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Identification of Key Productive Sectors in the Mexican Economy

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This article focuses on identifying what are the key sectors with high potential for drag induced investment in the Mexican economy, also characterizes the sectors according to their hierarchy, impact and degree of articulation. To achieve this the input-output matrix national 2003 was used (disaggregated into 20 sectors and 79 sub-sectors), provided by the official government agency responsible for generating statistical information, which applied the traditional method of calculation of multipliers which takes into account both relations hierarchical such as circular between the productive sectors of Rasmussen (1956). The originality of the work lies in the application of the social networks theory to determine (García, Morillas and Ramos 2005, 2008): a) total effects, b) immediate effects, and c) mediative effects of sectors and thus have a full diagnosis of key sectors of the economy under study. In general, the findings indicate that for the promotion of growth and productive development, efforts should focus on manufacturing industries, which means to apply an active industrial policy.

Keywords: *input-output analysis, social network theory, inter-sectorial relations, key sectors, Mexico, development, economic growth.*

JEL Classification: *O10, O11, O21, R11.*

1. Introduction

Mexico is a developing country facing a myriad of problems, one of the most important, in economic terms, is the low rate of growth of its economy, which has had severe consequences on the ability to generate jobs and therefore income that help to improve the welfare of the population. On annual average, between 1982 and 2014 the economy, in per capita terms, barely grew 0.5%, a truly insignificant figure. Given this situation, it becomes relevant, studies that contribute to clarify the way in which the authorities could act to solve the problem.

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This paper seeks to contribute in this regard, using information contained in the matrix of national input-output for 2003 with the aim of identifying those sectors that are the most important, through their productive linkages, both forward and backward, sectors with a high potential for drag. This is vital, since before resources that normally are scarce, its use in this way should be prioritized, and thus the paper by identifying sectors of greatest relevance contributes with information for decision-makers that are focused on the promotion of economic growth.

It should be stressed that the analysis of the productive structure of an economy based on so-called inter-sectorial linkages allows to characterize the degree of interaction and dependence between productive sectors, this type of analysis provides the following advantages: a) allows you to identify what are the key sectors with high potential for investment induced drag, b) characterizes the sectors according to their hierarchy (impact and degree of articulation, and c) provides information of practical use for planning the growth and productive development.

In the paper the task of identifying key sectors from the input-output matrix is performed using as a reference the traditional works of Leontief (1936) and Rasmussen (1956), but particularly García, Morillas and Ramos (2005 and 2008). The identification is carried out with 20 sectors (1: Agriculture, forestry, and fishing; 2: Mining; 3: Electricity, water and gas; 4: Construction; 5: Manufacturing industries; 6: Commerce; 7: Transportation; 8: Post office and storage; 9: Information in mass media; 10: Financial and insurance services; 11: Real estate and rental services; 12: Professional, scientific and technological services; 13: Corporate management and business; 14): Business support services; 15: Educational services; 16: Health and social care services; 17: Recreational services; 18: Hotels, food and beverages; 19: Other services; 20: Government activities) and 79 subsectors (by extension are specified in table 3).

The paper innovates in the Mexican case making use of the Social Networks Theory (SNT), which unlike the traditional analysis, focused the study on a set of observed relationships between the actors in a network or group –for example, the structure of supply and demand of an economy– and not on the individual characteristics of the same –e.g. volume of production in a sector, final demand, value-added, etc. –. In particular, the study of the productive structure allows us to respond to the following questions: What are the key productive sectors, driving, strategic and independent in the economy derived from their production chains? What is the relative influence that has, by its position, a sector particularly on the overall economy? What is the capacity and speed of diffusion of the relative influence between elements –sectors and subsectors of activity– and particular substructures of the economic framework?

The work was structured in three parts. The first summarizes the existing literature in this regard, according to a scan performed in the electronic databases Repec, Scielo, Dialnet and Jstor. The second presents a synthesis of the methodology used, as well as the source of the data. The third part presents the results of identification of key sectors with a breakdown of 20 and 79 subsectors. Finally the findings are summarized and brief suggestions of economic policy are made for the promotion of economic growth in Mexico.

2. Literature Review

Efforts to identify key sectors of an economy based on the information provided by the input-output matrix are numerous internationally, a first work encountered was that of Meller and Marfan (1981), who studied the relevance of the small and large industry in relation to the problem of job creation in a developing country. His work examines the forward and backward linkages and identifies key sectors for the generation of employment within the Chilean industrial sector. One of his most important findings is that the sectors associated with the manufacturing of large scale are those who have a greater positive effect on employment generation, particularly: large industry-food, beverages, textiles, wood, paper, leather, and basic metals; small industry-wood, machinery except electrical, and diverse manufacturing.

On the other hand, with information from the input-output matrix of the Andalusian economy for 1980, Cuadrado and Aurioles (1984), analyzed the intersectorial relationships with a simple and conventional methodology proposed by Chenery and Watanabe (1958), from which found that there are two separate structural imbalances in this economy, and prevailing high participation of the primary activities and a reduced share of industrial activities. The identified key sectors are agribusiness, certain branches linked to the export of natural resources and construction. His work also able to determine industrial sites that rely heavily on imported components that sell most of their production abroad.

Using the SNT and the input-product matrix of the Andalusian economy, García, Morillas and Ramos (2005) calculated the total, immediate and mediative effects, finding that the productive relations are not structured around branches of high technology that is an obstacle to the spread and development of it, their work is the first encountered in the implementation of this new approach and hence its reply to the Mexican

case in this paper. These authors recognize that although manufacturing industries continue to be key in the development, increasingly charges a greater boost the role of the services associated with the knowledge economy. García, Morillas and Ramos (2008) updated its previous research with information from the Spanish economy for 71 industries and the European Union for the year 1995 with 25 branches. Unlike the previous work, now added an index of sectorial influence, so that their results suggest that Spain shows a similar performance to the European Union, with the construction sector pushing the economy and an essential industry for the whole activity. The manufacturing sector reveals the basic differences between the two territories. Spain still shows a traditional structure with an important presence of the metallurgic sector due to its history, while Europe has a better relative position in the high technological segment. On other hand, the tertiary sector presents a similar position in both economies.

In the case of the Chilean economy, Soza-Amigo (2011), identifies the products and activities that are key to the Chilean regions, forming clusters and structural similarity that exists between them. For this, used a combination of so-called Important Coefficients and Fields of Influence. Their study lets you know the productive structure of each of the regions of that country from which makes a number of recommendations for economic growth.

Hernandez (2012), using data from the Colombian economy for 2007, to which applies the method of chains and multipliers of the input-output matrix, which allows you to determine that there are strong links between sectors and sectors of petroleum, chemical, plastics, electricity and gas, transport and communications have a great influence on the demand and the supply of others. Finally, it concludes that the sectors of civil works, other services and chemicals and plastics are the greatest generators of employment in the economy.

Finally, regarding the international review, in a recent study of the Spanish economy, Cansino *et al* (2013) present the social accounting matrix corresponding to 2007 at basic prices. From this, key sectors of the economy are identified through three different methodologies: the methodology proposed by Rasmussen, hypothetical extraction method and finally the method of product matrix multiplier. The analysis of key sectors with the use of these methodologies leads to conclusions which, in some cases, are very different and contradictory.

