Regional Industrial Development based on the Dynamics of the Technological Innovation Cycle

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ABSTRACT

This paper describes a systems dynamics model that reflects the possibility of having three levels of complexity together (*components of the business: macro level of the region, meso at the industry level and micro at the enterprise level*) *and articulated on a synchronous synergy of all relevant participants of value added systems: the activities at the firm level, networks of industries, and supporting organizations at the regional level. Following a systemic approach, we have identified eight parameters to measure the attractiveness effect of a region: Clustering and associativeness, Value added, Differentiation value, EVA, Attractiveness leverage, Global market coverage, Innovation and Social Capital. Based on these indicators, we have developed dynamic models for emergent industries which have uncertain trends and no previous regional developments. At this moment we are working on models for the Software, Biotechnology, Aerospace and Autoparts Industries that are currently in the process of clustering in the State of Nuevo Leon (Mexico).*

Key words: socio-economic industrial ecosystems, regional innovation systems, regional attractiveness, industrial dynamics, regional development model, emergent industries.

INTRODUCTION

The most effective economic impact of Information, Telecommunications and Computer Technologies (ICTs) on the competitive performance of a company is achieved when innovation and proper technologies are used to enable the synergy among the company's core business activities, its supporting industrial structures and its regional external drivers – all considered under a holistic framework.

Within this Systems Dynamics Framework, it is possible to identify the effective influence of technological enablers over the macroeconomic drivers, the attractiveness of industrial sectors, their supporting mechanisms, their related industries, and finally over the strategic performance of individual companies, and their differentiation vectors, creating positive increasing returns feedbacks and high performance industrial competitive drivers.

The purpose of this paper is to describe a systems dynamics model that reflects the possibility of having all three levels of complexity together (*the macro, meso and micro economic drivers -components of the business*) and articulated on a synchronous synergy of all relevant participants of value added firms, value networks of industries and value systems of firms, industries and supporting organizations. Approach capable to generate a viable structure and its interrelationships among the industrial stakeholders and their drivers for less developed environments, and transition economies and empower their regions to achieve world class performances.

The conceptual framework provides the bases of our assumptions. We have chosen some current cases where the model has been applied on Latin-American cases, describing the implementation issues and presenting its outcomes.

CONCEPTUAL FRAMEWORK

Nowadays, information and knowledge resources flow freely among all regions, around the globe. Yet this global flow is unbalanced.

Developing Countries (DCs) are currently spending resources and political lobbying, in improving low value-added processes by offering lower cost labor to foreign investors, as well as unbalanced protection policies, subsidies or unbiased agreements. Industrialized Countries (ICs) are increasing innovation, investing large percentages of their Gross Domestic Products (GDPs) and resources in Research and Development (R&D), they are expanding the requirements of outsourcing low value services and raw materials. They are adding substantial value to all their products and services, achieving substantial increments of their return on investments (ROI), creating great wealth for their communities.

From several findings [on UNIDO, 2003; Rosecrance, 1999] it can be observed that: **Skills**, **Foreign Direct Investment (FDI)** and **Infrastructures** are some of the key drivers for improving industrial performances. However, the involvement of **Technology** and **Innovation** in improving the MVA (Manufacturing Value Added) industry attractiveness, productivity and boosting higher value exports (and sustaining them), is probably the key to future success for DCs.

However, using technology efficiently requires considerable technological innovation, entrepreneurial skills, organizational structures, commercialization and managerial practices, which seldom exist in DCs (at least in Latin American countries; see Scheel, 2004). If this economical infrastructure (physical, financial, social capital, etc.) doesn’t exist, the “digital divide” is separating more and more low-value producers from their richer customers and demanding preferences.

Before a national policy for industries of Less Developed Countries (LDCs) can be formulated or a firm’s strategy implemented, it is necessary to build the <u>infrastructures</u>

and the proper conditions to allow the technology cycle to become a driving force. This will empower local capabilities and strengthen relationships, supported by local and/or foreign resources.

In this way, LDC regions can surpass the common "survival cycle," generating a prolific business cycle, achieving high competitive leverages, and delivering more complex activities that use emerging technologies, which add more value and sustain rising wages. This generates a positive feedback cycle of increasing returns.

The Ecosystem Environment[1]

An **environment** where the producers of **microeconomic** performances at company levels are not aligned to, and empowered by, **industrial** drivers, and where sectorial clusters of firms are not allied and linked to complementary and supporting institutions (Academia, Banking, Infrastructure, related Industries, Government policies and Social programs: ABIIGS), without producing competitive **macroeconomic** indicators cannot *experience a sustainable increasing returns effect. It is a completely non-articulated group of players, each one playing a different game and for different leagues.*

As a result, this kind of environment will not be able **to capitalize on Information, Telecommunication and Computer Technologies (ICT) enablers or technology cycle dynamics.**

In order to share macroeconomic benefits and reinforce positive feedback of economic growth, we must articulate a synergic cycle of growth, taking the following three levels of coverage as a *whole*.

All the components must be assembled into a recursive increasing value creation of all players at three levels. Emerging competent ***firms*** must be grouped in business-value networks, linked and leveraged by ICT micro ecologies, sharing knowledge with related ***industries*** and complementary and supporting institutions, forming strong alliances with world-class players, integrating larger meta-market systems, and finally assembling ***industrial ecosystem complexes*****.** This structure may produce a dynamic and sustainable cycle of *increasing returns* for all participants [Scheel, 1998].

It is a win-win growth cycle, where instead of linear supply chains we have value system cycles, continuous feedback of information and goods, benchmarking and learning from best practices and continuous leveraging, which breeds leadership positions and high-value world class system insertions.

This *Industrial Ecosystem* (IE) so formed includes the following components and activities.

- **Internal activities of the firms *(Manufacturers / Producers value chain)*, including business core processes.**

[1] Excerpts from: Assembling Industrial Ecosystem Clusters. C. Scheel. 2004

- **External value partners, including external activities with their administrative supporting practices; and**
- **External institutional drivers including the liaison with ABIIGS drivers (i.e. social capital institutions):**

Driver	Implicate
Academic institutions	**A**cademic networks of research centers, development centers and educational programs (sharing scarce high-skilled human resources).
Banking and financial institutions	High value integrated banking services, financial and new venture capital networks.
Infrastructure	Electronic connected inter- and intra- clusters of related industries.
Related **I**ndustries	Supporting Infrastructures (physical, etc.)
Governance policies	Electronic government, well-supporting National Innovation Systems and transparent regulatory systems. E-governance in general.
Social capital, cultural, political drivers	Social capital, cultural and political drivers and restrictions.

Table 1. ABIIGS divers and its implications.

These are the components of the *industrial ecosystem* learning cycle, which must be linked, benchmarked, leveraged and aligned with on the other lands. All must be interrelated, working toward a common goal: to create a proper environment that will *diminish barriers*, create a combinatorial *network effect* and a *perfect competition* market environment, *incrementing the returns* of all networking participants.

One of the main factors involving the ecosystem environment is the possibility of including a system dynamics learning cycle, with interaction among *macro* (region), *meso* (industry) and *micro* (firms) factors.

This provides a robust and sustainable environment where **all participants** enjoy a win-win process.

The Ecosystem cycle dynamics

Once all the elements of the *Industrial Ecosystem* are defined and assembled, it is necessary to configure a *meta-cycle* capable of performing the dynamics produced at the three levels of economic generation.

Technologies don't exist alone, but in an interlinked web or micro ecologies, ICT technologies enable firms and industries to implement the dynamics of business ecosystems [Moore], capable of transforming survival activities into business cycles and into technology cycles where all participants win.

Included is a proposal of how ICTs can link, leverage and position small and medium enterprises (SMEs) within world-class value systems, generating a high economic value for firms, industries and regions [Scheel, 2004]:

First, an overall systemic approach and interlinked web of participants is built.

