

# **Manufacturing Clusters in Functional Economic North-Central Region of Mexico: A spatial approach using input-output analysis.<sup>1</sup>**

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## **Abstract**

Regional analysis using an input-output table is an important tool for the understanding of regional economies. Nevertheless, they are based on political and administrative units - municipalities and states -. This fact does not allow understanding and knowing the economic spatial behavior of the region, which is the essence of economic regions performance. Therefore, spatial economic interactions between places or sites are not revealed, so the economic region is seen as a whole, without a precise spatial economic behavior. In addition, cluster analysis has been done, mainly from a sectorial and aggregate level, leaving aside their inherent spatial bases, so economic policy predictions and solutions are straightforward simple and reductionist, lacking of the essence of their economic behavior, which relies on spatial components. Furthermore, the way in which the regional input-output table is traditionally constructed, come from a national input-output matrix, reinforcing a homogeneous and a-spatial view of the region.

Therefore this essay is oriented to identify and analyze manufacturing clusters in a region, based on its economic functional structure and performance, by constructing in a first stage an interaction probabilistic index which reveals the existence of productive chains, complemented with spatial econometrics in order to validate the spatial economic dependence of the industry in the region. Then, as a second stage it is going to be constructed a regional input-output matrix from bottom to the top taking into account information from the national input-output table. Then, it will be analyzed its spatial representation and main economic and social impacts through different linkages index and multiplier analysis.

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It is worth to mention, that the estimation of the regional matrix will be based on identification and characterization of the economic and functional regional performance and its main manufacturing clusters, taking into account the National account system, state accounts and available information.

Finally, we will spell out the sectorial-spatial interactions as a result of cluster linkages, which reveal the productive structure spatially by pointing out the locations of production and consumption of the main manufacturing chains of the region and their main economic and social impacts.

**Keywords:** industrial activities, regional input-output matrix, production linkages, spatial dimension of economy.

## **Introduction**

The purpose of this paper is to show the analysis and methodology of a spatial approach of regional input-output for the analysis and construction of regional matrices from bottom-up supplemented with national matrix, which allow us to detect industrial clusters at regional level and its spatialization, besides being able to identify spatially within the region the location of economic activity and the formation of economic sites and their spatial interactions and impacts on economic and social development of regions. The importance of this work comes from the paradox that traditional economic analysis of regions is essentially based on indirect methods and techniques that provide an approximate and probabilistic knowledge of the regional economic interactions (See Asuad 2001). Moreover, the construction and analysis of regional input-output matrices is based largely on estimates coming from national matrices, justification of this, is the lack of adequate and sufficient information to build regional input-output matrices. However, the result is approximate, since adjustments are based on estimates from national input-output matrix, Miller and Blair (1985), which in aggregate presents information of the region without “specify the characteristics that distinguish it”. The regional input-output matrix is considered as a subdivision of the national input-output matrix (Fuentes, 2003)<sup>5</sup>. In addition, it is considered as a

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<sup>5</sup> The first applications of regional input matrix product was performed by Walter Isard (1951), Kuenne and Isard (1953), Leotief (1955), Chenery (1953), Moses (1955), Miller (1957), the reworkings of Leotief and Strout (1963), Morrison and Smith (1974), Round (1983) and Richardson (1985) for more information (see (Dávila, 2002) and (Fuentes and Brugués, 2001)). More recent studies correspond to Hewings and Jansen (1986), Anselin (1988) and Flegg, Webber and Elliott (1995 and 1996). Recent studies in the case of Mexico have been prepared by Aroche (2012), Bouchain (1999, 2001), Albornoz (2012), Soto (2000, 2001), Davila (2002), Chapa (2009) and Fuentes (2001, 2003, 2009 and 2010).

methodology to analyze the impacts on individual sectors of the region through changes in national economic policy. (Chapa et. Al., 2009).

So statistical methods are frequently used for constructing input-output regional matrices due to insufficient statistical data being that they enable the adjustment of regional coefficients according to the national matrix, further they provide insight into the cost structure of the region and determine the weight of local or external origin inputs in the production of certain sectors (Fuentes, 2003).

According to Chapa et. al. (2009), there are three main methods to build a regional input-output matrix: 1. Techniques based on surveys (survey techniques) - procedures expensive in time, and resources; 2. Non-survey techniques (non survey techniques), of which include the method of regional weighting coefficients, simple location coefficients (SLQ), location coefficients between industries (CILQ)<sup>6</sup> and the proposed location coefficients, highlighting among others those of Flegg (FLQ) and increased Flegg correction of these coefficients (AFQL) and 3. Hybrid Techniques or partly based on surveys (hybrid or partial survey techniques), highlighting the RAS method, entropy and GRIT.

These procedures are commonly used, because the methods based on regional surveys to collect information and build matrices are very expensive. However, differences in information and characteristics of national and regional input-output matrices, question its effectiveness. According to Miller and Blair (1985), these differences are related to trade and technology. In the case of regional trade, it should be take into account not only imports and exports with other countries, but also the purchase and sales between regions within the country, while the technology at national level is considered as an average of the country, which generally differs from sub national regions.

In addition to the limitations mentioned above, an essential aspect that contributes to the lack of precise knowledge of regional economy is the identification and delimitation of regions in which the national economy is divided. Generally, aggregate states are regarded as spatial units, it means political administrative units, which further limits the understanding of the economy of regions and their sectoral and spatial interactions. Although literature of the regional economy

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<sup>6</sup> In indirect estimation of input-output coefficients have made methodological comparisons between indirect calculations (non survey) and direct information: Czamaski and Malizia (1967), Schaffer and Chu (1969), Smith and Morrison (1974) and Harrigan, McGilvray and McNicoll (1981) However, Jensen et. al. (1980) notes that the method of comparison is limited by being compared unknown accuracy matrices.

consider analysis of economic interaction of regions through the approach of functional economic areas, which are characterized by identifying the spatial structure, its components, while their interactions are analyzed. However, this analysis is approximate and probabilistic.

Hence the need to seek indirect and hybrid methods that from a regional perspective, contribute to have a precise and accurate knowledge of economic and social performance of regions at different spatial scales, which would result in alternative methodologies for development of input-output regional matrices, from a spatial perspective, identifying the functional economic spatial units within each, complemented for missing information with data provided by the national input-output matrix.

Thus we seek to develop a spatial approach of regional input-output analysis and its methodology through the focus of economic concentration under the approach of the spatial dimension of the economy (Asuad 2014 and 2007a).<sup>7</sup>

To do this, it is taken as a study case the industrial activity in the North Central economic region of the country, which is functionally identified and delimited through economic interactions between economic sites that make up the region, building a probabilistic index of economic interactions (Asuad et al 2007b). Subsequently, regionally dominant existing industrial production chains are identified, including the automotive industry and other important chains like food industry and beverages among others, which is compared to the aggregate national production chain according to the 2008 input-output matrix, analyzing economic specialization of the links in production chain of industrial main branches considering the economic sites that make up the region.

In a second stage, from the interactions of industrial activities in the north central region and considering the national matrix, the matrix of the north central region is constructed, using the method of Flegg, Webber and Elliot (1995,1996) ; then through the analysis of the regional matrix, spatial linkages and interactions of auto industry between economic sites that make up the region are analyzed.

It should be noted that the commercial activity of the region and thus exports and imports, are obtained as a residue, which in turn is comprised of exports from the region to other regions and abroad. In the case of technology, analysis and

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<sup>7</sup> See, The approach of the spatial dimension of the economy, pp. 312-319, in Economic thought and space (2014), Normand Eduardo Asuad Sanen, FE-UNAM.

identification of key sectors of the regional economic activity and its breakdown to four digits, that is a branch of economic activity allow us to differentiate and particularize the technical coefficients of these branches and its difference with other sectors comprising the economy of the region. Finally it is important to clarify that this paper shows the first steps of a preliminary methodology for the construction of regional matrices for Mexico from the perspective of spatial dimension of the economy, later to be expanded as part of our research agenda in the topic, so their results are exploratory and preliminary.

## **2. Interpretation, methodology and techniques used**

According to the theoretical approach of economic concentration under the spatial dimension of the economy, it is considered that the economic concentration in space causes the formation of economic spatial units that determine and characterize the structure and functioning of the economy in space. Generically, these spatial units are called functional economic regions as a result of economic growth and economic and social development in space.

So that to identify and delimit the national geographical space we define them as functional geo-economic regions.

The economic growth in national space is not homogeneous and bounded in administrative political entities, states or municipalities. Rather it is characterized by giving rise to the formation of nodes of economic activity in a few geographical areas within states and municipalities, they economically interact with each other resulting production, exchange and consumption among them.

An economic node is defined as a place in economic space occupied by a dominant economic site, whose main characteristic is to link a number of economic sites that connect and compete. An Economic site comprises the geographical location where economic activity is concentrated and carried out, in which economic actors, produce, exchange and consume goods and services.

The nodes constitute spatial economic units within the national space, which is characterized by high economic and population density. They perform functionally as market areas, which concentrate consumption and production at the same time, they integrate a set of economic activities in its area of influence, so that flows of economic activity between them are established.

The economic importance of the nodes depends on the economic interaction that take place between them, which depends on their type of linkage and complementary market relationship, connection and / or competition.

Their interactions shape, if they are of national significance, sub economic national spaces. Economic interactions between economic sites give place to the creation of economic space, which consists on the ensemble of economic sites and interactions between them in a given geographical area. The creation of an economic space requires as a condition of existence at least a couple of economic sites.

Obviously, the economic space they do, does not match with the political space consisting of states and municipalities. Moreover, the political space does not determine the economic space, even though it influences in their behavior for their political attributions and the allocation of resources and economic development, but do not lead the development process of subnational economies in the country, economic performance and how the market is spatially structured.

The main category of the approach of the spatial dimension of the economy is the economic space and the categories are derived are territorial and economic region.

The interactions of subnational economies of the country are a result of market transactions, characterized by sectoral economic performance and its synergy with the natural environment in the various geographical areas of the country, leading to the formation of economic space, which territorially are configured for its cities system and transportation networks .

The methodology consists of the following stages: 1. Identification of the nodes of spatial economic concentration and hierarchy in the context of the natural space and its barriers; 2. Analysis of transport networks, considering origin and destination; 3. Identification and delineation of functional economic space units; 4. Probabilistic analysis of interactions; 5. Regionalization of input-output matrix; 6. Analysis of linkage and spatial interactions in the automotive industry between sites in the region.

### 2.2.1 Techniques and Methodologies to identify functional regions.

The identification and delimitation of functional economic regions is performed by two steps, first nodes are identified by simple participation rates and economic specialization, characterizing them by their economic and demographic figures, delimiting its area of influence through the transport network linking nodes and applying the Reilly index<sup>8</sup> to delineate areas of influence between nodes.

For the probabilistic index of economic interactions between sites it is determined by statistical association between a couple of sites. It is calculated using the statistical correlation coefficient for a series, subsequently calculating cross weights matrices, transforming the correlation coefficient into an interaction index according to the following formulation.

S is a vector economic sites  $S = (s_1, s_2, \dots, s_n)$  with n as total in a given region.

A =  $(a_{kl})$  is the economic activities matrix with  $k=1, \dots, m$  sectors of economic

activity and  $l=1, \dots, n+1$ , with  $m > n$  and being  $a_{kn+1} = \sum_{l=1}^n a_{kl}$  for all k.

R =  $(r_{ij})$  is  $n \times n$  matrix

We define R as the partial correlation matrix between different sites  $s_j$ , where the calculation of partial correlation coefficients of Pearson  $(r_{ij})$  is performed through the matrix A as follows:

$$R = \left( \frac{\hat{\beta}_2 \sum a_{1p} a_{2p} + \hat{\beta}_3 \sum a_{1p} a_{3p} + \hat{\beta}_4 \sum a_{1p} a_{4p} + \dots + \hat{\beta}_n \sum a_{1p} a_{np}}{\sum a_{1p}^2} \right)^{1/2}$$

Where  $\alpha$  and  $\beta$  are coefficients estimated by OLS (Ordinary Least Squares). According to the definition of partial Pearson correlation  $r_{ij} = r_{ji}$  then R is a symmetric matrix as follows:

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<sup>8</sup> Reilly index, which establishes the inverse relationship between scale and distance, as shown below  
 $BP = \frac{Pa+Pb}{\sqrt{2(Da+Db)}}$ , BP = Breaking Point, Pa = Population in site a, Pb = Population in site b, Da = Distance to site a, Db = Distance to site b

$$R = \begin{pmatrix} 1 & r_{12} & r_{13} & \cdots & r_{1n} \\ r_{21} & 1 & r_{23} & \cdots & r_{2n} \\ r_{31} & r_{32} & 1 & \cdots & r_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & r_{n3} & \cdots & 1 \end{pmatrix}$$

And so it is clear that  $r_{ii} = 1$  for all  $i$ .

Now let  $\mathbf{A}' = (a'_{kl})$  matrix' scores' or scores arising from A, containing such shares for each site  $s_j$  in each activity  $a_{kl}$  that is:

$$a'_{kl} = \frac{a_{kl}}{a_{kn+1}} \text{ for all } k$$

It is then  $a'_{m+1l} = \frac{\sum_{k=1}^m a'_{kl}}{m}$  for all  $l$ , with  $a'_{m+1l} = \text{pond}_l$  this is, defined as the total weight for each site  $s_j$ .

$P = (p_{ij})$  is a  $n \times n$  matrix, called matrix P of cross weight and is defined as follows:

$$P_{ij} = \text{pond}_i * \text{pond}_j \text{ for all } i \text{ and for all } j$$

This is, there are 'cross' total weight of sites  $s_i$  y  $s_j$  having as a result the cross weightes  $P_{ij}$ . It is clear that  $p_{ij} = p_{ji} \Rightarrow P$  is a symmetric matrix

Then, there exist interaction between pair of sites  $i, j$  for all  $i, j$  given by the economic relation between different sites  $s_j$ .

We have now:

$$e_{ij} = r_{ij} * p_{ij}$$

It means:



$$\begin{pmatrix} e_{11} & \cdots & e_{1n} \\ \vdots & \ddots & \vdots \\ e_{n1} & \cdots & e_{nn} \end{pmatrix} = \begin{pmatrix} r_{11} * p_{11} & \cdots & r_{1n} * p_{1n} \\ \vdots & \ddots & \vdots \\ r_{n1} * p_{n1} & \cdots & r_{nn} * p_{nn} \end{pmatrix}$$

Therefore it is through multiplication element by element of R and P that  $e_{ij}$  is defined. Finally, let E be a matrix of  $n \times n$  called economic interaction index, defined below:

$E=(e_{ij}^*)$ , donde:

$$e_{ij}^* = \begin{cases} \frac{e_{ij} - \text{Min}(e_{ij})}{\text{Max}(e_{ij}) - \text{Min}(e_{ij})} & \text{si } i \neq j \\ 1 & \text{si } i = j \end{cases}$$

So  $e_{ij}^* \in [0,1]$  and is called economic interaction index between pair of sites  $i,j$ . Here it is worth noting that E is also a symmetric matrix.

## 2.2.2 Regionalization of the input-output matrix

The regionalization of the input-output matrix, take as a starting point the north central region and the dominant sites whose performance results in economic interactions that determines its production structure. Within these interactions chain of the automotive industry in the region was analyzed, identifying the location and economic specialization<sup>9</sup> of the sites on the links in the production chain of the automotive industry.

Subsequently, from national input-output matrix of 2008, it was estimated the north central region matrix, using the method of Flegg, since this technique allows to consider the relative size of seller sectors and specialization of regions.

