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A New Way to Promote Economic Development in Mexico: The Technology Parks of the Tecnológico de Monterrey.

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Abstract

In the last two decades technological progress has enabled consumers to have access to products and services that are renewed at shorter periods each time. This promotes companies to be constantly looking for innovations that make them competitiveness. Technological Parks have shown to be an efficient way to promote innovation between local and national companies. In the last decade, in México, the Tecnológico de Monterrey has been working in Tech Parks as a way to promote local development fostering innovation across them.

Keywords: *New Methods, Economic Development, Technology Parks.*

Introduction

In the last two decades technological progress has enabled consumers to have access to products and services that are renewed at shorter periods each time. "The globalization phenomenon, characterized by intensification of international competition derived from the view of the world as a large market, has brought along with it deep productive and socio-economic transformations that constitute a process that is taking place at different levels (international regional and national) simultaneously and that imposes the need to have new methodological approaches with which to understand and stimulate competitiveness" (Solleiro and Castañon, 2005:1060). This promotes companies to be constantly looking for innovations that

allow them, on one hand, to maintain their market share and also to be competitive in this global environment.

It has been observed that these features, innovation and competitiveness, are key to maintaining the economic development of the countries, such is its importance that it has been developed a whole new theoretical framework that builds the economic growth based on intensive use of knowledge, which is expressed in human capital of any country, rather than in other factors of the production function as labor and capital. Therefore, the theoretical structure of technologists to economic development and the knowledge economy is the first item discussed in this article.

The relationship between human capital and growth can be roughly outlined as: it is through knowledge that the competitiveness by product innovation is promoted by the companies. This knowledge feeds on research and development (R & D) which is funded either by the companies, or the governments, or often in shared schemes. What experience shows, is that by sharing this knowledge and the face to face contact between its users and creators, this is exploited in a better way to be innovative and hence competitive.

A key element to transfer this knowledge and to generate innovation is to link companies with knowledge-generating institutions, namely universities and technology transfer centers. “The emergence and development of relationships between innovate actors (firms, R&D institutes, universities, etc) is crucial to transfer innovation relevant knowledge” (Werker, 2003:289). It is from the model created by Stanford University (Silicon Valley) that it is observed that technology-intensive activities with a high added value generation are well developed in complexes now known as Technology Parks.

"The immediate background of science and technology parks is closely linked to the experience of Silicon Valley. There, for several decades, cooperation between companies, military organizations, universities, departments of the U.S. government, and financial institutions of venture capital, were the agents needed to create a business, social and researcher environment which made possible a rapid techno-scientific advance." (Ondátegui, 2000:97)

Some examples of the impact of universities in their environment are:

- Stanford University: In the "Silicon Valley" it is generated 30% of high-tech jobs in the U.S.
- Massachusetts Institute of Technology (MIT): The monetary income of the MIT-born companies makes the equivalent of the twenty-fourth world economy.
- The companies promoted by this university -either incubated in it, or generated from intellectual property licenses- have an annual economic impact of $ 7.4 billion dollars in sales in the state of Texas.

From these experiences, this model has been tried to be replicated all over the world. According to Ondátegui (2000), in Europe, mainly in the north, technology parks have been a way to capitalize knowledge and support the development of society. Scotland, Holland, Germany, France, England, Sweden, Spain, Italy and recently Portugal, are examples of countries that have successfully promoted technology parks. In Asia, the emergence of the phenomenon has not been smaller, India, China, Singapore and Taiwan have moved from the assembly stages to more qualified development stages, the Technology Park of Hsin-Chu employed more than 60,000 people and was the main supplier of electronic and computer components and equipment in the world at the beginning of the century. The phenomenon has spread to other geographical areas, Australia, Israel, Africa and South America, where, as an example, in 1986 the Technology Park of the University of Brasilia was founded.

Mexico, so far, has not been a world class player in the field of high technology, however, the Tecnológico de Monterrey is aware of the importance to be one. Thus, given that the international experience suggests that one way to begin this relationship between universities and companies is through technology parks, the aim of this paper is to frame the effort that has been done in Mexico to promote technological innovation through the development of such parks and in particular, the case of the Tecnológico de Monterrey, which as a leading educational institution in Latin America, has permeated the business contact with high-tech and high added value companies. The efforts of this institution are done in four directions and through four models detailed in this article as follows: i) definition of technology park ii) Mexican government's drive to technology parks iii) the experience of the Tecnológico de Monterrey with its four operating models of Technology Parks (TP), iv) main results of the models, and v) conclusions.

The methodology followed in this article is based on an analysis to define what is a technology park as well as to describe the experience of Mexico and of the Tecnológico de Monterrey in the development and operation of TP. Logic models are developed from the definition of the four models used by the institute to classify its technology parks. And in turn, the results are summarized from the analysis of data collected by the Technology Parks Research's Dean of the Tecnológico de Monterrey.

The technologist's approaches to economic development and the knowledge economy.

Rivera (2006), places the work of Nelson-Winter (1982)[1] as the pillar of technologists approaches, and among the most important followers to Larry Westphal (1978)[2] and Linsu Kim (1980 and 1997)[3]. The company was the first unit of analysis, the second, the network of companies, finally, the concept of Innovation System. The precursor of this category was Christopher Freeman, referred by Chareles Edquist (1997: 8), who explains a National Innovation System as the network of institutions in the public and private sectors that initiate activities and important interactions, modification and promotion of new technologies.

Lundvall (1992), cited by Edquist (Op. Cit.) defines the concept of national innovation systems in a "broad" sense, including all parts and aspects of the economic structure and set-up institutions that affect learning as well as research. Where the production system, the market system and the system of financing have a subsystem in which learning takes place.[4]

Also, technologists explanations replace the concept of capital accumulation by the accumulation of technological capabilities whose base is knowledge[5]. Intangible capital that becomes increasingly important

[1] Nelson, Richard y S. Winter (1982), *An Evolucionary Theory of Economic Change*, Harvard University Press, Cambridge, Mass.

[2] Westphal, L (1978), "The Republic of Korea´s Experience with Export-Led Growth Industrial Development", *World Development Report*, num. 6.

[3] Kim, Linsu (1997), *Imitation to innovation. The Dynamics of Korea´s Technological Learning*, Harvard Business Scholl Press, Boston.

