology. Ecuador’s long-term goal is to develop technologies locally by emulating the path followed by other countries and benefit to regional and national economy (Yachay, 2013).

Considering data in this study came from previous adopters of the RP strategy, it is hoped that Yachay administrators and managers will find useful information and relevant data based on the experiences of other RP's directors, to inform its development and strategy. This study sought to explore the basic components necessary for a successful RP, and factors needed to nurture an innovation ecosystem.

1.3 Definitions and Terms

For the purpose of this study the following terms and definitions are identified:

AUTM - Association of University Technology Managers.

AURP - Association of University Research Parks

DEA - Data Envelopment Analysis

Effectiveness - For this study, effectiveness is associated with RPs directors' perception of the contribution of research parks to economic growth and job creation in the geographic area where they are located.

Efficiency - For this study, efficiency will refer to an organization or process performing or functioning at optimality condition according to RP's directors evaluation, rather than the traditional production function approach: ratio of inputs/outputs.

FAST - Federal and State Technology Partnership

IASP - International Association of Science Parks and Areas of Innovation

Innovation Ecosystem - This definition highlights the interactions between the different actors in an innovation-based economy -- including individual entrepreneurs as well as larger organizations, like industries and universities -- and their motivations. This definition is different than a National Innovation System in the sense the innovation ecosystem is not fixed or steady rather evolutionary and dynamic according to the needs, new policies and changing circumstances. The ecosystem approach focuses especially in the role of small businesses for job creation and contribution to the economic growth (Wessner, 2005, p.68).

National Innovation System (NIS) - The set of public and private sector institutions coordinating and working closely to “initiate, import, modify and diffuse new technologies” (Freeman, 1987). The different institutions working individually and collectively for the creation and use of new technologies, these institutions define the innovation process, which is normed and directed by national policies, laws and regulations. This set of interrelated institutions collaborates closely to "create, store and transfer the knowledge, skills and artifacts which define new technologies”. Besides the same technology policy, they are bonded by other common national elements like culture and language (Metcalfe, 1997, p. 289). “The elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge” that a nation has within its borders (Lundvall, 1992, p. 2).

OECD - Organization for Economic Cooperation and Development

PRP - Purdue Research Park

RPs - Research, Science or Technology Parks

SBIR -Small Business Innovation Research

SME - Small and Medium Enterprises

SRSTP - Survey for Research, Science and Technology Parks

SSIT - State Science and Technology Institute

STTR - Small Business Technology Transfer

Technology Transfer - (TT) The mechanism by which “skills, knowledge, technologies, methods of manufacturing and facilities” from governments, higher education institutions and other organizations, are transferred to the society for a wider use and benefit with the further development of discoveries through creation of new “products, processes, applications, materials or services” (Grosse, 1996, p. 782).

TTO - Technology Transfer Office

UKSPA - United Kingdom Science Parks Association

UNESCO - United Nations Economical, Scientific, and Cultural Organization

1.4 Statement of Purpose

The purpose of this research was to explore if significant differences exist in the evaluation of administrators regarding the efficiency and effectiveness of research parks across the world, as measured by, (a) the efficient interaction with the university, (b) the characteristic and (c) culture of innovation in the ecosystem and (d) the effectiveness of the RPs in the contribution to economic growth and job creation. An analysis of these differences and similarities led to the identification of the best practices for the successful performance of a research park and its interaction with the ecosystem, in different parts of the world.

1.5 Research Questions

The research questions central to this study were:

1. Is there a significant difference in what administrators view as best practices regarding the effectiveness of research parks across the world?
2. Is there a significant difference in what administrators view as best practices regarding the efficiency of research parks across the world?

1.6 Null Hypotheses

The following null hypotheses were formulated for this study:

Ho_1: There is no significant difference in the evaluation of best practices regarding effectiveness, as measured by the directors' perceptions of the RP's contribution to the economic growth and job creation, between Asian, European and North American research parks.

Ho_2: There is no significant difference in the evaluation of best practices regarding the efficiency in the interaction: "university-research park", between Asian, European and North American university-based research parks.

Ho_3: There is no significant difference in the evaluation of best practices regarding the efficiency as measured by the characteristics of the innovation ecosystem, between Asian, European and North American research parks.

Ho_4: There is no significant difference in the evaluation of best practices regarding the efficiency as measured by the culture of innovation in the ecosystem, between Asian, European and North American research parks.

1.7 Assumptions

This study had the following assumptions:

1. Permission from Purdue University College of Technology, and the Institutional Review Board was provided to conduct the study.
2. Participants responded to the survey instrument honestly, accurately, and to the best of their knowledge.
3. The number of participants for this study was sufficient to obtain the information needed.
4. Participants from non-English speaking countries understood the statements in the survey.
5. The language barrier did not affect the response rate negatively.
6. The directories of research parks around the world were updated and reflected the total amount of research parks.
7. The directories of research parks have accurate and updated data of park members, e-mail addresses and means of contact.

8. Collaboration from research parks associations encouraging members to cooperate with the study.

1.8 Delimitations

This study has the following delimitations:

1. The survey was applied using the institutional web-based platform: Purdue Qualtrics Online Survey Tool.
2. The survey was distributed using e-mail addresses from directories of research and science parks associations around the world.
3. The survey instrument for data collection was written in English language.

1.9 Limitations

This study has the following limitations:

1. The amount of collaboration from research parks associations encouraging members to cooperate with the study.
2. The number of willing participants to respond to the survey.
3. The survey was applied in English language; no translations to other languages were provided.
4. Participants had the freedom to choose not to answer any question when they believed it was not within their field of expertise or for any other reason.

5. The response rate affected by the language barrier in non-English speaking countries.
6. Inaccuracies in members' contact information in the directories of research parks worldwide.

1.10 Summary

Chapter One presented the introduction, scope and the significance framing this study, also the definitions of the terms and the purpose of this research. The research questions and four hypotheses guiding the research process were defined. Finally, the assumptions, delimitations and limitations were specified. Following, the Literature Review is presented in the next chapter.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to present a comprehensive review of the literature existing about research, science and technology parks. This review includes a historical perspective on how, when and where research parks first appeared; the theoretical background, an analysis of important studies available in the field, and the factors influencing the dissemination of research parks around the world.

2.2 Procedure for the Review of Literature

The literature review started during Fall 2012 followed by periodic updates; the most recent through the Fall 2014 semester. Databases like the Purdue University Libraries, and Google scholar were used to search for documents and publications. Combination of key words that were mostly used around the areas involved in this proposal included: research, science or technology parks, technoparks, technopolis, technology transfer, cities of knowledge, innovation ecosystems, national innovation systems, efficiency, effectiveness, innovation systems, AURP, AUTM, and IASP. Several journal articles, conference proceedings, manuals, books and web sites, were reviewed to feed the theoretical background and literature; the oldest reference dated from year 1934 and the most recently published books and articles are from year 2014.

2.3 Theoretical Background

Different researchers and academics have studied the research park phenomenon from a variety of perspectives. However, from a theoretical perspective, Phan, Siegel and Wright (2005) suggest there is no systematic framework to understand RPs due to a) the failure to realize their dynamic characteristics, as well as those of the tenants that locate within a RP; and b) the lack of precision identifying how RPs operate.

In the literature available, scholars have not yet offered a fully developed theory about the formation of parks. Cluster theory has been applied to the agglomeration of firms close to universities in the field of biotechnology (Link & Scott, 2007). Baptista (1998) argues that the accumulation of firms near universities is the result of supply and demand forces; on the supply side the availability of a highly trained labor force: faculty and graduates from universities near to the RP; and on the demand side, the tenants from the park competing for new developed and sophisticated technologies.

Recent studies convey new dimensions for the analysis and study about RPs and, as the population of parks grows worldwide, the complexity of these analyses also increases. RP’s were seen mostly in the developed world but they are now present in countries at all stages of economic development (Luger & Goldstein, 2006); as their performance is dissimilar thus stimulating an important academic debate whether the RP initiative is an effective catalyst of innovation.

The Science Park Administration Act provided grants and loans to states and local authorities for the construction of RPs, in two occasions this bill failed to pass approval by the U.S. congress, one attempt in 2004 and again in 2007. Link and Scott (2007) claim that this bill had implicit the assumption that RPs are an important part of the U.S. National Innovation System (NIS) because of their role as a knowledge based catalyst for economic growth. They also argue that a case can be made about RPs being an element of a NIS; “not necessarily a primary element but an important element nonetheless” (Wessner, 2009, p. 136).

In a NIS the knowledge flow between industry and university is a key factor and RPs provide an important link for this knowledge to flow. This link will become more imperative as activities between universities’ basic research and industrial applied research and development become more entangled (Link & Scott, 2007).

Link and Scott (2007) provide a model of innovation for economic growth for a technology based manufacturing firm and the effect of a research park, as is shown in Figure 2.1. The science base at the root of the model is the accumulation of scientific and technological knowledge resulting from basic research activities funded mostly by the government accomplished in universities and federal laboratories and is in the public domain.

If the firm performs research and development (R&D) activities within its facilities (in-house R&D), these activities, in the form of basic and applied research, continue through the proof of concept of a new technology, usually targeting discrete technology jumps to make its competition obsolete. This entrepreneurial activity takes the firm to manufacture a new product as the materialization of basic and applied R&D occurring within its own laboratories. The impact of the RPs in this model expands the science base and helps in the flow of knowledge between firm - firm and universities-firms, when a university is present, thus influencing innovation and competitiveness (Link & Scott, 2007).

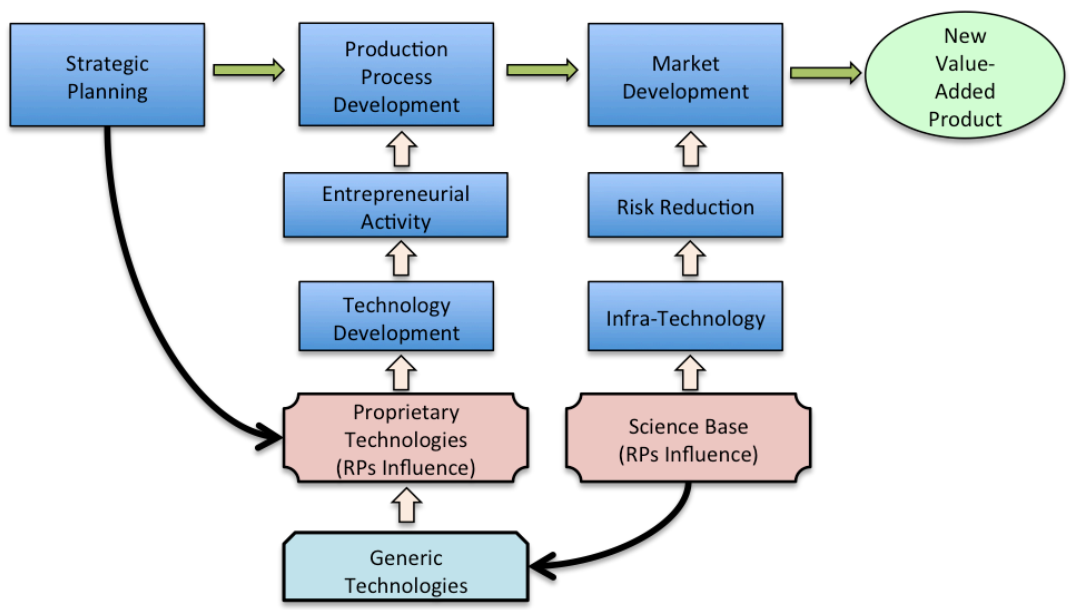


Figure 2-1 Model of Innovation for a Knowledge Based Manufacturing Firm

Source: Adapted from Link and Scott (2007)

2.4 The Research Park Concept

The Association of University Research Parks (AURP), which reports the characteristics and trends in North American Research Parks, defines a Research Park as a set of public and private facilities and support services devoted to R&D, where technology based companies perform research in close proximity with university researchers to foster collaboration and innovation, and promote "the development, transfer, and commercialization of technology" (Batelle, 2007, p. 3).

While the term RP is predominant in the United States, in Europe the term science park is more commonly used. The term technology park or technopark is prevalent in Asia. All of these terms represent a similar concept and can be used interchangeably (Link & Scott, 2007). A RP is "a cluster of technology-based organizations located on or near a university campus in order to benefit from the university's knowledge base and ongoing research. The university not only transfers knowledge but expects to develop knowledge more effectively with the tenants in the research park" (Link & Scott, 2006, p. 128).

These different definitions of RPs include similar components, which are: (a) a shared objective – the incubation of technology-based companies, and (b) a shared need – a common physical space with a high level of service support and facilities. RPs also require a permanent administrative body and formal links to a higher education or research institution located in the area and networked with similar institutions and specialized markets.

The ideas and research partnerships flow between the generators of technology and private companies established in the RP. These partnerships allow access to specialized university laboratories, which stresses the importance of the RPs' geographical location and proximity to university or research institution that facilitates the collaboration. The outcome of this cooperation between business and research institutions is the generation of knowledge, innovation, and technology. This dynamic drives the creation of new companies and strengthens the companies already in the RP, contributing to new jobs and the generation of income to the RPs' surrounding regions, This concept is represented graphically in Figure 2.2, adapted from Batelle Technology Partnership Practice (2007).

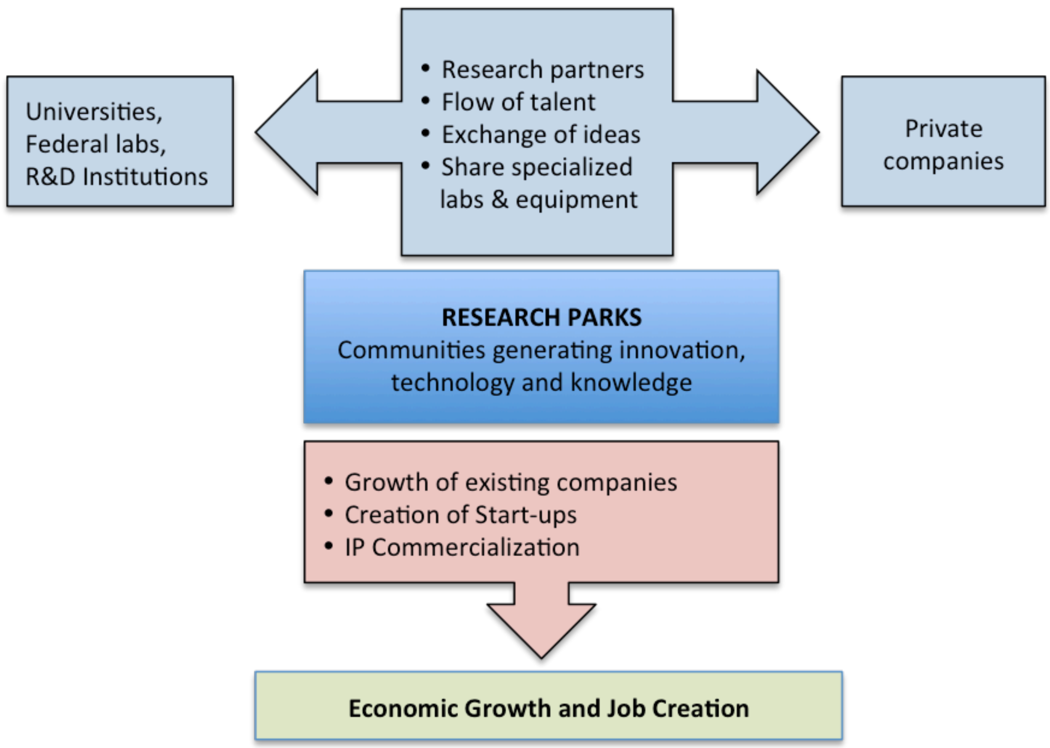


Figure 2-2 The Research Park Concept

Source: Adapted from Batelle (2007)

2.4.1 Origins of Research Parks

The first concept of a RP appeared in 1950s and was more related to real estate. U.S. industries realized the advantages and importance of being closer to well-known universities and started building facilities around academic institutions. Indeed, RPs were a strategy for local economic development (Castells & Hall, 1994; Drescher, 1998). The first RPs that emerged in the U.S. were the Stanford Research Park in 1951 in Palo Alto, California; the Cornell Business & Technology Park in 1952 in Ithaca, New York; the University Research Park -originally Swearingen Research Park- in 1957 in Norman, Oklahoma; Research Triangle Park in 1959 in Raleigh-Durham, North Carolina; and the Purdue Research Park in 1960 in West Lafayette, Indiana (Link & Link, 2003).

