Modeling the development of a biotechnological cluster

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Abstract

Worldwide competition is evolutionary and dynamic; therefore it is necessary that countries not only think in terms of immediate cost but that they foment the necessary conditions under which their companies or new companies can develop competitive advantages based on the innovation.
According to this, it is important that countries like México foment the creation and the development of new industries in the biotechnological cluster, in order to develop new areas in which we could be competitive.
This paper is about the design of a model that could help us to evaluate de viability of the development of a biotechnology cluster in Mexico.

Keywords: biotechnology, cluster development, Innovation

II. Background

The role that biotechnology plays now is critical; ours is a contaminated world with ecosystems affected by the impact of the industrialization. The development platform of modern biotechnology was the aptitude of isolating, editing and manipulating the material of living organisms, creating trough this transgenic organisms. The impact of this technology became present at the beginning in areas such as medicine, when protein producing microorganisms were designed to produce proteins such as insulin; later biotechnology became present in the cattle and agricultural sectors with the presence of transgenic plants and animals for the production of food and other satisfactory products. (Arias, et al. 2002).

This industry has captured the attention of many government officers worldwide, who want to capture the generated economic potential of this field. (Feldman, 2003).
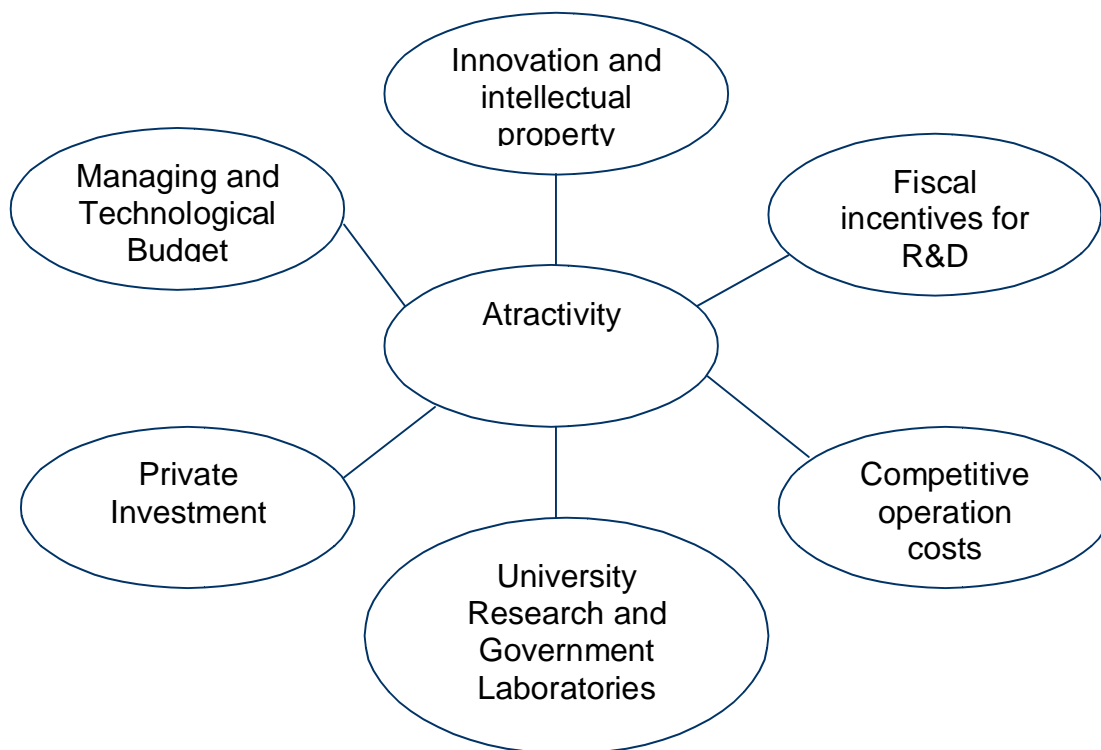
The industry of biotechnology is one based on the intellectual property, the intensive capital and led by knowledge, usually biotechnological industries are companies formed by investigators supported by the development of patents which beginnings are financed by risk capital. (Yu-Shan Su, 2003).
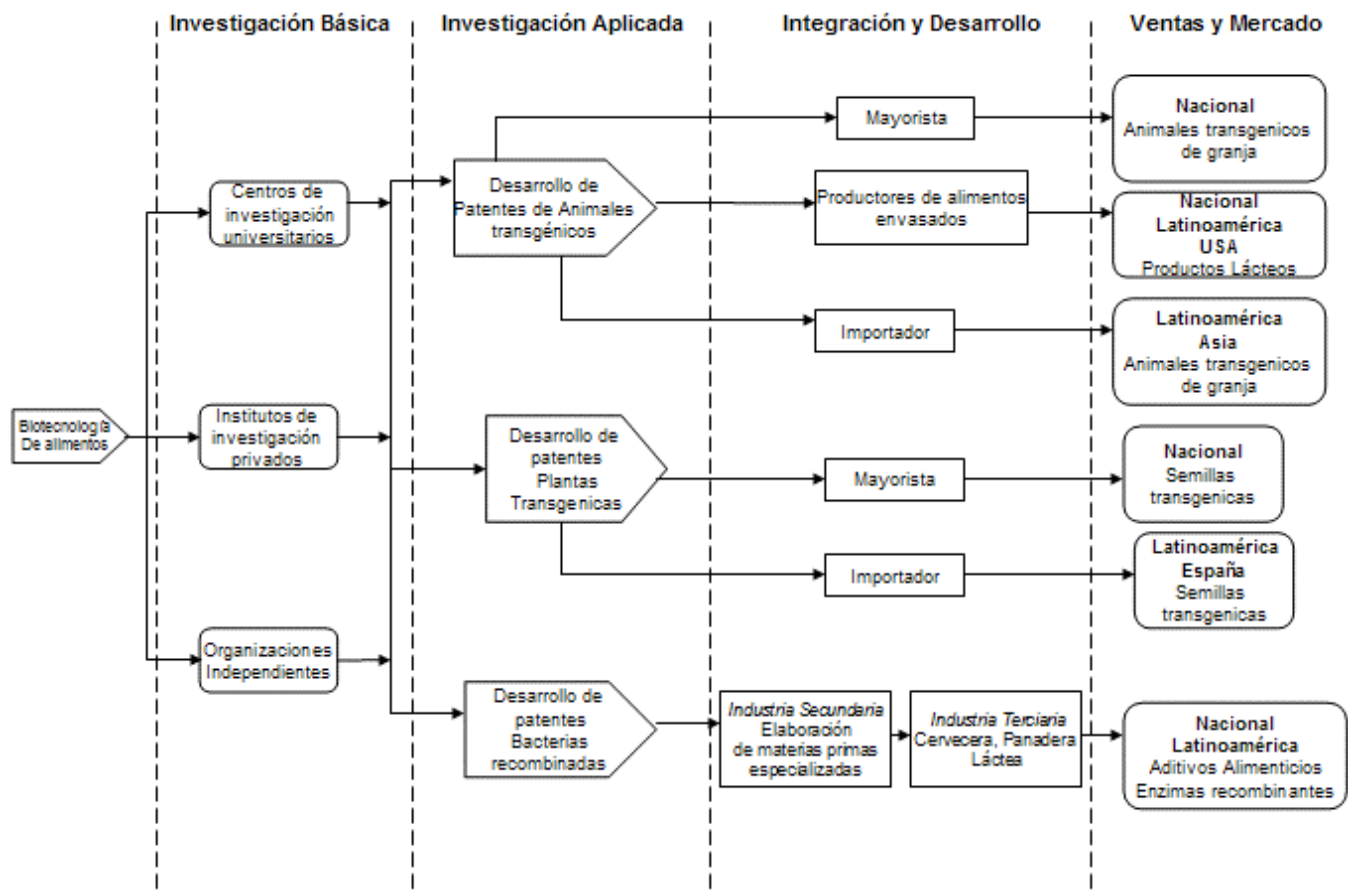
Biotechnology has strongly developed in the northern hemisphere, particularly in the United States and Europe, where science is cultivated as a socially important activity. The biotechnological

British market is the biggest in Europe and the second in the world, after the United States. In the year 2001 the value of this market was of 5,400 million dollars and it is foreseen that it has a 200% growth per year, with which it will achieve a value of 18,600 million dollars in the year 2006. It is also necessary to mention that the position of these countries in the field of Biotechnology owes its position to three crucial factors: a scientific base of first world class, a deep-rooted sector of strong financial services and the unconditional support of the Government (Singleton, 2003). The value chain of this industry appears in Fig. 1.

Another country with a high degree of cluster development is Canada, which counts with biotechnological clusters recognized world wide by their excellence, where the successful companies in this area develop around universities, research institutions and government laboratories. Some of these clusters are found in Quebec, Montreal, Ontario and Toronto (Canadian Government, 2004).