[4] Dimensions of Innovation Systems include: national, regional, international and technology. The technological system means: a network of agents interacting in a specific / industrial area under a particular set of institutional infrastructure or infrastructure including generation, dissemination and use of technology economy [Edquist, Charles. 1997, p.8]

[5] Quoting Sergio Ordoñez (2004): "According to a materialistic view of reality, the knowledge consists in the reproduction in thinking of the material world. The process of knowledge can have varying degrees of scientism, i.e. reflect a greater or lesser extent the essence of phenomena and its form of manifestation in appearance.
Consequently, there are two major types of knowledge:
1) The theoretical, explicit or rational: it systematically realizes the essence of phenomena and how it is presented in appearance,

in total productive wealth, becoming the most important productive force knowledge. Even the current phase of capitalism becomes named "knowledge capitalism".

Historically, the knowledge and the ideas have given rise to new products, processes, services and branches of economic activity. One of the civilizing aspects of capitalism was precisely the application of science in production. However, concerns Sergio Ordoñez (2004), the hallmark of the present capitalist stage is the emergence of a new productive force, which comes from the close links "between science and production, and production of science and knowledge in the form directly accessible and applicable for the production, particularly, through the development of software" (Ibid. p. 11). Because the software understood as codified and objectified knowledge, it can be used as a tool to create new knowledge.

This process has evolved during the current technological revolution, it has altered the objectification of knowledge in the social product into two categories. First, in the transfer of dead labor (objectified knowledge previously) to the product. This through the addition of a new productive force, the software, which is able to create new knowledge, it being knowledge previously codified and objectified. First, in the transfer of dead labor (objectified knowledge) to the product. This through the addition of a new productive force, the software, which is able to create new knowledge, being knowledge previously codified and objectified. Secondly, the creation of new knowledge by living labor, resulting in a faster process and intense. Particularly, the conception and design operations that achieve independence from the manufacturing phase.

The activities of conception, design and manufacturing hold different organic compositions of capital. The labor-intensive industries highly skilled maintain a capital composition (intensive variable capital) under which the valuation of knowledge acts as a "a new countertrend to the falling rate of profit" (Ibid. P. 12). Therefore, within the value chain, the capitals most benefited are those capitals that achieve industrial upgrading (See Scheme 1).

Also, according to Paul David and Dominique Forey (2002), the particular feature of the current economy based on knowledge it is the accelerated speed and unprecedented which knowledge is created, accumulated and depreciates in terms of relevance and economic value .

This process is also called New Economy due to "shift" from a industrial model to the hegemony of a new system based on the concepts and ideas for the production of goods and services. Particularly, the information-technology -- microprocessor, lasers, fiber optics, satellite --which have achieved rapidly

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2) The empirical, implicit, tacit or sensitive: it realizes the apparent unsystematically and, to a greater or lesser extent, how it hides certain essential elements.

The knowledge also involves two stages:

1) Your objectification of the social product, carried out by:

a) The transfer of knowledge to the product previously objectified in the dead labor (equipment, machinery and production equipment and raw and auxiliary materials)

b. The creation of new knowledge by living labor (workers, technical engineers and acting)

c. The incorporation of new knowledge to the product.

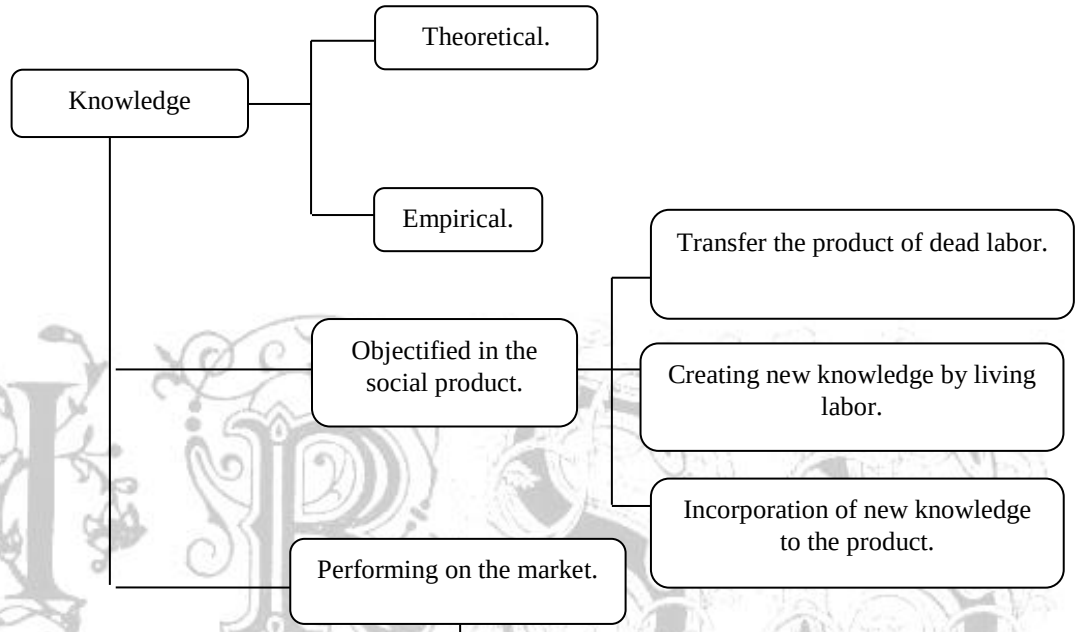
2) Its realization in the market "[Ordoñez, Sergio. 2004. p.10].

According to Amin, A. and P. Cohendet (2004) the importance of knowledge in the economy can be understood broadly to the extent it is considered a unique asset that appears as a product of the production process (such as studying the theory innovation) and as an input in the production process (such as studying the theory of competition). One of its main contributions is the criticism of orthodox economics which reduces knowledge to a linear transformation of the information.

increase productivity. [6] Moreover, the technologists approaches have been grouped in the so-called General Purpose Technologies. This theory disposes as "main force" of economic growth to "technological progress" in general and the "drastic innovations", in particular [Rodríguez, José. 2006: 8]. Investigations by the following authors: Romer (1990)[7], Aghion-Howit (1992)[8], Grossman y Helpman (1994)[9], correspond to this thesis, which is a reinstatement of historical approaches.

Scheme 1

The valorization of knowledge in the value chain



Assessment of knowledge			
Phases of the value chain	Organic Composition of Capital	Cost structure	Realization (large-scale production)
Conception and design	C. V* > C. Cte**	a. High production costs b. Minima production costs	Growing profits
Manufacture	C. V < C. Cte.	Production costs comparable to the costs of reproduction.	Diminishing returns

Note: *C. V: Variable capital (highly qualified work); **C. Cte: Capital constant (machinery and equipment) Source: Prepared based on Ordoñez, Sergio. 2004.