In Europe the first investments in RPs started in the early 1960s, but it was in 1969 when the first known research park, the Sophia-Antipolis was started in the south of France. The Sophia-Antipolis remains the largest RP in Europe, with about 24500 individuals employed by tenants, sitting on a 2300 hectares property. Now high densities of RPs are found in United Kingdom, and in Nordic countries like Finland and Sweden. Europe is now the continent with the largest number of parks: 401 RPs in 2015. A more detailed description about the population and location of RPs around the world will be provided in the next chapter of this study.

According to data from a 2007 survey of 134 university-based parks by the Association of University Research Parks and Battelle, an international science and technology enterprise related to commercialization of science and technology, university RPs in United States and Canada cover about 47,000 acres and have more than 300, 000 workers, with every job in these RPs generating an average of 2.57 jobs in the economy (Battelle, 2007). These numbers demonstrate the influence of university-based RPs on the North American economy.

The survey for the following period, years 2007 through 2012, reports that university RPs are effective at creating new employment opportunities for technology companies and have the encouragement of innovation and entrepreneurship as their top priority. Survey results claim a 27% increase in jobs gains respective to the previous period, and 963 new businesses graduating from RPs' incubators, with only a 19% mortality rate (start ups no longer in business) compared with the 50% national average (Batelle, 2013).

2.4.2 Diversity and Metrics in Research Parks

"If you've seen one research park... you've seen one research park" (Link & Scott, 2006, p. 45). With this expression Link and Scott illustrate the large variability found in RPs. One park is very different from another, and the dissimilarities are not only internal - which are due to the intrinsic characteristics of each park such as types of facilities, dimensions, available amenities, particular organizational structure or quality of the management level - but also external - which depends on the ecosystems surrounding them, the quality and expertise of researchers from the university the RP is linked to, areas of research specialization, funding opportunities, and industrial and business potential locally and in the surrounding region.

These differences also represent an obstacle to establishing metrics for evaluating RPs. The most common indicators are those related to economic performance; typically the evidence of success shows increased rates in invention disclosures, patent applications, new venture formations and new inventions available to the public. Other indicators include the growth in royalty revenues, industry sponsored research and number of TT transactions (Hamermesh, Lerner & Andres, 2011), land development, enhancement of research opportunities and capacities of affiliated universities (Luger & Goldstein, 1991).

Some limitations to analyzing RPs more deeply come from the failure to understand the dynamic interactions among the various stakeholders and different actors of RPs, and the effects of these interactions on the outcome of the RPs as well as on the companies forming part of the parks (Phan, Siegel, & Wright, 2005).

Regardless of these differences, RPs could be grouped in the three most typical categories (Link & Scott, 2006), the first two are: (a) laboratory RPs and (b)university-based RPs; a distinction based only on whether the park is linked to a university. The third category is a relatively new group of enlarged RPs called (c) cities of knowledge. Following is a brief description of each of these categories of parks.

The Laboratory RPs, funded continuously by the U.S. government, include examples such as the Sandia Science and Technology Park in New Mexico and the NASA Research Park (NRP), a laboratory based park started in 1998 and located in the heart of California's Silicon Valley. Some of the leading companies neighboring NRP are Google, Hewlett Packard, Apple, and Intel. The NASA Park's main goal is to procure public support for NASA by providing benefits for the local economy and supporting public education and the U.S. scientific base (National Research Council, 2001).

Second, the university-based RPs are those affiliated with a higher education institution. They benefit from the prestige and knowledge of their university associates.

Universities also receive benefits of this partnership beyond the commercialization of the outcomes from research laboratories, like higher publication rates; more successful patenting activities; a greater ability to hire eminent scientists; and an ability to gather larger extramural grants (Link & Scott, 2003).

The last category, the cities of knowledge, are different than the big RPs surrounded by urban and industrial developments in that they are not a spontaneous result of the dynamics of innovation, like the case in Silicon Valley and Route 128, but rather a planned project (Edvinsson, 2003). The model and the different components of these cities are envisioned and anticipated around one central activity; the generation of knowledge.

2.5 Factors for Success of Research Parks

Kang (2004) mentions some factors for the success of RPs that should be taken into consideration; they are shown in detail in Table 2.1. Kang emphasizes aspects related to the location of the park, facilities and infrastructure, availability of good services, a desirable living environment, supporting mechanisms of collaboration between universities, firms and research laboratories, and capital markets for entrepreneurs.

According to Kang (2004), key factors for the success of a RP is the proximity to a reputed engineering university, with renowned academics and scientists, and a high production of knowledge.

Table 2-1 Success Factors for Research Parks

Factors	Success factors	Key point
Location	• Existence of an eminent engineering university. • Desirable living environment • Accessibility to highway, airport and seaport. • Accessibility to fiber optic backbone, and pop site	Existence of an eminent engineering university
Facilities and Services	• Technology incubation center and innovation center. • Joint researches and frequency of contacts among employees in the park. • Low land price and building rent	Frequency of contacts among employees
Support Mechanism	• Collaborative relationships between universities, firms and research laboratories. • Existence of strong leadership in the region. • Vitalized venture capital.	Collaborative relationships and vitalized venture capital.

Source: Adapted from Kang B. (2004)

While RPs' characteristics vary depending on what part of the world they are located, in the symposium "Understanding Research, Science and Technology Parks: Global Best Practices" (2009), organized by the National Academy of Sciences, some common internal and external elements inherent to successful RPs were mentioned. Strong industrial and scientific organizations, accessibility to venture capital, presence of entrepreneurs, networking at the individual level, close collaboration among universities, industries and other organizations were the elements identified (National Research Council, 2009). In order to examine further the most important factors, they have been divided into: (a) general factors, (b) federal and state policy, (c) geographical factors, and (d) quality of research institutions related to RPs. These factors are discussed in more detail in the following sections.

2.5.1 General Factors

The State Science and Technology Institute (SSTI, 2006) is a leading United States national organization and recognized authority on technology-based economic development. Based on the experience in Silicon Valley, Research Triangle and Route 128, SSTI indicates that there must be at least five critical components in place to cultivate a successful research park initiative: (a) public or private research laboratories that generate new knowledge and discoveries; (b) physical infrastructure, including high quality telecommunications systems; (c) mechanisms for transferring knowledge between individuals and companies; (d) a highly skilled technical workforce available locally or at close proximity; and (e) sources of risk capital (SSTI, 2006).

According to the 2012 AUTM's survey of university RPs, the directors were asked about the key factors that should be in place to develop a successful research park. Answers from 108 respondents showed that six innovation-related activities are considered of particular importance: (a) A good match between the core competency of the affiliated university and the tenants; (b) the capacity to assist early-stage business organizations in commercialization; (c) access to capital markets for RP tenants; (d) priority availability of multi-tenant space for incubator graduates; (e) priority access to university resources, facilities, faculty and students; and (f) availability of a formal business incubator in the research park boundaries (AUTM, 2013).

According to Diedendorf (1997), the United Kingdom Science Parks Association (UKSPA) has identified the following reasons for the success of sciences parks in the United Kingdom. Among the most important factors the UKSPA pointed to, are: availability of funding, spaces for incubation of start ups, state of the art support services and a solid base of scientific research results.

2.5.2 Federal and State Technology Policy

Rasmussen (2008) points out that reforms in national research systems aiming to increase TT and the commercialization of research have become a global trend. The success of the U.S. efforts in bringing new research results to the marketplace has triggered legislative initiatives in many countries all over the world, stimulating universities to strengthen infrastructure and to build human resources capability for the commercialization of research.

In the United States, legal initiatives have promoted additional private sector R&D activity. For example, the Technology Innovation Act of 1980 (also known as the Stevenson-Wydler Act) established TT as a federal government mission aiming to enable transferring of federal-owned technology to nonfederal parties. And the University and Small Business Patent Procedure Act of 1980 (also known as the Bayh-Dole Act) reformed federal patent policy by providing increasing incentives for the diffusion of federally funded innovation results. Through this legislation universities were able to acquire titles to innovations to be developed with government funds (Tran, Daim & Kocaoglu, 2011).

The research and experimentation (R&E) tax credit was enacted soon after in 1981, providing a tax incentive to companies to increase their R&D expenses. The National Cooperative Research Act was legislated in 1984 to promote the formation of joint research ventures among U.S. companies and universities (Tran, Daim & Kocaoglu, 2011).

The Federal Technology Transfer Act introduced in 1986, made it possible for the transferring of technology from federal labs to industries by creating a charter and funding mechanism for the Federal Laboratory Technology Transfer Consortium FLC. The Act also enabled federal labs to partner with private sector parties for a Cooperative Research and Development Agreement (CRADA). Overall, these important pieces of legislation facilitated, among other administrative measures by the U.S. federal government, the transfer of technology from public research institutions to industry (Tran, Daim & Kocaoglu, 2011).

The Small Business Innovation Research (SBIR) is a phased structured program of federal economic awards that helps financing small R&D entrepreneurial initiatives that need funding to establish feasibility and technical merit. SBIR's competitive program main goal is to stimulate the culture of innovation in the U.S. by assisting financially to these R&D projects and to new technologies with scientific value and potential of commercialization (Wessner, 2005).

Small Business Technology Transfer (STTR) and Federal and State Technology Partnership (FAST) are two other federal programs aiming in the same direction as SBIR, working as a national policy intended to stimulate technology transfer from federal funded R&D innovation to the private sector, bridging basic science and commercialization.

2.5.3 Geographical Factors

One of the factors influencing economic growth is the geographical proximity between a university and a research park (e.g., Link & Scott, 2006; Luger & Goldstein, 1991). The close proximity of innovation activities within a geographical area can help to develop a community of innovation needed to transfer the ideas and discoveries from research laboratories to the marketplace (Coakes & Smith, 2007). The proximity also encourages more frequent interaction that builds the trust needed for mutual collaboration and for the dynamics of exchanging knowledge and skill (Saxenian, 1994).

Link and Scott (2006) hypothesized that the closer a park is to a university the greater the knowledge flows among park tenants and the university and, thus, the more attractive the park is for new tenants and employment growth. Among the 81 RPs existing in 2002 in the National Science Board's database, 28 parks were located on a university campus; another eight parks were within one mile of university campuses (Link & Scott, 2006).

Bianchi and Labory (2008) analyzed the different industrial policies controlling the structural transformation process in developed as well as developing economies around the world, they concluded that the proximity brings important advantages for high technology-based starter firm including: having a pool of highly-specialized and skilled human capital, the early awareness of the latest technological developments on the field of interest with access to market and specialized networks, and access to venture capital and state of the art amenities. When combining these advantages with a well-managed innovation environment the probabilities of success increased considerably (Bianchi & Labory, 2008).

2.5.4 Quality of Research Institutions

An important factor for the increment and success of RPs that should be taken into consideration is the quality of research universities where advancement in knowledge is of paramount importance. Nam Suh (1990) mentioned that among other valuable resources for technological innovation and Technology Transfer (TT) efforts in the U.S. are research universities.

The role of these research universities in the U.S. does not end at the boundaries of academia. For example, from the discoveries and inventions made at MIT, new companies have sprung up in the area of Cambridge, Massachusetts. Similarly, new venture companies were formed around the Bay Area of San Francisco and San Jose, California, which is known as Silicon Valley (Suh, 1990).

However not all institution are successful in the research commercialization efforts. Authors have taken different approaches to analyze and compare the factors influencing commercialization activities of intellectual property of faculty and scientists from research institutions. For example, a linear programming method called data envelopment analysis (DEA) (Charnes, Cooper & Rhosdes, 1978), has been used as an evaluation tool for multi-input, multi-output cases (e.g., Thursby & Kemp, 2002; Thursby

& Thursby, 2003; Siegel & Phan, 2004; Heher, 2006; Anderson, Daim & Lavoie, 2007), in combination with other statistical techniques, to show evidence of efficient and inefficient universities in the commercialization of technology. Thursby and Kemp (2002) using DEA, measured the relative efficiency of 57 universities from the U.S. They found a substantial growth in commercial activities in universities but also substantial evidence of inefficiencies. The growth, they conclude, is due to a higher desire of industry for university technologies, while the inefficiencies are a result of university's orientation towards basic research rather than commercial activities (Thursby & Kemp, 2002).

Friedman and Silverman (2002) used regression analysis with data sets from the Association of University Technology Managers (AUTM); the National Science Foundation (NSF); and the Nuclear Regulatory Commission (NRC). They concluded that higher royalty shares for faculty members are associated with greater licensing income for the University. Rogers, Yin and Hoffman (2000) applied correlation analysis to data sets from AUTM, NSF and NRC to conclude that there is a positive correlation between quality of faculty, age of TTO, and number of TTO staff and higher level of performance in TT. Foltz, Bradford and Kim (2000) applied linear regression to data sets from AUTM and NSF to show that faculty quality; federal research funding; and number of TTO staff have a positive impact on university patenting.

Debackere and Veugelers (2005), who applied surveys and interviews to eleven research universities in Europe, concluded that research commercialization happens more effectively in those universities that assign a higher percentage of royalty payments to faculty members. One important component of these universities was a decentralized management style, which was critical for success when transferring technology. Bercovitz, Feldman, Feller and Burton (2001) conducted a statistical analysis in AUTM data sets followed by interviews to analyze different organizational structures for TT success at Duke, Johns Hopkins, and Pennsylvania State universities. They reported that differences in organizational structures might be related to TT performance.

2.5.5 Culture of Innovation

Wong, Ho and Autio (2005) studied the impact of technological innovation on economic growth, using cross sectional data from 37 countries participating in the Global Entrepreneurship Monitor (GEM). They concluded that entrepreneurship accounted for most of the economic growth and job creation by small and medium enterprises. Technological innovation requires from scientists and researchers those additional skills necessary to understand and contribute positively to the TT process. Scientists' involvement in the process of technology commercialization increases the probability of success with commercializing the invention (Jensen & Thursby, 2001).

Entrepreneurship is closely related to TT activities, but laboratory scientists often lack these skills. To strengthen the TT process, it is therefore necessary to encourage the entrepreneurial and innovation abilities of scientists and university students (Siegel & Phan, 2005). Knowledge about the area of expertise is not enough; also necessary is understanding the business specifics; the legal framework and the social characteristics of technological progress. It is important to take into account that new technologies do not happen in a “social vacuum” nor succeed based on technical merits alone, but by the interest of groups and the selection process of the target users of the invention (Volti, 2010, pp. 39-40).

Successful innovation can only come about when new inventions are transformed into new products, which then are transferred from laboratories to the marketplace; only then does the implementation of knowledge and contribution to economic growth and development occur, and only then does the “creative destruction” that characterizes the Schumpeterian definition of innovation take place (Schumpeter & Opice, 1934).

