Assessment of Technology Parks: a University case

An empirical study about Technology Parks in Mexico

Jeroen Ringlever

UNIVERSITY OF TWENTE.

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Candidate

Name:	Jeroen Ringlever
Study:	Industrial Engineering and Management

University

University:	University of Twente
Place:	Enschede, the Netherlands
Faculty:	School of Management and Governance

Supervisor committee:

NL:	Dr.	Rob van Lambalgen
	Dr.	Laura Franco Garcia
MEX:	M.Sc.	Isabel Kreiner
	Dr.	Fernando Sandoval Arzaga

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Enjoy the reading of my report!

Jeroen Ringlever

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Abstract

Background

Mexico's competitiveness is facing presently a challenging moment. It is crucial for Mexico to transform from a primarily manufacturing-based country into a knowledge-based economy in order to compete with other emerging economies in the future. This explains the existence of Technology Parks in Mexico. The institution for which I carried our this research project counts with 16 Technology Parks at present and plans for opening new ones are already on development.

Problem description

We started this research under the assumption that in Mexico there was a lack of experiences about the implementation of international standards and best practices of Technology Parks. Additionally to that, we also faced some constraints to define the regional impacts of such Technology Parks. In order to provide information about the international standards and the regional impacts of technological parks in the Mexican context, we elaborated seven research questions which are:

1. *Which criteria have to be fulfilled by the technology parks to be considered 'technology park'?*
2. *How are the results of the technology parks measured against these established criteria?*
3. *Do the existing technology parks in Mexico fulfill these criteria and to what extent?*
4. *To what extent can we talk about knowledge transfer at Technology Parks?*
5. *Are sustainability criteria considered in the strategy of Technology Parks?*
6. *How is the contribution or impact on regional development evaluated/measured?*
7. *What are possible model improvements?*

Methodology

A theoretical framework of Technology Parks was constructed from the literature review. To give answer to most of the research questions empirical data was needed from the Mexican context. For the empirical data collection seven Technology Parks directors and some managers of tenants that are accommodated in the parks were interviewed by semi-structured interview formats. The already existing data on the Mexican context was analyzed by data mining. With this data the performance matrix was constructed and the prioritization of the parks was made. Based on seven criteria the performance of the seven parks is measured, to check if they fulfill to the international definition of Technology Parks.

Findings

Park 1, Park 2, Park 4, Park 5, Park 3b and Park 6 are all Technology Parks according to the definition. Campus Park 7 and Park 3a are not fulfilling to all the criteria (do not transfer knowledge) and are therefore not a Technology Park according to the definition. A prioritization based on seven criteria was made by applying AHP. The final ranking on the criteria from high to low is: Park 2, Parks 3, Park 6, Park 1, Park 5, Park 4, Park 7. Another prioritization related to knowledge transfer was made based on the collected data. The final ranking from high to low is: Park 2, Park 1, Park 3a, Park 5, Park 4, Park 6, Park 7. Most of the Technology Parks are not sustainable themselves and are not screening their (potential) tenants on eco efficiency/innovation yet, but the overall sustainability attention of the last couple of years seems to have influence on the Technology Parks that are built after 2008. Currently the measurement method of the park performance is not focused to check the advances towards meeting the goals of the Technology Parks, the international criteria of Technology Parks are not used and it does not cover impact measurement.

Conclusions and recommendations

In this research, we developed a performance matrix by applying AHP which might allow the management directors to rank the technological parks performance according to the international standards. What is crucial to keep on mind is the quality and quantity of the data as input for the performance matrix, in our case, we should run our analysis with scare and not always trustable data therefore the results of this research needs to be seen as a first trial with the AHP model. Actually, it should be taken as illustrative and preliminary for further improvements. Besides AHP, it is advisable to apply Dematel on the performance data, because Dematel identifies the criteria that have the most influence on the final result. Furthermore, it is suggested to management to fulfill the need of more social and networking events for more collaboration among the tenants and university. In that sense, park directors can use the intranet system, already put on place, for more intensive communication among the parks users. The technological parks' impacts on the region can also be in some extend measured by economic indicators and by including sustainability criteria in the screening procedures of potential tenants. Sustainability criteria implies per definition the ecological and social aspects of any activity which could contribute to measure the technological parks impacts in a broader approach.

Content

List of acronyms and abbreviations

NBIA	National Business Incubation Association
IASP	International Association of Science Parks
KPI	Key Performance Indicator
ICT	Information and Communication Technology
SME	Small and Medium Sized Entities
R&D	Research and Development
$I+D+i^2$	Acronym in Spanish for research, development, innovation and incubation
AR	Action Research
OECD	Organization for Economic Co-operation and Development
AHP	Analytical Hierarchy Process
MCDA	Multi Criteria Decision Analysis
DEMATEL	Decision Making Trial and Evaluation Laboratory

1. Introduction

In the '80s the popularity of the phenomenon of Technology Parks was growing rapidly. Nowadays there are several spin offs derived from this idea, like for example Science Parks, Industrial Parks, Knowledge Parks, Business Incubators, among the most common used. These spin-offs are founded all with the same purpose: to stimulate economic growth in the region (and eventually on national level) of the located cluster by linking business with knowledge. By grouping these knowledge-based activities, Technology Parks stimulate generation, transmitting and sharing knowledge in a more efficient way.
Especially in the situation of Mexico, where competitiveness is facing a challenging moment in time, it is crucial to transform from a primarily manufacturing-based framework into a knowledge-based economy (including high value added activities and high-technology based industries) in order to compete with other emerging economies in the future. So new strategies are required for accelerating the knowledge-based economy of Mexico.
Another spin-off similarity is the triangular structure, also known as the Triple Helix philosophy, including government, private companies and knowledge institutes which are the actors of innovation. Most of them are founded from public funding, but this does not apply for other international experiences with other type of funding sources.

According to several authors, the reason that drives people to a Technology Park is an economic one; people are working at Technology Park as innovators, inventors and entrepreneurs for a living. Why is it important for society Technology Parks are created where people might collaborate easily? It is a fact that, *new* firms (less than 5 years old) generate far more jobs than bigger firms, which is because they want to reduce the number of employees and in consequence cost reduction: more products against lower production costs. In the USA, for example, on average 3 million jobs are generated each year by start-ups. They also translate innovative ideas and theoretical knowledge into a business plan/model. By doing this Technology Parks commercialize the research that is available in the park. They create the net wealth in the society with new products and services. (Multimedia, 2012). Besides job creation and regional growth, Technology Parks also draw international firms, talented labor and investments to the region. Some competitive advantages that support the creation of new firms (Koh, Koh, & Tschang, 2003) are: a large pool of technical talent, availability of pre-existing infrastructure and large network of suppliers, access to venture capital, access to excellent educational facilities and research institutions and well-developed information networks.

Some governments also hoped that the Science and Technology Parks (Koh, Koh, & Tschang, 2003) will also help to:

1. "*Raise the level of technological sophistication of local industries, through promotion of industrial R&D*
2. *Promote foreign investments, especially in higher value-added activities*
3. *Accelerate the transition from a labor-intensive to a knowledge-intensive economy*".

A technology park is also a prestigious 'premium brand'. It offers a recognizable identity, a superior and prestigious image which supports the tenants and their products. It becomes easier to attract customers, suppliers, employees, business partners and media. This provides great leverage to small and medium enterprises. (Molina, Aguirre, Breceda, & Cambero, 2011). Other potential benefits for companies are that they can have access to greater number and variety of suppliers, technical expertise and potential business partners, all located within close distance. (Koh, Koh, & Tschang, 2003).

Technology Parks exist because of the need of socio-economic development in several countries. They act often as a catalyst for regional economic development, according to literature. The three general

goals of a Technology parks are: wealth increase, promotion of the entrepreneurial culture and increase competitiveness. Furthermore, they create jobs, contribute to R&D projects, improve the quality of employment, raise venture capital, improve technological capability and in a region, add high value to regional economy among other aspects, but the question is; do they provoke these improvements, and if so, how can this be measured? This is important for adapting and improving the Technology's Parks outcomes. Besides, performance and future prospects are valuable information for potential funders, stakeholders, financial sponsors and others. It is a way to take a step back and take a critical look at the program. As mentioned at the beginning, there are different kinds of Technology Parks and different terminology has broadly been used. This also holds for Parks that are connected with a Mexican institution. Examples of the differences are: type of funding, location, selection policy for companies in the Technology Parks, and some others. The management group of the institution want to evaluate whether these 16 Technology Parks are just buildings near a campus where enterprises can rent spaces, or that the Technology Parks firstly fulfill the international Technological Park criteria and secondly that they pursuit higher regional purposes.

In the Dutch context, different kinds of Science Parks are registered and in consequence the startup companies are very diverse. Some good examples of Dutch Science Parks are:

- Science Park, Twente
- High Tech Campus/Brainport, Eindhoven
- Bio Science Park, Leiden
- WUR Wageningen/Food Valley, Wageningen
- Chemelot – Sittard-Geleen
- Science Park Watergraafsmeer, Amsterdam

It is relevant to mention that the Science Parks' names are associated to specific research fields and research groups.

Other international best practices of Technology Parks:

- Silicon valley, California
- Hsinchu Science Park, Taiwan
- Cambridge Science Park, Cambridge

Following the line of identifying technology parks of other type of clusters, this study has 2 main purposes: in one hand the project aims to analyze the international criteria to nominate technology parks under the Mexican conditions and in the other hand it aims to identify the operational criteria which allow measuring Technology Park regional impacts. The next section will discuss the core problems and drivers of this research.

1.1 Problem identification

Currently there is a lack of information and experiences in Mexico about the international standard and best practices of Technology Parks. Among others, the management of the institution wants to find out about the impulses and drivers of Technology Parks and their potential outcomes. Assuming that rapidly growing innovation is one of the outputs of Technology Parks, the management of the institution wants to know what the drivers of innovation are and how do Technology Parks influence technological innovation. Is cooperation and collaboration between universities and enterprises in the Technology Park stimulating product and process innovation? Or is their contribution a negligible factor? This is important because innovation is the key factor of competitiveness. (OECD, 2007). As mentioned in the introduction, it is of national importance that Mexico can compete with other emerging economies.

Besides innovation Technology Parks also stimulate (high value) job creation in the region, which is an important result according to governmental instances. However, the kind of jobs created, more specifically the differences in level of education requested for the jobs, is another aspect where little information exists on. Parallel to this issue lies the question what kinds of companies are located in the Technology Park? And if so, do they currently contribute to innovation and consequently competitiveness? At present, it exists the "enterprise-selection" criteria for different kinds of Technology Parks, but the question is if they are implemented and if those are still up to date. Another questionable issue is the measurement of competitiveness. Has it been measured in the past? Are there models existing to measure innovation and competitiveness? And are they applicable for the Parks within the institution? Next, the researcher will briefly mention something about funding in Mexico. This is relevant because the government is an important institute in an ecosystem of a Technology Park and they assign funds to enterprises. How this is organized in a Technology Park will probably tell us something about performance of a Technology Park. Enterprises operating in new businesses can receive funding from the minister of economy if they show them an official stamped document from a business incubator. This process has not yet been verified and right now they do not know who can apply and under which conditions you might receive governmental payment.
Summarizing, the problem has to do with the lack of information and experiences in Mexico to identify what should be the criteria that the park should include for being considered a Technology Park. The definition 'Technology Park' is per se ambiguous because some universities describe their high tech incubators as Technology Park, while that is simply just a business incubator. Also the concept of knowledge transfer needs to be researched. The fact that there is an university or a research center present in the Technology Park does not automatically serves the statement that there is substantial knowledge transfer. Knowledge transfer will be addressed as well on this research. Another criterion that deserves some attention is sustainability. Probably because of the lack of manufacturing facilities there is little known about sustainability policies, however not less important to elaborate on. Especially in the development phase the product design can be of high influence on the sustainability of the production process. So do the parks screen companies on eco efficiency/innovation? Bus also; do the parks have a corporate responsibility policy themselves?
Furthermore it is necessary to elaborate on the feasibility of Dutch and/or international business models and if they can be (or not) transferred with adapted conditions to the Mexican context. Finally, on the basis of the above mentioned, the research will show some recommendations by identifying some potential success factors of Technology Park policy.

To sum up, in countries like Mexico, where Technology Parks are relatively new, some questions about the existing Parks are rising up. Firstly, the name of Technology Park should correspond to those holding the international standards / criteria to be entitled as 'Technology Park'. In existing literature certain criteria can be described in terms of what needs to be fulfilled up as Technology Parks. As second element of this research work, the researcher focused on the visibility to nominate and measure Mexican parks under international criteria. Thirdly, the regional impacts of those technology parks need to be considered by applying some model, which can be developed by extensive literature review.

1.2 Research objective and research questions

In order to be able to bring up some suggestions as solution to the problem stated in the previous section, this research work has as general research objective to provide the managers of Technology Parks connected to the university institutions with new information on the current status of the Technology Parks (not enough sufficient information on new international standards for Technology Parks) and give recommendations on how to improve the contribution to the region from best practices. Furthermore, those objectives can be stated as:

1. Identify the internationally accepted criteria for Technology Parks and summarize the drivers for innovation
2. Evaluate which Technology Parks fulfill to these criteria and to what extent.
3. Analyze to what extent sustainability and technology transfer criteria are considered.
4. Elaborate on measurement methods of impact on regional development currently used in the Technology Parks.
5. Analyze reasons why they are not measured and give additional measurement possibilities

In order to achieve the objectives indicated above seven research questions were formulated as follow:

1. Which criteria have to be fulfilled by the technology parks to be considered 'Technology Park'?
2. How are the results of the technology parks measured against these established criteria?
3. Do the existing technology parks in Mexico fulfill these criteria and to what extent?
4. To what extent can we talk about knowledge transfer at Technology Parks?
5. Are sustainability criteria considered in the strategy of Technology Parks?
6. How is the contribution or impact on regional development evaluated/measured?
7. What are possible model improvements?

In section 1.3 is the research scope and the contribution of the research determined.

1.3 Research scope and significance

The focus of this study is on Technology Parks connected to a certain university institution. This means that other Technology Parks in Mexico will be left out of the study. University has 33 campuses and 16 Technology Parks, which are located throughout the country. They diversify among others on size, research area, objectives and location. Only 7 Technology Parks will be considered in the remainder of the study, due to the short timeframe to carry out this research.

When the park directors will implement the recommendations of the research, they will notice a difference in their performance measurement methods. Also, the new insights gained from this report will perhaps change their way of managing their parks. Besides the managers the people in the region will perhaps notice a small positive change in the contribution of the Parks, through for example more efficiency, more jobs, more innovation, more green and eventually economic growth. The report also affects other stakeholders like the tenants in the Parks and students of the university by elaborating on the relationship criteria between research centers and Technology Parks.

2. Theoretical framework

In this section the theoretical frameworks is described for the topic of Technology Parks. The researcher has selected several relevant scientific publications in databases by typing the 'different kind' of 'technology clusters' and research is done about the criteria for selection either one or other type of park. Additional to the theoretical framework, the author reviewed some of the most common assessment criteria for Technology Parks.

2.1 Overview of cluster definitions

In table 1, several definitions are represented from literature. The various types of clusters can cause some confusion, so first some definitions are included in the theoretical framework.

Table 1: Adapted definitions of several types of technology clusters

Type of cluster	Definition
Research Park	A Research Park is a property based venture which has property for research and research commercialization, stimulates company growth, creates links with universities, research institutes and companies, and thus drives economic development by high technology. (Associations of University Research Parks (2012).
Industrial Park	An Industrial Park is a cluster of businesses that are sharing resources such as information, materials, water, energy and infrastructure in an efficient way to gain economic and environmental benefits. The businesses in the cluster cooperate with each other and with the region. Sharing activities are not necessarily focused on high-technology R&D. (Côté & Cohen-Rosenthal, 1998).
Office/business Park	The main services that office parks provide to their tenants are administration and property availability. It provides property to companies focused on R&D, but also to companies with office, light manufacturing and business supporting activities. (Zhang, 2005).
Science Park	Is property based and includes a formal and operational link with a university, encourages company incubation/growth, high quality space and transfers technology with the main aim to stimulate regional growth. Besides incubated companies, large international businesses can develop a close relationship with a knowledge institution for their mutual benefits. (IASP International Board, IASP official definition of Science Parks, 6 February 2002).

The table gives a short overview of the main existing clusters. Next, several Technology Park definitions and their meaning are given in a more extensive description below.

2.1.1 Technology Parks

With the spirit to come up to a consensual working concept of Technology Parks, some of the most used definitions are enlisted as follow:

"A Technology Park is a space, physical or cybernetic, managed by a specialized professional team that provides value-added services, whose main aim is to increase the competitiveness of its region or territory of influence by stimulating a culture of quality and innovation among its associated businesses and knowledge-based institutions, organizing the transfer of knowledge and technology from its sources to companies and to the market place, and by actively fostering the creation of new and sustainable innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high quality space and facilities". (L. Sanz, 3 Oct. 2001).

In 2007 Ratihno, Henriques and Maltez mentioned that the quality of the specialized management team is an important success factor for Science or Technology parks. "*A Science or Technology Park manager has to combine the profiles of a scientist, a politician and a businessman being able to communicate effectively and interact with different actors of the system of innovation*." Science Parks (but also

Technology Parks) are managed by a specialized team and therefore the quality of the management profile will also be considered in the criteria framework for the parks that are connected to the institution.

In 2005, Zhang adds this line to the definition: "*…with low or non-existent academic involvement, tenants are mostly engaged in technological development and commercial application of research*." This is also the definition that (Buck Consultants International, 2009) is using in their research on campuses of national interest. However, in the rest of the report the definition of Technology Parks is used where academic involvement is high. (L. Sanz, 3 Oct. 2001).
Science and Technology Park are 2 titles that are used in theory and refer to the same ecosystems and in reality we find a mixture of these parks because they have overlapping definitions. In 2005 Zhang stresses that in a Technology Park academic research is considered as less important and therefore academic involvement is low. However, in the rest of this report we consider Science and Technology Park as 2 different titles with the same content.
Literature can align our interpretation of the reality that we perceive and many definitions can enlighten the reader of just provoke confusion. In the following section, the author tries to bring some points for analyzing what is or can be a Technology Park.

What is and what is not a Technology Park
There are many synonyms for technology parks, including science parks, research parks, technopolis, and etcetera. However, some terms are definitely not synonyms for technology parks, for example: industrial park is not a synonym because it focuses on manufacturing, where technology parks aiming at R&D and product innovation. Business and office parks focus on administration and have little academic activities, so these parks are also different than technology parks. High-tech business districts are less organized, managed and planned than technology parks and science centers, and differ in the sense that they are not concerned with future developments in science and technology. It is more like a large individual company site with R&D focus. A technopole or technopolis is a mix of different types of parks and has a broad scope of real estate planning. Examples of a technopole are Kista Science City Berlin and Adlershof 22@ Barcelona. (Buck Consultants International, 2009). Research parks house activities focusing on knowledge creation, technology parks house activities focusing on knowledge application and commercialization and science parks house both the type of activities. (Zhang, 2005). The next section discusses the definition of Technology Parks that is used by the institute.

2.1.2 Definition of Technology Parks according to the institution

Because it is important to identify what makes a Technology Park in the Mexican context and even further in the environment of the university institution, here the concept: "*Technology Parks are physical premises designed to integrate firms aspiring to be incubated, accelerated, or adapted to the region (landing), through liaison and cooperation programs and activities among firms, with the campus resources and talent, and ultimately with academic, business, and government actor in the region*." (Aguirre, 2009). This definition is similar to the definition of Technology Parks of Sanz in Oct. 2001.
It has been reported in 2009 that for the institution, a Technology Park should take the following enlisted concepts into account:

- "*TP do not allow mass production or manufacturing processes.*
- *TP are not 'office space for rent' (unless activities are related to technology development and there exist relationships with the university)*
- *TP are not extended space for traditional university activities (R&D, teaching). University activities have to support business and entrepreneurial activities*". (Aguirre, 2009).