[6] The term "new economy" is used to designate an "economy in which investment in IT drives high rates of productivity growth" [Rodriguez, Jose. 2006: 12]

[7] Romer, Paul (1990), "Endogenous technological change", *Journal of Political Economy*, vol 98, no. 5: S71-S102.

[8] Aghion-Howit (1992), "A model of growth through creative destruction", *Econometrica*, vol 60, no.2, march: 323-351.

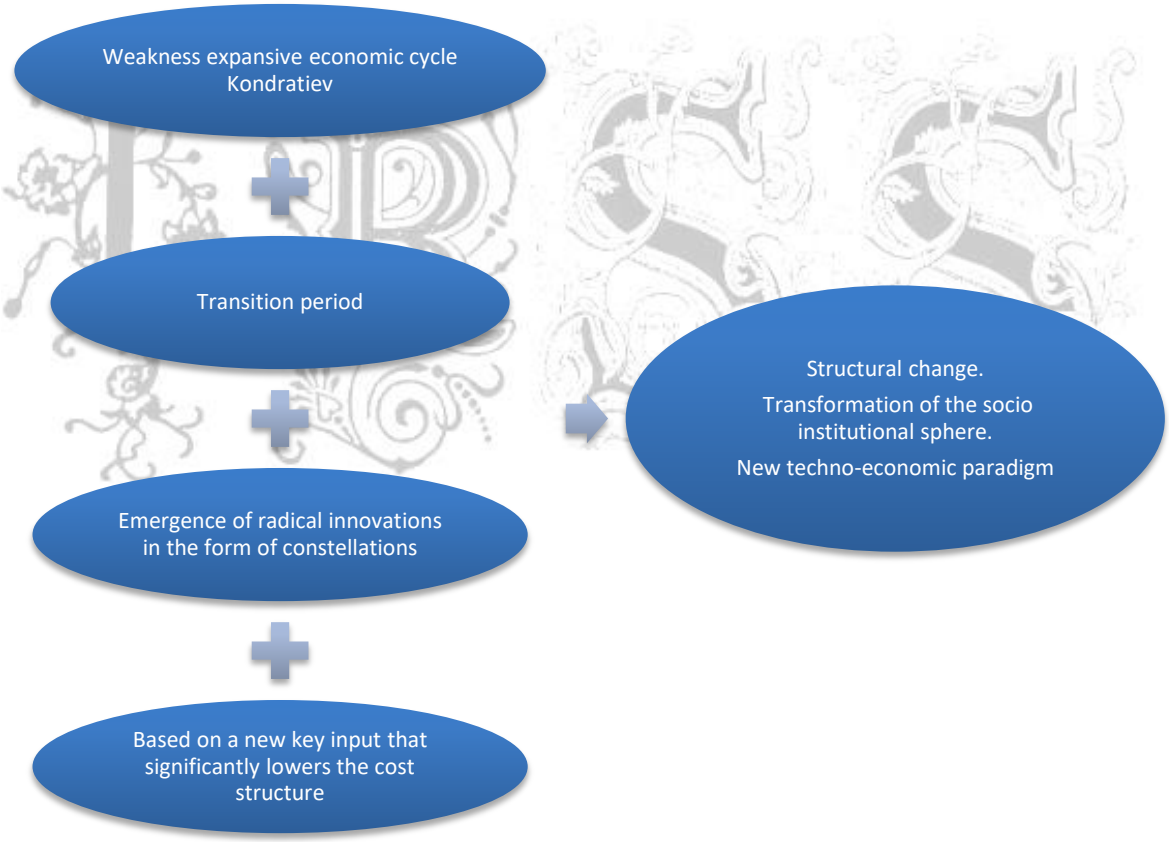
[9] Grossman-Helpman (1994), "Endogenous Innovation in the Theory of Growth", *Journal of Economic Perspectives*, vol. 8, no. 1.Winter: 23-44.

The analysis of the theory: General Purpose Technologies, part of very similar proposals to the school of Sussex, in the sense that the change in the economic cycle produces a strategic innovation, that can alter both the performance of the economic sphere and social, and the political structures.

Finally, according to the escula of Sussex -under the texts of Christopher Freeman and Carlota Perez- the expansive period of an economic cycle is explained by diffusion of a new economic paradigm and the depressive phase is explained for periods of structural adjustment where the social system and institutional adapting to new technologies.

A techno-economic paradigm refers to "a model of best practice consists of a set of technological and organizational principles, generic and ubiquitous, which represents the most effective way of implementing the technological revolution and use it to upgrade the rest of the economy. When adoption is widespread, these principles become the basis of common sense for the organization of any activity and restructuring of any institution" (Scheme 2.) [Freeman, Christopher and Carlota Perez. 2002. p. 41].

Scheme 2.
The establishment of a new economic paradigm.



Source: Prepared based on Freeman, Christopher y Carlota Perez: 2002 y 1998.

Now, a technological revolution is embodied in a new economic paradigm when radical innovations make use of a new key input (which meets the characteristics of low cost, availability of long-term, and potential

use) that affects the cost structure significantly[10]. The new economic paradigm was initially developed within the old paradigm showing a decisive advantage during the "weakness" of the previous growth cycle of Kondratiev. This paradigm is imponsed after the structural crisis and the adaptation of the socio institutional sphere.

Definition of Technology Park

While the technology park concept in principle is developed from the experiences of Silicon Valley, it has evolved and has incorporated concepts ranging from the simple use of space by companies up to the conception of these as areas of R & D. Therefore, the first step to understand the scope of a technology park is in its definition. Here are some definitions at the discretion of the authors that can be adjusted to the international experience and considered as commonly accepted definitions.

According to Ondátegui (1997), within the different metropolitan and technopolitan dynamics, one of the instruments which has been used to focus, develop and disseminate technology from knowledge and thus enhance innovation processes through synergies between scientific institutions and the needs of the productive sectors, has been the creation of science and technology parks. In these productive areas is where new scientific and socioeconomic structures are created, supported by knowledge, in the ideas and in the cooperation between institutional, academic and productive environments.

It is these sectors, which are intertwined with different intentions to make a unique synergy of the parks that is embodied in productivity for a country and its regions. Parks are then sectorial connecting factors focused on the economic growth of the regions from the social, economic and cultural perspective, since all three elements are represented by the different institutions. Following this definition, it is clear that the role of a technology park is to provide human capital, knowledge and relationship spaces to these companies so they can achieve a certain competitiveness enabling them to survive in globalized economies and rapidly changing markets.