There are different programs that can help to build researchers’ entrepreneurial skills, even though some of these characteristics could be innate from individuals. Bordogna (2006) defines an entrepreneur as an aggressive, innovative and energetic risk-taker. Entrepreneurs contribute key competitive abilities to the knowledge-based economy, contrary to conventional wisdom’s valuing of methodical, slow, and risk-conservative approaches.

For those scientists for whom innovation is not an innate strength, an early introduction to entrepreneurism could help to unfold their potential as innovators and build the University’s and the RPs’ innovation capabilities. Even though entrepreneurship education is believed to be complementary to an engineering program, these training programs can have a positive impact on the entrepreneurial activities of engineers. This conclusion is supported with data from a sample of former students of an entrepreneur program and a control group not being exposed to these programs (Miller, Walsh, Hollar, Rideout & Pittman, 2011). The study found that 73% of former entrepreneur students reported to be more likely to start a new company, 23% more likely to generate new products and 59% had high confidence in managing a start-up (Miller, Walsh, Hollar, Rideout & Pittman, 2011).

2.6 Barriers for Success of Research Parks

Kirkland (1999) describes some barriers for a successful technology innovation process: legal barriers; lack of legal framework for intellectual property rights (IPRs); deficiency of capital markets or financial resources; highly skilled workers; poor communication between universities-industries; research institutions not being capable to provide innovative solutions to industry companies; and the lack of human capital with innovative culture, skills and mobility.

Other barriers to take into consideration, especially in developing countries where political instability, corruption systems, or the absence of clear regulations for entrepreneurs exists, include regulatory and legal restrictions; bribes; violence or the threat of violence; sabotage; worker strikes; energy shutoffs; and communications interruptions. Whatever their form, barriers have the effect of increasing cost and delay the adoption of new technologies. Parente and Prescott (1994), for example, hypothesized that the presence of these barriers accounts for a large income reduction in the country’s economy.

2.7 Literature about Research Parks

The available literature about RPs is extensive in depth and scope, since the first RP, Stanford Research Park, within Silicon Valley, was started in California in 1951. Goldstein and Luger (1992) using descriptive analysis of university-based and non-university-based RPs in the U.S., conclude that ties with higher education institutions determine the success of RPs. These authors also provide early descriptive evidence, based on surveys with RPs directors from the U.S., that RPs contribute to regional economic growth and employment opportunities. Shearmur and Doloreux (2000) in a study of Canadian RPs, show empirical evidence of RPs' contribution to the regional economic growth and job creation through formation of new businesses and start-ups.

Westhead and Storey (1994); Westhead, Storey, and Cowling (1995); and Westhead (1997), used matched pair comparison to analyze performance of companies inside and outside RPs. Results from these studies show that the survival rate of tenants is greater than those equivalent firms working outside of a RP. Siegel, Westhead and Wright (2003) using UK firms' performance conclude that firms on RPs are more productive. Lindelof and Lofsten (2003, 2004) using a sample of Swedish firms conclude that there is no difference in the performance of firms on RPs. Ferguson and Ologsson (2004) point out that on-park Swedish firms have more innovative abilities and market orientation than those firms outside of RPs. Fukugawa (2006) determines that Japanese firms located in RPs develop better links for research and collaboration with universities than those firms located outside RPs.

Westhead and Batstone (1998) present empirical results of the reasons why firms decide to locate on a RP. Using the on-park and off-park comparison approach from UK firms, they conclude that the main reason to locate inside the park is to have access to universities' research facilities. They found that all the RPs in UK were located on or near a university. Using the same approach, Goldstein and Luger (1992) compared university and non-university based RPs from the United States. They conclude that the most important reason to locate in a park is the links firms develop with universities.

RPs' approach for transferring technology from universities to industries has been spreading rapidly around the world. RPs are no longer a phenomenon only seen in developed countries; rather, they can be found in more than 100 countries at different levels of development.

Reforms in national research systems aiming to increase technological innovation and the commercialization of research have become a global trend (Rasmussen, 2008). The success of the U.S. efforts in bringing new research results to the marketplace has triggered legislative initiatives in many countries all over the world, stimulating universities to strengthen infrastructure and to build human resources capability for the commercialization of research. As a result, these successful initiatives have inspired the establishment of RPs in other continents.

Successful RPs from the United States have influenced developed and developing countries to adopt the "park model" as a vehicle for technology-based economic growth and development. East Asian countries, such as Taiwan, South Korea, Hong Kong, and Malaysia, have been successful, especially in obtaining foreign investment and promoting growth of knowledge-based businesses in their countries (Vaidyanathan, 2008).

Different case studies about some of the major RPs have been conducted. For example, Castells and Hall (1994), Saxenian (1994), and Kenney (2000) studied Silicon Valley and Route 128 in Massachusetts. Luger and Goldstein (1991), Link (1995, 2002), Link and Scott (2003) studied the Research Triangle Park in North Carolina. And Wheeler, Lovell, and Weinschrott (2011) studied the Purdue Research Park (PRP). Hansson, Husted, and Vestergaard (2005) use case studies from firms in Denmark and UK to conclude among other important findings that location in the park responds to the need to have access to social capital that facilitates entrepreneurship and that RPs are catalysts for economic growth.

2.8 National Innovation Systems

Freeman (1987) defines a National Innovation System (NIS) from an organizational perspective as the set of public and private sector institutions in coordination and working closely to “initiate, import, modify and diffuse new technologies” (Freeman, 1987, p.1). Later on, Lundvall (1992) provided a similar concept adding a new element, the geographical component. He defined NIS as “the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge” that a nation has within its borders (Lundvall, 1992, p. 2).

Subsequently, Metcalfe (1997) contributes with a more comprehensive definition, including new components to the previous concepts, such as a common culture and language. He defined NIS as the different institutions working individually and collectively for the creation and use of new technologies; these institutions define the innovation process, which is normed and directed by national policies, laws and regulations. This set of interrelated institutions collaborates closely to "create, store and transfer the knowledge, skills and artifacts which define new technologies" (Metcalfe, 1997, p. 289). Besides the same technology policy they are bonded by other common national elements like culture and language.

The different perspectives presented in the definitions of NIS, reveal the complexities inherent to this concept. The authors' individual definitions do have an element in common: the generation and diffusion of knowledge as the fundamental part and the core of an innovation system. This core component combined with other elements: social bonds of a nation, a common culture and language, legal structure, territory, public and private institutions, and the interactions among them, embrace the concept of NIS.

In the following section, three of the most important countries in scientific innovation are briefly summarized.

2.8.1 The United States Innovation System

According to Leydesdorff and Wagner (2009), research results from the NIS of the United States have made many important contributions to the world in areas like medicine, engineering, communications, transportation, information systems, biotechnology, and nanotechnology. These have been a result of the innovation capabilities of U.S. scientists and their public and private research institutions. Important discoveries and inventions, later transformed into products in many areas of science, make the U.S. innovation system outperform most other innovative countries (Leydesdorff & Wagner, 2009).

To support U.S. universities' technology transfer capabilities in the area of biotechnology, DeVol, Bedroussian, Babayan, Frye, Murphy, Philipson, and Yeo (2006), in a global analysis of the transfer of commercialization and patents in biotechnology worldwide, report important findings. "More than 6,300 biotechnology patents were accounted for by the U.S. Patent and Trademark Office between 2000 and 2004. Biotechnology patents issued in the United States have increased dramatically, growing from a cumulative total of 433 through 1995 to 11,430 in 2004" (DeVol, Bedroussian, Babayan, Frye, Murphy, Philipson, & Yeo, 2006, p.12). Nine out of the top 10 universities in the world, with patents in the field of biotechnology, are U.S. universities. California has four of the top 10 universities, and six of the top 25. Of the top 100 institutions ranked, only 28 are foreign universities (DeVol, Bedroussian, Babayan, Frye, Murphy, Philipson, & Yeo, 2006, p.12).

The strength of the U.S. system is its diversity; the decentralized and properly distributed organization of universities and high research institutions across the nation, which are the agents of technological innovation; the high mobility of scientists and researchers, permeability of trained workers between private and public institutions;

and the workforce flexibility and adaptability to changing circumstances. Additionally, the scale and openness of the U.S. economy is divided in homogeneous segments of U.S. domestic market. A culture of innovation and entrepreneurship is structured to open the economy to new technologies and industries (Abramson, Encarnacao, Reid, & Schmoch, 1997).

Scientific innovation from U.S. universities has increased constantly in the last 30 years. The economic returns for some universities is substantial; the number of executed licenses reporting income grew six-fold, from less than $300 million in 1995 to almost $1.8 billion in 2009 (AUTM, 2009). Some license deals provided outstanding results for some U.S. universities; most well known examples, are the University of Florida’s $93 million from Gatorade patents; Stanford University $336 million from Google patents; Emory University’s $540 million from stakes HIV drug Emtriva; and New York University’s $1 billion for Enbrel, a rheumatoid arthritis drug. Through the impact of scientific and technological innovation, these universities are catalysts for regional economic development (Hamermesh, Lerner & Andrews, 2011). However, these are extreme cases of success and do not necessarily represent the typical university patent licensing operation. As was pointed earlier, there is evidence of efficient and inefficient universities in the commercialization of technology (e.g., Thursby & Kemp, 2002).

2.8.2 China Innovation System

China has shown its determination to become internationally competitive making significant national and regional investments in science-based economical growth (Walcott, 2003). China's plans for development are driven by technological progress, and the strategy they have adopted to carry out this goal is the creation of large-scale RPs (Motohashi & Yun, 2007). China has 54 state-level science and technology industrial parks devoted to electronics and information technology, biomedicine and new materials (Wessner, 2008).

There are three different types of research facilities in China. The first kind is the multinational development zones, located in Shenzhen, Dongguan, and Suzhou, which follows the transnational corporation model as the growth engine. The second type of research facility is the multinational learning zone; the most important of which is located in Shanghai and serves as the model for other parks of this kind. And finally, the third kind of research facility in China is the local innovation learning zone that are devoted to generating and transferring technology domestically with a few business relations with foreign companies. One example is Xian, which depends strongly on local university resources and in China's defense industry (Walcott, 2003).

China's national and local governments have an aggressive policy for the development of RPs. An example is the growth of a park like the Zhangjiang High-Tech (ZHT) Park, where government authorities clustered 30 research institutions, multinational corporations, 200 domestic Small and Medium Enterprises (SMEs), and biotechnology related companies. Near the park, two universities, Shanghai Jiao Tong University and Fudan University, contribute to the innovation system with a work force of 8,600 scientist and researchers (Su & Hung, 2008).

These Chinese clusters for research and technology provide a promising future for this country, which is building physical and intellectual infrastructure and a highly trained workforce. However, in a review of the legal systems and enforcement mechanisms, Bosworth and Yang (2000) exposed remaining issues that have limited China’s acquisition of intellectual property, needed to increase its potential for TT. These issues include concerns about intellectual property protection and enforcement, which were promoted by international pressure especially from the U.S., because of China's weak protection and piracy of U.S. products (Bosworth & Yang, 2000).

China is a developing economy that presented multinational firms with a threat of imitation, but some improvements have been accomplished within the past decade regarding intellectual property rights as an attempt to be part of the Word Trade Organization (Zheng, 1996). Evidence suggests that the strengthening of IPR in developing countries, especially in large economies, might play a positive role in attracting Foreign Direct Investment (FDI) and promoting technological innovation (Awokuse & Yin, 2010).

2.8.3 Innovation System in Germany

Germany is a one of the leading European countries for innovation; its technology transfer pattern is rather different than in U.S. or China. In Germany‘s model there are two different institutions in charge of pursuing either basic or applied research: (a) the Max Plank Society focus on basic research and (b) the Fraunhofer Gesellschaft (Institute) on applied research. The Max Planck Society is German's prominent research organization, it is composed by 83 research institutes and started in 1948 conducting basic research in the different fields of sciences; focusing specially on those innovative research fields and pioneering scientific developments.

Fraunhofer is a multi-institutional non-profit research organization with 60 institutes spreading not only throughout Germany, but, since 1994, it also has representation in the U.S. Each of these institutes has a different focus to generate basic research, as well as applied research and the development of innovative products, processes and services.

According to the Fraunhofer Annual Report (2011), Fraunhofer-Gesellschaft, founded in 1949, was the result of joint efforts from representatives of industry and academia, the government of Bavaria and the nascent Federal Republic, as part of the reorganization and expansion of the German research infrastructure, created to conduct applied research. In 1952 it was declared by the Federal Minister for Economic Affairs to be the third pillar of the non-university German research structure, alongside the German Research Council and the Max Planck Institute, which works primarily on basic research.

The institution has been making investments in important areas and developing key technologies, particularly in market segments needing intensive research. The main research areas are: health, nutrition, safety, information, communication, transportation, energy and environment. In the financial year 2011, Fraunhofer researchers disclosed 673 inventions and the number of active rights and patents totaled 6130 (Fraunhofer, 2011). In some aspects, the German innovation system is similar to the U.S. Both countries' portfolio of research areas is rich and diverse, and both systems embrace a wide range of engineering and science areas supporting respectable industries.

2.9 Summary

This chapter provided an overview of the literature available about RPs. A theoretical approach used in the field and a model for a technology based manufacturing firm was analyzed. An overview of the origins and evolution of RPs in U.S. and Europe, the diversity factor for metrics on RPs, the general conditions for success, the legal framework, the advantages of clustering or geographical proximity and the quality required from research institutions, was presented. A brief analysis of Innovation Systems from the U.S., China, and Germany, highlighting the role of RPs in those countries, was also mentioned. Following, the methodology for the study is analyzed in the next chapter.

CHAPTER 3. FRAMEWORK AND METHODOLOGY

The overall goal of the present research was to determine the differences in how managers and directors of RPs across the world evaluate their parks' efficiency and effectiveness. The research focuses on factors that have a positive influence on the technological innovation process, which henceforth will be categorized as "best practices."

Effectiveness was measured by assessing the director's perception of the RP's contribution to economic growth and job creation. RPs' efficiency was measured with respect to three general aspects: (a) the presence of basic characteristics in the innovation ecosystem, (b) the culture of innovation within the ecosystem, and (c) exclusively for university-based RPs, the interaction between the university and the research park.