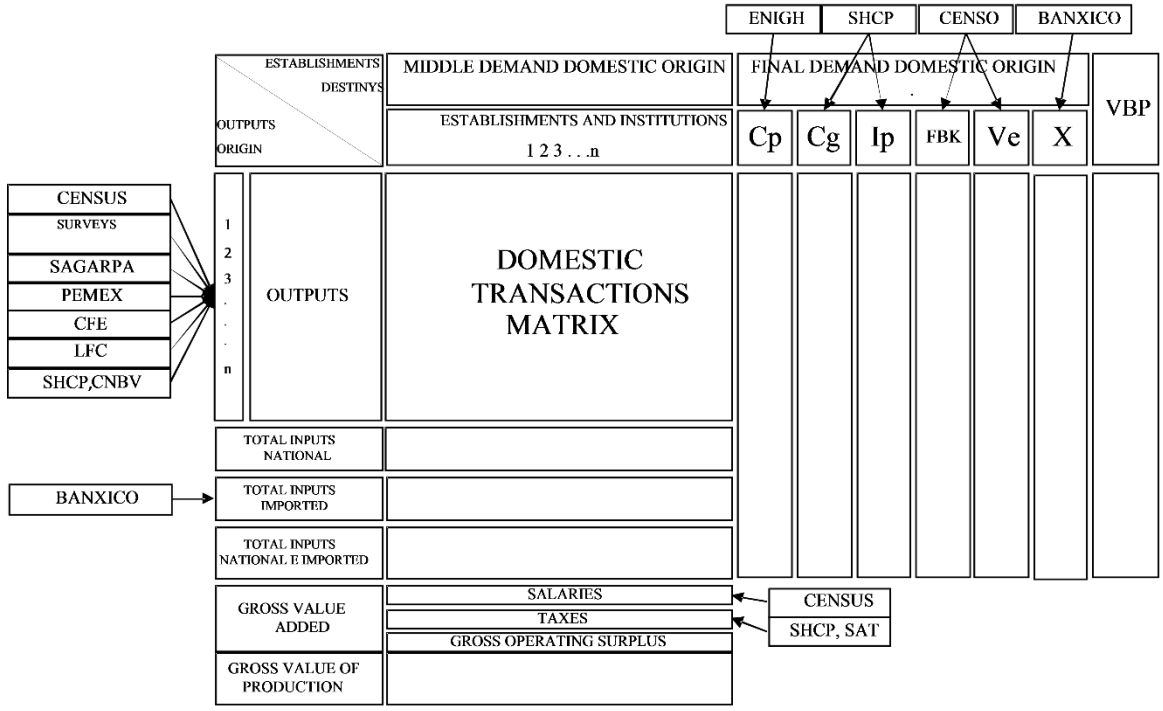
For the Mexican case highlights the work of Fuentes and Sastré (2001) and Fuentes (2009) who performed the identification of key sectors for two subnational economies; while Sobarzo (2011), from an applied general equilibrium model reproduces an input-output model, which serves as a basis for estimating Leontief's multipliers, allowing you to perform some exercises of impact of economic policy in a context of crisis. Finally, Albornoz, Canto and Becerril (2012), carried out the estimation of the input-output matrix for a sub-national economy in southeastern Mexico from which identified key sectors and propose how to best allocate resources to those sectors with greater linkages and therefore a notorious multiplier effect resulting in increased growth. The review shows that the exercise proposed in this article fills a gap existing in the literature by applying a new methodology for the identification of key sectors of the Mexican economy.

3. Research Methodology

The information contained in the matrix of the input-output from 2003, published by the National Institute of Statistics and Geography (INEGI in spanish), was used in the estimation of key sectors of the Mexican economy in two versions: one made up of 20 sectors and the other disaggregated 79 subsectors of economic activity. The input-output matrix of Mexico that was used was constructed using the rules of the North America Industry Classification System (NAICS).

For the construction of the matrix is required to put in place a set of activities, as the concentrating, analyzing and processing of basic information from multiple sources: economic censuses, agricultural, population censuses, household income and expenditure surveys, administrative records and fundamentally national accounts.

The information that concentrates the input-output matrix has its origin in the balance of supply and aggregate demand, that consists of comparing product-by-product supply and use of goods and services available in the economy, both domestic production and imports of products and services. Figure 1 details the sources of information used by the INEGI for building national matrix.



Cp: Private consumption
Cg: Public consumption
Ip: Public investment
FBK: Gross fixed capital formation
Ve: Variation of stock
X: Exports
VBP: Gross value of production

Figure 1*. Sources of information to construct the input-output matrix in Mexico*
Source: Own elaboration

From the matrix, two procedures were used for estimation of key sectors, on the one hand chains of Rasmussen (R) method and the Social Networks Theory (SNT). Rasmussen (1956) posed a quantification of linkages from the inverse matrix of the input-output table. Thus, adding the columns of the inverse scattering power of a sector or the expansion of its effects on the production network is obtained. Adding rows of the same matrix gets the sensitivity of dispersion of a sector or the extent in which the sector is dragged by the expansion of the economic framework. Thus, suggests two measures based on Leontief inverse matrix to quantify the direct and indirect effects backward (BL^R) and forward (FL^R) that a may experience a sector. The normalized measurements are obtained from the following expressions:

$$BL^R = \frac{ni'(I-A)^{-1}}{i'(I-A)^{-1}i}$$

$$FL^R = \frac{n(I-A)^{-1}i}{i'(I-A)^{-1}i}$$

Thus we have (BL^R) which is known as scattering power and (FL^R) as sensitivity of dispersion. From this indicator, the activities are grouped into four types: 1) sectors with weak backward and forward linkages (independent); 2) sectors with high forward linkages and low backward linkages (driving sectors); 3) sectors with low forward linkages and high backward linkages (base sectors); and 4) sectors with strong forward and backward linkages (key sectors). Due to which these measures are sensitive to extreme values, instead of using the arithmetic means the coefficient of variation (standard deviation from the average in their classification) was used for each indicator. With respect to the limitations of this technique, see Fuentes and Sastré (2001).

***Table 1**. Rasmussen's (R) production chains*

	BL^R < Average	**BL^R > Average**
FL^R > Average	II. Driving sectors	IV. Key sectors
FL^R < Average	I. Independent sectors	III. Base or strategic sectors

Source: Own elaboration

The SNT has erupted into economic science as a new tool for structural analysis based on the work developed by Bavelas (1948), Granovetter (1973), Friedkin (1991), Rauch and Castella (2001), Garcia, Morillas and Ramos (2005 and 2008), among others. This approach focuses the analysis on the set of observed relationships between actors in a network or group –for example, the structure of supply and demand in an economy– and not on the individual characteristics of the same –e.g., volume of production of a sector final demand, value added, and so on–. Similarly, the SNT allows to evaluate what are the effects generated by the central actors on the whole of the network, the speed with which an actor is related to the others and its transmission capacity of such effects.

The above is collected within the generic concept called centrality, to analyze the structural properties and the location of agents in the network. The concept determines the position of an agent in the network, either by its importance, influence, relevance or prominence. Similarly, this notion of centrality led input-output model helps to determine the relevance of a sector in the economic framework.

Following the methodology of Friedkin (1991) and Garcia, Morillas and Ramos (2008), the following indicators of centrality were used: a) total effects, b) immediate effects and c) mediative effects. These measures allow identifying the position, impact and degree of articulation presenting each of the productive sectors through the determination of the total effects exerted a sector on the whole economy, the speed with which relate to other sectors and importance as a transmitter element within the network of exchanges.

The indicator of total effects of centrality, as its name implies measuring the total effects of a sector and their relative influence on the other sectors in the economic framework, in the context of the input-output analysis global cross-sectorial effects are essentially determined by the number and length of the existing roads between sectors through specified productive relationships, this effect is captured from the following expression:

$$\boldsymbol{V} = (\boldsymbol{I} - \alpha\boldsymbol{A})^{-1}(1-\alpha) = (\boldsymbol{I} + \alpha\boldsymbol{A} + \alpha^2\boldsymbol{A}^2 + \alpha^3\boldsymbol{A}^3 + \ldots)(1-\alpha) \qquad 0 < \alpha < 1$$

In this case, V is an associated matrix from development of inversion matrix known as the method of expansion of powers, this technique captures the direct and indirect transactions, and may assert that the sector j influences globally relative to sector i, for $v_{ij} \neq 0$, being the v_{ij} the i,j-th coefficient of the matrix V; and at the same time the parameter (α) is a weighting which allows to quantify the capacity of influence between sectors. The matrix of full cross-sectorial effects (V) meets several conditions among which we can point to that it is a stochastic matrix by rows:

$$0 \leq v_{ij} \leq 1$$

and

$$\Sigma_j^n v_{ij} = 1$$

Of the foregoing, the more central is the position of a sector to interact with the rest –less number of steps through which two sectors are interrelated– the greater impact of their transactions; while equal distances between sectors caused effect depends on the intensity of the relationship in (αa_{ij}).

