A Comparative Kernel Structure of Mexico, Brazil and South Korea: A Pretopological Input-Output Analysis

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Abstract

The purpose of this paper is to perform a structural analysis of the fundamental (kernel) sectoral interdependence, in order to study the importance of the general economy structure in the development of each country: Mexico, Brazil and South Korea. The years of the research are 1995 , 2001, 2008 due structural paralell changes in the three economies, notably in trade and financial liberalization. After the Indsutrialization by Substitution of Imports (ISI) process, these economies applied different trade policies that resulted in the protection of some key sectors that support the currently growth of Brazil and South Korea unlike what happened in Mexico.

This work is based upon the pretopological concepts of pseudoclosure and minimal closed subsets. Firstly, we will generate a binary transaction matrix with a specific Decision Rule. Secondly, we will seek different core structures of each economy with an economics-based Function Decision Rule using the concept of minimal closed subsets. Finally, we will compare each of the structures and identify critical sectors which determine the structural topology of the different economies.

The expected results will be that economic policy applied to modify the structural conformation of an economy is fundamental in the sucess of the development process in open trade developing countries.

Introduction

In this paper a comparative structural analysis of the economies of Mexico, Brazil and Korea is presented. The study period is 1995-2010. For this analysis we rely on models of input - output and apply a pretopological approach to the economic structures depicted in those tables. Specifically we tried to model the economic channels that spread the economic impulses that multiply the overall activity. These channels are intrinsically related to the whole architecture of each country, so their similarities and differences are of interest.

The analytics of pretopology are well suited to identify kernels of economic activities within the input-output model. To this effect, we shall use the concepts of the so called minimal closed sets, which constitute kernels of the NIOT framework; they characterize interdependent

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homogenous parts of the structure that channelize exogenous economic impulses so we can model and compute a complex structure.

As in topology, in a pretopological approach we must get rid of the Euclidean metrics, so we shall dichotomize the inter-industry observed flows and work within a non-metric space. To do this task, we have to filter out the input-output coefficients matrix obtaining the so called "important coefficients" according to Schintke and Stäglin criteria (1988). With this structure we apply an algorithm proposed by Bonnevay, Largeron and Nicolayannis (2002).

The structure of the paper is as follows. Some background information about the economies we are going to study is presented in the first section. In the second section the methodology and data sources are presented. In the third section the empirical evidence and some results are shown. Finally, some conclusions and opinions derived from this research are presented.

I. Background of the studied economies.

The main objective of this paper is to present a structural analysis of the economies of Mexico, Brazil and Korea, making a comparative and temporal description between the years 1995 and 2010 of these countries. We present a brief sketch of each economy that could give us some hints of the quantitative results obtained with the methodological approach adopted.

Mexico

In the late fifties, the period begins in Mexico called "stabilizing development" which is identified as the period of greatest growth and macroeconomic stability in the country. During this period the process of industrialization that had begun since the Second World War accelerated.

Since the beginning of this period and until the eighties, a growing share of industry in the national product remained. However, after the crisis of the eighties, a change was conceived in economic policy favoring the free market and significantly reducing public sector involvement in the economy, both directly and within policy development and industrialization.

From the above, and in addition to which there was any instance in the country responsible for strengthening research and development, a level of dependence on overseas was achieved in two important aspects: capital flows for investment and technology to production. These are common weakness in Latin American countries .

Since the eighties , the industry began to lose weight in total output , while the service sector increased its share , reaching about 70 percent of total product for the mid- 2000s (Moreno Brid and Ros, 2010). We can then say that the premature deindustrialization Mexico when like Brazil, introduced the industry gave weight to services without having reached a stage of maturity or technological independence abroad.

Brazil

After the Second World War until the early eighties, Brazil presented a strong economic growth, which was driven by industrialization based on import substitution. The manufacturing sector was the one wearing the helm in industrialization, especially of capital goods and durable goods. However, the change in the production structure, where the primary activities diminish their contribution to national product ceding ground to the secondary sector was accompanied by factors that weakened macroeconomic stability, namely high dependence to foreign capital and high rates of inflation. This, according to Nassif , Feijo and Araujo (2012), is the result of rapid and intense structural change caused by rapid industrialization .