The key factors within the development of a biotechnological cluster according to the Quebec of Sequin, R. (2003) model are shown below.

Investigación Básica **Investigación Aplicada** **Integración y Desarrollo** **Ventas y Mercado**

Biotecnología De alimentos

Centros de investigación universitarios

Institutos de investigación privados

Organizaciones Independientes

Desarrollo de Patentes de Animales transgénicos

Desarrollo de patentes Plantas Transgenicas

Desarrollo de patentes Bacterias recombinadas

Mayorista

Productores de alimentos envasados

Importador

Mayorista

Importador

Industria Secundaria Elaboración de materias primas especializadas

Industria Terciaria Cervecera, Panadera Láctea

Nacional Animales transgenicos de granja

Nacional Latinoamérica USA Productos Lácteos

Latinoamérica Asia Animales transgenicos de granja

Nacional Semillas transgenicas

Latinoamérica España Semillas transgenicas

Nacional Latinoamérica Aditivos Alimenticios Enzimas recombinantes

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Investigación básica   **Investigación Aplicada**   **Integración y Desarrollo**   **Ventas y Mercado**

• **Centros de inv. Universitarios**
 Universidad Autónoma de Nuevo León
 ITESM (Centro de Biotecnología)
•**Organizaciones Privadas**
 Grupo Pulsar (DNAP

Holding)

Gruma Corp.
•**Financiamiento**
 Externo
 Nacional

•**Maquinaria y equipo**
 Proveedores locales y foráneos
•**Financiamiento**
 Externo
 Nacional

•**Industria en Alimentos**
 Productos Lácteos
 Productos de carne
 Grupo Pulsar (Seminis)
 Grupo Maseca
 Grupo Gamesa
 Cervecería Cuauhtemoc
•**Industria en la elaboración de materias primas**

Regulación de normas oficiales

SAGARPA, Agencias de ONU, Congreso de la unión

Fig. 1 Biotechnology value chain

Estimations show us how the world market of biotechnological products ascended to 800,000 million dollars in the year 2000, 17,000 million of which belonged to the food market, more than 4800 companies are part of this industry and that the occupied personnel in a direct way for the 1995-1996 period was over 160,000 people. (Arias, et al. 2002).

Following, a report of the worldwide biotechnological activity in the year 2002, by Ernst & Young (Abate, T., 2002):

CANADA
Income: $1,021 million
Gross Income: -$507 million
Employees: 7,005
Companies: 331 private, 85 public

UNITED STATES
Income: $25,319 million
Gross Income: -$4,799 million
Employees: 141,000
Companies: 1,115 private, 342 public

EUROPE
Income: $7,533 million
Gross Income: -$608 million
Employees: 34,180
Companies: 1,775 private, 104 public

ASIA
Income: $1,001 million
Gross Income: -$19 million
Employees: 6,518
Companies: 441 private, 91 public

In our country and the rest of the world, the development of biotechnology is incipient and we strongly depend on the technological transfer coming from the developed countries. In third world countries, numerous factors limit the formation of human resources, amongst which we can mention a 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 same fact makes that several disciplines are not properly cultivated and this seriously limits the development of biotechnology in these countries. Another important factor is our limited experience in the technological transfer between universities and companies of the productive sector and also, the jealousy which a lot of scientists have to the association with the productive sector, probably due to our fundamentally Hispanic cultural heritage. (Loannes, quoted in SIMBIOSIS, 2000).

Another factor which has limited the development of biotechnology has been the geographic isolation imposed by the distance of the Latin American countries to the sources of knowledge, nevertheless, the access to the modern communication networks primarily internet and e-mail-allow us to think that in a near future, the massive access to marketing information, state of the art technologies and scientific discoveries wont be limited by this geographical distance. Inadequate technical aptitude to compete on included markets, in which the quality requirements will be indispensable to penetrate the borders of the national markets (SYMBIOSIS, 2000).

III. Situation of Biotechnology in Mexico

The advances Mexico has experienced in biotechnology, especially in the research field, give it a worldwide recognized quality, since it is one of top ten countries in the world which plant genetically modified crops. Hereby our country has been consolidated as one of the more advanced developing nations in Latin America, in the field of biotechnology; nevertheless this capacity is weak in relation to the population and the economic value of the country (BioPlanet, 2000).

The development of modern biotechnology is a prior topic in Mexico to be able to produce our own biological technology. The country has resources and capacities in the area of biotechnology, which are necessary to coordinate and support in a concise way among the different actors who have under their responsibility the development of the biotechnology: the government, the industry and the academic (Arias, et to. 2002).

In our country, most of the projects in biotechnology are supported by resources from the institutions; nevertheless, these resources are not sufficient for what most of them submit work proposals to different instances for the obtaining of additional resources. The principal source of resources is the CONACYT, by means of different programs which are indicated below (Arias, et to. 2002):

- Support granted by means of the Scientific Investigation Direction, which has finances 167 projects in the last two years, with a one two five year duration each.
- Support granted by means of 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 summons published in the year 2000 to obtain "Support to develop research projects and technological development en the field of biotechnology", 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.

Same 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 (Loannes mentioned in SYMBIOSIS, 2000).

Monterrey is a city located in the North-East side of Mexico, border with The United States, Monterrey is considered 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.

Monterrey is also considered the most important educational center in Mexico given that its educational level is three years greater than national average, 63% of the state budget is invested in educating, 4,176 school teach English as a second language, it counts with 59 bilingual schools and 3 schools which teach 100% English, 231 technical schools and 2 Technological universities and more than 30 superior level institutions:

UANL: The best public university in Mexico.
ITESM: The best university in Latin America
UDEM y UR: World Class Universities
Duxx, IPADE y EGADE: World Class post-grade schools.
Besides that, Monterrey is leader in virtual universities.

In Monterrey, the development of biotechnology is critical because of the following data:

- In the year 2001, the UANL and the ITESM already counted with research centers in the field of food biotechnology (Arias, et al 2002).
- The UANL in the year 2001 counted with 13 researchers dedicated to this field (Arias, et al, 2002).
- In the year 2001, the ITESM counted with 10 researchers in the center.

According to the data obtained through the Center of Biotechnology of the ITESM Campus Monterrey, we can say the following:

- This center currently (2004) counts with 15 researchers in the field.
- It currently owns a patent in the field of food biotechnology and another one in the field of pharmaceutics.
- The ITESM has a Masters in Biotechnology since 1994.
- The ITESM has a doctorate in Engineering Sciences with a specialty in Biotechnology since august 2003.
- The Biotechnological Center has a great interaction with the National Industry with groups like, GAMESA, MASECA, AGROINSA, SUKARNE, CERVECERIA CUAUHTEMOC, BIMBO, CYDSA, and others. It also interacts with international consortia like Bristol-Myers Squibb, IVAX.
- The funding of this center comes from Government Funds destined to the CONACYT, private funds which come from the industry and also foreign funds.
- The Biotechnological center of the ITESM receives a foreign funding of 150,000 USD per year since the year 2001.
- The vision for the year 2006 of the Biotechnological center of the ITESM is to earn national and international recognition as a leading group of companies in the field of biotechnological incubation.

According to the already mentioned, it is important that countries like ours foment the creation and development of biotechnological clusters in the field of food so we can have new areas in which we can be competitive.

IV. Fundamental Hypothesis

"If we can develop the attractiveness of the region we can attract foreign investment to generate a world-wide competitive biotechnological sector"

Based on this hypothesis the following questionings arise which will take us to prove the hypotheses stated above.

1.- Questioning related to the "Cluster Growth".