Flegg method takes into account two important deficiencies in the method of coefficients of specialization: 1. overestimating of regional multipliers ignoring the

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<sup>9</sup> It is measured by the share of activity n in all activities of the site i, with respect to the participation of the activity

$$Ien_i = \left( \frac{n_i}{z_i} \right) \left( \frac{n_r}{z_r} \right)$$

n of the region in their total activities, at time t, which is denoted as: where n is the economic activity of the site i and  $Z_i$ , the total activity on the site i, between economic activity n in the region r divides the total economic activity of r. If result is equal to the unit (1) it specializes in that activity.

relative size of the sectors of supply and purchase, and 2. Estimation errors deriving from inadequate aggregation, see Chapa (2009) and Soto (2000) and Flegg, Webber and Elliot (1995 and 1996), Davila (2002). Then the estimation procedure is as follows:

1. National input-output matrix 2008 and industrial, commercial and service census for 2008 are considered, being official source of data the National Institute of Statistics and Geography INEGI.
2. The sectors that are not significant for the region and are present in the national matrix are eliminated, considering two criteria: 1. If the buying and selling values are zero, especially the value of the diagonal, and 2. If there are sectors that have no relevance in the North Central region.
3. Proportion of total employment in the North Central region compared with total national employment is calculated, and is represented as follows  $E_t^r/E_t^n$  where E represents employment, r the region value, n the national value and t total sectors. From the quotient presented, scalar  $\lambda^\beta$  is calculated, which in the case of north central region is 0.72

$$\lambda = \log_2 \left( 1 + \left( \frac{E_t^r}{E_t^n} \right) \right)$$

$$\lambda^\beta = \log_2 \left( 1 + \left( \frac{E_t^r}{E_t^n} \right) \right)^\delta$$

According to Weber and Flegg a value  $\delta=0.3$  minimize the differences between multipliers obtained between the interindustrial location coefficients and the ones calculated through direct observation, however according to Tohmo (2004) for the value of  $\delta$  the following formula is used:

$$\delta = \frac{\log \left[ \left( \frac{E_t^r}{E_t^n} \right) / \left\{ \log_2 \left( 1 + \left( \frac{E_t^r}{E_t^n} \right) \right) \right\} \right]}{\log \left[ \log_2 \left( 1 + \left( \frac{E_t^r}{E_t^n} \right) \right) \right]}$$

The resulting value of the formula  $\lambda$  increases monotonically as the size of the region becomes larger, ie to the extent that the region is larger, the value of  $\lambda$  will be larger without it happen otherwise.

4. Interindustrial location coefficients (CILQ<sub>ij</sub>) and simple location coefficient (SLQ<sub>i</sub>) is calculated, when i = j the resulting value will be equal to 1 in this case the formula does not take into account the relative size of the regional industry as far as along the main diagonal as follows:

$$CILQ_{ij} = \frac{E_i^r / E_i^n}{E_j^r / E_j^n}$$

$$SLQ_i = \frac{E_i^r / E_t^r}{E_i^n / E_t^n}$$

Where E represents employment, r = region value, n = national value, t = total sector value, i = selling industry, j = buyer industry.

The rational use of this coefficient is examined in Richardson (1972), Round (1978) and Flegg, Weber and Elliot, which is interpreted as follows:

If  $CILQ_{ij} > 1$ , then input requirements i by industry j can be obtained within the region.

Si  $CILQ_{ij} < 1$ , then some input requirements i by industry j will have to be imported.

This coefficient is defined as the ratio between the proportions of regional and national employment attributable to a particular sector. We then calculate the FLQ<sub>ij</sub> An interesting proposal by Flegg, Webber and Elliot (1995) suggests a modification of FLQ multiplying so that these three variables are captured as follows:

$$FLQ_{ij} = CILQ_{ij} \times \lambda_r^\beta$$

Dónde,  $FLQ_{ij}$  = Flegg Coefficient et al.,

$CILQ_{ij}$  = Interindustrial location coefficients

$\lambda_r^\beta$  = weighing coefficient of relative size of the region

With  $FLQ_{ij}$ ,  $t_{ij}$  are calculated according to the next condition:

$$\text{Si } FLQ_{ij} \geq 1 \therefore t_{ij} = 1$$

$$\text{Si } FLQ_{ij} < 1 \therefore t_{ij} = FLQ_{ij}$$

From these coefficients regional trade coefficients are obtained  $r_{ij}$  :

$$r_{ij} = t_{ij} * a_{ij}$$

According to sectoral aggregation, Flegg et al. (1995), mention that if the sector aggregation is done before regionalization, we resort to additional bias error, which must be obtained coefficients regional trade after (Davila, 2002, Nuñez and Cruz, 2009).

5. For cross flow matrix we proceed as follows:

$$VA_{ij} = r_{ij} * PBT_j$$

Where:

$VA_{ij}$ =Value added of economic activities

$r_{ij}$ = Regional trade coefficient

$PBT_j$ = Gross value of production or the total gross production.

The backward effects measure the proportion of inputs per unit of output of sector j. They are obtained from the technical coefficient matrix as follows:

$$IS_j = \frac{\sum_{i=1}^n z_{ij}}{X_j} = \sum_i^n a_{ij}$$

To calculate the effects of forward simple interdependence the following formula is used:

$$IS_j = \frac{\sum_{i=1}^n z_{ij}}{X_i}$$

This index indicates when it approaches zero that as input for other sectors, is most poorly required and when the value tends to one it indicates that the entire production is required as input for the other sectors.

In calculating the effects of total interdependence is made from the input inverse matrix product which is designated as  $rij$ . Which are classified according to their

forward and backward impacts. Total forward interdependence effects can be interpreted as follows:

$$R_j = \sum_{i=1}^n r_{ij}$$

This is interpreted as the total increase in the production of all sectors that is needed with a unit increase in final demand of sector j.

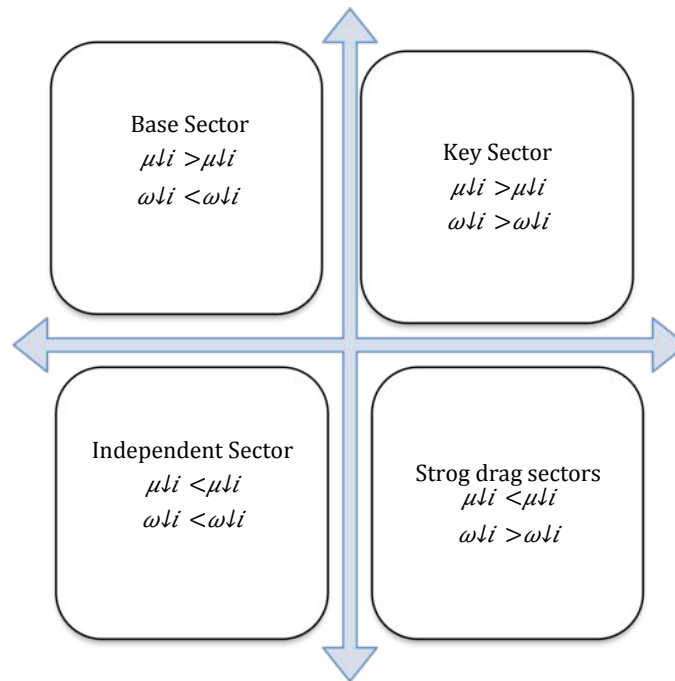
As for the effects of total forward interdependence, these are interpreted as the increase in production in the sector i which is required to deal with a unit increase in final demand of all sectors simultaneously.

$$R_i = \sum_{j=1}^n r_{ij}$$

Through the input-output matrix of North Central region there were used different rates, among them the one of Chenery and Watanabe, 1958, who conducted a classification of linkages, whose effects are above average and are classified as below:

- Base sectors , referring to industrial activities with high forward linkages and low backward linkages,
- Key sectors refers to economic activities with strong forward and backward linkages
- Sectors of strong drag, refers to activities with low forward linkages and high backward linkages
- Independent sectors are activities with low backward and forward linkages.

**Figure 1. Clasification of sectorial linkages**



(Chenery y Watenabe, 1958) define  $\mu_i$  y  $\omega_j$  index:

$$\mu_i = \sum_j z_{ij} / Z_j \qquad \omega_j = \sum_i z_{ij} / Z_i$$

Where  $Z_i$  and  $Z_j$  are respectively, the actual production of branch  $j$  and the total output of the  $i$ . Also  $z_{ij}$  is use the branch  $j$  makes of intermediate inputs of the industry  $i$ .

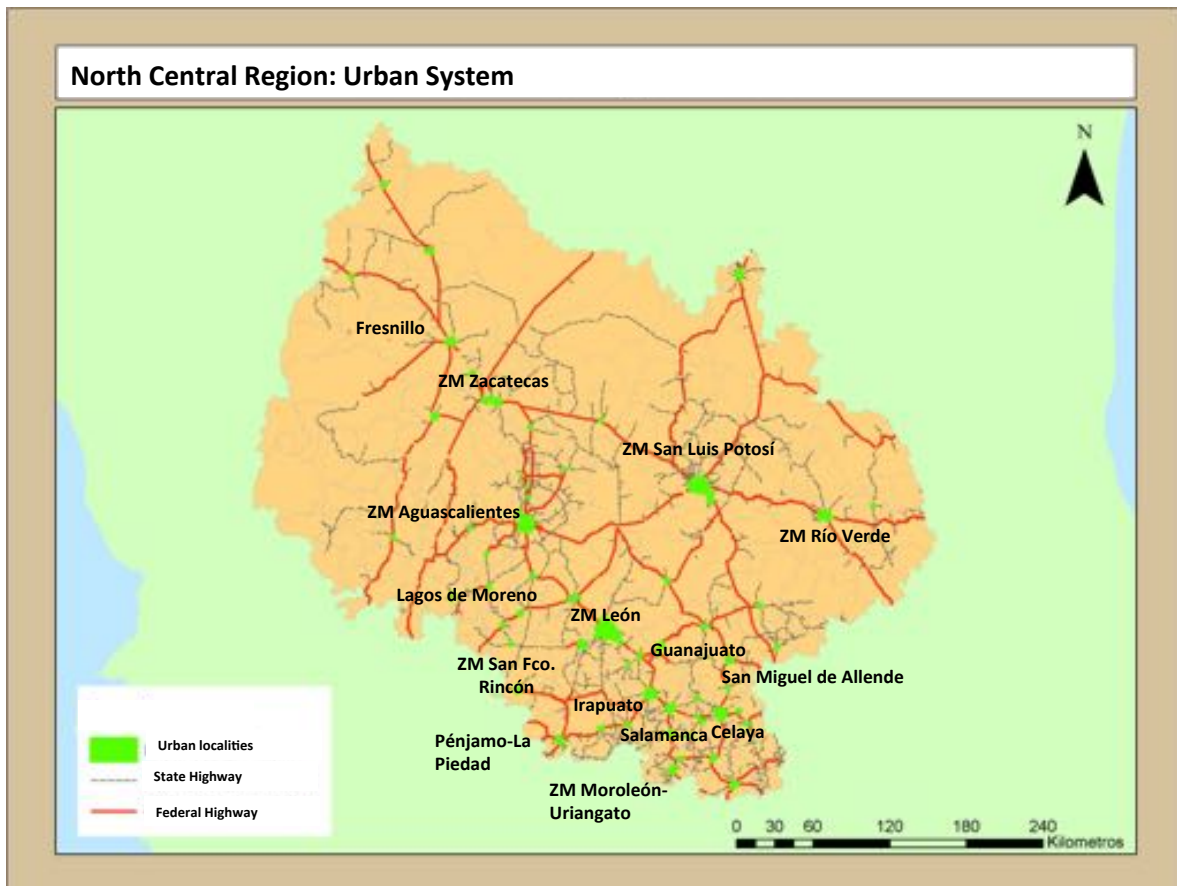
### 3. North Central Region and industrial activity<sup>10</sup>

The functional north central economic region is made up of 175 municipalities in the states of Aguascalientes, San Luis Potosí, Guanajuato and Jalisco, located in

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<sup>10</sup> This part of the article was prepared based on the following work: Vazquez, RC (2010). Functional economic regionalization. North Central Region of Mexico. 1994-2004. A case of spatial approach of economy using Geographic Information Systems (GIS's). Thesis (BA in Economics), Mexico City: Faculty of Economics, UNAM. 311 p. Vazquez, R. C. (2013). Industrial economic concentration and the formation of industrial functional areas in the north central region of Mexico. 1998-2008. Thesis (Master on Urban and Regional Economy), Mexico City: Faculty of Economics, National Autonomous University of Mexico.

the north and central area of Mexico. According to the analysis of economic and population concentration the regional urban system is made up of 15 key nodes which together make 84% of the value added, 78% of employment and 63% of the population according to 2008 data. In this urban system there must be highlighted the MZ (metropolitan zone) of Leon, San Luis Potosí and Aguascalientes because of its hierarchy.<sup>11</sup>



Source: CEDRUS with information from INEGI

The economic base of the dominant nodes is analyzed by calculating the specialization node, which according to the table below is shown how the three major population-economic levels, Leon, San Luis Potosí and Aguascalientes, have complementarity; as both San Luis Potosi and Aguascalientes have industrial specialization, while Leon, the main center of economic concentration, is

<sup>11</sup> The database used with the variables used corresponds to the municipal level of economic censuses, grouping for the characterization of the nodes, in the event that these are characterized by serving as metropolitan areas. In the case of cities, they were considered, assuming the value of the municipality of these activities are concentrated in the main urban area after taking into account the weight and distribution of the population employed in these sectors.

specialized in the trade and service sector, working as a supplier of advanced services such as financial and professional services, which requires industrial activity.

<b>North Central Region: Urban System</b>			
	<b>Industry</b>	<b>Trade</b>	<b>Service</b>
<b>ZM de León</b>	0.85	1.12	1.35
<b>ZM San Luis Potosí</b>	1.10	0.82	0.84
<b>ZM de Aguascalientes</b>	1.13	0.91	0.70
<b>Celaya</b>	1.00	1.10	0.92
<b>Guanajuato</b>	0.94	0.35	1.64
<b>Irapuato</b>	1.06	1.35	0.56
<b>ZM de Zacatecas-Guadalupe</b>	0.50	2.38	1.39
<b>Salamanca</b>	1.38	0.50	0.30
<b>ZM de La Piedad-Pénjamo</b>	0.59	2.17	1.29
<b>Fresnillo</b>	1.30	0.77	0.32
<b>San Miguel de Allende</b>	0.60	1.96	1.41
<b>ZM de San Francisco del Rincón</b>	1.10	1.27	0.51
<b>ZM de Rioverde-Ciudad Fdz.</b>	0.31	3.08	1.41
<b>ZM de Moroleón-Uriangato</b>	0.48	3.25	0.80
<b>Lagos de Moreno</b>	1.32	0.79	0.26
<b>Urban System</b>	1.03	1.01	0.91

\*In blue index > 1 = especialization

\*Specialization calculated with value added

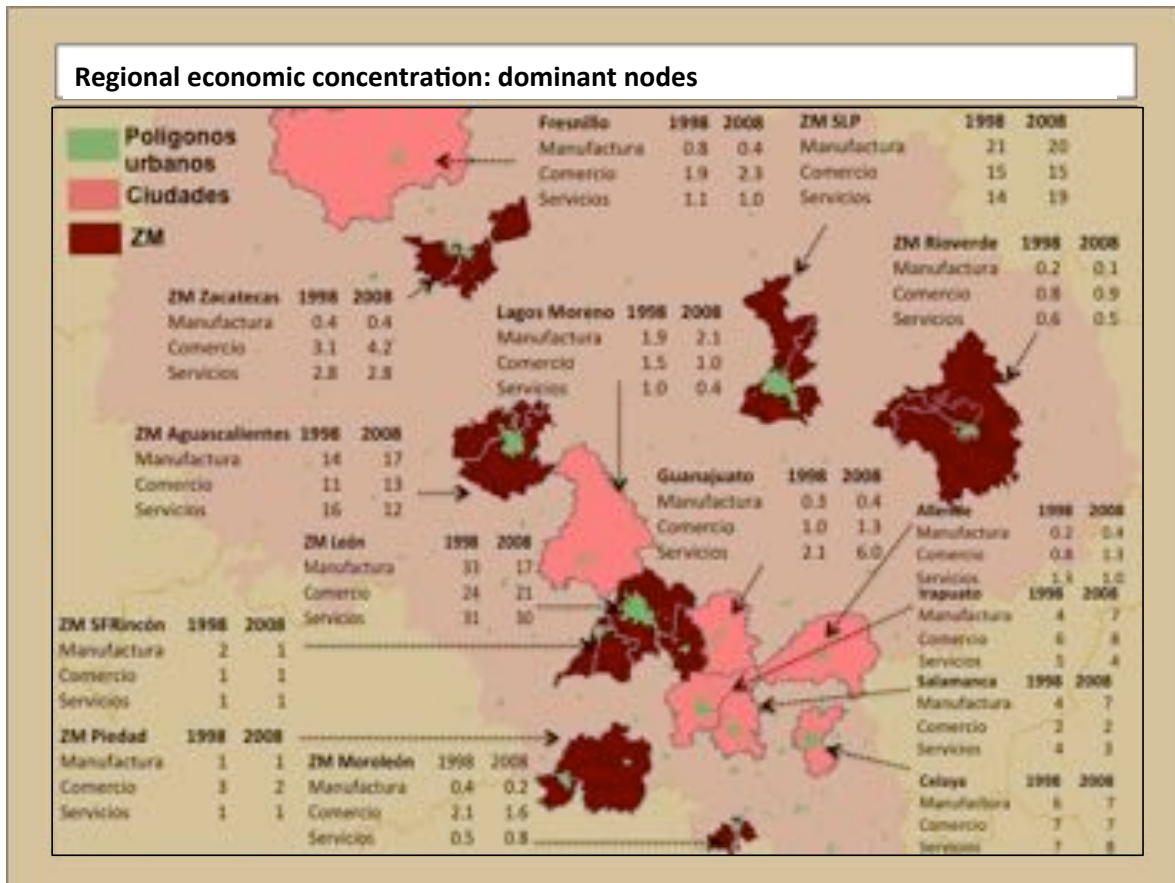
Source: INEGI

Additionally, we can see that other cities considered, present a higher level of specialization in industry and commerce; which match with a greater number of key nodes with expertise in such sectors.

