Lessons learned of science parks development in Colombia.

Efrén Romero Riaño - Industrial University of Santander - Colombia
Luis Eduardo Becerra - Industrial University of Santander - Colombia
Gerardo Angulo Cuentas - University of Magdalena - Colombia

Abstract

Science Parks or Technology Parks (STPs) have been emerging as an strategy based on diverse actors (mainly government, academia or industrial associations) willing to promote economic local development through fostering technology and knowledge transfers among academia, well established companies and new technology based firms (NTBFs). Several countries like Korea, Taiwan and Spain have created STPs as a regional development strategy. In Spain almost half of the universities own STPs. Due to its importance for regional development STPs researches have been directed to explore the effects on factors performance such as Leadership, Strategy, Relations with higher education institutions and other knowledge generators, management, facilities management, staff and organizational structure, development stage and management. Previous analyses refers parks in developed countries and they are in mature development stages. The phenomenon of STPs in Colombia arises in the late 90s and their most development stage of its parks is incubation stage. Colombian STPs have not had a typical development process and the lessons learned of their development have had low levels of documentation in the scientific literature. In this paper, we report our experience in analysis of lessons learned of Colombian STP development process and includes lessons deriving depth analysis of the experiences of the Antioquia and Guatiguará parks.

This search is oriented on mixed research approach and the case study methodology was selected due to the emerging nature of the subject within the scientific literature and limited information about the Colombian STPs. This work is a multiple case study based on the five STPs recognized by Colombian STPs Policy. Colombian STPs are surveyed in order to identify lessons learned and the survey was based on written questionnaires followed by semi-structured phone interviews to each park top managers. Interviews include STPs founders, managers and consultants involved in the development of feasibility studies of Colombian STPs projects and initiatives. This multiple case study considers the application of the following techniques: (i) written questionnaires, (ii) semi-structured interviews (iii) content analysis and (iv) structural analysis.

Results include a literature review-based description of lessons learned, and the lessons effects on Colombian STPs' development from their leaders' perspective. There were reported more than 22 lessons learned reported by the administration of the surveyed STPs. However in this work we present only the 11 lessons that we verified by interviews and visits. We classify identified lessons according to previously identified factors. The discussion of the results contrasts lessons identified in Colombian STPs versus those reported in other countries.

Keywords: science parks, lessons learned, development process, converging countries, quality of management, institutional leadership.

1. Introduction

Science parks (SP) have been established throughout the world as spurs to economic develop-ment (Rathino and Henriques, 2009). A "science park" is a property-based initiative which (i) has formal operational links with centers of knowledge creation, such as universities and (public and/or private) research centers, (ii) is designed to encourage the formation and growth of innovative (generally science-based) businesses, and (iii) has a management function which is actively engaged in the transfer of technology and business skills to "customer" organizations. Characteristics that are generally associated with a SP are the presence of a business incubator and the localization on park of research laboratories, that may belong to the park, to partner (academic or non-academic) institutions, to

other non-profit organizations, or to business firms (Colombo and Delmastro, 2001). Many universities have established science parks and incubators to foster the creation of start-up firms based on university-owned (or licensed) technologies (Link and Scott, 2003). Public universities (and some private universities) also view these institutions as a means of fostering regional economic development. In the United States, The Association of University Research Parks (AURP) reports that there are 123 university-based science parks (Link and Link, 2003) and in U.K., the Science Park Association, UKSPA, report 49 science park in 1999. In addition, there are more than 200 science parks in Asia and still growing, with Japan topping the list at 111. China, which built the first one in the mid-1980s now has about 100. India established 13 parks in late 1980s but with the exception of Bangalore, India's Silicon Valley, all have failed (Phan et al, 2005). This same phenomenon, has happened in Colombia in where the only one of science parks initiatives promoted by both public universities and public institutions, has been Guatiguara SP. Science parks and incubators have become an international phenomenon that get in to South America in late 1990s with fastly growing in Brazil, in where nowadays, there are 22 operatives science parks. In this sense, in Mexico there are 21 science parks and five science parks in Argentina and Colombia (Rodríguez-Pose, 2012). On the other hand, practitioners claim the success of SPs (e.g. UKSPA, 2003) others criticize their actual role as promoters of regional growth (Amirahmadi and Saff, 1993; Castells and Hall, 1994; Massey et al.,1992; Quintas et al.,1992).

SP development process has been little studied in the context of both developed and emerging countries (Angulo, Camacho, and Romero, 2014). This development process pursue the success of this kind of initiatives in USA such as Silicon Valley, Route 128 in Massachusetts (Castells and Hall, 1994) and the Research Park Triangle in North Carolina (Link and Scott, 2003a) and Cambridge in the UK (Koh et al., 2005). As a mean for reply these success, several studies focus on identify best practice and lessons learned from this science parks models in developed countries and transfer it to emerging initiatives in middle size countries. However, no systematic framework to understand SP development process has been used and hence the current lack of clarity in identifying the nature of their performance (Amirahmadi and Saff, 1993; Phan et al., 2005) and transfer these lessons learned. Studies in this area includes lessons learned from countries such as Italy (Colombo and Delmastro, 2002), Portugal (Ratihno & Henriques, 2010), Taiwan (Yang et al, 2009) and Greece (Sofouli & Bonortas, 2004, Bakouros et al, 2002). Yet little has been done in middle-sized converging countries such as Colombia and it may be argued that these little efforts obey to: quantity, quality (development state) and also that it possess younger SP, making it more difficult to assess their lessons and contributions to science parks movement. Apart from own studies, the only previous effort to document SP in Colombia was made by Morales (Morales, 2011) focusing exclusively on literature review and identifying development state of parks initiatives. Recent work focus on Latin America, analyzed tenants from incubators and science parks in an emerging country, Brazil, and analyses specific attributes of collaboration (Schmid et al, 2016).

