Input Output Workshop
Mexico-UNAM, 25-26 July 2013

# *"Structural Analysis of Mexico's industrialization and Global Value Chains"*

**Martin Puchet Anyul**

**Universidad Nacional Autónoma de México. Facultad de Economía**

**Valentin Solis y Arias**

**ECLAC /Mex**

# *Introduction*

In this paper we consider the relationships between industrialization and Global Value Chains (GVC). To accomplish this goal, we compare some countries (Germany, Brazil, South-Korea, USA and Mexico) within its international and temporal settings using methods and techniques of the input- output economic analysis. We will use tools of linear algebra, as well as complex networks analysis.

The discussion on the industrialization processes after the industrialization by substitution of imports was branched off in two main paths. In Latin America, it was associated with the exhaustion of the State driven policies and it was considered that the new world economic order, initiated after the oil crisis, would lead to the region to an increasing deindustrialization. In countries of late industrialization, i.e. South Korea, their industrialization was considered as a result of the growth driven by exports and reforms pro market, that leaded that economy to the adaptation to the competitive advantages of the international trade.

The case of Mexico is paradigmatic because it would have, according to the defenders of the economic reforms and the North America Free Trade Agreement (NAFTA), two distinguishing characteristics:

a) Would show the way out of the import substitution process, that was conducted by a strong State during the period 1950 - 1981, by means of reforms pro market and the NAFTA between 1982 and 1996, and

b) Would make visible that the deindustrialization could be surpassed by means of a virtuous integration of the economies of Mexico and the United States.

In fact the degree of integration between the Mexican and USA economies grew quickly , however, its results have been a very limited repercussion, in terms on the value added to Mexico's exports , on the other hand , an important deindustrialization on the other.

This situation could be the result of the acceleration of the integration of the Mexican industry to the GVC. The process of fragmentation of the productive processes must be understood in several ways, i.e. macro, messo, regional and micro levels studying a complex set of economic flows that are divided in segments located within each country and segments that correspond to the trade between countries.

The central policy issue is how to assure that these new productive structures, organized by means of GVC, reinforce the internal structures and how much value added and employment generated globally, is captured by each economy.

In order to evaluate this issues, in this work we evaluate the density of the internal flows with a measure that weigh the circuits that connect a sector with others, and then how those flows come back to its origin. When we do this operation for all the economic sectors we have got a measure named "circularity". On the other hand we have evaluated the so called "vertical specialization" meaning the adoption, in certain countries, of certain stages in the sequence of production within a GVC. In practical evaluations that concept is measured as the proportion of imported inputs that are necessary to produce exports .

## Circularity.

The circularity index (ci) is given by the following expression: $ci = \frac{1-\Delta}{\Delta}$

Where $\Delta$ stands as the determinat of the Leontief Matrix.

The interpretation of such a measurement will show that an economy will have a greater industrialization when this number increases, so the interactions between sectors and the weight of the same are progressively greater when the economy becomes industrialized.

For the countries studied, the results are :

| Year | 1997 | | 2007 | | 1997 – 2007 Rates of growth (%) | |
|---|---|---|---|---|---|---|
| Country | ci | VS | ci | VS | Ci | VS |
| Germany | 13.03 | 11.13 | 14.80 | 17.43 | 13.57 | 56.60 |
| Brazil | 21.12 | 5.58 | 16.83 | 8.25 | -20.34 | 47.78 |
| Korea | 50.93 | 19.55 | 110.87 | 25.15 | 117.69 | 28.65 |
| USA | 28.54 | 6.29 | 18.35 | 8.61 | -35.71 | 36.70 |
| Mexico | 5.97 | 14.29 | 4.90 | 14.70 | -17.92 | 2.58 |

Observations:

a) The American countries shown a decrement of the internal circularity of their economies with a corresponding increase of the vertical specialization; on the other hand, Germany and South Korea increase both their circularity and their vertical specialization.

b) The circularity in 2007 shows very dissimilar values of: Mexico has an index around 5, Germany, Brazil and EUA register a value between three and four times greater than Mexico, South Korea shows a very high value with respect to the others.

c) The indicator of vertical specialization has values for Brazil and USA around 8%; Germany and Mexico between the 14 and 17 percent and Korea in 25%. These results implies that Brazil and USA are more closed, so they are not taking advantage of the cheaper international supplies on the contrary from the other countries specially Korea.