For this representation we used some ideas from the Viable System Model of Stafford Beer, where a basic recursion cycle operates, from reproducing simple patterns and relationships at three different levels or scales, with which we can set up a robust and more complex network. It is a way of taming complexity of the environment and their relations:

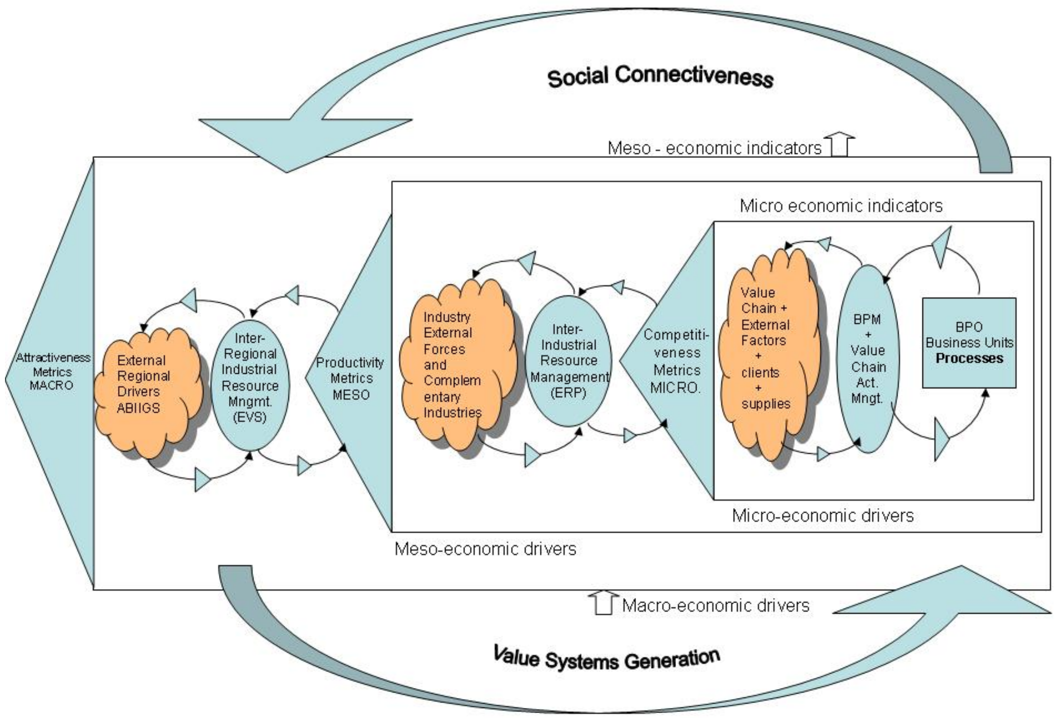


Figure 1. Interlinked Web of subsystems.

In figure 1, we observe how information flows from entity to entity, as well as the value (economic, emerging, etc.) added by each one of the implemented value networks.

Once the main framework has been established, we can assemble the business ecosystem components and all their external forces, drivers and indicators that influence the performance of the entire relational system. The components of the Industrial Ecosystem Model are represented in figure 2.

In the macro diagram (see figure 2), we observe how the core business processes are interlinked by means of a process management system, decision support systems, intranet information systems, Web-based systems, etc.).

At this point, the strong interaction of the three levels of activities (macro level of the region, meso at the industry level and micro at the enterprise level) with the

macroeconomic driven indicators is clear. Each driver must be produced by the interaction of all components at the three levels.
Once the internal activities are linked into an effective subsystem value chain, other members of the industrial cluster are connected, such as: complementary industries, support services, procurement systems, market places, strategic allies, etc. (by means of SCMs, CRMs, or any other mechanism of the Integrated Enterprise Resource Planning Applications type).

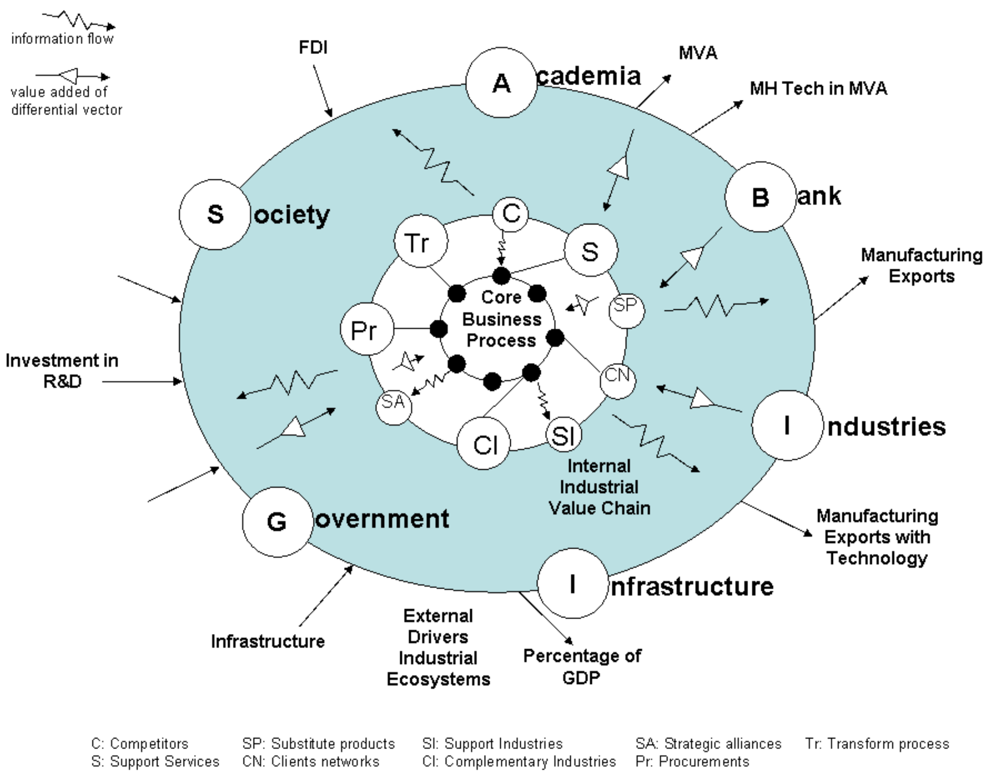


Figure 2. The Industrial Ecosystem components.

Thus, connectivity can provide the means to add more intra-industrial value, creating an **extended industrial value system network**.

Continuous benchmarking against best practices exposes the collaboration needed by external drivers for the industrial clusterization. To complete the ecosystem architecture, a liaison with the proper partners (i.e. social capital) is structured, and external ABIIGS drivers are inserted into the network, forming a robust and sustainable value system.

With the participation of the external drivers and all macro, meso and micro levels, a new configuration may be designed to:

- Create higher value network effects.
- Reduce or eliminate barriers to entry.
- Create perfect competitive market environments.

- Produce higher vector differentiation patterns among firms of the extended value system.
- Produce higher increasing returns, and economic positive feedback to all participants.

Once the industrial ecosystem has been created, a dynamic cycle must be developed so that a synergy among all components and drivers can generate an economic value and sustain it.

The Technology Cycle Dynamics

The dynamics of the technology cycle is proposed with the objective of supporting the environment needed to articulate the proper relationship among all players in the industrial ecosystem. Its purpose: **to emphasize the impact of ICT on the macroeconomic performances, as well as on industry attractiveness and on the unique differentiation of firms.**

Figure 3 shows the relations of the main producers and indicators at the macroeconomic level, capable of producing competitive performance leverage. This diagram includes the UNIDO (2003) drivers and macro indicators, as well as the technology and innovation drivers critical to success in this approach.

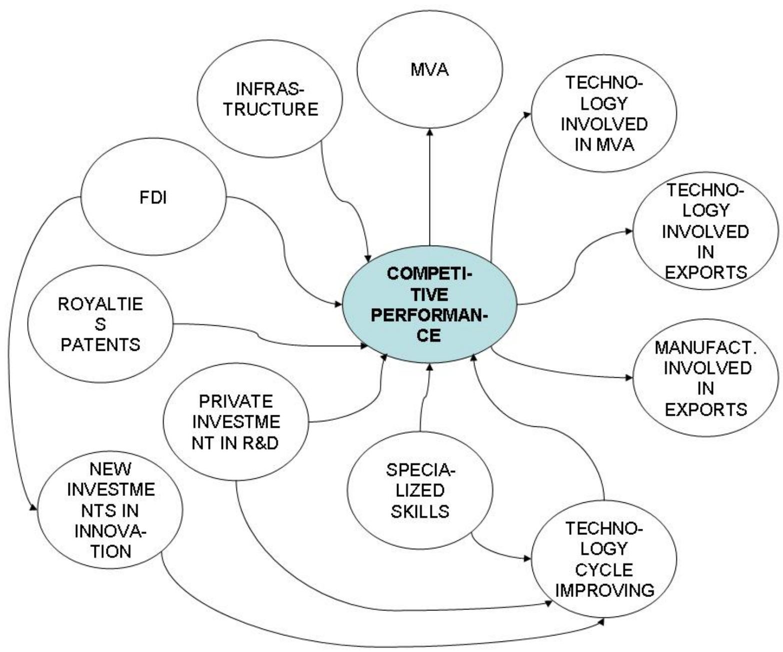


Figure 3. Cause-effect relationship of Macro producers of Wealth and Global Competitiveness Index.

However, this relationship is incomplete, if we can not implement linkages among all parts, as well as the proper conditions capable of creating this leverage.

In order to have a well-tuned strategy, aligned with all components of the chain, we have designed a scoreboard of factors that should be determined at the three levels of the proposed structures: **macro**, **meso** and **micro**.