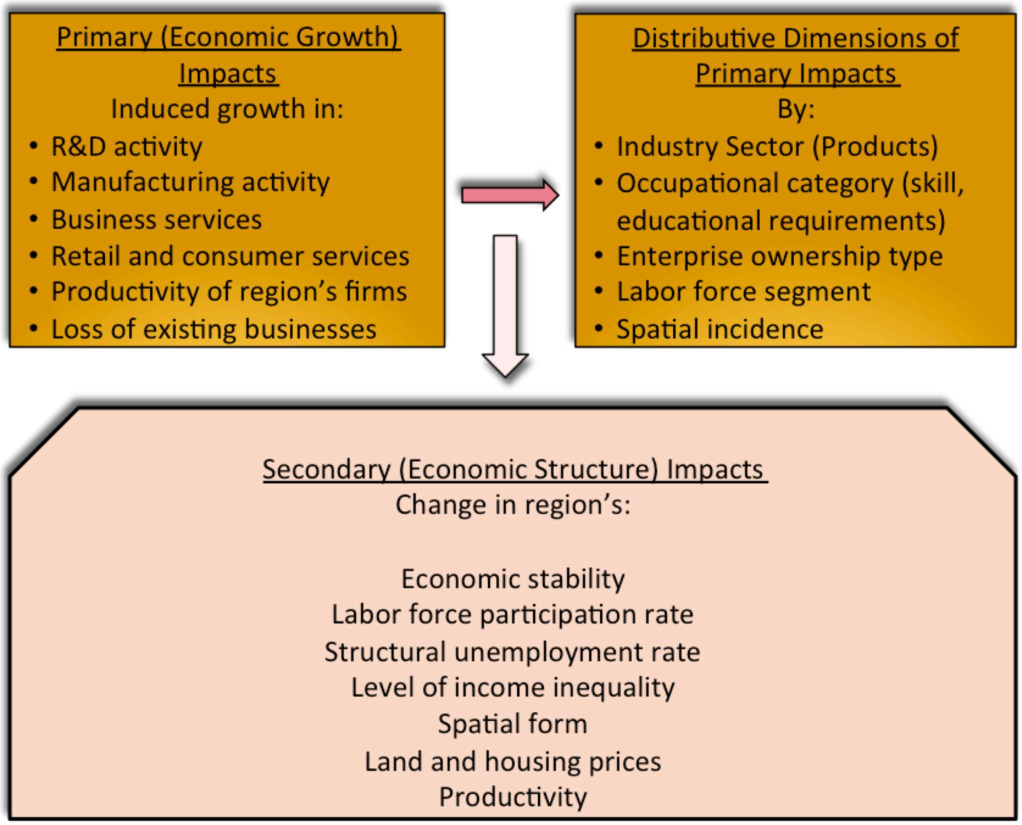
3.1 Design of the Study

The data was collected through the institutional web-based platform Purdue Qualtrics Survey Software, taking advantage of two important characteristics of this mode of data collection (Fowler, 2014). First, the Internet and e-mail enabled access to high quality directories of addresses for the target population of RPs worldwide.

Second, e-mail facilitated contact with RPs in all three continents targeted in this study, making it an economically advantageous research design (Creswell, 2009). E-mail also allowed for relatively rapid turnaround from the time initial e-mail contact was made until high quality data was collected from the participating RPs.

The data collection instrument was a cross-sectional survey of all participants using an online self-administered questionnaire, the *Survey for Research, Science and Technology Parks* (SRSTP*).* This survey consists of the 25 questions itemized in Appendix A. The questions from the survey were inspired and adapted from the work of Luger and Goldstein (1991), who studied the U.S. RPs and their expected regional development outcomes, using the lenses of multiple theories: 1) growth pole/growth center and innovation diffusion theories, where emphasis is given to the relationships with industries or individuals, and 2) entrepreneurship and regional creativity theories, which prioritize places or individuals.

Luger and Goldstein (1991) predicted a set of regional development outcomes from RPs by combining the abovementioned theories with previous results from empirical studies about R&D location and technology diffusion. Figure 3.1 shows a classification scheme of the possible primary and secondary impacts of RPs. Primary impacts refers to the change in the magnitude of the activity, while secondary impacts affect the structure. The most important impact refers to the increment of R&D activities in the industries within regions where RPs are located, which take advantage of the availability of a specialized labor force, facilities, research institutions, and particular types of social and cultural environments.



Source: Adapted from Luger and Goldstein (1991)

Figure 3-1 Potential RP's impacts on Regional Economic Development

The survey is composed of five sections. Items in Section I are mostly demographic questions, intended to determine the demographic characteristics of the RPs participating in the study, including the country (and the state, for RPs in the US) where the park is located and the ownership of the park (to differentiate between university- non university-based RPs). The goals for each of the demographic questions are detailed below in Table 3.1.

Table 3-1 Itemized Survey Objectives for Section I

Question	Objective/Purpose of demographic items
1.	Demographic characteristics of participants: geographical location/region
2.	Demographic characteristics: Location state (For U.S. parks only)
3.	Filter question, to determine operating, developing and planning RPs projects
4.	Demographic characteristics of the sample: urban setting
5.	Filter question, to select participants from university-based research parks

The items in Sections II through V were used to assess RPs' effectiveness and efficiency and were based on the work of Luger and Goldstein (1991), and adapted by the researcher for use in a broader and more diverse target population. The objective of the items from Section II is to evaluate the park's effectiveness, measured by its contribution to economic growth and job creation. This section was displayed to all participants regardless of the park's ownership and location. It helped to determine if significant differences exist between RPs across the world with regards to their contributions to technological innovation and their role as catalysts in the economy of the regions where they are located. The aspects assessed in this section are: the prevalence of local professional workers employed by tenants, the influence of the park in attracting tenants, scientists, students, and sponsor research to the area, and the park as a job source for university students and graduates.

Items in Section III were used to assess the mutual influence or interaction between the university and the research park. This section starts with a filter question, and items in Section III were only displayed to respondents from university-based RPs, otherwise participants were taken to the next section. The items in this section were intended to measure the following aspects: the impact of the park in the quality and visibility of the university, the generation of sponsor research from government and industry, faculty activity as entrepreneurs, the degree to which park functioned as a magnet for researchers and students coming to the university, and the tenant's trend to hire from university professionals and students.

The goal of the items from Section IV was the appraisal of the efficiency of the characteristics of the innovation ecosystem. This section was displayed to all participants regardless of the park's ownership and location. It helped to determine if significant differences exist between RPs across the world regarding the presence of the elemental building blocks or fundamental innovation components and agents in the area where the park is located.

The aspects evaluated in this section are: accessibility of venture capital for start-up creation; the characteristics of public services, transportation, primary and secondary education; the presence of non-professional workforce; the intellectual property regulations available; the existence of high-tech based SMEs in the area; and the availability of an anchor institution, public or private, within or close to the park.

The objective of the items in Section V was the assessment of the efficiency of the culture of innovation. This section was displayed to all participants regardless of the park's ownership and location and helped to determine if significant differences exist between RPs with respect to entrepreneurial potential and the condition of the fundamental components required to nurture the process of technological innovation.

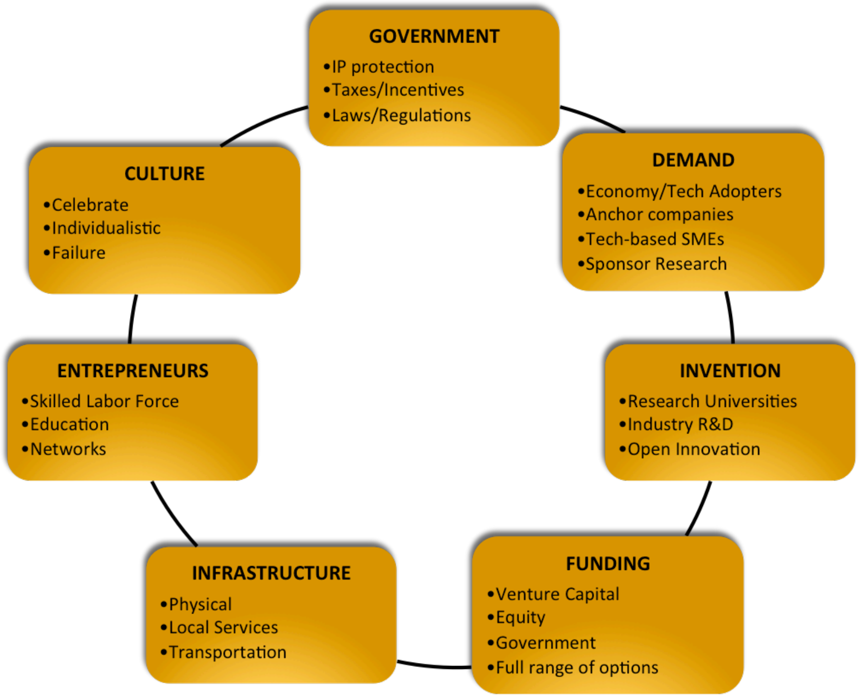


Figure 3-2 Systems View: The Innovation Ecosystem

Source: Adapted from Bill Aulet, MIT Entrepreneurship Center

The aspects assessed in this section are: opportunities for social and informal interaction between entrepreneurs and innovators, characteristics of the majority of the workforce, local availability of profitable research results, networking among tenants, and the entrepreneurial culture of the population.

Objectives for Sections II to V and questions 6 through 25 are presented in more detail in Table 3.2. The structure of the questionnaire is represented using The Innovation Ecosystem representation from Figure 3.2. The survey instrument was designed with a five-point bipolar Likert-type scale with a neutral position, and had the following response categories: *(1) strongly disagree, (2) disagree, (3) neutral, (4) agree, (5) strongly agree*.

Table 3-2 Survey Objectives for Sections II through V

Section	Questions	Objective/Purpose of sections
		Effectiveness
II	6 to 10	Participant's evaluation of the effectiveness measured by the contribution in the economic growth and job creation
Section	Questions	Efficiency
III	11 to 15	University-based RPs participant's evaluation regarding the interaction: "university - research park"
IV	16 to 20	Participant's evaluation regarding the characteristics of the innovation ecosystem
V	21 to 25	Participant's evaluation regarding the cultural of innovation in the ecosystem

3.2 Population

The researcher searched published directories from worldwide associations, as well as an extensive online search, to identify the world population of research, science, and technology parks. Directories included the International Association of Science Parks and Areas of Innovation (IASP), the United Kingdom Science Parks Association (UKSPA), the Association of University Research Parks (AURP), The Baltic Association of Science, Technology Parks and Innovation Centers (BASTIC), the European Business and Innovation Centre Network (EBN), the United Nations Educational, Scientific and Cultural Organization (UNESCO), The World Alliance for Innovation (WAINOVA), and the Asian Science Parks Association (ASPA). At the time of this study, the total population was approximately 874 RPs. This number includes 64 RPs that are in the construction process, but already have an administrative board in place (IASP, 2014). The database for this study was collected by accessing online published data from these associations of RPs in North America, Asia, and Europe. The information was cross-referenced, analyzed, and completed, taking into consideration that not every RP is affiliated with an organization and that some RPs are members of more than one association.

These directories list other types of organization members, not all of them RPs. These members include service providers, material suppliers, technical assistance providers, planners, designers, architects, and training providers, which were not taken into consideration in creating the RP population database. In the process of refining the population list, organizations were included if they contained the words science, research, and technopark or technology park. In cases where data was not evident or clear, in order to avoid accidentally excluding a park, more information was obtained directly from web pages. Whenever two or more similar names were found in the directory, the exact address was used to eliminate duplicates.

Table 3.3 shows the world population of research, science, and technology parks, which were allocated using the distribution and composition of geographical (continental) regions and sub-regions of the United Nations Statistics Division. According to data gathered from the total population, 401 parks are located in Europe, 234 in Asian countries, and 158 in North America; the RPs in these three regions account for 91% of parks worldwide.

The remaining 81 parks, about 9% of the total, consist of 38 RPs located in countries in South and Central America, 33 in African countries, and the remaining 10 located in Oceania. Most of these RPs are concentrated in a very few regions, as is the case in Northern Africa (16), or owned by a few countries, as is the case in Brazil (19), Australia (9), and South Africa (7), among others. The distribution of RPs by continent is presented graphically in Figure 3.1.

Table 3-3 World Population of Research, Science and Technology Parks*

AMERICAS		EUROPE				ASIA			
North America		Northern E.		Western Europe		Eastern Asia		South-Eastern A.	
USA	158	U.K.	99	France	61	China	97	Malaysia	8
Canada	21	Finland	30	Germany	18	Japan	23	Philippines	3
Central America		Sweden	22	Belgium	8	S. Korea	19	Others	5
Mexico	5	Denmark	11	Netherlands	8	Taiwan	5	Western Asia	
Others	4	Estonia	4	Switzerland	8	Hong Kong	2	Turkey	15
South America		Others	11	Others	7	Southern Asia		S. Arabia	8
Brazil	19	Southern E.		Eastern Europe		Iran	21	Israel	5
Others	9	Spain	31	Russian F.	22	India	5	Others	18
Americas: 217		Italy	15	Poland	15	Asia: 234			
OCEANIA		Greece	10	Slovakia	3	AFRICA			
Australia	9	Portugal	9	Czech R.	2	South Africa	7	Morocco	4
N. Zealand	1	Others	5	Others	2	Algeria	5	Others	17
Oceania: 10		Europe: 401				Africa: 33			

*Includes 64 RPs being developed and having a functioning administration body: Spain (13), Brazil (5), Slovakia (3), Saudi Arabia (3), China (3), Mexico (3), USA (2), Portugal (2), Poland (2), Ecuador (2), and 25 other countries with (1) RP.

Source: Author, Cross-referenced from public databases, ASPA, AURP, IASP, UKSPA, UNESCO

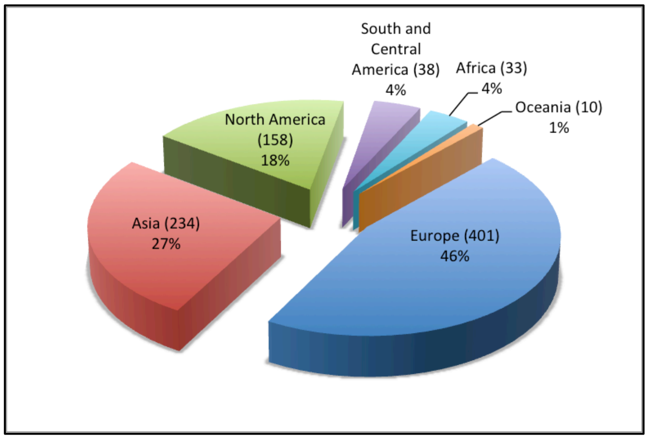


Figure 3-3 World Distribution of Research Parks by Continent
Source: Author, Cross-referenced from public access databases

A total of 13 RP new projects are located in Asian countries, two RPs are being built in African countries that are developing a park for the first time, and the remaining three new parks are under construction in North America. Table 3.4 shows the distribution, by region, of the 64 RPs in construction. They are located in 36 different countries, 11 of which are building a research park for the first time and have no previous history of RPs. Exactly 50% of these new projects (31) are being developed in Europe, and the Americas are building almost 30% of the new parks, with the majority of the new American projects (15) located in Central and South America. This illustrates that more countries in this part of the world are adopting the research park strategy. Figure 3.2 below shows the distribution of these new projects by continent.

A total of 134 countries out of the 217 countries recognized by the United Nations do not have a research park. Most of these countries are located in Africa (45, or 33.5%), 27 (20%) are in the Caribbean region, 11 (8%) are in Central and South

America, 23 (17%) are in Europe, 23 (17%) are Asian countries, and 1 country is in Oceania.