How does attractiveness impact the growth of research centers and the implantation of new biotechnological companies in the region?
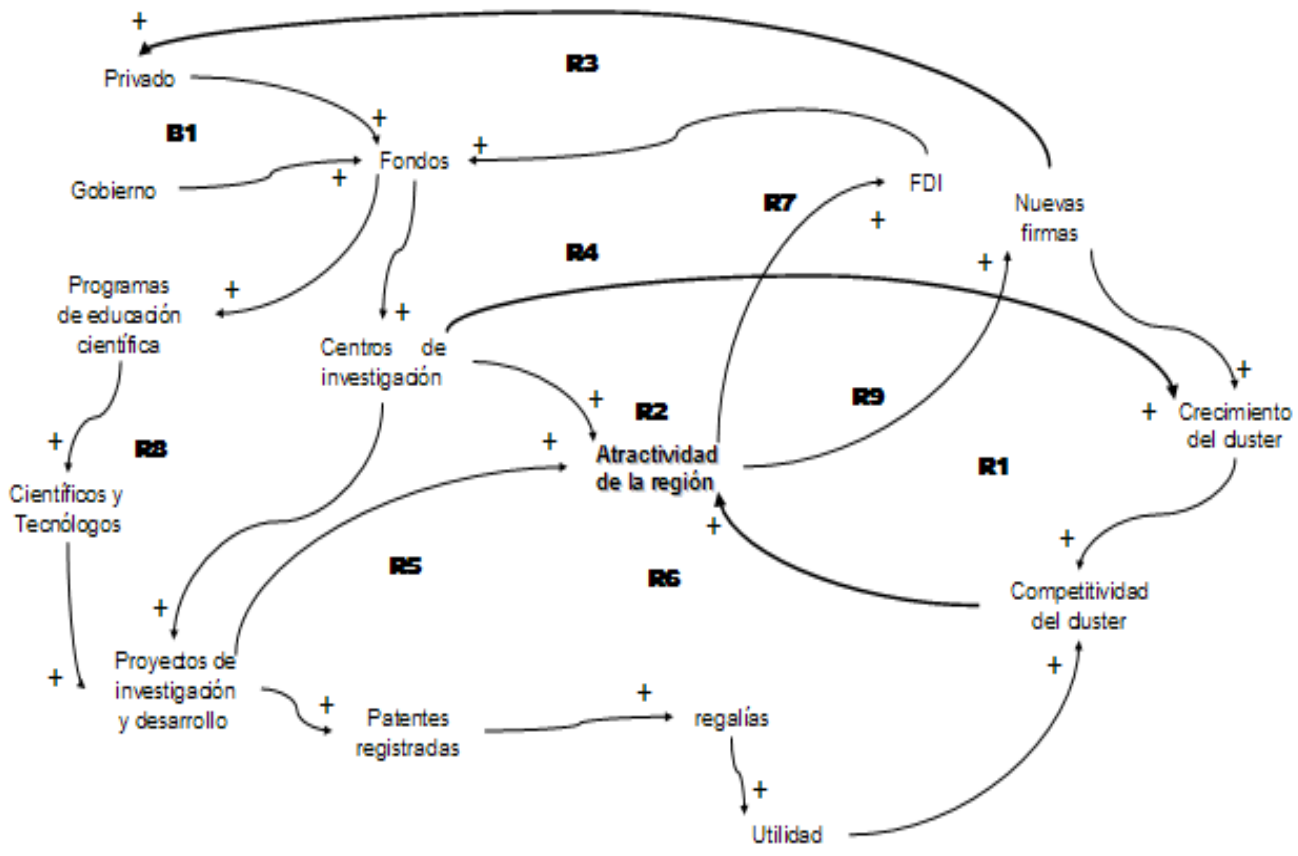
2.- Questioning related to "Foreign Investment".

In what degree does attractiveness impact foreign investment?

3.- Questioning related to "Regional Competitiveness".

In what degree does the regional attractiveness impact the cluster competitiveness?
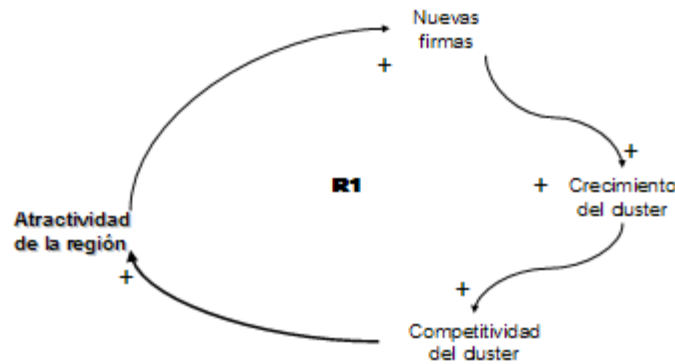
V. Causal Loop Diagram

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Privado

R3

B1

Gobierno

+ Fondos +

+ FDI

R7

Nuevas
firmas

Programas
de educación
científica

+

+ Centros de
investigación

+

R4

+

R9

+

Crecimiento
del cluster

+

Científicos y
Tecnólogos

R8

+ Atractividad
de la región

R2

+

R1

+

R5

R6

+

+

Competitividad
del cluster

+

+

Proyectos de
investigación
y desarrollo

+ Patentes
registradas

+ regalías

+

Utilidad

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.
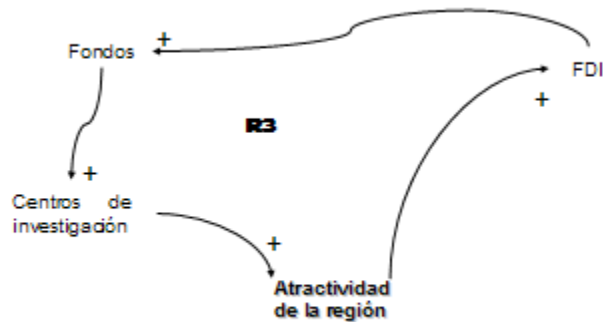
- R2
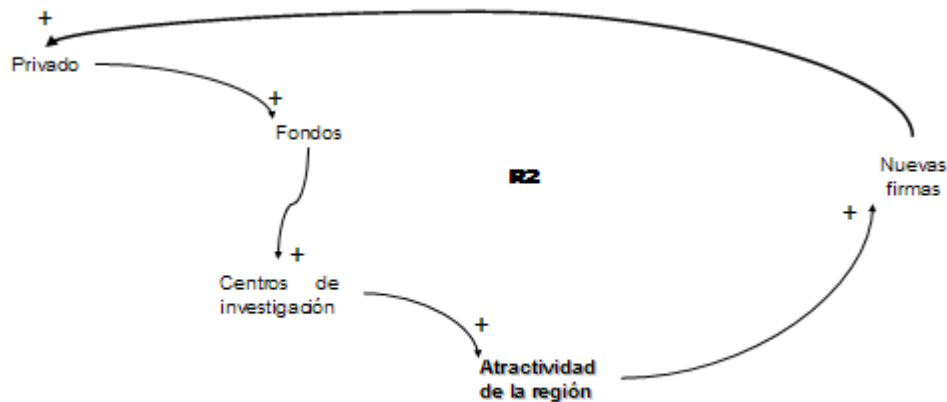
   – If there is an increment in the attractiveness of the region, there will be an increment in the number f new biotechnology firms.
   – If there is an increment in the number of new biotechnology firms, there will be an increment in the private funding.
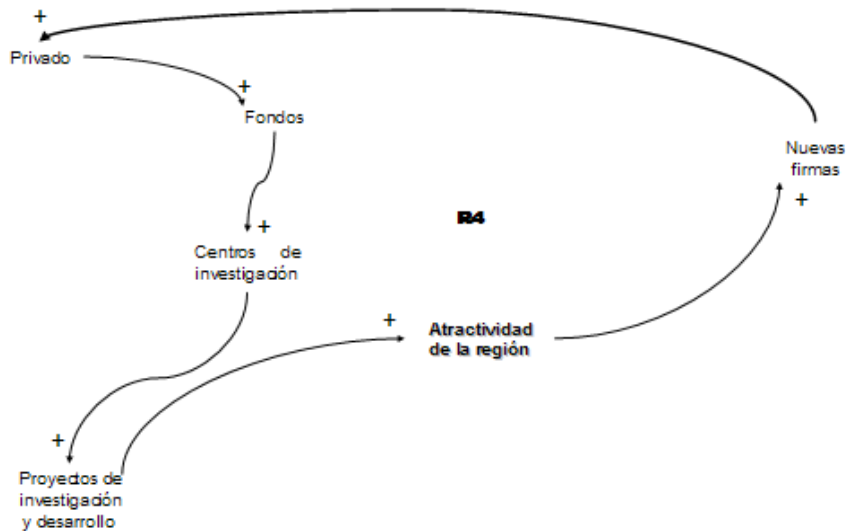   – If there is an increment in the private funding, there will be an increment in the funding.

- 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.
  - 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.
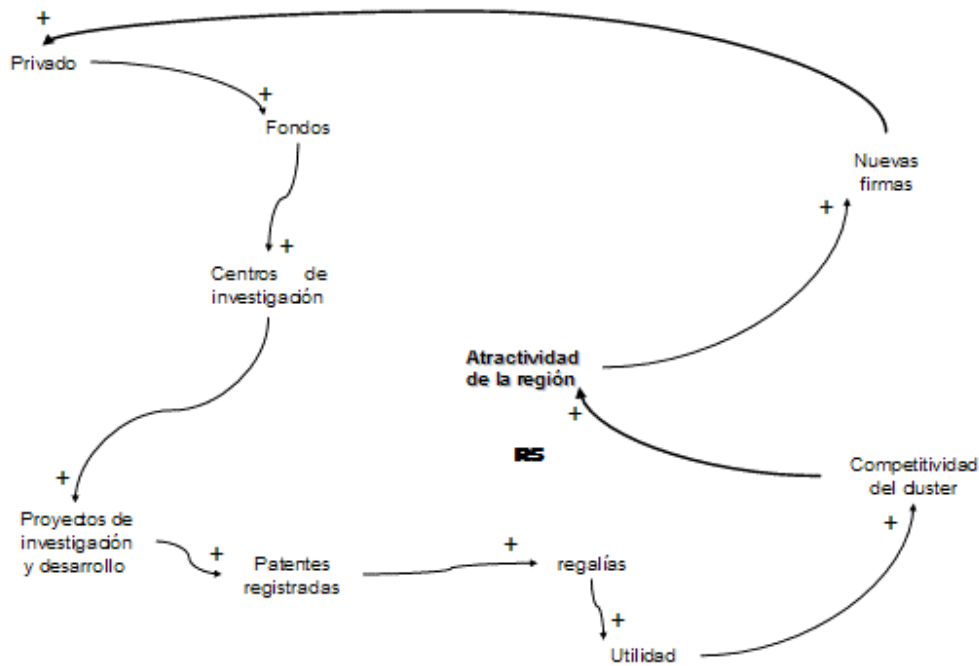- R4