In section 2.2 are assessment frameworks discussed that are used to establish the performance of technology parks.

2.2 Assessment methods for Technology Parks existing in literature

In this section existing models to assess Technology Parks are discussed because one of the research questions focus on how to develop an assessment model for the institution. Some models are only theoretical ones, others are tested in practice. It is important to elaborate on this subject in order to know what is already existing on the subject of assessing parks and what might be useful for constructing a new model that can be implemented in the context of the institution.

2.2.1 Assessment framework

Chan and Lau in 2004 elaborated an assessment framework which is disclosed in table 2 for technology incubators with a summarized list of criteria, some examples of specific indicators can also be seen.

Table 2: Assessment framework (Chan & Lau, 2004)

Assessment criteria	Examples of specific indicators
Pooling resources	Organising staff training and development activities, marketing events, exhibitions, press conference
Sharing resources	Sharing laboratory facilities, office equipment, testing equipment, administrative support (e.g. meeting room, library, reception area)
Consulting/counselling services	Provision of legal, accounting, business, technical advices at low cost (or free-of-charge)
Public image	Image of the Science Park/University/Government
Networking	Access to clients/suppliers/subcontractors, partnership opportunity with other technology firms within the incubator, knowledge sharing/dissemination
Clustering	Development of a pool of skill labour, externalities from logistics arrangement, externalities from supporting network (e.g. emergence of complementary industry)
Geographic proximity	Access to market, research centre, universities
Costing	Rental subsidies, subsidies on telecom/computer network access, other subsidies related to cost reduction
Funding	Access to venture capital (VC) funding, banking facilities, other funding sources

Some of these criteria and indicators will be useful in the development of a suitable assessment framework for the Technology Parks that are connected to the university institutions.

2.2.2 Performance matrix

In the workshop organized by the IASP on measuring Science and Technology parks' success (Manchester, 2010), a matrix of key performance indicators was constructed. First the participants discussed and decided "*what a successful science park means to different stakeholder*". So they wrote down several aspects from the perspective of different stakeholders. Next, they prioritized the aspects and came up with indicators to measure progress on those aspects. Those indicators were translated into a performance matrix. The structure of the performance matrix could be interesting for the new performance model that will be developed for Technology Parks that are linked to the institution. (Dabrownska, 2011).

2.2.3 Method to define campuses of national interest

In 2009, Buck consultants international researched the question if stimulating campuses could have economic surplus value. According to their analysis, successful campus performs well on the four major

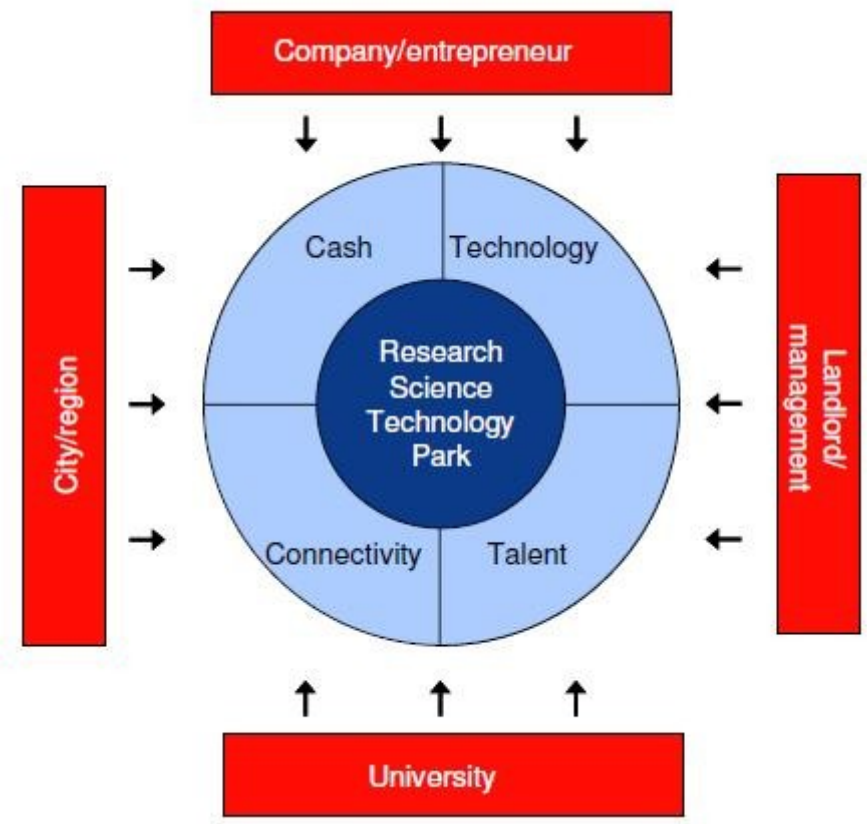

Figure 1: Important factors for a successful campus (Buck Consultants International, 2009)

factors: technology, talent, connectivity and cash. Those factors and interconnections are shown in figure 1.

The first step in the process to determine if a campus is of national importance, is to divide the campuses in 4 different stages with different maturities. In the figure 2, a distinction of the different type of campuses can be made based on several characteristics. The 4 stages are:

- Idea stage: initiative is in the exploration/feasibility phase
- Startup stage: physical environment is realized
- Growth stage: campus develops by increasing researchers and companies
- Adult stage: a large number of research institutes and R&D companies established on campus

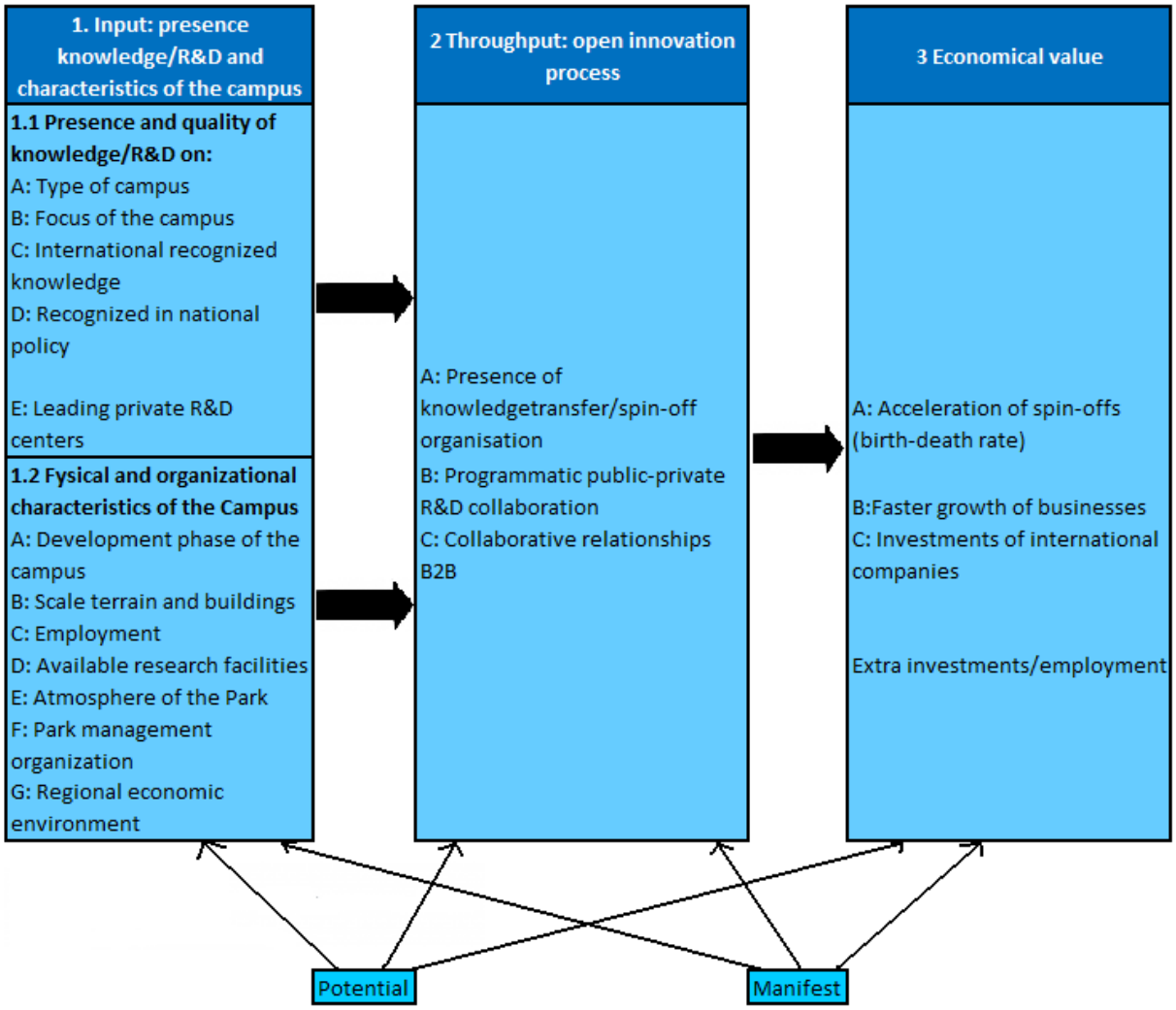

Figure 2: Framework for determining whether a campus is of national importance (Buck Consultants International, 2009)

The definition of 'campus' and 'national interest' can be determined also by following up the structure on figure 2. Two criteria are used to determine if a campus is of national interest. The first criterion is about the innovation policy of the region and the second one about economic mass (in terms of knowledge workers and R&D activities). If the campus (or Technology Park) currently does not has sufficient economic mass, the potential to generate the sufficient economic mass has to be considered. The main purpose of a campus is to facilitate the open innovation process and to stimulate knowledge exchange (Technopolis, 2009), but studies in Sweden and Italy also show that 'new technology based firms' in science parks perform better in terms of revenue growth, employment growth, intensity of relationships with universities and adoption of new technologies than new companies outside a science park. Summarizing, science and technology parks are because of their distinctive character an innovation accelerator on national level. In the international competition on R&D and knowledge economies, a well performing science or technology park can be an advantage in size. (Buck Consultants International, 2009). Assessment frameworks of technology parks are discussed in previous sections, but business incubators have not been addressed yet. The next section elaborates on this subject.

2.2.4 NBIA discussion on impact measurement incubators

Because Technology Parks almost always have an incubator included in their parks, the researcher shortly discusses the impact of incubators. Incubation is, especially in the discussed parks, an important service and process where tenants can profit from. When measuring impact of Technology Parks a short discussion which indicators should be used is necessary. An article that most probably can contribute to this discussion is written by Amezcua in 2010. Based on survival (number of years a company has black figures), employment growth (number of jobs created) and sales growth (faster revenue acquisition) the researcher is comparing the performance on these indicators of incubated new businesses with unincubated new businesses. According to the general conclusion stated in the report, the survival chances of incubated firms are less than unincubated firms. On the other variables, employment and sales growth, incubated firms perform better. Despite these conclusions a lot of discussion is still going on. In the end, the ROI indicator seems to be the most important indicator because it expresses the economic contribution in a quantitative way. (Amezcua, 2010). When using a set of criteria it is important to check from time to time if this set is still up-to-date and covers all the important domains. Section 2.2.5 describes an example of such an evaluation tool.

2.2.5 Evaluation tool for indicator lists

Measurement tools and indicator lists have to be updated and evaluated once in a while. Tools can be outdated or designed based on old ideas. To evaluate this, the evaluation matrix in table 3 can be used as a basic format. It contributes to the completeness of the list and indicators are evaluated by the goals of the Technology Park and selection criteria.

Indicators are used because they can monitor progress and help to project future consequences in the decision-making processes. A big advantage of indicators but also something that must be realized is that they are abstractions of reality. Furthermore, indicators allow comparison among parameters and domains, as is shown in table 3.

Table 3: Urban Sustainability Indicator Evaluation Matrix (MacLaren, 1996)

Domain	Potential Indicator	Tec Park Goals								Indicator Selection Criteria							Pressure	State	Response
		1	2	3	4	5	6	7	8	A	B	C	D	E	F	G			
Environmental																			
Social																			
Economic																			

The indicator selection criteria consist of different criteria that check if the right indicator is chosen and if the indicator measure up to certain important characteristics of indicators. Examples are:

A. Based on accurate, available and accessible data of known quality
B. Representative of the phenomena being measured
C. Relevant to users, decision-makers, local and global sustainability challenges
D. Understandable to the local and broader communities
E. Geographically and temporally comparable
F. Attached to a clear and ambitious goal
G. Reflective of the community's capacity to effect change

Adapted from (Cole, 2003, p. 34) Campus Sustainability Assessment Framework

Summarizing the findings in the study of Taylor in 2012, it can be concluded that organizations often use inconsistent numbers of domains and indicators, have lack of focus on long-term considerations, use indicators that are not attached to goals, use in abundance 'state' indicators and most processes are top-down. When using indicators for measurement purposes it is important that people that have to work with indicators can realize the benefits of a collaborative approach and that openness (of tenants) is a requirement. A disadvantage of the collaborative approach is that common indicators often do not give the right representation because of the unique local environment and requirements. And that is something that people do not want to lose, those unique working circumstances. (Taylor, 2012).

2.2.6 Recommendations on impact studies

The NBIA production Business Incubation Works (Michigan, NBIA, Council, & University, 2001) revealed a set of recommendations on incubator-specific impact studies. Those recommendations are useful when implementing the measurement tools, so they are focused on the implementation phase. Recommendations are to develop and utilize a common set of metrics and measures; make ongoing use of benchmarking; develop methods to have a high response rate on measurement tools; make use of stakeholders and industry experts; find control groups and; take into account that economic models may or may not be cost effective for estimating the total economic impacts of the incubation program on the local community.

2.3 Mexican context of Technology Parks implementation

The Mexican context will be described below. It is necessary to understand the economic, political and social conditions in Mexico, because these conditions have impact and influence on Technology Parks operation in Mexico. First the general Mexican context will shortly be discussed and next the report focuses on the system of the institution and its conditions.

2.3.1 General Mexican context

Mexico is a big country with an important economic growth potential, but the last couple of years the competitive position in different OECD rankings decreased. (Aguirre, 2009). The last 10 years exporting activities have increased largely, but economy has not been growing fast enough to create enough jobs for the working population. Employment figures are not as they should be and compared to fast growing economies as China and India, Mexico is behind on schedule. Mexico cannot go backwards to a low wage manufacturing country, but it also has not access to international markets because development of high-value products and services is low. The CEPAL report stresses the importance of promotion of technological innovation and support of local suppliers. This is also stated in the report of Aguirre in 2009: "*Federal and State governments are looking for alternatives to economic development, with a particular emphasis on high-value activities, sustainability, and long-term competitiveness*". So the reason why Mexico started to implement technology clusters is obvious. The importance of high-technology clusters is underlined by the government and University will not have to worry about governmental support in future projects. In Mexico, firms and universities rarely work together and the Mexican government interferes a lot in innovation clusters. Yes, the government should push companies and universities together but after that has happened they should just facilitate and not interfere the process frequently. These Mexican conditions are important to take into account when conducting a research on Mexican Technology Parks. The context of the specific parks that are linked to the institution is described in the next section.

2.3.2 The institution

The system of the institution consists of 4 entities. The institution is a higher education institution, which educate citizens who are ethical responsible, with a humanistic and international outlook. They carry out scientific and technological research. With their network of Technology Parks and business incubators and accelerators they promote creation of wealth and well-being in the different regions of the country; and with entrepreneurial and social development programs they contribute to the improvement of living conditions in other sectors of the population. It also has two graduate schools.
Their main academic areas are: engineering, ICT, business, health, humanities and social sciences and environmental sciences. Today, the institution has 65 incubators in Mexico located in 16 Technology Parks. (Aguirre, 2009).

The main reason why the institution started with building Technology Parks is stated as follow: "*the quality of science and the contributions of Mexico to global science is of high level. However, the contribution of Mexico's science and technology system to societal development has been hampered by two main factors, namely: lack of demand-driven technological support institutions, with associated centralized control by federal agencies and an over-emphasis on the supply of science and technology services versus incentives for articulation of demand*." (Molina, Aguirre, Breceda, & Cambero, 2011)

In figure 3, a graphical presentation of the 6 different systems present in the theoretical model of Mexican Science and Technology institutions can be seen. They are interacting with each other. The main actors agree on other global models used by these kind of institutions. The figure indicates 2 things: the complexity of managing 6 interacting systems and the potential advantages that can be achieved by clustering these systems. In most of the parks linked to the institution the government is not represented, but they are needed for company attraction and funding of research.

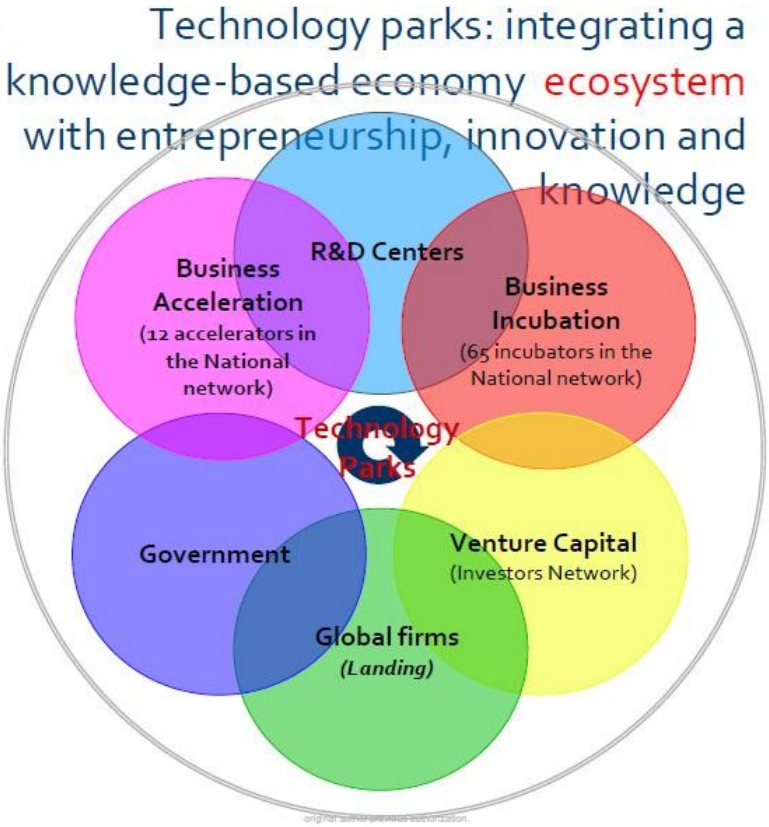

Figure 3: The ecosystem of Technology Parks in Mexico (Aguirre, 2009).

Considering the natural, economic, demographic, and social policies of each region, the institution has developed four models to the national reality and conditions. These models are based on best practices around the world, but adapted and shaped to the Mexican reality.

2.3.2.1 Different Technology Parks models used by University

When the institution started with the development of multiple Technology Parks, they made a classification of the Technology Parks by using 4 models. These models are designed by management of the institution and any of them were neither copied among them not from existing theory. Below the 4 models will shortly be discussed.

Model 1: Technology Parks for High-value employment

Vision of the model: a park that permits students and alumni to work on high-value activities. These technology parks are designed to accommodate companies looking for human resources for high-value activities, which do not require science and research. The parks provide specialized talent to technology companies in an environment close to the university. Immediate feedback on the part of the companies is necessary to enrich the educational model and thus improve the profile of graduates.

Model 2: Technology Parks for the attraction and development of companies

Vision of the model: parks to facilitate the commercialization / transfer of Tec technologies, the high-value domestic and foreign companies. These parks are principally combinations of high-tech incubators (to boost start-ups) and landing centers to accommodate foreign technology enterprises that wish to set up operations in the region. Technology Parks of this type strongly support consulting services, administration of technology, networks and specialized exchange between R&D capacities of

universities with the businesses. These centers do not include the R&D themselves, but provide a group of managers and brokers who are highly trained in the technological area.