Assuming the existence of a network of influence regular; i.e., without sectorial extreme polarization and the hypothesis that the cross-sectorial influences weighting coefficient tends to the unit ($\alpha \rightarrow 1$) the matrix V could converge to a V_u matrix defined as:

$$\boldsymbol{V_u} = \begin{bmatrix} \boldsymbol{c}_1 & \ldots & \boldsymbol{c}_n \\ \ldots & \ldots & \ldots \\ \boldsymbol{c}_1 & \ldots & \boldsymbol{c}_n \end{bmatrix}$$

With the characteristic that the total cross-sectorial effects *j* are constant, i.e., $v_{ij}=c_i$, where $(0\leq c_i\leq 1)$ convergence of the matrix of total effects of centrality is guaranteed if and only if (for a formal demonstration see Friedkin and Johnsen, 1990):

$$\boldsymbol{V}=\lim_{\alpha\to 1}-(\boldsymbol{I}-\alpha\boldsymbol{A})^{-1}(\boldsymbol{I}-\alpha)=\boldsymbol{A}^{\infty}=\boldsymbol{V}_{\boldsymbol{u}}$$

Such that A^{∞} coincide with the matrix V_u which in turn reflects the steady state of the process $(c_1,\ldots,c_n)$. Hence the total effect of centrality of a particular sector *j* in the network are listed in column *j* of the matrix $V=V_u$, such that the total effect of centrality ($T_{TEC(j)}$) is defined as:

$$\boldsymbol{T}_{\boldsymbol{TEC}(\mathrm{j})}=\mathbf{V}'\boldsymbol{\Phi}$$

Where *T* is a vector (nx1) order; $\Phi = \{1/n\}$ is a vector (nx1) order and *V*' is the transposed matrix *V*. The matrix expression is simply the average of the elements in the columns of the matrix *V*, in such a way that the higher this value, greater force shall in the sector totals on the overall economy.

The second measure of centrality of a sector refers to the speed of transmission of the sectorial total effects in the network, in other words, sectors whose effects are transmitted through long paths of economic relations have one smaller economic impact than those others with a high number of direct transactions. In this way, not only are seen smaller multiplier effects (Morillas, 1983), also there is a minor effect in the transmission of processes of innovation (García, Morillas and Ramos, 2008).

To formalize this measure requires two assumptions: first, the sequence of cross-cutting influence of sector *j* to a sector *i* in which the first sector appears only once, and second, take again the hypothesis that ($\alpha\rightarrow$ 1) in the context of a network of regular influence, once obtained such effects is defined influence relative of a sector *j*, as the average length of their economic transactions weighted sequences each of them by the force of established sectorial relations (Kemeny & Snell, 1960, p. 79, quoted in Friedkin, 1991, p. 1486).

$$\boldsymbol{M}=(\boldsymbol{I}-\boldsymbol{Z}+\boldsymbol{E}\boldsymbol{Z}_{\boldsymbol{dg}})\boldsymbol{D}$$

Where *D* is a diagonal matrix with elements $d_{ii}= \{1/c_i\}$, c_i is an element of the matrix V_u; *Z* the fundamental matrix defined as $Z=(I-\alpha A + A^{\infty})^{-1}$; *E* is a unitary matrix of order (nxn); and Z_{dg} is *Z* setting to zero the elements outside the main diagonal.

How quickly a sector relates to which economically with others is expressed in the respective columns of the matrix *M*. The immediate effects ($T_{IEC(j)}$) indicator is calculated as the inverse of the average lengths of intersectorial relations (roads) a sector *j*-th.

$$\boldsymbol{T}_{\boldsymbol{IEC}(\mathrm{j})}=\left(\frac{\sum_{i=1}^{n}\boldsymbol{m}_{\boldsymbol{ij}}}{\boldsymbol{n}}\right)^{-1}$$

In matrix is expressed as:

$$\mathbf{r}=\mathbf{n}\boldsymbol{\varphi}$$

Where

$$\varphi=\{\varphi_{\mathrm{j}}\}=\left\{1\Big/\sum_{i=1}^{n}\boldsymbol{m}_{\boldsymbol{ij}}\right\}$$

is a vector (nx1) order and m_{ij} is an element of *M*. From the above we have that, the greater the value of the index's immediate effects ($T_{IEC(j)}$), the greater the rapidity with which to propagate the total effects of the sector considered. It is important to note that the immediate effects of centrality or the speed of dissemination of the full effects are not considered by the traditional approach, so it is a contribution of the SNT to the structural analysis (García, Morrillas and Ramos, 2008).

The third measure of centrality indicates the degree of importance that a particular sector has as the overall effects transmitter; in other words, it indicates those sectors that provide the performance and economic

interconnection. These economic sectors operate in the system as connectors and are relevant to the joint development of the economy.

The estimation of the mediative effects is obtained from the matrix *M* by decomposition in the number of steps from one sector *j* to another sector *i*, through several intermediate steps:

$$m_{ij} = \sum_{k=1}^{n} t_{(j)ik} \qquad i \neq j \neq k$$

Where $t_{(k)ik}$ is the i_k generic element of the matrix *T*, which is defined as:

$$T_{(j)} = (I - \tilde{A}_{(j)})^{-1}$$

So $\tilde{A}_{(j)}$ is the resulting matrix of eliminating the *j*-th row and column of the matrix *A* (Kemeny and Snell, 1960 cited in García, Morillas, and Ramos, 2008). The mediative effects ($T_{MEC(j)}$) indicates the relevance of a *j*-th block as a transmitter for connecting the economic framework.

$$T_{MEC(j)} = \left(\frac{\sum_{k=1}^{n} \bar{t}_{(k)j}}{n} \right) \qquad j \neq k$$

Where:

$$\bar{t}_{(k)j} = \left(\frac{\sum_{k=1}^{n} t_{(k)ij}}{(n-1)t_{(k)ij}} \right) \qquad i \neq j$$

The effects of intermediation, indicative of the importance of a particular sector as a transmitter or as a crossroads for the economic network connection can be expressed from the definition of the matrix

$$\bar{T} = \{\bar{t}_{(k)j}\}$$

$$\mathbf{c} = \bar{\mathbf{T}}\boldsymbol{\varphi}$$

Where

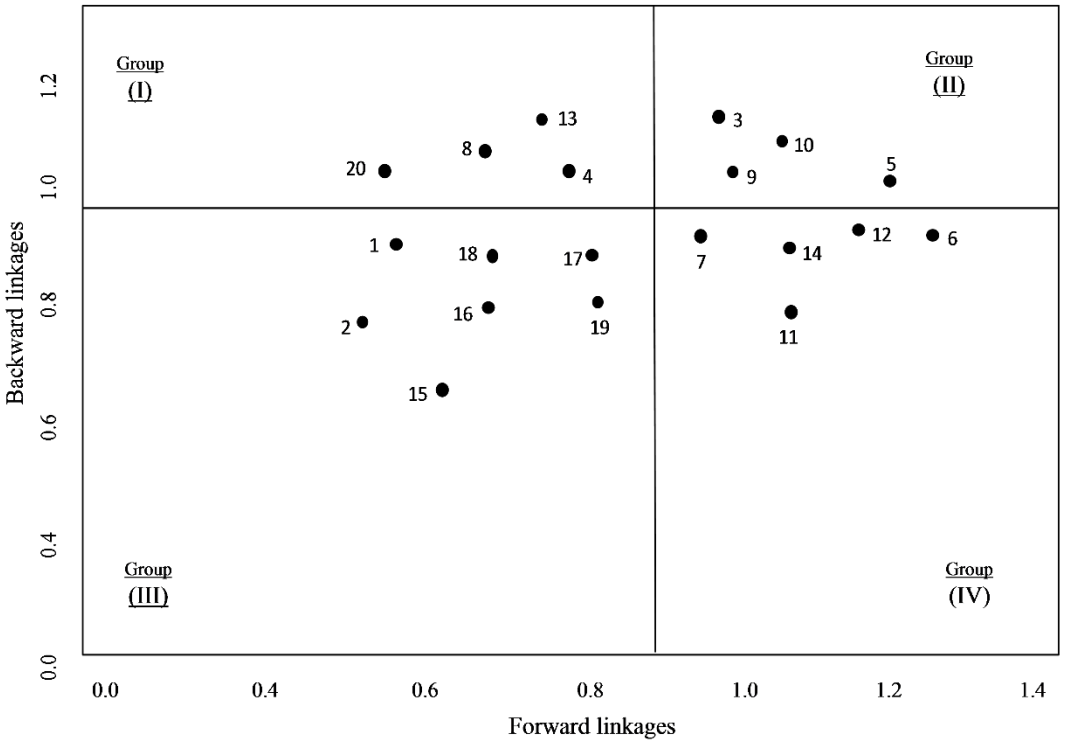
$\boldsymbol{\varphi}$ is a column vector (nx1) whose elements are (1/n).

