Geographic Information System: The economic clusters of the Industrial Sector in Mexico.

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1. Introduction.

Mexico's Federal Secretariat of the Economy retained the services of the Socio-Economic Research Center of Coahuila Autonomous University to develop a Geographic Information System on the Economic Clusters of the industrial sector of the Mexican Republic.

What relationship exists between this project and the policies of industrial development deployed by Mexico's Federal Government?

Both the National Development Plan 2001-2006 (PND), and its corresponding Entrepreneurial Development Program (PDE), recognize the strategic importance of strengthening productive chains and value chains.

In the PND both value chains as well as economic clusters are concepts used to define the routes leading to two of the 5 objectives leading to quality economic growth: The increase and the extension of the country's competitiveness and the promotion of a balanced regional economic development.

Similarly, the success of at least two of the five strategies of the PDE (Linking to development and technological innovation as well as regional and sectorial structure and integration) are supported by value chains and economic clusters as they are by a third factor intimately related to the previous two: industrial sub-contracting.

There are powerful reasons for these relationships: Innovation, understood as the capacity to create, broadcast and apply knowledge to economic tasks has consolidated as a key factor of economic growth in today's world. Also, productive linkages, each day more numerous and more complex among individuals, companies and institutions that generate knowledge, have become the ideal way to develop the capacity to innovate. Relationships among economic factors which can be simultaneously local, national and international are more and more interweaved with the value chains generated by economic clusters (OCDE, 2001 a).

The approach retained by Mexico's Federal Government for the design of its policies of growth and of competitiveness responds to these new situations. From this point of view, the identification of the economic clusters of the Mexican economy, the availability of indicators about their performance and what is their presence in some of the most relevant regions are important supports for the execution of the above mentioned proposals of the PDE.

The orientation of these Mexican policies coincides with the recommendations that the OCDE made on their review of Mexico's territorial policies (Territorial Review on Mexico, 2002. Policy Brief) In fact, the development of the present System of Geographical Information responds to one of OCDE's specific recommendations: "...a national system of indicators must be established to monitor results and to fine-tune such policies" (Op. cit.)

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Concretely, the System pretends to contribute to answer five questions:

1. Which are the economic clusters existing in the industrial sector of Mexico’s economy?
2. How are their value chains integrated?
3. What has been their performance?
4. Where are they located?
5. How can opportunities for their development be identified?

2. Basic Characteristics of the Information System.

   Its first characteristic is the use of the most recent and most robust technical procedures for the identification of economic clusters in a given national economy. One of the authors of this methodology, Edward M. Bergman, coordinated one of OCDE's most recent publications on the subject (OCDE, 2001 a; Feser and Bergman, 2000)

   Besides its reliability, the System can generate short term results as its calls on available statistical sources (Economic Census and Mexico's National Accounts) For this same reason, the costs of applying this methodology are lower than in other cases.

   The System works with acceptable levels of sector detail (the 57 branches of economic activity of the industrial sector included in the System of National Accounts of Mexico) and can even display information at the finer level of class of economic activity of the Mexican Catalogue of Activities and Products (CMAP)

   This last aspect is relevant because besides facilitating the identification of the main actors of the clusters, it establishes an excellent sampling frame for the undertaking of more specific studies on the different operating characteristics of the clusters at the micro-economic level.

   Its capacity to produce result is also flexible for 4 different spaces: 1) The Republic of Mexico 2) The five mesoregions considered by the PND; 3) Mexico's 32 states as well as 4) Its 56 more populated metropolitan zones.

   Also, it can identify potential opportunities for development for clusters in any of the 4 geographical levels because the System makes possible:

1. The detailed identification of existing productive chains;
2. The analysis of the evolution of productive chains over time, facilitating the evaluation of the industrial promotion policies based on the strategy of strengthening industrial clusters, and;
3. The detection of opportunities to integrate new productive chains, to incorporate new links in existing chains or to increase local added value in existing links.

   It is convenient also to underline the great updating capacity, as it allows for the easy incorporation of the most recent statistical results of the Input-Output matrices, of the Economic Censuses and of the National Accounts System.