In order to measure the vertical specialization, concerning individual countries, two indicators are used: i) the imports necessary to make exports and ii) the domestic added value necessary to make exports. In order to give a scale to those measures, usually it is divided the value of the imports and the amount of the value added, on the total of exports of the economy. The conventional formulas are:

$$VS = \frac{s'M(I-A)^{-1}e}{s'e} \qquad VA = \frac{w'(I-A)^{-1}e}{s'e}$$

## Results:

| Year | 1997 | | 2007 | | 1997 – 2007 Rates of growth (%) | |
|---|---|---|---|---|---|---|
| Country | ci | VS | ci | VS | Ci | VS |
| Germany | 13.03 | 11.13 | 14.80 | 17.43 | 13.57 | 56.60 |
| Brazil | 21.12 | 5.58 | 16.83 | 8.25 | -20.34 | 47.78 |
| Korea | 50.93 | 19.55 | 110.87 | 25.15 | 117.69 | 28.65 |
| USA | 28.54 | 6.29 | 18.35 | 8.61 | -35.71 | 36.70 |
| Mexico | 5.97 | 14.29 | 4.90 | 14.70 | -17.92 | 2.58 |

The following stylized facts are observed:

a) The American countries shown a decrement of the internal circularity of their economies with a corresponding increase of the vertical specialization; on the other hand, Germany and South Korea increase both their circularity and their vertical specialization.

b) The circularity in 2007 shows very dissimilar values of: Mexico has an index around 5, Germany, Brazil and EUA register a value between three and four times greater than Mexico, South Korea shows a very high value with respect to the others.

c) The indicator of vertical specialization has values for Brazil and USA around 8%; Germany and Mexico between the 14 and 17 percent and Korea in 25%. These results implies that Brazil and USA are more closed, so they are not taking advantage of the cheaper international supplies on the contrary from the other countries specially Korea.

**Strategic Sectors**: The linkage of a sector is determined by the matrix of direct and indirect import requirements for the exports: $i'(M(I-A)^{-1})$where is the unitary vector. In the same way, the linkage of a sector determined by the requirements of value added necessary for the exports is $i'(\hat{w}(I-A)^{-1})$ These indicators, by sector, can be standardized by their average, allowing us to express them as a hierarchy; resembling the Chenery-Watanabe-Rasmussen indicators .

The comparison of the hierarchies of sector linkages through time and between countries will be making by means of the Spearman's rank coefficient, whose values goes from -1 up to 1 and becomes 0 when there is no correlation at all.

The results are:

| | | 2007 | | | | |
|---|---|---|---|---|---|---|
| | 1997-2007 | Alemania | Brasil | Corea | EUA | México |
| **Ger** | 0.55 | 1.00 | 0.14 | -0.12 | 0.48 | -0.07 |
| **Bras** | 0.72 | | 1.00 | 0.11 | -0.13 | -0.69 |
| **Korea** | 0.27 | | | 1.00 | -0.29 | -0.42 |
| **USA** | 0.57 | | | | 1.00 | 0.03 |
| **México** | 0.50 | | | | | 1.00 |

The following facts are observed in the table:

a) Brazil maintained its hierarchic structure of linkages whereas Korea modified it. The other three countries have a coefficient that it indicates that they changed in around half of the sectors and the others did not change.

b) In terms of the similarity of the structures, Brazil and Mexico are alike but with inverse sectoral hierarchies. On the other hand, Korea has certain similarity with the hierarchy of the USA and opposite with the Mexican one. The other cases are dissimilar emphasizing the almost null correlation of the hierarchic structures of the linkages of USA and Mexico.