It should be added that the indicator of mediative effects to quantify the importance of intersectoral linkages effects, have similar coefficients Streit (1969) interpretation. However, the mediatives effects not only collect direct relations between the different sectors but also the indirect. Therefore it is a global indicator of the intensity of the total transactions; additionally, this indicator can clarify questions relating to the speed of diffusion of the considered total effects measuring the average length of the sequences of economic exchanges. The program Excel (hypothetical matrix), Matlab (calculation of the inverse matrix) and Netminer (social network analysis) was used for the calculations.

4. Analysis and Results

In what follows are presented the results of the application of the methods exposed to the information contained in the input-output matrix to determine the key sectors of the Mexican economy. The exercise was conducted with 20 sectors and 79 subsectors. In order to compare the results of the approach of SNT with traditional methods (Rasmussen, 1956), in the first order the sectorial management is presented from the economic weight of the relations of causality or productive backward and forward linkages.

The reason for exposing these indices is due to the advantages with regard to measures made by Chenery and Watanabe (1958), since they incorporate in estimating the effects of global chain that occur between both the supply side and the demand side, also include the effect of sectorial dispersion and weightings in the sectorial chains according to their relative importance in the final demand (Hazari, 1970). The results are presented in Graph 1.



Graph 1. *Rasmussen's productive chains (R)*
* Every number correspond to one sector, see the Table 2
Source: Own elaboration with information from input-output matrix at 20 sectors

From the obtained classification, group sectors base or strategic –most demanded in an economy sectors, but which in turn are plaintiffs, which are important for the cross-sectorial sales– make up sectors of commerce (6), transportation (7), real estate and rental services (11), professional, scientific and technological services (12) and business support services (14).

The group of key sectors –characterized for being strong intersectorial applicants suppliers of intermediate inputs and products, which are forced to step sectorial flows in an economy consists of the activities of electricity, water and gas (3), manufacturing industries (5) information in mass media (9) and financial and insurance services (10).

The group of drive sectors –that have few linkages forward, but which are, in general, sectors that have wide possibilities of drag and induce economic growth– includes construction (4), postal office and storage (8), corporate management and business (13) and government activities (20).

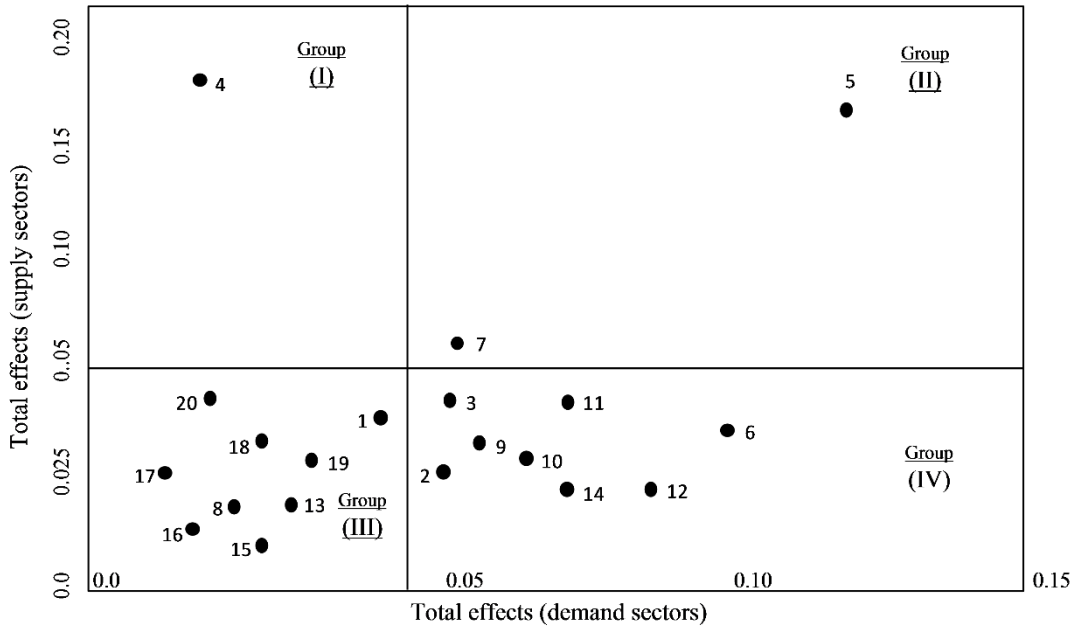
Within the group of independent or little linked with other sectors and to produce without great requirements or by other sectors –basically demanding supplies primary– have the sectors of agriculture, forestry and fishing (1), mining (2), educational services (15), health and social care services (16), recreational services (17), and other services, except government activities (19).

The above sectorial classification relating to sectorial global linkages based on the criteria of Rasmussen (1956) shows that five of them are classified as base or strategic activities, seven activities are independent, four activities are classified as drivers, and finally only four activities make up the group called key sectors.

The previous analysis is illustrative of the structural characteristics of the economic activities in terms of their chains or links with other sectors of the economy, but at the same time is incomplete, because that takes economic activities separate and depending only of the economic weight of each sector.

In an effort to complement the analysis, presents the results obtained when you enter the capacity for intersectoral influence; in other words, when we focus on the existence and intensity of cross connections from a global point of view, perspective posed by network theory. In the first order, the sectorial management based on the ability to pick intersectorial influence through rates overall effects of centrality as network theory is

presented (see Graph 2). The results were classified into four groups according to their centrality: I) semi-peripheral position, II) center position, III) peripheral position and IV) semi-central position.



Graph 2. *Total effects of centrality ($T_{TEC(j)}$)*
* Every number correspond to one sector, see the Table 2
Source: Own elaboration with information from input-output matrix at 20 sectors

A first difference from traditional analysis approach relates to the classification of the 20 economic activities in Mexico; only two activities have a central location; nine of them have a peripheral location; eight form the classification of semi-central location; and, finally, just one sector presented semi-peripheral localization.

Introducing weighting relative to the capacity of cross-cutting influence on the coefficients input-output, clearly presents a disturbing element that allows you to pick up the sensitivity of the sectors to its structural location within the network, an aspect not considered in the classical approach.

As it can be seen from Graph 2 the group of core sectors –which have a position of centrality in the economic network and play a key role in the intermediation of intersectorial linkages in the rest of the production set– is composed only by manufacturing industries (5) and transportation (7).

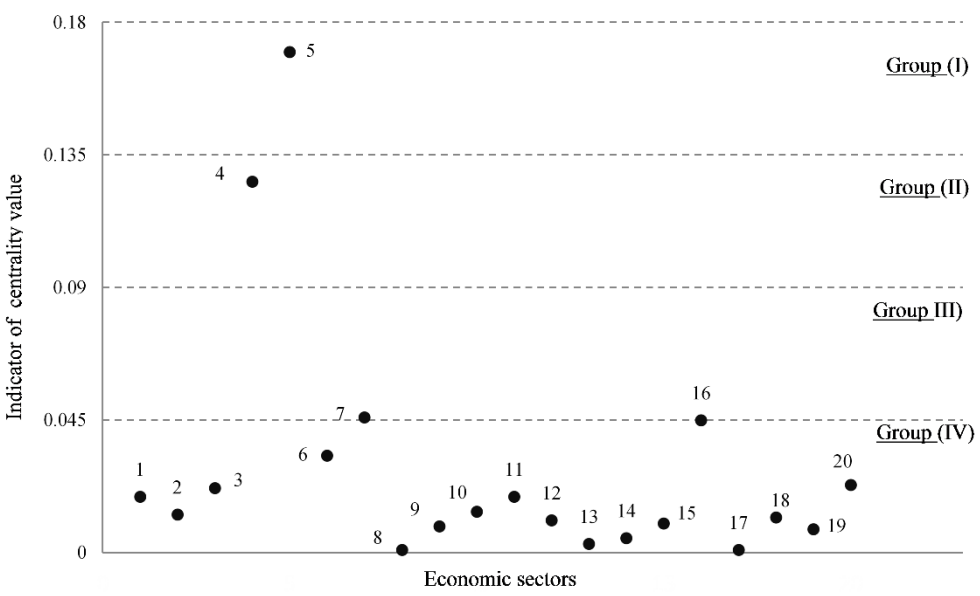
The peripheral sectors – that have a less central position and therefore, under the possible effects on the set economic network– consist of agriculture, forestry and fishing (1), corporate management and business (13), business support services (14), educational services (15), health and social care assistance (16), recreational services (17), hotels, food and beverage (18), other services except the government (19) and activities of the government (20).