   All the above-mentioned advantages can be put to profit in a simple manner, as the program operation is practical and is managed in a general-use computing platform.
3. Composition of economic clusters of the industrial sector.

The determination of the branches of economic activity to include in each cluster is defined by the intensity of the commercial relationships among them. Such intensity is measured by an association coefficient whose value may vary between 0 (no linkage) and 1 (maximum linkage)\(^2\).

In order to be classified as an element of a cluster, the branch of economic activity must have an association coefficient with other elements of the cluster of 0.35 or more.

Three kind of branches may exist within a cluster:

1) Primary: Branches are classified as primary within the one cluster with which they reach their greatest association coefficient;
2) Secondary, yet strongly associated (coefficient greater than 0.5), and;
3) Secondary, weakly associated (coefficient within a range from 0.35 to 0.5).

Consequently, a branch can be primary in only one cluster. If they also have association coefficients like those of 2) and 3) above, a branch can also belong to other cluster or clusters.

As an example, figure 3.1 presents the composition of the cluster of Food Products (C 4).

This cluster is made up by 8 branches of economic activity; six of them are primary branches and 2 are secondary. The primary branches are: other food products (19), Preparations of fruits and legumes (12), bottled non-alcoholic beverages and bottled water (22), production of sugar (16), alcoholic beverages (20), and wheat milling (13).

The two secondary branches are edible fats and oils (17) and animal feeds (18). In both cases, their linkage to the cluster is weak.

Three branches of this cluster are also a part of cluster 12 (Animal Feeds): Branches 17 y 18, as primary branches and branch 13, as a secondary branch.

Only one of the 57 branches of the industrial sector of the System of National Accounts of Mexico (15 Processing of coffee cherries and coffee milling), did not reach the minimal criterion of participation to a cluster.

The other 56 branches were grouped into 12 clusters of the industrial sector of Mexico. Their names as well as their share in the value added and in the employment of the industrial sector are shown in figure 3.2.

\(^2\) For a greater detail, please consult the methodology notes at the end of this document.
Figure 3.1. Composition of the Cluster of Food Products (C 4)

<table>
<thead>
<tr>
<th>Ranura</th>
<th>Primaria</th>
<th>Secundaria Fuertemente Asociada</th>
<th>Secundaria Diblemente Asociada</th>
<th>Coeficiente de Asociación</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 Otros productos alimenticios</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>0.689</td>
</tr>
<tr>
<td>12 Preparación de frutas y legumbres</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>0.766</td>
</tr>
<tr>
<td>20 Piñones y aguacate</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>0.766</td>
</tr>
<tr>
<td>16 Azúcar</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>0.774</td>
</tr>
<tr>
<td>20 Bebidas alcohólicas</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>0.726</td>
</tr>
<tr>
<td>13 Miel de trigo</td>
<td>4</td>
<td>12</td>
<td>-</td>
<td>0.628</td>
</tr>
<tr>
<td>18 Alimentos para animales</td>
<td>12</td>
<td>-</td>
<td>4</td>
<td>0.416</td>
</tr>
<tr>
<td>17 Aceites y grasas comestibles</td>
<td>12</td>
<td>-</td>
<td>4</td>
<td>0.358</td>
</tr>
</tbody>
</table>

La pertenencia de las ranuras a un agrupamiento se determina por su coeficiente de asociación al interno, al cual debe alcanzar un valor mínimo de 0.35. Puede haber tres tipos de ranuras en un agrupamiento: 1) Primaria: Una ranura se clasifica como primaria del agrupamiento con el cual alcanza su coeficiente de asociación más alto. 2) Secundaria fuertemente asociada (coeficiente mayor a 0.53) y 3) Secundaria débilmente asociada (coeficiente ubicado en un rango de 0.35 x 0.53). Los números bajo las columnas correspondientes a las ranuras primarias y secundarias, corresponden a los códigos de cada uno de los 12 agrupamientos identificados. El descanso de las ranuras secundarias es una necesidad.
4. Value chains of economic clusters.