From the mid-eighties, the industry began to lose share in total income, from 40.9 %in the year 1980 to 27.5% in 2010. Meanwhile, the services sector has increased its share in the national product, which suggests a process of de-industrialization of the Brazilian economy, as in the developed economies, but at a premature point, ie , without the Brazilian industry has reached a point of maturity.

This can be explained on the one hand, thanks to the growing technological gap in manufacturing that has worsened since the mid- nineties. Furthermore, in response to a persistent trend of overvaluation of the Brazilian currency, which has led to decrease the share of manufactures in total Brazilian exports (Nassif , Feijo and Araujo, 2012).

Korea

The process of industrialization in Korea started in the sixties, with structural changes that mimic those of developed countries like the U.S. and England, but with a much greater acceleration. In the early years it was a major boost to the manufacturer of high density of labor, under a relatively high endowment of skilled workers. However, from the following decade and the loss of competitiveness in this area, Korean policy makers chose to develop capital- intensive manufacturing and high technologies. Originally the government policy was to support companies directly, Sakong and Koh (2010) point out that the way they were given support favored companies already established processes and led to concentration of capital, which could explain the strong linkage between the productive branches.

From the eighties began to shift in targeting investment and industrialization policy, which has resulted in reduction of the technological gap with advanced countries from the nineties. This narrowing of the gap is reflected in a strengthening of the sectors in which products are manufactured or services with high technological content are provided.

From the 2000s, the tendency to prioritize research and development remained, which has led to position Korea as a pioneer in major industries globally, namely, electronics, steel, automotive, shipping company, other. Note that this process of industrialization and technological progress has led, as in any structural change linked to development, to increase the share of services and reduce the involvement of the primary activities in the Gross Domestic Product.

II. Methodology and data

Intersectoral economic relations are recorded in an input- output table, where purchases and sales transactions between sectors represent intermediate inputs that are required to carry out the production process. The National Input-Output (NIOT) matrices for the countries studied, are available in 35 sectors from the World Input Output Database (Marcel, 2012). We used 34 sectors because the sector households does not have records.

Some Pretopological Concepts and an Algorithm

The notion of pretopology is used to operate on a discrete system like a NIOT, where E depicts the set of points to be classified, and each element of E represents each entry of the matrix.

Pretopological Space

Let E be a set of n elements, where n is finite and different from zero. The relationships amongst the elements of E constitute a family, which enables to state the notion of neighborhood of each element of E:

$$\forall x \in E, \forall i \in \{1,...,k\}, R_i(x) = \{y \in E / xR_i y\}$$

Where $R_i(x)$ is the set of elements having a relationship i between x and y. $R_i(x)$ is called the neighborhood of x and each one of the elements of $R_i(x)$ is called a neighbor of x. The only requirement asked for $R_i(x)$ is to be reflexive, i.e. $x \in R(x)$ if and only if xRx.

Definition 1. *Let P(E) be the set of the parts of E and let 8 be a mapping from P*(E) *to P(E). S is said to be a pseudo closure mapping on E if*

$$K1 : \delta(\theta) = \theta,$$

$$K2 : \forall A \in P(E), A \subseteq \delta(A)$$

Definition 2. *The pair (E, S) satisfying K1 and K2 is a Pretopological Space.*

Definition 3. *A more limited Pretopological Space can be built up if the mapping also satisfies*

$$K3 : \forall A \in P(E), \forall B \subseteq P(E), A \subset B \Rightarrow \delta(A) \subset \delta(B)$$