The group of semi-central sectors –which are in a better position within the structure to influence– exclusively includes construction (4). Within the group of semi-peripheral sectors –which are best placed within the structure to be influenced– stand mining (2), electricity, water and gas (3), commerce (6), information in mass media (9), financial and insurance services (10), real estate and rental services (11), professional, scientific and technological services (12) and business support services (14).

As it was expected, the grouping of sectors depending on the centrality substantially change considering the capacity of intersectorial influence, appear only in this case, the manufacturing industries (5) and transportation (7) as key sectors. Moreover, by having a position of important centrality in the economic network, construction (4), manufacturing industries (5), commerce (6) and transportation (7), can transmit the total effects on the whole of the economy relatively quickly, playing an important role in the intermediation of intersectorial linkages with the rest of the productive sectors.

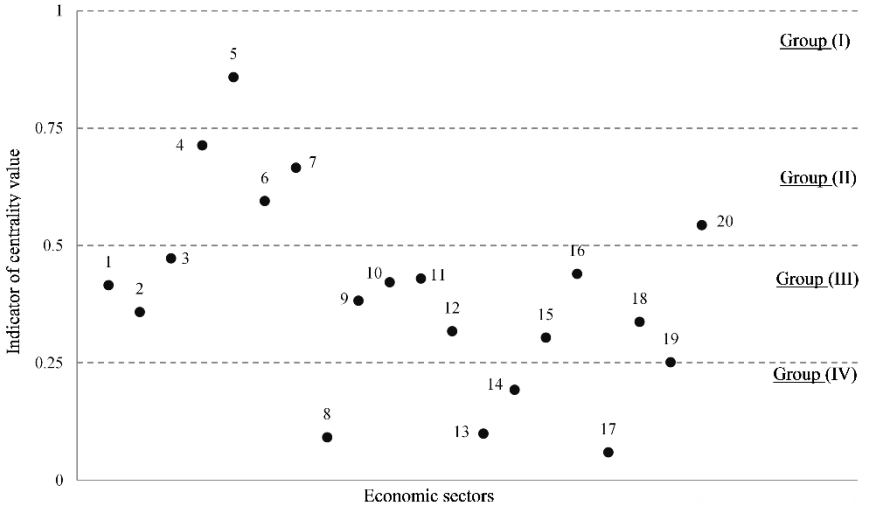
Continuing with the analysis, management sector now comes from the intensity of interconnections between sectors measured from the immediate effects of centrality. The sector with the greatest immediate effects of centrality is manufacturing (5) located in group I and construction (4) in group II. Followed with a wide gap sectors located in group IV which include primary activities such as agriculture, forestry and fishing

(1), mining (2), electricity, water and gas (3) secondary activities or commerce (6) and tertiary activities such as information in mass media (9), financial and insurance services (10), professional, scientific and technological services (12), educational services (15) and government activities (20), among others. In this indicator, the highlights were manufacturing industries (5) and construction (4) sectors, productive activities with greater impact and effects send all the activities of the national economy (see Graph 3).



Graph 3. *Immediate effects of centrality ($T_{IEC(j)}$)*
* Every number correspond to one sector, see the Table 2
Source: Own elaboration with information from input-output matrix at 20 sectors

Mediative effects of centrality indicator results are presented in Graph 4. Like previous results, the analysis confirms the relevance of manufacturing industries (5) as the sector with the highest overall effect of interconnection. In the following order –above the average level– are construction (4), commerce (6), transportation (7) and government activities (20). The former sectors are characterized by their direct and indirect effects that can be transmitted to other activities are very significant.

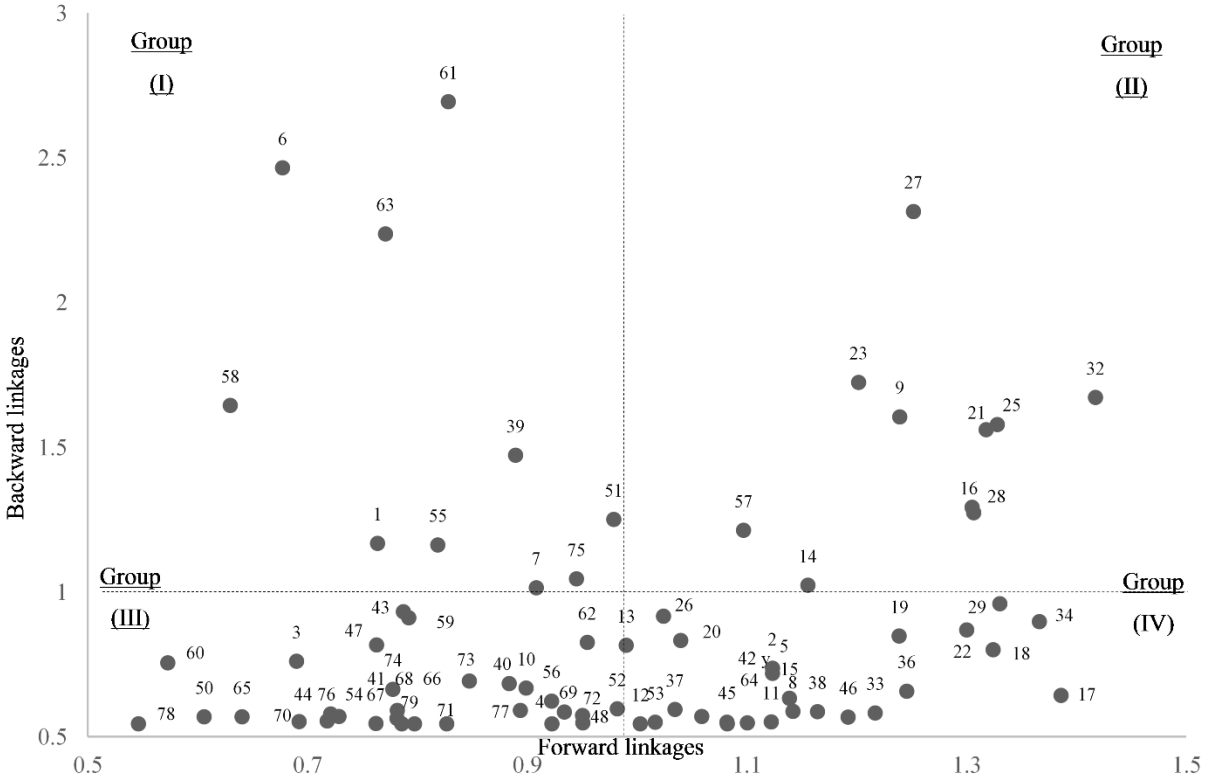


Graph 4. *Mediative effects of centrality ($T_{MEC(j)}$)*
* Every number correspond to one sector, see the Table 2
Source: Own elaboration with information from input-output matrix at 20 sectors

Among the sectors with lower transmission effects are post office and storage (8), corporate management and business (13), business support services (14) and recreational services (17). Similarly, highlights the low involvement of sectors related to human resources training, professional, scientific and technological services (12) and educational services (15).

In general terms, the structural analysis at this level of disaggregation indicates that there are strongly related sectors whose production dynamics is relevant within the economic structure. However, a better approach to structural analysis requires studying the national productive structure at a higher level of disaggregation, hence interest analysis to level for the 79 subsectors of activity.

As the first element of the input-output 79 subsectors of activity analysis, shows the sectorial management based on the productive chains according to the method proposed by Rassmusen (1956) (see Graph 5).