In this sense, the technology park can be defined, in a broader context as well-founded organizations seeking business acceleration through knowledge agglomeration and resource sharing (Phan et al., 2005). In general, science and technology parks have proven to be useful vehicles for the interaction between research and industry. A generally accepted definition is provided by the International Association of Science Parks (IASP) which is a worldwide lead agency in the field, as it is the responsible to study and document them:

[10] Freeman and Perez (1998) present the following taxonomy of innovation

1) Incremental innovations: These types of innovations occur more or less continuously in any industry or service activity although at different rates, industries and countries, depending on a combination of demand pressures, socio-cultural, technological opportunities and technological trajectories.

These are not the product of R & D (research and development) deliberate but the result of inventions and improvements suggested by engineers and others, directly linked to production processes or as a result of initiatives and proposals of users. These are associated with scaling plant, equipment and quality of inputs to produce goods and services. The combination of their effects is extremely important for productivity growth.

2.Radical innovations: They are discrete events that result from deliberate activities in R & D in companies and / or universities and government laboratories.

3. New Technologies Systems (change "technological system"): These have a broad in scope in technology, affecting a wide of sector economy and new sectors.

4. Changes in the "techno-economic paradigms" (technological revolutions): Some changes in technological systems are too far away for their effects and have a major influence on the behavior of the entire economy. A change of this type carries many clusters of incremental innovations, and future includes several new technology systems.

A science park is an organization managed by specialized professionals whose main objective is to increase the welfare of their community by promoting the culture of innovation and competitiveness among business partners and knowledge-based institutions (the university). To achieve these purposes, the science park stimulates and manages the flow of knowledge between universities, R & D institutions, companies and markets, facilitates the creation and growth of knowledge-based companies through incubation and the spin-off process and, finally, also provides other value-added services together with spaces and facilities of the highest quality (IASP, 2007).

Finally, according to the IASP, the term science park is used to define a property based initiative which:

- Has operational links with one or more universities, research centers or other institutions of higher education.
- It is designed to encourage the formation and growth of knowledge-based industries and other organizations that are normally found at the site.
- It has a leadership role which is actively engaged with the transfer of technology and business skills to tenant organizations.
-

The Organization for Economic Cooperation and Development (OECD) also proposes elements of localization and definition of technology parks (OECD, 2009):

- Its main function is to concentrate high-tech industries and specialized service centers.
- It has, as essential component, at least one university department or technology institute with which the concentrated companies in the area can easily communicate in the material and intellectual area.
- The activities carried out by the companies, research centers and institutes include a significant component of research and development.

A forgotten component from these perspectives is the space, which is very important in Technology Parks, since a function of these is to provide leasing space to companies interested in being close to educational institutions to use their "spillovers" so there are other conceptualizations that implement this vision and say that:

- A technology park is a real estate project that brings benefits in the field of image. It is a real estate business that seeks economic performance to its promoter.
- It is a technology business community that obtains benefits and provides value to each of its participants due to its network of mutual interests. It identifies with an even broader international community of interests in the business of technology commercialization.
- It acts as a magnet for heavy investment in technology. It attracts businesses that are dedicated to apply an innovative technology. It is a bridge to the commercial field of research, which is an aspect of importance to commercial interests.
- A park is an incubator for technology-based activities that allows researchers to start a business using innovative ideas without necessarily abandoning their academic work.

The Tecnológico de Monterrey defines a technology park as:

"... an organization established in one or more buildings within a specially designed environment, which includes companies, research centers, incubators, accelerators, academic activities, and a range of services designed to promote business competitiveness based on innovation and high value added activities" (Itesm url, 2009).

A further aspect of Technology Parks is that they are places where property rights are exploited by the universities to obtain remuneration when in the past they did not have this revenue due to the concept of research that they perform. The Tecnológico de Monterrey was the Mexican university with the most ownership of patents between January-December of 2013 (IMPI, 2015) after a great big push on these activities.

Thus, in this work we understand that a TP is an element that combines various functions such as attraction, incubation, acceleration of business and technology transfer with a close relationship and feedback with a knowledge-generating center such as a university. All this in the field of high technology which, generates high value-added companies that seek to boost the development of their immediate environment and therefore of the country.

The Case of Mexico

According to Molina et al. (2009), during the nineties it emerged in the country the idea of implementing business incubation activities through federal agencies like the National Council of Science and Technology (CONACYT by its initials in Spanish) and the Ministry of Economy (SE by its initials in Spanish) that supported these types of activities. However, these efforts were not successful, the initiative of scientific and technology parks of the CONACYT basically failed due to the lack of an appropriate operation model of these parks and to the financial sustainability strategy under which they were created (Corona et al. 2006)

From the beginning of the XXI century a second and stronger attempt on the creation of technology parks and business incubation occurred, now under the auspices of universities, public and private, which proposed a new configuration, new operational models and management strategies for incubators. According to the National Business Incubation System, there are about 324 incubators in Mexico, of which 18 are devoted exclusively to high technology (Molina et al., 2009).

More recently, the commitment of the government has been the continuous promotion of these incubators through a scheme closest to the idea of a technology park, from the point of view, perhaps, of an area of linkage. The Ministry of Economy (SE) implemented a program for the Development of the Software Industry (PROSOFT by its initials in Spanish), whose objective was to position Mexico as a global player in the industry of Information Technology (IT). The PROSOFT fund, which was intended to support projects that promote the creation, development, consolidation, viability, productivity, competitiveness and sustainability of companies in the IT sector and encourage its use in the economic sectors of the country, supported the creation as well as the consolidation, and the initiatives for the development of technology parks on which from 2004 to 2006 it was detonated a total investment of 227 million pesos, on which the Ministry provided over 36% through the said fund (SE, 2007).

During the fiscal year 2007, PROSOFT allocated more than 25 million pesos to boost Technology Parks' projects including technological equipment, usable space, consulting and expert advice. These projects led to the establishment of 144 employments (SE, 2007). The importance to the Mexican government in the creation of this type of spaces is reflected in the Special Program of Science and Technology 2008-2012 (PECYT by its initials in Spanish) which states that:

"An essential aspect for the development of scientific and technical abilities is related to the establishment of a systematic investment policy in infrastructure and scientific equipment that properly considers the human resources that the system itself has developed.

It is important to promote collaboration schemes between the different actors of the SNCYT that allow to harness and enhance the scientific and technological infrastructure of the country. Conacyt has initiated actions to create and strengthen the links between research centers, higher education institutions and companies through networking, technology parks, and consortiums that promote joint projects" (Conacyt, 2008).

Parallel to this action by the government to promote the development of high technology companies, the Tecnológico de Monterrey has implemented a strategy to support high value added companies in the technology sector. For over 20 years, in this institution we have tried to implement an entrepreneurial culture in all the programs implemented to make our Campus true business incubators, and this innovating vision continues to be fostered through a new action that is complementary to the government's, the implementation of technology parks.