These factors have been cataloged in 14 categories. The combination of these critical success factors is needed to produce the determinant **conditions** (Industry Determinants Conditions: IDS) for leveraging business units, firms, industries and regions:

a. Market share or **market** positioning.
b. Special **competencies** or capabilities to compete.
c. **Infrastructures** (physical, financial, etc.)
d. Producers of **economic** value (networking, etc.)
e. **Human Resources**
f. Direct **Government** enabling factors.
g. **Technology** and innovation enablers.
h. Business styles, manufacturing and/or **production** factors.
i. Supporting and **complementary industries** related to the target industry
j. **Financial** conditions
k. **Demand** or factors created by customers.
l. General **constraints** and **restrictions.**
m. **Social** and **cultural** conditions.
n. **Global** conditions for internationalization and/or achieving world-class standards.

In figure 4, we can see the correlation among the factors and the effects created by the ICT Technologies. These effects are: the ***Network*** effect, which adds value to each participant, making it affordable for more entrants into the network due to the ***Low Entry Barriers***, produced by the ICT structures, creating a ***Perfect Competition Market*** environment, which finally evolves into a positive feedback of ***Increasing Returns*** for all participants of the ***Industrial Ecosystem Structure.*** The effects above constitute the core of the concept of transforming the technology and innovation cycles into economic value.

Each determinant (out of the 14 IDS factors) category may have several drivers and/or activities or processes at the three structural levels. A company's business processes create indicators that produce industry performance, which impact a region's macro indicators.

All these structures create a framework capable of producing a direct influence on the industrial (meso level) indicators. This is a positive feedback cycle.

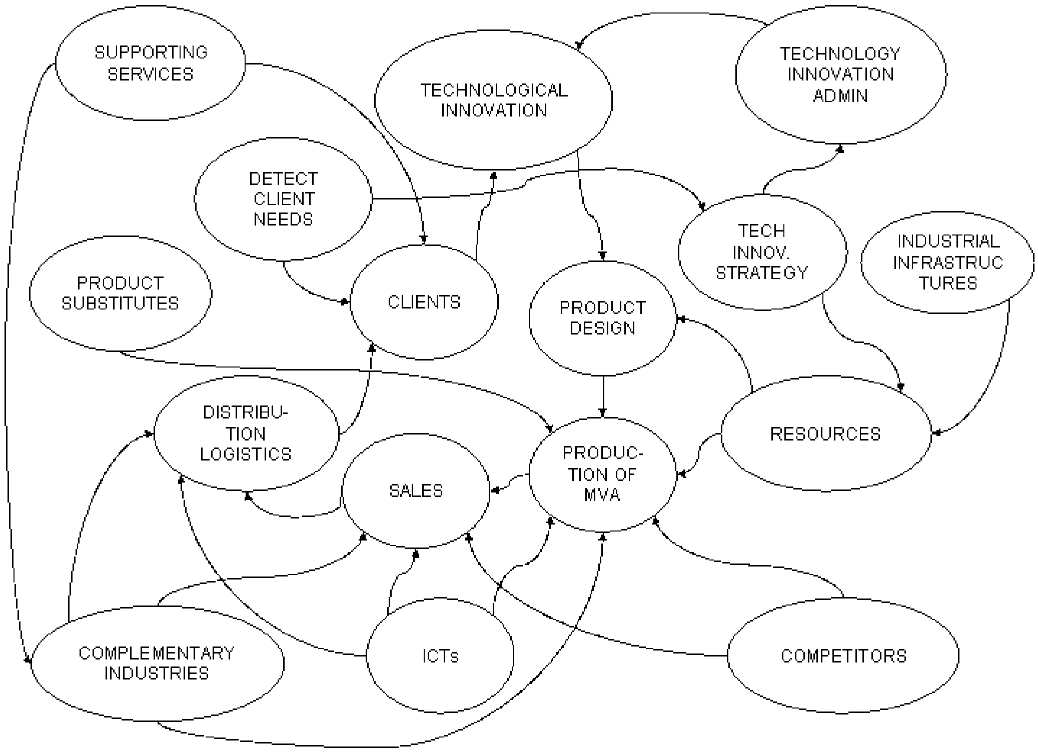


Figure 4. Relational Model of the Industrial Ecosystem Internal Activities Framework

Finally, with all the players together, the ***Technology Cycle*** can be assembled and will be able to produce a real **economic value added** to all levels: regional (macro), industrial (meso) and entrepreneurial (micro).

In figure 5, we present a "cause-effect diagram" (although I prefer to call them producer – product diagram), including how the ***Technology Cycle*** can create an ***economic value*** for the firm and the corresponding industries [Mandel, 2000]. The relevance of this diagram are the two loops that are generated around the GDP (Gross Domestic Product)[2]; showing a clear evidence that the technological cycle main objective is to create economic value at the regional, industry and firm levels.

[2] GDP represents the impact produced in the Industry by the GDP of the Region.

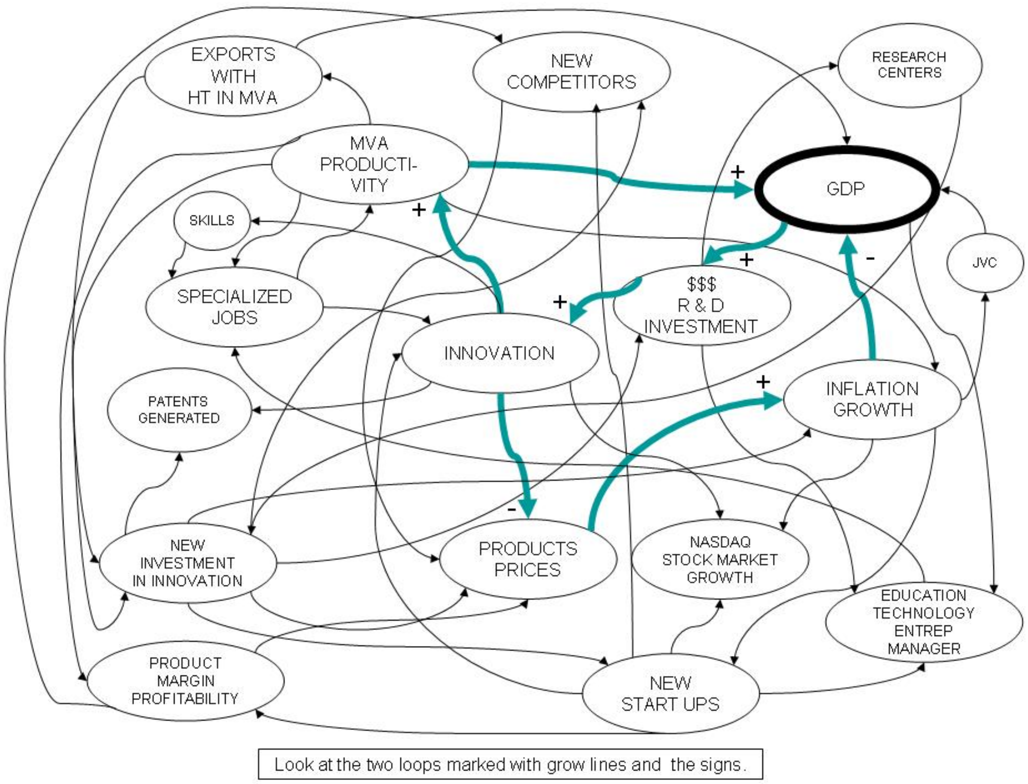


Figure 5. How the technological cycle can create economic value.

History dynamics of the diagram (figure 5):

- If the innovation increases, the capacity to have greater abilities (skills) increases.
- If the abilities (skills) increase, the ability to work by specialization increases.
- If R&D investment increases, the innovation increases.
- If the innovation increases, there is an increment on the levels of productivity of the MVA.
- If the levels of productivity of the MVA increase, it increases the level of the GDP.
- If the level of the GDP increases, the inflation diminishes.
- If the inflation diminishes, the capacity to have technological education in the companies increases.
- If the capacity to have technological education in the companies' increases, there is an increment to have more specialized works.
- If the ability to have specialized works increases, the capacity of innovation increases.
- If R&D investment increases, the research centers increases.
- If the research centers increases, innovation on research (new investment innovation) increases.
- If new investment innovation increases, the amount of generated patents increases.

Within this System Dynamics Framework, it is possible to identify the effective influence of technological enablers over the macroeconomic drivers, the attractiveness of industrial sectors, their supporting mechanisms, their related industries, and finally over the strategic performance of individual companies, and their differentiation vectors, creating positive increasing returns feedback and high performance industrial competitive drivers.

IMPLEMENTATION

Contextual description

Today, information and knowledge resources flow among all regions, and due to technological innovations, money, skills, machines, and other goods needed for production are freely moving, continuously adding value, linking product manufacturing chains and closing the business cycles all around the globe.