Model 3: Technology Parks for enterprises with scientific activities

Vision of the model: parks to globally position research and the generation of high technology companies in key sectors requiring specialized infrastructure. This model has similar characteristics to those of Model 2, but includes specialized laboratories designed to satisfy the needs of highly sophisticated companies in sectors such as biotechnology and nanotechnology, which require immediate access to laboratories.

Model 4: Regional Technology Parks with different sponsors

Vision of the model: science and Technology Park that contribute to the transformation of the regional economy. Diverse business and academic organizations – of both the public and private sectors – invest and participate in them. These parks belong to the most widely used model of science and technology parks in the world, built on large tracts of land, with infrastructure like a college campus, with various R&D centers, universities, companies and services sharing the same space thus facilitating the relationships among various of entities. These regional projects are mainly funded by governments, given their high costs and scope.
(Aguirre, 2009).

Concluding, we can say that some models are designed for R&D activities, while other models are designed for teaching/training-centered activities. Nevertheless, all the Technology Parks include technology transfer, technology commercialization and technology business brokering activities. See figure 4 for a visual representation of the models.

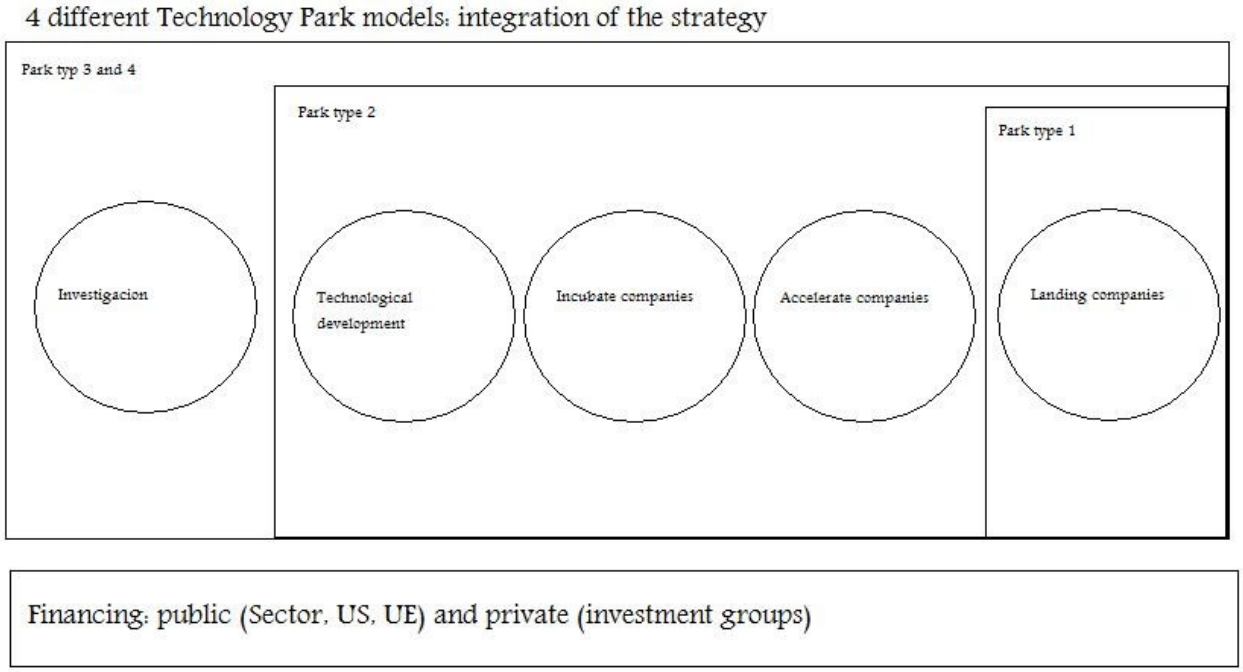

Figure 4: Visual explanation of the 4 models (Molina, Aguirre, Breceda, & Cambero, 2011)

2.3.2.2 *Action Research planning methodology used for implementing the models*

The collaborative and competitive nature of the technology park models proposed by the institution requires a "*planned creation*", which can be achieved by using action-research (AR) methodology at various stages of the process. AR is defined as a spiral process that allows action (i.e., design, implementation, change, improvement) and research (i.e., understanding and knowledge) to be achieved at the same time and is represented in figure 6. The main characteristics are:

- Cyclic: similar step tend to recur, in a similar sequence
- Collaborative: clients and informants are involved as partners, or at least active participants, in the research process
- Qualitative: it deals more often with language than with numbers
- Reflective: critical reflections upon the process and outcomes are important parts of each cycle.

(Molina, Aguirre, Breceda, & Cambero, 2011).

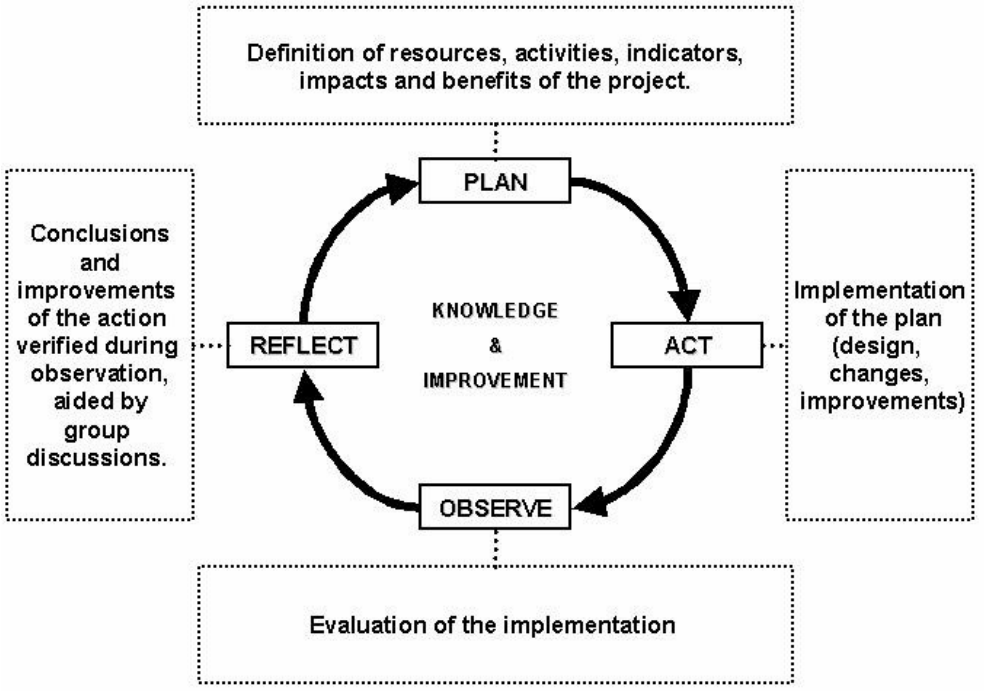

Figure 5: Action Research phases (Molina, Aguirre, Breceda, & Cambero, 2011)

For the design, creation, implementation, evaluation and improvement of a Technology Park, a research group at the institution identified three initial action research cycles: Technology Park model conceptualization, Technology Park pilot or exploratory test bed and Technology Park growth and consolidation. Figure 6 shows a visualization of these cycles. (Molina, Aguirre, Breceda, & Cambero, 2011).

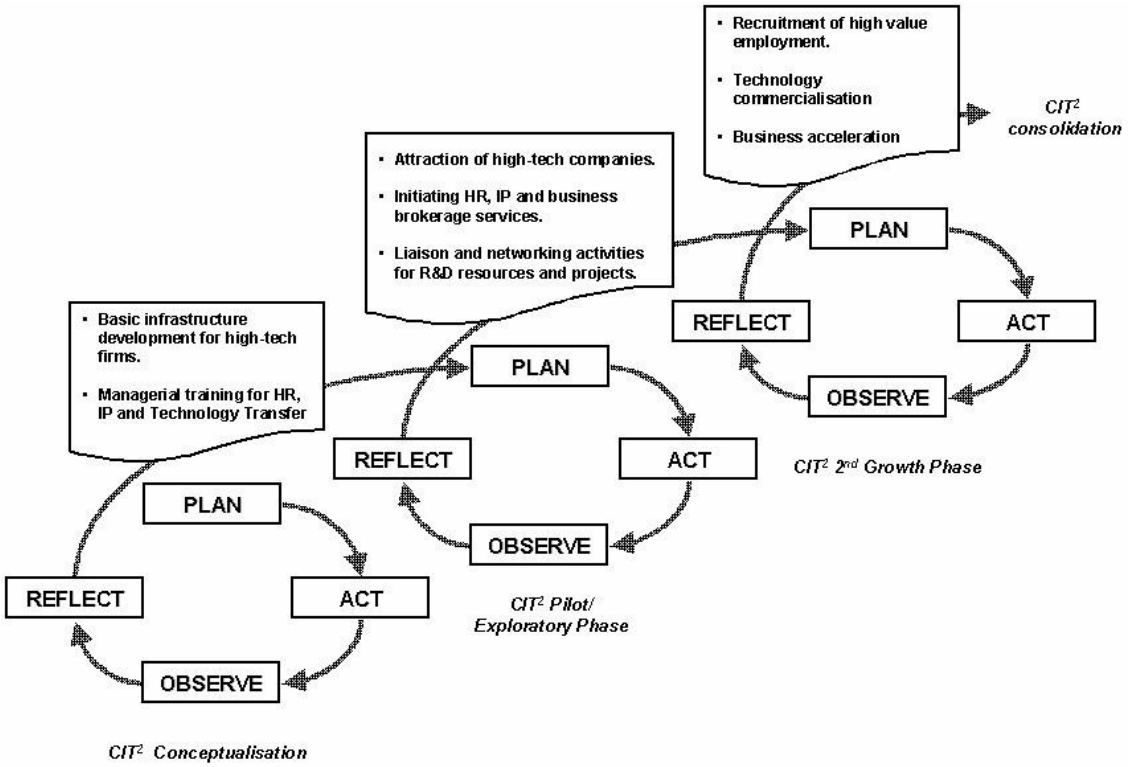

Figure 6: Example of the Action Research cycle (Molina, Aguirre, Breceda, & Cambero, 2011)

Before the institution develops and builds a Technology Park, the potential region was thoroughly assessed on 2 important aspects:

- Are there enough resources in the region? (Money, people)
- Does a Technology Park fit in the economic future/purpose of the region?

If both answers to the questions were positive then the development cycle could start. If not, then the possibility to create a desirable environment was considered. (Aguirre, 2009).

2.3.2.3 Funds

The basic structure for funding the Technology Parks is the same for all parks. Basic characteristics are similar though the details differ from state to state. The primary resource for building a park is ground, which in general is possessed by the university system. They have a partnership with company X which provides, for example, the cement for the buildings for free. For the completion of the buildings the institution has to do an investment. The additional equipment to fill the empty building(s) can be done by money from the state government. Some parks also apply for federal funds (which are provided by the federal ministry of economy), an example of this is the PROSOFT fund. The funding budget in the IT sector increased in 2006 to X million USD with the main goal to increase the average level of IT investment in order to meet the average rates of from other OECD countries, increase a local production of X million USD annually by 2010 and to convert Mexico into the Latin America leader in IT developing services. (PROSOFT Grants). To have some return on the investment the institution is renting the office space to the companies, further description was reported on 2010 by the USP see figure 8.

Funding of research

Companies can apply for (federal) funding if it was used for R&D purposes. The Technology Park management provides the companies with information where to sign up for funding; the rest can be done by company members themselves. With the funds the companies can also pay human resources

(student/professor salary). In a certain state, for example, there exist rights on receiving funds so that PhD students and students with a master degree for the next 2 years can be hired by the tenants, if the purpose is in line with the R&D policy of the government.

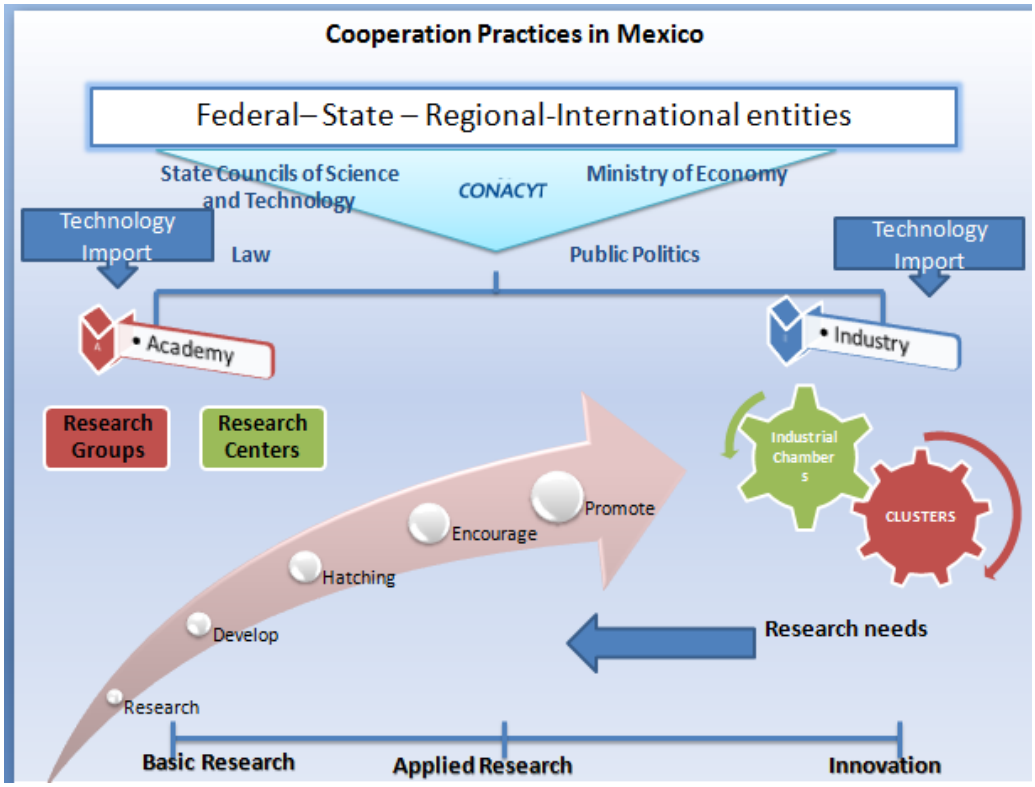

Figure 7: Funding model University (USP, 2010)

Figure 7 is an abstract of the innovation model of Mexico. Clusters are an important aspect of innovation, also in Mexico. In the upper halve of the picture some funding entities are mentioned that supply an important part of the technology funds.

The next section elaborates on the methodology that is used during this research. To gather data interviews were held with directors of Technology Parks and the employees of tenants. Besides this, it will be explained which databases are used and which techniques are available and were used to analyze the empirical data.

3 Research methodology

In this section, the methodology to carry out this research is described, including methods that were used in data collection and sample selection. With the interest to have an integral overview of the methods which were applied for answering the seven research questions enlisted in section 1.2. Additionally, the researcher included per question the most suitable sources of information. The overall research methodology is shown in table 4. The types of information to be gathered are from primary and secondary sources. Target groups to be consulted and desired outputs were also indicated.

Table 4: Research strategy

Research questions	Research methods	Target group	Output
1	Literature review (secondary source)		Clear list of criteria to identify the Technology Parks and a general accepted definition
	Interviews by semi-structured questionnaires	People specialized in Dutch and Mexican spin-offs organizations (expert opinion)	Information if it is actually possible to make a distinction of what exactly a Technology Park is
2	Literature review (secondary source)		Identification of the most used indicators and procedures to measure the established list of criteria in RQ 1
	Interviews by semi-structured questionnaires	People specialized in Dutch and Mexican spin-offs organizations (expert opinion)	Determine how specialists gathered their empirical data
3	Interviews (primary source) See annex 2.	Directors of Mexican Spin-offs	Empirical data that can be used to determine which Technology Parks can be considered as 'Technology Parks'
	Data mining (from primary source)		Complementary information about Technologic Parks criteria from official sources
	Telephone interview (primary source) See annex 3.	Companies in the Technology Park	Operationalization of the criteria found from Q1, Q3 (questionnaire)

4	Literature review (secondary source)		Clear list of criteria that are related to the university - research center relationship and a definition of research centers
	Interviews (primary source) See annex 4.	Directors of Mexican Spin-offs	Current state of amount of knowledge transfer at the different Technology Parks
5	Additional literature review (secondary source)		Some background information about sustainability in Technology parks that can be used as starting point for data analysis
	Data generated from the interviews in RQ 3 in comparison with the sustainability criterion (primary source)		List of Technology parks that are considering the sustainability criterion to a certain extent (to what extent also has to be measured because every park probably will have 'something' about sustainability included)
6	Interviews (primary source) See annex 4.	Directors of Mexican Spin-offs	Empirical data that can be used to determine how the impact of Technology Parks is measured
	Data mining (from primary source)		Complementary information about the measurement of impact of Technology parks from Official sources
	Telephone interview (primary source) See annex 3.	Companies in the Technology Park	Operationalization of the measurement methods of Technology parks
7	Literature review (secondary source)		Best practices, success factors and model improvements for the subject 'Technology Park'

By using this methodology the right information for this research will be gathered. It is important to keep in mind that this methodology is adaptable.

3.1 Research structure

Figure 8 is a graphical representation of the basic research structure. The purpose of this picture is to show the reader the red line of the report in a graphical way. The two main lines are: determine the performance of the Technology Parks on international criteria and improve the performance and impact measurement.

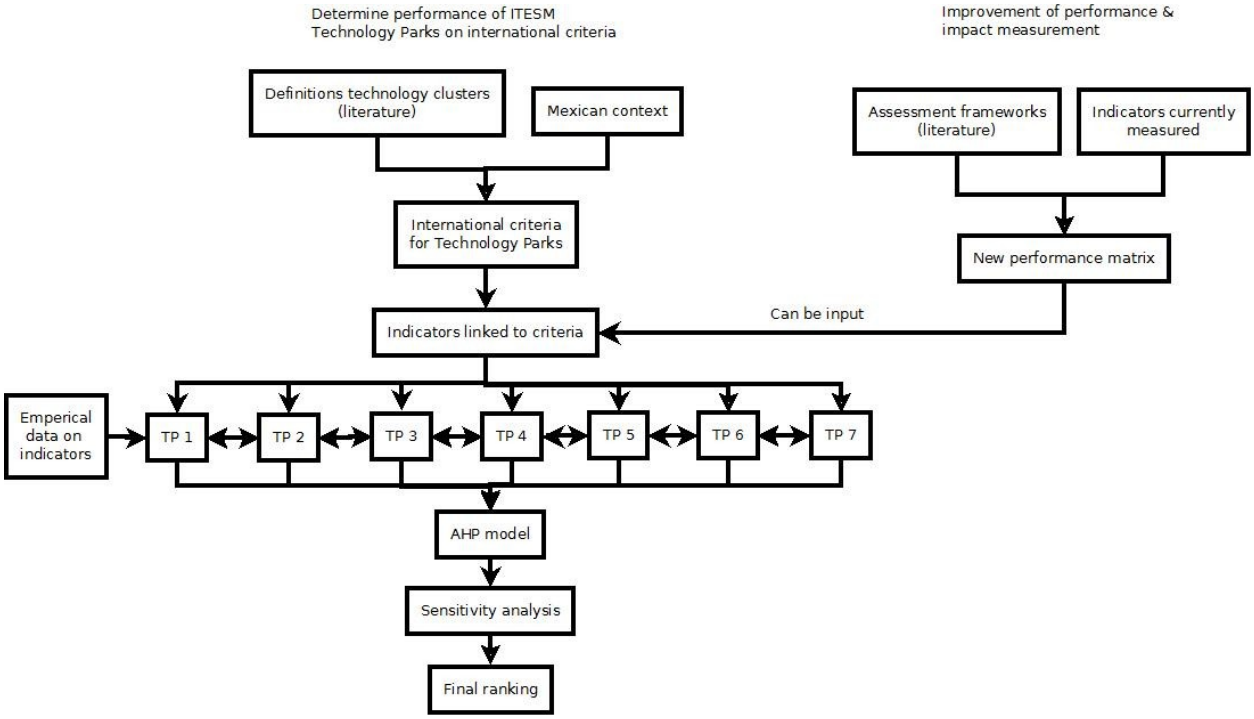

Figure 8: Graphical representation of the research structure

It is important to understand that the constructed performance matrix *should* be the input of the assessment of Technology Park performance, but at present this is not the case. This is indicated with the line from 'new performance matrix' to 'indicators linked to criteria'.