The Experience of the Tecnológico de Monterrey

The Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM) is one of the most prestigious higher education institutions in the country, from Latin America and recognized by most of the schools of higher quality worldwide. As a leading university, the Tecnológico de Monterrey is committed with the development of the country so it has implemented a strategy within its Campuses aimed at attracting and creating technology-based companies, as well as to the training of its students skills focused on the use of State-of-the-art technology. According to Ph.D. Rafael Rangel Sostmann, Dean of the ITESM system, "the vision of the Tecnológico de Monterrey is aimed to make of it the most recognized educational institution in Latin America due to the leadership of its graduates in the private, public and social sectors, the research and technological development to bolster the economy based on knowledge, for generating management models and business incubation and assist in the improvement of public administration and public policy, for the creation of innovative systems and modules for sustainable community development"

To fulfill its vision towards the year 2015, the Tecnológico de Monterrey has developed a strategy based on the following aspects:

- To promote sustainable regional development
- To capitalize knowledge for the benefit of society
- To develop environments that lead to innovation
- To generate faculty and students with experience in technology transfer, technology commercialization and business and companies' incubation
- To consolidate the Tecnológico de Monterrey as an academic, scientific and entrepreneurial ally

The aim of this strategy is to impact regional development in the country through the use of knowledge to attract and create companies in the high technology sector that are intensive in the use of it and that generate high added value, in addition to scale economies that can activate the regional economy. For this, the model implemented by the Tecnológico de Monterrey to transform ideas into knowledge and drive innovation is based on "Technology Commercialization Processes" as defined by Jolly (1997), which describes nine different activities to commercialize new technologies (Molina et al., 2008:8).

Thus, the model defined as "Model for Transforming through Knowledge" is based on ten strategic programs that frame what is known as strategy R + D + i2 (Research + Development + Innovation + Incubation) of the Tecnológico de Monterrey, and that frames the processes to be followed to achieve the vision set by the system. Namely, these ten programs are:

1. Development and attraction of human resources
2. Increase of undergraduate and graduate programs
3. Feed the institutional support strategy for research groups
4. Increase R & D centers for the excellence within the institution
5. Improvement of the research networks within the institution
6. Improvement of the network technology development at the institution
7. Consolidation of the institutional centers for industrial assistance
8. Move to the next level of business incubation and acceleration of networks
9. Development of scientific and technology parks
10. Promotion of the sustainable growth and innovation
11. Integration strategies in knowledge intensive phase in global production chains.
12. Strengthening the domestic market through the development of human capital and technological sovereignty.

The last three points are the consolidation of the strategy set by the institution to generate synergy between companies, university and society leading to economic growth in the region. This model of technology parks, as already mentioned, has been exploited successfully in the world and the Tecnológico de Monterrey has adapted to the Mexican reality four models based on the resources it has as an institution and the support of local, state and national governments.

"As in most educational institutions (e.g. universities) most of people are research oriented and most of them do not have the capability to promote their R&D knowledge to develop business or new projects in association with local or national industries or institutions" (H.-K. Ifan et al., 2004:996). The Tecnológico de Monterrey strongly believes that the four Tech Parks models designed are the way to change this vision about educational institutions and her roll in local and national development.

Technology Parks of the Tecnológico de Monterrey System

Since the beginning of what we now know as TP, how to define the same has been an adaptation to the needs and realities of each country that has tried to implement from the successful experience of Silicon Valley. Taking into account the fundamental characteristics of a TP that can be summarized as: i) to be an instrument of economic and social development, ii) create knowledge, and iii) have formal relationships with an university to transfer technology, and considering that these are centers of concentration of innovative activity and high technology, how to define these spaces is a function of the form and intensity with which these features are linked and the resources available to each country.

The Technology Parks program developed by the Tecnológico de Monterrey has been formulated in close proximity to the regional community governments, taking into account the distribution of the 33 Campuses of the system and the advantages that each one of these accounts. Each of the models developed is designed on the features that each Campus has in terms of infrastructure, programs and training of human resources and research centers. The process of consolidation of the four models was based, above any other element, on the experience gained by some professors and researchers of the system on visits to various technology parks in the world.

Each model was defined in terms of the generation of logical models that are developed based on the characteristics of each type of defined park. The parks share objectives under each of its modalities, and this common goal of each model provides the basis for adoption of a common working structure to define the benefits of the different models and the logical models of each one of them. The logical model allows to define, depending on the objective that each park model has, the activities undertaken to achieve such goal, what the results of these activities will be, the effects they will have on different areas, the impacts that will

be the basis of the indicators to consider for the evaluation of each model, and the direct benefits expected for the stakeholders involved.

Therefore, technology parks are the consolidation of a strategy of the Tecnológico de Monterrey to encourage in all its activities an entrepreneurial attitude throughout its community, both academic and corporate. The guide for developing each of the models is based on the common features observed in all these visits and to determine which ones can be reproduced depending on the features that each Campus of the system has. So it was determined that four models were the offer covering the characteristics of any of these Campuses.

Model I: Technology parks for high-value employment

These parks are designed to house technology companies seeking human resources for high-value activities, but do not require science or research. These technology parks are a good way to provide specialized talent to technology companies in an environment close to the university. Immediate feedback from the companies is necessary to enrich the educational model and thus improve the profile of the graduates (Aguirre, 2008:56)

These parks are designed to be supported mainly by Tec Milenio University which is part of the system, in which mainly human resources of high value are generated but there are no research and graduate activities. Therefore, it is seek to attract companies that require human resources and any other extra activity of R & D they need, it can be provided by other Campus with a more complete infrastructure.

This type of parks (Table 1) are basically supported by a high education institution, they require office space for the companies use, the space needed for its construction is 500 to 4000 m^2 and it is roughly estimated that it takes 5, 000 Mexican pesos per square meter of construction, and the time to begin operations is six months.

There are currently 5 parks built of this kind in different Campuses of Tec Milenio, as shown in Table 2, and the main activity of these parks has to do with Information and Communication Technology (ICT). These parks are home to international companies such as Infosys, which is a multinational based in Bangalore, India, and is dedicated to the services of information technology, up to local companies like Fractalia, which specializes in the same field and serves Mexican companies like IUSA group, Alma de Mexico and Tabasco state government.