This search take in account definitions of a converging economy as a country between developed and developing and converging exclusively in terms of economic performance (Harvey and Carvalho, 2002). In addition, we consider converging economies as countries having the economic performance of developed countries, its improved governance provides value and yet lagging behind in innovation performance. Our research results cover the population of science parks in Colombia, a converging country. The main proposition is to analyses performance of science park development process in a converging economy to derive lessons that can be transferred. In order that SP provide a mechanism to promote and stimulate commercial and industrial innovation (Kharabsheh, 2011) and ensure sustainable regional development, in addition we research what are the main underlying determinants for the success of SPs development process in developing countries.

This search starts with scientific literature review for definitions and lessons learned of science parks development. We analyses most developed science parks in Colombia by mean of multiple case study methodology and make comparisons of lessons learned in both developed and developing countries. After presenting a general outlook of development state and discuss underlying determinants found to explain differences between development of two most developed Colombian science parks. These are i) quality of management: comprising management profile and strategy; and ii) institutional leadership: which encompasses related to development approach and infrastructure consolidation. Results suggest this contribution to be modest, mainly as a result of a generalized poor performance according to the underlying determinants for development process in terms of time and evolution or R&D outputs.

2. Literature review

This work is based on the work of others who have researched on several issues concerning SPs to investigate their contributions to draw up lessons learned for science parks development process. This literature review starts with the definitions presented below. In addition, we discuss the most common factors and characteristics of SPs for converging countries that will allow us to better investigate the underlying determinants for performance of SPs development process.

2.1 Definitions

About the definition of SPs, there is no consensus. Practitioners also further similar concepts emphasising in their definitions the business development processes rather than in providing space (IASP, 2002; UKSPA, 2006). SPs have been more focused on regional development (Amirahmadi and Saff, 1993) by supporting regional technological strengths or promoting the development of new ones development (Castells and Hall, 1994; Link and Scott, 2003a). Supporting young technology-based firms to establish and flourish (Amirahmadi and Saff, 1993) as well as attracting anchor firms to a given location (Felsenstein, 1994) is also often among their objectives. Most of these have common themes such as regional development, technology focus, job and wealth creation and alike (Ratinho and Henriques, 2009). Researchers have found more commonalities between both SPs and BIs definitions positing they are mostly property-based organisations sharing the mission of business development using knowledge agglomeration and resource sharing (Phan et al., 2005).

From international associations perspectives, one of the most accepted definitions used in the scientific literature, is given by the International Association of Science Parks (IASP, 2002): “A Science Park is an organization managed by specialized professionals whose main aim is to increase the wealth of its community by promoting the culture of innovation and competitiveness of its associated businesses and knowledge based institutions”. In this sense, the Association of University Research Parks, AURP, defines a university research park as a property-based venture, which: master plans property designed for research and commercialization, creates partnerships with universities and research institutions, encourages the growth of new companies, translates technology and drives technology-led economic development (AURP, 2011)
In Latin America, the leader country in development of SPs is Brazil, with 90 parks initiatives upon which 22 are operative. The National Association of Innovative Ventures (ANPROTEC) defines SPs as: industrial and scientific-production complex technology based services, planned, formal character, focused and cooperative, which aggregates companies whose production is based on technology developed in research centers and R & D related to the park (ANPROTEC, 2011).

2.2 Factors and characteristics of science parks

Several factors emerge from literature review. The literature reviewed about factors affecting SPs performance mainly concern two issues: 1) factors associated with success (Vaidyanathan, 2008, Karabsheh, 2011) and 2) factors affecting the performance (Bakouros et al, 2002, Lindelöf & Löfsten, 2002, Siegel et al, 2003). On performance analysis of SPs, there are studies which evaluate their development through a series of stages (Yang et al, 2009, Koh et al, 2005) or by the results of tenants firms (Detwiler et al, 2002, Löfsten & Lindelöf, 2003).These studies, take as reference the factors mentioned by definitions, functions and objectives formulated by diverse concerned institutions such as IASP, UKSPA, APTE and AURP. The main factors under study are: location (infrastructure), university relationships, management, human talent, innovation and firms. In this search we take in account the main characteristics related with Colombian science park development state. In Colombia, the development of SPs, there are not the typical behavior because after twelve years of support provided by the Colombian state for these projects, three parks keep in incubation stage, as projects; the leading institution until 2012, Antioquia Technology Park announced its liquidation; and Guatiguará Technology Park although of advances in its development process, keeps in the incubation stage (Angulo et al, 2014). Incubation stage in science parks development models focus on conditions of SP such as: ideas, feasibility studies, creation of the managing body and development of detailed studies (Luger and Goldstein, 1994), initial planning, agreements between stakeholders and procurement of funds for start-

up (Allen, 2007). In this context, rise as the most important factors and characteristics for performance of science parks development the quality of management and institutional leadership.