3.2 Research databases

Researchers describe here the approach used to search in different specific sources of information about Technology Park criteria and measurement of regional impact of Technology Parks. Indeed, the online search engines such as Google Scholar and Web of Science and the university library of the University of Twente helped in a trustworthy way to build up the information baseline about the core issues of this research. Furthermore, the researcher browsed through the bookstore of the NBIA organization. NBIA is an international organization and a knowledge source specifically for Business Incubation. By searching through this database the researcher came across with some interesting books which were ordered as starting point of the literature review. Another database specifically on Business Incubation is the IASP bookstore with substantial amount of papers and articles with case studies.

3.3 Empirical data-collection methods

For this research, there exist two data gathering methods that provide empirical data. The researcher shortly discusses the pro's and con's of the three techniques.

3.3.1 Interviews

The main benefit of the interviewing technique is the possibility to depth information exchange. Not only spoken words are recorded, but also nonverbal behavior can be analyzed. However, according to the literature about interviewing as empirical research method, it is required a set of skills which includes high interpersonal and communication skills, experience with interviewing techniques, among others. Another drawback is the time required for each interview. A semi structured questionnaire was used per target group interviewed; the technology park directors (annex 3) and companies based in the technology park (annex 2).

3.3.2 Data mining

The advantage of data mining is that it will provide the researcher with hard quantitative data. Generally, people trust quantitative data more than qualitative data because qualitative date leaves room for different interpretation and speculation. (Babbie, 2010).

3.4 Multi criteria decision analysis (MCDA) technique

Before the Technology Parks of the institution can be assessed by a Multi criteria decision analysis technique, it is relevant to provide a short introduction to the MCDA techniques. Those techniques support decision makers or management to structure decision problems that consist of multiple criteria and to analyze data. There are more than 20 MCDA techniques and two of them are described below. Both are suitable for analyzing Technology Park performance on criteria or indicators, but both have different purposes, input and output.

Analytical Hierarchy Process (AHP)

AHP (Saaty) is one of the many multi criteria decision analysis (MCDA) approach and is used very often in complex decision making models. AHP is a method for translating complex decisions into a rational framework that is used in making the right decision. It is used among others for problems like decision making processes, ranking, prioritization, resource allocation and benchmarking. It assesses the relative weights of multiple criteria against multiple options making pairwise comparisons. Four basic steps are identified:

1. Structuring the decision problem and selection of criteria
2. Priority setting of the criteria by pairwise comparisons
3. Pairwise comparisons of options on each criterion
4. Obtaining an overall relative score for each option

AHP can be used to rank performances of Technology Park in a structured way by compare the performance of a Technology Parks with other Technology Parks against certain criteria. It is an analytical way to prioritize performance of alternatives on certain criteria and indicators. (Nadja Kasperczyk, 2004).

Sensitivity analysis

In MCDA techniques the attribute with the highest priority weight is usually considered as the most important criterion. Changes in an attribute with the highest priority weight should affect the final ranking, but this is not the case in AHP. The smallest change that causes an alternative ranking is not automatically related to the attribute with the highest weight or priority. Therefore it is recommendable to perform a sensitivity analysis after using AHP and identify for each attribute the minimum change that cause a change in final ranking. (Zhu, Aurum, Gorton, & Jeffery, 2005).

DEMATEL

The DEMATEL (Decision Making Trial and Evaluation Laboratory) technique is used to construct the relationship structure of aspects/criteria. It can help finding the critical aspects/criteria of complex structure system. It is a quantitative way to determine the relationship between the evaluation criteria and establish their values structures. When improving the performance of Technology Parks it is important to identify the important criteria that have the most influence on the final performance. Next, technology park policy can be adapted to improve performance on these set of important criteria to gain big improvements in results. In annex 8 is an example set of criteria that can be used when applying the DEMATEL technique. (Chia-Li Lin, 2009).

The researcher chose to use the AHP technique and not DEMATEL. The reason was that for applying the Dematel methodology the satisfaction degree and the priority/importance level on all the criteria are required and the researcher did not evaluate those aspects for the purpose of this project. However, further investigation of the technology park performance by Dematel can definitely contribute to the ranking method. It is mostly used to show the relationship structure of criteria and translate that to a complex performance matrix. Its final goal is to find the most influencing criteria on other criteria. That means that by improving those criteria the performance will be influenced in a magnified proportion. Basically, the main difference between AHP and Dematel is their focus. AHP focus is on assigning weight to criteria by pair wise comparison and Dematel focuses on the defining the relationships between the criteria. Both goals are interesting, but for performance measurement and analyzing performance on criteria the AHP methodology is more suitable.

3.5 Target population and sample size

The target population will consist of 7 Technology Parks (instead of 16) connected to the institution, due to a limited time frame. In consultation with the director of all the Technology Parks was decided which are interesting for the study and suit within the subject of the research. The directors of the Technology Parks are my main focus group for data collection. However, these directors possibly will not be entirely objective so it would be recommended to have controlling target population. Therefore the researcher will interview the tenants in the park for a different perspective to see if outcomes and result are objective.

4 Findings

In this section the researcher will present the important findings that are necessary to give answer to the research questions. The collected data from the Mexican context is very extensive, however not all findings are relevant for this research and because that, can be useful for management of the institution and further research on Technology Parks.

4.1 International criteria of Technology Parks

As mentioned in section 2.1, there exist different definitions on Technology Parks, Science Parks, Research Parks, among others and in consequence their application might cause confusion. Some definitions state that 'Technology Parks' have manufacturing activities, some authors say that 'Technology Parks' have small manufacturing activities and some say they have no manufacturing activities at all. The Mexican strategy of Technology Parks differs from the European strategy and approach. European Parks are big regional parks with multiple buildings (>10) build on a large piece of land. This is too expensive for the economic situation Mexico faces right now, so that is why the strategy is somewhat different. The Mexican parks focus on very high technology projects with short term result. (Aguirre, Interview park directors, 2012).

The focus of Technology Parks is more on high technology application and commercialization when compared to Science and Research parks that have a more research and development focus. The researcher compiled a set of criteria from 3 different definitions out of literature and constructed a framework for Technology Parks. The main idea was to create a set of criteria that covers completely the definition of Technology Parks. The researcher chose to exclude a criterion about manufacturing activities, because this is not a criterion for all Technology Parks and management of the institution explicitly added to the definition that in these parks manufacturing activities are not allowed (see section 2.2.1).

This is because the parks want to have employment of college educated people, preferably having a master degree, with high value jobs (and thus high salary) instead of the low value jobs manufacturing brings along. A motivational argument for this criterion is to use the maximum available capabilities of educated people. So, let the engineers work on the same professional level as their study educated them. In Mexico, there is a demand for high technology companies who can supply in these high value jobs. High value companies are screened on three important criteria: have they high value products? Do they have a R&D focus and do they make use of science? Even if the company itself is high-tech, like for example Sony, there is no place for a manufacturing facility of DVD-players. The R&D department of Sony is more than welcome in the parks, but production facilities are a "no go". Management has to be very strict on this issue. (Aguirre, Interview park directors, 2012).

According to different definitions found in literature, these are Technology Park criteria:

1. Has to be managed by a specialized professional team with a certain level of quality that (Ratinho, Henriques, & Maltez, 2007):
    i. Has the capability of comprising three different but integrated perspectives in daily operational management, i.e., science, business and policy;
    ii. Has the capability of providing adequate innovation support services to tenants and
    iii. Has the capability of exploring innovative ideas and establishing management practices that go beyond tenants needs and expectations
    a. Provides value-added services (L. Sanz, 3 Oct. 2001)

b. Aim to increase competitiveness of the region (L. Sanz, 3 Oct. 2001)
c. Stimulates a culture of quality and innovation among associated businesses and knowledge institutions (L. Sanz, 3 Oct. 2001)
d. Organize the transfer of knowledge and technology from its sources to companies (L. Sanz, 3 Oct. 2001)
e. Actively foster the creation of new and sustainable innovation-based companies through incubation and spin-off processes (L. Sanz, 3 Oct. 2001)

2. Has a formal and operational link with university/higher education institution/research center (Chan & Lau, 2004).
3. Encourages the formation and growth of knowledge-based business normally resident on site; has to include an incubator (Chan & Lau, 2004).
4. Provides other value-added services together with high quality space and facilities (IASP international board, 2002)

To make these criteria measurable, additional indicators are required. The researcher linked to each criterion one or more indicators. The indicators the researcher used were already evaluated therefore the researcher was able to use that specific set of indicators.

Technology Park definition from park directors

Table 5 shows the compilation of director's opinions about what makes a park a technology one. It is relevant to know the personal definitions of management on Technology Parks.

Table 5: definitions from park directors

Park	Definition
Park 1 (model II)	*"A Technology park is a physical space that accommodates knowledge, professors and students and connects them with companies to generate an entrepreneurial environment. Also important that it generates employment and development in the region."*
Park 2 (model II)	*"A Technology Park is a habitat where companies and entrepreneurs create networking between the companies, this is an important requirement. Also important is the presence of a business incubator and landing companies in the same place. Technology and innovation are important in a technology park, it has to an innovative area for designing innovative technology."*
Park 3 (model II & IV)	*"A Technology Park is a physical space that combines research and development activities and has a relationship with a university or research institute. And has a connection with companies that are interested in knowledge and knowledge workers. So it combines a knowledge generator and companies that applies the knowledge for industrial and commercial purposes. Many technology parks share the characteristics that they have big green areas, common spaces and facilities, attractive work spaces to have a good environment for knowledge worker."*
Park 4 (model II)	*"There are several accepted definitions of Technology Parks. For us it is a building with facilities where you have companies that are interacting. We have companies that are landing here, a business incubator and accelerator, a lot of technical services provided to the companies. For example a machine center, a welding lab, a lean manufacturing center, so different kind of services that are offered to the community and region. The Technology Park is the facility that integrates all the different programs and services either for students or the companies."*
Park 5 (model II)	*Technology Parks are spaces or infrastructures that promote the regional development. They are located within an university and are linked with the activities of academies like project development and research."*
Park 6 (model II)	*"A Technology Park offers support to business in incubation and acceleration periods and also in the landing process of international businesses allowing them to successfully install themselves in the region of the park. Generating businesses and improving existing ones are criteria for Technology Park success and added value."*
Park 7 (model II)	*"A Technology Park is a space to promote innovative and technology based products, services and business model to create improving value and contribute to regional development."*

When reading through the table 5 some factors are coming back in every definition. Terms as company creation/incubation, acceleration, landing, entrepreneurial environment, research and development, physical space, university are mentioned several times. The definitions also emphasize on networking, relationships, connections etc. Compared to the original definition of the institution, "*Technology Parks are physical premises designed to integrate firms aspiring to be incubated, accelerated, or adapted to the region (landing), through liaison and cooperation programs and activities among firms, with the campus resources and talent, and ultimately with academic, business, and government actor in the region*." (Aguirre, 2009). In some concepts, there are missing crucial terms, but the basic idea is in alignment with the original definition, except for one aspect. The government actor was not mentioned by any of the park directors, while governments are included in the definition. Perhaps this can be explained by the fact that most parks do not have a governmental institution in the park. Like earlier mentioned interaction with the government is mainly about funding or company attraction. Also, all parks (except for Park 3b) are model II parks which are park that "*facilitate the commercialization / transfer of technology, the high-value domestic and foreign companies*". Focus on regional contribution and scientific research development is low compared to model III and model IV.
The global definition of the institution on Technology Parks is in align with the definition of Technology Parks by Sanz in 2001. Definitions of the park directors are more or less similar to the global definition of the institution. So according to this comparison the Technology Parks should try to fulfill the criteria found on literature for the Technology Parks.

4.2 Data availability and currently used measurement methods

First of all the researcher has to say that interviewing companies in the park provided a different perspective on technology park measurement. Almost all interviewed companies answered negatively to the question if park management frequently ask data on company performance, while most interviews with park directors indicated a 6 month evaluation of company performance. So the opinion of the 2 different groups interviewed differs on this subject. The researcher did not found a consistent measurement form that can be used by all the Technology Parks to evaluate park performance or impact on the region. However, intranet that is used by all the parks is used for performance measurement. Each 6 months all the park directors have to fill in new figures on the intranet, but these figures are only about the number of incubation companies and the number of companies in the landing phase. It is not possible to make a complete performance indication based on only 2 indicators. The researcher does not know what possible sanction are if the targets figures are not met by Technology Parks.

4.2.1 Information available on management

Information on management of the Technology Parks dates back to 2010 and is measured through an indicator list. This list has only quantitative indicators. The content of the indicator list is included in one of the annexes for an impression of indicators evaluated. In 2010, it was the last time that this list was used and 60% of all the indicators were evaluated. So quantitative data provided by this tool is neither complete nor up-to-date.

4.2.2 Information available on services

The services provided by the Technology Park are among others measured by the indicator list (for example the number of public funds managed by the Technology Park for the companies) but can't only be expressed in figures. These services need to be evaluated and if necessary adapted to the needs of the tenant firms. In the campus of Park 7 and Park 4 the services are not evaluated frequently yet. In Park 6, Park 2, Park 5 and Park 1 the services are frequently (after each semester) evaluated by the park

management and improved by the Plan, Act, Observe, Reflect cycle. The Technology Parks that do evaluate, sometimes include the opinions from the companies to evaluate a service, others do not. A transparent evaluation of the services provided is critical in Technology Park performance management.

4.2.3 Information available on regional contribution

Regional contribution of the Technology Parks is measured by the indicator list. For many park directors this is an important goal of Technology Parks and with this is in mind the number of indicators might be not sufficient for proper measurement.

4.2.4 Information available on quality/innovation and knowledge transfer

The culture of quality and innovation is properly measured by the indicator list and quantitative indicators. Most of the Technology Parks know exactly how many new patents, products and services are generated in one year. The participation of companies in R&D projects is also monitored very precisely because every company is obligated to have innovative R&D projects in collaboration with the university. Participation of companies in R&D projects is something that is underlined by all the Technology Parks and this process is monitored very precisely. This is overlapping with knowledge transfer because all the Technology Parks, with exception of Park 7, emphasize the importance of collaboration with students/professors in R&D projects. Some of the parks even consider this as the existence of the Technology Park. It is measured by the number of students/professors working in R&D projects together with the companies. Also, the technology park management has insight in future project plans of the companies. In that way they can optimally respond to the human resource wishes and needs of the companies. The park management brings students and companies in contact with each other. Based on the project type and size (wishes of the company) they will search for the right students.

4.2.5 Information available on incubation services

The performances of the incubation services are evaluated by the indicator list and in some parks by a special incubator form. Information on the number of incubated companies is monitored by intranet and park director have to update the figures each 6 months. Management of the incubators will have more figures on performance of the tenants. It can be questioned if this can be done more extensive because the incubators play a significant role in the growth of valuable high-technology based firms.

4.2.6 Information available on facilities

Facilities in the Technology Park are not evaluated by the management. Interviews with the companies gave an indication of a need of more social events to stimulate networking among companies. Also the lack of office space in some Technology Parks (Park 1, Park 2) is a problem for companies that have the ambition to grow. This represents a big problem and the researcher does not know if management is aware of the size of this problem and if they have thought about the solution.

When reflecting on Technology Parks it is relevant to have their opening year in mind. Also sometimes their alternative names are mentioned. An overview can be found in table 6.

This is relevant because parks that are very young will have different short-term goals than parks that already exist a few years. For example, for young parks it is more important to fill open office space with tenants compared to older parks. Also the availability of information will be different in new parks, because older parks will have more evaluation data available.

4.3 Performance of the Technology Parks

The findings for measuring to what extent Technology Parks fulfill to the definition are compiled from the interviews and available quantitative data. Below each park is evaluated on the 7 criteria extracted from literature.

4.3.1 Prioritization by park directors

Each park director was asked to prioritize the following criteria of a Technology Park:

- Organizes knowledge transfer (Know Trans);
- Stimulates a culture of quality and innovation among companies and universities (Qua Inno);
- Increases regional competitiveness (Compet);
- Encourages the creation and growth of new and sustainable innovation-based companies (Creation);
- Provides value added services (Services);
- Managed by a specialized team that has the capability to comprise different perspectives (Managed);
- Provides high quality space and facilities (Facilit);

As result of such enquiry, table 6 summarizes the director's opinion on the prioritization of Technology Park criteria.

Table 6: prioritization by park directors

	Opinion Park Directors							
Total	Park 7	Park 6	Park 5	Park 4	Park 3	Park 2	Park 1	
21	7	3	5	NA	4	1	1	**Know Trans**
23	5	6	2	NA	3	5	2	**Qua Inno**
13	1	5	1	NA	1	2	3	**Compet**
19	2	4	4	NA	2	3	4	**Creation**
27	3	1	6	NA	6	6	5	**Services**
32	4	7	3	NA	5	7	6	**Managed**
33	6	2	7	NA	7	4	7	**Facilit**

Priorities of management often indicate the focus of the Technology Park. Hence, when discussing the parks, management preferences should be considered. That is why this table is included in the report. This table is also used in the AHP model in section 6.

4.3.2 Overview of performance of the institution sample

Below a table is constructed about the performances of the parks on the seven criteria. The descriptions are short summarized lines which are specific for each of the parks. Representing the information this way allows easily making comparisons.