As we can see through the logical model of this type of parks (Table 3), the main activities of these parks have to do with the construction of basic infrastructure and the networks that these parks can generate to benefit companies that settle in it. Usually, an aggregate value of these parks is the contact that the companies have with the university and the feedback between the two to generate graduates with specific profiles. This reinforces the generation of updated resources in the technology sector and makes the region more competitive by having them.

The fact of having specialized human resources in high technology activities and the specialization of most of them with advanced degrees causes the region to increase its income per capita, which translates into improved quality of life for its inhabitants. The economy is reactivated and there are greater employment opportunities, due to scale economies. It is expected that this type of parks, generate a virtuous cycle in economic terms with all the advantages that technology companies generate, as their activities are considered of high value added.

Model II: Technology parks to attract and develop companies

These technology parks are primarily combinations of high-tech incubators to boost start-ups and landing facilities to accommodate foreign technology companies wishing to establish operations in the region. These technology parks strongly support consulting services, technology management, networking and specialized exchange of research and development abilities of the universities with the companies. These technology parks do not include R & D activities but they provide in these areas, a group of managers and highly trained technology brokers.

The necessary conditions for the implementation of these parks, (Table 1) is to have facilities for incubators and accelerators, networking with R & D, offices are required for administration and technology transfer, the surface for the construction of a park of this type is 4, 000 to 10, 000 m^2, with an approximate cost per meter of 6, 000 Mexican pesos, and the time to begin operating these facilities is approximately one year.

Table 1: Characteristics of the parks' models of Tec de Monterrey

	Model 1	Model 2	Model 3	Model 4
Concept	• Development of high value employment	• Technology transfer acceleration, landing	• Development of research and spin offs based on high technology	• Innovation and Technology Parks
Necessary Conditions				
Resources and main activities	• Academic Institution	• Incubators / accelerators • Networks with R&D centers	• R&D centers • Laboratories • Incubators/accelerators	• Incubators/accelerators • R&D centers • Specialized and competitive infrastructure and meaningful contribution of government funds
Requirements				
Necessary resources	• Office for talent management	• Office for Technology management and transfer	• Office for Technology management and transfer	• Regional project • Participation of the government universities and companies • Professional management of the park
Space	• 500-4,000 m^2	• 4,000-10,000 m^2	• 4,000-10,000 m^2	• More than 20 Ha.
Estimated Investment (Mexican Pesos)	• 5,000/m^2	• 6,000/m^2	• 7,000/m^2	• 4.5 million/Ha.
Start Time	• Six months	• One year	• Two years	• From two to three years

Source: Technology parks and knowledge-based development in México (Molina et. al. 2011:209).

Table 2: Parks type I Tec de Monterrey

Campus	Park	Model	Specialized Area	Companies	Start date
Ferrería	TecMilenio Ferrería	I	ICT	Softtek	2004
Monterrey	TecMilenio Las Torres	I	ICT	Infosys; Grupo Nasa; Aleph 5	2005
Culiacán	TecMilenio Culiacán	I	ICT	Neoris	2006
Guadalajara	TecMilenio Guadalajara	I	ICT	Gpo. Baratz, Integradores de Capital Humano	2006
Villa Hermosa	TecMilenio Villa Hermosa	I	ICT	Fractalia; G8 TI; INTEC; L&D Technologies	2008
Mazatlán	TecMilenio Mazatlán	I	ICT		2010
Reynosa	TecMilenio Reynosa	I	ICT		2010
San Luis Potosí	TecMilenio San Luis Potosí	I	ICT		2010

1. Years 2009 and 2010 indicate in which year it is expected the parks to be operating

Source: Development based on: Technology Parks: regional development tools (2009).

With these types of parks the Tecnológico de Monterrey began its project of TP. The Innovation and Technology Transfer Center of Campus Monterrey (CIT2) initiated this road in 2005, and is currently the most developed park within the steps required by the AR methodology. The AR methodology feeds on the experience of the actors of the project in place and allows changes to improve the process. The main feature of the AR methodology is in the ability of people to analyze and reflect on their own activities.[11]

This park has the function of promoting the development of technology-based companies, facilitate technology transfer activities, accelerate the commercialization of new technologies, and facilitate the adaptation of technology-based companies to global markets, particularly in Latin America.

By mid-2008, the CIT2 managed to attract and regionally adapt nine global technology companies and the growth of 15 local technology companies. Additionally, it coordinated the startup of seven projects between the Tecnológico and the member companies, and assisted in the creation of two spin-offs companies housed by the CIT2 and generated more than 130 high-value jobs in the area of software, telecommunications and engineering (Aguirre, 2008:109).

[11] For further reference on the RA methodology see: Molina et. al. 2011, Kemmis, S. and McTaggart, R., (1988)

Table 3: Logical Model for technology parks type I

Model/Objectives	Activities	Results	Effects	Impacts	Benefits
Model I These Technology Parks are designed to accommodate companies seeking human resources for high value activities but, that do not require of science and research	Development of basic infrastructure for companies seeking to get high-tech human resources Promotion of programs and human resources at a national and international level Link between networks and activities for the service of the hosted companies Generate a feedback system by the companies to improve the profile of the graduates Support to the host companies with R&D services from other parks with that same activity	Physical infrastructure (business offices, conference rooms, common areas, etc.) Training of human resources, updated in the needs of the high technology sector Inter parks cooperation Reformulation of curricula at the university in terms of current market trends Services provided to the hosted companies Local staff recruitment for the companies	Knowledge of the university of the latest trends in high technology Knowledge of the companies of the ability of the university to serve as a source of specialized human resources. High participation of students in high tech companies Continuous improvement processes in the programs and curricula of the university Management of human resources based on the activities of all Technology Parks	Creation of high added value employments Attracting of foreign investment. Positioning of the region in high technology activities Revenue generation for the parks from the rental of the land	Increase of human capital in the region: researchers, post graduates in science and technology, etc. Per capita income growth Emergence of new companies to serve the hosts. Increased infrastructure in the regions due to the development high tech companies Positioning of the university as source of high level human resources

Source: Development based on: Technology Parks: regional development tools (2009).

There are 5 more parks of this kind in operation within the Chihuahua, Cuernavaca Culiacan, North of Sonora and Estado de México Campuses (Table 4). Some of the companies that have settled in these parks are: Blocnetworks; Power Engineering Services and Solutions, Ecofreeze International, Sasken Communication Technologies Mexico, WIPRO Technologies and M-Sights in the CIT2 and, Visteon, Freescale Semiconductors, in Campus Chihuahua.

As shown in Table 5, the main activities of this type of parks are the average infrastructure development to receive high-tech companies, administrative training for network management, network development for R & D projects; business acceleration, etc. It is expected that this type of park has an impact on the region where it is developed so that the human resources employed change the society where they are set into a digital one, i.e. that they incorporate the technology advances provided by the TP.