  - 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.
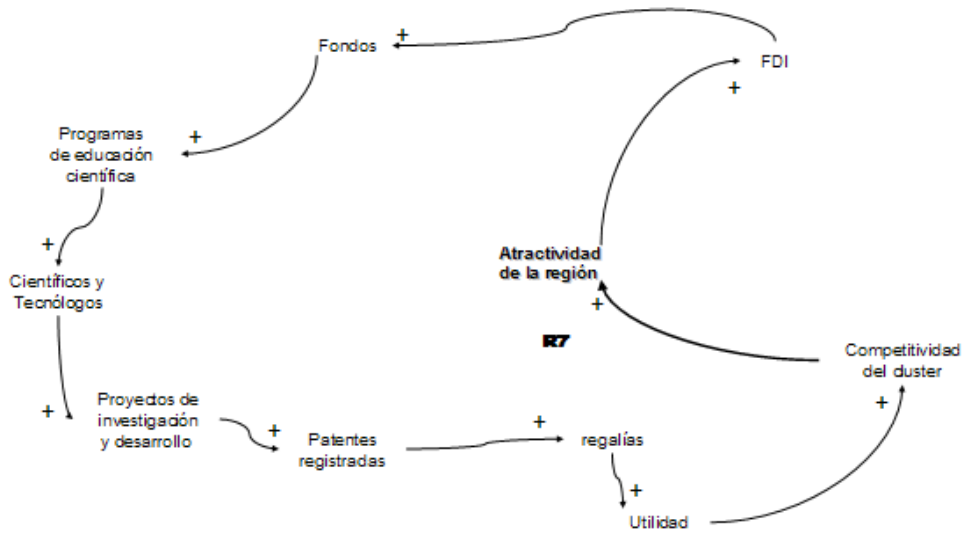
• R5

–   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.
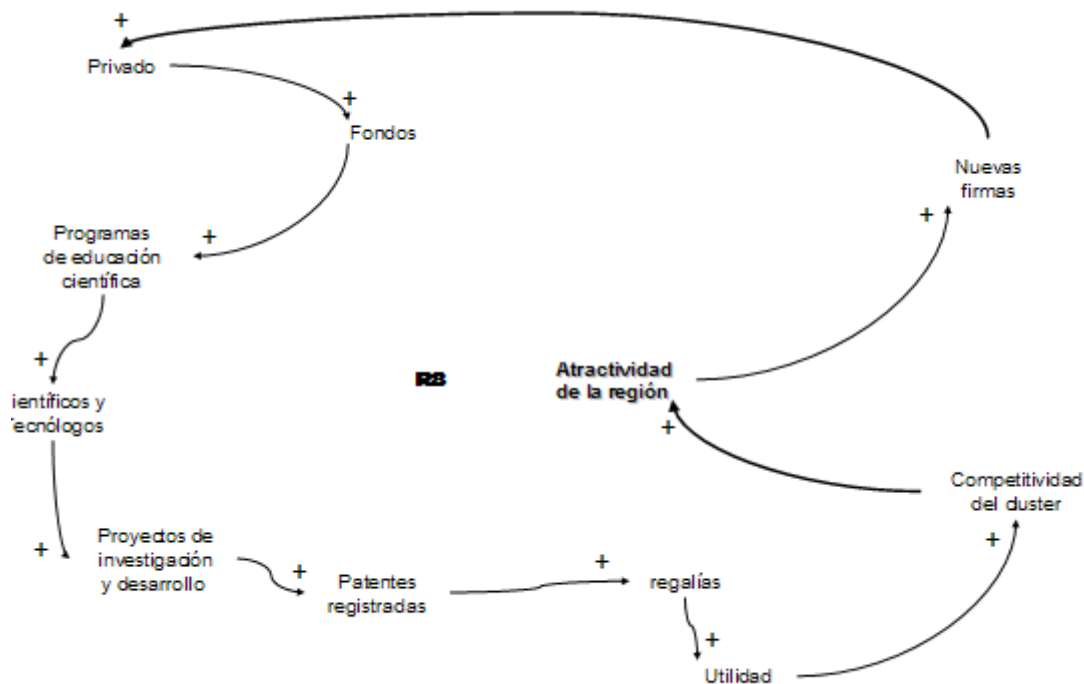
- R6

- If there is an increment in the attractiveness of the region, there will be an increment in the 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 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 the registered patents.
- If there is an increment in the 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.

- 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 it's degree of attractiveness.

- R8

+

Privado

+

Fondos

Nuevas firmas

+

Programas de educación científica

+

Atractividad de la región

RB

+

ientíficos y 'ecnólogos

+

Competitividad del cluster

+

Proyectos de investigación y desarrollo

+

+

Patentes registradas

+

regalías

+

Utilidad

-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, it's attractiveness degree, will also increase.

VI. Assumptions behind 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.

<u>Research and Development</u>

As one of the important factors to consider are the funds granted by diverse sources and their impact in the increment of the industry development.

Another key factor is the number of scientific education programs in the field because it impacts directly in the number of scientists and technologists who will develop the research projects.

<u>Cluster Growth</u>

This considers as primary factors, the number of new companies and their impact with the creation of new research centers.

<u>Competitiveness</u>

This considers the utilities generated by the granted licenses for the use of patents and by the royalties obtained from these patents.

These three stages of our model are what will prove our hypothesis given that they are the principal generators of the attractiveness of the region.

VII. Model Scopes

The model implemented in this work covers Basic and Applied research of the biotechnological industry.

For modeling effects, factors regarding independent organizations are not being taken into consideration.

The period of time considered for the modeling is of 20 years, and this will be reflected in the scenarios and the analysis of the results.

Due to the lack of time which the experts in the biotechnological field were able to give us relevant data, and to the fact that the data in the industry of Monterrey is not registered, our model has a lot of factors working under assumptions obtained from national statistics.

VIII Detailed description of generated questionings

The model was implemented in Ithink, incorporating each and every sub-model until the complete model was obtained, which will behave as close to reality as possible.

Questioning 1:

How does attractiveness impact the growth of research centers, and the implantation of new biotechnology companies in the region?

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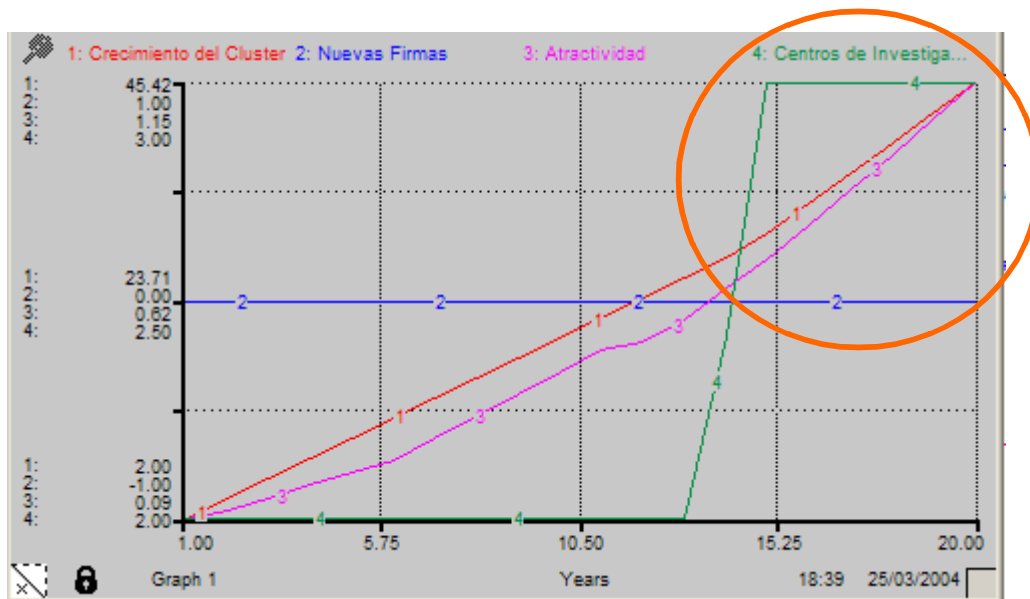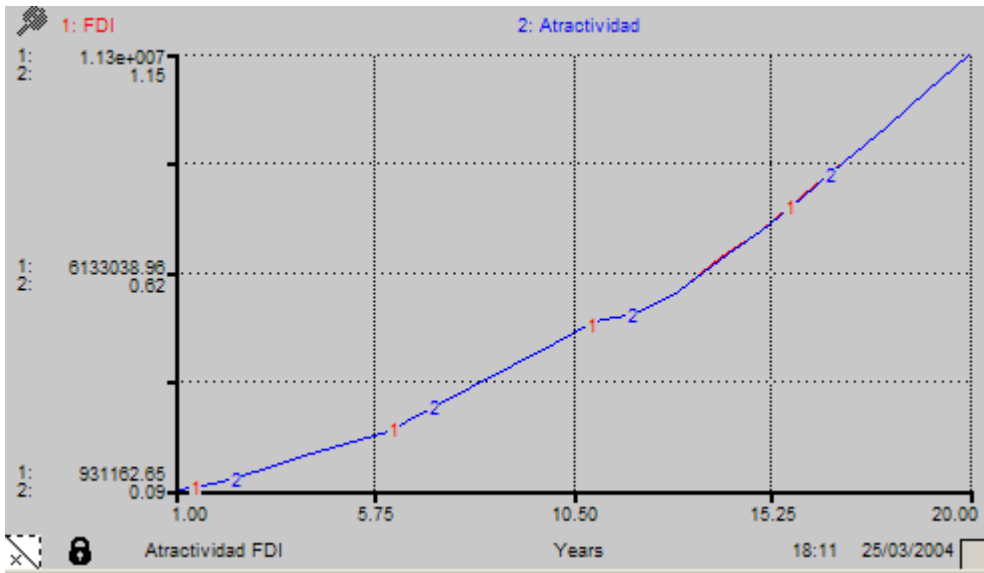