However, this global flow is unbalanced. Less Developed Countries (LDCs) are still spending resources and political lobbying, to improve protectionism laws to support low value added programs, and offering low-cost labor to foreign investors, lands and services, as well as unbalanced protection policies, subsidies or unbiased agreements.

Industrialized Countries (ICs) are increasing innovation, investing large percentages of their GDPs and resources in R&D, are expanding the outsourcing of low value services and raw materials to LDCs, achieving substantial increments of their ROIs (Return Of Invesment) and creating great wealth for them (ICs), without sharing much with their supplier regions.

Therefore, before formulating industrial polices or implementing national strategies, it is necessary to build the **proper conditions** – empowering local capabilities and leveraging their relationships – supported by local and/or foreign resources. In this way, LDCs regions can achieve competitive leverages to deliver more complex activities that use emerging technologies, adding more value and sustaining high competitive performances.

However, these conditions must be produced by **viable structures**, such that these regions may interact equally (or at least less unbalanced) with ICs. These structures should be **enablers**, robust and capable of eliminating current and long inherited behaviors, such as: [Fairbanks and Lindsay, 1997; UNIDO, 2003; Scheel, 2004]

- lack of trust;
- lack of integration and linkage among companies;
- lack of strategic thinking and dialogue among world-class players;
- lack of industrial policies and strategies, etc.
- lack of industrial policies and strategies, etc.
- chaotic public services, and public policies;
- no shared consensus;
- no visionary perspectives;
- no strategic alignment;
- inability to:
    - identify opportunities of "outside" players, liaisons or other strategic alliances;inability to identify current or future customer demands;
    - identify new market opportunities;
    - identify opportunities of "outside" players, liaisons or other strategic alliances;
    - identify current or future customer demands;
    - identify new market opportunities;
- inability of moving out of “surviving” cycles to more competitive levels;

- inability to effectively join complementary industries;
- an atomized and quite limited vision of global environments;
- infrastructures incapable of supporting global economic growth;
- infrastructures incapable of supporting global economic growth;
- inability of moving out of "surviving" cycles to more competitive levels;

Any structure chosen for leveraging LDCs must first manage most of these drawbacks as a core objective; then it may be possible to articulate how technological innovation may generate a **differentiable** strategic positioning.

It is not a matter of just dumping economic resources, government subsidies or selecting the latest technology to achieve fast but unsustainable results; it is a matter of cultural educated change, and of exercising a new *paradigm*.

The LDCs need this new *paradigm* due we are living amid a transcendental breakthrough provided by the fast development of digital technologies (ICTs), which have set up the basis for the well-known platform of network economies. These new environments are producing great wealth for large transnational corporations, a reduced number of entrepreneurs from industrialized countries and of a few privileged sectors.

The reasons why most SMEs (medium size enterprises) can not take full advantage of ICTs enabling competitive advantages can be summarized by a lack of:

- *Trust (privacy and security).*
- *Cultural and entrepreneurial collaboration.*
- *Connectiveness and clustering mechanisms.*
- *Modern organizational architectures.*
- *Knowledge-based think tanks and innovation systems.*
- *Appropriate use of enabling technological resources.*
- *High value and differentiation strategies.*
- *Sustainable competitive leverages.*

These are some of the main issues that the new paradigm must manage if an effective and sustainable impact is to be produced in LDC regions.

Parameters and metrics to be measured in a cluster

Based on the previous framework and additional research, we have identified eight parameters to measure the attractiveness of the region (figure 6): Clustering and associativeness, Value added, differentiation value, EVA, Attractiveness, Global market coverage, Innovation and Social Capital.

At the moment, we have selected clusters with potencial development in the State of Nuevo Leon (Mexico). We have worked models for the following clusters: Biotechnology, Software, Aerospace and Autoparts Industries.

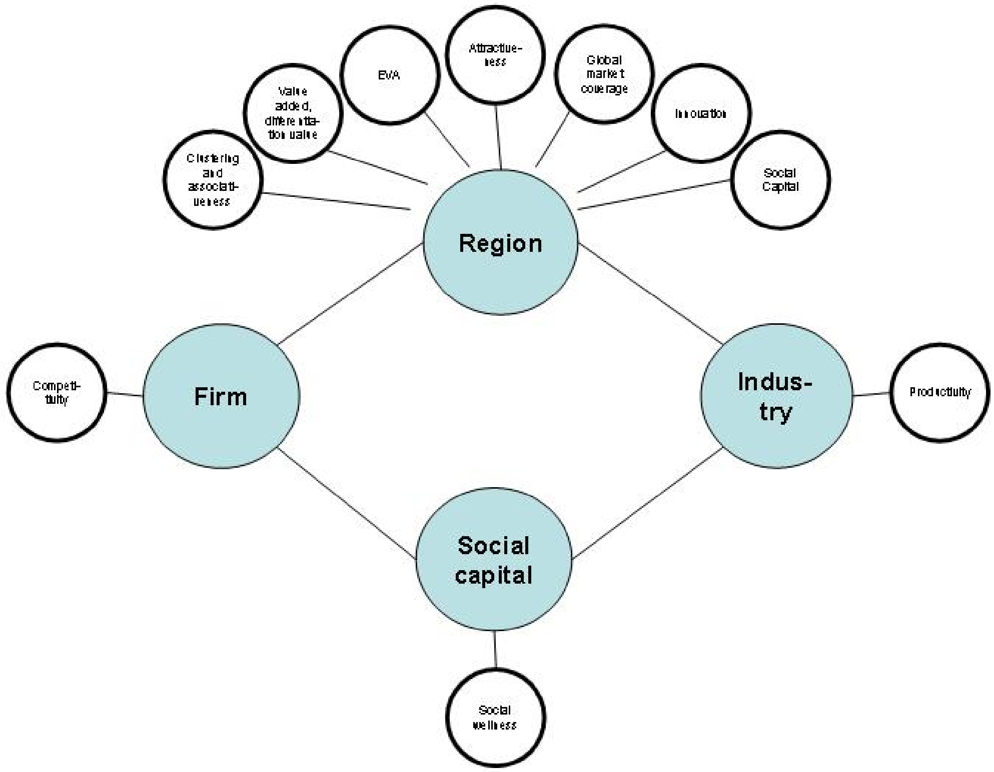


Figure 6. Parameters identified to measure the attractiveness of a region.

These models have been developed selecting a particular metrics for each one, considering the main conditions of this region, and competitive level:

The Biotechnology Industry	→	requires to build an attractive region (***Attractiveness***) so that foreign capitals may arrive.
The Software Industry	→	requires to build ***value added***.
The Aerospace Industry	→	requires to attract an anchor company, therefore requires to build ***Attractiveness*** conditions.
The Autoparts Industry	→	requires modernizing its production plant and supplier chains, it requires ***Innovation*** of the whole extended value system.

Case implementation in the Biotechnology Industry

In Latino America, the same as the Developed Contries (DCs), the biotechnology area is not too developed, still incipient. Even though, we depend on the technological transfer who comes from the DCs. In Less Developed Countries (LDCs) there are many factors which limit the human resources development and the biotechnology industry (SIMBIOSIS, 2000):

- an *undergraduate education* which doesn't stimulate scientific vocations and as a consequence of this, basic science struggles to develop because of the lack of economic and qualified human resources. This cause that several disciplines are not cultivated properly and this becomes a serious limit to the development of biotechnology.
- *our limited experience in the technological transfer* between universities and companies.
- the *lack of open minded and information sharing* that many scientists have with the common link between the research and the productive sector. Probably due to our Hispanic cultural heritage.
- the *geographic isolation* among the Latin American countries *to the sources of knowledge*. Nevertheless, the access to actual communication networks (mainly: internet and e-mail) will allow to access massive information, and knowledge of the state of the art of technologies and scientific discoveries. So, this limitation is not a big issue at least in the concern to the access of knowledge resources.
- the *lack of the appropriate technical aptitude to compete* on global markets, where the quality requirements are essential to get into the borders of the national markets.

Situation of Biotechnology in Mexico

Mexico has experienced advances in biotechnology area, especially in the research field. This gives to Mexico a worldwide recognized quality, being one of top ten countries in the world that plant crops modified genetically. Hereby the country has been consolidated as one of the more advanced and developed countries in Latin America in the field of biotechnology. Nevertheless, this capacity is weak compared to the population and the economic value of the country (BioPlanet, 2000).

The development of modern biotechnology is a prior topic in Mexico. This will lead to be able to produce its own biological technology. Mexico has resources and capacities in the area of biotechnology. It is necessary to coordinate and support the different actors who have responsibility in the development of the biotechnology: the government, the industry and the academic (Arias, et al. 2002).

In Mexico, most of the projects in biotechnology are supported by resources from the institutions. These resources are not sufficient to cover the expenses of their work proposals, and need to obtain additional resources (Arias, et al. 2002).