Table 4: Parks Type II Tec de Monterrey

Campus	Park	Model	Specialized Area	Companies	Start date[1]
Monterrey	Innovation and Technology Transfer Center	II	Mechatronics, ICT	Blocnetworks; Power Engineering Services and Solutions; Ecofreeze International; Sasken Communication Technologies México; WIPRO Technologies; M-Sights	2005
Chihuahua	Innovation and Technology Transfer Park	II	Automotive, ICT	Visteon; Freescale Semiconductors	2008
Cuernavaca	Industry Innovation Center	II	Biotechnology, ICT		2009
Sonora Norte	Automotive and Aerospace Technology Development and Research Center of Sonora	II	Automotive, Aeronautic		2009
Culiacán	Agribusiness Technology Park	II	Agribusiness, Biotechnology		2009
Estado de México	Innovation and Technology Transfer Center	II	Automotive, ICT		2009
Puebla	Innovation and Technology Transfer Center	II	Agribusiness, Biotechnology		2009
Aguascalientes	Technology Park	II	Automotive, ICT		2010
Ciudad Juárez	Innovation and Technology Transfer Center	II	ICT		2010
Irapuato	Agribusiness Technology Park	II	Agribusiness, Biotechnology		2010
León	Innovation and Technology Transfer Park	II	Logistics, ICT		2010
Saltillo	Automotive Engineering and Design Park	II	Automotive		2010
San Luis Potosi	Automotive Technology Park	II	Automotive		2010

1. Years 2009 and 2010 indicate the years in which the parks are expected to be operating.

Source: Development based on: Technology Parks: regional development tools (2009).

Model III: Technology Parks for companies with scientific activities

These technology parks are very similar to model II, except that they incorporate appropriate infrastructure for R & D activities of the guest companies. In reality these parks are a combination of high-tech incubators to encourage the creation of new companies and landing facilities to accommodate foreign companies wishing.

Table 5: Logical Model Type II

Model/Objectives	Activities	Results	Effects	Impacts	Benefits
	Development of average infrastructure to host high technology companies	Physical infrastructure (business offices, conference rooms, common areas, etc.)	Knowledge of the university of the latest trends in high technology	Number of newly created technology companies	Increased human capital in the region: researchers, post graduates in science and technology, etc.
	Administrative training for HR, IP and technology transfer	Qualified managers in key areas of the high technology sector	Focused and highly specialized recruitment process	Number of R&D joint projects between companies and the university	Regional per capita income growth
Model II				Amount of financial resources	
These Technology Parks are combinations of high technology incubators to boost start-ups and landing centers to accommodate foreign technology companies that wish to establish operations in the region.	Attraction of high technology companies	Start-ups and global companies established in the park	Government awareness of the emergence of a high-tech sector	attracted by the companies	Productivity of the superior industry due to innovation
	Commencement of HR, IP and brokerage of business services	Services provided to the settled companies	Recognition of university resources by the companies	Revenue of the technology parks due to projects	More direct foreign investment in high technology companies
	Link of network activities for R&D and projects	R&D links between the hosted companies and the university	Interdisciplinary and multidisciplinary projects	Number of high technology employments created	Development of new clusters in high added value sectors
	High value employment recruitment	Local staff recruitment for the companies	High participation of students in high tech companies of recent creation		Increasing number of high value services for the society (education, commerce, amusement
	Business acceleration	New Products and services to the market	Accelerated growth of a business spirit in the technology sector within the university		Increased support infrastructure for technology intensive activities: technology parks
			Accelerated growth of business opportunities based on the innovation within the community		business centers, urban development
					Export of high value products and Mexican technology
					Rapid evolution of a digital society

Source: Development based on: Technology Parks: regional development tools (2009).

to establish operations in the region. They also include specialized laboratories in order to meet the needs of highly sophisticated companies in sectors such as nanotechnology and biotechnology on which laboratories are needed in an immediate and constant manner.

This type of park requires a space that ranges from 4,000 to 10,000 square meters and requires an investment of about 7,000 pesos per square meter to be built. Additionally, it is estimated that the time to begin operations is 2 years. The spaces needed for their development are focused on R & D centers, laboratories and business accelerators and incubators.

In Table 6 it is shown that there are two parks of this type in the system so far, the Biotechnology Center at Campus Monterrey and the Scientific and Technology Park in Campus Guadalajara. The first one due to its longest time in service has hosted companies like: PROTEOMICS-X; DQA Solutions Chimiques; NUTRETEC and; Bio-refineries de Mexico (BRM). The latter has housed MetaCubes and New Art Jalisco. The activities related to this type of parks, Table 7, are very similar to that presented in the previous section of model II, with a difference in the development of specialized laboratories in the areas of biotechnology and nanotechnology, moreover, this kind of park is fully committed with the generation of *spin-offs.*

Table 6: Parks type III Tec de Monterrey

Campus	Park	Model	Specialized Area	Companies	Start date[1]
Monterrey	Biotechnology Center	III	Biotechnology	PROTEOM-X; DQA Solutions Chimiques; NUTRETEC; Bio-refineries de México (BRM)	2005
Guadalajara	Scientific and Technology Park	III	ICT	Metacube; New Art Jalisco	2008

1. Years 2009 and 2010 indicate the years in which the parks are expected to be operating.

Source: Development based on: Technology Parks: regional development tools (2009).

Table 7: Logical Model technology parks type III

Model/Objectives	Activities	Results	Effects	Impacts	Benefits
Model III **These Technology Parks area similar to the previous but they include also, specialized laboratories with the aim to satisfy the needs of the highly sophisticated companies, in sectors such as biotechnology and nanotechnology**	Development of average infrastructure to host high technology companies Development of laboratories for biotechnology and nanotechnology companies Administrative training for HR, IP and technology transfer Attraction of high technology companies Commencement of HR, IP and brokerage of business services Link of network activities for R&D and projects High value employment recruitment Business acceleration Incubation and generation of spin-offs	Physical infrastructure (business offices, conference rooms, common areas, etc.) Specialized laboratories Qualified managers in key areas of the high technology sector Start-ups and global companies established in the park Services provided to the settled companies R&D links between the hosted companies and the university Local staff recruitment for the companies New Products and services to the market	Knowledge of the university of the latest trends in high technology Focused and highly specialized recruitment process Government awareness of the emergence of a high-tech sector Recognition of university resources by the companies Interdisciplinary and multidisciplinary projects High participation of students in high tech companies of recent creation Accelerated growth of a business spirit in the technology sector within the university Accelerated growth of business opportunities based on the innovation within the community	Number of newly created technology companies Number of R&D joint projects between companies and the university Number of patents generated in the laboratories Amount of financial resources attracted by the companies Revenue of the technology parks due to projects Number of high technology employments created	Increased human capital in the region: researchers, post graduates in science and technology, etc. Regional per capita income growth Productivity of the superior industry due to innovation More direct foreign investment in high technology companies Development of new clusters in high added value sectors Increasing number of high value services for the society (education, commerce, amusement Increased support infrastructure for technology intensive activities: technology parks business centers, urban development Export of high value products and Mexican technology Rapid evolution of a digital society

Source: Development based on: Technology Parks: regional development tools (2009).