In fact looking at the pattern of economic concentration in the period 1998-2008, highlights by the consolidation in terms of the manufacturing economic hierarchy, specially in commercial and service activities of the three dominant economic nodes: Leon, San Luis Potosí and Aguascalientes, even though the fall in

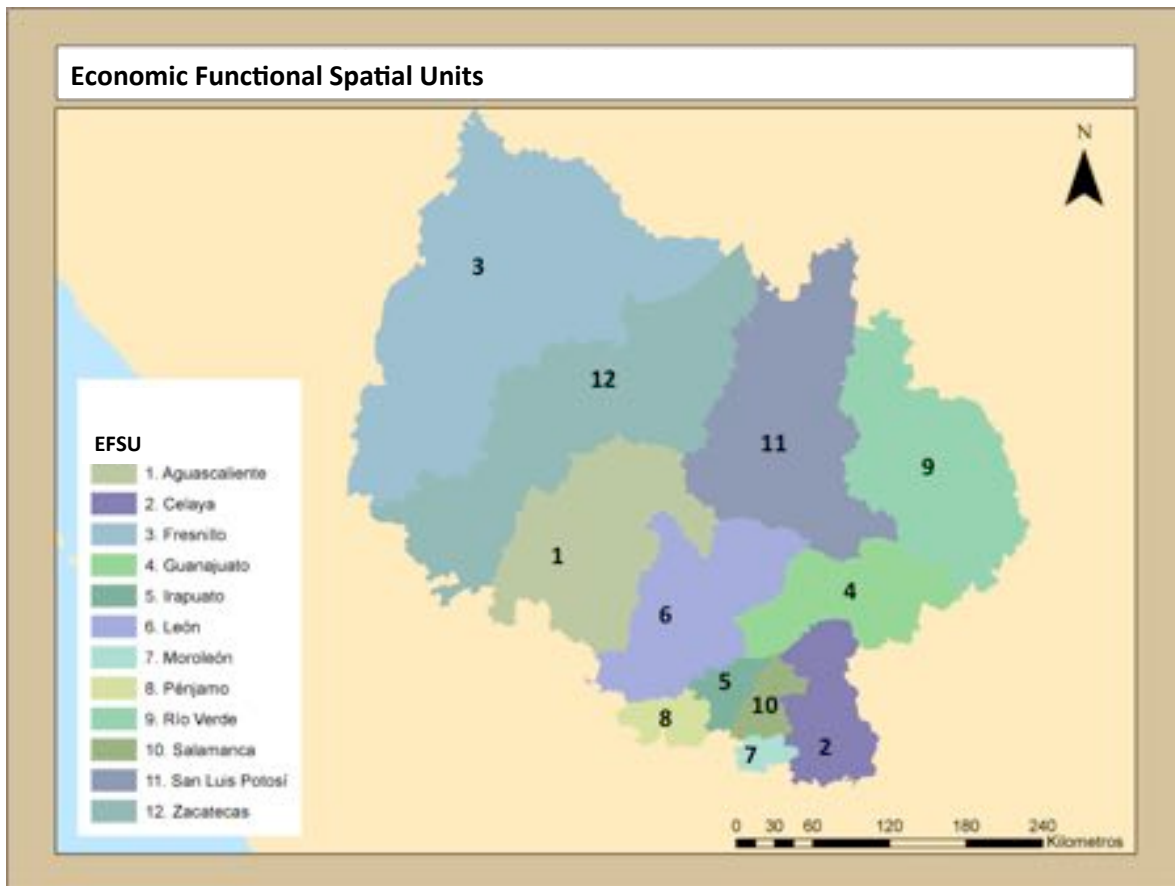


participation that occurred in that period; its worth to mention the increase of lower range nodes as Celaya, Irapuato and Salamanca, for its location and specialization have managed to become subcenters of concentration mainly linked to the industrial corridor connecting Celaya to Leon.



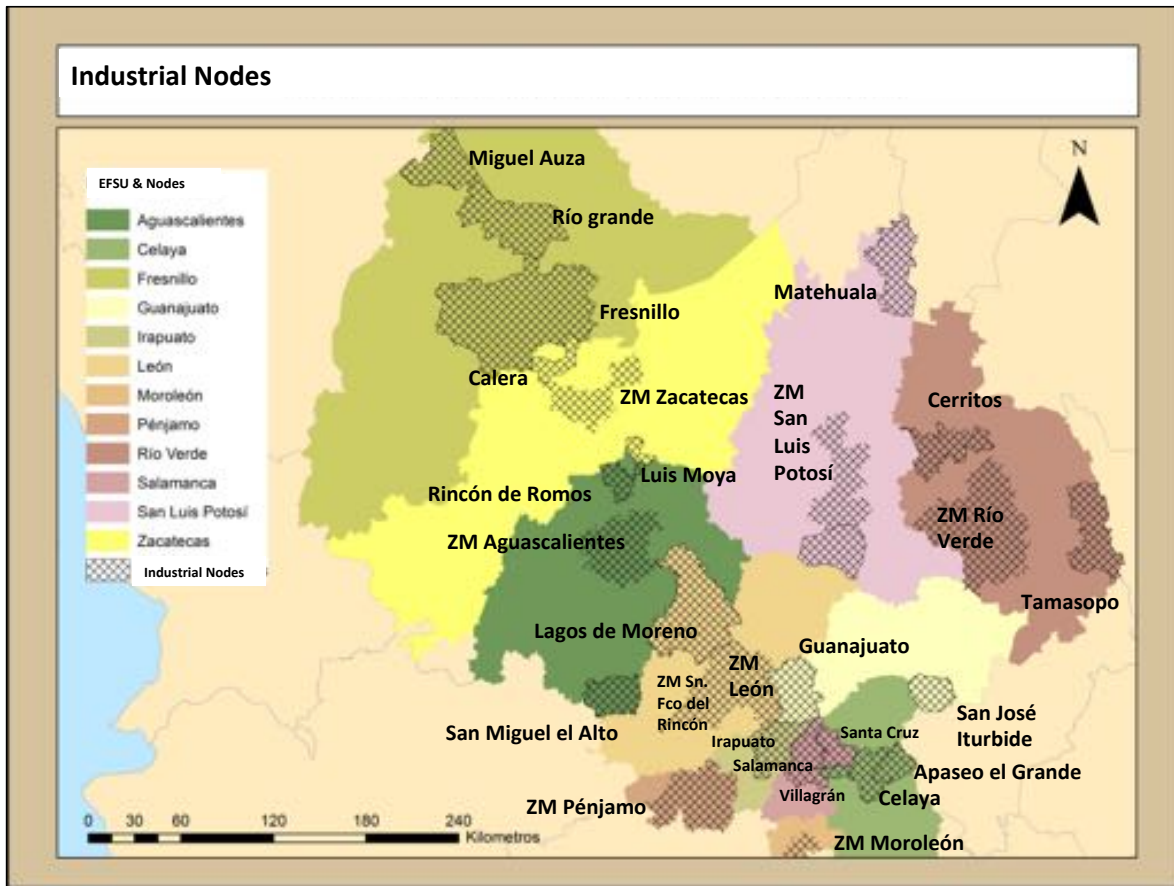
Source: CEDRUS with information from INEGI

So according to the pattern of economic concentration at the regional level, considering the levels of spatial agglomeration by dominant economic sites of value added and employment and their influence, calculating Reilly index there were identified and delimited 12 economic functional space units as an outcome of stroke market areas, which constitute the functional economic regions of the north central region, as shown below.



Source: CEDRUS with information from INEGI.

Subsequently, according to economic specialization and the presence of specialized branches, specifically in manufacturing, distribution and characteristics of industrial activity in the region was analyzed. The region is characterized by its important industrial activity with a share above 50% in generating regional value added in the period 1998 to 2008. In this regard, taking the functional economic regionalization of north central Mexico, there were identified key industrial nodes, highlighting 27 nodes, which concentrate in 2008 95% of manufacturing value added in the region in 2008, similar to 1998 when their participation reached 94% of manufacturing value added.

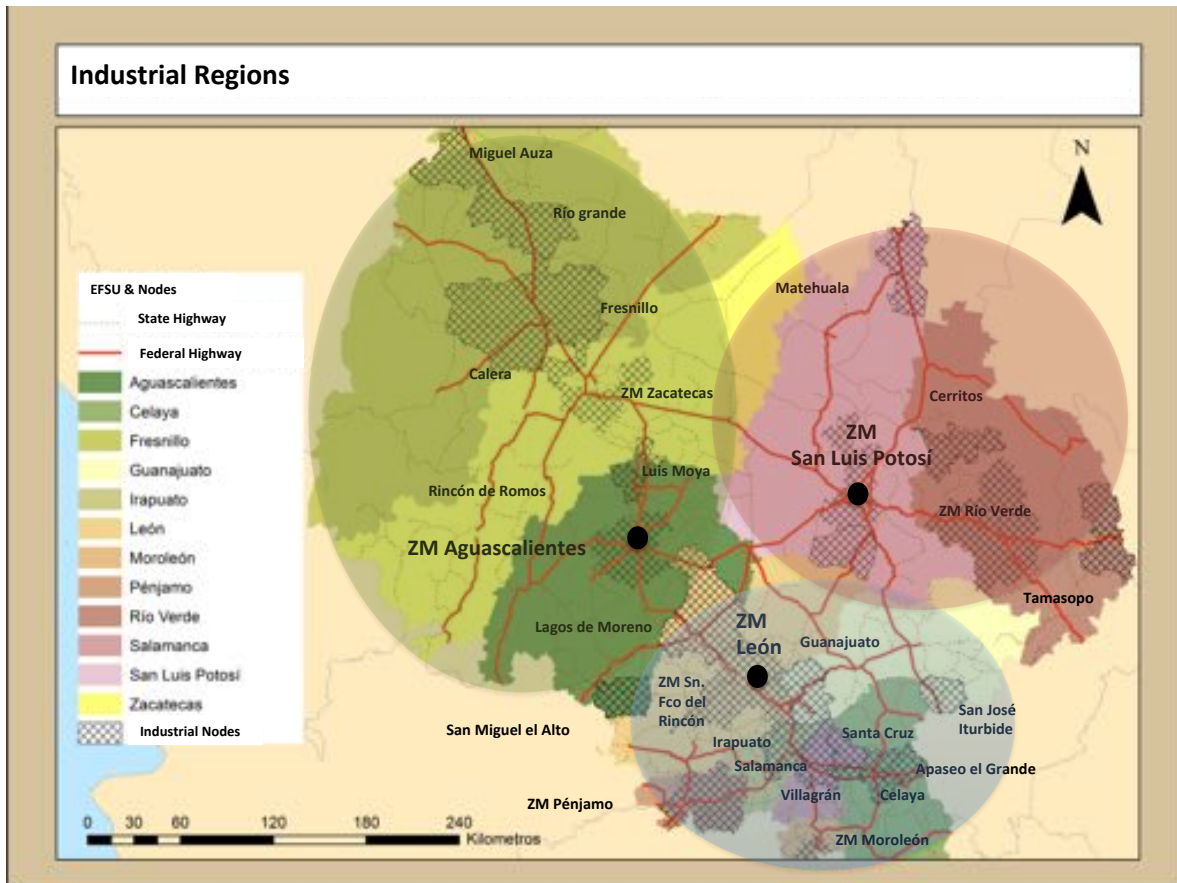


Source: CEDRUS with information from INEGI.

However, a very similar pattern to that of total economic activity was shown by the industry, highlighting the prevalence and importance of major dominant economic sites of the cities of Leon, San Luis Potosi and Aguascalientes, while stand out as major industrial manufacturing sites the cities of Celaya and Salamanca. From 1998-2008, the aforementioned cities contributed 82.5% of manufacturing value added, corresponding respectively to 21.7%, 21.7%, 18.3%, 13.1% and 7.7%.

In addition to analyze the economic interactions between industrial nodes considering the greater weight of the industrial activities of the nodes, considering the theoretical chain sector as a reference and applying probabilistic index of economic interactions between sites was confirmed at the regional level the centrality and operation of Leon as the main regional center and San Luis Potosi and Aguascalientes as regional sub-centers, while the other nodes that make up the regional urban system are established as nodes with low hierarchy according to their interaction with the main functional economic areas.

Hence, spatially considering economic industrial concentration and economic interaction, there were identified three great industrial regions having a main regional center in Leon and two sub-centers in the cities of San Luis Potosí and Aguascalientes.



Source: CEDRUS with information from INEGI.

In order to analyze the interaction of industrial, trade and services activities, 70 branches of specialized activity were identified, which together account for 70 percent of the total gross production in the region.

Of all branches in the north central region, in total 266, only 70, ie 26% of the total, have specialization regarding the regional total, which is why those branches were considered for the construction of the probabilistic interaction index.<sup>12</sup>

To have a concrete analysis of dominant specialized branches there were selected 21 of them by Pareto approach, these branches are shown in the following table

<sup>12</sup> See Annex

and considered as representative in terms of economic concentration in the region considering the total regional economic activity.

<b>Specialized Branches</b>	
<b>Code</b>	<b>Description</b>
<b>3241</b>	Fabricación de productos derivados del petróleo y del carbón
<b>3361</b>	Fabricación de automóviles y camiones
<b>3363</b>	Fabricación de partes para vehículos automotores
<b>3115</b>	Elaboración de productos lácteos
<b>3121</b>	Industria de las bebidas
<b>3312</b>	Fabricación de productos de hierro y acero
<b>3162</b>	Fabricación de calzado
<b>3256</b>	Fabricación de jabones, limpiadores y preparaciones de tocador
<b>3352</b>	Fabricación de aparatos eléctricos de uso doméstico
<b>2122</b>	Minería de minerales metálicos
<b>5171</b>	Operadores de telecomunicaciones alámbricas
<b>3114</b>	Conservación de frutas, verduras y alimentos preparados
<b>3111</b>	Elaboración de alimentos para animales
<b>4311</b>	Comercio al por mayor de abarrotes y alimentos
<b>3359</b>	Fabricación de otros equipos y accesorios eléctricos
<b>3116</b>	Matanza, empackado y procesamiento de carne de ganado, aves y otros animales comestibles
<b>3311</b>	Industria básica del hierro y del acero
<b>3314</b>	Industrias de metales no ferrosos, excepto aluminio
<b>3222</b>	Fabricación de productos de cartón y papel
<b>4611</b>	Comercio al por menor de abarrotes y alimentos

Source: INEGI.

As an example, we include some results obtained in the case of the first five branches, which reveal the interaction within the region in activity sectors related to oil industry, automotive industry, food and beverage industry and manufacture of iron and steel.

In the case of oil industry, specifically regarding manufacturing products deriving from petroleum and coal maximum interaction is achieved between San Luis Potosí y

Aguascalientes, while a low interaction is presented within the pair Aguscalientes-Guanajuato and San Luis Potosí Guanajuato.

Considering the results in the matrix, there are highlighted in blue the statistically significant interactions between the functional economic spatial units, and the main levels of interaction appear un blue shadow.