2.2.1 Quality of management.

The organization and management quality of the S&T parks/incubator, are key to 'success' (Sofouli and Vonortas, 2004). This quality concerns to management practices implemented thorough strategy and management profile (Rhatino and Henriques, 2010) in SP. In this sense, practice or best practice refers to process that are better than any other, regarding a particular result (Bergek and Norman, 2008). The activities that had a direct relationship with a better performance of process being studied are considered best practices (Angulo, Camacho, and Jaime, 2015), however, literature does not describe which management practices specific to SPs are more effective in terms of increasing their performance for development process.

2.2.2 Institutional leadership.

This leadership includes the sum of the following variables: focus on development approach and research infrastructure consolidation (Romero, 2015) as well as institutional efforts for fulfilling conditions derived from SP development models. Most of science parks analyzed have links with universities, private or public. In Portuguese SP analysis Rathino and Henriques claims that Institutional commitment is a key factor for science park performance.

These characteristics emerge as the general determinants for the success of SPs and BIs. We will investigate, however, what constitutes in fact institutional leadership and quality of management and response the question, what are the underlying determinants for the success of SPs development.

Colombia is a middle-sized country located in the north- western tip of Latin America. It covers about 1 141 748 km² of continental land and its current population is 47.6 million inhabitants (MinInterior, 2015). After a period of high economic growth in the ending of the 2000s until 2008 crisis, with a growth of 4.4 percent on average for three lustrum, Colombia has been slowly reducing its growing average converging towards 3%. In terms of innovation performance, Colombia go down from 60 to 68 place (GII, 2014); and referring its general position in Global Competitiveness Report its placed 66, mainly by low performance in innovation, business sophistication and institutions (GCR, 2014).

3. Methodology

This search approach follows a qualitative case method approach due to the low number of sample elements and newness of our topic. We use the case study method as suggested by Yin (2003) and (Winfried and Barbara, 2008) and others as the appropriate analytical approach given our sample parameters. Case studies were written using a written survey combined with a semi-open phone interview (Dillman et al., 2008).
The main proposition is analyze the performance of science park development process in a converging economy to derive lessons that can be transferred. In order to develop it, SPs need to be planned and operated to be successful. Therefore, our research question is: What are the determinants for success of Science Parks development?. Success is a normative concept, so one must have a frame of reference, or in this instance, a set of goals or conditions against which to compare it. The challenge here is to identify stages during the park development process that are success (or failure) thresholds and particular characteristics of parks and their environment (Luger and Goldstein, 1991).
Our model focuses on the underlying determinants for performance within the two main categories of determinants derived from literature. In this sense, we will investigate which underlying determinants explain differences in performance of SPs development process. One of the problems in defining performance of SPs development process is that there is only one approach identified for this task. This approach is proposed by Angle Technology for UKSPA and mainly claims that in early stages of development, SPs performance could be measured by progress in meeting the conditions for maturation. To improve our analysis, we listed the factors and conditions of SPs and the variables in which they are expected do have result on mainly incubation stage results (Table 1).

Table 1. Condition, factors and expected results

Conditions and factors	**Expected Result**
Conception of the idea to develop science park	Defined idea
Initial planning	Urban planning
Agreement from the park's stakeholders	Statement
Acquisition of funds sufficient for the commencement of operations	Institutional commitment for financing facilities development
Feasibility studies	Availability of financial and institutional resources to build and sustain the park
Initial governing structure	Governance structure
Required legal documents	Formal announcement of the park
Detailed planning studies and recruitment activities	Master Planning
Initial infrastructure creation	Access roads, electricity service, sewer mains
Financial self-sustainability	Financial Breakeven
R+D Organizations on park	Operative R+D Organizations

3.1 Case studies

This multiple case study considers the application of the following techniques: (i) written questionnaires, (ii) semi-structured interviews and (iii) content analysis (Piñuel, 2002). The questionnaires ask about the general characteristics of the STPs and the influence of endogenous factors in their own development process. Interviews include SPs founders, managers and consultants involved in the development of feasibility studies of Colombian SPs projects and initiatives. Study results include the identification (by the literature review) of endogenous factors affecting the development of Colombians STPs, and the estimation of their importance from the point of view of SPs' leaders and managers (through the structural analysis). Despite our focus on characteristics of STPs, we triangulated data interviewing a sample managers for accurate information. Additionally, we surveyed some of the operational features of the SPs and BIs, such as strategy, selection criteria, self-assessment criteria. These case studies can be categorised as exploratory (Yin, 2003) since our research question aimed to derive the underlying determinants for the success of SPs. However, we also drew a framework to qualitatively define success of park development process.

4. Results

We set out to study the whole population of Colombian SPs, given their reduced absolute number. This study is based in all Colombian SPs recognized policy. Results are concentrated in these parks, because they contain at least one of the endogenous identified factors. The factors identified in the theoretical revision. These factors apparently have potential impact on the performance and success of SPs. This phenomenon is quite recent in Colombia and therefore we group each SP by development stage.