Model IV: Technology parks of various sponsors

This type of parks is the most widely used model in the world. Technology parks of this model are built on large sites and have an infrastructure like that of an university Campus, they house various research and development centers, universities, companies and services that share spaces, which facilitates the relationship between the various entities. Given its high cost and scope, these parks are mainly regional projects funded by governments (Aguirre, 2008:150).

Space requirements for this type of parks are bigger than those of the three previous models, we are talking here of over 20 hectares of land necessary for their development, and obviously the costs are way above to what has been mentioned, per every hectare it is needed about 4.5 million pesos. The estimated time for the development of a park of this type is 2 to 4 years and requires full support from the government for its development.

The only park built so far of this type is the Research and Technology Innovation Park of the State of Nuevo Leon (PIIT). In 2003 the state of Nuevo Leon was proposed to move towards a knowledge-based economy and one of the instruments to achieve this is the PIIT. Its construction began in 2006, covers an area of 70 hectares, is located northeast of Monterrey City, a few hundred meters from the international airport. Its development has cost the state government 100 billion pesos.

Table 8: Parks type IV Tec de Monterrey

Campus	Park	Model	Specialized Area	Companies	Start date[1]
Monterrey	Technology Innovation and Research Park	IV	Mechatronics, Materials, ICT	Motorola; Rodhe & Schwarz	2008
Morelia	Tres Marías Technology Park	IV	Digital Design, ICT		2009
Estado de México	Industry Innovation Center	IV	Automotive		2010

1. Years 2009 and 2010 indicate the years in which the parks are expected to be operating.

Source: Development based on: Technology Parks: regional development tools (2009).

Some of the centers established in this park are:

- The Innovation, Research and Development Center in Engineering and Technology of the Autonomous University of Nuevo Leon.
- The Engineering and Industrial Development Center of the National Council of Science and Technology and the Federal Government.
- The Advanced Materials Research Center of the National Council of Science and Technology and the Federal Government.
- The Research and Advanced Studies Center of the National Council of Science and Technology and the Federal Government.
- Research and Technology Innovation Park of the State of Nuevo Leon, PIIT, of the Tecnológico de Monterrey.
- Motorola

Table 9: Logical Model technology parks type IV

Model/Objectives	Activities	Results	Effects	Impacts	Benefits
	Development of university campus like infrastructure for high technology companies	Physical infrastructure (business offices, conference rooms, common areas, etc.)	Knowledge of the university of the latest trends in high technology	Number of newly created technology companies	Increased human capital in the region: researchers, post graduates in science and technology, etc.
	Development of inter networks and intercompany with the anchor university	Specialized areas	Focused and highly specialized recruitment process	Number of R&D joint projects between companies and the university	Regional per capita income growth regional.
Model IV		Generation of patents in key areas of the high technology sector		Number of patents generated in the laboratories	
These technology parks are the most widely used model. They are built on large land and posses a university campus like infrastructure. They are mainly financed by state and federal governments.	State governments resources management for the park operation		Support from the different levels of government to the emergence of a high technology sector		Productivity of the superior industry due to innovation
		Global companies established in the park		Amount of financial resources attracted by the companies	More direct foreign investment in high technology companies
	Attraction of high technology companies		Recognition of the university resources by the companies		
		Services provided to the hosted companies		Revenue of the technology parks due to projects	
	Commencement of HR, IP and brokerage of business services		Interdisciplinary and multidisciplinary projects		Development of new clusters in high added value sectors
		R&D links between the hosted companies and the university		Number of high technology employments created	
	Link of network activities for R&D and projects		High participation of students in high tech companies of recent creation		
		Local staff recruitment for the companies		Generation of the support infrastructure to the companies provided by the local government	Increasing number of high value services for the society (education, commerce, amusement)
	High value employment recruitment		Accelerated growth of a business spirit in the technology sector within the university		
		New Products and services to the market			Increased support infrastructure for technology intensive activities: technology parks
	Business acceleration				
	Incubation and generation of spin-offs	Improvement services to the community provided by the government	Accelerated growth of business opportunities based on the innovation within the community		business centers, urban development
	Generation of high technology clusters	Position Mexico in the forefront of technology	Use of university patents in the companies and the region		Export of high value products and Mexican technology
					Rapid evolution of a digital society

Source: Development based on: Technology Parks: regional development tools (2009).

The development of this park was achieved thanks to the support offered by the Tecnológico de Monterrey to the State Government in the planning and strategy for its implementation, therefore the institute has a management role within the park and with all the companies that integrates it, therefor it is not only one more element as it is in the other institutes.

Conclusions

Since the last decade of the twentieth century, the human capital and the innovation system have become key piece to be competitive in any business activity. In addition, as part of its historical role, the innovations have marked the cycles of growth and development of the techno-economic paradigms, together with the institutional framework that supports it.

Building a strong innovation system is the challenge for any country and empirically it is observed that Technology Parks are one of the means to achieve it. The Tecnológico de Monterrey aware of its role in the development of our country established in its mission and vision towards 2015, to promote regional development through knowledge and technology for which it established different lines of action converging on the development of a system of Technology Parks. Through the development of four models to suit the characteristics of each Campus and our country: 1. TP for the high-value employment, 2. TP for the attraction and development of companies 3. TP for the companies with scientific activities and, 4 TP of several sponsors; and from the adaptation of the Action Research methodology (AR) to realize the implementation and the proper performance of the Parks, the Tecnológico de Monterrey has over 12 parks operating on different Campuses.

The design of these models has allowed that since 2005 to date there are more than 20 parks projects in the system and although there is no parameter to measure their performance, we can say that there is not a similar case documented throughout Latin America. Furthermore, considering that Mexico is a developing country, the achievement of operating more than 20 TP when completing the first decade of the beginning of this adventure of the Tecnológico de Monterrey, is sign that our country has the resources to lead the technology sector in the region.

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