The main resource is the CONACYT (National Council of Science and Technology), by means of different programs which are indicated below (Arias, et to. 2002):

- The Scientific Investigation Direction, which has financed 167 projects in the last two years. Each one length: one, two, five years.
- The Scientific Development Direction and the Regional Technological Institute has supported the development of 200 projects by means of different established trust funds.
- By Means on a specific called published in the year 2000 to obtain "Support to develop research projects and technological development en the field of biotechnology". In that period, 35 million pesos were assigned to 12 projects out of a total of 40 submitted for evaluation.

It is evident that the development of biotechnology depends on the transference of knowledge and technology from the academic towards companies with innovative capacity, which are capable of assimilating technology and, on the bases of market requirements, may be capable of developing products and services.

As the rest of the world, the agents involved in the development of biotechnology compromise the knowledge generating institutions like universities and private research institutes (SYMBIOSIS, 2000).

The State of Nuevo Leon is located in the North-East side of Mexico, border with the United States. It is considerated the State with greater development and growth in Mexico. Its capital, Monterrey city is recognized to be the Industrial Pole of Mexico. It distinguishes itself for its great commercial development, its great level as a financial center and because it is an important attraction center for foreign investment.

Fundamental Hypothesis

> "*Developing the attractiveness of the region will attract direct foreign investment and this will generate a world-wide competitive biotechnological sector*".

To prove this hypothesis we have formulated the following questions:

1. How does ***attractiveness*** impact the growth of research centers and the implantation of new biotechnological companies in the region? (Related to the *cluster growth*)

2. In which degree does ***attractiveness*** impact the foreign investment? (Related to *foreign investment*)

3. In which degree does the regional ***attractiveness*** impact the cluster competitiveness?
   (Related to *regional competitiveness*)

Elements of *attractiveness*

It is easier to have an idea of the outputs produced by the ***attractiveness*** but it is not that simple to find its inputs.

In figure 7, we observe the key variables identified to produce ***attractiveness***. The right sides of the diagram are the output values**.** From these outputs, we look backward measurable and viable inputs variables to produce these outputs. Values at the left side[3] are the inputs that were obtained from a documental research that stated that all of this variables are indispensable to obtain ***attractiveness***.

These inputs variables were located in several levels from region[4], industry[5] and firm[6] level.

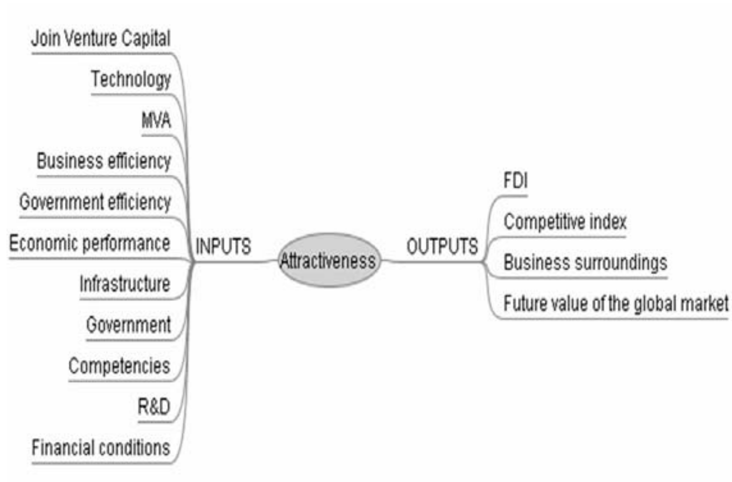
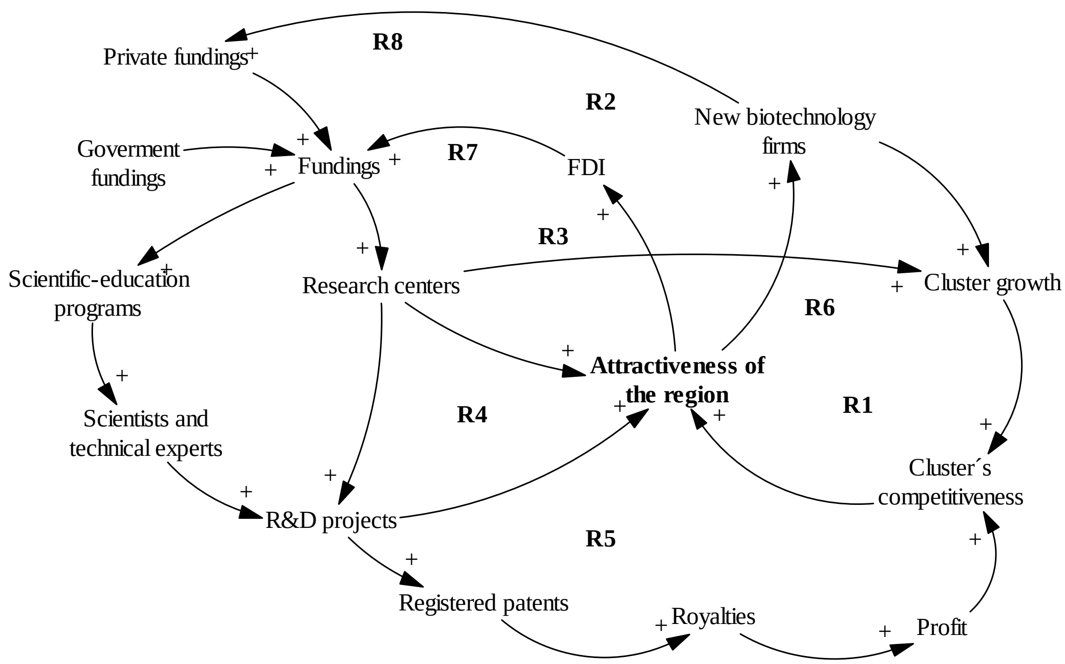


Figure 7. Elements of attractiveness.

[3] It is easier to measure the ***attractiveness*** outputs variables if we can clarify more variable levels at the left side: inputs.
[4] Macro level.
[5] Meso level.
[6] Micro level.

***Attractiveness* Causal Loop Diagram**

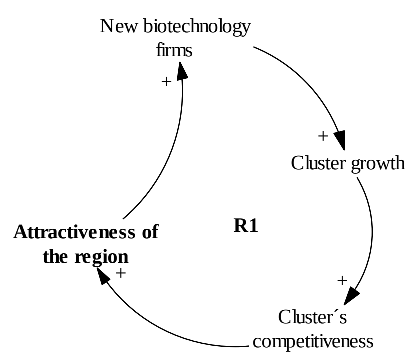


Assumptions represented by the model

For the elaboration of the model which represents the behavior of the biotechnological cluster this study focused on those activities which had a direct relation with the generation of the attractiveness of the region and which will impact the situation presented.

Stories behind the feedback loops:

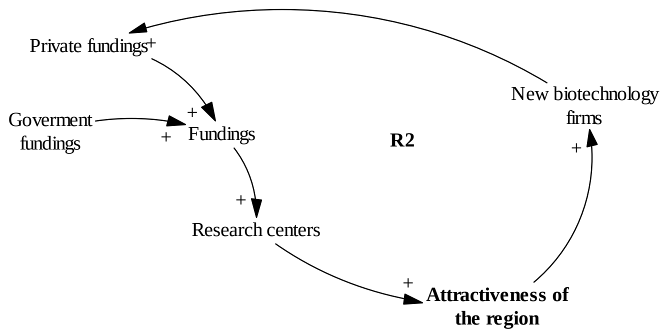
- R1



– If an increment in the attractiveness of the region exists, there will be an increment in the number of biotechnology firms.
– If the number of biotechnology firms increases there will be an increment in the growth cluster.

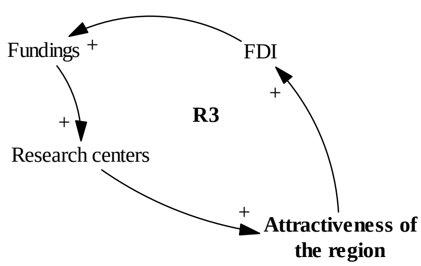
– If there is an increment in the growth cluster, there will be an increment in the competitiveness cluster.
– If there is an increment in the competitiveness cluster, there will be an increment in the attractiveness of the region.

• R2



– If there is an increment in the attractiveness of the region, there will be an increment in the number f new biotechnology firms.
– If there is an increment in the number of new biotechnology firms, there will be an increment in the private funding.
– If there is an increment in the private funding, there will be an increment in the funding.
– If there is an increment in the funding, there wil be an increment in the research centers.
– If there are more research centers, there will be an increment in the attractiveness.