4.1 Data gathering.

Colombia has currently identified 10 SPs: 4 developing, 3 just starting and 3 idea or project (Rodríguez-Pose, Andrés, 2012). In Colombia, the first one try for national network of science park consolidation, was made in 2010 in principle by 11 parks: Science Park of Antioquia, Guatiguará Technology Park, Parquesoft Colombia, Manantiales Technology Park, Technology Park of Umbria, and those still under construction such as the Universities of Atlantic, the Francisco Jose de Caldas District, the University of Sabana, the National University of Colombia and Techno-ecological Usme Park, Universidad Antonio Nariño. Although some could not be surveyed, we still find useful to mention them in order to describe the entirety of the current SPs population in this paper. From the perspective of developmental stage, two groups differ of SPs: a first group corresponds to the parks initiatives that reach significant progress, culminating or they are about to complete its incubation stage. Furthermore, data were not disclosed by all institutions. We were unable to survey or interview Manantiales Technology Park, Caribe Technology Park, Techno-ecological Usme, Francisco Jose de Caldas District, and therefore any reference to these institutions hence forth relies on information in the public domain. All questionnaires and phone interviews were conducted between February and July 2013, during Second International Congress of Science Park in Bogotá, Colombia, and the remainder data collected between August and October 2013.

The SP phenomenon is quite recent in Colombia, dating from the ending of the 1990s. However, since the beginning 2000s, a new wave of SPs has been observed. The population of Portuguese SPs has several common features: (i) promoted collaboratively by universities, local or regional authorities, and private organizations (trade organization and industrial associations, etc.); (ii) located in mixed urban and rural areas; (iii) funded predominantly by public universities and enjoying extra funding via national incentives programs through Administrative Department of Science, Technology and Innovation, COLCIENCIAS; and (iv) no business incubator located on park (Table 2). In Colombia, the lack of specific governmental policy in this area led to a failure in establishing a model for setting up and developing SPs and therefore they exhibit differences in their evolution. In June of 2000, the first one try of Colombian SPs' policy (Colombia, 2003) promoted the development of five SPs and the second one is being formulated in collaboration with Korea´s Knowledge Sharing Program, KSP, and finish on 2016. Categories related to different stages of development can be observed:

- **Developing (4):** We consider them developing given that they have operated in a stable way for some years and this parks are fulfilling its facilities development. Guatiguará SP opens its research building on 2013 and next inaugurating the expanded area in the main building for firms, in addition, recently set up its first tenant company. At the time of research Antioquia SP recently begins a new phase with the acquisition of mains actives of park by its foundress university, Parquesoft take in account more than 300 companies and 1,000 workers software and Umbría built the 50% of its projected facilities.
- **Just starting (3):** originally planned in 2000, Sabana Science park and Caribe Science Park, and launched in 2005 and 2013. They are formulating master plan and still did not have any tenant company at the time of research. Biopacífico science park has been developing activities for consolidation as a park through international technological missions, management of intellectual property conventions, implementation of a quality management model of the park and developing the service portfolio.
- **Idea of project (3):** these institutions are being developed and trying to position themselves according to their environment: Techno-ecological Usme science park was considering a thematic focus in environmental and sustainability; Manantiales science park it is in the process of strengthening by its main partner, Antioquia´s Development Institute, IDEA.

Keeping in mind these differences and based on the analysis of all the detailed case studies (Romero, 2015), we will present the major lessons that can be distilled from the Portuguese case study.

Table 2. Main characteristics of Colombian science parks

Science Park	Location	R+D institutions on park	Main sectors of activity	Service provided

Antioquia	Carmen de Viboral	1	Biotechnology	Vegetable biotechnology and project management
Guatiguará	Piedecuesta	14	Energy resources, materials, ICT, Biotechnology	Specialized analysis
Umbria	Cali	0	Technology innovation and entrepreneurship	Consulting
Parquesoft	Cali	0	ITC	Business incubation

5. Lessons learned: the underlying key factor for SPs development performance.

The general outlook yields mostly similarities in both groups. Yet the observed differences among them are enough to explain performance of science parks development differentials and derive the lessons learned from this particular experiences. These lessons obey mainly from detailed case studies of Antioquia and Guatiguara SPs, the most successful experience in Colombia as well as recognized by Colombian government institutions SPs projects (Table 3).

5.1 Quality of management for SP development

This research identified the critical role of management for the performance of SPs (Löfsten and Lindelöf, 2002; Kihlgren, 2003). While these authors underline the importance of management they do not provide examples of good management or what may be considered suitable management tools (Rathino, 2010). We explored quality of management using two underlying determinants: management profile and strategy.