Table 7: Technology Park performance on the seven criteria

	Management	Services	Regional competitiveness	Quality & Innovation	Knowledge Transfer	Incubation process	Facilities
Park 1	Enough staff people to develop new services that are used by the tenants. Management is of high quality.	The most important service in this park is to link companies with the university.	The Technology Park aims to increase competitiveness in the region but their real contribution in terms of jobs generated and external employees is small.	The large number of laboratories and rules on participation in R&D projects indicate a R&D environment.	Knowledge transfer is the most important aspect in this park.	Start-ups only can join the park if they are student initiatives and if they went through the incubation process.	High quality facilities are present, but on a very small scale. The size of the park in m2 is very small.
Park 2	The staff has the right capabilities but the park is fully occupied and that is probably why they have problems manpower.	They provide value added services, especially networking services are of high quality and are organized frequently.	Impact on the region is high because of the high number of external employees working in the park and high number of incubated companies. Also through CEI.	Not all tenants are necessarily high technology companies, but the high number of patents generated indicates innovation. The R&D institution CIDEC is located in the park.	Knowledge transfer is organized through the Center for Entrepreneurship and Innovation (CEI), with the objective to promote economic development in the region.	The number of companies that make use of the incubation services is very high.	Office spaces, laboratories, sport fields and park lots are from high quality. It is a new building with a modern design.
Park 3	Management might be understaffed.	Main services that are provided are landing, incubation, recruiting, support of startups, networking, connecting them with consultants.	Park 3a measured this and concluded that they contributed to the region by job and company creation. Park 3b was too young to measure and the collaboration between the companies and the university is low, but maybe in the future this will increase.	Park 3b accommodate a lot, laboratories, research institutes and research company centers to create knowledge and research. Park 3a has some small research activities.	Park 3a is focusing on company creation and collaboration. So knowledge transfer is high in this park. Park 3b does not transfer but creates knowledge.	Park 3a is focusing on company creation and collaboration. A lot of start-ups are generated in this park.	Park 3a is not a very extensive area, but Park 3b is very big park with nice infrastructure and facilities.
Park 4	There are enough employees to	Services provided by the park are	The park contributes to regional growth	The companies do not make	This park organized knowledge	The number of companies	No information is available on

	execute the daily tasks, not for doing new things. There is very little communicatio n between park management and the tenants.	not evaluated and the park isn't currently measure anything.	by supporting local companies and government projects with academic labor, knowledge, etc.	use of the four available laboratories.	transfer through collaborative projects, especially those projects with government funding.	that make use of the incubation services is high compared to the size of the park.	this subject.
Par k 5	Management of the park has the knowledge and skills, but not enough manpower (and capability) to provide enough innovative support and exploring innovative ideas	The main services that are provided to the companies are student capital and the basic infrastructure . All services are evaluated after each semester.	By special business clinics the Technology Park tries to generate new businesses and jobs for the region.	The 4 laboratories and the 40 research institutes indicate a high quality and innovation based environment.	The high number of students that are working in projects with companies indicate a high amount of knowledge transfer.	According to the figures the incubator has not many clients.	No information is available on this subject.
Par k 6	The management has enough manpower, but they would like to see more cooperation between other parks in the Mexico and in the world.	The main services provided to the companies are related to technology information, competitor strategy and government funding. Service are frequently evaluated.	The Technology Park gives opportunities to students in whole Mexico to start with high technology ICT projects. The park develops human capital and also generate employment. All companies are based on high technology.	According to the number of patents and new products / services generated, Park 6 has a lot of R&D and innovation going on.	The park management offers seminars to transfer technology to the companies. University and companies exchange operational science.	The incubator in the park is important because it is the most valued aspect according to the entrepre-neurs. The number of incubated companies is very high.	It is a very new building with modern features like a convention center (1500 people), an auditorium (130 people), surveillance systems and infrastructure for voice and data connectivity with world-class standards
Par k 7	Extra employees are necessary according to the management. Even for daily tasks there are not enough employees.	Incubation, acceleration, networking and meeting rooms are the services that are provided to the companies. These are not frequently evaluated (yet).	This Technology Park encourages to work together to create products and services which solve problems in the market. It uses technology resources to amplify a spectrum of	The willingness of companies to participate in R&D projects is very high and Conacyt research centers are located in the park.	There exists a formal link between the Technology Park and the university, but currently there is no operational link so the transfer of knowledge is currently not organized.	Twelve of the fourteen companies in the park are start-ups and thus active in the incubation process. So the incubator is performing well.	Spaces for companies, meeting rooms, innovation areas, laboratories, cafeteria, parking, communicatio n and business support are examples of facilities in the

		solutions and generate competitive advantages.	Technology Park.

The biggest differences in table 7 can be explained by differences in park focus. For Park 2 networking events are important, for Park 1 knowledge transfer is important and for Park 3a company creation is important. Having this knowledge and information, the next step is to do something with it that contributes to the insight of the 7 Technology Parks. In section 6 this information will be further analyzed by the AHP method and eventually the 7 parks will be prioritized.

4.4 Classification of parks based on quality/innovation and knowledge transfer

In order to have a better understanding of the position of each park, a classification can be made based on 2 aspects. Such classification will represent the current status of the parks and the new insights gained, this approach can be useful for the management. They can change or maintain the overall strategy and targets to make sure the park is moving in the right direction. Below, some information is represented on each park that is related to the criterion 'quality and innovation'. In table 8 the priorities of the park managers are included. This table is a copy of the second row of table 6. For the managers of Park 1, Park 5 and Park 3, a culture of quality and innovation is on place 2 or 3 and thus important. For the managers of the other parks this criterion has less priority and is ranked in a lower position (place 5 or 6 out of 7).

Table 8: Priority of park managers based on 7 goals of a Technology Park

Priority of criterion: a culture of quality and innovation	
Technology Park	Place
Park 1	2
Park 2	5
Park 3	3
Park 4	NA
Park 5	2
Park 6	6
Park 7	5

Park 1

The fact that Company X has its R&D department located in Park 1 underlines the presence of an innovating culture. Other companies located in the park develop commercial and some R&D activities in the park, but R&D does not comprehend the majority of the activities.

Park 2

The R&D institution is located in the Park 2. This center belongs to the company group Y. Park 2 has technology based companies, but not necessarily high technology. Right now, there are three companies with R&D projects.

Park 3

Park 3b (owned by the institution) is inside the technology cluster (owned by the government) and started in 2005/2006. It really developed in 2007/2008 and it houses a lot of national research institutes

like Conacyt (national research council) and 7 research company centers. Some of those are from the food industry and companies from the energy sector. Several universities have their buildings and small technology parks, not only an university from the institution, but also the state and regional universities. The center is for example focusing on design and packaging and others are focusing on design for automotive industry. The big difference is that Park 3a (Technology Park) does not has sophisticated laboratories (not designed for that) like Park 3b has. That park has all kinds of laboratories and infrastructure for development and testing. Not only the university but also companies can benefit from those laboratories. Knowledge creation is more extensive in a park designed as Park 3b in X then Park 3a because that is more a collaboration/relationship/company creation park. The parks are working together because management is the same of both park and also companies are move from one park to the other one. Company Z was first in Park 3a for recruiting operations (60 engineers) and after that moved to Park 3b because they wanted to make use of the laboratories. Park 3a was build on initiative of the institution. TP was built as a joint initiative. The government wanted to have a place where knowledge is a central issue.

Park 4
The companies do not make use of the available laboratories very often.

Park 5
This park has 40 research institutes. The Technology Park has a close relationship with an research institute.

Park 7
This data shows that Park 1 is performing very good on quality and innovation. Especially the number of new products, laboratories and square meter of laboratories are impressive compared to the other parks, even after calculating ratios.

Based on the indicator framework formulated above in this section and considering the results while comparing the Technology Parks in terms of knowledge transfer (section 4.5) and the culture of quality and innovation (section 4.4), the researcher made a classification of the Technology Parks of the institution which is shown in figure 9.

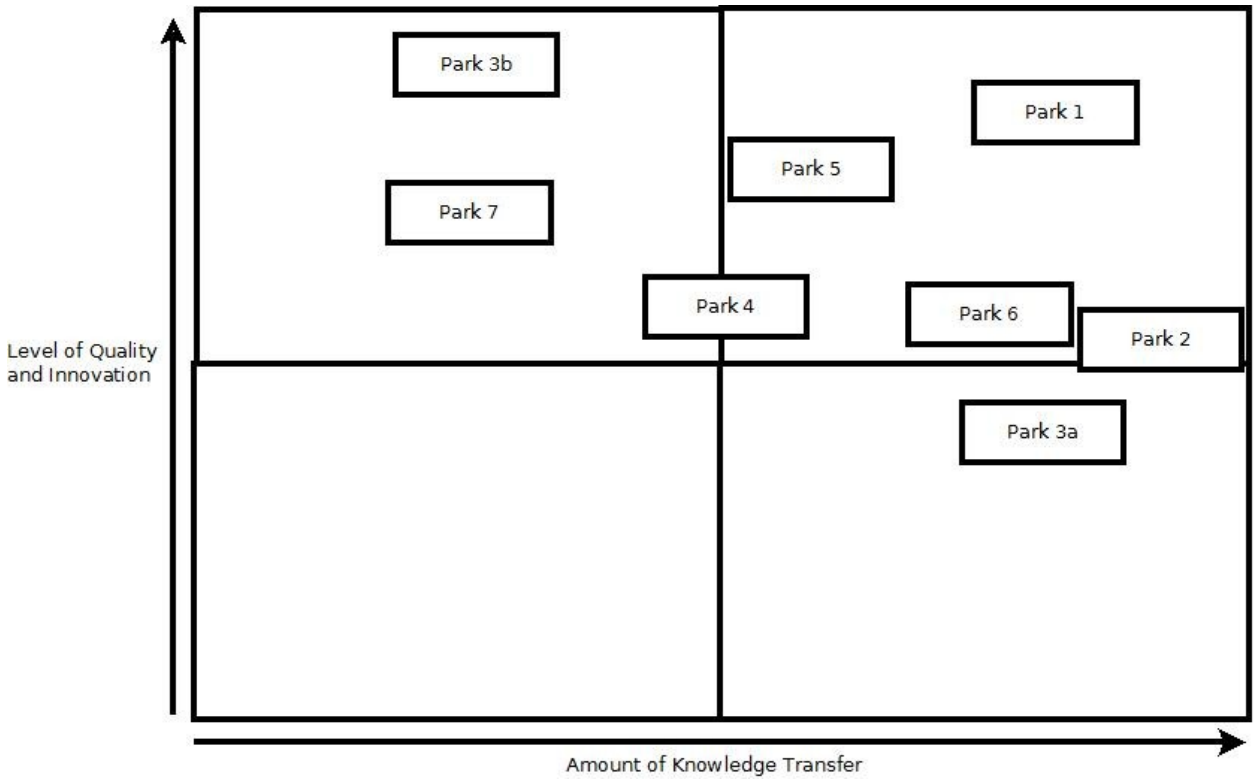

Figure 9: Classification of parks based on the amount of knowledge transfer and level of quality and innovation

This model is a classification based on only two factors and is therefore not a perfect classification, but it can be used as a starting point when describing the parks. The figure tells us that Park 3b and Park 7 main activity is generation of high quality knowledge by laboratories and research institutes (private and public). The transfer of this knowledge into products/services is low. Park 3a, Park 6 and Park 2 have opposite characteristics. In these parks a substantial amount of new companies, products and services are generated with available knowledge, but this knowledge is not necessarily scientific or high technology. So the amount of research developed is lower in these parks. Park 1 and Park 5 are performing on both aspects but their output and impact is small compared to the bigger parks. Park 4 has some knowledge transfer and R&D, but their focus is more on networking between the companies and adapting the education program according to the needs of the business environment.

4.5 Knowledge transfer

Findings for research question 4 are about knowledge transfer between tenants in the park and the university and research institution. Firstly, it is convenient to have a common understanding on what is 'knowledge transfer' and from literature is was found that: "Knowledge transfer is the process by which the knowledge, expertise and intellectually linked assets of Higher Education Institutions are constructively applied beyond Higher Education for the wider benefit of the economy and society, through two-way engagement with business, the public sector, cultural and community partners". (Holi, Wickramasinghe, & van Leeuwen). For the institution, this means to transfer research on high technology into improvements and commercialization of high technology products and services.

All the Technology Parks have formal contracts signed by the tenants including a condition that all the companies have to have collaborative projects with the university. When they develop innovative products and services the participation of students and professors are a requirement according to these

contracts. In some of the evaluated parks knowledge/technology transfer works both ways. For example the companies design projects that are synchronized with courses in the study program of the students, or the companies give presentations about their business. There are many ways to achieve the goals.

The 2 main reasons of the companies to work with the university is either they see it as an efficient recruitment service or as a source of high level science (professors). This depends on the type of company (very practical vs. very scientific) and their main activities (R&D or also other activities). The role of the Technology Park management is very important in this process. In the researchers opinion the management should facilitate this cohesion in the best possible way. That is an important part of their job description and the researcher noticed some differences between the parks on this subject. Of course tenants should emphasize their demand related to this subject, but on the other hand it is the task of park management to know which services need extra attention or need to be adapted. Therefore the evaluation of company opinions on the delivered services by the park is crucial. A mismatch between services provided and the needs of the tenants should always be prevented, because it contributes to the ineffectiveness of the park.

The most important tool to stimulate the knowledge transfer is to organize networking events where companies and students/professors meet. In Park 2 they even have a special department to manage the transfer and in park 1 a coordinator connects company with special human resource wishes with the right students. Interviews with tenants in Park 6 gave the impression that not enough networking events were organized according to the needs of the tenants. They do not know the core business of the neighbor companies in the park, which is not a good impression of a technology cluster. The prioritization of the park managers is an important reflection of their opinion on knowledge transfer. This is summarized in table 9 which is a copy of the first row of table 6.

Table 9: priority of park managers based on 7 criteria of a Technology Park

Priority of criterion: knowledge transfer	
Technology Park	Place
Park 1	1
Park 2	1
Park 3	4
Park 4	NA
Park 5	5
Park 6	3
Park 7	7

All the Technology Parks accommodate a business incubator that incubates student ideas and initiatives from the region. The large number of firms that are in the incubation process (table 10) indicates that the transfer of new high technology ideas into commercial companies is the link between the business incubators and the universities is of high quality. In all the technology parks 3849 companies are finding themselves in the pre-incubation, incubation or post-incubation phase. This is partly due to the entrepreneurial environment that the institution has created and the message they are sending out to their students.

Table 10: the number of companies incubated by the 7 Technology Parks

	Park 1	Park 2	Park 3	Park 4	Park 5	Park 6	Park 7
Openings year	2009	2010	2005	2009	2009	2010	2011
# incubated companies							

Below some specific information about the Technology Parks related to knowledge transfer is represented.

Park 1: X graduates were hired last year. Knowledge transfer is very important in the policy of this park. Park 1 checks if companies have R&D projects to develop new products, if it involves hiring of students, how many and what type of projects there are planning to execute. The involvement of students/professors in these projects is the most important issue in the Technology Park, because this is one of the reasons that a Technology Park exists. Knowledge transfer works both ways, so also from companies to the university (students). For example, managers are asked to give a presentation about theory in practice or to organize a conference to transfer this knowledge.

Park 2: knowledge transfer is organized through the XX. The objective of this center is to promote economic development in the region with a new generation of entrepreneurs, promoting business opportunities with high disruptive value proposition and overall impact. The XX offers four programs: 1) Entrepreneurial Families, 2) Attracting Investment, 3) Transfer of Technology and 4) Linking Entrepreneurship. The entrepreneurial families program has an agreement with a university in Canada, to develop business ideas based on a portfolio of patents and working prototypes of their allies in Canada, under the charter of intended for sale exclusively in Latin America. In total 15 graduate students were hired by the companies in 2011. Knowledge transfers in this park works also on the other way around, so the university and students have benefits from the tenant.

Park 3: events should be organized between researchers and companies to know their strengths and what each party is working on. These events are the responsibility of the park but it does not assure knowledge transfer. Feedback from the companies is important to the students in learning how to present themselves and how to construct a curriculum vitae. These are subjects that are discussed during recruitment events. In the past, fresh graduates from a certain degree didn't fulfill to one of the competence that were important to the high-technology companies. When this happened the university changed the program and added an additional subject on this topic. All these activities are related to Park 3a and not to Park 3b. Park 3a is more a collaboration/relationship/company creation park and has a high amount of knowledge transfer.

Park 4: through the collaborative projects the park organizes the knowledge transfer. The Technology Park is installing a welding classroom and an owner of a company helped building it and he can certify welders with AWS certification. This is an example of technology transfer. Especially those projects with government funding are often collaborative projects with the university. Knowledge transfer from the university to the companies exists, but we also can speak of transfer of knowledge the other way around, so from the companies to the university.

Park 5: at least X graduate students have been hired in 2011 by the X companies. Many of the students are at present working in projects with companies. The tenants make use of the knowledge of students, students can learn about practical experiences. Also, companies give presentations in different courses (guest lectures) about different subjects.

Park 6: the park management of Park 6 offers seminars to transfer technological knowledge to the companies. The companies also give practical experiences to the Technology Park. Some students receive the opportunity to work for a pre-established period by tenants and after this period tenants evaluate their performance and decide if they will invite the capable students after they graduate. In

2011, X graduates were hired by the all the companies of the Technology Park. Company B for example needs currently X new graduates each month. It is very important for them to be close to academic labor specialized in ICT.

Park 7: X graduates were hired in 2011. Technology Park Park 7 does not transfer knowledge right now, but they are working hard to be able to transfer knowledge and technology in the future. X uses German experience to promote knowledge and technology transfer between companies and research centers in this park.

The two important indicators measured by the parks are the number of linkage projects and the number of students and professors working in these projects. The figures of each park can be found in the graphs below. These figures were evaluated in the first months of 2012.

Based on figure 9 Park 1, Park 2 and Park 3 are performing good, but the researcher calculated some ratio's to make more direct comparisons. From these ratio's can be concluded that Park 5 is also performing good.

Based on all the data represented in this chapter, a ranking can be established related to the amount of knowledge transfer between companies and the knowledge institution:

1. Park 2
2. Park 1
3. Park 3a
4. Park 5
5. Park 4
6. Park 6
7. Park 7

4.6 Sustainability components

Findings of research question 5 are about the subject of sustainability. But firstly, what is sustainability? According to sustainabilitydefinition.org (2012) business sustainability refers to management of the threefold bottom line. "Threefold bottom line also commonly referred to as triple bottom line is the procedure by which companies handle their economic, societal plus environmental hazards, responsibilities as well as prospects". It is researched if the companies in the Technology Parks consider sustainability and if the Technology Parks themselves are active on sustainability.
The indicator list has very few indicators to measure sustainability. There are some indicators that measure job generation and job security which can indicate the performance on the social issues and there are 2 indicators on company satisfaction, but clearly this does not cover the whole sustainability definition. After reading the strategies, missions and goals of different Technology Parks it is clear sustainability is not included in their strategy and that is why it is not measured properly. Below some specific information about the Technology Parks related to sustainability is represented.

Park 1: there does not exist a screening criterion on sustainability policies of the companies, the park management does not ask about the environmental plans. However, they support green company projects. For example, one company is in the plastic recycling business, one company is specialized in electronic billing (reduction of paper usage) and another company developed a pill that can be inserted in the gasoline tank to drive more kilometers with the same amount of gas. They do not have a formal corporate responsibility strategy, but companies empower employees and are managed in a democratic

way. They can't have an official address in the campus; the institution is not responsible for angry customers (for instance, if they do not have received promised products), but if the company acts unethical then the park takes actions against that company. The policy in company X is that new products need to be environmental friendly. An example is the electronic billing mobile service (use of less paper). The company X is another example, they develop projects that focus on energy savings and green technologies. They do not report anything about sustainability to green instances. The fact that they are a green company does not have anything to do with the Technology Park.

Park 2: there does not exist a screening criterion about sustainability intentions when the Technology Park is selecting companies. The TP fulfills to the same regulations as the campus regulations and the building was designed and constructed to be environmentally friendly and is currently in the process of LEED certification (Leadership in Energy and Environmental Design). They also reduce energy consumption through movement sensors. The park management does not know the stakeholders' attitude towards environmental problems. So the park itself (the building) tries to stay ahead of environmental regulations by applying for the LEED certification, but when selecting companies for the park they do not have a sustainable criteria. The main focus is to let companies grow in high technology development, sustainability is in this phase subordinate according to park management. A company example: the company X does not report to legal instances, but they have some sustainable goals. The lifetime of the products has to be large (4/5 years) and they make sure that batteries have a long lifetime. Also all the components of the products are led free.

Park 4: there is a renewable energy center inside the Technology Park and they support green technologies, but they do not have a corporate policy on sustainability.

Park 5: companies are not screened on sustainability intentions, but they have to reduce their waste. The park itself is not staying ahead of environmental regulations and does not have a corporate responsibility. However, there are plans to accomplish LEED certification and do more on environmental issues because until now it wasn't high on the priority list. For energy consumption a bank of capacitor is installed to improve the power factor and reduce the energy consumption.

Park 6: X companies belong to men, one company belongs to women. Based on the experience, stakeholders and people in the park show a participatory attitude towards environmental problems. Park management itself also supports development of green technologies. Soon they are about to receive a company that is actively working on this issue. Companies are screened on sustainability policy every X months. The park buildings themselves have strict policies on energy savings and waste separation. There are also plans for consumption reduction and they already have special dumpsters and solar cells to reduce waste and energy consumption.