**Manufacturing products deriving from petroleum and coal**  
**Interaction matrix**

Interaction matrix		Branch 3241											
		Manufacturing products deriving from petroleum and coal											
		1	2	3	4	5	6	7	8	9	10	11	12
		AGIASCALIENTES	CELAYA	FRESNILLO	GUANAJUATO	IRAPUATO	LEON	MOROLEON	PENJAMO	RIO VERDE	SALAMANCA	SAN LUIS POTOSÍ	ZACATECAS
1	AGIASCALIENTES												
2	CELAYA	0.10											
3	FRESNILLO	0.08	0.00										
4	GUANAJUATO	0.19	0.01	0.02									
5	IRAPUATO	0.05	0.03	0.00	0.01								
6	LEON	0.07	0.20	0.01	0.06	0.07							
7	MOROLEON	0.01	0.00	0.00	0.00	0.00	0.01						
8	PENJAMO	0.01	0.01	0.00	0.00	0.01	0.02	0.00					
9	RIO VERDE	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
10	SALAMANCA	0.15	0.05	0.01	0.01	0.02	0.00	0.00	0.01	0.02			
11	SAN LUIS POTOSÍ	1.00	0.04	0.08	0.21	0.00	0.07	0.00	0.00	0.02	0.11		
12	ZACATECAS	0.07	0.05	0.00	0.01	0.03	0.10	0.00	0.01	0.00	0.03	0.03	

Source: Authors with data from INEGI

Knowing the elements above, and according with two branches related with the automotive industry we obtained the maximum interaction probabilistic index between Leon and Aguascalientes in the cas of manufacturing od vehicles and between the next three pairs in the case of manufacturing of vehicle parts: San Luis Potosí-Aguascalientes, León-Aguascalientes and Celaya-Aguascalientes.

It is worth to mention that these two branches of economic activity are relevant in terms of the regional activity and part of the automotive productive chain. Also, it is need to point out that the specific results can have a validation through empiric data, so there are several automotive plants in the region, fairly established in the territory of Leon, Aguascalientes and San Luis Potosí, having brands like GM and NISSAN running operations since a couple of decades ago.

## Vehicle Manufacturing

### Interaction matrix

Interaction Matrix		Branch 3361											
		Manufacturing of vehicles											
		1	2	3	4	5	6	7	8	9	10	11	12
		AGUASCALIENTES	CELAYA	FRESNILLO	GUANAJUATO	IRAPUATO	LEON	MOROLEON	PENJAMO	RIO VERDE	SALAMANCA	SAN LUIS POTOSÍ	ZACATECAS
1	AGUASCALIENTES												
2	CELAYA	0.17											
3	FRESNILLO	0.01	0.01										
4	GUANAJUATO	0.02	0.01	0.01									
5	IRAPUATO	0.02	0.05	0.00	0.00								
6	LEON	1.00	0.04	0.00	0.01	0.01							
7	MOROLEON	0.00	0.00	0.00	0.00	0.00	0.00						
8	PENJAMO	0.00	0.02	0.00	0.00	0.00	0.01	0.00					
9	RIO VERDE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
10	SALAMANCA	0.02	0.02	0.00	0.00	0.02	0.03	0.00	0.00	0.00			
11	SAN LUIS POTOSÍ	0.35	0.39	0.03	0.10	0.03	0.05	0.00	0.01	0.00	0.06		
12	ZACATECAS	0.00	0.01	0.00	0.00	0.01	0.02	0.00	0.01	0.00	0.01	0.02	

Source: Authors with data from INEGI

## Vehicle parts Manufacturing

### Interaction matrix

Interaction matrix		Branch 3363											
		Manufacturing of vehicle parts											
		1	2	3	4	5	6	7	8	9	10	11	12
		AGUASCALIENTES	CELAYA	FRESNILLO	GUANAJUATO	IRAPUATO	LEON	MOROLEON	PENJAMO	RIO VERDE	SALAMANCA	SAN LUIS POTOSÍ	ZACATECAS
1	AGUASCALIENTES												
2	CELAYA	0.25											
3	FRESNILLO	0.02	0.01										
4	GUANAJUATO	0.05	0.02	0.00									
5	IRAPUATO	0.06	0.02	0.00	0.01								
6	LEON	0.79	0.22	0.03	0.10	0.08							
7	MOROLEON	0.00	0.00	0.00	0.00	0.00	0.00						
8	PENJAMO	0.00	0.00	0.00	0.00	0.00	0.00	0.00					
9	RIO VERDE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
10	SALAMANCA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
11	SAN LUIS POTOSÍ	1.00	0.51	0.02	0.07	0.05	0.65	0.00	0.00	0.00	0.01		
12	ZACATECAS	0.03	0.01	0.00	0.00	0.01	0.05	0.00	0.00	0.00	0.00	0.03	

Source: Authors with data from INEGI

Regarding the case of dairy product manufacturing, the main interactions were found between Irapuato-Aguascalientes, Celaya-Aguascalientes and Irapuato-Celaya reflecting a linkage between one of the main nodes which would be represented by Aguascalientes and nodes of a low hierarchy like Celaya and Irapuato, but been an important component of the industrial belt formed within the region.

## Dairy products Manufacturing

### Interaction matrix

Interaction matrix		Branch 3115 Manufacture of dairy products											
		1	2	3	4	5	6	7	8	9	10	11	12
		AGUASCALIENTES	CELAYA	FRESNILLO	GUANAJUATO	IRAPUATO	LEON	MOROLEON	PENJAMO	RIO VERDE	SALAMANCA	SAN LUIS POTOSÍ	ZACATECAS
1	AGUASCALIENTES												
2	CELAYA	0.63											
3	FRESNILLO	0.02	0.01										
4	GUANAJUATO	0.04	0.08	0.00									
5	IRAPUATO	0.73	0.61	0.01	0.05								
6	LEON	0.02	0.34	0.00	0.28	0.04							
7	MOROLEON	0.00	0.00	0.00	0.00	0.00	0.00						
8	PENJAMO	0.02	0.00	0.00	0.00	0.01	0.01	0.00					
9	RIO VERDE	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00				
10	SALAMANCA	0.40	0.75	0.03	0.10	0.25	0.39	0.01	0.03	0.01			
11	SAN LUIS POTOSÍ	0.01	0.85	0.03	0.35	0.09	1.00	0.01	0.02	0.02	1.00		
12	ZACATECAS	0.23	0.11	0.00	0.05	0.12	0.18	0.00	0.06	0.00	0.22	0.05	

Source: Authors with data from INEGI

Finally, looking at the interaction matrix of the industry of beverages we have the maximum interaction between León and Aguascalientes, then followed by León-Celaya and Celaya-Aguascalientes, which complement the linkages with low levels of interaction between low hierarchy economic spatial units like the case of Guanajuato and Rio Verde, as can be seen in the matrix below.

## Industry of beverages

### Interaction matrix

Interaction matrix		Branch 3121 Industry of beverages											
		1	2	3	4	5	6	7	8	9	10	11	12
		AGUASCALIENTES	CELAYA	FRESNILLO	GUANAJUATO	IRAPUATO	LEON	MOROLEON	PENJAMO	RIO VERDE	SALAMANCA	SAN LUIS POTOSÍ	ZACATECAS
1	AGUASCALIENTES												
2	CELAYA	0.42											
3	FRESNILLO	0.00	0.00										
4	GUANAJUATO	0.00	0.02	0.00									
5	IRAPUATO	0.02	0.03	0.00	0.01								
6	LEON	1.00	0.76	0.00	0.05	0.04							
7	MOROLEON	0.00	0.00	0.00	0.00	0.00	0.00						
8	PENJAMO	0.00	0.01	0.00	0.03	0.00	0.01	0.00					
9	RIO VERDE	0.06	0.04	0.00	0.00	0.00	0.10	0.00	0.00				
10	SALAMANCA	0.04	0.06	0.01	0.02	0.01	0.01	0.00	0.01	0.01			
11	SAN LUIS POTOSÍ	0.06	0.02	0.01	0.26	0.04	0.13	0.00	0.01	0.00	0.07		
12	ZACATECAS	0.20	0.11	0.02	0.02	0.04	0.24	0.01	0.00	0.02	0.06	0.24	

Source: Authors with data from INEGI

Economic interaction between industrial branches, including automotive and other industries, is encouraged further as a result of industrial specialization and diversification and complementarity that occurs with other regional industrial nodes;

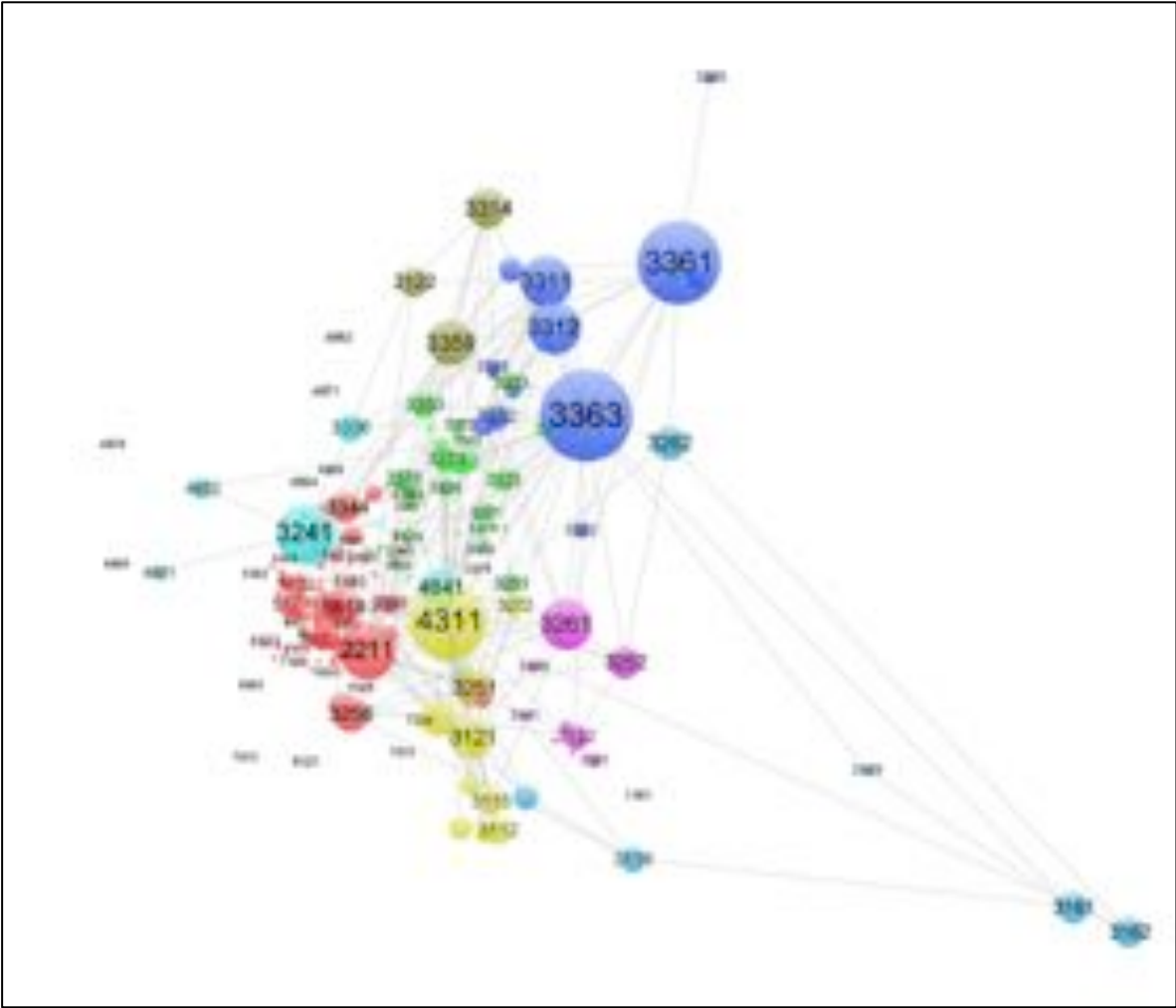


strengthened and extended results from the use of input-output techniques as can be seen in the following section.

### 3. Identification of manufacturing clusters

With the matrix of the north central region, through the technique of graphs and the program VOSviewer ten Cluster were identified, as can be seen in the following figure. Considering its economic relevance and the result of linkages owe consider seven cluster.

**Cluster Identification**



Source: Authors with VOSviewer.

This technique also allows us to identify which is the most important sectorial node of each cluster. In the case of the North Central region, one of the cluster that has major interactions is the automotive industry and its predominant branch node

belongs to auto parts manufacturing (3363). Same as explained in more detail below:

### **3.1.1 Automotive Cluster**

Mexico has great importance in the automotive sector internationally. With a production of 2.88 million vehicles our country is now the seventh vehicle producer worldwide, ranking above Brasil, France and Spain, countries with a long tradition this sector, besides being the second largest economy with higher sales in Latin America and number one in economic growth in the period 2011-2012 According to data from the Ministry of Economy and INEGI, Mexico's automotive sector accounts for 4% of total GDP and 20% of manufacturing GDP in 2012.

The North Central Region highlights the automotive industry as a key industrial economic activity, which contributes 15.7% of total activity in the region, 22.3% of the regional total manufacturing and 35.2% of the value chain in the domestic automotive industry.

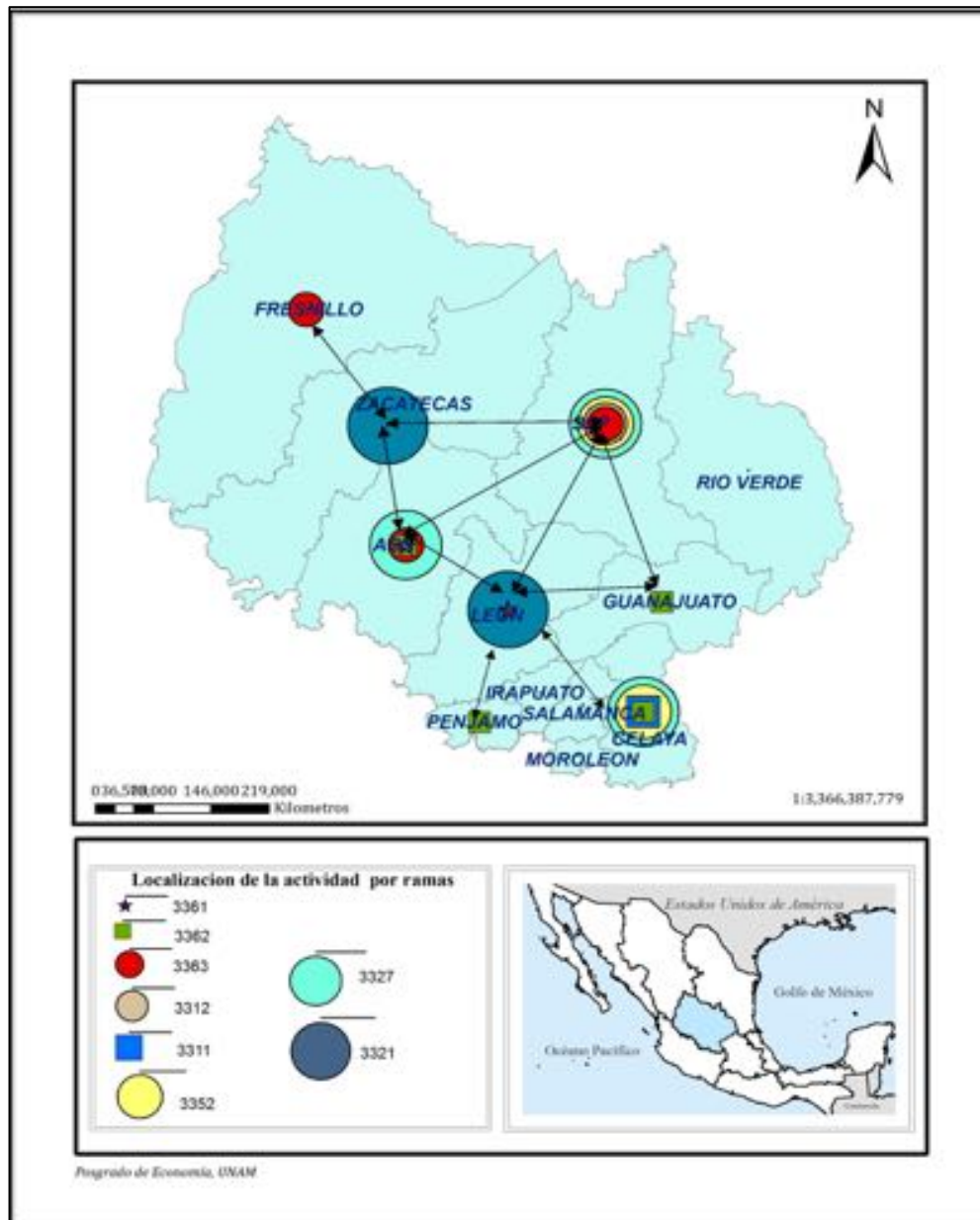
The branches of vehicle and trucks manufacturing (3361), manufacture of bodies and trailers (3362), manufacture of parts for motor vehicles (3363), manufacture of iron and steel (3312), basic industries of iron and steel ( 3311), manufacture of electrical household appliances (3352), Metalworking and manufacturing of screws (3327) and manufacture of forgings and stampings (3321) are economic activities that make up the automotive cluster and are interrelated.