The management profile

Management of SPs requires specific expertise (IASP, 2002) or competent science park management (Kharabsheh et al, 2011) since it involves complex processes such as technology transfer (McAdam et al., 2005). Furthermore, SPs are often part of a regional economic development strategy (Phan et al., 2005) and have to satisfy demands of several diverse share- holders (Amirahmadi and Saff, 1993; Massey et al., 1992; Quintas et al., 1992). In a recent conference, a round table constituted of managers of European SPs highlighted the critical role of management from the very beginning of any SP operation. As practitioners, their perception is that a SP manager has to combine the profiles of a scientist, a politician and a business- man being able to communicate effectively and interact with several actors of the local and regional system of innovation (Ratinho and Henriques, 2010). Apart from scale, the management profile for SPs and BIs does not differ greatly. In Colombian SPs, most infrastructures are owned by local or national public or private universities. Antioquia, Guatiguará and Umbría illustrate well this holistic view applied to SP management:

- Antioquia SP is a rural project which converge the three views in its management. It was able to attract International prominent biotechnology R&D centers (the focus of the park). Scientist, as its university founder involvement, Universidad de Antioquia, suggest. Business, as the orientation towards markets and the creation of anchor companies suggest (e.g. Seeds Biofactory)). Policy, by its recognition from the Colombian SPs Policy (2000).
- Guatiguara SP is an urban project Park combines as shareholders a significant number of important actors of the regional system of innovation including technology development centers, recognized research groups with the highest category in country and the most important the most important research institute in the area

of oil and gas in Colombia as customer. It is completely owned and managed by the University of Santander and it is based on the premises of several engineering schools. Furthermore, management is not sufficiently business- oriented, as the current lack of tenants and internal policies in the university for promoting the SP evolution from actual to next one development stage. In terms of policy, the existence of a significant regional cluster of oil and gas companies is disregarded in terms of legacy and preferential sectors of activity for relocating companies in the park.

On the contrary of previous parks that evidence an effective way of incorporating policy, science and business orientation in their management, Umbría SPs shows a different picture.

- Umbría SP is strongly linked to a university via one research institution (owned completely by the University of San Buenaventura) and it is also the precursor to the SP project in development in the city. The policy view was disregarded by Umbria's management who did have not recognized by Colombian Ministry of Commerce, Industry and Tourism, until 2013. The existence of a nearby SP project, BioPacifico, carrying also activities in an attractive location for traditional regional cluster, agroindustry, has potentially contributed to the stagnation of this SP.

Strategy

Strategy is one of the facilitators of the organizational excellence according to the EFQM Excellence model EFQM (2009a, 2009b, 2009c, 2009d). Also strategy appears as the category of processes called "Developing a vision and strategy" in the framework APQC-PCF (APQC, 2010) and is considered in the PWC-PCF framework (PWC, 2011) within operational processes as "developing the vision and strategy". According to Bigliardi et al (2006) official statements are often not a useful starting point for identifying the current "mission" and the goals of STPs. In most cases, the business model and the strategic behavior of a PCT is influenced by implicit strategies that do not necessarily coincide with the missions and goals that have been formally declared. The mission and, therefore, the "real strategy" only arises after the STP has existed for a period of time and has taken advantage of the opportunities that have been offered it, has created its own "living space" and consolidated its structures. On the other hand, Finland understood a technology- and innovation-oriented growth strategy to be necessary, as increasing exposure to foreign competition required world-class innovative capacity, efficiency, and value-adding capacity (Sang-Chul Park Seong-Keun Lee and Kwan-Ryul Lee,2004).

While management profile perspective have highlighted the key factors for science park development process performance, additionally, in this paper we try for understand the broader forces that influence the underlying determinants for science parks from strategy perspective. To this end, we identify three primary aspects that are critical to an understanding of how a science park starts and develops over time. These are:(a) Growth mechanisms: These are the factors and capabilities that sustain a science park and enable it to grow over time; (b) Technological capabilities: This aspect is concerned with the development and strengthening of capabilities in R&D and the creation of competitive advantages in specific technology sectors; and (c) Global role and market integration: This aspect addresses the linkages between the region and the global or national economies, the degree of integration with regional or global markets, and the creation of the region's niche in the global system (Koh, Koh and Tshang, 2005). At this case, we analyses the only first and second one primary aspects.

Table 3. Lessons destilled from Antioquia and Guatiguara SPs case studies.

SP	Quality of management	Institutional leadership
Antioquia	Broad scope of activities: managing SP, convention centre, events, development of urban area. No laboratorial space. Many shareholders. Continuity of leadership (8 years max.)	No significant universities or R&D institutions present. Academic managers (Social Sciences). ST focused on selling infrastructures services. No focus in regional strengths terms of sectors of activity present in the region.

		Lack of university business incubator and academic start-ups absence
Guatiguara	Limited scope of activities: research activities, no specialized managing SP. Shared of laboratorial space as well as office space. One shareholder. Continuity of leadership (6 years max.). Technology screening in academia and local to foster new scientist areas activities.	Existence of R&D institution within the park. Academic managers (Engineering and Technology Management). ST focused on selling infrastructures services. Focus in regional strengths in terms of sectors of activity. Strong links to specific cluster and its R&D technological centre. Preserve the park during incubation stage. Internal clusterization as mean for development accelerator. Lack of university business incubator on park and academic start-ups absence