Park 7: there exists a screening criterion on sustainable intentions of the companies. The broad criterion assesses if their business is environmental friendly. The park has a corporate responsibility but it does not explicitly support the development of green technologies. However, environmental problems are important for each member of Park 7 and the companies are ready to apply the best practices. The park itself is staying ahead of environmental regulations and there are plans for water recycling

In total the researcher interviewed 10 companies in 3 different parks and each company was very satisfied in the park. Also the employees of the companies feel very safe in the park. Almost every company has employees of Mexican origin. Only T-systems had some international students from Germany and the USA working in their company. This is not strange because Mexico is not multi

cultural. The average travelling time for employees is between 30 minutes to one hour. Based on the information above, the table 11 has been composed.

Table 11: Sustainability performance of the Technology Parks

	Park 1	Park 2	Park 3	Park 4	Park 5	Park 6	Park 7
Sustainability criteria park	No	Yes	NA	No	No	Yes	Yes
Sustainability criteria companies	NE	No	NA	NA	No	Yes	Yes

NE: Not entirely

Table 11 shows in the first row which parks have sustainability criteria for the Technology Park itself, the policy, the building and the facilities. Some of the parks have for example LEED certification, waste reduction plans or energy saving plans. The second row shows which parks have sustainability criteria that influence the policy of the tenants. So here was identified which parks are demanding from their tenants a sustainable attitude in the development process of new products and services.

4.7 Impact evaluation

This section aims to gather enough information and data to answer the research question 6 on table 4. The year 2010 was the last year that a survey was conducted and the performance of all the Technology Parks was assessed. In the past, a comprehensive indicator list has been composed with quantitative indicators on several Technology Park performance area's like impact, employment, R&D, service, company generation, operation, management, and networking. This list was evaluated for approximately 60% and is thus not complete.

Each park has its own set of indicators to measure impact and performance, but the researchers discovered a similarity on 3 indicators. They are represented below in table 12. Indicators with the same colors are of the same category.

Table 12: Indicators that are currently used for performance measurement of the Parks

Park 1	Park 2	Park 3	Park 4	Park 5	Park 6	Park 7
Indicators with similar characteristics						
# of jobs generated	Missing	# of jobs generated	# of jobs are created in landing and business incubator	# of jobs created	# of new jobs created	# and quality of employment
Missing	# of companies created in the business incubation	# of companies created	# of companies created by the business incubator (yearly)	Missing	# of new businesses created	Innovation or technology based companies created
# of students/professors working in projects.	collaboration (main criterion): number of students linked with companies (internships, projects)	Missing	# of students/professors are working in projects with companies	# of projects developed in the TP with participation of students	# of students and teachers collaborating on projects with companies	Missing
Indicators without similar characteristics						
# of projects linked with university	occupation of office spaces (right now full capacity, no offices left)	# of patents generated	# of companies in landing	# of patents	# of new jobs conserved	# of patents or copyrights generated
# of jobs conserved	average level of salaries in the park and the average revenues of the companies	Total revenues of the companies	# of projects that are supported by government funding		# of students hired by companies.	Economic sustainability
the occupation of space (%)	collaboration between the companies (TP organizes events/activities for the companies to create networking)					

In consequence, the number of jobs generated, companies created and the number of collaborative projects between companies and the university are important impact indicators and are commonly used. From the table can be read that there is missing one indicator in the column of Park 1, Park 2, Park 3, Park 5 and Park 7. It can be questioned why the park directors have not mentioned these specific indicators. A solid conclusion cannot be drawn from this table, but it might be that because they have not mentioned them in the interviews these indicators are less important for them and for their Technology Park.

4.8 Model improvements

During this the application of research methods to answer the research question number 7 (see table 4), the researcher discovered some problems with performance and impact measurement. Other findings sections already elaborated on these problems. During the literature review the researcher came across some interesting theory on assessment frameworks. Together with the available data a performance matrix has been constructed.

4.8.1 Performance/impact measurement improvements

The first argument why measurement of technology park performance is important is about financial support. Public institutions invest in clusters because they fit in the picture of regional economic development. The government invests with a reason so they want to know about performance and result. Private institutions also invest in technology parks with the objective to gain benefits. They expect a return on their investment. The second argument is that a good performance will be noticed by potential tenants, talented people and other interesting actors. A good professional image will draw the attention of international high-technology firms and institutions, which will be handy in attracting capital. The third argument is that park management needs performance metrics to manage the park towards the desired direction. Feedback from the organization is necessary to adapt targets and make strategic decisions. The last argument it that decision makers have to decide if the initiative has enough economic mass or the potential to generate (for example by the number of knowledge workers and R&D activities) and therefore worthwhile to keep investing in the park. This is an underestimated statement. The added value of a technology parks is sometimes difficult to express, but not less important.

Based on the interviews held and the available data analyzed, the creation of a model for the Technology Parks on performance measurement is a necessary instrument. Data are outdated and not measured with the right objective in mind. It is essential that park directors understand and agree on the goals that are most important to each Technology Park and then measure their performance against the agreed goals using a set of performance indicators. When using a common set of metrics comparisons are possible. The researcher designed a performance matrix for the institution. The designing process will be explained in section 5, in the discussion.

5 Discussion

As previously mentioned, along the interviews with the directors of Technology Parks, it was possible to identify those particular goals and indicators associated to measure the execution of the strategic planning of Technology Parks. From such findings, the researcher was able to build a performance matrix by taking into account the following:

Technology Park goals (from interviews):

1. Support/encourage regional economic development
2. Promote economy based on knowledge
3. Creating entrepreneurial environment
4. Transfer technological advances into products with market value
5. Incubate new technology based companies
6. Attract international technology based companies
7. Create optimal landing conditions for companies
8. Create high value jobs
9. Commercialize new technologies
10. Linking research/innovation from academia to facilitate technology transfer to the productive sector of the region
11. Assure the link between the university and companies by students working in innovation projects
12. Improving existing business
13. Deliver value adding services to the companies

Some of those goals have been translated to indicators for measuring Technology Park performance (from interviews):

1. Number of innovation based companies created
2. Number of high value jobs created
3. Number of patents/copyrights generated
4. Economic benefits from sustainability projects
5. Number of collaborative activities among companies
6. Number of students linked with companies (internships, projects)
7. Occupation of office space
8. Number of projects between companies and university
9. Average level of salaries in the park
10. Average revenues of the companies
11. Number of jobs conserved
12. Number of projects supported by the government
13. Number of companies in landing

Once the goals and metrics to reach the goals were elaborated, the implementation processes were also the object of this proposal and its description will take the attention of the rest of this section.

Designing process

Based on the above requirements (performance indicators and metrics) the researcher composed a first design on how the performance matrix for Technology Parks should look like (table 13). Not only the above requirements are input for the design, but also the theory of Dabrownska (2011) on performance matrices, the theory of Chan and Lau (2004) on assessment frameworks for incubators and the existing

indicator list currently used by the institution were taken into consideration constructing the matrix. With specific indicators the performance matrix covers the measurement of the sustainability criterion, the regional impact criterion and the international criteria of Technology parks. The main objective of this matrix is to show in an organized way what the financial, non-financial, internal, external, leading, lagging and short and long-term performance of a Technology Park can be.

Table 13: initial design of a performance matrix for THE INSTITUTION Technology Parks

		Performance indicator	Measures	Baseline	Target
Commercial	1.1	Profitability of the park	Profit before interest and tax - % of budget		
	1.2	% occupancy figure	Sq ft occupied/nett lettable sq ft		
	1.3	External Funding raised	Number of received funds		
	1.4	Financial performance cf budget	Services cost recovery (exclude voids & subsidies)		
	1.5	Investment returns	Internal Rate of return (IRR)		
Stakeholder Perspective	2.1	Tenants satisfaction	Average company satisfaction		
			Opinion on provided services		
			# of training courses/seminars provided by the Technology Park		
			Lease Renewals & Expansions as a % of total expiries		
	2.2	Innovation & innovationsupport	# of projects supported by the government		
			# of organized conferences (sharing and networking)		
	2.3	Company growth/improving	% of tenants growing (turnover)		
			Survival rate of tenants that have been in the Technology Park		
			# of external employees		
			% of tenants growing (employees)		
	2.4	Company innovation profile	# of graduates hired by the companies		
			# of patents/copyrights exploited by tenants		
			# of products/services developed by tenants		
			total amount companies invest in R&D		
	2.5	Quality of tenants	# of innovation based companies created		
			Average level of salaries in the park vs. average salary level in the region		
			# of high value jobs created		
	2.6	(Economic) Sustainability	# of job conserved		
			Average travelling time of employees		
			Average education level op employees		
			# of green companies		
			# of implemented recycling/waste reduction measures		
			Gender ratio		
			# of companies that use eco innovation		
	2.7	Commercialize new technology innovations	# of students hired by the companies (internships, projects)		
			# of projects between companies and university		
			Collaboration between companies		
	2.8	Landing conditions	# of landing companies in the park		
	2.9	Entrepreneurial environment	# of companies in incubation		
			% of university spin-offs/total number of tenants		
			Number of companies owned by teachers		
			Number of companies owned by students		

Brand & reputation	3.1	Size of the technology park's community	# of companies in the science park
	3.2	International attraction profile	# of companies in landing
			# of foreign companies established in the park
			total amount of international funds received
	3.3	Media coverage	Pieces of coverage received /# of marketing events
Internal Business Processes	4.1	Employee satisfaction	Staff turnover - previous 3 year average
			# of personal development opportunities - average number/employee
			Staff sickness absences - days/employee
	4.2	Effective security service	# of security incidents
	4.3	Communication of important information	# of meetings between management and tenants
	4.4	Reliable IT system	# of IT outages lasting > 3 hours
	4.5	Facilities	Average company satisfaction on facilities
	4.6	Management	# of years of professional experience
			Academic grades

Maturity, contextual conditions and size

This framework assesses the goals of Technology Parks and that is why it is important to identify the mission of the Technology Park when designing the framework. Other crucial points to take into account are the stages of the Parks' lifecycle, the contextual conditions in which it operates and the size of the park. The goals of a technology park can have different priorities at different maturities. This means for example that when a Technology Park just has been launched the attraction and creation of new companies in the park is more important than intensifying the number of collaborative projects and knowledge transfer. Thus, target values will be different for young/older parks. The institution is making use of a conceptualization phase, a pilot phase and a consolidation phase. The first phase is about the exploration of the initiative and deciding if the project is feasible. In the second phase the physical environment is realized. Feedback from participants is important for the development of the park. The third phase consists of growth and consolidation. The seven Technology Parks discussed in this report are all in phase 2 of in the first stage of phase 3 (growth), except Park 3. Park 3a finds itself between growth and consolidation and already exists 7 years. The rest of the parks are very young and there is a lot of space for improvements and growth. That is why it is so important that stakeholders/participants in the park provide feedback to the park management.

The second point, the contextual conditions, has to do with the (economic) needs of the region. A Technology Park can be a tool with the purpose to generate new high technology companies, to bring innovative ideas consisting of high level science to the region or to boost the quality of the existing high technology. These factor need to be kept in mind when designing a performance matrix and setting targets.

When setting targets it is important to take the size of the park into consideration. A small park with 5 tenants and a 100% occupancy rate will generate less new products/services or jobs than a big park with 20 tenants and a 50% occupancy rate. Zooming into the size of the parks table 14 was constructed.

Table 14: Ranking of Technology Parks based on 3 criteria to identify the size of the parks

Ranking based on	Nr of companies in landing, incubation, acceleration	Area of m2	Nr of employees
Park 6			
Park 7			
Park 2			
Park 5			
Park 4			
Park 1			
Park 3			

Clearly there are 3 big parks: Park 3, Park 6 and Park 2. The rest of the parks are scoring equal on the different criteria. Looking to the figures, these parks are somewhat smaller than the three big ones. A performance matrix can also contribute to collaboration between parks, parks can learn from each other. It will create a more competitive environment that consequently increases the performance.

In the process of selecting the right metrics for the performance indicators, the evaluation format in table 15 can be used.

Table 15: Example of an evaluation matrix for performance indicators

Domain	Potential indicator	Technology Park goals													Indicator selection criteria							Pressure	State	Response
		1	2	3	4	5	6	7	8	9	10	11	12	13	A	B	C	D	E	F	G			
Commercial	# of funds		X		X					X					X		X		X					
	IRR																							
Brand																								
Internal																								

Table 15 may simplify the completeness of the list of indicators. The indicators are evaluated by the goals of the Technology Park and the selection criteria. The 13 goals are already defined by evaluating the answers that were given in the interviews. Examples of the selection criteria that can be used to assess the indicator framework, here as follow:

A. Based on accurate, available and accessible data of known quality
B. Representative of the phenomena being measured
C. Relevant to users and decision-makers of Technology Park performance measurement
D. Understandable to potential users
E. Geographically and temporally comparable
F. Attached to a clear and ambitious goal
G. Reflective of the community's capacity to effect change
H. Responsive to potential user
I. Cost-effective to collect and use

If necessary these criteria can be deleted or changed, it depends what is most important to the top management of the Technology Park.
Every Technology Park operates in an unique environment with different requirements and goals. Operating circumstances will be different, but still it is possible to have a measurement tool that only evaluates the main goal(s). Benefits of such a collaborative approach must be emphasized by the management and certainly offer openness to sharing information is required to succeed in this project, both for companies in the Technology Park and the Technology Park itself.
In section 6 a multi criteria assessment of the Technology Parks will be step by step described.

6 AHP model for prioritizing Technology Parks based on Technology Park criteria

There exist software programs for applying AHP to very complex problems, but the researcher made a model in Excel that is adaptable to the wishes of the management. Technology park strategy and goals can change over time so therefore one important condition is the adaptability of the model. The model should be based on the performance matrix that is constructed by the researcher. Unfortunately, the data for this framework is not complete and only available data on indicators can be used. Section 4.3 already discuss to what extent the different parks fulfill to the definition in quantitative and qualitative way. In this section we use mainly the available quantitative data, some qualitative data and expertise from the researcher to go deeper in the performances of the Technology Parks compared to each other and compared to the criteria for Technology Parks. Hence, we basically continue with answering research question 3 in a more mathematical way with the goal to establish a final ranking of the parks. The data from section 4.3 was used in this process. Below, the model is explained step by step using examples of different tables together with guiding description.

Step-by-step explanation of the AHP

Step 1: placement of framework elements and problem structuring (hierarchy diagram)

For the sake of having an overview, the first thing to do was to build a hierarchy diagram. This gives insight in the overall structure of the decision/problem and it includes the goal, relevant criteria and sub criteria and the alternatives. (See figure 10).

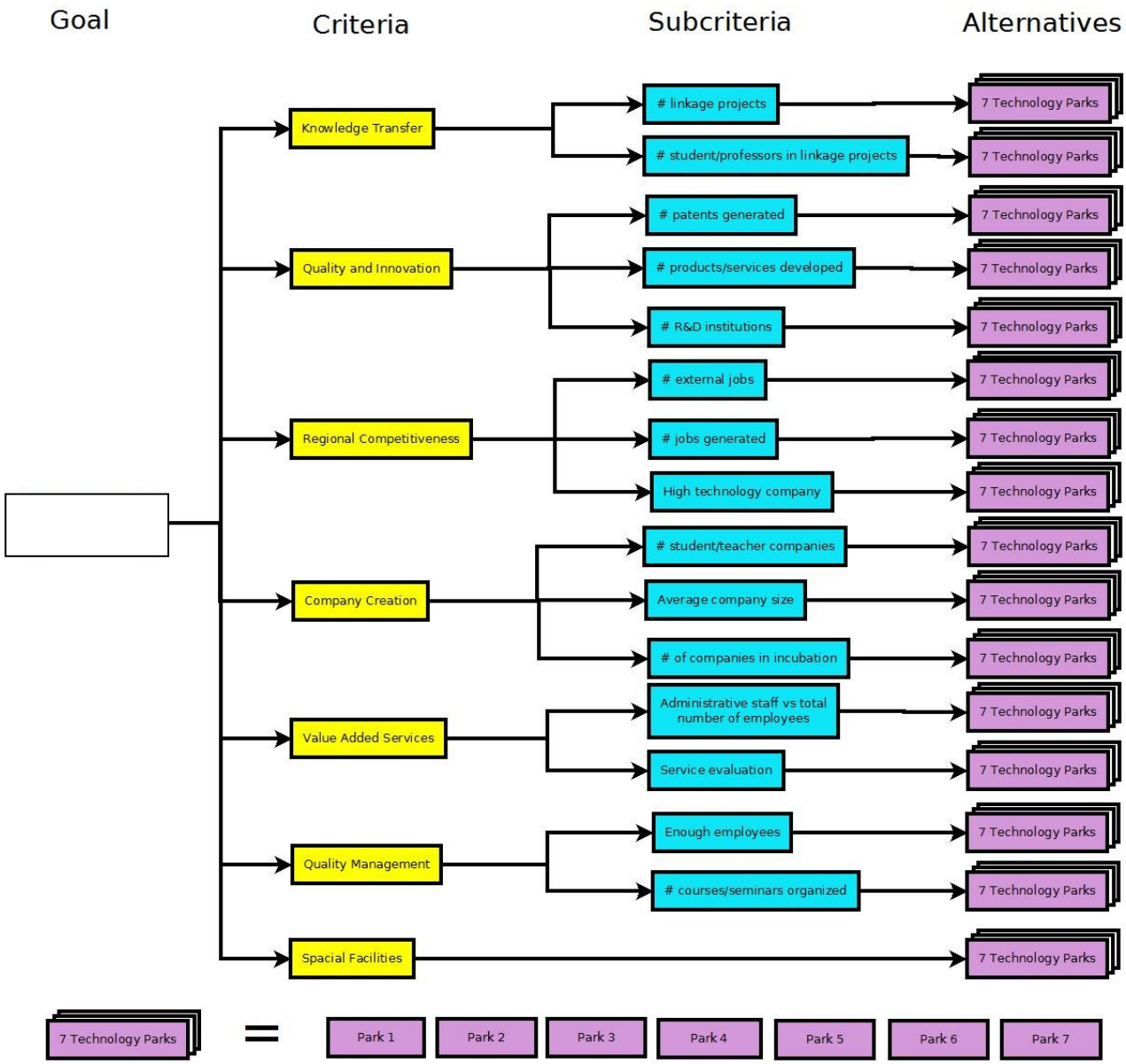

Figure 10: AHP hierarchy diagram

Step 2: Pairwise comparison matrices between parameters at different levels

The next step is to make a pair wise comparison on 3 different levels:

1. Make comparisons of the criteria related to the goal. The researcher made the comparisons in table 16 based on the collected answers from the interviews with park managers. They were asked to prioritize the following aspects of a Technology Park: stimulates knowledge transfer (Know Trans), stimulates a culture of quality and innovation among companies and universities (Qua Inno), increases regional competitiveness (Compet), encourages the creation and growth of new and sustainable innovation-based companies (Creation), provides value-added services (Services), managed by a specialized team that has the capability to comprise different perspectives, support innovation and explore innovative ideas (Managed), and finally provides high quality space and facilities (Facilit). All the fractions in the left side of the diagonal of the matrix become total numbers in the right side of the diagonal of the matrix with the value of the denominator. All the total numbers in the left side of the diagonal of the matrix become

fractions in the right side of the diagonal of the matrix with a denominator value equal to the whole numbers. For example, 'Know' 'Trans' is strongly favoured compared to 'Managed' indicated with the number 7. When $cell_{16}$ is 6, $cell_{61}$ is 1/6. And when $cell_{31}$ is 5, $cell_{13}$ is 1/5.