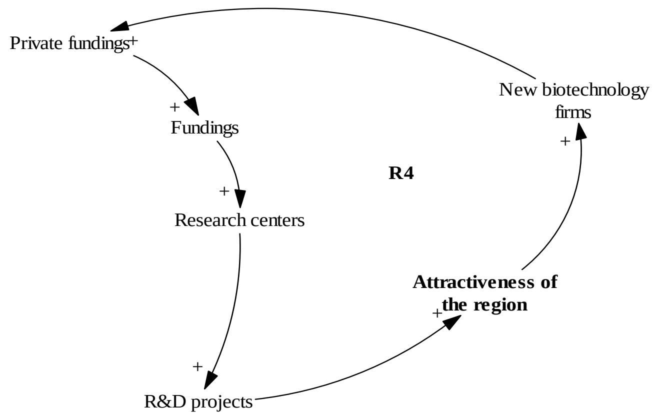
• R3



– If there is an increment in the attractiveness of the region, there will be an increment in the FDI[7].
– If there is an increment in the FDI, there will be an increment in the funding.
– If there is an increment in the funding, there will be an increment in the research centers.
– If there is an increment in the research centers, there will be an increment in the attractiveness of the region.

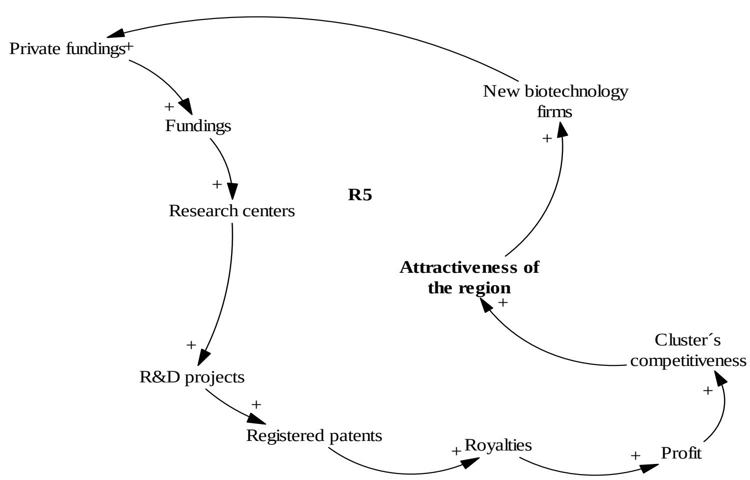
[7] Foreign direct investment.

- R4



– If there is an increment in the attractiveness of the region there will be an increment in the number of new biotechnology firms.
– If there is an increment in the number of new biotechnology firms, there will be an increment in the private funding.
– If there is an increment in the private funding, there will be an increment in the funding.
– If there is an increment in the funding, there will be an increment in the research centers.
– If there are more research centers, there will be an increment in the research and development projects.
– If there are more research and development projects, there will be an increment in the attractiveness of the region.

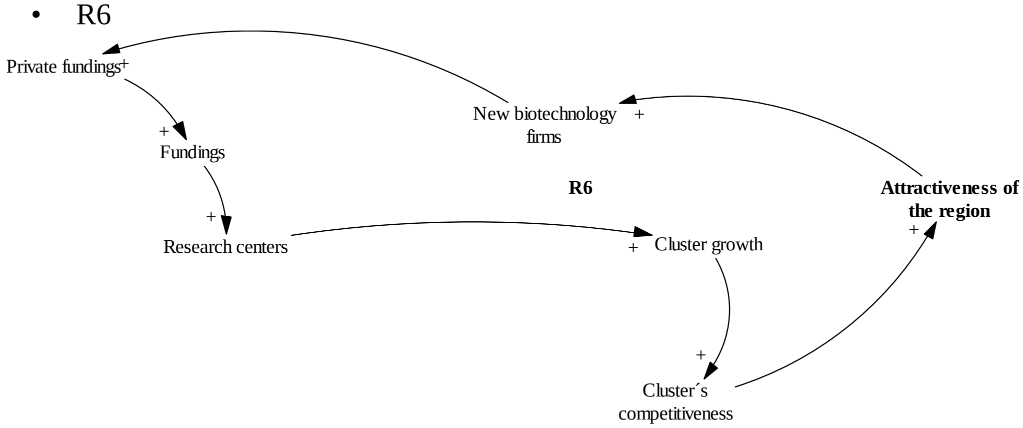
- R5



– If there is an increment in the attractiveness of the region, there will be an increment in the number of new biotechnology firms.
– If there is an increment in the number of new biotechnology firms, there will be an increment in the private funding.

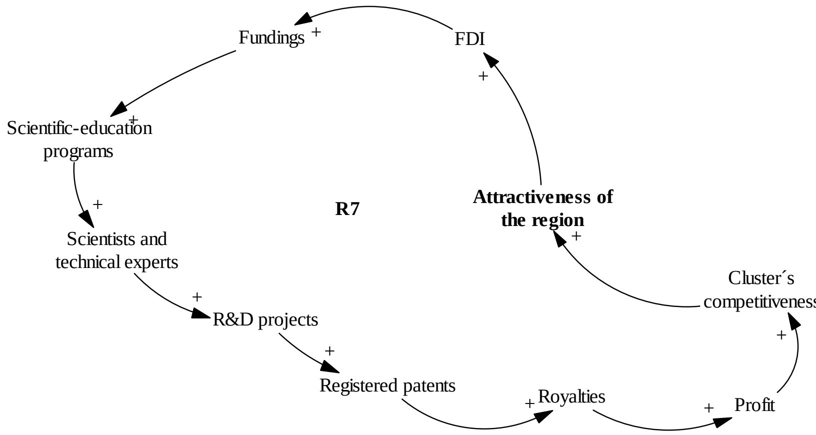
– If there is an increment in the private funding, there will be an increment in the funding.
– If there is an increment in the funding, there will be an increment in the research centers.
– If there is an increment in the research centers, there will be an increment in the research and development projects.
– If there is an increment in the research and development projects, there will be an increment in re number of registered patents.
– If there is an increment in the number of registered patents, there will be an increment in the royalties.
– If there is an increment in the royalties, there will be an increment in the utility.
– If there is an increment in the utility, there will be an increment in the competitiveness of the cluster.
– If there is an increment in the competitiveness of the cluster, there will be an increment in the attractiveness of the region.

- R6



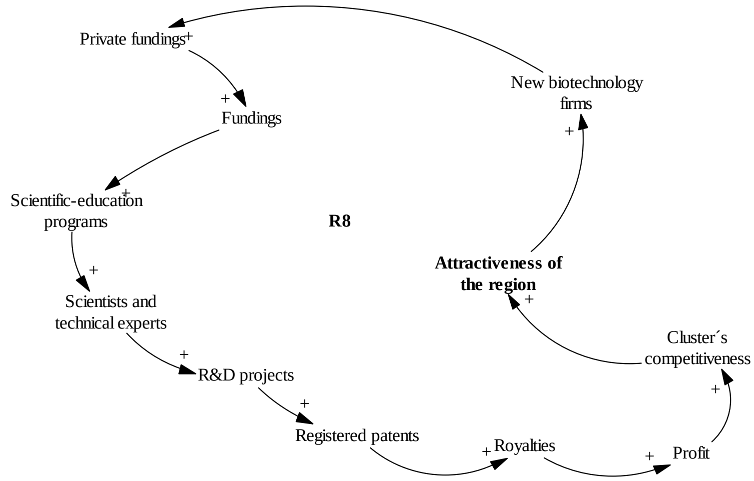
– If there is an increment in the attractiveness of the region, there will be an increment in the number of new biotechnology firms.
– If there is an increment in the new biotechnology firms there will be an increment in the private funding.
– if there is an increment in the private funding, there will be an increment in the funding.
– If there is an increment in the funding, there will be an increment in the research centers.
– If there is an increment in the research centers, there will be an increment in the cluster growth.
– If there is an increment in the cluster growth, there will be an increment in the competitiveness of the cluster.
– If there is an increment in the competitiveness of the cluster, there will be an increment in its degree of attractiveness.

- R7



- If there is an increment in the attractiveness of the region, there will be an increment in the FDI.
- If there is an increment in the FDI there will be an increment in the funding.
- if there is an increment in the funding, there will be an increment in the scientific education programs.
- If there is an increment in the scientific education programs, there will be an increment in the number of scientists and technologists dedicated to the field.
- If there is an increment in the number of scientists and technologists, there will be an increment in the number of research and development projects.
- If there is an increment in the number of research and development projects, there will be an increment in the registered patents.
- If there is an increment in the generated patents, there will be an increment in the royalties.
- If there is an increment in the royalties, there will be an increment in the utility.
- If there is an increment in the utility, there will be an increment in the competitiveness of the cluster.
- If there is an increment in the competitiveness of the cluster, there will be an increment in its degree of attractiveness.