Growth mechanisms: about these, Koh (2005) claims that the growth factors compounding growth mechanism, are broadly classified into subgroups: (a) gestation and takeoff factors, which provided the initial impetus for the exemplar's establishment and development; (b) growth sustaining factors, which are the capabilities that enable the science park to renew and sustain itself. Gestation and takeoff factors includes gestation and early advantage, evolution and constraints and the growth sustaining factors includes sustaining factors, tenants, R&D stages contained within park or region and additional enabling factors (Seely Brown and Duguid, 2002). In general, the growth mechanism commonly implemented in the analyzed SPs, correspond one to mixed directed mechanisms (public and private). Guatiguara SP strategy is mainly oriented towards financing through public calls and own public resources. In this sense, Antioquia SP, is mainly oriented towards financing through private shareholders and own public resources. Antioquia had rapid growth based on the consolidation of a private legal entity, with partners in the productive sector that actions financed by the park's operation. Explaining current development operative state of Guatiguara, arise the agglomerative effects based on internal clusterization of own research centres on park. Referring gestation and takeoff factors of both science park's, these are initially government led, but later followed by strong industry (Antioquia) and university linkages (Guatiguara). Its evolution have been self-directed in both cases and the main constraints are: no major industries developed around its territory and poor tradition of financing of research and development by the regional private sector.

Technological capabilities: Guatiguara SP get competitive advantages in specific technology oil and gas sector through financing acquisition of world class equipment's for specialized services, positioning services based on technological acquisitions and improving the propensity to patent. Antioquia SP is mainly focus on positioning based on the number of articles and citations, and joint work between research centers groups for development and transfer of research results for accelerate SP development process. However, both parks are mainly known for basic research, but also includes pure science, and applied research. The status of technological sophistication is middle level for both parks. The R&D framework presented in Amsden and Tschang (2003) is applied to this purpose (Table 4).

Table 4. Stages of research and development

Stage of research	**Activity**	**Skills requirement**
Pure science	Outputs usually in scientific journals and possibly patents.	Scientific expertise needed
Basic research	Similar outputs as pure science approach, but conducted with specific long-term corporate objectives.	Scientific expertise needed

Applied research	Involves transforming or localizing existing product knowledge, or reapplying known research results to other areas.	Less scientific, more engineering expertise needed
Exploratory development	Development and prototyping of design and other systems.	Product development expertise
Advanced development	Addressing of manufacturing considerations for products.	Manufacturing and product development expertise.

Source: Adapted from Amsden and Tschang (2003).

In the case of the Antioquia, the main type of R&D appears to be the basic research output of Universidad de Antioquia other new funded research institutes in the region, as Seed Biofactory. The initial focus was in Biotechnology and Social Sciences, which later focused to Vegetable biotechnology. For Guatiguara SP, its growth is oriented around specific technology sector of oil and gas and concentrations of Centers of Technology Development with close relationship with the sector such as: paving, gas and corrosion, which located on park. In the case of the Guatiguara Science Park, the main type of R&D appears to be the exploratory development research output of Universidad Industrial de Santander, UIS, and other nationally funded research institutes in the region, such as Instituto Colombiano del Petroleo, ICP, the main Colombia´s research institute.

5.2 Institutional leadership for science park development

Our research confirmed the role of institutional leadership as critical for the success of SPs development especially at initial or incubation stage. Most of Colombian SPs, have some kind of linkage to universities or other centres of knowledge production. In this sense, we take in account main conditions for incubation stage, the most current state of colombian science park development, and compares it focus on fulfilling of conditions in both case studies, Antioquia and Guatiguara (Table 5).

Table 5. Fulfilled conditions through institutional leadership

Conditions and factors	**Antioquia**	**Guatiguara**
Conception of the idea to develop science park	Defined idea	Defined idea
Initial planning	Urban planning	Urban planning
Agreement from the park's stakeholders	Agreements for controlling shareholder by the Universidad de Antioquia	No agreements for starts second development stage.
Acquisition of funds sufficient for the commencement of operations.	Institutional commitment for financing facilities acquisition	Execution of building works for location of host firms financed with state and own resources.
Feasibility studies	Initial studies	Business, Marketing and communication planning.
Initial governing structure	New Governance structure based on university leadership.	There are no agreements on the most appropriate structure for the growth phase of the park
Required legal documents	Formal announcement of assets acquisition from Universidad de Antioquia.	Absence of a formal document of park´s foundation.
Detailed planning studies and recruitment activities	No Master Planning	Master Planning in development.

Initial infrastructure creation	Access roads, electricity service, sewer mains and networks.	Complete Initial infrastructure, research buildings and equipments. Firm's facilities in construction.
Financial self-sustainability	No Financial Break even	No Financial Break even
R+D Organizations on park	None Operative R+D Organizations	Four Operative R+D Organizations

- Development approach: Definitions of SPs mention knowledge transfer arising from universities and R&D institutions to mature firms on park or foster the creation of start- ups as one development medium for SPs. In both cases, the absence of academic start-ups might be a reflexion of the role of the university itself in promoting such activities as an integral part of a professorship or a research career (Ratinho, 2010). Guatiguara SP implements an internal development approach and remains as an extension of its founder university. This approach includes critical mass strengthening, internal research capabilities development and specialized training in Science Park development as well as institutional decisions and commitment for internal funding. Oppositely, Antioquia SP has implemented external development approach across external research and development capabilities transfer from recognized R&D institutions and commissioning of actions for external financing of regional and national companies. These contrasting approaches let faster growing for Antioquia and slower growing for Guatiguara but they have in common the support provided by the prestige of the founding universities as recognized research institutions