Table 16: Comparison table of the criteria related to the goal of a Technology Park

	Pairwise comparisons of criteria						
	Know Trans	**Qua Inno**	**Compet**	**Creation**	**Services**	**Managed**	**Facilit**
Know Trans	1	3	1/5	1	4	7	8
Qua Inno	1/3	1	1/6	1/4	2	5	6
Compet	5	6	1	5	6	8	9
Creation	1	4	1/5	1	4	7	8
Services	1/4	1/2	1/6	1/4	1	4	5
Managed	1/7	1/5	1/8	1/7	1/4	1	2
Facilit	1/8	1/6	1/9	1/8	1/5	1/2	1

2. Make comparisons of the sub-criteria related to the criteria. For example the sub-criteria "# of linkage projects" and "# students/professors working in linkage projects" are pairwise compared to criterion Knowledge Transfer in table 17.

Table 17: Comparison table of the sub-criteria on the criteria Knowledge Transfer

	Knowledge Transfer	
	# students/ professors	**# linkage projects**
# students/ professors	1	1/3
# linkage projects	3	1

Here, the number of linkage projects is seen as moderate important over the number of students/professors working in these projects. Table 16, 17 and 18 are assigned based on Saaty's scale for AHP preferences.

3. Make comparisons of the alternatives related to the sub-criteria and if there are no sub-criteria for a certain criterion then compare the alternatives only with this criterion. See for a comparison of the alternatives against the number of linkage projects table 18.

Table 18: Comparison table of the alternatives on the sub-criteria "# of linkage projects"

	Pairwise comparison of TP on sub-criteria # linkage projects						
	Park 7	**Park 6**	**Park 5**	**Park 4**	**Park 3**	**Park 2**	**Park 1**
Park 7	1	1/4	1/6	1/3	1/7	1/9	1/3
Park 6	4	1	1/2	1	1/4	1/5	2
Park 5	6	2	1	3	2	1/4	4
Park 4	3	1	1/3	1	1/3	1/6	1/7
Park 3	7	4	1/2	3	1	1/2	3
Park 2	9	5	4	6	2	1	5
Park 1	3	1/2	1/4	7	1/3	1/5	1

A worksheet can be a helpful tool to make the right decisions in the many pairwise comparisons. After all, there are a lot of comparisons to be made and table 19 is an example to represent the comparative information in a structured way.

Table 19: Worksheet tool for better comparisons

Worksheet for comparisons on the sub-criteria # linkage projects													
	Comparison		# linkage projects					nr projects/company			Rational thought		
#	A	B	A	B	more projects	Amount	Ratio	A	B	better ratio	Better park	Intensity	Rationale
1	Park 1	Park 2	13	46	B	33	3.538	1.300	0.939	A	B	5	
2	Park 1	Park 3	13	34	B	21	2.615	1.300	1.360	B	B	3	
3	Park 1	Park 4	13	3	A	10	4.333	1.300	0.136	A	A	7	
4	Park 1	Park 5	13	28	B	15	2.154	1.300	3.500	B	B	4	
5	Park 1	Park 6	13	22	B	9	1.692	1.300	0.489	A	B	2	
6	Park 1	Park 7	13	9	A	4	1.444	1.300	0.643	A	A	3	
7	Park 2	Park 3	46	34	A	12	1.353	0.939	1.360	B	A	2	
8	Park 2	Park 4	46	3	A	43	15.333	0.939	0.136	A	A	6	
9	Park 2	Park 5	46	28	A	18	1.643	0.939	3.500	B	A	4	
10	Park 2	Park 6	46	22	A	24	2.091	0.939	0.489	A	A	5	
11	Park 2	Park 7	46	9	A	37	5.111	0.939	0.643	A	A	9	
12	Park 3	Park 4	34	3	A	31	11.333	1.360	0.136	A	A	3	
13	Park 3	Park 5	34	28	A	6	1.214	1.360	3.500	B	B	2	
14	Park 3	Park 6	34	22	A	12	1.545	1.360	0.489	A	A	4	
15	Park 3	Park 7	34	9	A	25	3.778	1.360	0.643	A	A	7	
16	Park 4	Park 5	3	28	B	25	9.333	0.136	3.500	B	B	3	
17	Park 4	Park 6	3	22	B	19	7.333	0.136	0.489	B	B	1	
18	Park 4	Park 7	3	9	B	6	3.000	0.136	0.643	B	A	3	
19	Park 5	Park 6	28	22	A	6	1.273	3.500	0.489	A	A	2	
20	Park 5	Park 7	28	9	A	19	3.111	3.500	0.643	A	A	6	
21	Park 6	Park 7	22	9	A	13	2.444	0.489	0.643	B	A	4	

By using the available quantitative data, ratio's and own insight a rational comparison can be made. This should be done by the decision makers of the process. For the pairwise comparison the scale of Saaty is used.

Table 2. Saaty's scale for AHP preference

Saaty's Scale for AHP preference		
Intensity for Importance	**Definition**	**Explanation**
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate Importance	Experience and judgment slightly favour one over another
5	Strong Importance	Experience and judgment strongly favour one over another
7	Very Strong Importance	Activity is strongly favoured and its dominance is demonstrated in practice
9	Absolute Importance	Importance of one over another affirmed on the highest possible order
2, 4, 6, 8	Intermediate Importance	Used to represent compromise between the priorities listed above
Reciprocal of above non-zero numbers	If activity (i) has one of the above non-zero numbers assigned to it when compared with activity (j), then (j) has the reciprocal value when compared with (i)	

Figure 11: Saaty's scale for pairwise comparison (Saaty, 1980)

Step 3: calculate relative priorities, global priorities and the internal consistency ratios for all the comparisons matrices

After the comparisons have been made it is important to calculate the consistency ratio. This ratio represents the internal consistency of the comparisons that were made in table 16. First the relative priorities of the criteria are calculated. The values are calculated by dividing $cell_{ij}$ by the sum of $column_j$ using the values of table 16. After this, the relative priority is the average of the normalized row_i. Example for 'Know Trans': Know $Trans_{11}$ / sum(Know $Trans_1$) = 1/sum(1+1/3+5+1+1/4+1/8+1/7) = 0.127 Calculate this for every value and a matrix in table 20 can be constructed.

Table 20: The table to calculate the relative priority

	Calculate relative priority of criteria							
	Know Trans	**Qua Inno**	**Compet**	**Creation**	**Services**	**Managed**	**Facilit**	**relative priority**
Know Trans	0.127	0.202	0.102	0.129	0.229	0.205	0.215	0.173
Qua Inno	0.042	0.067	0.085	0.032	0.115	0.154	0.154	0.093
Compet	0.637	0.404	0.508	0.644	0.344	0.231	0.246	0.430
Creation	0.127	0.269	0.102	0.129	0.229	0.205	0.215	0.182
Services	0.032	0.034	0.085	0.032	0.057	0.128	0.123	0.070
Managed	0.016	0.011	0.056	0.016	0.011	0.026	0.015	0.022
Facilit	0.018	0.013	0.063	0.018	0.014	0.051	0.031	0.030

When the relative priority of each criterion is known, the consistency ratio can be calculated. First the values of the pairwise comparison matrix (table 17) are multiplied by the relative priorities given in table 20. So multiply $cell_{i1}$ (i=1…7) with 0.173, multiply $cell_{i2}$ (i=1…7) with 0.093, etcetera and insert these values into a new matrix (table 21). The next step is to calculate the ratio by summing up the values of each row and divide the addition by the relative priority on that criterion (table 20). Example for 'Know Trans': 1.386/0.173= 8.012. This is done for all values and is represented in the table 21.

Table 21: Matrix for calculating the consistency ratio

	Calculate consistency ratio for criteria <0.1 (control method)									
	Know Trans	**Qua Inno**	**Compet**	**Creation**	**Services**	**Managed**	**Facilit**	**som**	**ratio**	**CI**
Know Trans	0.173	0.279	0.086	0.182	0.280	0.176	0.210	1.386	8.012	0.109
Qua Inno	0.058	0.093	0.072	0.046	0.140	0.132	0.150	0.690	7.418	**CI/RI**
Compet	0.865	0.558	0.430	0.910	0.420	0.198	0.240	3.621	8.421	0.083
Creation	0.173	0.372	0.086	0.182	0.280	0.176	0.210	1.479	8.126	
Services	0.043	0.047	0.072	0.046	0.070	0.110	0.120	0.507	7.242	
Managed	0.022	0.016	0.048	0.023	0.014	0.022	0.015	0.159	7.211	
Facilit	0.025	0.019	0.054	0.026	0.018	0.044	0.030	0.215	7.152	

The consistency index can be calculated by the following equation: CI = (average $ratio_j$ - n)/(n-1). The variable n represents the size of the pairwise comparison matrix (n x n), which is in this case 7. For example in table 21, the consistency index was calculated by: ((the average of the column 'ratio' – 7)/6) = 0.109. The random consistency index (RI) is given in table 22.

Table 22: Saaty's random consistency index values (RI)

Saaty's random consistency index values									
Size of matrix	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Random consistency index	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

The consistency ratio CR is obtained by CI/RI. The value of CR should be less or equal to 0.1 (CR <= 0.1) to be consistent.

The global priorities for the subcriteria are simply a multiplication of the relative priorities of the sub-criteria and the relative priority of the main criteria. The global priorities for the alternatives (Technology Parks) are a multiplication of the relative priorities of the alternatives and the global priority of the sub criteria. These are copied into the final prioritziation table. Eventually this results in the prioritization table below, with all the global priorities of all the criteria/sub-criteria for each alternative. The total of

Table 23: Final prioritization table

all the global priotities has to be 1. If it is not equal to 1 something went wrong, so this is a controle method.

Final prioritzation																		
Technology Park	Knowledge Transfer		Quality & innovation			Regional Competitiveness			Company creation			Value added services		Management		Spacial facilities	Totaal	Scores
	# students/	#linkage pr	# patents	#products/s	R&D institu	# external en	# jobs genera	high techno	# student/t	average co	# companie	evaluation of	# courses/s	administra	enough em			
Park 7	0.001	0.004	0.001	0.009	0.000	0.006	0.002	0.016	0.002	0.001	0.004	0.002	0.001	0.000	0.001	0.003	0.052	7
Park 6	0.002	0.011	0.003	0.006	0.000	0.006	0.002	0.097	0.011	0.002	0.045	0.011	0.001	0.001	0.002	0.005	0.206	3
Park 5	0.005	0.020	0.001	0.004	0.003	0.009	0.004	0.016	0.001	0.009	0.002	0.011	0.000	0.001	0.001	0.001	0.089	5
Park 4	0.005	0.007	0.001	0.002	0.001	0.003	0.001	0.007	0.004	0.001	0.015	0.002	0.000	0.002	0.007	0.001	0.058	6
Park 3	0.005	0.028	0.004	0.015	0.004	0.041	0.017	0.045	0.006	0.005	0.011	0.011	0.005	0.000	0.002	0.008	0.210	2
Park 2	0.014	0.048	0.008	0.003	0.001	0.030	0.013	0.045	0.015	0.001	0.032	0.011	0.002	0.001	0.002	0.002	0.228	1
Park 1	0.011	0.013	0.001	0.025	0.001	0.016	0.006	0.045	0.002	0.003	0.008	0.011	0.003	0.002	0.007	0.001	0.156	4
Total indicato	0.043	0.130	0.019	0.063	0.011	0.112	0.046	0.272	0.042	0.022	0.118	0.058	0.012	0.008	0.022		0.978	
Total criteria	0.173		0.093			0.430			0.182			0.070		0.030		0.022	1.000	
Total	1.000																	
CI/CR	0.063	0.095	0.057	0.067	0.071	0.048	0.078	0.038	0.070	0.068	0.094	0.013	0.074	0.069	0.035	0.050		
=<0.1?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		

Conclusions from AHP

According to the table the Technology Parks can be ranked as follow:

1. Park 2
2. Park 3
3. Park 6
4. Park 1
5. Park 5
6. Park 4
7. Park 7

This means that based on the quantitative data/interviews and by using the given criteria and sub-criteria, Park 2 is the best Technology Park. The criteria used in the AHP model are derived from the definition of Technology Parks, then Park 2 fulfills the best and Park 7 fulfills the worst to the definition. This is based on the available quantitative data, findings for research question 3, interviews and prioritization of park directors. For more calculations and formulas the excel sheet gives more information. (*Tables_BA_Jeroen_Ringlever_s0167142.XLS*)

6.1 Sensitivity analysis

Because the differences between some of the end values of the alternatives are small, it is recommendable to execute a sensitivity analysis. Sensitivity analysis identifies for each attribute the minimum changes that cause a change in the final ranking. This helps the decision maker to decide for the best choice. The researcher made a sensitivity diagram of the criterion knowledge transfer, because this is an important criterion according to the park directors. First the average relative priority of each criterion is calculated and these values are represented in a matrix (table 24). The researcher chose to investigate the priorities of the first level criteria.

Table 24: The average relative priority per criteria on each alternative

	Average relative priority per criteria on the alternatives						
Technology Park	**Know Trans**	**Qua Inno**	**Compet**	**Creation**	**Services**	**Managed**	**Facilit**
Park 7	0.028	0.069	0.053	0.035	0.055	0.030	0.154
Park 6	0.063	0.091	0.154	0.244	0.123	0.147	0.224
Park 5	0.135	0.117	0.080	0.151	0.108	0.053	0.056
Park 4	0.079	0.055	0.025	0.090	0.027	0.277	0.058
Park 3	0.165	0.294	0.305	0.156	0.307	0.074	0.371
Park 2	0.347	0.188	0.238	0.233	0.164	0.101	0.104
Park 1	0.183	0.186	0.146	0.090	0.219	0.320	0.032

Next, compile an adapted matrix by multiplying the matrix in table 24 with the relative priorities on each criterion (figure 12). So for the value of knowledge transfer for Park 7, 0.005, is gained by multiplying 0.028 with 0.173. The matrix in table 25 is generated.

Table 25: Adapted matrix

	Adapted matrix (Score are multiplied with relative priority)							
Technology Park	**Know Trans**	**Qua Inno**	**Compet**	**Creation**	**Services**	**Managed**	**Facilit**	P
Park 7	0.005	0.006	0.023	0.006	0.004	0.001	0.003	0.049
Park 6	0.011	0.008	0.066	0.044	0.009	0.004	0.005	0.148
Park 5	0.023	0.011	0.034	0.028	0.008	0.002	0.001	0.106
Park 4	0.014	0.005	0.011	0.016	0.002	0.008	0.001	0.057
Park 3	0.029	0.027	0.131	0.028	0.021	0.002	0.008	0.247
Park 2	0.060	0.017	0.102	0.042	0.011	0.003	0.002	0.239
Park 1	0.032	0.017	0.063	0.016	0.015	0.010	0.001	0.154
Sum								1.000

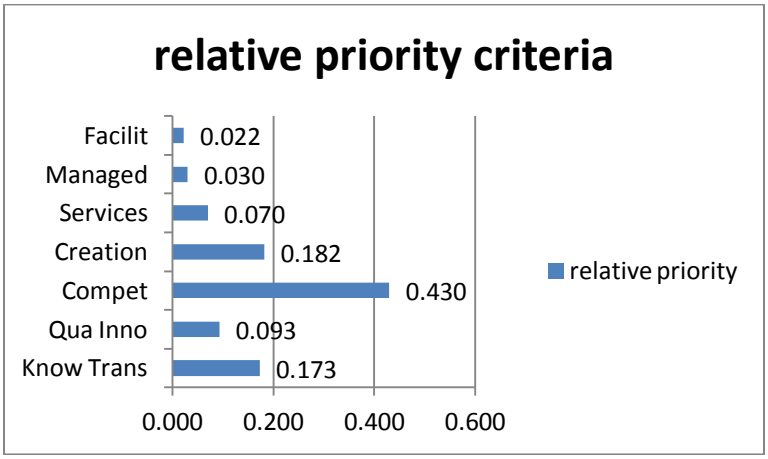

Figure 12: Relative priority

Once this is done the D-value can be calculated by the equation in figure 13. The D-value is equal to the minimum change (in absolute terms) in weight/priority of a criterion such that the final ranking will be changed.

$$D'_{k,i,j} = \frac{|(P_j - P_i)|}{|(a_{jk} - a_{ik})|} \times \frac{100}{W_k}$$

Figure 13: Equation to calculate the D-value

The smallest D-values are the most interesting in sensitivity analysis. For each criterion the D-value is calculated. The D-values are percentages.

Table 26: Smallest D-value on each criterion

Criteria	Alternative i	Alternative j	Dkij
Know Trans	Park 2	Park 3	26.53
Qua Inno	Park 6	Park 1	67.36
Compet	Park 2	Park 3	29.00
Creation	Park 6	Park 1	21.31
Services	Park 2	Park 3	83.16
Managed	Park 6	Park 1	115.41
Facilit	Park 6	Park 1	141.39

Another way to identify the minimum changes that influence the final ranking is gradient diagrams. The basic idea is to change the relative priority of for one criterion from 0 to 1 with steps of 0.1. If the relative priority of a criterion changes, all other prioirties are changing too and have to be recalculated. Eventually the scores on each alternative are multiplied with the new priorities. This can be represented in graphs. The precise values are hard to read from these graph and the D-value is thus a more precise method.

Conclusions from sensitivity analysis

From table 26 we can see that when changing the weights of the criteria, the ranking of the four best parks (Park 2, Park 3, Park 6, Park 1) will change first. The criteria 'company creation' is the most sensible of all the criteria. A small change of 21% will cause a different final ranking. Park 2 and Park 3 are performing almost at the same level. Differences are small.

7 Conclusions

As mentioned in the introduction an uncountable different types of technology clusters exist. In Mexico the criteria for Technology Parks are different in comparison with the European criteria for Technology Parks. Important in this issue is to pre determine the criteria that are relevant and be consistent. Based on seven criteria the performance of the seven Technology Parks is measured, to check if they fulfill to the definition of a Technology Park. Park 1, Park 2, Park 4, Park 5 and Park 6 are all Technology Parks according to the definition. Campus Park 7 and Park 3a do not organize knowledge transfer between knowledge institutions and tenants. Hence, they are not fulfilling to one of the Technology Park criteria and are therefore not a Technology Park according to the definition. Their focus is on the creation of scientific research and they are not transferring this knowledge into companies/products. Park 3b, the other park in Park 3, is performing weakly on the criterion quality and innovation. Although in very small amounts, it has some research activities and together with the rest of this parks' characteristics it is considered a Technology Park.

Besides the fact that they fulfill/do not fulfill to the Technology Park criteria, the report also elaborates to what extent the parks perform on these criteria. To do this in a structured way, a prioritization was made by applying the Analytical Hierarchy Process (AHP) method and sensitivity analysis on the available data set. Park 2 has the best performance on all the criteria, followed closely by Park 3 and Park 6. The places four, five, six and seven are assigned to Park 1, Park 5, Park 4 and Park 7.

The criterion knowledge transfer has been discussed in a more extensive way, both quantitative and qualitative. Quantitative indicators used to determine the amount of knowledge transfer are the number of students/professors working in collaborative company projects, the number of collaborative projects per year and the number of incubated companies. For qualitative information was researched how the knowledge transfer is organized in the parks. Based on the collected data a prioritization can be made from the highest amount to the lowest amount: Park 2, Park 1, Park 3a, Park 5, Park 4, Park 6 and Park 7. In general the knowledge transfer is high in number of students working in company projects and in number of incubated companies, but low in the number of networking events organized. Some companies do not know the core activities of their neighbor-companies and would like to meet professors/students more often. Some parks have the ability to organize more networking events in order to create more cohesion and more coordination of the transfer process is required by pointing companies into the right direction (how many/which students are needed) to gain more efficiency. As mentioned before the company projects are properly synchronized with the education program. In the Technology Parks connected to the institution cooperation and collaboration between universities and enterprises has stimulated product and process innovation when looking at the number of patents/products generated. In consequences, for the technology innovation, the transfer of knowledge is relevant.