According to the data presented in the graphic we can observe how attractiveness generated 20 years from now is not enough to be able to generate new firms, but there is a foundation to impulse basic research inside this field.

Questioning 2

In what degree does attractiveness impact foreign investment?


As we can see in the graphic, when there is an increase in the attractiveness of the region, there is also an increase in the foreign investment funds for development of the biotechnological industry in Monterrey. We can also observe that in 20 years the attractiveness of the region is not adequate to become competitive world-wide, following is the generated chart.

16:27 25/03/2004

Years	FDI	Atractividad
Initial		0,09
1	931.162,65	0,12
2	1.143.319,67	0,14
3	1.432.001,48	0,17
4	1.731.243,40	0,21
5	2.030.528,34	0,24
6	2.332.107,39	0,29
7	2.838.605,71	0,34
8	3.364.641,95	0,39
9	3.903.545,06	0,45
10	4.427.878,39	0,50
11	4.954.828,11	0,52
12	5.152.355,43	0,57
13	5.676.688,77	0,65
14	6.469.862,06	0,72
15	7.135.184,64	0,80
16	7.960.184,64	0,89
17	8.792.919,02	0,97
18	9.617.919,02	1,06
19	10.465.629,75	1,15

Questioning 3

In what degree does the attractiveness of the region impact the competitiveness of the cluster?

In order to answer this question, we observe the following variables: FDI, Utility, and Competitiveness
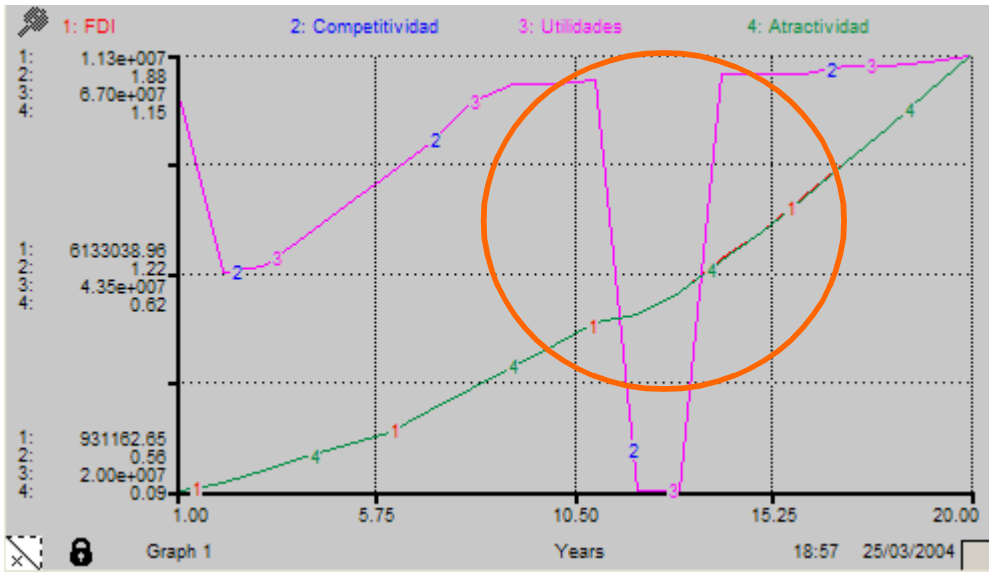

As we can see, attractiveness doesn't affect directly the competitiveness of the cluster, which diminishes with the decrease of utility on the generated patents, following, the generated chart:

Years	FDI	Atractividad	Competitivida
3	1.432.001,48	0,17	1,34
4	1.731.243,40	0,21	1,43
5	2.030.528,34	0,24	1,52
6	2.332.107,39	0,29	1,62
7	2.838.605,71	0,34	1,74
8	3.364.641,95	0,39	1,80
9	3.903.545,06	0,45	1,80
10	4.427.878,39	0,50	1,81
11	4.954.828,11	0,52	0,56
12	5.152.355,43	0,57	0,56
13	5.676.688,77	0,65	1,83
14	6.469.862,06	0,72	1,83
15	7.135.184,64	0,80	1,83
16	7.960.184,64	0,89	1,85
17	8.792.919,02	0,97	1,85
18	9.617.919,02	1,06	1,87
19	0.465.629,75	1,15	1,88

IX. Scenario Development

Scenario 1

The cluster doesn't receive foreign funding. Following is the behavior of this scenario.
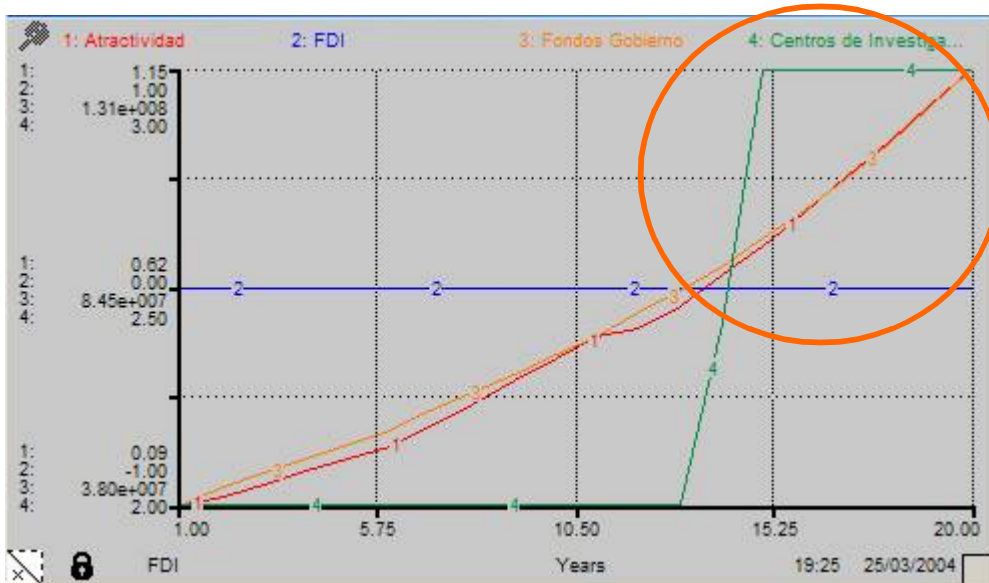
In this scenario we can appreciate that the cluster, without foreign investment, stays with the government funding which allow a development in the research centers, which allow basic investigation and this allows the activity to continue its growth.