Thanks to the information of intermediate transactions of productive inputs, it is feasible to determine the links of the value chains of each and every cluster. As an example, we present the case of cluster 7 (Electronics and its parts)

This cluster is made up by four branches of economic activity of the electronic industry as well as by the one of production of plastic articles (42), glass and glass products (43) and other products of wood and cork (30).

The weight of these three last branches in the supply of parts and components to the cluster, makes them primary branches, even though they are related to other clusters (2, 3, 6 and 9)

Quite the contrary occurs with the manufacture of electric equipments and apparatuses (55), as well as with electric machinery and apparatuses (52) These branches are secondary within the cluster. In both cases their predominant association is with cluster 2. They are also important suppliers to the automotive industry and that is why both appear in such a cluster (1)
Economic activities linked to two or more clusters we call "hinges". This kind of activities, in the measure they can lead the birth of new clusters, are called to play an essential role in the regional strategies of productive diversification.

Branch 42 (plastic articles), provides parts and components to all other branches (Figure 4.1.)

**Figure 4.1.**

| Eslabones más importantes de la cadena de valor. |
| Agrupamiento 7: Electrónica y sus partes. |

Manufacture of electronic equipments and apparatuses (54), also plays a central role in this value chain. It sustains intermediate transactions with five other activities. Its interchange is bilateral with branches 55 (electrical equipments and apparatuses) and 43 (glass and glass products); it buys inputs from branch 30 (other wood and cork products) and from 42 (plastic articles); it supplies branch 52 (electrical machinery and apparatuses) and 53 (Home appliances)

From another point of view, the manufacture of electrical equipments and apparatuses (55) supplies three other branches of the electronic industry (52 to 54) and is supplied from branch 42 (plastic articles), branch 43 (glass products) and branch 54 (electronic equipments and apparatuses)

The manufacture of electrical machinery and apparatuses (52), acquires inputs from branches 42, 54 and 55, while it supplies the manufacture of home appliances.
This last branch buys from the productive chains of branches 42, 52, 54 and 55. The manufacture of glass and glass products, purchases inputs from branch 42 (plastic articles), while selling to branches 54 and 55.

Finally, the manufacture of other wood and cork products (30), supplies the branch of plastic articles (42) and purchases from the manufacturers of home appliances.

In the system, there is the option to consult input-output operations for each of the branches of the clusters. In figure 4.2, we show, the case of intermediate purchases made by the manufacture of home appliances (53) within this cluster.

**Figure 4.2. Intermediate Purchases of the branch of Home appliances (53) within the cluster of Electronics and its parts (C 7)**

5. Performance Indicators.

Also in figure 3.2., we can notice the global performance of each cluster in the totality of the Mexican economy. On this, information is provided with respect to their mean product, as well as on the average yearly growth rates of their three main components (value-added, employment and average product) Calculations are presented

These same indicators exist for each of the primary and secondary branches that make up each of the twelve clusters. Similarly, total values for the clusters are included as well as subtotals for primary and secondary branches.

On the national level, all the options mentioned above are available for the years 1988 to 2001 and there exists the flexibility for the user to set freely the desired initial and final years. These options are fed with data from Mexico’s National Accounts System. In figure 5.1., the data corresponding to the metal-mechanic and automotive clusters are shown.

**Figure 5.1. Performance Indicators, on the national level, of the metal-mechanic and automotive cluster (C 1)**

For the different sub-national spaces included in the System (Mesoregions, States and Metropolitan Zones) two techniques of regional economics are used to analyze available data:

1. Localization Coefficients, useful to identify the importance of a given economic activity in a given zone. A value above 1 indicates a strong
regional presence of the activity. Likewise, the contrary is indicated when its value is less than 1.

2. Change-Participation Analysis. This technique gives a retrospective vision of economic growth explained by three components: a) The dynamics of the National Economy; b) The national performance of the corresponding economic branch; and; c) The Regional competitiveness of the branch.\(^3\)

As an example, we can review the general performance of the value added in twelve clusters of Querétaro's Metropolitan Zone (Figure 5.2.) Five clusters of the industrial sector have an outstanding presence in this Zone: Metal-mechanic and automotive (C 1); Chemical Products (C 3); Food Products (C 4); Electronics and its parts (C 7), and; Inputs for the production of autoparts (C 9)

Figure 5.2. Metropolitan Zone of Querétaro: General Indicators of the performance of its industrial clusters. Value-Added. Period: 1993-1998.