According to the coefficients location, just in Aguascalientes and Leon is located manufacturing activity cars and trucks (3361) in Aguascalientes machining of metal parts and manufacturing of screws (3327) is also located, which is also located in San Luis Potosi and Celaya. Leon and Zacatecas also forged manufacturing activities and stamped metal products (3321) are located. The manufacture of bodies and trailers (3362) is located in Aguascalientes, Pénjamo, Celaya and Guanajuato. In San Luis Potosi the manufacture of auto parts is located, jointly with Fresnillo and Aguascalientes.

The importance of analysis involves combining location coefficients and input-output matrix. In this sense, one can know what activities make up the automotive cluster and how they interact within the economic region. It is also important to note that the functional economic space unit of Leon is the main node, ie it exists a

strong interaction with other functional units in the case of the auto industry, the results are presented in the following map.

**Interactions by site and activities of the main chain of automotive industry in the north central region. 2008**



Source: Authors with ARCGIS 10 and the matrix of the North Central region.

Forward simple analysis of interdependence show us the analysis of the main branches of the automotive activity. In the case of the manufacture of parts for motor vehicles with a coefficient 0.41 it indicates that the production of this branch should be 41% due to the incorporation of regional inputs. Meanwhile, the

manufacture of bodies and trailers having a coefficient of 0.36, indicating that the total product generated in this branch, is 36% due to the incorporation of regional input. The effect of the domestic manufacturing of vehicles and trucks has a coefficient of 0.35, this implies that the product of this industry is due to the incorporation of 35% of regional inputs.

The interpretation of the simple backward interaction index involve indicates the use of that branch for the rest of the branches, in the automotive industry we observe a contrast because while the manufacturing of parts for motor vehicles is required as input for the other sectors as a whole (coefficient of 1.39), the manufacturing of vehicles and trucks is most poorly required by the other sectors (coefficient 0.0094)

The effects of total backward interdependence show that an increase of one mexican peso of the final domestic demand of manufacture of parts for motor vehicles branch requires a increase greater tan one mexican peso and 63 cents of the different sectors of the economy and in the case branch of manufacturing vehicles and trucks as well as body and trailer manufacturing has a value of 1.53, meaning that if final demand in this branch increases one peso, the gross value of production should increase in 1.53 pesos.

As for the total forward interdependence effects the manufacture of bodies and trailers is 1.07, meaning that, with the increased of one peso of final demand of all industrial branches in the North Central region, the value of production of the branch of manufacture of bodies and trailers should increase weight 7 cents, in the case of the domestic manufacture of parts for motor vehicles, indicates that with the increase of one peso of the final demand for all industrial branches of the North Central region, the production value of the domestic production of parts for motor vehicles should be increased by 2 pesos whith 94 cents, and finally the coefficient of manufacturing vehicles and trucks indicates that with the increase of one peso of final demand of all branches of the North Central region, the production value of manufacturing of vehicles and trucks should increase by 1.4 pesos in order to be able to cover demand for intermediate inputs from other branches and of itself. As is shown in the following table:

### Simple and total Interdependence effects

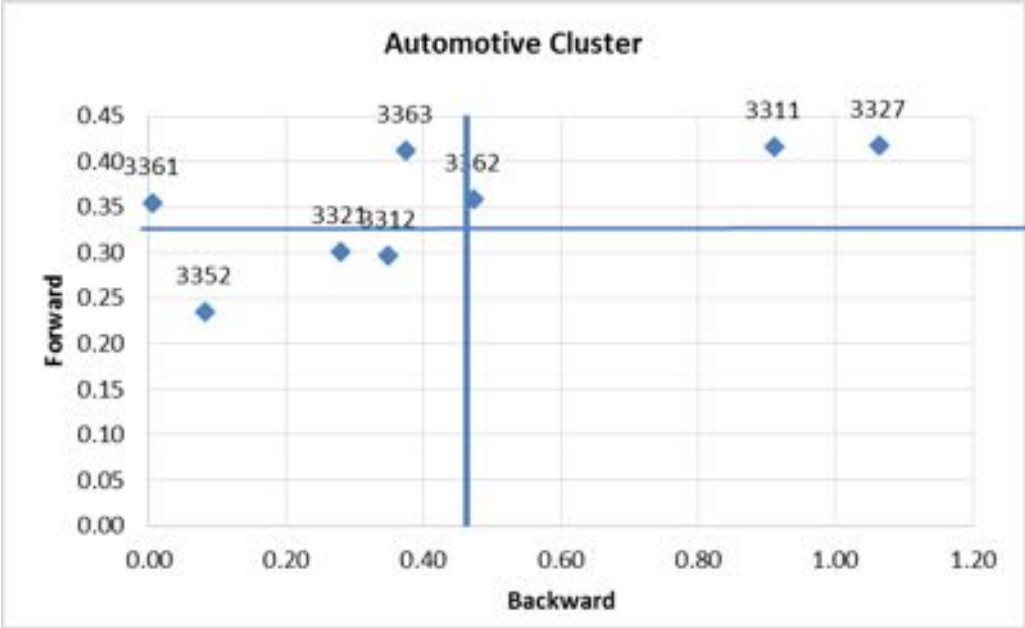
Branch	Name	Backward simple interdependence	Forward simple interdependence	Backward total interdependence	Foward total interdependence
3363	Manufacture of automotive vehicle parts	0.412233	1.392925	1.63647	2.946705
3361	Manufacture of cars and trucks	0.354256	0.031821	1.531863	1.043087
3312	Manufacture of iron and steel	0.296338	2.216977	1.440938	4.110208
3311	Basic industries of iron and steel	0.416532	1.784509	1.577853	4.241936
3352	Production of electrical household appliances	0.235299	0.107499	1.345881	1.130805
3327	Metalworking and manufacture of screws	0.417911	0.310512	1.596655	1.523122
3362	Manufacture of bodies and trailers	0.357986	0.063168	1.529919	1.070463
3321	Manufacture of forged and stamped metal products	0.300638	0.122121	1.466374	1.1726

Source: Authors with data from INEGI and the matrix of the North Central region

Economic concentration and specialization of the links in the chain of automotive industry and the Chenery and Watanabe index, allow to validate the characterization of the economic-spatial structure of the chain in four types of chains: a) “Strong drag” respect activities with low forward linkages and high backward linkages. b) “Base” with high forward linkages and low backward linkages. c) The “key sectors”, concerning economic activities with strong forward and backward linkages. d) “independent sectors”, ie activities with low backward and forward linkages.

Therefore base sectors are located in the main nodes of Leon, Aguascalientes and San Luis Potosi and are characterized by their forward linkage and low backward linkages. However also in case of Leon and San Luis Potosi there are located

strong drag sectors. Also there are key sectors found in Leon, Aguascalientes and San Luis Potosi. Hence, in general, automotive chain present high linkages considering the main nodes that match the main industrial activity nodes in the region.



Source: Authors with data from INEGI and the matrix of the North Central region

### 3.1.2 Construction Cluster

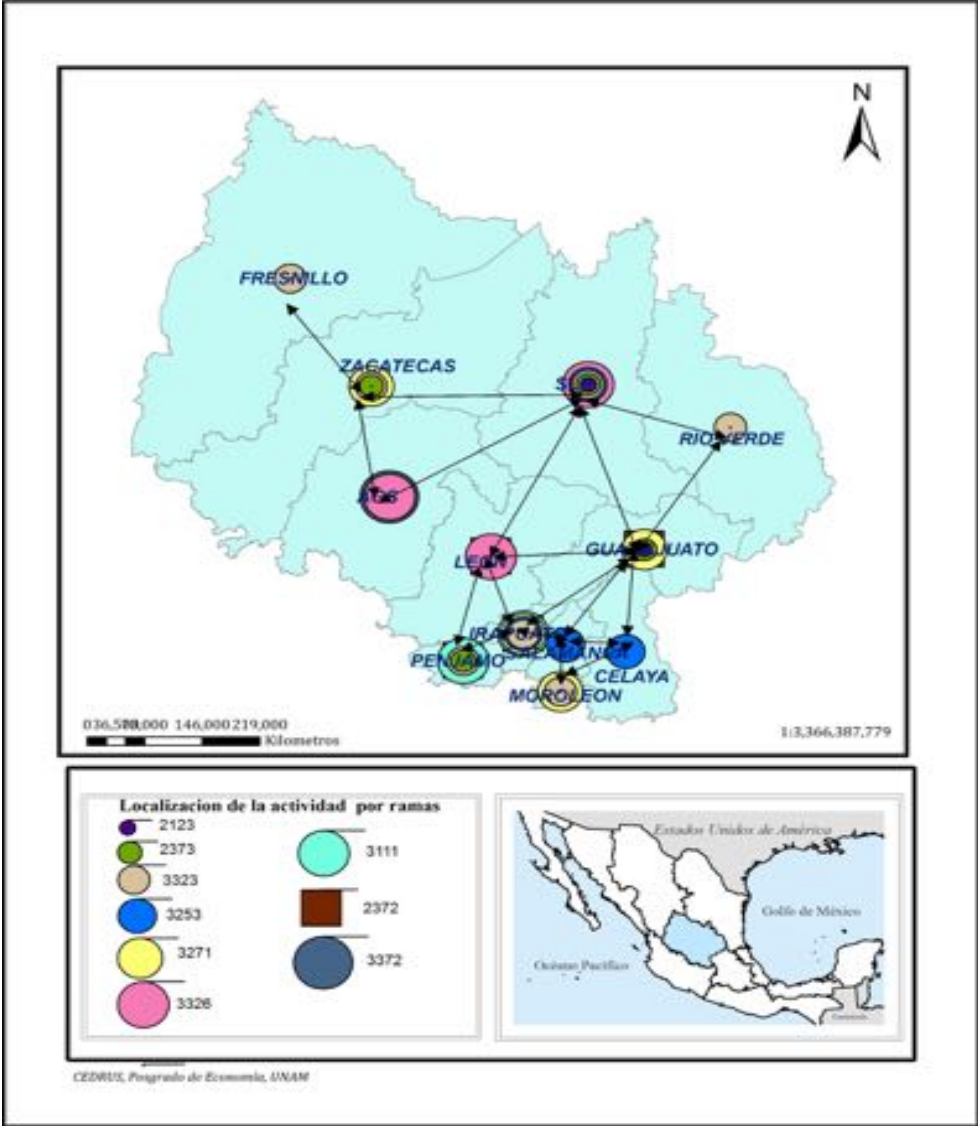
The Cluster's main activity is the construction of means of communication (2373), which accounts for 1.13% of the total GDP of the North Central region, followed by non-metallic mineral mining (2123) which accounts for 0.3% of total GDP. The total of the activities that make up this cluster in the region accounts for 4.47% of GDP.

The activities included in this cluster are: Nonmetallic Mineral Mining (2123), construction of roads (2373), manufacture of metal structures and blacksmith products (3323), manufacture of fertilizers, pesticides and other agrochemicals (3253) Manufacturing of products based on clays and refractory minerals (3271), manufacture of wire, wire products and springs (3326), preparation of feed (3111), division of the land and construction of urbanization (2372), manufacturing office furniture and shelving (3372).

The results of the coefficients of the location for the construction cluster, point out that manufacturing activity of wire products and springs (3326) is localized in the

main nodes of Aguascalientes, San Luis Potosí y León. The main activity of the chain, the construction of pathways (2373) is localized in Zacatecas, San Luis Potosí, Guanajuato and Pénjamo. The results are in the following box:

**Interactions by site and activities of the main chain of construction industry in the north central region. 2008**



Source: Authors with ARCGIS 10 and the matrix of the North Central region.

The analysis of interdependence for the Construction Cluster threw the main results. The activities of Construction roads, is due in 26% of the incorporation of regional inputs, but this sector is not much required for the other sectors, with the analysis of total interdependence shows that an increase of weight on the final demand requires more tan 1.38 pesos cents of the different sectors of the economy

and an increase of one peso in the other branches making the production value of this sector increase by 0.02 cents.

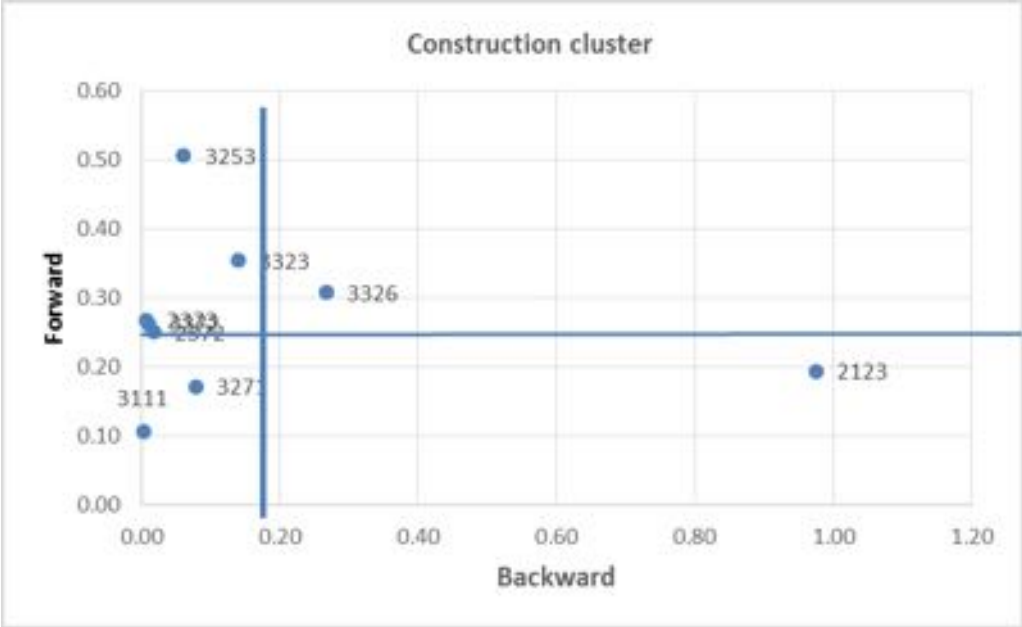
### Simple and total Interdependence effects

Branch	Name	Backward simple interdependence	Forward simple interdependence	Backward total interdependence	Foward total interdependence
2123	Nonmetallic Mineral Mining	0.194294	0.684646	1.269573	1.855943
2373	Construction of roads	0.268457	0.022375	1.380759	1.023574
3323	Manufacture of metal structures and blacksmith products	0.354638	0.154175	1.514966	1.175678
3253	Manufacture of fertilizers, pesticides and other agrochemicals	0.506332	0.190365	1.661392	1.216694
3271	Manufacture of products based on clays and refractory minerals	0.172112	0.137053	1.229926	1.163333
3326	Manufacture of wire, wire products and springs	0.308072	0.320338	1.447173	1.416126
3111	Basic industries of iron and steel	0.107355	0.259865	1.1345	1.262833
2372	Division of land and construction of urbanization	0.250805	0.01911	1.359149	1.019964
3372	Manufacture of office furniture and shelving	0.263264	0.005938	1.376357	1.006311

Source: Authors with data from INEGI and the matrix of the North Central region



According to the Chenery and Watanabe index, activities that are considered to have a strong drag corresponds to the activities of greater contribution to GDP, Mining of nonmetallic minerals (2123), while activities classified by this index as key are manufacturing structures blacksmithing and metal products (3323) and the production of wire, wire products and springs (3326), the construction of roads (2373) corresponds to base activities.