- Infrastructure consolidation: this is considered the main factor by which Guatiguara has been in the last three years, the leading SP in Colombia, by strengthening its research infrastructure (buildings and equipments) within the park mainly focused on four strategic areas (biotechnology, new materials, energy resources and Information Technology and Communications, TIC). For Antioquia SP, the consolidation and strength of its infrastructure, mainly in information networks, allows it to develop international events, gain visibility and strengthen its brand. Its infrastructure is geared towards the dissemination of research results and to the business location. The applicability and relevance of the technology infrastructure in line with the vocations of the consolidated developed clusters at regional level, are relevant factors for science park development performance and park's growth in incubation phase.

Discussion and conclusions

We set out to investigate the efficacy of SPs development in converging countries context. This proposition will only be true if SPs are successful in the fulfilling conditions from development models and incorporate practices for speed up its growing and evolution level. As a result, we also researched the underlying determinants, key factors, for SPs development, already grouped in two main categories derived on the literature review.

Concerning the quality of management, our findings confirm its crucial role in the performance of a SP (Sofouli and Vonortas, 2004; Löfsten and Lindelöf, 2002). Most Colombian SPs and are owned by combinations of local, regional and national universities and other centres of knowledge production as Technology Development Centers in Guatiguara's SP case and, chambers of commerce and private real developers as Antioquia SP. This, in fact, is typical of this kind of infrastructures worldwide (Ratinho, 2010). Quality of management drives science parks development and it requires combining special political skills by management of science parks to incorporate SPs as axes of regional economic development strategy.

Concerning the Institutional leadership the overall conception of a science park as an engine of regional development, as well as vision and institutional commitment to the planning and execution of projects, are routers and medium for long process of developing a science park, especially in the context of converging countries like Colombia, where political and funding of intensive research and development have low levels of development and where private companies still do not change their paradigm regarding investment in R & D activities. The leadership of the

university management is crucial to design and implement the "strategy" of the park so allow creating a shared vision with regional actors and promote permanence in time, financial sustainability and the development of institutions such factor given their long-term horizon. Likewise leadership in research, is critical to convene all regional actors, clusters of companies, local governments and recognized research institutions.

The nature of performance for science park development process, lies in the ability to combine capacities, political will and institutional commitment to generate both internal governance of the science park as the recognition of regional stakeholders in the science technology system and link effectively on a long-term process and compliance requirements quality research environments and compliance requirements and conditions to bring the park project since its incubation phase to the growth phase in a successful manner. PTG bases its development process performance in focuses on increasing the level of research and development of technological capabilities and that approach is betting on a change of culture to move from pure science research and basic research to applied research, which has led to consolidate granting the first five patents for the UIS and seven patent search to be approved by the Superintendency of Industry and Trade.

An alternative perspective of our findings suggests that the success of SPs in incubation stage is buttressed on incorporating R&D institutions from diversified industrial sectors that promote the strengthening of research capacities and specialized shareholders management which encompasses the objectives and interests of each promoter and shareholders for governance of SPs and it allows to prepare the transition to the stage of development of growth.

Acknowledgements

References

AURP. Asociation of University Research Parks. On line: Retrieved from: http://www.aurp.net/what-is-a-research-park.[23-12-2015].

Amirahmadi, H., Saff, G.,. Science parks: a critical assessment. Journal of Planning Literature. 1993, 8(2), 107–123.

Amsden, A.H., Tschang, T., 2003. A new approach to assessing the technological complexity of different categories of R&D (with examples from Singapore). Res. Policy 32, 553–572.

Angulo, G., Camacho, J., & Romero, E. (2014). Análisis del desarrollo de los parques científico-tecnológicos (PCTS) en Colombia. En R, Llamosa Villalba (Ed.). Revista Gerencia Tecnológica Informática, 13(36), 49-59. ISSN 1657-8236.

Gerardo Luis Angulo Cuentas, Jaime Alberto Camacho Pico & Astrid Jaime Arias (2015) Frameworks to Identify Best Practices at the Organization Level: An Analysis, Journal of Business Economics and Management, 16:4, 861-875, DOI:10.3846/16111699.2012.745813.

Bakouros, Y., Mardas, D., & Varsakelis, N. (2002). Science parks, a high tech fantasy? An analysis of the science parks of Greece. Technovation, 22(2), 123-128.

Bergek, Anna y Norrman, Charlotte. Incubator best practice: A framework. En: Technovation, 2008, no.1, vol.28, p. 20-28.

Bigliardi, B.,Dormio, A. I.,Nosella,A.,Petroni,G.,2006. Assessing science parks' performances: directions from selected Italian case studies. Technovation, 26(4), 489–505.

Castells, M., Hall, P., 1994. In: Technopoles of the World: The Making of Twenty- first-Century Industrial Complexes .Routledge, London.

Colombo, M; Delmastro M. How effective are technology incubators?. Evidence from Italy. Research Policy 31 (2002) 1103–1122.