The development of cluster 3 (Chemical Products), draws especially our attention. Supported by its competitive component, its added value grew at real rates of 23.7 per

\(^3\) The calculation procedures to determine the localization coefficients and the change-participation analysis are described in the Attachment on Methodology.
cent per year between 1993 and 1998 that made its localization coefficient pass from 1 to 1.5. Its primary and secondary branches generated 27.4 per cent of the Gross Internal Product of the industrial sector of this zone.

What was the behavior of the added value in each of the branches of this cluster? Data are shown in figure 5.3.

Figure 5.3. Metropolitan Zone of Querétaro. Performance Indicators of the branches of the Chemical Products cluster (C 3). Variable: added value. Period: 1993-1998.

To facilitate interpretation of the results, localization coefficients are shown in yellow if they are greater than 1. Also shown are the branches or clusters that have the best (shown in turquoise) or the worst (shown in red) performance in their competitiveness component.

On the other hand, there are diverse reporting options that to show data in graphs. Besides simplifying their observation, this allows for time comparisons and for the vision of trends in the evolution of the absolute values and the structures of variables under study.
In the case of the Federal District, the primary branches of clusters 1 (Metal-mechanic and Automotive), 2 (Non-Metallic Minerals and other Metal Products) and 7 (Electronics and its parts), have lost relative importance in the generation of jobs within the industrial sector. The reverse is observed in the clusters of Chemical Products (C 3), Food Products (C 4), Textiles (C 6) and Paper and Cardboard Products(C 8) (Figure 5.4.)


In all sub-national spaces (Mesorregions, States and Metropolitan Zones), the territorial localization of the industrial sector's clusters can be visualized. The System's visualizer generates maps in which each of the 5 mesoregions and each of the 32 states are shown.

In the same way, the System calculates the values of added value and of employment by mesoregion and by state. It also computes what is their share on the national total as well as the absolute values and accumulated percentages. All those operations can be carried out for each one of the 12 clusters and for the set of all twelve. It can also compute data for the primary and secondary branches or only for the primary ones.

The example shown in figure 6.1., corresponds to the Center-West Mesoregion.
As per the regionalization determined in the 2001-2006 PND, this mesoregion is composed by 9 states: Jalisco, Guanajuato, Querétaro, San Luis Potosí, Michoacán, Aguascalientes, Zacatecas, Nayarit and Colima.

Figure 6.1. Center-West Region. Level of regional employment in the 12 clusters of the industrial sector.

In the table on the central-right part of the window, data on employment by primary and secondary branches of the set of economic clusters of the industrial sector of that mesoregion are shown for 1998. Data corresponding to each state are also shown.

As can be seen on the buttons of the lower central mesoregion of the screen, we also have data for years 1988 and 1993.

In the case of the states, the different tones allow the graphic presentation of the different ranks reached by the states on the variables and options consulted. Also, the concentration of employment by state or the added value in each cluster or in the set of all clusters can be quickly identified.

In the case of the analysis at the state level, the program defines automatically the ranks of concentration of added value or of employment for each of the available options in the lower part of figure 6.2.

Also, under the buttons to manipulate maps, there is a small window in which concentration ranks from 0 to 100 can be defined. Once a rank is defined, the system will show in yellow and will attach tags to the states that have the specified level of concentration of the variable. This information is also displayed in one table. In both
cases, the program allows for options to export data.

Figure 6.2. States that concentrate 70 per cent of the added value of primary and secondary branches of cluster 3 (Chemical Products)

In the selected example are shown the states of Mexico that account for 70 per cent of the total added value of the primary and secondary branches of the Chemical Products cluster (C 3) They are the State of Mexico, the Federal District, Veracruz, Jalisco, Nuevo León and Tamaulipas.