Table 3-4 World New Projects of Research, Science and Technology Parks

AMERICAS				EUROPE				ASIA	
North America		South America		West. Europe		Northern E.		Western Asia	
USA	2	Brazil	5	Austria	1	Denmark	1	S. Arabia	3
Canada	1	Ecuador*	2	Belgium	1	Estonia	1	Armenia	1
Subtotal	3	Colombia	1			Lithuania	1	Azerbaijan	1
Central America		Paraguay*	1	Subtotal	2	Subtotal	3	Kuwait	1
Mexico	3	Peru*	1	Southern E.		Eastern Europe		Oman	1
Nicaragua*	1	Uruguay*	1	Spain	13	Slovakia	3	Syria	1
Subtotal	4	Subtotal	11	Portugal	2	Poland	2	Eastern Asia	
Americas: **18**				Greece	1	Bulgaria	1	China	3
AFRICA				Italy	1	Russian F.	1	South-Eastern A.	
Tunisia*	1	Nigeria*	1	Serbia	1	Subtotal	7	Thailand	1
				Macedonia	1			Southern Asia	
				Subtotal	19			Iran	1
Africa: **2**				Europe: **31**				Asia: **13**	
*Countries building a Research Park for the first time									

Source: Author, Cross-referenced from public databases, ASPA, AURP, IASP, UKSPA, UNESCO

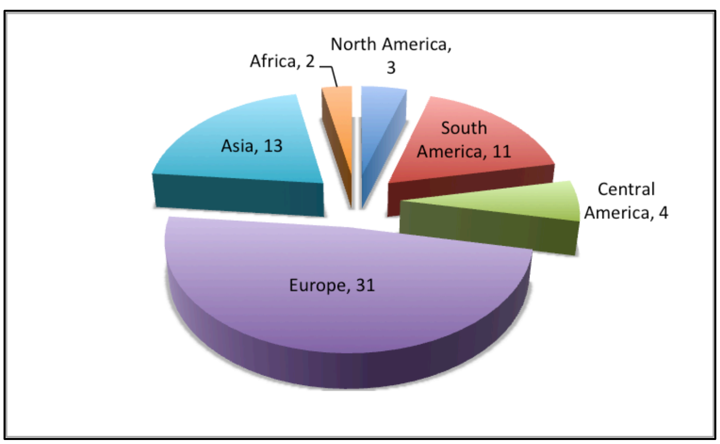
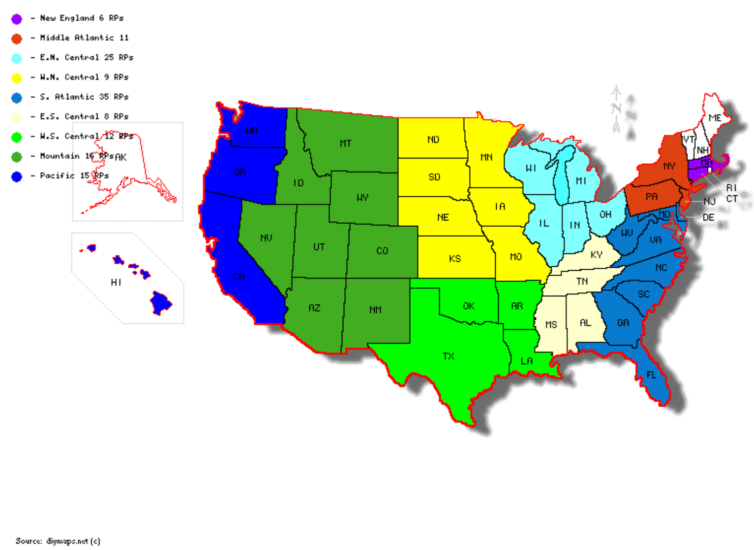


Figure 3-4 New Research Park Projects by Continent
Source: Author, Cross-referenced from public access databases



Region 1: Northeast		
New England		6
Middle Atlantic		11
Subtotal	12%	17
Region 2: Midwest		
E. N. Central		25
W. N. Central		9
Subtotal	25%	34
Region 3: South		
S. Atlantic		35
E. S. Central		8
W. S. Central		12
Subtotal	40%	55
Region 4: West		
Mountain		16
Pacific		15
Subtotal	23%	31
TOTAL	100%	137

*Regions and Divisions according to the U.S. Census Bureau
Source: Map courtesy of diymaps.net, public access. Data and map edition by author

Figure 3-5 Location of Research Parks in the U.S. by Region

The majority of North American RPs are located in the United States, which has 137 RPs compared to the 21 RPs in Canada. Figure 3.3 shows detailed information about the distribution and percentage of the U.S. parks by region, according to the regions and divisions designed by the U.S. Census Bureau. The states located in the South region have the greatest percentage of RPs, with 55 RPs; this region accounts for the 40% of the total U.S. RP population. The Midwest and Western regions have about the same amount of RPs, with 34 and 31 RPs, respectively, and the least populated region is in the Northeast, with 17 RPs. The most populated division is the South Atlantic, with 35 RPs, and the least populated division is New England, with six RPs.

RP density per state is shown in Figure 3.4 below. The most populated state is Florida, with 10 RPs. Six states have a high density of RPs (6-7), and seven states have a medium density of RPs (4-5). The majority of states with RPs (17) have a low density of RPs (2-3). Finally, 13 states have only 1 RP, for a total of 137 RPs.

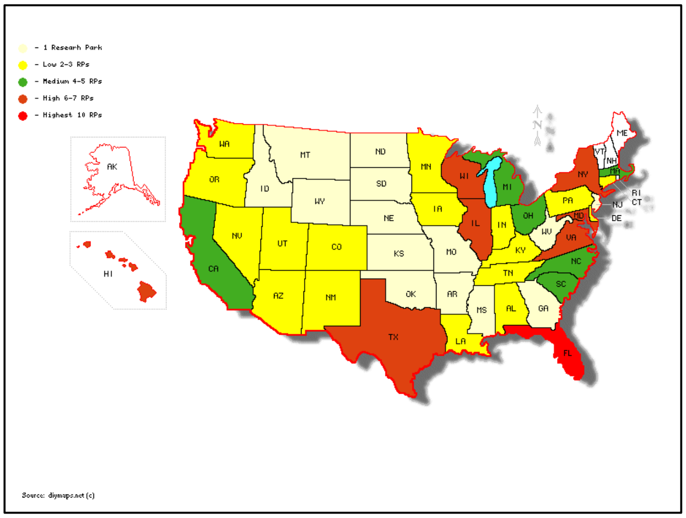


Figure 3-6 U.S. RPs Population Density by State

3.3 Sampling

It was necessary to know the population distribution and density of RPs in each continent, region, and state in order to adopt an appropriate sampling process that reflects the differences in the RP population worldwide. This allows for an overall representation of the subgroups for which estimates are required and a grasp of the diversity of RPs and ecosystems within the same country. A good sample captures participants with the characteristics and most of the potential factors that produce variability.

Fowler (2014) provides a sampling method appropriate for this study that uses a combination of random and cluster sampling in a multistage sampling process. He uses one of the most generally useful multistage strategies for sampling a geographically defined population, namely dividing the target regions into exhaustive, mutually exclusive subregions with identifiable boundaries. These subregions are the clusters that take into consideration the percentage composition of the worldwide population in each continent, subcontinent, region, and country, and within every region and division of the U.S. RP population.

Table 3-5 Sample size for values of 10, 15 and 20% of the World Population of RPs

CONTINENT	RPs Subregions	Percentage Region	World Percentage	Sample **p = 10%**	Sample **p = 15%**	Sample **p = 20%**
AFRICA	**33**		3.78%	**3**	**5**	**7**
Eastern Africa	3	9.09%	0.34%	0	0	1
Middle Africa	0	0.00%	0.00%	0	0	0
Northern Africa	16	48.48%	1.83%	2	2	3
Southern Africa	9	27.27%	1.03%	1	1	2
Western Africa	5	15.15%	0.57%	1	1	1
AMERICAS	**196**		**22.43%**	**20**	**29**	**39**
Caribbean	1	0.51%	0.11%	0	0	0
Central America	9	4.59%	1.03%	1	1	2
South America	28	14.29%	3.20%	3	4	6
North America	158	80.61%	18.08%	16	24	32
ASIA	**234**		**26.77%**	**23**	**35**	**47**
Central Asia	0	0.00%	0.00%	0	0	0
Eastern Asia	146	62.39%	16.70%	15	22	29
Southern Asia	27	11.54%	3.09%	3	4	5
South-Eastern Asia	16	6.84%	1.83%	2	2	3
Western Asia	45	19.23%	5.15%	5	7	9
EUROPE	**401**		**45.88%**	**40**	**60**	**80**
Eastern Europe	44	10.97%	5.03%	4	7	9
Northern Europe	177	44.14%	20.25%	18	27	35
Southern Europe	70	17.46%	8.01%	7	11	14
Western Europe	110	27.43%	12.59%	11	17	22
OCEANIA	**10**		**1.14%**	**1**	**2**	**2**
Australia	9	90.00%	1.03%	1	1	2
New Zealand	1	10.00%	0.11%	0	0	0
TOTAL	**874**	**874**	**100.00%**	**87**	**131**	**175**

Source: Author, Cross-referenced from public access databases

Table 3.5 shows the percentage distribution and the number of parks needed for sample sizes of 10, 15, and 20% of the world population of RPs. A fundamental factor used to evaluate a sampling method is the probability of selection of that percentage of the population that needs to be described, and the degree to which those excluded are distinctive (Fowler, 2014, p.17).

3.4 Data collection

The survey was distributed using the institutional web-based platform Purdue Qualtrics Survey Software. This method of data collection takes advantage of the e-mail use and basic computer skills assumed to be present and active in the target population on a daily basis that are needed to complete the self-administered online questionnaire, which contains closed statements to be answered by clicking or checking a box. Fowler (2014) points out that one of the drawbacks of a self-administered data collection instrument is getting participants to complete the survey when no interviewer is present. Because of this, the response rate can vary widely depending on the topic and the target population. People who are interested in the research subject seem to be more likely to respond to the questionnaire and prefer e-mail as a method of communication; however, repeated contacts and reminders may still be necessary (Fowler, 2014).

The questionnaire was distributed using the same steps for mailing surveys, and follow-up e-mails were used to ensure high response rates. As suggested by Salant and Dillman (1994), participants were sent a short introductory e-mail one week before they received the survey instrument. The introductory e-mail included a cover letter explaining the purpose and goals of the study. Participants received also a third e-mail reminder between one and two weeks after the second contact. Finally, non-respondents received a personalized e-mail four weeks after the second e-mail was sent (Creswell, 2009, p.150).

3.5 Survey Validity and Reliability

Before the questionnaire was used with actual respondents, the survey instrument was validated. To ensure that the level of analysis is appropriate and to assess the degree to which the survey instrument is measuring what it is suppose to measure, Mason and Bramble (1989) proposed three general approaches: content validity, construct validity, and criterion-related validity. Face and content validity of the survey instrument was conducted by asking two RP directors and two experienced researchers in the field to review and provide feedback on the level of consistency and alignment between items in the survey design; phone interviews and e-mail questionnaires were used for this purpose. Out of 40 questions initially presented, 20 questions with 30 items were retained and used in the SRSTP.

Internal consistency reliability estimates the degree to which a group of items in a survey that are considered to be measuring different aspects of the same construct actually do so (Litwin, 1995). The items in the SRSTP measured two different parts: effectiveness was evaluated using question 6 through 10 to assess the director's perception of the research park's contribution to economic growth and job creation in the region. Efficiency of RPs was measured with respect to three aspects: (a) the presence of basic characteristics in the innovation ecosystem, using questions 16 through 20, (b) the culture of innovation within the ecosystem, using questions 21 through 25, and (c), exclusively for university-based RPs, the interaction between the university and the RP, using questions 11 through 15.

Cronbach's Coefficient Alpha, which provides a unique estimate (Cronbach, 1951), was used to measure the internal consistency for the reliability of the survey instrument. For the items on the SRSTP, Cronbach's Coefficient Alpha was $\alpha = 0.865$. According to Nunnally and Bernstein (1994) an $\alpha = 0.8$ and above is a good level of reliability.

3.6 Variables

For this study, the independent variables are geographical location, and ownership. The dependent variables evaluated in this study are effectiveness (as measured by the directors' perceptions of the contribution of their RPs to economic growth and job creation) and efficiency, as measured by the directors' perceptions of the characteristics of the innovation ecosystem, the culture of innovation, and the interaction between the university and the research park (exclusively for university-based RPs).

3.7 Data Analysis

Items from the returned surveys were analyzed using the Statistical Package for the Social Sciences (SPSS, Chicago, IL), a computerized statistical analysis software tool available at Purdue University. A descriptive statistical analysis was performed on items in Section I (questions 1 through 5) to establish the demographic characteristics of the sample of participants across the regions. Sections II through V (questions 6 to 25) measured a total of 30 items; descriptive statistics are presented, including means and standard deviations of scores.

Each item in the survey was scored from 1 (strongly disagree) through 5 (strongly agree), and the neutral position (neither disagree nor agree) assigned an intermediate value of 3. The items were then averaged and used to evaluate differences between the targeted continental regions. The null hypothesis was tested using a one-way analysis of variance (ANOVA) test instead of multiple t-tests, as more than two regions were compared, and after checking data compliance with assumptions for normality, independency, and equal variance (Howell, 2002).

A multivariate analysis of variance (MANOVA) was used to test for the interaction of the dependent variables, effectiveness and efficiency of the RPs, to account for the potential correlation between these two measures, while also testing for significance and protecting against the Type I error that can occur if conducting multiple ANOVA tests independently. This helped to determine if significant differences existed that were not revealed when using the ANOVA test (Cooley & Lohnes, 1971).

The probability that the test statistic will take a value as extreme as the one obtained (i.e., the unlikeliness for this value to have occurred by chance), also known as *p*-value, was computed assuming that the null hypothesis in this study is true when they were tested for significance. Small *p*-values that are lower than a pre-determined significance α level, ($p \leq \alpha$), which is usually set to range between 0.0 and 0.1 and most commonly $\alpha = 0.05$, will indicate strong evidence against the null hypothesis (Moore, McCabe & Craig, 2012).

3.8 Sample Characteristics

A Shapiro-Wilk's test ($p > 0.05$) (Shapiro & Wilk, 1965; Razali & Wah, 2011) and a visual inspection of their histograms, normal Q-Q plots and box plots showed that the scores for the dependent variable Effectiveness were approximately normally distributed for North American, Asian and European RPs, with a skewness of -0.788 (SE = 0.464) and a kurtosis of 0.122 (SE = 0.902) for North American RPs, a skewness of -0.080 (SE = 0.550) and a kurtosis of -0.345 (SE = 1.063) for Asian RPs and a skewness of -0.745 (SE = 0.383) and a kurtosis of -0.136 (SE = 0.750) for European RPs. The scores for the dependent variable Efficiency were also approximately normally distributed for North American, Asian and European RPs, with a skewness of -0.309 (SE = 0.464) and a kurtosis of 0.006 (SE = 0.902) for North American RPs, a skewness of -0.531 (SE = 0.564) and a kurtosis of -0.574 (SE = 1.091) for Asian RPs and a skewness of -0.462 (SE = 0.409) and a kurtosis of -0.609 (SE = 0.798) for European RPs. (Cramer, 1998; Cramer & Howitt, 2004;

Doane & Seward, 2011). A Levene's test verified the equality of variances in the three samples ($p > 0.05$) (Martin & Bridgmon, 2012).

3.9 Summary

This chapter addressed the design of the study, specifically its composition, objectives, and the plan to validate and pretest the survey instrument. The existing population of RPs and their distribution worldwide was presented, as was an inventory of new RP projects and countries adopting the RP strategy for the first time. The sampling method, steps to distribute the survey instrument, and sample size were discussed. Finally, methods for the analysis of data and the sample characteristics were discussed. Chapter Four will present the findings of the data collected during the study.

CHAPTER 4. DATA ANALYSIS

This chapter presents the results of the SRSTP. These results were analyzed to determine the differences in how managers and directors of RPs across the world evaluated their parks' effectiveness and efficiency. Effectiveness was measured by assessing the director's perception of the RP's contribution to economic growth and job creation in its region.

The efficiency of RPs was measured with respect to three general aspects: (a) the basic characteristics of the innovation ecosystem, (b) the culture of innovation within the ecosystem, and (c) exclusively for university-based RPs, the interaction between the university and the RP.

4.1 Survey Results

The survey was distributed using the institutional web-based platform Purdue Qualtrics Survey Software. The survey was uploaded on January 24, 2015 for consideration and feedback from a panel of experts, and it was released to participants on March 17, 2015. A total of 235 surveys were distributed worldwide, of which 42 e-mails were rejected. The last request to participate in the study was sent on May 20, 2015, and answers were collected until June 15, 2015. A total of 130 surveys were collected for analysis; of which 95 completed surveys were considered valid and came from operating RPs, resulting in a response rate of 67.36%.