Source: Authors with data from INEGI and the matrix of the North Central region

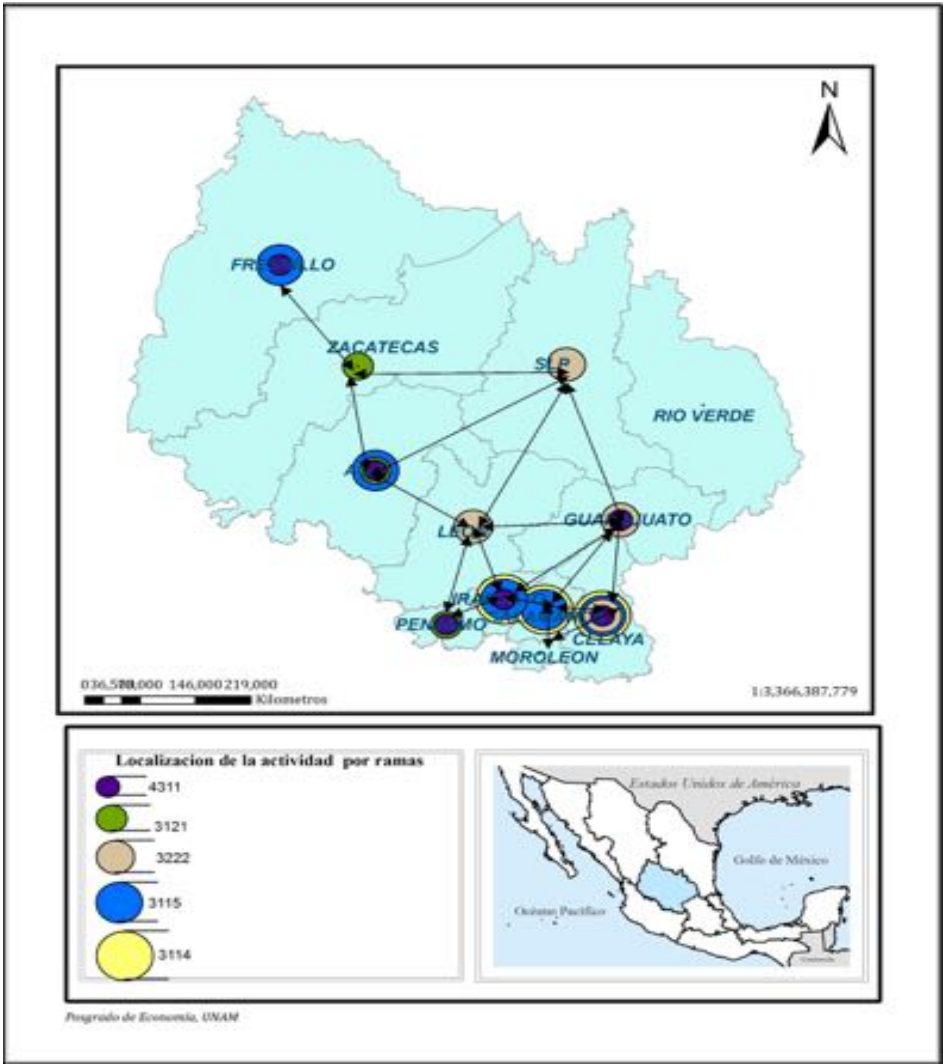
### 3.1.3 Food Manufacturing Cluster

Food manufacturing cluster has a very important role in the region, because of the sum of the GDP of the branches that provide this Cluster represents 9.8% of total output in the region. While the branches that have greater weight in the Cluster are; beverage industry and dairy processing, which account for 3.7 and 3.7% of GDP.

With the analysis of interactions five branches that interact in this cluster were detected, of which the activity of Commerce (4311) is the most important because the number of interactions it has with other branches in the functional areas, however it does not have the mayor economic weight, as previously mentioned these correspond to the beverage industry (3121) and the production of dairy products (3115), other branches are the manufacture of cardboard and paper (3222) and conservation fruits, vegetables and prepared foods (3114).

Dairy production is located in Fresnillo, Aguascalientes, Irapuato, Celaya and Salamanca, while the production of beverages is located in Zacatecas, Aguascalientes and Pénjamo. The manufacture of paper and paperboard products is strategically located in San Luis Potosi, Leon and Guanajuato and finally the preservation of fruit, vegetables and food prepared by the advantages offered by the physical space is located in Celaya and Moroleón, and Irapuato.

**Interactions by site and activities of the main chain of construction industry in the north central region. 2008**



Source: Authors with ARCGIS 10 and the matrix of the North Central region.

As mentioned earlier, trade is the activity that generates more drag in the automotive industry, however with the results obtained only 13% is due to the incorporation of regional inputs. While simple forward index refers to the activity of commerce is required for the rest of the sectors. Rates indicate that total

interaction facing to an increase in final demand of trade would require 16 cents increase in the other sectors and an increase of one peso in the final demand of other trade activities should increase by 10.87 pesos.

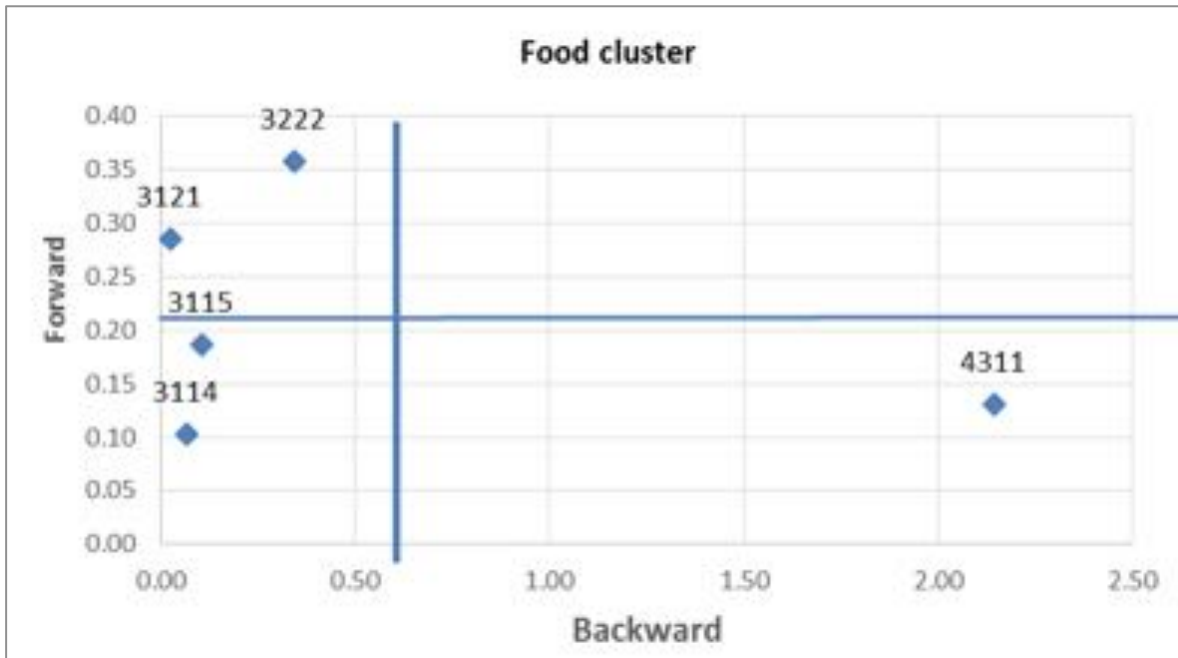
The manufacture of paper and paperboard products is the activity that generates more forward linkages, the product is due to 0.35% of regional inputs, their product is mostly required by other activities in the region. With regard to final demand, with an increase in this, this branch specifically requires an increase of 54 cents from the rest of the activities in the region, eventually an increase of one peso of the rest of the branches requires an increase in production of 1.28 pesos of cardboard and paper products. These indexes are listed in the following table:

### Simple and total Interdependence effects

Branch	Name	Backward simple interdependence	Forward simple interdependence	Backward total interdependence	Forward total interdependence
4311	Trade	0.130484	7.055683	1.16946	10.87918
3121	Beverage industry	0.285694	0.25186	1.390548	1.285334
3222	Manufacture of paper and paperboard	0.35779	0.823265	1.548625	2.300363
3115	Manufacture of dairy products	0.186174	0.156751	1.240151	1.185278
3114	Canned fruits, vegetables and prepared foods	0.102255	0.084771	1.132803	1.099425

Source: Authors with data from INEGI and the matrix of the North Central region

The characterization of the economic-spatial structure refers to four types: a) strong drag; b) base, c) key and d) Independent. Trade is classified as a strong drag, while the beverage industry, the manufacture of paper and cardboard and dairy processing sectors are classified as base. This result is consistent with the expected, since food production is a product of final demand, which allocates all its production to retail or wholesale.



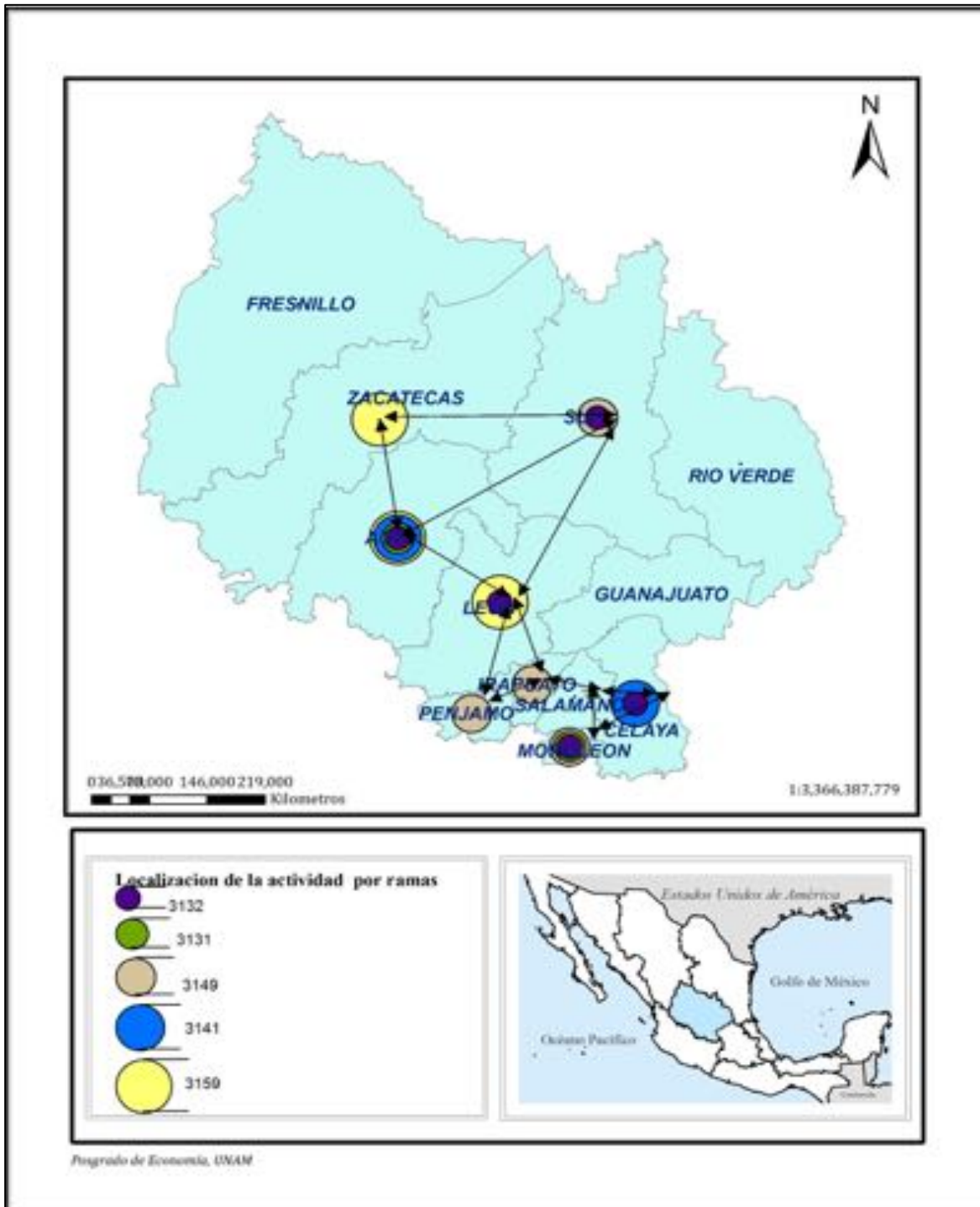
Source: Authors with data from INEGI and the matrix of the North Central region

### 3.1.4 Textile Cluster

The activities included in this cluster are: manufacture of textiles (3132), preparation and spinning of textile fibers and yarn manufacturing (3131), manufacture of other textiles, except apparel (3149) Manufacture of carpets, white and similar (3141) confection of clothing accessories and other clothing not elsewhere classified (3159). Together these sectors account for 1.02% of GDP, this cluster is considered because it highlights the interaction of their activities despite not represent a significant share of GDP in the North Central region.

Activities of clothing accessories and other clothing are located in Zacatecas, Aguascalientes and Leon. The manufacture of fabrics in this case is the most important activity within the Cluster, concentrating 0.47% of total regional GDP. The manufacture of fabrics is located in Aguascalientes, Leon, San Luis Potosi and Celaya Moroleón. In contrast, carpet weaving, white and similars, is located in San Luis Potosi, Aguascalientes, Pénjamo and Irapuato.

## Interactions by site and activities of the main chain of textile industry in the north central region. 2008



Source: Authors with ARCGIS 10 and the matrix of the North Central region.

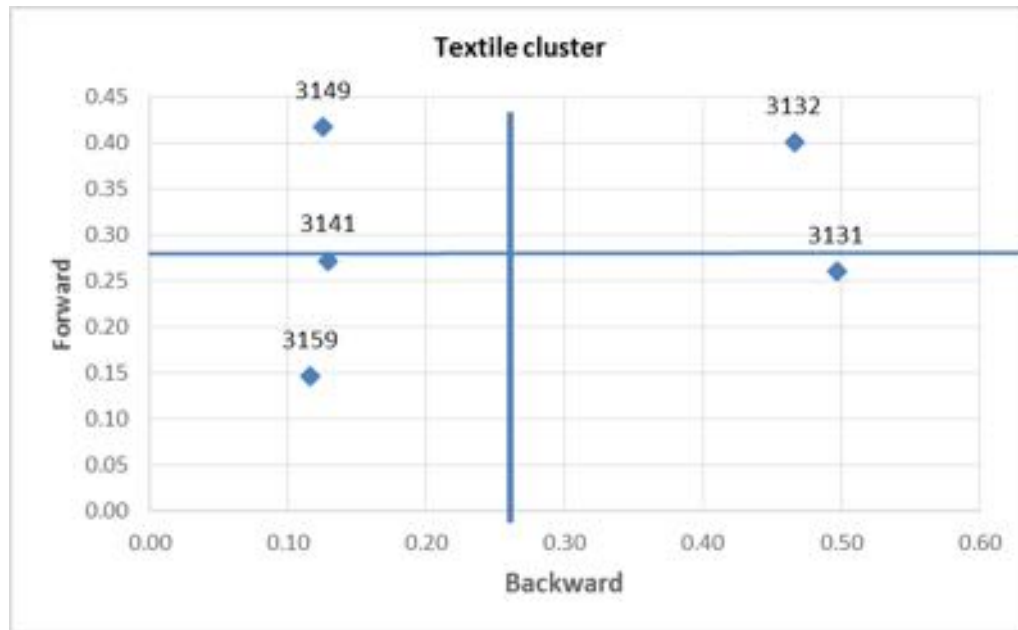
The activity that generates more backward chaining is the manufacture of other textiles, except apparel, which owes its product to the incorporation of 41% of regional inputs. While simple forward index refers to the activity of commerce is totally required for the rest of the sectors. Total interaction index indicate that an increase in final demand of this branch, it would be needed an increase of 61 cents in the other sectors and that an increase of one peso in the final demand of other activities should increase at 1.13 pesos. For more detail of other sectors, see the following table:

### Simple and total Interdependence effects

Branch	Name	Backward simple interdependence	Forward simple interdependence	Backward total interdependence	Foward total interdependence
3132	Fabric manufacturing	0.400406	0.598239	1.562447	1.728189
3131	Preparation and spinning of textile fibers, yarn manufacturing	0.260306	0.330883	1.358146	1.438027
3149	Manufacture of other textiles, except apparel	0.417821	0.111725	1.610108	1.133469
3141	Carpet weaving, whites and similar	0.272393	0.084884	1.3886	1.101655
3159	Manufacture of other electrical equipment and fittings	0.146813	0.046757	1.194022	1.053388

Source: Authors with data from INEGI and the matrix of the North Central region

According to the Chenery and Watanabe index, activity having a greater backward and forward linkage is the manufacture of fabrics, according to this index the activity that generates backward drag is the preparation and spinning of textile fibers and manufacture of wire and strong forward chaining are: the manufacture of other textiles, except apparel and carpet weaving, white and similars.