The same options are available for the 56 most populated Metropolitan Zones of the country. 4

This option is presented in figure 6.3, that identifies the six metropolitan zones of the country that concentrate 50 per cent of the added value in the primary and secondary branches of the Metal-mechanic and Automotive cluster (C 1) In this group concur Mexico City, Monterrey, Puebla, Saltillo, Toluca and Ciudad Júarez.

The capability of breaking the basic numbers down to the level of class of economic activity of CMAP (Mexican Catalogue of Activities and Products), facilitates the detailed description of the productive tasks that the clusters carry out within each

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geographical level. This also facilitates the identification of individual actors within the clusters, and provides valuable elements for building sampling frames, which are indispensable to carry out micro-economic analyses of clusters (at the company level).

**Figure 6.3. Metropolitan Zones that concentrate 50 per cent of the value added generated in the primary and secondary branches of cluster 1 (Metal-mechanical and Automotive)**

As an example, figure 6.4. contains the employment and added value levels of some of the activity classes that make up the branches of cluster 7 (Electronics and its parts), as well as their corresponding shares in the industrial sector, in the Metropolitan Zone of Guadalajara, Jalisco.
7. Identification of development opportunities of the clusters.

The input-output transactions that the economic branches of the industrial sector sustain among themselves constitute a basic element for the articulation of economic clusters.

(Feser, E. 2000) proposes a typology that considers three types of clusters: 1) Existing; 2) Emerging, and; 3) Potential. In the first type are considered those clusters that have reached an important critical mass, both in terms of their absolute dimensions as in terms of their diversification. The second type is that of clusters that, by their dynamism, may reach the critical mass. Finally, in the third type are those clusters for which development opportunities have been identified but their chances of emerging are uncertain.

Once the existing and emerging clusters have been identified at the different territorial levels, it is possible to outline strategies to strengthen them by developing their productive chains.
Recording of the links of the value chain of each cluster, as well as comparing the national and local structures of each cluster, the methodology adopted by this study allows for the identification of theoretical opportunities of local or regional development of productive chains.

The transformation of theoretical opportunities unto tangible opportunities, depends of additional factors among which the following ones outstand:

1. The local allocation of productive factors and/or the capacity of attracting them from other regions of the country or of the world;
2. That the optimal scale of operations of the productive processes and the dimensions of the potential markets make viable establishing an additional productive in the zone, and;
3. That the industrial, urban and logistic requirements for the operation of an additional productive unit can be provided.

The detection of opportunities for enlarging value chains is done by putting the sector structures of clusters in contrast. The whole Mexican economy constitutes the point of reference and the variables to analyze are employment and added value.

Using added value, figure 7.1., visualizes the potential for development of the cluster of Electronics and its parts (A 7), in the Metropolitan Zone of Monterrey.

Only two of the seven branches than make up this cluster are under-represented in this industrial Metropolitan Zone of North-Eastern Mexico. For that very reason, there is a potential to have the local productive chains reach new heights. In the two cases, they are primary branches of this cluster.

Additionally, the system points out the ranges of average product (High -A--; Medium -M-, and; Low -B-) of the branches that make up the clusters. Also, if we select the variable "employment" the system displays information on the ranges of value of fixed assets per person at work.
Figure 7.1. Monterrey Metropolitan Zone. Development Opportunities of the cluster Electronics at its parts (C 7)
Methodology Notes:

I. Procedure to determine the composition of industrial clusters.

1. Information is used on input-output transactions of the different branches of economic activity available from the input-output matrices.
2. The branches that make up each cluster are defined by the intensity of the businesses linkages, as measured by an association coefficient. To these ends a multi-variate statistical analysis technique called Method of Main Components is used.
3. Then the presence of each cluster in any desired territorial level (Country, Mesoregion, State, Metropolitan Zone, etc.) is quantified. This method was developed by Edward J. Feser and Edward M. Bergman, in a paper published in the year 2000: “National Industry Cluster Templates: A Framework for Applied Regional Cluster Analysis”, *Regional Studies*, Vol. 34-I, pp.1-19.
4. The Association Coefficient may vary between 0 and 1, 1 indicating maximum association.
5. There may be three types of branches within each cluster:
6. Primary. Each branch is a primary branch of the cluster with which it has the largest association coefficient;
7. Secondary, strongly associated. These are branches whose association coefficient is greater than 0.5, and;
8. Secondary weakly associated. These are branches whose association coefficients are greater than 0.35 but less than 0.5.
9. Each branch can be primary to only one cluster but it can be secondary to one or more.