The second criterion that has broadly been discussed is sustainability. Considering the strategies, missions and goals of different Technology Parks it is clear sustainability has not been priority in the strategy and few data is available on this subject. Two important aspects were evaluated: if the park itself is sustainable and if the tenants (and their products) in the park are sustainable. Only Park 6 and Park 7 and to a lesser extent Park 2 have some sustainable intentions. These parks are very new and the buildings have an ecological design, but in the beginning it had not the priority to look at eco and green indicators in the operations of the park. However, especially in the development phase, the product design can be of high influence on the sustainability of the production process and therefore is very important to consider. Unfortunately, most of the Technology Parks are not screening their (potential)

tenants on eco efficiency/innovation yet, but the overall sustainability attention of the last couple of years seems to have influence on the Technology Parks that were build after 2008.

Currently the measurement method of the Technology Park performance is not similar with the goals of the Technology Parks, the international criteria of Technology Parks and does not cover the subject 'impact measurement'. A very big indicator list was used in the past but due to the size of the list it was not completely evaluated last couple of years. The second measurement tool is intranet, but it assesses only two indicators and should be expanded for more coverage. With all available data, a new assessment framework has been constructed that covers all the areas. It is an initial design and can be adapted to the wishes of the directors. It is advisable that all the parks measure their performance with the same indicators for comparable reasons. Another thing that can be concluded from the research is that Technology Parks do not receive sufficient information on tenant performance. The Technology Parks have very few data on the results of the companies, while they are one of the most important actors in a technology cluster. Performances of the incubation department are available and many historical data is existing on the incubation process.

8 Recommendations

In this section the researcher bring up some suggestions for following up his analysis to solve the research questions driving this project.

1. Performance matrix

Use (or first adapt) the initial design of the new performance matrix from section 4.7. It is important to understand that it is an initial design based on the interviews, the available data and the theory. It is recommendable to invite park directors to participate in the design of the final matrix. It is essential that park directors understand and agree on the goals that are most important to each Technology Park. Obviously this will lead to a more suitable and professional matrix. When designing such a matrix an important thing to keep in mind is that the matrix assesses all aspects of the Technology Park performance, it might be more comprehensive and can provide a concise picture. Benefits of such a collaborative approach must be emphasized by the management and of course enhance the openness of sharing information which is required to succeed in this project, both for companies in the Technology Park and the Technology Park itself. Eventually it will contribute to collaboration between the parks; parks can learn from each other. Besides, a performance tool will create a more competitive environment that will increase the performance.

2. AHP

It is possible to combine this tool with the AHP method discussed in section 5. The format in Excel used for this study can be adapted for application by the management. The only thing that needs to be changed is the input, cells are connected by formulas so everything changes automatically. Using such a measurement method in practice requires apart from discipline also a data collection tool, reporting methods and planning (baseline and target numbers have to be set).

3. Intranet

The last statement is in line with the next recommendation, it is convenient to develop an intranet between technology parks with clear procedures how to use it. As far as the researcher knows this has not been developed yet, but can be of great contribution to the effectiveness of the Technology Park system. The director of Park 1 mentioned that they are currently working on a virtual network that eventually should connect companies between different parks to exchange information on companies, suppliers, available professors, funding, competitor information, and etcetera. Perhaps, performance measurement can be included in the virtual network project description for a better data collection in the future. Right now parks are not collaborating with each other to its full potential. Cooperation with international Technology Parks is also an attractive option because international approaches differ from the Mexican approaches and different perspectives might give new insights, but this is something for further research, as well.

4. Dematel

In this study the Dematel technique is briefly mentioned in section 6 about MCDA techniques. Instead of Dematel, AHP has been used to analyze data, but applying Dematel on the different Technology Parks of the institution can be very interesting. When improving the performance of Technology Parks it is important to identify the important criteria that have the most influence on the final performance. Generally, this is what Dematel does. After the identification of the most important criteria, the technology park policy can be adapted to improve performance on these set of important criteria to gain big improvements in results. This is something for further research and examples already exist in literature, with a case study included. (Chia-Li Lin, 2009).

5. Social and networking events

Another recommendation is to organize more social and networking events. During the interview with companies the lack of networking events was regularly mentioned. Employees of tenants would like to have more contact with other tenants, students and professors. The effect of social events (for example a sport tournament) should not be underestimated. The fact that companies, university and government are in the same building does not mean that they automatically meet and collaborate with each other, this is something that the park management has to stimulate.

6. Policy on office space

This recommendation is about the shortages of office space. In some interviews people were discussing the lack of office space in some Technology Parks (Park 1, Park 2). This is an important issue, because companies want to expand and if this is not possible in the current setting their satisfaction degree will decrease. When analyzing this situation three solutions are considered:

- Expand the park with square meters. Often this is not possible because of financial limitations.
- More space to specific companies, less space to potential new companies. This does not fit in the general goal of a Technology Park (contribute to regional economy). Eventually, the companies should establish themselves in the region then new companies can move into the park to grow in successful high technology based companies.
- Let them move out of the Technology Park and help them find a suitable office building in the region of the park. The company can still make use of services of TP but they have a slightly different contract (adapt by a legal bureau) compared with companies in the park. Important for the park management is to discover what according to the companies are the biggest benefits of Technology Park.

7. Sustainability criterion

The Technology Parks give few attention to sustainability, but as stated earlier sustainability becomes more and more important. A small but easy recommendation is to include a sustainability criterion in the screening procedures of potential tenants. If a tenant showed the willingness to do something on sustainability it should be monitored in a later stage. Especially eco design deserves more attention, because large benefits related to sustainability can be made in the product development phase.

8. Impact indicators

The final recommendation is about measuring regional impact of Technology Parks. It still is very hard to calculate the contribution of Technology Parks on the region and to express this in figures, even international literature about best practices do not give consistent solutions. However, knowing the impact of technology clusters is very important for the people that are supporting the parks with money or other resources. Right now management of the institution is only considering measurable things in the Technology Parks, but influences on the region can also be measured by economic figures from the region. Only input (number of new companies, number of new jobs generated) from the Technology Park on the region are considered, not the effects and outcomes of these inputs. Economic development can be measured by for example the growth of wages and purchasing power, but also by unemployment figures and sales data.

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Annex 1: Background information Mexican context

Stage of research	Description of activity and output	Entity performing it and skill requirements
Pure science	Research for the pursuit of knowledge, with outputs usually in scientific journals and possibly patents	Universities (scientific expertise needed)
Basic research	Similar outputs as pure science approach, but conducted with specific long-term corporate objectives (such as future products) in mind	Corporate laboratory (scientific expertise needed)
Applied research	Medium-term research on known technologies; typically involves transforming or localizing existing product knowledge, or re-applying known research results to other areas.	Corporate laboratory (less scientific, more engineering expertise needed)
Exploratory development	Development and prototyping of design and other systems	Corporate product development departments (product development expertise)
Advanced development	Addressing of manufacturing considerations for products	Manufacturers (manufacturing and product development expertise)

Table 27: A classification of the Stages of R&D (Koh, Koh, & Tschang, 2003)

Annex 2: Interview format companies

The interview format comprises 3 types of questions. The first 5 questions ask for quantitative figures which will need to be prepared if you don't have this data ready. The following 5 questions are yes/no questions and will take you 5 minutes to answer. The last 14 open questions don't need any preparation time, responses would be of descriptive nature and thus consuming most of the interview time. By estimation the interview time will be less than 1 hour. The better prepared, the faster the interview can be finished.

Quantitative that require preparation:

1. In what frequency does the company make use of university resources (HR, library, special equipment, training, conferences)?
2. How many employees are involved in joint R&D projects in 2011?
3. How many different employees origins does the company has?
4. What is the average travelling time for employees?
5. What is the average education level of the employees?

Yes/no questions:

6. Has the company plans to participate in future R&D projects?
7. Does the company use eco innovation/efficiency when developing products, report on sustainability to the OECD or other sort like instances or has an environmental management accounting method?
8. Do the companies (heavily) invest in developing new products/services?

Qualitative and open questions:

9. What are the core activities of this company?
10. For what reason(s) is the company in the Park?
    - What did the company expected when moving into the park?
    - Are those expectations fulfilled?
    - How intense was the screening performed by the Technology of company to be in the Park (on subjects as sustainability/R&D activities/use of students)?
11. What kind of research service level provided by the university is used by the company? (scientific, applied, development, improvement testing)
12. Please fill in this priority list about the advantages your have being in the park
    1. Networking options
    2. HRM related (close to academic labor)
    3. Image
    4. Synergy
    5. Safety
    6. Business Incubation services
    7. Cheap rent
    8. Shared services
    9. Others
13. If you had to express the company satisfaction, what would you fill in? (very dissatisfied, somewhat dissatisfied, neither satisfied nor dissatisfied, somewhat satisfied, very satisfied)
14. Is the service provided by the Technology Park for applying for funds sufficient?
15. Do you think that your company contributes to the stimulation of competitiveness in the region?

    - How?
16. Which provided university facilities are really contributing to technology improvements according to the company?
17. Do you have regular conversations with the management about approaches how to measure performance and impact of your company on the region?
18. Does the management of the park request quantitative data for measurement purposes?
19. To what extent employees have development/growth opportunities?
20. Are there sufficient social services (day care center, sporting facility) provided for an easier life of employees?
    - Are there facilities missing?
21. Do the employees feel safe in the Technology Park environment?
    - Why/why not?
    - Which signals indicate this?
22. What important service(s) do you miss in the Technology Park?

23. Do you have other subject related comments/recommendations that I can use in my research?

Thank you very much for participating in this study!

Annex 3: Interview format park directors

The interview format comprises 3 types of questions. The first 8 questions ask for quantitative figures which will need to be prepared if you don't have this data ready. The following 11 questions are yes/no questions and will take you 5 minutes to answer. The last 19 open questions don't need any preparation time, responses would be of descriptive nature and thus consuming most of the interview time. By estimation the interview time will be less than 1 hour. The better prepared, the faster the interview can be finished.

Quantitative that require preparation:

1. In what year was the official opening?
2. What is the average size of the companies in the Park expressed in employees in 2011?
3. In what growth stage are the companies? (startups, growth, mature etc.)
4. How many copyrights and patents are generated in 2011?
5. How many new products/services are generated in 2011?
6. How many graduate students have been hired by the companies in the Park in 2011?
7. What is the average gender ratio of the companies in the Park in 2011?
8. What is the total investment amount in the Park in 2011?
    - Who are investing?
    - What is the total investment amount spend on R&D activities?

Yes/no questions that require preparation:

9. Is there an incubator in the Park?
10. Is there an R&D institution in the Park?
11. Has the Technology Park a formal link with a university/higher education institution/research center?
12. Does there exist a screening criterion (when selecting companies for the park) about interest/capability of companies to participate in R&D projects?
    - If so, what is the definition of this criterion and how is this screening performed in practice?
13. Does there exist a selection/screening criterion about sustainability policies of the companies?
    - If so, what is the definition of this criterion and how is this screening performed in practice?
14. Is the Park itself staying ahead of environmental regulations?
15. Are there plans for reducing waste/water/energy consumption of the Technology Park buildings?
    - If so, how?
16. Can the companies in the Park be titled as high technology innovation-based companies with high value jobs?
17. Has the Park management provided information sessions and conferences in emerging industry technologies?
    - What kind of technologies/training? Other training tools to support companies? (for example facilitate companies to take courses)
18. Does the Park management still make use of the Plan, Act, Observe, Reflect cycle to improve the Technology Park?

Qualitative and open questions:

19. What is your definition of a Technology Park?

20. What is in short the history of the Park?
    - Who initiated the building of the Technology Park? (Eg. university, government and/or business)
    - How is the start-up funding for the Technology Park arranged? Who financed it? How are Park expenses covered?
21. What are your criteria for Technology Park success and added value?
22. What is your contribution to economic growth, and how can you prove that?
    - How do you measure that? Which performance indicators are important to you?
23. To whom do you report? (E.g. University, government and/or business)
24. What kinds of services are provided to the companies?
    - Support in regulation, innovation, funding, other, etc.
    - Are these services frequently (yearly) evaluated?
25. What kind of facilities are in the Technology Park?
26. Who makes use of the laboratories?
27. What are the most important actors/stakeholders in the Park?
    - Why are they important?
28. Which institutes are in the ecosystem?
29. How does the technology park increases competitiveness in the region?
    - Does management share and discuss information on competitor strategy with the companies?
30. Is the amount of employees you have at your disposal sufficient for the main tasks of the Technology Park, according to your opinion?
    - Does existing staff has the time and manpower to develop additional value adding projects/services in addition to the daily work?
31. To what extent/in what frequency has the Park management contact with the companies?
    - Through which channels (meetings, newsletter, email)?
    - About what and why do they meet?
32. What can you say about the willingness of companies to participate in R&D projects?
33. How does the Park organize transfer of knowledge and technology from the knowledge institutes to the companies in the Park?
    - We can also speak of knowledge transfer the other way around (from companies to knowledge institutes)?
34. How do you measure the performance of the Park and in what frequency?
    - What do you do with this knowledge (the results)?
35. What is the stakeholder' attitude (customers, employees) towards environmental problems (is this known by the Park management)?
36. Does there exist a corporate responsibility for the whole Technology Park?
37. Is there a shared HRM policy between the companies?
    - For example a pool of technicians that are exchanged between companies /campuses.
38. Does the Park management support development and implementation of technical progress and innovation of green technologies?
    - In what ways is this done?
39. How does the Technology Park encourage company creation?
40. What can you tell me about the presence of different kind of spin-off processes?
41. Prioritize the following aspects of a Technology Park:
    1. Organizes knowledge transfer
    2. Increases regional competitiveness

3. Encourages the creation and growth of new and sustainable innovation-based companies
4. Provides value added services
5. Stimulates a culture of quality and innovation among companies and universities
6. Provides high quality space and facilities
7. Managed by a specialized team that has the capability to comprise different perspectives, support innovation and explore innovative ideas
8. Other, namely: ….

42. Do you have other subject related comments/recommendations that I can use in my research?

Thank you very much for participating in this study!

Annex 4: Overview of indicator linked to criteria

Technology Park Criteria	Indicator	Present in existing list
1. i+ii+iii	Academics grade of the management	X
	Years of experience in science, business and politics	
	Number of years of professional experience (staff)	X
	Number of years of business experience (staff)	X
	Average years of professional experience of the administrative staff	X
	Years of administrative experience	X
	Academic degree of administrative staff	X
	Number of persons making up the adm. staff	X
	Average years of professional experience of the support linkage staff	X
	Average years of experience in the university business of the support linkage staff	X
	Academic grade of the support linkage staff	X
a.	What kind of services are provided?	
	Satisfaction of companies in the park	X
	% of staff against the total number of people working in the park	X
	Number of public funds managed for the companies	X
	Total amount of funding managed for the companies	X
b.	Number of jobs generated in the park	X
	Number of indirect jobs generated in the region	
	Venture capital	
	Number of meetings between companies and campus staff	
	Number of external employees working for companies in the Park	X
c.	Amount of investments spend on R&D companies	
	Patents generated	
	Copyrights generated	
	Number of new products/services generated	
	Number of laboratories	X
	Number of training courses and seminars provided by the park	X
	Number of teachers on campus involved in projects with companies	X
d.	Number of jobs held by graduates of Tec or UTM	X
	Revenues from the use of laboratory service	
	Number of projects between companies and research centers	X
	Number of linkage projects	X
	Number of students and teachers in projects and activities	X
	Number of students working on projects with companies in the park (professional and graduate)	X
e.	Total amount of income from Tec projects with companies	
	Number of graduate students who have been hired by	

	companies in the Park	
	Number of companies in the Park that are owned by students	X
	Number of companies in the Park that are owned by alumni	
	Number of companies in the Park that are owned by teachers	X
	Companies f from the park	X
	Number of registered companies that are physically in the incubation area of the campus	X
	Number of registered companies that are physically in the acceleration area of the campus	X
	Number of companies (spin-offs) created from any patent generated on campus	X
	Number of companies (spin-offs) created after a research initiative from teachers or researchers within the research centers on campus	X
	Number of companies (spin-offs) generated from businesses in the Park	X
	Number of teachers starting a business in the Park	X
2.	University in TP?	
	R&D institutions in the TP?	
3.	Incubator present?	
	Number of companies generated in the Park	
	Incubation resources	
4.	Square meters (m2) of land, construction, laboratories and R&D areas, administrative offices, meeting rooms, lounges, cafes and common areas	X
	Number of intellectual property licenses that companies have purchased (occupancy)	X
Brand name	Total amount of funds received from other institutions (international and national)	X
	Number of landing companies in the Park	X
	Number of foreign landing companies in the Park	X
	Occupancy of company space	X
	Total amount of funding received from governments	X
Sustainability criteria (environmental, social and economic)	Average number of years employees working in the Technology Park	X
	Number of jobs preserved	X
	Age of staff	X
	Gender ratio	
	Average income	
	Origin of employees	
	Education index	
	Environmental performance	
	Democracy index	
	Plans for reducing waste/water/energy etc.	
	Life quality and welfare	
	Development possibilities for employees	

Knowledge transfer/links companies - university	See criteria 1c, 1d,1e and 2

Annex 5: Description of criteria for the Technology Parks used by DEMATEL (Chia-Li Lin, 2009)

Criteria Description	
A. Human resource	
A.1. Supply of qualified personnel	The supply of qualified personnel will help the exploration of business
A.2. Human brain cultivation organizations	Human brain cultivation organizations will provide sufficient training courses required by enterprises
A.3. Quality of R&D engineers	Qualified engineers will upgrade the ability of R&D results
A.4. New jobs creation	Talented personnel will apply for a good job
A.5. Incubator resources	Sufficient incubation resources will contribute to the establishment of new start-up companies
B. Technology resource	
B.1. Quality of research institution	The quality of research institutions will influence obtaining technologies of enterprises
B.2. Cooperation between industries and academics	The better the cooperation, the easier the gain of new technologies
B.3. Circulation of industry information	Faster circulation of information will enhance the competitive abilities of enterprises
B.4. Quality of enterprises	Good stationed enterprises will contribute proposals to enter the park
B.5. Occasion for enterprises cooperating	Higher cooperating chances will improve the ability of technology R&D of enterprises
C. Investment environment	
C.1. The scale of industries	The scale of industries will affect the scale of industrial value chains
C.2. The territory of science park	More enterprises could enter the park with larger territories
C.3. Incentives for investment	Good incentives will raise the intention of enterprises to enter the park
C.4. Informational infrastructure construction	Good information infrastructure will raise the intention of enterprises to enter the park
C.5. Legislation and government policy	Exact and precise legislation and government policies will raise the intention of enterprises to enter the park
C.6. Operation costs	Low operating costs will raise the intention of enterprises to enter the park
C.7. Regional traffic networks	Better traffic networks will raise the intention of enterprises to enter the park
C.8. Regional development outlook	Better development outlook will raise the intention of enterprises of entering the park
C.9. Living utilities	Better living utilities will raise the intention of enterprises to enter the park
C.10. Regional infrastructure construction	Well infrastructure construction will raise the intention of enterprises to enter the park
D. Market development	
D.1. Benefit of economies of scale	More stationed enterprises can contribute to attain economies of scale and raise the efficiency of manufacture and operation
D.2. Supply networks	Closer networks will tighter the relationship and reduce the operating cost
D.3. Competition status	Fierce competition status will enhance the competitive ability
D.4. Reputation	The performance of stationed enterprises will affect the reputation of the park
D.5. Completion of supply chain	Clarified industry division will enhance the supporting firms and tighten the industrial supply chain
D.6. Bargaining power	Bargaining power will affect the procurement power
D.7. Quality of outsourcing providers	Better qualified outsourcing providers will raise the intention of enterprises to enter the park
D.8. Prospects of industries	Brightening prospects of industries will raise the intention of comp. to enter the park