Years	Centros de Investigacion
Initial	2,00
1	2,00
2	2,00
3	2,00
4	2,00
5	2,00
6	2,00
7	2,00
8	2,00
9	2,00
10	2,00
11	2,00
12	2,00
13	2,42
14	3,00
15	3,00
16	3,00
17	3,00
18	3,00
19	3,00

SCENARIO 2

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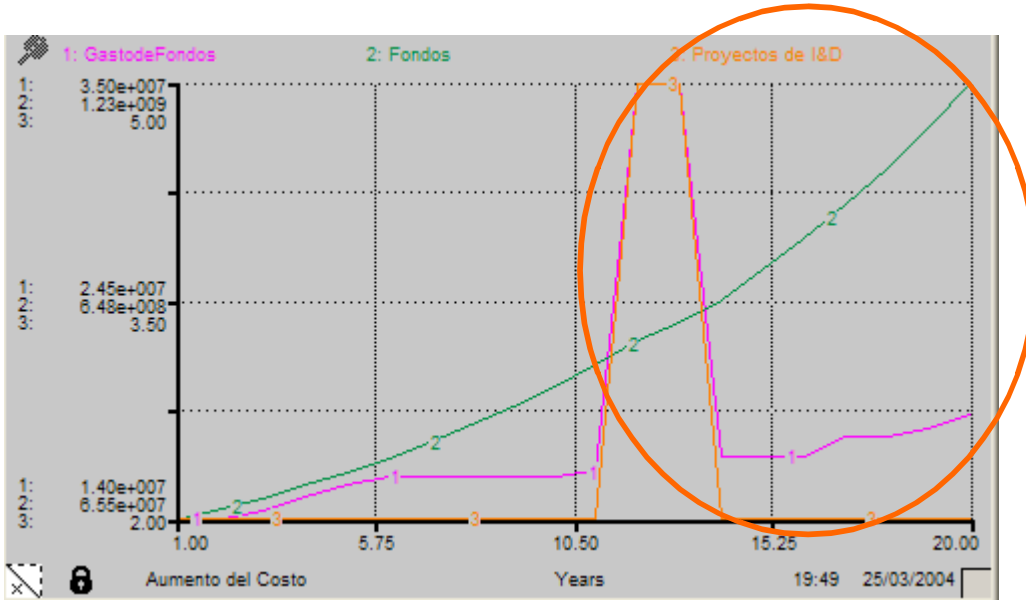
In this scenario we observe how they remain constant for a period of time, but when an increment of costs in the projects of 100% exists, it is understandable that the expenses of the funding increment, but after having so many projects, these begin to decrease which causes the expenses to go down for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

Years	Fondos	GastodeFondos	Competitividad	Atractividad
Initial	65.500.000,00		0,39	0,07
1	91.364.230,10	13.983.704,68	0,39	0,10
2	121.518.215,76	13.983.704,68	0,41	0,13
3	154.533.602,00	14.413.812,21	0,42	0,16
4	190.228.337,96	15.026.715,43	0,44	0,19
5	228.602.423,64	15.639.618,66	0,45	0,22
6	269.923.580,89	15.983.704,68	0,45	0,26
7	315.629.732,73	15.983.704,68	0,45	0,31
8	365.826.240,13	15.983.704,68	0,45	0,36
9	420.539.004,56	15.983.704,68	0,45	0,41
10	479.782.987,50	15.983.704,68	0,46	0,46
11	543.206.000,98	16.338.543,39	0,98	0,53
12	593.978.616,30	34.959.261,70	0,98	0,58
13	649.982.450,12	34.959.261,70	0,48	0,62
14	729.323.097,22	16.983.704,68	0,48	0,68
15	815.292.396,04	16.983.704,68	0,48	0,77
16	908.097.528,19	16.983.704,68	0,51	0,85
17	1.007.746.329,62	17.983.704,68	0,51	0,93
18	1.115.230.964,37	17.983.704,68	0,52	1,02
19	1.231.188.705,82	18.349.296,08	0,53	1,11

X Analysis of the data generated by the model

The following results were observed analyzing the model with all the factors related to the generation of activity to increment the FDI:

CURRENT SCENARIO

The current scenario allows us to observe that the attractiveness 20 years from now in the region of Monterrey is very small which causes the competitiveness not to obtain the necessary level to create optimal conditions which could attract an anchor company that can favor the creation of the cluster.
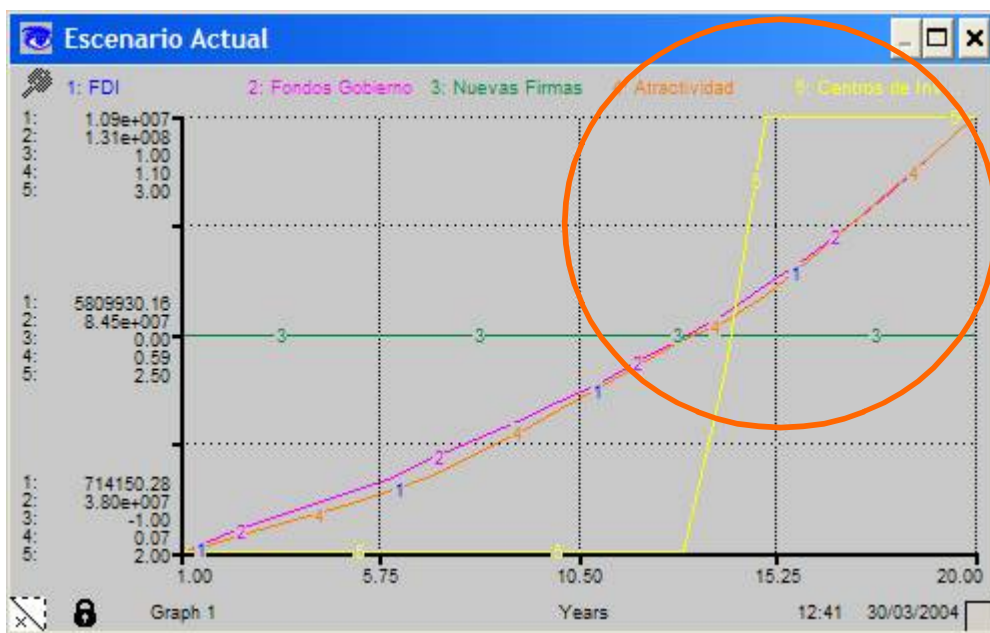
Strategy Development

Strategy

We decided to present just one strategy which will develop in counting with a greater economical support from the government and the private industry so the attractiveness of the region can be raised.
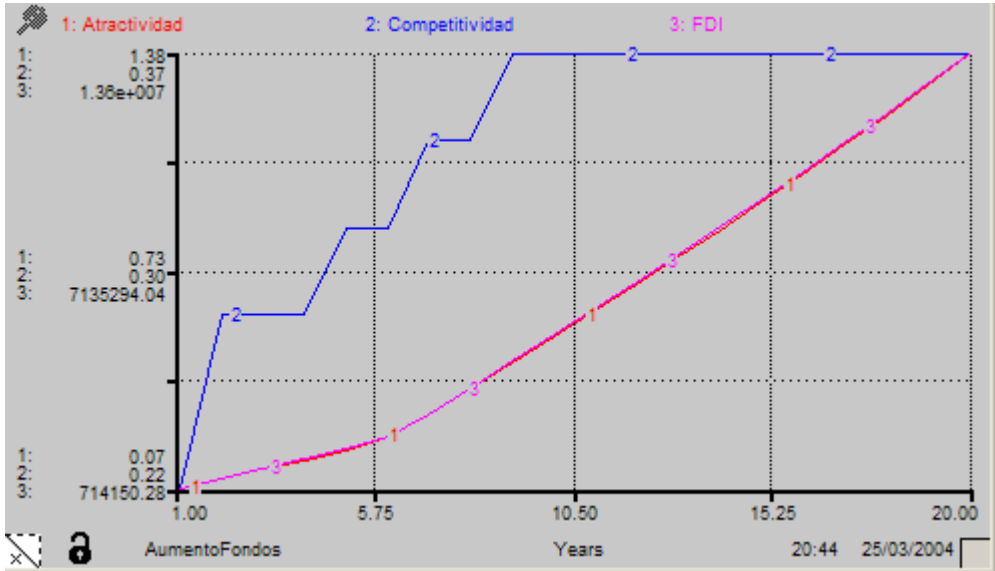
As it can be observed in the graphic, when the funding increases, there is a 1.38 increase in the attractiveness from the 1.10 that can be observed with the current situation. It can also be observed that the competitiveness is also benefited with this increment.

Years	Atractividad	Competitivida
Initial	0,07	0,22
1	0,10	0,28
2	0,13	0,28
3	0,16	0,28
4	0,19	0,31
5	0,23	0,31
6	0,30	0,34
7	0,37	0,34
8	0,45	0,37
9	0,53	0,37
10	0,61	0,37
11	0,69	0,37
12	0,77	0,37
13	0,85	0,37
14	0,94	0,37
15	1,02	0,37
16	1,11	0,37
17	1,20	0,37
18	1,29	0,37
19	1,38	0,37

Validation of the model

<u>Validation of the model vs the current situation of a real cluster</u>

In this section we compare the results obtained against the real behavior of the biotechnological industry identified in literature.

Regarding the behavior of attractiveness, the result of the simulation shows how it is increasing in a very small proportion through time, and it is the same as it currently presents. This behavior is because of the little growth of the cluster.

The yield obtained with the simulation of the current scenario is the same as the current yield.

<u>Comparing the results obtained with the simulation model VS the world-wide clusters</u>

Biotechnology has strongly developed in the northern hemisphere, particularly in the United States, Canada and Europe, where science is cultivated as a socially important activity.