The proportion of participants per continent, calculated using the number and percentage of surveys collected is shown in Table 4.1. The total sample size was 95 RPs, equivalent to 11.98% of the added population of 793 RPs in these three continents. The largest sample proportion was from North American RPs, at 16.46%. The smallest sample proportion was from Asian RPs (10.26%), and the European sample was 11.22%, representing 45 participant RPs out of 401 total in the continent.

Table 4-1 Sampling Proportion per Continent and Total

Continent	RPs Population	Participants	Percent
North America	158	26	16.46
Asia	234	24	10.26
Europe	401	45	11.22
TOTAL	793	95	11.98

The demographic data of participants, frequency and percentage are presented using Table 4.2. From the 95 respondents, 27.37% (*f* = 26) RPs are located in North America, 25.26% (*f* = 24) in Asia and 47.37% (*f* = 45) RPs are located in Europe.

Table 4-2 Geographical Location of Participants per Continent (N=95)

Continent	Frequency	Percent
North America	26	27.37
Asia	24	25.26
Europe	45	47.37
TOTAL	95	100.00

Table 4.3 shows the demographic data collected on the type of urban setting where the participating RPs are located. Of the 95 respondents, most of the participant

RPs, 34.73% (*f* = 33) were located in an urban setting with a population of more than 1,000,000 people; 21.05% (*f* = 20) of participant RPs were located in urban areas having a population between 50,000 and 200,000; 18.95% (*f* = 18) of participant RPs were located in urban areas having a population between 200,001 and 500,000; 18.95% (*f* = 18) of participant RPs were located in urban areas having a population between 500,001 and 1,000,000 people; and finally 6.32% (*f* = 6) of participant RPs were located in the urban areas having a population of less than 50,000 people.

Table 4-3 Type of Urban Setting (N = 95)

Type of Urban Setting	Frequency	Percent
Population less than 50,000	06	6.32
50,000 to 200,000	20	21.05
200,001 to 500,000	18	18.95
500,001 to 1,000,000	18	18.95
More than 1,000,000 people	33	34.73
TOTAL	95	100.00

Table 4.4 shows the demographic data collected on the type of ownership for the RPs participating in the study, to differentiate university-based from non university-based research parks. Of the 95 RPs who responded to this question, 63.16% (*f* = 60) participants were from university-based RPs and 36.84% (*f* = 35) of participants were from non-university-based RPs.

Table 4-4 Ownership of Participant Research Parks (N=95)

Ownership	Frequency	Percent
University-based RPs	60	63.16
Non university-based RPs	35	36.84
TOTAL	95	100.00

4.2 Mean Data

The mean scores for each of the 20 questions, which contain the 30 items on the SRSTP, are shown in Table 4.1, with data presented in descending order. Answers were obtained from a Likert-type scale that measured the participant's assessment of their degree of agreement to the statements in the survey; scores range from one (strongly disagree) to five (strongly agree).

SRSTP question number 24, *there is an important amount of technology-based Small and Medium Enterprises (SME) in the area,* had the highest mean score (*M = 4.26, SD = 0.65*). SRSTP question number 14, *the park has helped to increase enrollment of students to the University*, had the lowest mean score (*M = 3.22, SD = 0.80*), when comparing scores on RPs from the three continents, North America, Asia and Europe.

Table 4.2 presents the scores, in descending order, from the directors of North American RPs; SRSTP question number 12, the *university encourages faculty entrepreneurship,* had the highest mean score (*M = 4.08, SD = 0.64*). SRSTP question number 18, *easy access to venture capital helps us create start-ups*, had the lowest mean score (*M = 3.08, SD = 1.14*), when comparing scores of participant RPs from North America.

Table 4.3 presents the mean scores, in descending order, from participants from Asian RPs. SRSTP question number 24, *there is an important amount of technology-based Small and Medium Enterprises (SME) in the area,* had the highest mean score (*M = 4.50, SD = 0.52*). SRSTP question number 15, *tenants in the park hire a large* *proportion of scientists from the host university*, had the lowest mean score (*M = 3.21, SD = 1.12*), when comparing scores of participant Asian RPs.

Table 4.4 presents the mean scores, in descending order, from European RP directors. SRSTP question number 24, *there is an important amount of technology-based Small and Medium Enterprises (SME) in the area,* had the highest mean the (*M = 4.38, SD = 0.61*). SRSTP question number 14, *the park has helped to increase enrollment of students to the university*, had the lowest mean score (*M = 3.09, SD = 0.79*), when comparing scores of participant RPs from Europe.

Table 4-5 Survey Results from all Research Parks

Item	Statement	Mean	SD
24	There is an important amount of technology-based Small and Medium Enterprises (SME) in the area	4.26	0.65
29	Tenants within the park are linked to businesses and organizations outside the park	4.01	0.54
20	The following local condition contributes to the continuous growth of this park: Living conditions	4.00	0.76
6	The park has increased the student's opportunities to get jobs	3.99	0.77
23	Intellectual Property Protection is in place to encourage entrepreneurship in the region.	3.99	0.67
12	University encourages faculty entrepreneurship	3.96	0.69
27	There are social informal activities to stimulate interaction among innovators and entrepreneurs	3.95	0.92
28	Local availability of applicable science and technology is the primary factor for innovation	3.92	0.66
8	The park has helped to improve the Visibility of the University	3.91	0.81
11	University facilitates faculty entrepreneurship	3.89	0.72
19	The following local condition contributes to the continuous growth of this park: Public services	3.77	0.69
25	There is a public anchor institution inside or close to the park working as a catalyst	3.75	0.83
7	The park has helped to improve the Quality of the University	3.73	0.80
22	The following local condition contributes to the continuous growth of this park: Primary and secondary education	3.69	0.84
2	The park is a magnet for scientists to universities in the area	3.68	0.99
16	Tenants in the park hire a large proportion of graduates from host U.	3.68	0.90
5	Tenants hire a large proportion of employees from local U. graduates	3.68	0.90
1	A relatively large proportion of the parks' professional workforce has been recruited from this area	3.66	1.03
26	There is a private anchor institution inside or close to the park working as a catalyst	3.64	0.81
30	Population in this area have a prevailing entrepreneurial culture	3.62	0.86
10	The park helps the university to generate private sponsor research	3.55	0.84
21	The following local condition contributes to the continuous growth of this park: Transportation system	3.53	0.94
17	Tenants in the park hire a large proportion of students from host U.	3.50	0.92
3	The park is a magnet for students to universities in the area	3.47	0.98
18	The easy access to venture capital help us creating start-ups	3.45	1.05
4	The park attracts sponsor research to local universities	3.44	0.85
13	The park has helped to attract Scientists to the University.	3.42	0.82
9	The park helps the university to generate public sponsor research	3.41	0.83
15	Tenants in the park hire a large proportion of scientists from host U.	3.32	0.94
14	The park has helped to increase enrollment of Students to the U.	3.22	0.80

Table 4-6 Survey Results from North American Research Parks

Item	Statement	Mean	SD
12	University encourages faculty entrepreneurship	4.08	0.64
23	Intellectual Property Protection is in place to encourage entrepreneurship in the region.	4.04	0.73
24	There is an important amount of technology-based Small and Medium Enterprises (SME) in the area	3.96	0.68
8	The park has helped to improve the Visibility of the University	3.96	0.95
29	Tenants within the park are linked to businesses and organizations outside the park	3.92	0.58
20	The following local condition contributes to the continuous growth of this park: Living conditions	3.88	0.83
6	The park has increased the student's opportunities to get jobs	3.88	0.88
28	Local availability of applicable science and technology is the primary factor for innovation	3.88	0.54
25	There is a public anchor institution inside or close to the park working as a catalyst	3.88	0.85
11	University facilitates faculty entrepreneurship	3.87	0.81
16	Tenants in the park hire a large proportion of graduates from host U.	3.83	0.76
7	The park has helped to improve the Quality of the University	3.79	0.88
5	Tenants hire a large proportion of employees from local U. graduates	3.76	0.88
27	There are social informal activities to stimulate interaction among innovators and entrepreneurs	3.72	1.06
15	Tenants in the park hire a large proportion of scientists from host U.	3.71	0.75
19	The following local condition contributes to the continuous growth of this park: Public services	3.64	0.57
26	There is a private anchor institution inside or close to the park working as a catalyst	3.60	0.91
22	The following local condition contributes to the continuous growth of this park: Primary and secondary education	3.60	0.87
10	The park helps the university to generate private sponsor research	3.52	0.82
4	The park attracts sponsor research to local universities	3.52	0.77
1	A relatively large proportion of the parks' professional workforce has been recruited from this area	3.52	0.96
17	Tenants in the park hire a large proportion of students from host U.	3.52	0.77
2	The park is a magnet for scientists to universities in the area	3.50	0.93
13	The park has helped to attract Scientists to the University.	3.46	0.78
30	Population in this area have a prevailing entrepreneurial culture	3.46	0.83
21	The following local condition contributes to the continuous growth of this park: Transportation system	3.36	0.86
9	The park helps the university to generate public sponsor research	3.33	0.70
3	The park is a magnet for students to universities in the area	3.17	0.96
14	The park has helped to increase enrollment of Students to the U.	3.12	0.78
18	The easy access to venture capital help us creating start-ups	3.08	1.14

Table 4-7 Survey Results from Asian Research Parks

Item	Statement	Mean	SD
24	There is an important amount of technology-based Small and Medium Enterprises (SME) in the area	4.50	0.52
6	The park has increased the student's opportunities to get jobs	4.35	0.61
3	The park is a magnet for students to universities in the area	4.20	0.68
19	The following local condition contributes to the continuous growth of this park: Public services	4.13	0.72
23	Intellectual Property Protection is in place to encourage entrepreneurship in the region.	4.06	0.57
2	The park is a magnet for scientists to universities in the area	4.06	0.90
1	A relatively large proportion of the parks' professional workforce has been recruited from this area	4.06	0.83
20	The following local condition contributes to the continuous growth of this park: Living conditions	4.00	0.63
11	University facilitates faculty entrepreneurship	3.93	0.59
29	Tenants within the park are linked to businesses and organizations outside the park	3.88	0.62
22	The following local condition contributes to the continuous growth of this park: Primary and secondary education	3.81	0.83
21	The following local condition contributes to the continuous growth of this park: Transportation system	3.81	0.91
28	Local availability of applicable science and technology is the primary factor for innovation	3.81	0.66
27	There are social informal activities to stimulate interaction among innovators and entrepreneurs	3.81	0.98
12	University encourages faculty entrepreneurship	3.80	0.68
13	The park has helped to attract Scientists to the University.	3.80	0.77
18	The easy access to venture capital help us creating start-ups	3.75	1.00
26	There is a private anchor institution inside or close to the park working as a catalyst	3.73	0.96
16	Tenants in the park hire a large proportion of graduates from host U.	3.71	1.14
5	Tenants hire a large proportion of employees from local U. graduates	3.71	0.77
8	The park has helped to improve the Visibility of the University	3.69	0.48
7	The park has helped to improve the Quality of the University	3.69	0.48
30	Population in this area have a prevailing entrepreneurial culture	3.69	0.70
14	The park has helped to increase enrollment of Students to the U.	3.67	0.72
25	There is a public anchor institution inside or close to the park working as a catalyst	3.63	0.89
17	Tenants in the park hire a large proportion of students from host U.	3.50	1.22
10	The park helps the university to generate private sponsor research	3.50	0.89
9	The park helps the university to generate public sponsor research	3.31	0.95
4	The park attracts sponsor research to local universities	3.24	1.03
15	Tenants in the park hire a large proportion of scientists from host U.	3.21	1.12

Table 4-8 Survey Results from European Research Parks

Item	Statement	Mean	SD
24	There is an important amount of technology-based Small and Medium Enterprises (SME) in the area	4.38	0.61
27	There are social informal activities to stimulate interaction among innovators and entrepreneurs	4.18	0.73
29	Tenants within the park are linked to businesses and organizations outside the park	4.15	0.44
20	The following local condition contributes to the continuous growth of this park: Living conditions	4.09	0.77
28	Local availability of applicable science and technology is the primary factor for innovation	4.00	0.75
8	The park has helped to improve the Visibility of the University	3.97	0.83
12	University encourages faculty entrepreneurship	3.94	0.74
23	Intellectual Property Protection is in place to encourage entrepreneurship in the region.	3.91	0.68
6	The park has increased the student's opportunities to get jobs	3.89	0.73
11	University facilitates faculty entrepreneurship	3.88	0.73
25	There is a public anchor institution inside or close to the park working as a catalyst	3.73	0.80
30	Population in this area have a prevailing entrepreneurial culture	3.70	0.95
22	The following local condition contributes to the continuous growth of this park: Primary and secondary education	3.70	0.85
7	The park has helped to improve the Quality of the University	3.70	0.88
19	The following local condition contributes to the continuous growth of this park: Public services	3.70	0.73
2	The park is a magnet for scientists to universities in the area	3.63	1.05
26	There is a private anchor institution inside or close to the park working as a catalyst	3.63	0.66
5	Tenants hire a large proportion of employees from local U. graduates	3.61	0.97
10	The park helps the university to generate private sponsor research	3.59	0.86
1	A relatively large proportion of the parks' professional workforce has been recruited from this area	3.58	1.13
18	The easy access to venture capital help us creating start-ups	3.58	0.97
16	Tenants in the park hire a large proportion of graduates from host U.	3.56	0.89
21	The following local condition contributes to the continuous growth of this park: Transportation system	3.53	1.02
9	The park helps the university to generate public sponsor research	3.50	0.86
17	Tenants in the park hire a large proportion of students from host U.	3.48	0.91
4	The park attracts sponsor research to local universities	3.47	0.83
3	The park is a magnet for students to universities in the area	3.37	0.97
13	The park has helped to attract Scientists to the University.	3.24	0.82
15	Tenants in the park hire a large proportion of scientists from host U.	3.09	0.91
14	The park has helped to increase enrollment of Students to the U.	3.09	0.79

4.3 Null Hypothesis One

Ho_1: There is no significant difference in the evaluation of best practices regarding effectiveness, as measured by the directors' perceptions of the RP's contribution to economic growth and job creation, between Asian, European, and North American RPs.

Table 4.5 provides the mean scores for items one through six, which assessed the effectiveness of RPs as measured by directors' perception of the RP’s contribution to economic growth and job creation within the region. The table presents the means for RP directors from Asia, Europe, and North America. For the three groups, SRSTP item number six (*the park has increased the student's opportunities to get jobs)* had the highest mean score.

The lowest mean scores were different among the three samples. For North American RPs, it was SRSTP item number three, *the park is a magnet for students to come to universities in the area*; for Asian RPs, SRSTP item number four had the lowest mean score, *the park attracts sponsor research to local universities;* and for European RPs, it was SRSTP item number three, *the park is a magnet for students to come to universities in the area,* that had the lowest mean score in each sample.

Table 4.6 presents a one-way ANOVA comparing directors’ evaluation of RPs from North America, Asia, and Europe on RP effectiveness, measured as the RPs' contribution to the economic growth and job creation within the region, at the level

$p < 0.05$ [$F = 2.336$, $p = 0.104$]. Therefore, not enough evidence is available to reject null hypothesis one.