The association coefficients of branches to different clusters, are estimated by a statistical analysis of main components with varimax rotation. The twelve factors identified by the method of main components, explain 85 per cent of the variations in the matrix's data.

The input-output relationship of intermediate consumption between industries “$i$” and “$j$”, can be expressed by four coefficients:

$$a_{ij} = \frac{x_{ij}}{c_j} ; \quad a_{ji} = \frac{x_{ji}}{c_i} ; \quad b_{ij} = \frac{y_{ij}}{v_i} ; \quad b_{ji} = \frac{y_{ji}}{v_j}$$

Where:

$x_{ij}$ = Value of the purchases of intermediate inputs of industry “$j$” from industry “$i$”.

$c_j$ = Value of the total purchases of intermediate inputs of industry “$j$”.

$x_{ji}$ = Value of the purchases of intermediate inputs of industry “$i$” from industry “$j$”.

$c_i$ = Value of the total purchases of intermediate inputs of industry “$i$”.

$y_{ij}$ = Value of sales of intermediate inputs of industry “$i$” to industry “$j$”.
\( v_i \) = Value of total sales of intermediate inputs of industry “\( i \)”.

\( y_{ji} \) = Value of sales of intermediate inputs of industry “\( j \)” to industry “\( i \)”.

\( v_j \) = Value of total sales of intermediate inputs of industry “\( j \)”.

The first step is the calculation of the 4 coefficients for every pair of industries. In the case of Mexico, the input-output matrix is made up of 72 sectors of economic activity, of which 57 make up the industrial sector. Consequently, four matrices of 57 lines by 57 columns are obtained, one for each type of coefficient.

Then the correlation matrices are calculated for each of the four coefficient matrices defined in the first step. This allows to establish the linkages between the \( nxn \) pairs of industries.

From the four correlation matrices the coefficient with the greatest value for each pair of industries is selected. This permits to obtain one mixed matrix of 57 by 57, to which, as a last step, the main component analysis is applied.

II. Information on intermediate consumption.

Obtained from the matrix of inter-sector flows of the Mexican Economy for the year 1996, estimated by Consultoría Internacional Especializada, S.A. de C.V. and available in the software package \textit{STATA-MATRIX}, version 2.0.

III. Variables analyzed.

The behavior of three variables is analyzed: employment, added value and average product. The source of information are the Economic Censuses from INEGI for years 1989, 1994 and 1999, which provide data for years 1988, 1993 and 1998.

IV. Analysis Techniques used.

Information is analyzed using two techniques of regional economics:

1. Localization coefficients. These coefficients are useful for identifying the importance of a given economic activity in a given zone. When the value of the coefficient is greater than 1 it indicates a strong regional presence of the activity. The contrary happens when the value is smaller than one.

2. Change-Participation analysis. This technique gives a retrospective vision of economic growth, which is considered as made up of three components: a) The dynamics of the national economy; b) the national performance of the corresponding branch, and; c) the regional competitiveness of the branch.
V. Delimitation of Metropolitan Zones.

To define the most important economic zones of Mexico, we adopted the criteria established by Mexico’s National Population Council (CONAPO) for the construction of the Demographic Atlas of Mexico (Atlas Demográfico de México) (Gustavo Garza, 1999). These criteria were adjusted in the year 2000 by Luis Jaime Sobrino, in coordination with Gustavo Garza, both by cartographic observation and by the analysis of the demographic dynamics of the border municipalities of the metropolitan zones in 1995. Population data correspond to the Twelfth General Census of population and Dwelling (XII Censo General de Población y Vivienda, México, 2000) (INEGI, 2001).
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