The Cluster in Quebec is one of the most competitive world-wide reason why it was chosen as a point of comparison for our model.

Some important data of the Quebec Cluster is the following:

Research Centers in Quebec:

⇒ Institute of Research in Biotechnology (IRB).
⇒ Institute in Veterinarian and Food Biotechnology (IVFB).
⇒ Quebec Biotechnology Innovation Centre (QBIC),
⇒ Biotechnology Development Centre
⇒ Collegial Center of Transference of Biotechnological Technology (TRANSBIOTECH)

Biotechnology Companies in Quebec: 130

According to the data obtained in TTC – Bio-Industries; the expenses in Quebec in the field of Biotechnology in the year 2001 were of 337 million Canadian Dollars with an increase of 60% over the following years.

In the year 2002 the utilities obtained by Quebec were of 202 million dollars. Of which approximately 40 million were in the field of food.

The advances experimented by Mexico in Biotechnology, specially in the research field, give it a world-wide recognized quality, because it is one of the ten principal countries which plant genetically modified crops.

This way, our country has consolidated as one of the most advanced developing nations in the field of biotechnology; nevertheless this capacity is weak in relation to the population and the economic value of the country.

The Government funding destined to Science and Technology is the following:

According to the data obtained from the National plan of science and technology during 2001 the funding destined to science and technology for the area of Monterrey were of approximately 746 million pesos, amount which by the year of 2002 was of 792 million pesos. By the year 2003 the funding was of approximately 800 million pesos.

According to the National plan of science and technology during the year 2001 the creation of 18 mix funds in support of science and technology was initiated. The constitution of these funds multiplied the impact of public resources destined to this field. One of these funds was destined to Nuevo Leon, with 32 million pesos. By the year 2002 the Mix-Fund for Nuevo Leon increased to 60 million pesos.

We couldn't find information about the 2003 mix-fund but according to the data gathered from the years 2001 and 2002, we can infer that the mix-fund for Nuevo Leon was of approximately 75 million pesos.

According to the data found we infer that a 5% of this fund goes to the field of biotechnology.

According to the data gathered from CONACYT, the private investment in biotechnology in Monterrey has been of about:

2001	2002	2003
26 million pesos	30 million pesos	35 million pesos

This is because the biotechnology centers in Monterrey have a great interaction with the national industry with groups such as GAMESA, MASECA, AGROINSA, SUKARNE, CERVECERIA CUAUHTEMOS, BIMBO, CYDSA, and others.

According to the data of the ITESM Biotechnological Center, this center counts, since the year 2001, with a foreign investment of 150,000 dollars per year. This money is granted by international agencies such as UNDP and NSF.

Important centers of superior education like the Monterrey Institute of Technology and Superior Studies, the Autonomous University of Nuevo Leon, The University of Monterrey, The Universidad Regiomontana, are found in Monterrey.
According to our investigation, educational programs in biotechnology to the level professional, Masters and doctorate are found only the ITESM and the UANL.

Monterrey Institute of Technology and Superior Studies (Instituto Tecnológico y de Estudios Superiores de Monterrey Campus Monterrey)ITESM:

- Engineer in Biotechnology (2004)
- Masters in Biotechnology (1994)
- Doctorate in Engineer Sciences with specialty in Biotechnology (2003)

Universidad Autónoma de Nuevo León:

- Doctorate in Biotechnology (1992)

Álvarez (2004) mentions that at the moment in the Center of Biotechnology of the ITESM they are making 4 projects in the area of biotechnology in foods and that in the Center of Biotechnology of the UANL are 5 projects in which they are working on, some of which have been developed for 3 years now.

COST OF RESEARCH PROJECT

PROJECTS FINANCIATED DIRECTLY BY CONACYT ACCORDING TO THE RESEARCH AREA				
Research area	Number of projects	%	Assigned budget	%
Biotechnology and Chemistry	79	25.90%	$ 121,088,392.00	4.10%
Medicine and Health Sciences	77	25.20%	$ 2,619,599,684.69	88.90%
Physics and Math, and Earth Sciences	59	19.30%	$ 82,363,974.00	2.80%
Biotechnology and Earth Sciences	32	10.50%	$ 47,918,836.00	1.60%
Engineering	28	9.20%	$ 33,258,897.00	1.10%
Humanities and Conduct Sciences	18	5.90%	$ 22,499,616.00	0.80%
Social Sciences and Economics	12	3.90%	$ 20,333,195.00	0.70%
Totals	305	100.00%	$ 2,947,062,594.69	100.00%

According to this chart presented by the CONACYT, a biotechnology project requires approximately $1'497,463.00 a year.

A very important aspect to take into account is the expedition of the developed product's patent; these expenses according to collected data of the IMPI (Mexican Institute of the Industrial Property) are of 11.113 pesos unfolded in the following:

$\Rightarrow$ Internacional Request: 5665 pesos.
$\Rightarrow$ Designations in favor of the International Office: 1220 pesos
$\Rightarrow$ Tariff of transaction in favor of the elect office through the international office: 2038 pesos

XI 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 lead to increase competitiveness.

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

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

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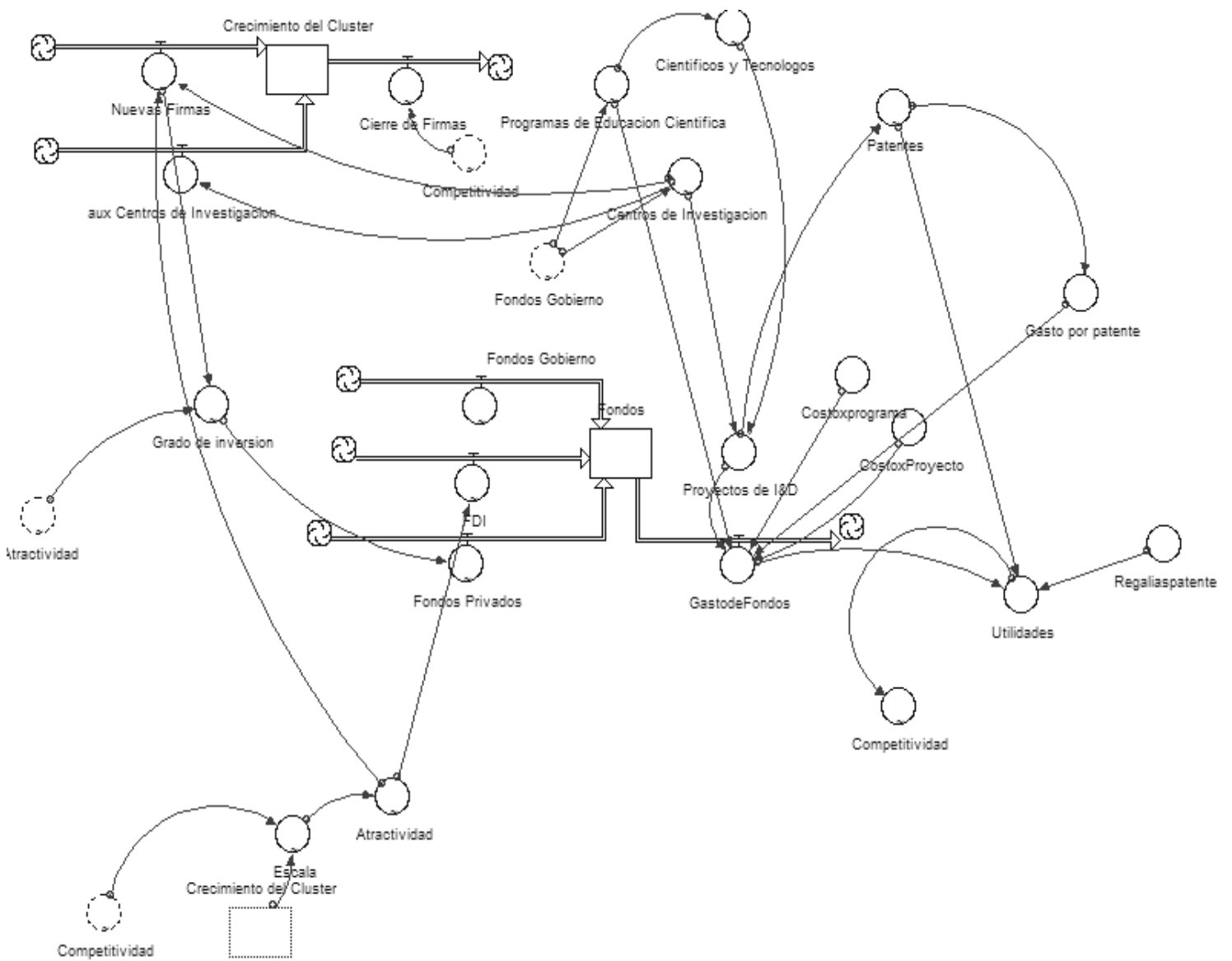
Appendix
1. Definition of the variables and represented equations.