**Betweenness centrality** is a measure of a node's centrality in a network. It is equal to the number of shortest paths from all vertices to all others that pass through that node.

A vertex with low degree of centrality by degrees can play an important role like intermediary among others vertices in the network; its evaluation allows detecting branches whose position is crucial for the diffusion of economic impulses in the entire network.

In order to approach some numerical results, we will show the betweenness centrality for the domestic value added in exports, which are the complement to the imports embedded in exports, due to the fact that this index is more intuitive.

| *Germany* | | *cent* | *Brazil* | | *cent* | *Korea* | | *cent* | *USA* | | *cent* | *Mexico* | | *cent* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | Renting of M&Eq and Other Business Activities | 144 | 30 | Renting of M&Eq and Other Business Activit | 139 | 23 | Inland Transport | 86 | 30 | Electricity, Gas and Water Supply | 155 | 23 | Inland Transport | 183 |
| 18 | Construction | 138 | 1 | Agriculture, Hunting, Forestry and Fishing | 108 | 30 | Renting of M&Eq and Other Business Activities | 73 | 31 | Public Admin and Defence; Compulsory Social Security | 138 | 15 | Transport Equipment | 98 |
| 17 | Electricity, Gas and Water Supply | 63 | 18 | Construction | 80 | 18 | Construction | 55 | 18 | Construction | 125 | 30 | Renting of M&Eq and other Business Activities | 78 |
| 6 | Wood and Products of Wood and Cork | 56 | 3 | Food, Beverages and Tobacco | 61 | 17 | Electricity, Gas and Water Supply | 54 | 28 | Financial Intermediation | 86 | 29 | Real Estate Activities | 73 |
| 34 | Other Community, Social and Personal Services | 48 | 28 | Financial Intermediation | 54 | 15 | Transport Equipment | 48 | 29 | Real Estate Activities | 44 | 21 | Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods | 57 |

As we can see, most of the countries have intermediaries related to services, as renting machinery, inland transport, financial intermediation and some inputs of general use, as electricity, gas and water supply. It is noticeable that in Germany and Korea the intermediaries sectors are related to logistics, as in Brazil and USA the financial services are among the top 5 intermediaries. It will be necessary to extend this analysis with more countries.

***Eigencentrality of a valuated digraph.***

The measures based on the degrees of a graph can be extended beyond the direct connections to include indirect connections. In this case, the relevant vicinity is extended to include more distant connections. The eigencentrality of a vertex is proportional to the sum of the centralities of the adjacent vertices with which it is connected. One calculates this centrality as the eigenvector of the adjoint matrix.

An extension of the eigencentrality is obtained from flows of purchases and sales between sectors represented in a graph *G (V, E and, w)*, without self-references (zeroes in the main diagonal) and in which there is a set of vertices (sectors) connected by a set of arcs with weights *w* (purchases and sales). We construct square complex adjacency matrix *A* with *n* members by $a_{kl} = m + ip$ with m the value of sales from node *k* to node *l*, and *p* the value of purchases from node *l* to node *k* and *i* representing the imaginary unit. From the matrix we define a hermitian matrix *H* like:

$$H = (A + iA^T)e^{-i\frac{\pi}{4}}$$

a hermitian matrix (or self-adjoint matrix) is a square matrix with complex entries that is equal to its own conjugate transpose—that is, the element in the *k-th* row and *l-th* column is equal to the complex conjugate of the element in the *k-th* row and *l-th* column, for all indices *k* and *l*.

These matrices induce, through the operation of the internal product, a complete normed space denominated space of Hilbert. An element of a Hilbert space can be uniquely specified by its coordinates with respect to a set of coordinate axes (an orthonormal basis), in analogy with Cartesian coordinates in the plane.