Graph 5. *Rasmussen's productive chains (R)*
* Every number correspond to one subsector, see the Table 3
Source: Own elaboration with information from input-output matrix at 79 subsectors

Based on this classification, the group of sub-sectors classified as strategic or base –which are the sectors most demanded in an economy, but which in turn are plaintiffs, which are important for the cross-sectorial sales– is made up of 27 sub-sectors (34%) where industry-related activities are observed: beverage and tobacco industry (15), manufacture of textile products, except apparel (17), manufacture of garments (18) wood industry (20), paper industry (21), plastics industry and rubber (25), manufacture of machinery and equipment (29), transport by rail (37), tourist transport (42), courier and parcel services (45), among others.

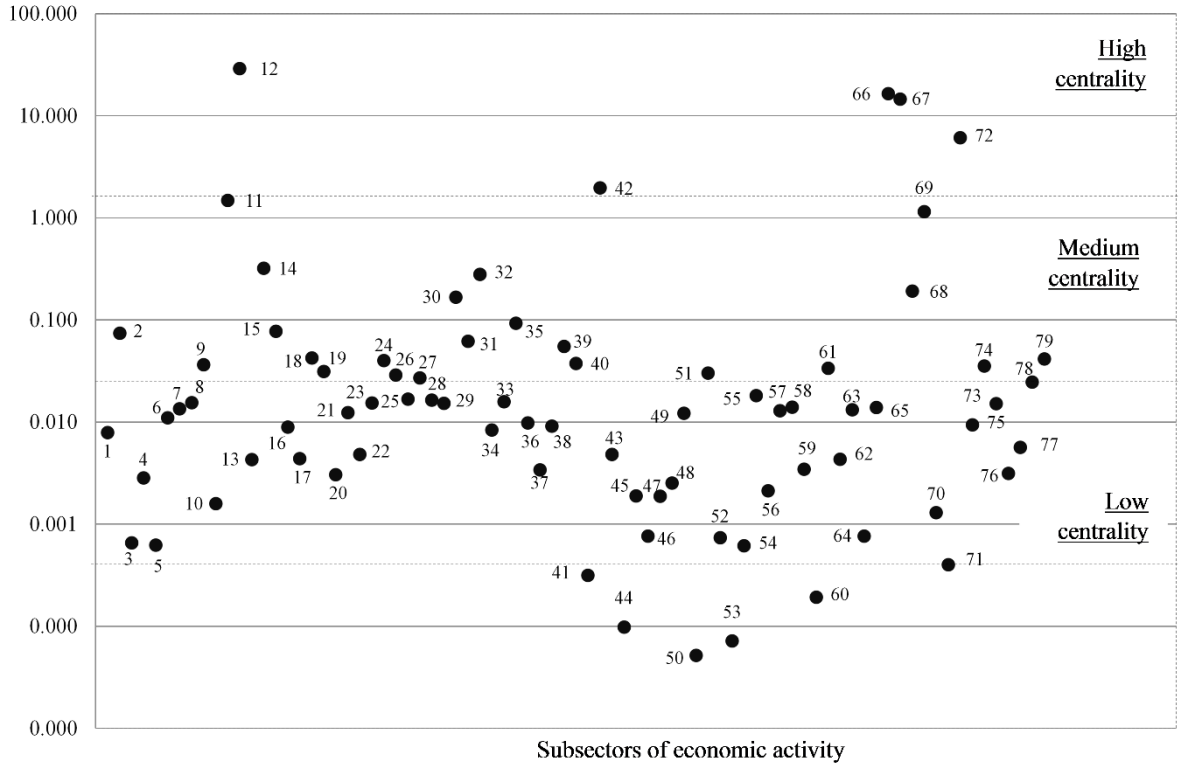
The group of key sectors –characterized for being strong intersectorial applicants suppliers of intermediate inputs and products, which are forced to step sectoral flows in an economy– is made up of 10 sub-sectors (13% of total). Again as expected, chiefly for industry related activities: generation, transmission and supply of electricity (9), food industry (14), manufacture of textile inputs (16), paper industry (21), petroleum and coal products manufacturing (23), plastic and rubber industry (25), basic metal industries (27), manufacture of metal products (28), manufacture of transport equipment (32), bonding, insurance and pensions (57).

The group of driving sectors –which have few linkages forward, but they are, in general, sectors that have significant potential to drag and economic growth-inducing– include 10 sub-sectors (13% of total) of the economy; in this group are primary activities: agriculture (1), oil and gas extraction (6), mining of metal ores, except oil and gas (7), and related human resource training high activities level as telecommunications (51),

professional, scientific and technical services (61), business support services (63), repair and maintenance services (75).

Finally, within the group of independent sectors or loosely bound to the rest and produce no major requirements from other sectors are 32 subsectors (40% of total) of the economy, this block concentrated activities mainly related to the services sector: passengers, except railway transport (40), pipeline transportation (41), postal services (44), editing publications and software, except for internet (47), creation and dissemination of content via Internet (50), central banking (54), foreign exchange trading activities and financial investment (56), business support services (63), educational services (65), consultation external an related medical services (66), residences of welfare and health care (68), artistic, sports and other related services (70), museums, historical sites, botanical and similar gardens (71), personal services (76), among others .

In this way, analysis of productive linkages to 79 sub-sectors reveals in greater detail the workings of the economy as a whole, at this level of disaggregation is possible to determine in terms of their productive connections, what are the key activities, base or strategic, independent and driving. However, it is incomplete because it takes economic activities separate and depending only of the economic weight of each subsector.



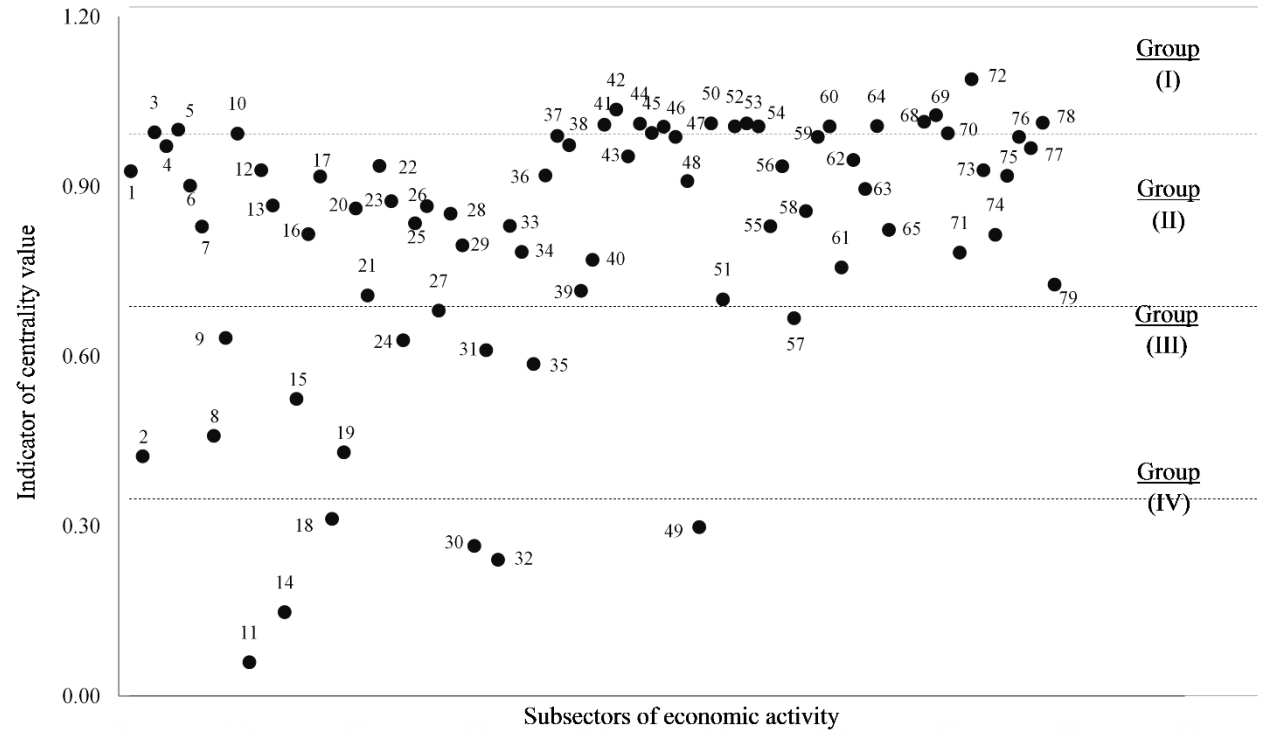
Graph 6. *Total effects of centrality ($T_{TEC(j)}$)*
* Every number correspond to one subsector, see the Table 3.
The centrality indicator values are presented on a logarithmic scale
Source: Own elaboration with information from input-output matrix at 79 subsectors

In order to perform a better representation of the structure and functioning of the economy, measures of centrality based on social network theory (SNT) were calculated. As the first element of the SNT total effects (see Graph 6) centrality indices are presented. After entering the relative ability of intersectorial influence on input-output coefficients, it is possible to observe the sensitivity of the subsectors of their structural location within the network, an aspect not considered in the traditional approach of input-output analysis.