- R8



- If there is an increment in the attractiveness of the cluster, there will be an increment in the number of biotechnology firms.
- If there is an increment in the number of biotechnology firms, there will be an increment in the private funding.
- If there is an increment in the private funding, there will be an increment in the funding.
- If there is an increment in the funding, there will be more scientifically education programs.
- If there is an increment in the scientifically education programs, there will also be an increment in the scientists and technologists.
- If there is an increment in the number of scientists, and technologists, there will be an increment in the number of research and development projects.
- If there is an increment in the number of research and development projects, there will be an increment in the registered patents.
- If there is an increment in the number of generated patents there will be an increment in the royalties.
- If there is an increment in the royalties, there will be an increment in the utility.
- If there is an increment in the utility, the competitiveness of the cluster will increase.
- If the competitiveness of the cluster increases, its attractiveness degree will also increase.

OUTCOMES

We found that there are three stages in our model that will prove support to our hypothesis. These factors represent the principal generators of the attractiveness of the region:

- Research and development: Funds granted by diverse resources and their impact in the increment of the industry development are important factors to be consider. Another key factor affected is the number of scientific education programs in the field therefore if affect directly in the number of scientists and technologists who will develop the research projects.

- Cluster growth: Its importance lies in the number of new companies and their impact with the creation of new research centers.
- Competitiveness: It involves the utilities generated by the granted licenses for the use of patents and by the royalties obtained from these patents.

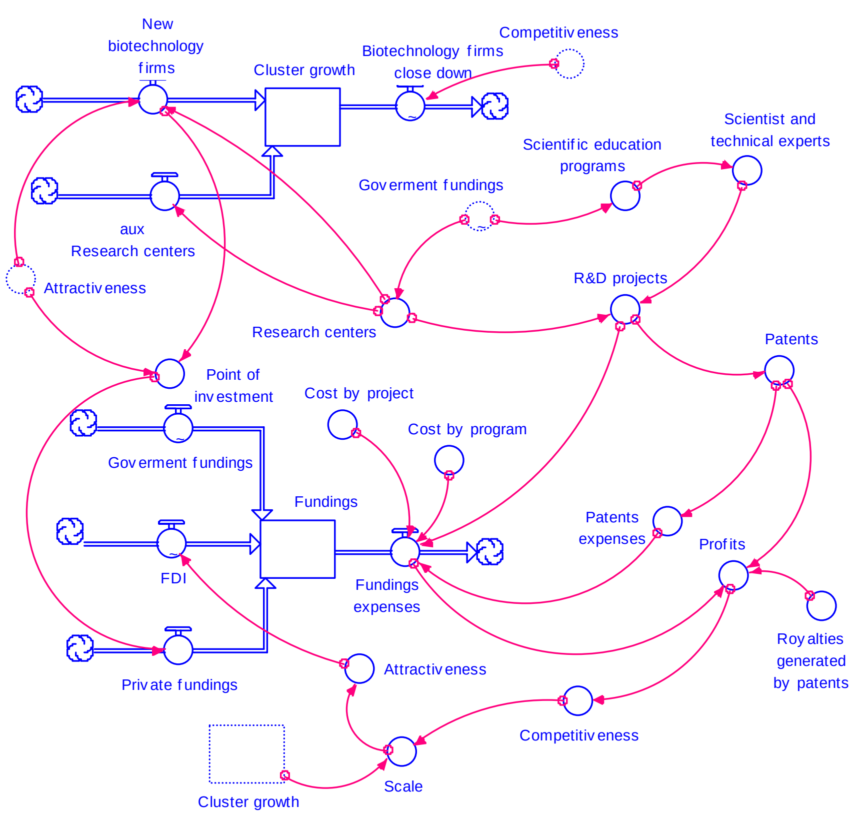
Model Scope

It is important to mention that the model implemented in this work covers a *basic and applied research* of the biotechnology industry. Therefore, factors related to independent organizations are not considerate for modeling purpose.

For this model, sceneries and the analysis of the results were considered for a period of time of 20 years.

Our model has many factors worked under inferences and suppositions obtained from national statistics documents. As result of the lack of time of the experts in the biotechnological field during our research and the lack of registered data in Monterrey related to this industry.

Model for the *attractiveness* of the biotechnology industry



The model was implemented in I-think. Each sub-model was included to obtain the complete model. The result was a model which behavior is close to the reality.

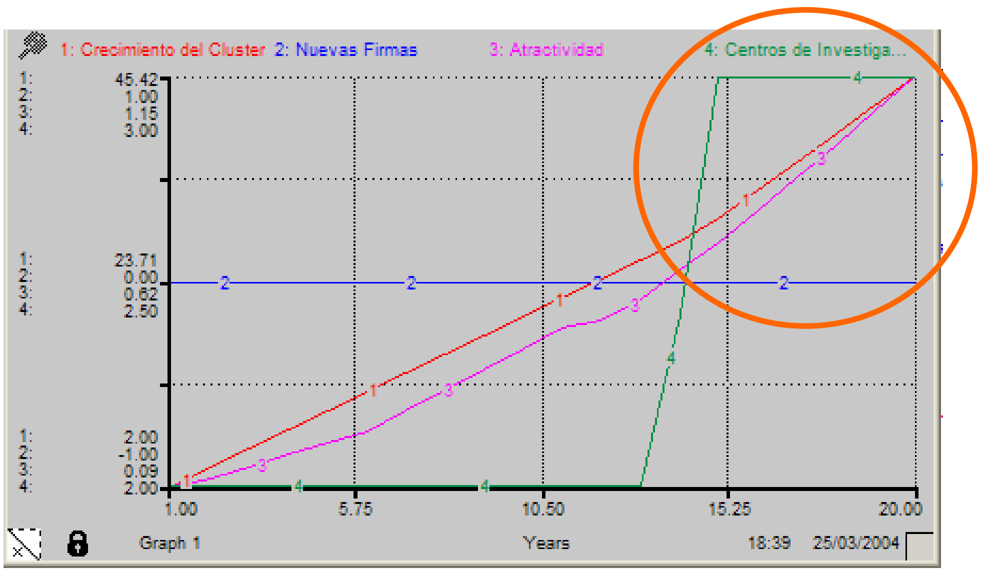
Perez et al (2005) presents detailed information about this model.

Questions formulated by the hypothesis supported by the model.

The input variables for this scenario are: Attractiveness of the region, evaluated by means of Competitiveness and Cluster Growth, Funding and New biotechnological firms.

Question 1:

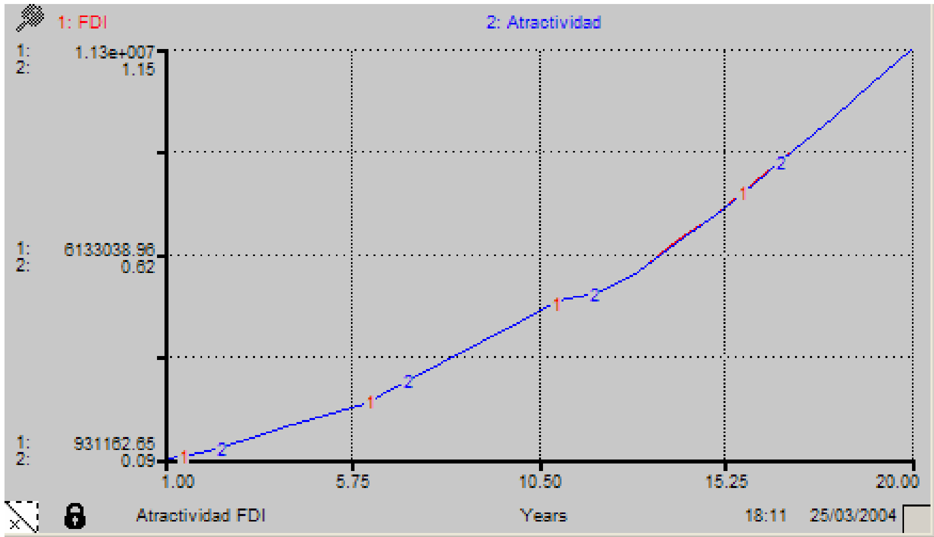
How does ***attractiveness*** impact the growth of research centers and the implantation of new biotechnological companies in the region?
(Related to the *cluster growth*)



We observe how attractiveness in next 20 years is not enough to generate new biotechnological firms, but there are enough basis to impulse basic research in this field.