Source: Authors with data from INEGI and the matrix of the North Central region

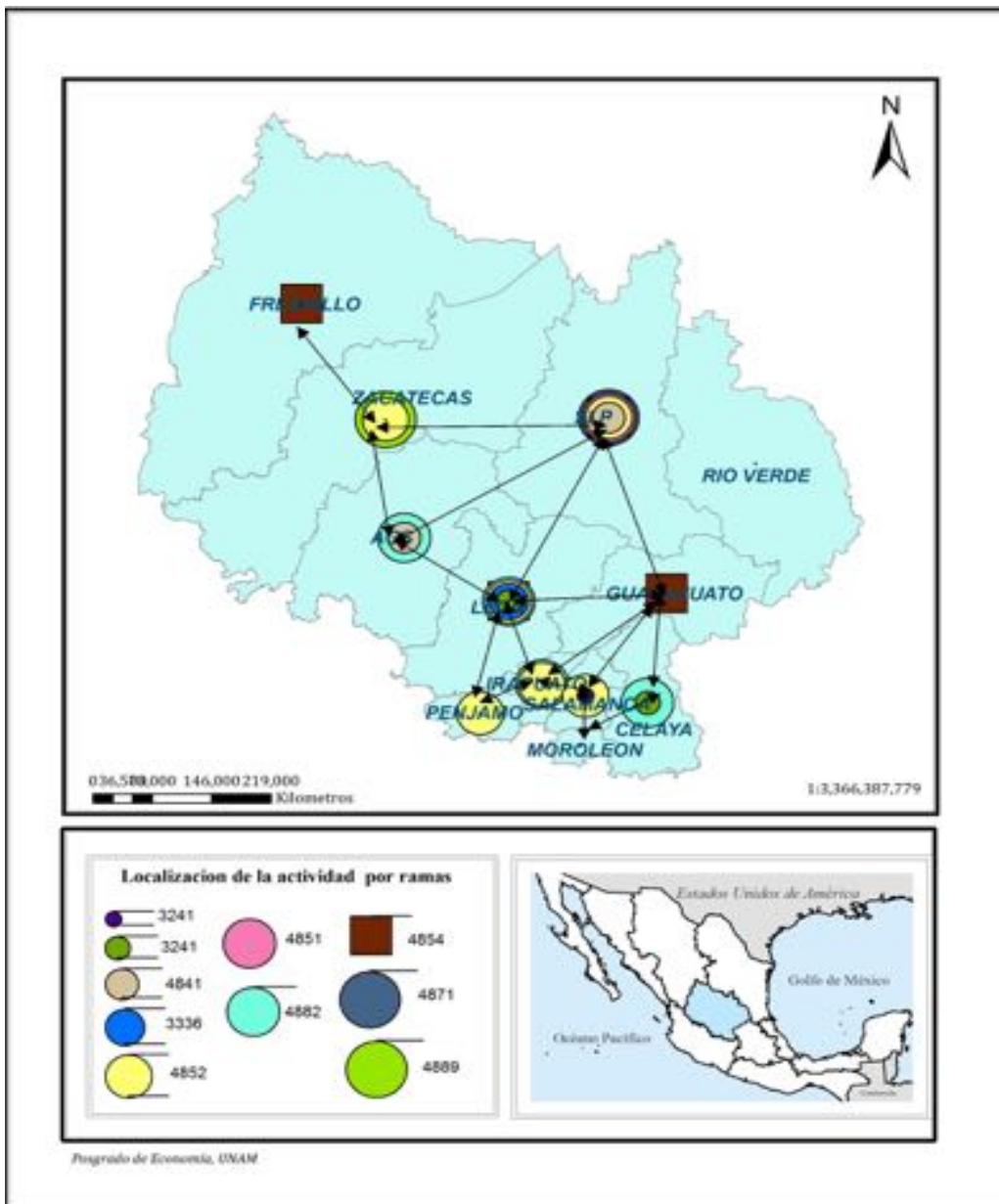
### 3.1.5 Transport cluster

In this cluster, although most of its activities are services, the activity that generates a major boost to the economy is the production of petroleum products and coal concentrating 13.82% of GDP.

The activities comprising this cluster is the production of petroleum products and coal (3241), trucking transport (4841), the manufacture of internal combustion engines, turbines and transmissions (3336), the foreign of public transport fixed route passengers (4852), urban public transport and suburban passenger fixed route (4851), services related to rail transport (4882), school transport and personnel (4854), tourist transport by land (4871) services other land passenger transport (4859), related to transport (4889) and other tourist transport (4879) services.

The manufacture of petroleum products and coal, being localized products, they specialize in the refinery in Salamanca. And the other sectors are distributed in the rest of the functional areas, except Rio Verde.

## Interactions by site and activities of the main chain of transport industry in the north central region. 2008



Source: Authors with ARCGIS 10 and the matrix of the North Central region.

The effects of total simple backward interdependence indicates that manufacturing petroleum products contain 30% of regional inputs and a increase of one peso would cause an increase of 44 cents in the other sectors. The forward linkages then give us information about this sector, from which is required totally by the other sectors, while for every increase of one peso of other sectors is increased by 12.49 pesos. The same can be interpreted to other sectors as shown in the following table:

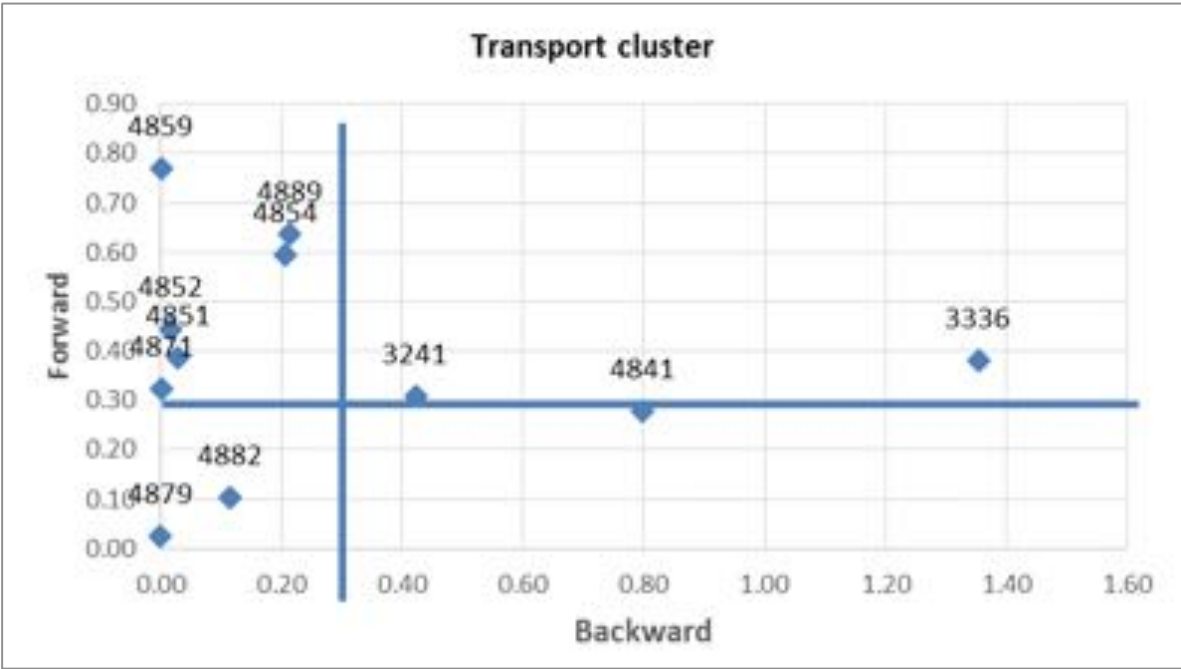


### Simple and total Interdependence effects

Branch	Name	Backward simple interdependence	Forward simple interdependence	Backward total interdependence	Foward total interdependence
3241	Manufacture of petroleum and coal	0.307886	6.395304	1.442269	12.49922
4841	General cargo transportations	0.278867	1.147109	1.39752	2.694347
3336	Manufacture of internal combustion engines, turbines and transmissions	0.379794	1.440581	1.57602	3.089843
4852	foreign collective passengers transport, fixed route	0.443158	0.05165	1.630308	1.058817
4851	Urban public transport and suburban passenger fixed route	0.385364	0.075063	1.548167	1.095743
4882	Services related to transportation by rail	0.103607	0.042889	1.14853	1.061746
4854	School and personnel transport	0.594273	0.01829	1.832266	1.022599
4871	Land Sightseeing Transportation	0.322793	0.000629	1.435079	1.000777
4859	Other land passenger transport	0.769088	1.24E-05	2.081028	1.000016
4889	Other services related to transportation	0.635494	0.000425	1.919435	1.000795
4879	Another tourist transport	0.023719	8.99E-08	1.033486	1

Source: Authors with data from INEGI and the matrix of the North Central region

The classification by type of chain, can be seen in the following chart: The activities that are classified as key for its strong backward and forward linkage is the manufacture of internal combustion engines, turbines and transmissions, while strong drag are the manufacture of petroleum products and coal and trucking service. Finally, base industries relate to other land passenger transport, other transportation-related services and transportation in general.

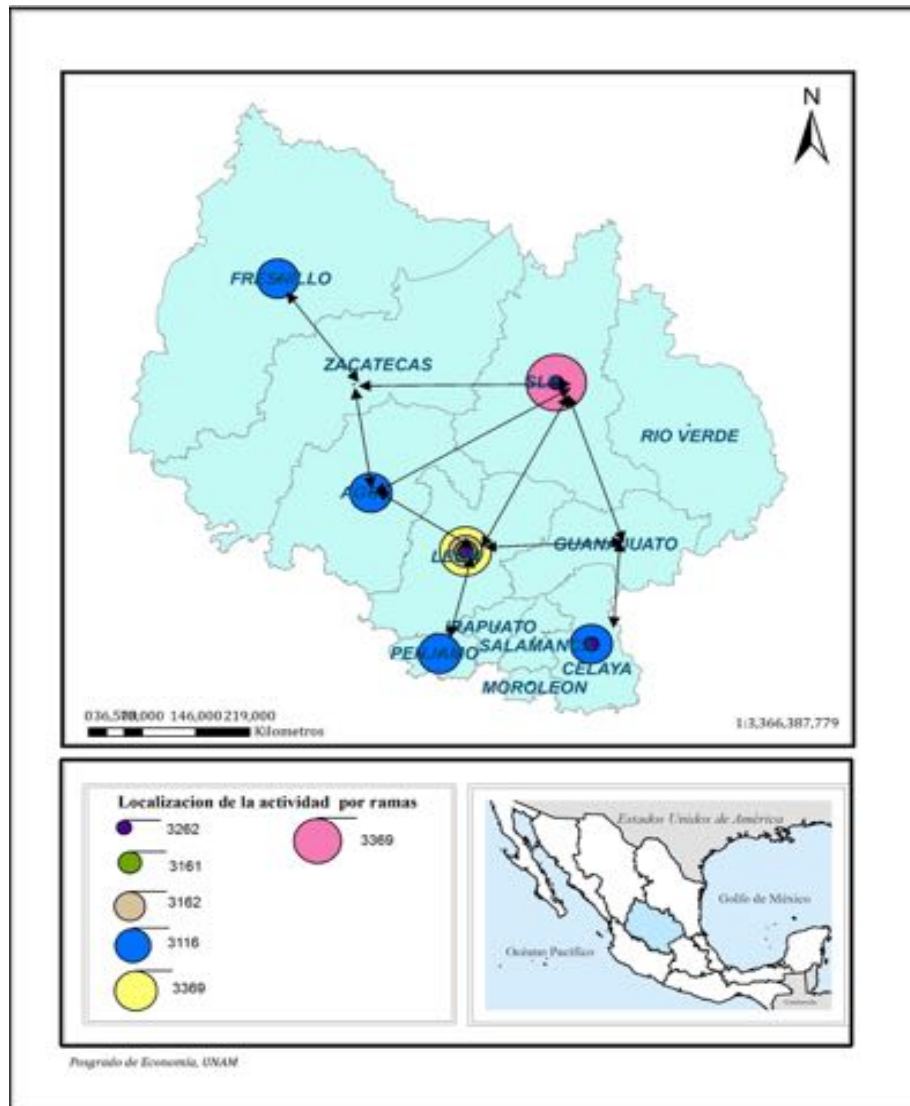


Source: Authors with data from INEGI and the matrix of the North Central region

### 3.1.6 Footwear industry Cluster

Manufacture of footwear (3162) is located in Leon and concentrates 2.06% of GDP. The rest of the specialized activities in the North Central region relates to the manufacture of rubber products (3262) located in San Luis Potosí, Celaya and León, tanning and finished leather (3161) is only specialized in Leon like killing, packaging and processing of beef cattle, poultry and other edible animals (3116) and making other leather products, leather and substitutes materials (3169). These activities concentrate 4.66% of total GDP in the North Central region.

## Interactions by site and activities of the main chain of footwear industry in the north central region. 2008



Source: Authors with ARCGIS 10 and the matrix of the North Central region.

The simple forward analysis of interdependence allows us to understand the effects on the activities of the footwear cluster. For the manufacture of footwear its content is due 22% of the incorporation of regional inputs. Interpretation of backward simple interaction index involve the use of that branch for the rest of the branches, this activity is most poorly required as input for other sectors as a whole (coefficient of 0.04).

The effects of total backward interdependence show that an increase one peso of the final demand of the shoe making industry needs more than a 1.26 pesos

increase of the various sectors of the economy. As, for the purposes of total forward interdependence footwear manufacturing should increase by 1,047 pesos facing an increase of one peso of the final demand of all industries of the North Central region.

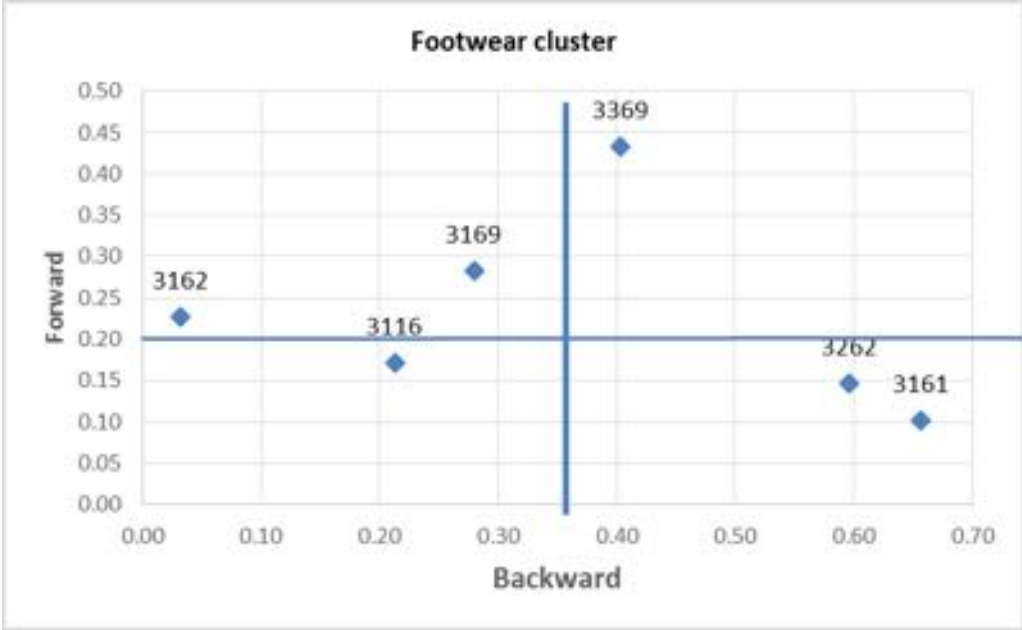
The branch of activity containing 28% content of regional inputs, and so be the one with a higher value within the region, is the manufacture of other products of leather, fur and substitute materials. The data of interdependence can be seen in the following table:

### Simple and total Interdependence effects

Branch	Name	Backward simple interdependence	Forward simple interdependence	Backward total interdependence	Foward total interdependence
3262	Manufacture of rubber	0.146686	0.448037	1.208356	1.609166
3161	Tanning and dressing of leather and fur	0.102213	0.442232	1.122084	1.501426
3162	Shoemaking	0.227175	0.036736	1.265102	1.046596
3116	Slaughter, meat packing and processing of livestock, poultry and other edible animals	0.17113	0.279958	1.21362	1.399663
3169	Manufacture of other products of leather, fur and substitute materials	0.283152	0.039085	1.337231	1.059172
3369	Manufacture of other transport equipment	0.432303	0.260264	1.651988	1.354194

Source: Authors with data from INEGI and the matrix of the North Central region

Tanning and finishing of leather skin, and manufacturing rubber are classified as activities with strong drag, while those who have strong forward linkages are making other leather products, leather and substitutes materials and manufacturing footwear.