As is clear from the analysis, the group of sectors "high centrality" – that have a position of centrality in the economic network and play a key role in the intermediation of intersectorial linkages in the rest of the production set– brings together seven subsectors (9% of total) which include: building (11), construction of civil engineering works or heavy work (12), food industry (14), tourist transport (42), hospitals (67), and other welfare services (69).

In the group of "medium centrality" activities or semi-central sub-sectors –who are in a better position within the structure– are 37 subsectors (47% of the total), some of these sectors are: livestock (2), generation, transmission and supply of electricity (9), beverages and tobacco industry (15), manufacture of transport equipment (32), government activities (79), among others.

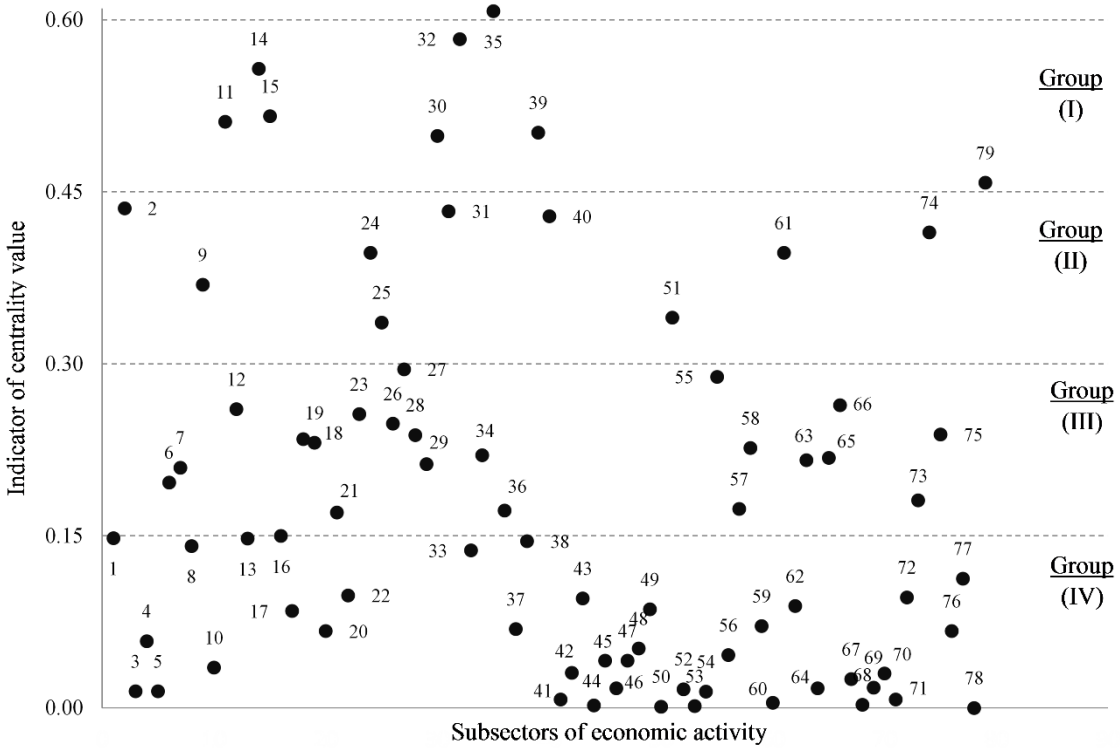
Finally, in the activities of the "low centrality" or peripherals group – which have a less central position and therefore least potential effects on economically network– they are 37 subsectors (44% of the total) and are as follows: forest harvesting (3), services related to agricultural and forestry activities (5), transportation by pipelines (41), postal services (44), creation of and dissemination of content via the internet (50), central banking (54), rental of trademarks, patents and franchises (60), and others.



Graph 7. *Immediate effects of centrality ($T_{IEC(j)}$)*
* Every number correspond to one subsector, see the Table 3
Source: Own elaboration with information from input-output matrix at 79 subsectors

Continuing with the analysis, sector classification is presented in terms of the intensity of interconnections as the immediate effects of centrality (see Graph 7). Highest to lowest impact on the speed of transmission in the economic fabric shows that Group I agglomerates 25 subsectors (32% of total), the group II 29 subsectors (49% of total); Group III to nine subsectors (11% of total); and finally, the group IV to six subsectors (8% of total).

Among the sectors most direct interconnection are transport services in general: rail (37), water transport (38), pipeline transportation (41), tourist transport (42); postal services (44), courier and parcel services (45), storage services (46), providers of internet access, search services in the network and information processing (52), other information services (53); movable property rental services (59), rental of trademarks, patents and franchises (60); residences of welfare and health care (68), other welfare services (69). These subsectors are characterized by their high capacity to transmit direct effects on the total economic framework.



Graph 8. *Mediative effects of centrality ($T_{MEC(j)}$)*
* Every number correspond to one subsector, see the Table 3
Source: Own elaboration with information from input-output matrix at 79 subsectors

Finally, to identify the intensity of global interconnections are used to gauge mediative effects of centrality (see Graph 8). From this measure of centrality, the sub-sectors of importance for its transmitters or nodal effects for economic networking results in the following classification. The first group focuses eight subsectors (10% of total), the second group to nine subsectors (11% of total), and the third group of 21 subsectors (27% of total); finally, the fourth group 41 subsectors (52% of total). Among the sub-sectors with higher overall effects of interconnection with the rest of the economy are: building (11), food industry (14) beverages and tobacco industry (15), commerce (35), and government activities (79), among others.

An important result derived from this indicator is lower interconnection capacity of just over half of economic activities; mainly related subsectors primary industries: agriculture (1), forest harvesting (3), fishing, hunting and capture (4), services related to agricultural and forestry activities (5), mining-related services (8); service activities: tourist transport (42), transport-related services (43), postal services (44), courier and parcel services (45), radio and television, except vita the internet (49), and so on. The latter group also includes activities of the financial sector: central banking (54), no brokerage credit and financial institutions (55), foreign exchange trading activities and financial investment (56).

5. Discussion and Conclusion

Applying Rasmussen indexes at 20 sectors highlights the group of key sectors, manufacturing, electricity, water and gas supply pipelines to the final consumer, mass media information, and financial services and insurance. When the analysis is completed and arises from the point of view of the SNT, stand out, the total effects of centrality indices, those who have a central position, such as the manufacturing industry and transportation. In terms of the immediate effects of centrality, excels the manufacturing industry (again) and construction. The mediative effects of centrality emphasizes and confirms the importance of the manufacturing sector, followed by construction, commerce and transport.

The results of analysis of productive chains based on Rasmussen for the 79 sub-sectors, show that in the group of key subsectors, ten subsectors that comprise it, nine belong to the sector of manufacturing, which once again ranks as one of the most important in the economic network. By analyzing through the SNT, with indices of total effects of centrality, highlights the Group's "high centrality" subsectors, which are key in the

intermediation of intersectorial linkages, they are seven, among which is the construction, the food industry and hospitals. The immediate effects of centrality show that the sub-sectors with higher direct interconnection have related to transport by rail, by water, services and tourism; storage and postal services. Finally, the mediative effects of centrality highlights eight subsectors, including construction, food industry, beverage industry and tobacco, commerce and government activities.

From the techniques used to identify key sectors of the Mexican economy was reached results that are consistent with other studies (Sánchez, 2011, 2013, 2013a; Palacios, 2013 and Olmedo, 2014), which underline the importance of manufacturing as the engine of economic growth. The evidence presented serves as an input for the establishment of an active industrial policy that will allow to overcome the current stage of economic stagnation. In the hands of a State that intervenes creatively in key sectors, supported axis of budgetary transparency and efficient management of resources, the economy of Mexico can become one of the most dynamic of the American continent, which would translate into job creation and greater well-being for its inhabitants.