Question 2:

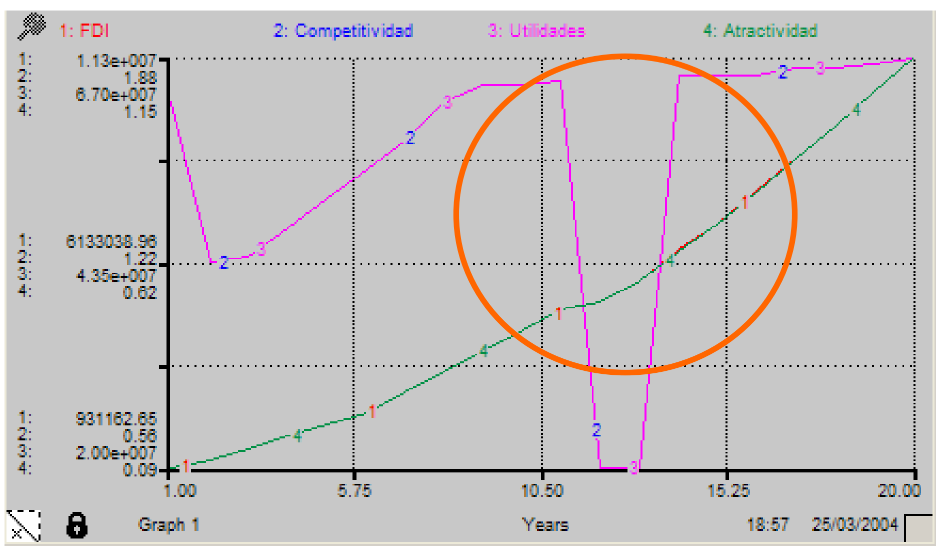
<u>In which degree does ***attractiveness*** impact the foreign investment? (Related to *foreign investment*)</u>



The attractiveness of the region and in the foreign investment funds for development of the biotechnological industry in Monterrey will growth in next 20 years. Although, we can not state clearly the world-wide competitive level of this industry of this region.

Question 3

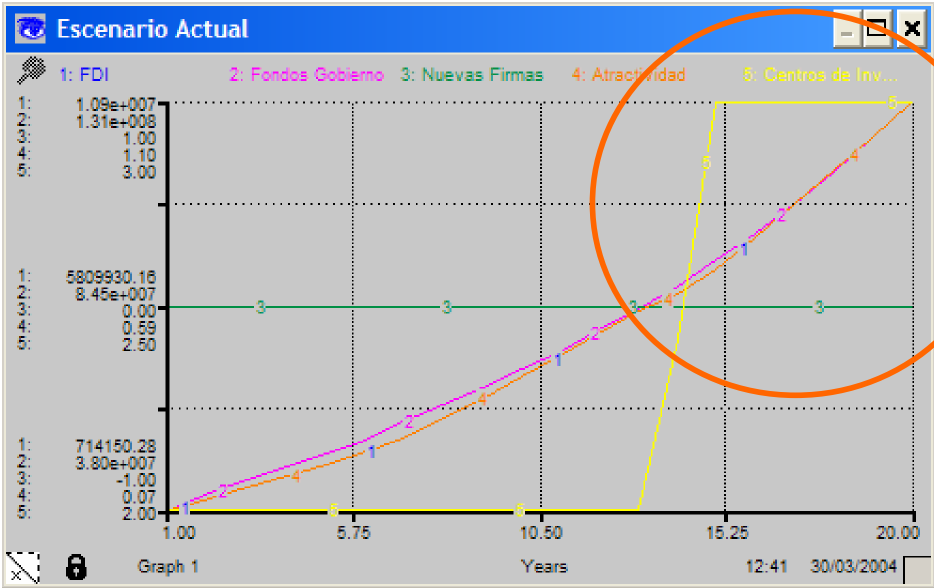
<u>In which degree does the regional ***attractiveness*** impact the cluster competitiveness? (Related to *regional competitiveness*)</u>



We observe the following variables: FDI, Utility, and Competitiveness. Attractiveness does not impact directly the competitiveness of the cluster, which diminishes with the decrease of utility on the generated patents.

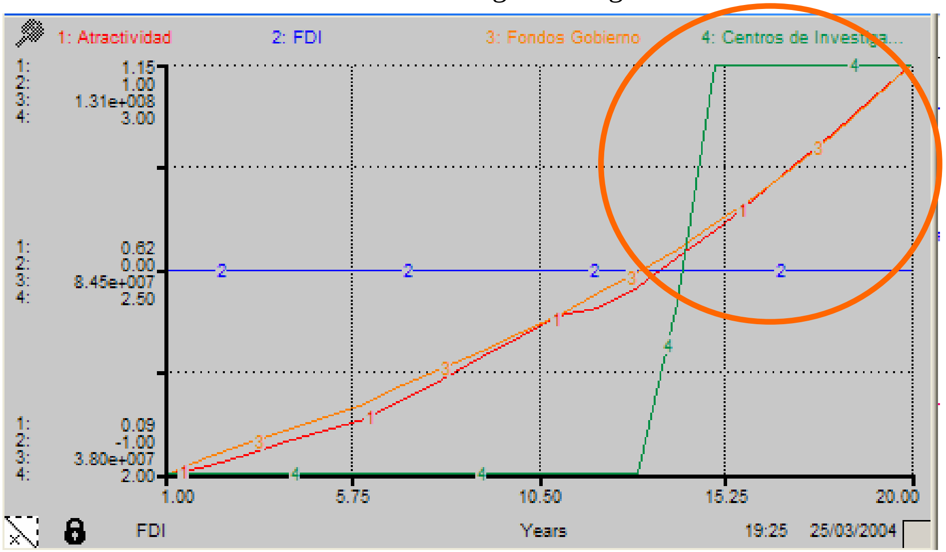
Scenarios and analysis of the results

Current scenario



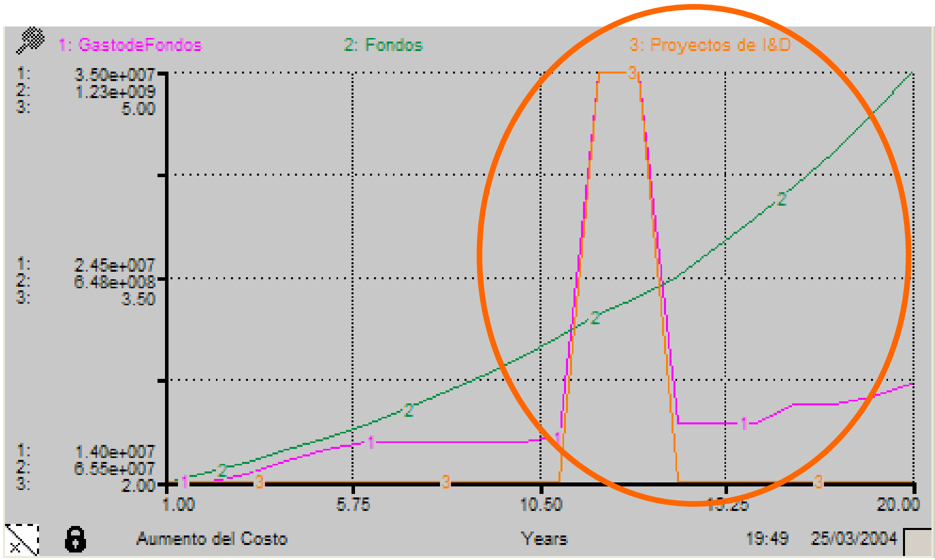
We observe that attractiveness in the region of Monterrey in the next 20 years is too small. One of the causes is the level of the competitiveness to create the optimum conditions to attract the investment in a company that can benefit by the creation of the cluster.

Scenario 1: The cluster does not receive foreign funding.



In this scenario, we observe that the cluster, not counting with foreign investment, stays with the government funding which allow a development in the research centers, which allow basic investigation and this allows the activity to continue its growth.

Scenario 2: Increase of the project development cost by 100%.



In this scenario we observe how they remain constant for a period of time, but when an increment of costs in the projects of 100% exists, it is understandable that the expenses of the funding increment, but after having so many projects, these begin to decrease which causes the expenses to go down for a period of time and then start incrementing again.

CONCLUSIONS

We can conclude that there exist key factors that can increase the attractiveness of the region to attract any company and by this, let Foreign Investment Fund for the development of biotechnological clusters such as public and private funds that enable the basic research in the field to continue developing, allowing the creation of scientific educational programs as well as new research centers to continue developing projects that will produce patents that will become utilities to reach an optimum level of competitiveness.

Through the constructions of a model we try to show the behavior of these factors and how they can be improved to achieve the attractiveness of the region.

This model attempts to show s all three levels of complexity together and articulated on a synchronous synergy by the dynamic imposed by the processes.

By making the simulation of the model, we prove that having economic support from the Government as well as from the private sector, a higher quality in basic and development research is produced.

FURTHER RESEARCH

This research is part of a model capable to create the enabling conditions for developing and transition economies, where the dynamics is represented by this approach.

We contemplate developing a *Decision Support System* for innovation and technology based on this model. This simulation tool will allow evaluating and simulating the investment and development of a real cluster so that Governments can simulate this pole before invests money.

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