Definition 4. *The above constructed pretopology becomes topological if and only if the closure is idempotent, i.e., if and only if:*

$$K4 : \delta(\delta(A)) = \delta(A)$$

In this case, the neighborhood relationships is used to build a pretopological mapping $\delta(A)$ from P(E) into itself as follows:

$$\forall A \subset P(E), \delta(A) = \left\{ x \in E / \forall i \in \{1,...,k\} \; R_i(x) \cap A \neq \theta \right\}$$

Closed Set

A subset A of E is closed if an only if $\delta(A) = A$ Due to the fact that the pseudo closure operator δ is not idempotent, it is possible to develop an iterative mapping of a subset A of E to generate a successive spreading of the subset:

$$A \subseteq \delta(A) \subseteq \delta^2(A) \subseteq \delta^3(A) \subseteq \delta^4(A) \subseteq ...$$

And because E is finite, there is an integer $m < n$ where the successive mappings stop, so the closure of a subset A of E is computed by successive pseudo closures of A. When this occurs, the pretopology has become topology.

Closed set, elementary closed set and minimal closed set

From all possible closed subsets in a discrete and finite pretopological space, there are some of them of particular interest. Such closed sets are the singletons of the set E. Belmandt (1994), Largeron and Bonnevay (1997) and Martínez and Solis (1985) have shown that for each one of them, there is always a closed set obtained from the spreading of the pseudo closure operator. These closed sets are called elementary closed sets.

Let C_e be the set of elementary closed sets, which is composed of closures C_x of singletons $\{x\} \in E$, then the relationship between elementary closed sets is based on the property derived from the fact that if $C_x \cap C_y \neq \theta$ then for all z in $C_x \cap C_y$, $C_z \subset C_x \cap C_y$. This property shows the relationships amongst elementary closed sets: Any two elementary closed subsets are disjoint, either one is included in the other one or their intersection contains elements whose elementary closure is included in this intersection. From all possible elementary closed sets there is a particular subset that is important for us: the minimal closed sets, defined by inclusion within the elementary ones.

What characterizes this approach in economic terms is that it does model a diffusion process of the myriad of economic transactions between production sectors and institutional agents registered in a NIOT. The diffusion process departs from the so called minimal closed sets, which constitute kernels of the NIOT framework; they characterize interdependent homogenous parts of the structure that channelize exogenous economic impulses. With such an approach we can model straightforward a complex structure; while other methods used to classify or analyze a structure are so indirect methods. The notion of closed sets resembles directly observable economic phenomena. For instance, an almost closed set could be beheld in the links between the agricultural goods and food industries without significant reference to

relationships to other economic sectors; this observed fact is caught easily with the pretopological approach when we get the closure of the diffusion process established in simple income and expenditure relationship within food and agricultural sectors.

A three stage computational structuring algorithm

The structuring algorithm used in this paper relies on the behavior of this pseudo-closure mapping, and it was suggested by Belmandt (1994), and further improved by Largeron and Bonnevay (1997, 1999) , and by Bonnevat, Lamure, Largeron and Nicolayannis (1999).

In the first stage we obtain the elementary closed sets applying iteratively the pseudo-closure operator to each one of the singletons of the set. The operator is stopped when the adherence of the singletons becomes idempotent. Computationally, this can also be obtained by the inverse of the adjacent matrix expressed in Boolean terms.

The second stage works over the elementary closed sets in order to obtain, by inclusion, the minimal closed sets. These sets constitute kernels of the main structure of the NIOT.

The previous results are structured in the third stage. It is based on a recursive approach to enlarge the kernels obtained in the second stage, superimposing the elementary sets over the minimal ones. The result is that the NIOT data are classified in highly interdependent and homogeneous groups.

In order to obtain the structuring of the NIOT, we got a Boolean representation of the multiplier matrix, filtered it out at certain sensible level, and applied the algorithm described above. The filter was applied using the Schintke and Stäglin`s (1988) important coefficients technique (Aroche, 1996, 2002). A warning must be inserted here, the NIOT was normalized by rows, i.e., $D_{ij} = X_{ij} / X_i$ so its multipliers $(I - D)^{-1}$ are read as elasticities so, the basic binary relationship xRy is read as “x is influenced by y”.