NAME	DESCRIPTION	MEASURE	TYPE
Attractiveness of the region	Degree of interest that the region can generate.	Correspondent number to the scale	Non controllable
Research centers	Where biotechnological scientific research will take place.	Number of centers	Controllable
Scientists and Technologists	People in charge of the research development and science projects.	Number of scientists and technologists	Controllable
Cluster growth	Increase on the number of cluster memers given by the number of new biotechnological firms and allowing a better development of projects in the field.	Number of new biotechnological firms	Controllable
Cluster competitiveness	Capacity of maintaining comparative advantages that enable it reach, sustain and improve any given position in the socioeconomic environment.	Generated economic utilities	Non controllable
Government funds	Resources that the government gives to support the development on a field.	Economic resources	Controllable
Private funds	Resources that the private sector gives to support the development on a field.	Economic resources	Controllable
Foreign Direct Investment (FDI)	Resources that companies or international organizations give to support development.	Economic resources	Controllable
New Biotechnological Firms	New companies dedicated to the development of biotechnological research.	Number of new companies specialized in the field	Controllable
Patents	Certificates given for discoveries in the field to enjoy the benefits derived from them.	Number of registered patents	Controllable
Scientific Education Programs	Education programs related to the development and advance of science.	Number of programs	Controllable
Research and development projects	Projects related to science to achieve advances in it.	Number of projects	Controllable
Exemptions	Income or profit coming from the use of patents.	Gained economic resources	Controllable

2. Model

Crecimiento del Cluster

Nuevas Firmas

Cierre de Firmas

aux Centros de Investigacion

Competitividad

Programas de Educacion Cientifica

Centros de Investigacion

Cientificos y Tecnologos

Patentes

Gasto por patente

Fondos Gobierno

Grado de inversion

Fondos Gobierno

Fondos

Costoxprograma

CostoxProyecto

Atractividad

FDI

Fondos Privados

Proyectos de I&D

GastodeFondos

Utilidades

Regaliaspatente

Competitividad

Atractividad

Escala
Crecimiento del Cluster

Competitividad

3. Equations

STOCK

INFLOWS

- **Crecimiento_del_Cluster(t)** = Crecimiento_del_Cluster(t - dt) + (Nuevas_Firmas + aux_Centros_de_Investigacion - Cierre_de_Firmas) * dt

    INIT Crecimiento_del_Cluster = 2
- **Nuevas_Firmas** = IF Atractividad=3 AND Centros_de_Investigacion=3 THEN 1 ELSE
  IF Atractividad=4 AND Centros_de_Investigacion=3 THEN 2 ELSE
  IF Atractividad=5 AND Centros_de_Investigacion=5 THEN 3 ELSE 0
- **aux_Centros_de_Investigacion = Centros_de_Investigacion**

OUTFLOWS

- **Cierre_de_Firmas** = GRAPH(Competitividad)
  (0.00, 0.00), (10.0, 0.00), (20.0, 0.00), (30.0, 0.00), (40.0, 0.00), (50.0, 0.00), (60.0, 0.00), (70.0, 0.00), (80.0, 0.00), (90.0, 0.00), (100, 0.00)

STOCK
INFLOWS

- **Fondos(t) =** Fondos(t - dt) + (Fondos_Privados + Fondos_Gobierno + FDI - GastodeFondos) * dt
  INIT Fondos = 65500000
- **Fondos_Gobierno** = GRAPH(TIME)
  (1.00, 3.8e+007), (2.00, 4.2e+007), (3.00, 4.5e+007), (4.00, 4.8e+007), (5.00, 5.1e+007), (6.00, 5.4e+007), (7.00, 5.8e+007), (8.00, 6.2e+007), (9.00, 6.6e+007), (10.0, 7e+007), (11.0, 7.4e+007), (12.0, 7.9e+007), (13.0, 8.4e+007), (14.0, 8.9e+007), (15.0, 9.5e+007), (16.0, 1e+008), (17.0, 1.1e+008), (18.0, 1.2e+008), (19.0, 1.2e+008), (20.0, 1.3e+008)
- **FDI** = GRAPH(Atractividad)
  (0.00, 0.00), (0.556, 5.5e+006), (1.11, 1.1e+007), (1.67, 1.6e+007), (2.22, 2.1e+007), (2.78, 2.7e+007), (3.33, 3.2e+007), (3.89, 3.8e+007), (4.44, 4.4e+007), (5.00, 5e+007)

OUTFLOWS

- **GastodeFondos**=(CostoxProyecto*Proyectos_de_I&D)+(Programas_de_Educacion_Cientifica *Costoxprograma)+(Gasto_por_patente)+(Proyectos_de_I&D*CostoxProyecto)

- **Costoxprograma** = 1000000
- **CostoxProyecto** = 1497463

- **Gasto_por_patente** = Patentes*11113
- **Proyectos_de_I&D** = IF(Centros_de_Investigacion=2) AND (Cientificos_y_Tecnologos=23) THEN 3
  ELSE IF (Centros_de_Investigacion=2) AND (Cientificos_y_Tecnologos=40) THEN 5 ELSE
  IF (Centros_de_Investigacion=2) AND (Cientificos_y_Tecnologos=48) THEN 6
  ELSE 20
- **Regaliaspatente** = .03
- **Utilidades** = (GastodeFondos-(Patentes*Regaliaspatente))
- **Atractividad** = GRAPH(Escala)
  (0.00, 0.025), (1.00, 0.325), (2.00, 0.65), (3.00, 1.03), (4.00, 1.43), (5.00, 1.85), (6.00, 2.43),
  (7.00, 3.03), (8.00, 3.58), (9.00, 4.15), (10.0, 5.00)
- **Centros_de_Investigacion** = GRAPH(Fondos_Gobierno)
  (3.8e+007, 2.00), (4.3e+007, 2.00), (4.8e+007, 2.00), (5.3e+007, 2.00), (5.8e+007, 2.00),
  (6.2e+007, 2.00), (6.7e+007, 2.00), (7.2e+007, 2.00), (7.7e+007, 2.00), (8.2e+007, 2.00),
  (8.7e+007, 2.00), (9.2e+007, 3.00), (9.7e+007, 3.00), (1e+008, 3.00), (1.1e+008, 3.00),
  (1.1e+008, 3.00), (1.2e+008, 3.00), (1.2e+008, 3.00), (1.3e+008, 3.00), (1.3e+008, 3.00)
- **Cientificos_y_Tecnologos=** GRAPH(Programas_de_Educacion_Cientifica)
  (0.00, 0.00), (1.00, 7.00), (2.00, 14.0), (3.00, 21.0), (4.00, 29.0), (5.00, 40.0), (6.00, 48.0),
  (7.00, 56.0), (8.00, 64.0), (9.00, 72.0), (10.0, 80.0)
- **Competitividad** = GRAPH(Utilidades)
  (0.00, 0.00), (3.6e+007, 1.00), (7.1e+007, 2.00), (1.1e+008, 3.00), (1.4e+008, 4.00), (1.8e+008,
  6.00), (2.1e+008, 7.00), (2.5e+008, 8.00), (2.8e+008, 9.00), (3.2e+008, 10.0)
- **Escala** = GRAPH(Crecimiento_del_Cluster+Competitividad)
  (0.00, 0.05), (13.5, 0.7), (27.0, 1.80), (40.5, 2.80), (54.0, 3.80), (67.5, 5.05), (81.0, 6.05), (94.5,
  7.10), (108, 7.95), (122, 8.90), (135, 10.0)
- **Grado_de_inversion** = GRAPH(Atractividad+Nuevas_Firmas)
  (0.00, 0.125), (10.0, 1.75), (20.0, 3.38), (30.0, 5.63), (40.0, 7.13), (50.0, 9.25), (60.0, 12.4),
  (70.0, 14.8), (80.0, 17.9), (90.0, 21.0), (100, 25.0)
- **Patentes** = GRAPH(Proyectos_de_I&D)
  (0.00, 0.00), (10.0, 1.80), (20.0, 4.80), (30.0, 7.80), (40.0, 10.6), (50.0, 13.6), (60.0, 16.6),
  (70.0, 21.6), (80.0, 26.4), (90.0, 32.6), (100, 40.0)
- **Programas_de_Educacion_Cientifica** = GRAPH(Fondos_Gobierno)
  (3.8e+007, 2.00), (4.3e+007, 2.00), (4.8e+007, 3.00), (5.3e+007, 4.00), (5.8e+007, 4.00),
  (6.2e+007, 4.00), (6.7e+007, 4.00), (7.2e+007, 4.00), (7.7e+007, 5.00), (8.2e+007, 5.00),
  (8.7e+007, 5.00), (9.2e+007, 5.00), (9.7e+007, 5.00), (1e+008, 5.00), (1.1e+008, 6.00),
  (1.1e+008, 6.00), (1.2e+008, 6.00), (1.2e+008, 6.00), (1.3e+008, 7.00), (1.3e+008, 7.00)