Detwiler, P., Lindelöf, P., & Löfsten, H. (2002). Utility of location: A comparative survey between small new technology-based firms located on and off Science Parks—Implications for facilities management. Technovation, 26(4), 506–517.

EFQM. (2009a). EFQM Excellence Model: Excellent Organisations achieve and sustain superior levels of performance that meet or exceed the expectations of all their stakeholders.

EFQM. (2009b). EFQM Transition Guide How to upgrade to the EFQM Excellence Model 2010. Retrieved from http://www.efqm.org/en/PdfResources/ Transition_Guide.pdf

EFQM. (2009c). Introducing the EFQM Excellence Model 2010. Retrieved from http://www.efqm.org/en/PdfResources/ EFQMModel_Presentation.pdf

EFQM. (2009d). RADARise Your Business For Success. European Foundation for Quality Management.

Felsenstein, D., 1994. University-related science parks—''seedbeds'' or ''enclaves'' of innovation?. Technovation 14 (2), 93–110.

Harvey, A.C. and Carvalho, V. M. d.(2002) Models for Converging Economies. Cambridge Working Papers in Economics, Faculty of Economics, University of Cambridge, from http://econpapers.repec.org/RePEc:cam:camdae: 02 16 May 2002.

IASP. International Association of Science Park. (2002). Board of directors. ["Definitions"]. URL: http://www.iasp.ws/ publico/index.jsp.

Kharabsheh, R; Magableh, I and Arabiyat, T. (2011). Obstacles of Success of Technology Parks: The Case of Jordan. International Journal of Economics and Finance, 3(6), 219-226.

Koh, F.C.C.,Koh, W.T.H.,Tschang,F.T.,2005. An analytical framework for science parks and technology districts with an application to Singapore. Journal of Business Venturing. 20(2), 217–239.

Lindelöf, P., & Löfsten, H. (2002). Growth, management and financing of new technology based firms—assessing value-added contributions of firms located on and off Science Parks. Omega, 30(3), 143–154.

Link, A.N., Scott, J.T., 2003 a. The growth of research triangle park. Small Business Economics 20(2), 167–175.

Löfsten, H & Lindelöf P (2003). Determinants for an entrepreneurial milieu: science parks and business policy in growing firms. Technovation, 23(2), 51-64.

Luger, M., & Goldstein, H. (1991). Technology in the garden. Research parks and regional economic development. North Carolina: University Press. p.35.

McAdam, R., Keogh, W., Galbraith, B., Laurie, D., 2005. Defining and improving technology transfer business and management processes in university innovation centres. Technovation 25 (12), 1418–1429.

Morales, M., Plata, P., and Casallas, C. (2011).Los parques tecnológicos en Colombia como mecanismo de vinculación universidad-entorno. Libre Empresa, 15(2), 11-29.

Phan P.H et al. Science parks and incubators: observations, synthesis and future research. Journal of Business Venturing 20 (2005) 165–182.

Ratinho, T. .Henriques. E. The role of science parks and business incubators in converging countries: Evidence from Portugal. Technovation 30 (2010) 278–290.

Rodríguez-Pose, Andrés. Los parques científicos y tecnológicos en América Latina: Un análisis de la situación actual. Banco Interamericano de Desarrollo. 2012. Publication code: IDB-MG-131.pag.24.

Romero, E. Análisis de las iniciativas de parques tecnológicos en Colombia mediante la metodología de estudio de caso. Tesis de Maestría. Universidad Industrial de Santander. 2015.

Siegel, D., Westhead, P., & Wright, M. (2003).Assessing the impact of university science parks on research productivity: exploratory firm level evidence from the United Kingdom. International Journal of Industrial Organization, 112-124.

Schmidt, S; Balestrin, A; Machado, R; Bohnenberger, M. Collaborative R&D and project results within Brazilian incubators and science parks. International Journal of Entrepreneurship and Small Business

Volume 27, Issue 1, 2016, Pages 1-18.

Sang-Chul Park Seong-Keun Lee * Kwan-Ryul Lee. (2004). A Comparative Study of Development Strategies and Government-Industry University Linkages of Science and Technology Parks in Finland and South Korea. Korea Observer, Vol. 35, No. 4, pp. 0-10.

Sofouli, E., & Vonortas, N. (2004). S&T Parks and business incubators in middle sized countries: the case of Greece. Journal of Technology transfer, 32 (3), 525-544.

UKSPA. In: Evaluation of the Past and Future Economic Contribution of the UK Science Park Movement. United Kingdom Science Parks Association, Cambridge. 2003.

Vaidyanathan, G. (2008). Technology parks in a developing country: the case of India. Journal of Technology Transfer, 33(4), 285–299.

Winfried R Y Barbara W. Research notes and commentaries what passes as a rigorous case study. En: Strategic Management Journal. 2008, vol.29, p.1465 – 1474.

Yang, C., Motohashi, K., & Rong-Chen, J. (2009). Are new technology-based firms located on science parks really more innovative? Evidence from Taiwan. Research Policy, 38 (6), 77–85.

Yin, R., 2003. In: Case Study Research: Design and Methods third ed. Sage Publications, Thousand Oaks.