Table 4-9 Survey Results on Contribution to Economic Growth and Job Creation

No.	Statement	N.AMERICA		ASIA		EUROPE	
		M	SD	M	SD	M	SD
1	A relatively large proportion of the parks' professional workforce has been recruited from this area	3.52	0.96	4.06	0.83	3.58	1.13
2	The park is a magnet for scientists to universities in the area	3.50	0.93	4.06	0.90	3.63	1.05
3	The park is a magnet for students to universities in the area	3.17	0.96	4.20	0.68	3.37	0.97
4	The park attracts sponsor research to local universities	3.52	0.77	3.24	1.03	3.47	0.83
5	Tenants hire a large proportion of employees from local University graduates	3.76	0.88	3.71	0.77	3.61	0.97
6	The park has increased the student's opportunities to get jobs	3.88	0.88	4.35	0.61	3.89	0.73

Note: Scores in a five-points scale: (1) strongly disagree to (5) strongly agree

Table 4-10 Summary of ANOVA Comparing Location with Contribution to Economic Growth and Job Creation

Source	Sum of Squares	df	Mean Square	F	Sig.*
Between Groups	1.537	2	0.768	2.336	0.104
Within Groups	24.013	73	0.329		
Total	25.550	75			

*Significance level at $p < 0.05$

4.4 Null Hypothesis Two

Ho_2: There is no significant difference in the evaluation of best practices regarding efficiency, as measured by the interaction between university and RP, between Asian, European and North American university-based RPs.

Table 4.7 provides the mean scores for items seven through 17, regarding the efficiency of the interaction between the university and the research park. The table presents the mean scores from directors of participant RPs from Asia, Europe, and North America. For the North American sample, SRSTP item number 12, the *university encourages faculty entrepreneurship,* had the highest mean score; while for Asian participants, SRSTP item number 11, *the university facilitates faculty entrepreneurship,* had the highest mean score, and for European participants, SRSTP item number eight, *the park has helped to improve the visibility of the university,* had the highest mean score.

The lowest mean scores for North American and European RPs was SRSTP item number three, *the park is a magnet for students to come to universities in the area;* for Asian RPs, it was SRSTP item number 15, *tenants in the park hire a large proportion of scientists from the host university*.

Table 4.8 presents a one-way ANOVA that compared the directors' scores from North American, Asian, and European RPs on the efficiency of the interaction between the university and the RP, at the level $p < 0.05$ [$F = 0.373$, $p = 0.690$]. Therefore, not enough evidence is available to reject null hypothesis two.

Table 4-11 Survey Results on Interaction University - Research Park

No.	Statement	N.AMERICA		ASIA		EUROPE	
		M	SD	M	SD	M	SD
7	The park has helped to improve the Quality of the University	3.79	0.88	3.69	0.48	3.70	0.88
8	The park has helped to improve the Visibility of the University	3.96	0.95	3.69	0.48	3.97	0.83
9	The park helps the university to generate public sponsor research	3.33	0.70	3.31	0.95	3.50	0.86
10	The park helps the university to generate private sponsor research	3.52	0.82	3.50	0.89	3.59	0.86
11	University facilitates faculty entrepreneurship	3.87	0.81	3.93	0.59	3.88	0.73
12	University encourages faculty entrepreneurship	4.08	0.64	3.80	0.68	3.94	0.74
13	The park has helped to attract Scientists to the University.	3.46	0.78	3.80	0.77	3.24	0.82
14	The park has helped to increase enrollment of Students to the U.	3.12	0.78	3.67	0.72	3.09	0.79
15	Tenants in the park hire a large proportion of scientists from host U.	3.71	0.75	3.21	1.12	3.09	0.91
16	Tenants in the park hire a large proportion of graduates from host U.	3.83	0.76	3.71	1.14	3.56	0.89
17	Tenants in the park hire a large proportion of students from host U.	3.52	0.77	3.50	1.22	3.48	0.91

Note: Scores in a five-points scale: (1) strongly disagree to (5) strongly agree

Table 4-12 Summary of ANOVA Comparing Location with Interaction University - Research Park

Source	Sum of Squares	df	Mean Square	F	Sig.*
Between Groups	0.209	2	0.105	0.373	0.690
Within Groups	17.932	64	0.280		
Total	18.141	66			

*Significance level at $p < 0.05$

4.5 Null Hypothesis Three

Ho_3: There is no significant difference in the evaluation of best practices regarding efficiency, as measured by the characteristics of the innovation ecosystem, between Asian, European, and North American RPs.

Table 4.9 provides the mean scores for items 18 through 26, regarding the efficiency as measured by the characteristics of the innovation ecosystem. The table presents the mean scores for directors' evaluation of RPs from Asia, Europe, and North America. For the North American sample, SRSTP item number 23, *intellectual property protection is in place to encourage entrepreneurship in the region,* had the highest mean score, while for Asian and European participants, SRSTP item number 24, *there is an important amount of technology-based Small and Medium Enterprises (SME),* had the highest mean scores.

The lowest mean scores were different among the three samples. For North American RPs, it was SRSTP item number 18, *easy access to venture capital helps us create start-ups*; for Asian RPs, it was SRSTP item number 25, *there is a public anchor institution inside or close to the park working as a catalyst;* for European RPs, it was SRSTP item number 21, *the following local condition contributes to the continuous growth of this park: transportation system,* that had the lowest mean score in each sample.

Table 4-13 Survey Results on Characteristics of the Innovation Ecosystem

No.	Statement	N.AMERICA		ASIA		EUROPE	
		M	SD	M	SD	M	SD
18	The easy access to venture capital help us creating start-ups	3.08	1.14	3.75	1.00	3.58	0.97
19	The following local condition contributes to the continuous growth of this park: Public services	3.64	0.57	4.13	0.72	3.70	0.73
20	The following local condition contributes to the continuous growth of this park: Living conditions	3.88	0.83	4.00	0.63	4.09	0.77
21	The following local condition contributes to the continuous growth of this park: Transportation system	3.36	0.86	3.81	0.91	3.53	1.02
22	The following local condition contributes to the continuous growth of this park: Primary and secondary education	3.60	0.87	3.81	0.83	3.70	0.85
23	Intellectual Property Protection is in place to encourage entrepreneurship in the region.	4.04	0.73	4.06	0.57	3.91	0.68
24	There is an important amount of technology-based Small and Medium Enterprises (SME) in the area	3.96	0.68	4.50	0.52	4.38	0.61
25	There is a public anchor institution inside or close to the park working as a catalyst	3.88	0.85	3.63	0.89	3.73	0.80
26	There is a private anchor institution inside or close to the park working as a catalyst	3.60	0.91	3.73	0.96	3.63	0.66

Note: Scores in a five-points scale: (1) strongly disagree to (5) strongly agree

Table 4.10 presents a one-way ANOVA comparing directors' scores of RPs from North America, Asia, and Europe that reflect how they evaluate efficiency, as measured by the characteristics of the innovation ecosystem, at the level $p < 0.05$ [$F = 1.429$, $p = 0.247$]. Therefore, not enough evidence is available to reject null hypothesis three.

Table 4-14 Summary of ANOVA Comparing Location with the Characteristics of the Innovation Ecosystem

Source	Sum of Squares	df	Mean Square	F	Sig.*
Between Groups	0.635	2	0.317	1.429	0.247
Within Groups	14.439	65	0.222		
Total	15.074	67			

*Significance level at $p < 0.05$

4.6 Null Hypothesis Four

Ho_4: There is no significant difference in the evaluation of best practices regarding efficiency, as measured by the culture of innovation in the ecosystem, between Asian, European and North American RPs.

Table 4.11 provides the mean scores for items 27 through 30, which assess efficiency as measured by the culture of innovation in the ecosystem. The table presents the mean scores from directors of participant RPs from Asia, Europe, and North America. For the North American and Asian samples, SRSTP item number 29, *tenants within the park are linked to businesses and organizations outside the park,* had the highest mean score, while for European participants, SRSTP item number 27, *there are social informal activities to stimulate interaction among innovators and entrepreneurs,* had the highest mean score.

The lowest mean scores were the same for North American, Asian, and European RPs: SRSTP item number 30, the *population in this area has a prevailing entrepreneurial culture.*

Table 4-15 Survey Results on the Culture of Innovation

No.	Statement	N.AMERICA		ASIA		EUROPE	
		M	SD	M	SD	M	SD
27	There are social informal activities to stimulate interaction among innovators and entrepreneurs	3.72	1.06	3.81	0.98	4.18	0.73
28	Local availability of applicable science and technology is the primary factor for innovation	3.88	0.54	3.81	0.66	4.00	0.75
29	Tenants within the park are linked to businesses and organizations outside the park	3.92	0.58	3.88	0.62	4.15	0.44
30	Population in this area have a prevailing entrepreneurial culture	3.46	0.83	3.69	0.70	3.70	0.95

Note: Scores in a five-points scale: (1) strongly disagree to (5) strongly agree

Table 4.12 presents a one-way ANOVA comparing directors' scores of RPs from North America, Asia, and Europe on efficiency, as measured by the culture of innovation in the ecosystem, at the level $p < 0.05$ [$F = 1.840$, $p = 0.167$]. Therefore, not enough evidence is available to reject null hypothesis four.

Table 4-16 Summary of ANOVA Comparing Location with the Culture of Innovation

Source	Sum of Squares	df	Mean Square	F	Sig.*
Between Groups	0.897	2	0.449	1.840	0.167
Within Groups	16.577	68	0.244		
Total	17.474	70			

*Significance level at p < 0.05

Further analysis was conducted using a MANOVA to test for the interaction of the two dependent variables: effectiveness and efficiency, to account for the potential correlation between these two variables, while also testing for significance and protecting against the Type I error that can occur if conducting multiple ANOVA tests independently. Table 4.13 presents the results of the multivariate tests and Table 4.14

presents the results of a MANOVA that compares directors' scores of RPs from North America, Asia, and Europe on the interaction of efficiency and effectiveness; there were no significant differences between the groups at the level $p < 0.05$.

Table 4-17 Results of the Multivariate Tests

	Effect	Value	F	Hyp. df	Error df	Sig*.
CONTINENT	Pillai's Trace	0.083	1.233	4.000	114.000	0.301
	Wilks' Lambda	0.917	1.238	4.000	112.000	0.299
	Hotelling's Trace	0.090	1.241	4.000	110.000	0.298
	Roy's Largest Root	0.089	2.548	2.000	57.000	0.087

*Significance level at p < 0.05

Table 4-18 Summary of MANOVA test for the interaction of Effectiveness and Efficiency

Source	Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.*
Corrected Model	Effectiveness	1.869	2	0.935	2.547	0.087
	Efficiency	0.206	2	0.103	0.690	0.506
CONTINENT	Effectiveness	1.869	2	0.935	2.547	0.087
	Efficiency	0.206	2	0.103	0.690	0.506
Error	Effectiveness	20.918	57	0.367		
	Efficiency	8.503	57	0.149		
Total	Effectiveness	817.278	60			
	Efficiency	839.385	60			
Corrected Total	Effectiveness	22.787	59			
	Efficiency	8.709	59			

*Significance level at p < 0.05

4.7 Summary

Chapter 4 presented the results and analysis of the data collected through the SRSTP. Tables containing the mean scores and standard deviation for each of the samples were presented. The statistical analysis of these results, using ANOVA and MANOVA tests, showed no significant differences in the RPs director’s evaluation of their parks related to effectiveness, as measured by the directors' perception of the RP's contribution to the economic growth and job creation. Tests also showed no significant differences in the RPs director's evaluation of efficiency, as measured by (a) the basic characteristics in the ecosystem, (b) the culture of innovation within the ecosystem, and (c) for university-based RPs, the interaction between the university and the RP.

CHAPTER 5. DISCUSSION

Chapter 5 presents a general overview of the study, the most relevant findings from the analysis of the data collected, and a discussion of these findings. The conclusions, recommendations and questions for further research are provided at the end of the chapter.

5.1 General Overview

The purpose of this study was to determine the differences in how managers and directors of RPs across the world evaluate their parks' effectiveness and efficiency, by utilizing the SRSTP. Effectiveness was measured by assessing directors' perceptions of the RP's contribution to economic growth and job creation in the region where it is located.

The efficiency of RPs was measured with respect to three general aspects: (a) the presence of basic characteristics in the ecosystem, (b) the culture of innovation within the ecosystem, and (c) for university-based RPs, the interaction between the university and the research park.

This study answered the following two research questions:

1. Is there a significant difference in what administrators view as best practices regarding the effectiveness of research parks across the world?
2. Is there a significant difference in what administrators view as best practices regarding the efficiency of research parks across the world?

To accomplish the goals of this study, the research questions were divided into the following four sub questions:

1. Is there a significant difference in the evaluation of best practices regarding effectiveness, as measured by directors' perceptions of the RP's contribution to economic growth and job creation, between Asian, European, and North American RPs?
2. Is there a significant difference in the evaluation of best practices regarding efficiency, as measured by in the interaction "university - research park" between Asian, European, and North American university-based RPs?
3. Is there a significant difference in the evaluation of best practices regarding efficiency, as measured by the characteristics of the innovation ecosystem, between Asian, European, and North American RPs?
4. Is there a significant difference in the evaluation of best practices regarding efficiency, as measured by the culture of innovation in the ecosystem, between Asian, European, and North American RPs?

The SRSTP, an online questionnaire with 30 items, was used to collect data with samples from the three continents. Comparisons of item scores by region using the one-way ANOVA test were used to test each of the four hypotheses, and a $p < 0.05$ level of significance was used. A total of 130 surveys were returned for a response rate of 67.36%.

5.2 Major Findings

The answers from the SRSTP were used to determine if there was a significant difference in what administrators of RPs from Asia, Europe, and North America (independent variable) view as best practices regarding the effectiveness of RPs, as measured by the directors' perceptions of the RP's contribution to economic growth and job creation. These answers were also used to assess potential differences in RP administrator's views of the efficiency of RPs, which were measured by the interaction between the university and the research park, the characteristics of the innovation ecosystem, and the culture of innovation (dependent variables). Results from Chapter 4 generated the following major findings:

1. There was no significant difference in the evaluation of best practices regarding effectiveness, as measured by the directors' perceptions of the RP's contribution to economic growth and job creation, between Asian, European, and North American research parks, $p < 0.05$ [$F = 2.336$, $p = 0.104$].

2. There was no significant difference in the RP directors' evaluation of best practices regarding efficiency, as measured by the interaction: “university-research park”, between Asian, European, and North American university-based RPs, $p < 0.05$ [$F = 0.373$, $p = 0.690$].
3. There was no significant difference when comparing RP directors' evaluation of best practices regarding efficiency, as measured by the characteristics of the innovation ecosystem, between Asian, European, and North American RPs, $p < 0.05$ [$F = 1.429$, $p = 0.247$].
4. There was no significant difference when comparing the RP directors' evaluation of best practices regarding efficiency, as measured by the culture of innovation in the ecosystem, between Asian, European, and North American RPs, $p < 0.05$ [$F = 1.840$, $p = 0.167$].
5. No significant differences were found when MANOVA treatments were conducted to analyze the responses by continent (i.e., Asia, Europe, and North America), and the interaction between the dependent variables: effectiveness and efficiency.

5.3 Discussion

This study shows no significant differences between Asian, European, and North American RP directors' evaluation regarding best practices, which are described through the 30 items in the SRSTP.

Results from the study show no significant continental differences in director’s perception of RP effectiveness in providing job opportunities for a skilled labor force, employing university students, and recruiting a large proportion of the park's professional workforce from the area. The increase of job opportunities for students and skilled and professional labor force seems a natural consequence of locating an RP within the ecosystem, and it was a common characteristic typically found in each of the three continents: Asia, Europe, and North America, supporting the findings of Goldstein and Luger (1991), Shearmur and Doloreux (2000), Link and Scott (2006), and is also in agreement with the results of Bianchi and Labory (2008).