To finish, indicate that as part of the research agenda is making new estimates with the array of input-output matrix of 2008 which was published in 2013, which will help to compare our present results and know if they continue to be consistent, especially towards the implementation of an active industrial policy as a strategy for promoting economic growth.

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Appendices

Table 2. *Total effects ($T_{TEC(j)}$), immediate effects ($T_{IEC(j)}$),mediative effects ($T_{MEC(j)}$), 20 sectors*

Number	Sectors	Total effects		Immediate effects	Mediative effects
		TTEC(i)	TTEC(j)	TIEC(j)	TMEC(j)
1	Agriculture, forestry, and fishing	0.023	0.036	0.019	0.416
2	Mining	0.014	0.044	0.013	0.359
3	Electricity, water and gas	0.028	0.045	0.022	0.473
4	Construction	0.266	0.008	0.126	0.714
5	Manufacturing industries	0.247	0.245	0.170	0.859
6	Commerce	0.036	0.117	0.033	0.595
7	Transportation	0.051	0.054	0.046	0.666
8	Post office and storage	0.001	0.004	0.001	0.092
9	Information in mass media	0.011	0.062	0.009	0.383
10	Financial and insurance services	0.017	0.067	0.014	0.422
11	Real estate and rental services	0.019	0.084	0.019	0.430
12	Professional, scientific and technological services	0.011	0.104	0.011	0.318
13	Corporate management and business	0.003	0.017	0.003	0.100
14	Business support services	0.006	0.079	0.005	0.193
15	Educational services	0.010	0.001	0.010	0.304
16	Health and social care services	0.030	0.032	0.005	0.145
17	Recreational services	0.001	0.001	0.001	0.060
18	Hotels, food and beverage	0.012	0.0140	0.012	0.338
19	Other services	0.008	0.0232	0.008	0.252
20	Government activities	0.025	0.0027	0.023	0.544

Source: Own elaboration with information from input-output matrix at 20 sectors.

Table 3. *Total effects ($T_{TEC(j)}$), immediate effects ($T_{IEC(j)}$),mediative effects ($T_{MEC(j)}$), 79 subsectors*

No.	Subsectors of economic activity	Total effects		Immediate effects	Mediative effects
		TTEC(i)	TTEC(j)	TIEC(j)	TMEC(j)
1	Agriculture	0.000	0.026	0.928	0.148
2	Livestock	0.001	0.039	0.424	0.436
3	Forest harvesting	0.000	0.052	0.996	0.014
4	Fishing, hunting, and capture	0.000	0.064	0.972	0.058
5	Services related to agricultural and forestry activities	0.000	0.077	1.001	0.014
6	Oil and gas extraction	0.000	0.090	0.902	0.197
7	Mining of metal ores, except oil and gas	0.000	0.103	0.830	0.210
8	Mining-related services	0.000	0.116	0.460	0.141
9	Generation, transmission and supply of electricity	0.000	0.129	0.633	0.369
10	Water and supply of gas by pipeline to the final consumer	0.000	0.141	0.994	0.035
11	Building	0.019	0.154	0.060	0.511
12	Construction of civil engineering works or heavy work	0.373	0.155	0.929	0.261
13	Specialized construction works	0.000	0.180	0.867	0.148
14	Food industry	0.004	0.193	0.149	0.557
15	Beverages and tobacco industry	0.001	0.205	0.525	0.516
16	Manufacture of textile inputs	0.000	0.218	0.816	0.150
17	Manufacture of textile products, except apparel	0.000	0.231	0.919	0.085
18	Manufacture of garments	0.001	0.244	0.313	0.234
19	Manufacture of products of leather, leather except apparel	0.000	0.257	0.431	0.231
20	Wood industry	0.000	0.270	0.862	0.067
21	Paper industry	0.000	0.282	0.708	0.171
22	Printing and allied industries	0.000	0.295	0.937	0.098
23	Petroleum and coal products manufacturing	0.000	0.308	0.875	0.256
24	Chemical industry	0.001	0.321	0.629	0.397
25	Plastic and rubber industry	0.000	0.334	0.836	0.336
26	Manufacture of non-metallic mineral products	0.000	0.346	0.866	0.248
27	Basic metal industries	0.000	0.359	0.681	0.295
28	Manufacture of metal products	0.000	0.372	0.853	0.238
29	Manufacture of machinery and equipment	0.000	0.385	0.797	0.213
30	Manufacturing equipment of computing, common, measurement and other equipment, components and electronic accessories	0.002	0.398	0.266	0.499
31	Manufacture of equipment of power generation, equipment and electrical accessories	0.001	0.411	0.612	0.433
32	Manufacture of transport equipment	0.004	0.423	0.241	0.583
33	Manufacture of furniture and related products	0.000	0.436	0.831	0.137
34	Other manufacturing industries	0.000	0.449	0.785	0.220
35	Commerce	0.001	0.462	0.587	0.608
36	Air transport	0.000	0.475	0.920	0.172
37	Transport by rail	0.000	0.487	0.990	0.069
38	Water transport	0.000	0.500	0.974	0.145
39	Freight trucking	0.001	0.513	0.716	0.502
40	Passengers, except railway transport	0.000	0.526	0.771	0.429
41	Pipeline	0.000	0.539	1.010	0.007
42	Tourist transport	0.025	0.539	1.037	0.031
43	Transport-related services	0.000	0.564	0.954	0.095
44	Postal services	0.000	0.577	1.012	0.002
45	Courier and parcel services	0.000	0.590	0.995	0.041
46	Storage services	0.000	0.603	1.007	0.017
47	Editing publications and software, except for Internet	0.000	0.616	0.988	0.041
48	Industry film and video, and sound industry	0.000	0.629	0.910	0.052
49	Radio and television, except via the Internet	0.000	0.641	0.299	0.086
50	Creation and dissemination of content via the Internet	0.000	0.654	1.012	0.001
51	Telecommunications	0.000	0.667	0.701	0.340
52	Providers of Internet access, search services in the network and information processing	0.000	0.680	1.007	0.016
53	Other information services	0.000	0.693	1.012	0.002
54	Central banking	0.000	0.705	1.007	0.014

No.	Subsectors of economic activity	Total effects		Immediate effects	Mediative effects
		TTEC(i)	TTEC(j)	TIEC(j)	TMEC(j)
55	No brokerage credit and financial institutions	0.000	0.718	0.830	0.289
56	Foreign exchange trading activities and financial investment	0.000	0.731	0.936	0.046
57	Bonding, insurance and pensions	0.000	0.744	0.668	0.174
58	Real estate services	0.000	0.757	0.857	0.227
59	Movable property rental services	0.000	0.770	0.988	0.071
60	Rental of trademarks, patents and franchises	0.000	0.782	1.007	0.005
61	Professional, scientific and technical services	0.000	0.795	0.758	0.397
62	Corporate management and business	0.000	0.808	0.947	0.089
63	Business support services	0.000	0.821	0.897	0.216
64	Management of wastes and remediation services	0.000	0.834	1.007	0.017
65	Educational services	0.000	0.846	0.824	0.218
66	Consultation external and related medical services	0.212	0.846	1.257	0.264
67	Hospitals	0.187	0.859	1.210	0.025
68	Residences of welfare and health care	0.002	0.872	1.015	0.003
69	Other welfare services	0.015	0.885	1.027	0.018
70	Artistic, sports and other related services	0.000	0.911	0.995	0.030
71	Museums, historical sites, botanical and similar gardens	0.000	0.923	0.784	0.007
72	Entertainment recreational institutions and other services	0.078	0.923	1.090	0.096
73	Temporary accommodation services	0.000	0.949	0.929	0.181
74	Food and beverage preparation services	0.000	0.962	0.816	0.415
75	Repair and maintenance services	0.000	0.975	0.920	0.239
76	Personal services	0.000	0.987	0.988	0.067
77	Associations and organizations	0.000	1.000	0.969	0.113
78	Households with household employees	0.000	1.000	1.013	0.000
79	Government activities	0.001	1.026	0.727	0.458

Source: Own elaboration with information from input-output matrix at 79 subsectors.