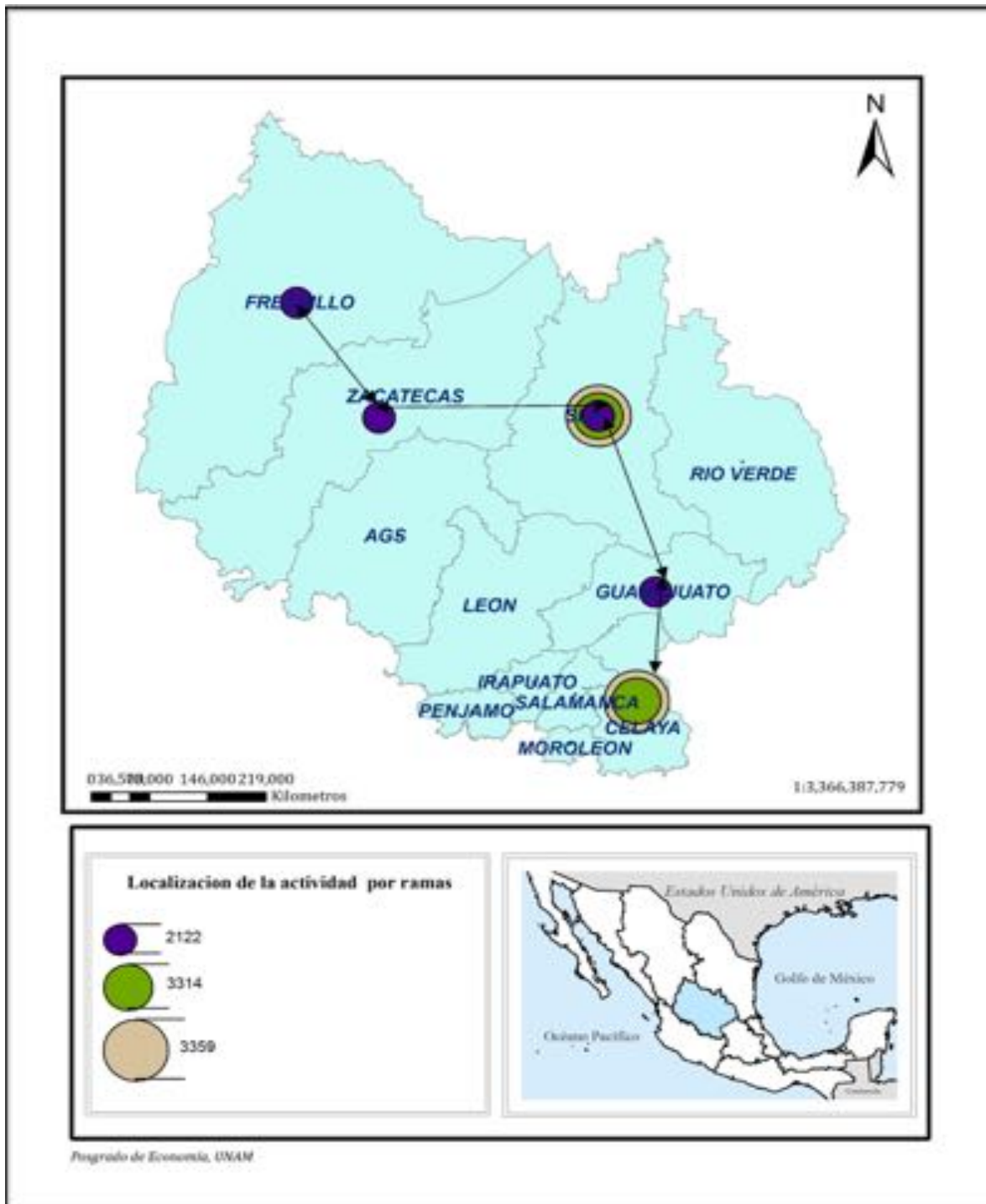


Source: Authors with data from INEGI and the matrix of the North Central region

### 3.1.7 Mining Cluster

This cluster is formed by metal ore mining (2122), the industry nonferrous metals, except aluminum (3314) and Manufacture of other electrical equipment and accesories (3359). The cluster of metallic minerals is directly linked to the automotive industry, as part of the value chain of the industry, however, according to the analysis of interactions, this does not have strong relationships and therefore taken as another Cluster .

These activities together account for 2.60% of regional GDP and are located primarily in San Luis Potosi, Fresnillo, Zacatecas, Guanajuato and Celaya.



Source: Authors with ARCGIS 10 and the matrix of the North Central region.

As for the manufacture of other electrical equipment and accesories, simple and total interaction index point out that this activity has the mayor linkages. Its product is due is in 52% to specialized inputs in the region. In addition its product is totally required by the other sectors of the region.

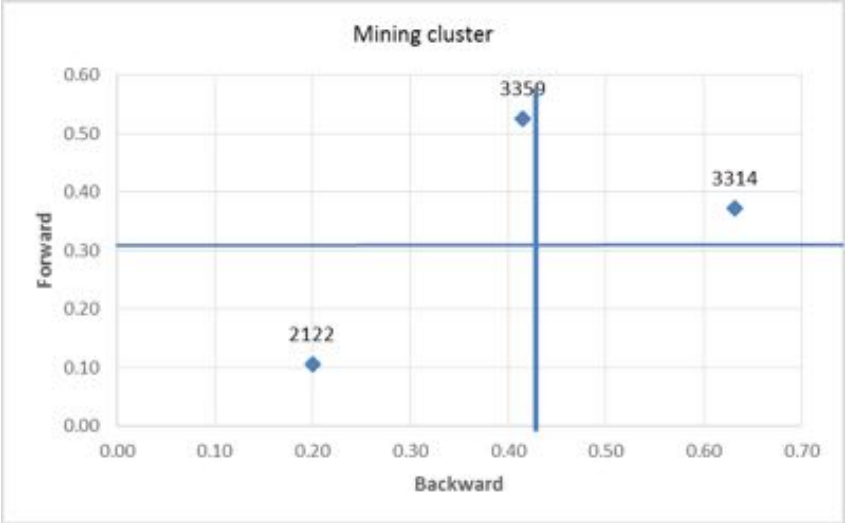
The case of the total interdependence to an increase of one peso of the manufacture of other electrical equipment and accesories, all other branches should increase by 80 cents. While to an increase of one peso of the other branches, the manufacture of other electrical equipment and fittings must increase by 2.56 pesos.

**Simple and total Interdependence effects**

Branch	Name	Backward simple interdependence	Forward simple interdependence	Backward total interdependence	Foward total interdependence
2122	Mining of metal ores	0.104873	0.301206	1.135143	2.019673
3314	Industries nonferrous metals except aluminum	0.37212	1.17492	1.495428	3.278651
3359	Manufacture of other electrical equipment and fittings	0.525843	0.991788	1.805391	2.566668

Source: Authors with data from INEGI and the matrix of the North Central region

Chenery and Watanabe index let us to validate the characterization of the economic-spatial structure. In this Cluster, the activity that generates strong backward and forward linkages is the industries of nonferrous metals, except aluminum and is located in San Luis Potosi and Celaya. While manufacturing activity of other electrical equipment and accesories only generates strong forward linkages.



Source: Authors with data from INEGI and the matrix of the North Central region

#### **4. Conclusions**

The application of regional input-output spatial approach shows the results of the production chains of different industries and its association with the spatial structure of the north-central region. So, the methodology approach lead to validated as key centers of industrial activity, the cities of Leon, Aguascalientes and San Luis Potosi, which coincides with the main nodes of regional economic activity.

Moreover, the drag effects given by chains located allow us observing the effect of pulse and spread of such centers spread over the rest to expand the production chain in each case and the response they have if there is a change in the final regional demand.

These results contrast with the agregate character and spatially homogeneity to be derived from having built the regional matrix from adjusting the national matrix, which would imply their lack of usefulness to understand how it is structured and how economy operates in the region and eventually for formulating policies for economic and social development.

However, it is considered that this approach should be deepened methodologically, in order to allow a discussion of the economic performance of the region, which involves generating additional information, probably by estimating regional economic accounts, homologated with the country and by expanding subregional and inter-regional analysis.



## References

Asuad Sanen Normand Eduardo (2014) Pensamiento económico y espacio, Colección economía regional y urbana, Volumen Primero, Facultad de Economía de la UNAM.

Asuad Sanen Normand Eduardo (2007a) Un ensayo teórico y metodológico de sobre el proceso de concentración económica espacial y su evidencia empírica en la región económica megalopolitana de 1970 a 2003 y sus antecedentes.

Asuad Sanen Normand Eduardo (2007b) Una propuesta metodológica para la delimitación de regiones económicas a través de un índice de interacciones económicas, el caso de la región Noreste del país.

Asuad Sanen Normand Eduardo (2001) Economía regional y urbana. Introducción a las teorías, técnicas y metodologías básicas. Benemérita Universidad Autónoma de Puebla, Colegio de Puebla, Asociación de Exalumnos de economía de la FE-UNAM.

Dávila, F. (2002). Matriz de insumo-producto de la economía de Coahuila e identificación de los flujos intersectoriales más importantes. Economía Mexicana. Nueva Época, Vol. XI, núm. 1.

Flegg A. T., Webber C.D. & Elliot M. (1995). On the appropriate use of location quotients in generating regional input-output tables. Regional Studies, Vol. 29, No 8.

Flegg A. T. & Webber C.D. (1997). On the Appropriate Use of Location Quotients in Generating Regional Input-Output Tables: Reply. Regional Studies, 1997, vol. 31, issue 8, pages 795-805.

González O. E. (2010). Identificación de Cadenas de Suministro Agrupadas en Clusters en México. México: Quinto Coloquio Interdisciplinario de Doctorado-Universidad Popular Autónoma del Estado de Puebla.

Fuentes, N. A. y Brugués A. (2001), "Modelos de insumo-producto regionales y procedimientos de Regionalización," Revista Comercio Exterior, Vol. 51 Núm. 3 págs. 33-54.

Fuentes A. (2003). Matrices de insumo-producto de los estados fronterizos del norte de México. México: Universidad Autónoma del Estado de Baja California.

Chapa Cantú, J., Ayala E. y Hernández D. (2009) Modelo de insumo producto para el noreste de México. Ciencia UANL, Vol. 12, No.4

Chapa et al. (2009). Modelo insumo producto para el Noreste de México. Ciencia UANL, vol. XII, No. 4, págs. 409-416.

Miller y Blair (2009), Input.Output Analysis, Cambridge University

Soto. V.G. (2000). "El insumo-producto, diseño y uso en los análisis de economía regional: el caso de Nuevo León". Estudios Económicos, núm. julio-diciembre, pp. 281-309.

Vazquez, RC. (2010). "Regionalización económico-funcional de la Región Centro Norte de México. Un caso del enfoque espacial de la economía utilizando Sistemas de Información Geográfica (SIG's)". Facultad de Economía . UNAM. Tesis de Licenciatura.

Vazquez, RC. (2013). "Concentración económica industrial y la formación de áreas funcionales industriales en la Región Centro Norte de México. 1998-2008." Facultad de Economía . UNAM. Tesis de Maestría.

Quiñones LE. (2014). Cluster automotriz en la región Centro Norte de México: metodología e impactos en el crecimiento económico, 1993-2008. Un enfoque espacial. Facultad de Economía. UNAM. Tesis Maestría. *En proceso*

## Annex

Specialized Branches			
Code	Description	Code	Description
3241	Manufacture of petroleum and coal	2372	Division of land and construction of urbanization
3361	Manufacture of cars and trucks	3253	Manufacture of fertilizers, pesticides and other agrochemicals
3363	manufacture of automotive vehicle parts	3336	Manufacture of internal combustion engines, turbines and transmissions
3115	Manufacture of dairy products	8123	Funeral services and cemetery management
3121	Beverage industry	3321	Manufacture of forged and stamped metal products
3312	Manufacture of iron and steel	3362	Manufacture of bodies and trailers
3162	Shoemaking	5614	Secretarial service, photocopying, collections, credit research
3256	Manufacture of soap, cleaning and toilet preparations	2123	Nonmetallic Mineral Mining
3352	Production of electrical household appliances	3327	Metalworking and manufacture of screws
2122	Mining of metal ores	6211	Medical offices
5171	Wired telecommunications operators	8113	Repair and maintenance of machinery and agricultural, industrial, commercial equipment and services
3114	Canned fruits, vegetables and prepared foods	4321	Wholesale trade of textiles and footwear
3111	Animal food processing	4341	Wholesale of agricultural raw materials and forestry
4311	Wholesale Grocery and food	3141	Carpet weaving, whites and similar
3359	Manufacture of other electrical equipment and fittings	4633	Retail footwear

<b>3116</b>	Slaughter, meat packing and processing of livestock, poultry and other edible animals	<b>3149</b>	Manufacture of other textiles, except apparel
<b>3311</b>	Basic industries of iron and steel	<b>4882</b>	Services related to transportation by rail
<b>3314</b>	Industries nonferrous metals except aluminum	<b>3131</b>	Preparation and spinning of textile fibers, yarn manufacturing
<b>3222</b>	Manufacture of paper and paperboard	<b>8131</b>	trade associations, labor, professional and recreational organizations
<b>4611</b>	Retail stores and food	<b>3372</b>	Manufacture of office furniture and shelving
<b>3262</b>	Manufacture of rubber	<b>3169</b>	Manufacture of other products of leather, fur and substitute materials
<b>2373</b>	Construction of roads	<b>4869</b>	Pipeline transportation of other products
<b>4312</b>	Wholesale of drinks, ice and snuff	<b>5619</b>	Other support services to business
<b>3161</b>	Tanning and dressing of leather and fur	<b>3369</b>	Manufacture of other transport equipment
<b>3271</b>	Manufacture of products based on clays and refractory minerals	<b>4631</b>	Retail trade of textile products, except clothes
<b>4841</b>	General cargo transportations	<b>3333</b>	Manufacture of machinery and equipment for trade and services
<b>2221</b>	Collection, treatment and supply of water	<b>4351</b>	Wholesale of machinery and agricultural, forestry and fishing equipment
<b>4684</b>	Retail trade of fuels, oils and greases	<b>3159</b>	Confection of clothing accessories and other clothing not classified elsewhere
<b>3344</b>	Manufacture of electronic components	<b>6244</b>	kindergartens
<b>4852</b>	foreign collective passengers transport, fixed route	<b>4871</b>	Land Sightseeing Transportation
<b>3323</b>	Manufacture of metal structures and blacksmith products	<b>7113</b>	Promoters of artistic, cultural, sports and similar events
<b>5223</b>	Credit unions and savings institutions	<b>5152</b>	Programming production of channels for tv systems, cable tv or satellite
<b>3326</b>	Manufacture of wire, wire products and springs	<b>7115</b>	Artists, writers and independent technical
<b>3132</b>	Fabric manufacturing	<b>4879</b>	Another tourist transport
<b>3255</b>	Manufacture of paints, coatings and adhesives	<b>6231</b>	Homes with nursing care for convalescent, rehabilitation, incurable and terminal