It can be shown that the hermitian matrices (Solis and Garcia Perez, 2008) can be transformed into a diagonal matrix and that their eigenvalues add to zero (necessarily one or several eigenvalues are negative). All eigenvectors are unique, and it is possible to choose a complete orthonormal base and to represent sub-spaces that reveal the structure of the relation of their elements.

The use of hermitian matrices allows us to make an interpretation of the spectra of their eigenvalues. These measure the intensity and total variation of the purchases and sales registered in the matrix. The interpretation of its eigenvectors, that include values in the space of the complex numbers, allows identifying, in the case of the dominant eigenvector, the centrality of the economic nodes (sectors or countries) and in the case of the second and subsequent eigenvectors, subgroups of associated suppliers and clients.

A complex number $z$ can be represented in algebraic or exponential form: with the real part of $z$ being denoted as $Re\ (z) = a$, and the imaginary part as $\mathrm{Im}(z) = b$, the absolute val as $|z| = \sqrt{a^2 + b^2}$ and the phase as $0 \le \phi = \arccos \frac{\mathrm{Re}(z)}{z} \le \pi$ , with $i$ as the imaginary unit. Some results of this procedure are shown below. We present the absolute value of the complex numbers.

# Input-Output Workshop
# IIOA- INEGI-UNAM

*Five top elements of the dominant eigenvector of the hermit matrix of purchases and flows required direct and indirectly to export in 2007.*

| ***Alemania*** | | ***EV*** | ***Brasil*** | | ***EV*** | ***Corea*** | | ***EV*** | ***EUA*** | | ***EV*** | ***Mexico*** | | ***EV*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | Basic Metals and Fabricated Metal | 1 | 2 | Mining and Quarrying | 1 | 2 | Mining and Quarrying | 1 | 2 | Mining and Quarrying | 1 | 12 | Basic Metals and Fabricated Metal | 1 |
| 15 | Transport Equipment | 0.84 | 8 | Coke, Refined Petroleum and Nuclear Fuel | 0.89 | 8 | Coke, Refined Petroleum and Nuclear Fuel | 0.85 | 8 | Coke, Refined Petroleum and Nuclear Fuel | 0.91 | 14 | Electrical and Optical Equipment | 0.86 |
| 13 | Machinery, Nec | 0.64 | 9 | Chemicals and Chemical Products | 0.54 | 12 | Basic Metals and Fabricated Metal | 0.47 | 31 | Public Admin and Defence; Compulsory Social Security | 0.28 | 18 | Construction | 0.81 |
| 14 | Electrical and Optical Equipment | 0.57 | 12 | Basic Metals and Fabricated Metal | 0.44 | 9 | Chemicals and Chemical Products | 0.33 | 17 | Electricity, Gas and Water Supply | 0.24 | 15 | Transport Equipment | 0.72 |
| 2 | Mining and Quarrying | 0.51 | 1 | Agriculture, Hunting, Forestry and Fishing | 0.3 | 15 | Transport Equipment | 0.23 | 30 | Renting of M&Eq and Other Business Activities | 0.22 | 9 | Chemicals and Chemical Products | 0.54 |

In the above table, the following facts are observed:

a) For the economies of Brazil, Korea and EUA sectors 2 (Mining and Quarrying) and 8 (Coke, Refined Petroleum and Nuclear Fuel) are the main sectors with a high rank of importance, at least doubling the value of the other elements. None of the remaining elements represents more of 30% of first one.

b) For the economies of Germany and Mexico the main sectors are 12 (basic Metals and Fabricated Metal), 15 (Transport Equipment) and 14 (Electrical and Optical Equipment). The other sectors still represent around 50% of first.

c) It is remarkable the fact that for Brazil, Korea and USA it is crucial the access to imports of primary sectors, mining, minerals and petroleum. On the contrary, for Germany and Mexico the important external supplies concern to metallic products equipment of transport, and electrical and optical parts.

**Some preliminary conclusions will be obtained from the workshop.**

**Thank You!**

Martin Puchet
Valentín Solís