One of the byproducts from this study is the ability to understand the priority that participants give to the different components in their own innovation ecosystems. There are no significant differences in the director's perception of the effectiveness and efficiency of RPs between the three samples. The ranking of each component in the corresponding ecosystem varies among the three continents, as is shown in tables 4.6 through 4.8, where the order of factors differ for each continent.

Minor differences were shown in the RP director’s criteria regarding the role RPs play in attracting new students and research funds to the ecosystem. While North American (M=3.17, SD=0.96) and European participants (M=3.37, SD=0.96) neither agree nor disagree that RPs help attract new students to universities located in the area, Asian participants (M=4.20, SD=0.68) agree that RPs do influence new students’ decision to come to neighboring universities. North American (M=3.52, SD=0.77), Asian (M=3.24, SD=1.03), and European participants (M=3.47, SD=0.83), neither agree nor disagree about the ability of RPs to help attract sponsored research to local universities.

North American RP directors agree (M=4.04, SD=0.73) that having a legal framework in place, such as intellectual property protection laws, is important to encourage entrepreneurship. They also agree (M=3.96, SD=0.68) that the presence of a significant amount of technology-based SMEs, the presence of a public anchor institution that serves as a catalyst in the region (M=3.88, SD=0.85), and good living conditions (M=3.88, SD=0.83) are all important factors for nurturing a healthy innovation ecosystem.

Asian participants agree that important factors that help to nurture the RPs' growth are the presence of a good number of SMEs in the area (M=4.50, SD=0.52), the quality of public services (M=4.13, SD=0.72), and good living conditions (4.00, SD=0.63); they also agree that intellectual property protection should be in place to encourage entrepreneurship in the region (M=4.06, SD=0.57). This shows Asian RPs' directors awareness about the importance of intellectual property and is in accordance with the findings of Bosworth and Yang (2000), who exposed lingering issues that have limited China’s acquisition of intellectual property, which are necessary to increase the nation’s potential for TT. These issues included the concerns of western nations about intellectual property protection and enforcement, which were promoted by international pressure especially from the U.S., because of China's weak protection and piracy of U.S. products (Bosworth & Yang, 2000, p.461).

Regarding how the interaction between universities and RPs promotes scientific innovation, directors of North American university-based RPs agree that universities encourage faculty members to become entrepreneurs (M=4.08, SD=0.64); this in agreement with Jensen and Thursby (2001), who also pointed out that scientists' involvement in the process of innovation increases the probability that they will succeed in commercializing their inventions. With regard to Asian (M=3.80, SD=0.68) and European participants (M=3.94, SD=0.74) some participants agree and some disagree with this statement.

When analyzing the second of the three dimensions used to assess the efficiency of a research park (i.e., the characteristics of the innovation ecosystem), it is notable that the most important characteristic of an innovation ecosystem for Asian (M=4.50, SD=0.50) and European participants (M=4.38, SD=0.61m) is the presence of a significant number of technology-based SMEs. In contrast, North Americans believe intellectual property protection regulations should be prioritized in order to encourage entrepreneurship in the region (M=4.04, SD=0.73), although the presence of a significant number of SMEs in the area is the second highest priority identified (M=3.96, SD=0.98). This finding is in agreement with Kirkland (1999), who mentions the following barriers for a successful technology innovation process, among others: lack of legal framework for intellectual property rights and the deficiency of capital markets.

The three groups differed on which characteristics need to be improved in order to nurture a healthy environment of innovation. European directors believe it is the transportation system (M=3.53, SD=1.02), Asian directors think it is public and private anchor institutions (M=3.63, SD=0.89), and North American directors prioritize increased availability of venture capital to aid in the creation of more start-ups (M=3.08, SD=1.14).

Finally, the last dimension that measured the RPs' efficiency is the culture of the innovation ecosystem. In this aspect, North American and Asian participants agree that the most important factor in boosting innovation is that tenant companies residing inside the park have close ties with organizations and business networks from outside of the park, followed by the availability of relevant science and technology.

5.4 Conclusions

The following conclusions have been obtained under the assumptions, delimitations and limitations framing this study:

1. There are no significant differences in the evaluation of .s regarding effectiveness, as measured by the directors' perceptions of the RP's contribution to the economic growth and job creation, between Asian, European and North American RPs. Therefore, null hypothesis one was retained.
2. There are no significant differences between North American, Asian and European RPs directors' evaluation of efficiency, measured by (a) the interaction between the university and the research park, (b) the characteristics of the

innovation ecosystem, and (c) the culture of innovation. Therefore, null hypotheses two, three, and four, were retained.

Finding no statistically significant difference does not mean there are not differences between the three samples, but rather the geographical position of a RP has no effect on directors' perceptions of RP's effectiveness and efficiency. The best practices or key components of a RP within its innovation ecosystem seem to be evident for most RPs' directors, regardless of its location. This conclusion implies that efficiency and effectiveness of a RP, in the terms stated in this study, could be enhanced taking into account the findings from the SRSTP.

5.5 Recommendations

As a corollary to this study, it is important to frame the RPs within the larger ecosystem concept and to put the research park initiative into context, so as to formulate recommendations for new or existing project developers. RPs are an important element of technological innovation, but they cannot work in isolation, as they are one part of a complex system. In this system, all components fulfill a specific role and interact with each other to create the dynamic forces needed for a successful innovation ecosystem. New supporters of technological innovation as a strategy to stimulate economic growth must consider the components that are needed beyond investments in technological infrastructure; all of these components are irreplaceable, must co-exist, and should be planned and developed simultaneously.

The cornerstone of innovation ecosystem is people; without the scientists' and researchers' creation of suitable technologies, the innovation process could not begin. Technological infrastructure is another component, as scientists need laboratories where they can work, experiment, and train future scientists. Also irreplaceable are government grants for basic research, because basic research takes a great deal of effort, patience, constancy, and even serendipity until tangible results can be seen, making it unattractive for private sector involvement.

Availability of venture capital is an essential component. Practitioners and policy makers should note the importance of availability of early stage funding for innovative ideas with a technological base as a way to promote an entrepreneurial culture and enhance the scientific base. To this end, the role of the government is important, programs like SBIR, STTR, and FAST, discussed earlier in this study, help proliferate SMEs with a technological base, which in turn positively influence the generation of economic growth and job creation.

The proposed factors presented in the SRSTP for effectiveness and efficiency does not pretend to be a comprehensive and exhaustive list of factors. However, these factors could serve as a guide or the basic components that should be taken into account, regardless of geographic location, political system or cultural differences, to start or improve an innovation ecosystem, according to the perspectives of RPs' directors from North America, Asia and Europe.

In addition to providing research funds to the university system as well as to national laboratories, the government also furnishes an adequate and reliable legal framework in order to entice and promote private sector participation. This provides an environment that not only guarantees but also incentivizes private industry involvement. Risk is always implicit in these kinds of investments due to their inherent uncertainties; this is why private sector involvement requires an environment with a trustworthy legal system and regulatory organizations within the ecosystem.

Universities and national laboratories have proven to be appropriate drivers of technology. Their role in the ecosystem is to compete for and to channel public financial resources and to turn them into intellectual property. Royalties and shares produced from the commercialization of these technologies by private companies generate additional economic revenues that feed back into the system to sustain the research endeavors. These private companies, interested in the potential applications of these discoveries, buy the patents and invest through in-house research to further develop the invention until a marketable product is attained; alternatively, they sponsor the applied research within the university in exchange for equity.

When the chances of economic return and potential application of the new technology are promising, the university, with the involvement of the inventor or scientists, continues funding the research through the development of the product. They accomplish this by using their own resources and encouraging their teachers and scientists to become entrepreneurs. Sometimes, universities will even set up processes that facilitate this transformation.

In the product development stage, government investment typically decreases or disappears and the private sector takes on the role of financing the costs of research for product development. This financial transition, commonly known as the "valley of death," is the turning point where discoveries either receive an injection of fresh private capital to pay for the additional research needed for the successful development of the new product, or remain just another invention disclosure without a proven practical application.

Universities are an important part of the innovation ecosystem because they create knowledge, which drives economic growth. In a competitive higher education system, universities (besides competing for government research funds towards basic and applied research) build a scientific base and produce knowledge—this is the first step in the innovation process. The most prestigious universities are like giant magnets, attracting the best talent from around the world and the best faculty to serve as mentors.

Through scientists' work with the most promising students to transfer explicit and tacit knowledge, and through experimenting in their laboratories and testing new ideas, universities become crossroads where ideas converge. Along with building the knowledge and scientific base, universities prepare the future scientists in the ecosystem. There is a permanent competitive race between universities to attract the most qualified human talent, faculty, researchers, and students.

RPs are the showcase for applied technologies, and as such they are responsible for marketing the university's intellectual property to private businesses or for creating start-ups. These start-ups are usually located within the park to take advantage of the proximity to faculty, students, laboratories, and amenities, which assists start-ups in their financial growth. Here, the start-ups take advantage of the business networks and links formed with companies outside of the park to commercialize new products, capture resources from capital markets, venture capitalists, or angel investors, and fund the development of the new products.

The constant stream of innovative products promotes the presence of a large number of technology-based SMEs, creating demand for the technologies developed at the university and offering jobs to university students and graduates. These companies become catalysts for economic growth and job creation in the region.

5.6 Questions for Further Research

As the population of RPs is increasing in all regions of the world, in the near future it might be feasible to obtain sample sizes that expand the limitations of this study by comparing existing RPs with those emerging in Africa, South America, and Australia. A comparative analysis might determine if the conclusions from this study are applicable to the entire world population of RPs.

Another way suggested to reexamine this study is using pairwise comparisons of RPs among the three continents, where each participant in the sample has a pair or equal in every other sample. The purpose would be to study each participant country that is in close similar ecosystem conditions as possible with its counterparts: similar infrastructure, urban setting, level of income, quality of the neighboring universities and research institutions generating knowledge. In this way variability and confounding factors are reduced, and reliability of results is increased.

There were some other aspects that were not considered for this study, one of them was maturity of RPs. This study did not consider the effect of the years of operation of RP on effectiveness and on efficiency. According to some authors, maturity plays an important role in performance of RPs (e.g., Luger & Goldstein, 1991). The other aspect not under consideration was experience of RPs' directors, so it is unknown the effect of years operating RPs on the directors' perceptions regarding effectiveness and efficiency.

In addition some questions to enhance this study include:

1. What is the effect of the maturity of research, science, and technology parks from Europe, Asia, and North America, on efficiency and effectiveness?
2. What is the effect of the type of urban setting where the innovation ecosystem is located on the efficiency and effectiveness of research, science, and technology parks, which are located in Europe, Asia, and North America?
3. What is the effect of incubation facilities for research, science, and technology parks in Europe, Asia and North America on efficiency and effectiveness?

5.7 Summary

The purpose of this study was to determine if significant differences exist in the evaluation on effectiveness and efficiency between North American, European, and Asian RPs, as well as between university-based and non-university-based RPs, as assessed by park directors and staff who responded to the SRSTP. The study focused on effectiveness (as measured by the RPs' contribution to economic growth and job creation) and efficiency (as evaluated by the interaction between the university and the RP, the characteristics of the ecosystem, and the culture of innovation).

After collecting a total of 130 surveys from three samples of differing sample size and from each of the three continents, and analyzing their responses to 29 items, this study found no significant differences in RPs director’s evaluation of effectiveness and efficiency. The four null hypotheses guiding this study were retained. Discussion, conclusions, and recommendations were presented to finalize the study.

Governments that are including RPs as part of the regional and national innovation systems to overcome underdevelopment and poverty could benefit from the results of this study. Efficiency and effectiveness of a RP could be achieved taking into account the statements presented in the SRSTP, although it does not pretend to be a comprehensive and exhaustive list of factors, rather to present those basic characteristics for the continued existence and improvement of an innovation ecosystem with a RP. These governments might assess the applicability of these findings to evaluate the potential of new projects that they are currently funding or considering funding.

Considering data in this study came from previous adopters of the RP strategy, it is hoped that Yachay administrators and managers in Ecuador, will find useful information and relevant data based on the experiences of other RP's directors, to inform its development and strategy. This study sought to explore the basic components necessary for a successful RP, and factors needed to nurture an innovation ecosystem.

There are several projects in the implementation stage in different parts of the worlds, yet the impact these parks will have in the economic development of these countries remains unknown. This study could provide a framework for different components that an innovation ecosystem should have, in order to frame the RP initiative within the context it needs, in order for the RP to survive, reach the maturation stage, and serve as a catalyst locally or regionally.

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APPENDIX

APPENDIX

Survey for the Evaluation of Research, Science and Technology Parks

This survey is volunteer and confidential; it will take approximately 10 to 15 minutes to complete. Only aggregate data will be used for research purposes. You may skip any question(s) or exit the survey at any time.

Section I

1. Country_____________
2. State __________ (For U.S. parks only)
3. Current park's development stage (Please select one):

____ Planning phase (End of survey)

____ Implementation/Construction

____ Fully Operational

4. Population in the area of influence where park is located (Please select one):

___ Less than 50,000 ___ 500,001 to 1,000,000

___ 50,000 to 200,000 ___ More than 1,000,000

___ 200,001 to 500,000

5. Does the park have a host University? ___ Yes No___

Please rate how strongly you disagree or agree with each of the following statements by placing a check mark in the appropriate box:

Section II

Effectiveness in the contribution to Economic Growth and Job Creation					
(1): strongly disagree **(2):** disagree **(3):** DO NOT know/apply **(4):** agree **(5):** strongly agree	**1**	**2**	**3**	**4**	**5**
6. A relatively large proportion of the park's professional work force is recruited from the region					
7. The park is a magnet for scientists and students to universities in the area					
8. The park attracts sponsor research to local universities					
9. Tenants hire a larger proportion of employees from local university graduates					
10. The park increases the students' opportunities to get jobs					

Section III

Interaction: University - Research Park					
(1): strongly disagree **(2):** disagree **(3):** DO NOT know/apply **(4):** agree **(5):** strongly agree	**1**	**2**	**3**	**4**	**5**
11. The park helps to improve the quality and visibility of the university					
12. The park helps the university to generate public and private sponsor research					
13. University facilitates and encourage faculty entrepreneurship					
14. The park attracts scientists and increases enrollment of students to the university					
15. Tenants in the park hire a larger proportion of scientists, graduates and students from the host university					

Section IV

Characteristics of the Innovation Ecosystem					
(1): strongly disagree **(2):** disagree **(3):** DO NOT know/apply **(4):** agree **(5):** strongly agree	**1**	**2**	**3**	**4**	**5**
16. Local access to venture capital help us in the creation of start-ups					
17. The following local services are ideal for the continuous growth of this park: public services, living conditions, transportation, primary and secondary education					
18. Intellectual property protection is adequate to encourage entrepreneurship					
19. There is an important amount of technology-based Small and Medium Enterprises					
20. There is an anchor institution (public and/or private) inside or close to the park					

Section V

Culture of Innovation					
(1): strongly disagree **(2):** disagree **(3):** DO NOT know/apply **(4):** agree **(5):** strongly agree	**1**	**2**	**3**	**4**	**5**
21. There are social informal activities to stimulate interaction among innovators and entrepreneurs					
22. The dominant occupational group in the area is formed by professionals, managers, engineers and technicians					
23. Local sources for science and technology are the primary factor in the development of innovation					
24. Tenants within the park are linked to organizations and businesses outside the park					
25. The population in this area have a prevailing entrepreneurial culture					

Source: Sections II through V adapted from Luger and Goldstein (1991)