III. Results

We analyzed those sectors that represent the basic structure of each economy in relation to two main categories: a) Connection Power b) Connection Dynamism. That is, we detect the branches in which an economic impulse is transferred to the larger number of sectors (Connection Power); and in those who manage to hit as many sectors more directly, i.e., in the first adherence (Connection Dynamism).

Mexico

Sectors with the greatest Connection Dynamism for the Mexican economy are presented in Table 1, indicating the cardinality of its direct influence.

It is noted that in 1995 the sectors with greater Connection Dynamism are: Wholesale (20) Chemical Industry (9), financial intermediation (28) Rental of machinery and equipment (30) and Retail trade (21). The same sectors have a higher Connection Power (31 sectors included in its closure), with the exception of Real estate (29) having little Connection Dynamism but its

Connection Power is 32 sectors .

In 2010, the sectors most influence are the rental of machinery and equipment (30) Wholesale (20) Chemical Industry (9) Retail (21) and basic metals (12). The rental industry machinery and equipment and other business improves its position of influence in 2010, the sector of oil refining and nuclear fuel are also prominent and the real estate sector and the agricultural sector lose their influence in relation to 1995. The Connection Power for this year is much more variable and in the top five sectors include between 31 and 24 sectors in its closure. The Connection Dynamism in four of the five largest sectors is greater than their counterparts in 1995.

We can sort these sectors: primary, secondary and tertiary. In 1995 from twelve major sectors five were related to the tertiary activities, five related secondary activities and two related primary activities, while in 2010, from the ten major sectors, four were related to tertiary activities, five related to secondary activities and primary activities.

The basic structure of the Mexican economy is almost the same in the two years of analysis. The only difference is that financial intermediation has left the group of five most dynamic sectors and their place has been taken by basic metals. The most dynamic sectors are in the services sector and in particular in the marketing of products and rental equipment.

The Mexican development strategy has not been modified in the last 20 years. There is no systematic policy aimed to amend the productive structure of the Mexican economy in order to promote industrial development, infrastructure and the production of goods with high value added.

The fact that the Connection Power for elementary sectors of the Mexican economy are lower in 2010 compared to 1995 indicates a “fade out” process of industrial activities in Mexico. It is possible that this process obeys a deep vertical specialization (understood as in the global value chains literature) of the Mexican sectors linked to the US economy; however, the nature of this disconnection should be studied further in the future.

A particular phenomenon in the Mexican economy is the increase of its Connection Dynamism between 1995 and 2010, despite the decline of the Connection Power in the same sectors. A tentative interpretation of this phenomenon is what we call “Structural Rigidity”. That is, the absence of a targeted industrial policy in Mexico reproducing the same elementary and asymmetric structure, conducting to a loss in the malleability of the economic structure over the years. Also as a result of this blind policies the concentration of economic activities is growing leading to a sort of "Sectoral Gigantism”.

One possible interpretation to explain this phenomenon of "Sectoral Gigantism” is due to the concentration the basic markets in 1995 have more amplitude (more sectors), this provides an important growth potential compared to other sectors. The broad markets that have these activities tend to raise capital in these sectors and make them more efficient. In turn, this concentration of capital and increased efficiency generate further growth in these sectors, which is reflected in their increased Connection Dynamism. However, this phenomenon

involves increased elemental structural rigidity in the Mexican economy. Over time, it becomes more difficult to redirect the economy because the important sectors are increasingly important.

Table 1

Connection Dynamism for Mexico 1995 and 2010

Mexico 1995			
Number	Sector	First Pseudo-Clousure	Clousure
c20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	14	31
c9	Chemicals and Chemical Products	13	31
c28	Financial Intermediation	13	31
c30	Renting of M&Eq and Other Business Activities	12	31
c21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	11	31
c12	Basic Metals and Fabricated Metal	7	9
c7	Pulp, Paper, Paper , Printing and Publishing	5	31
c29	Real Estate Activities	5	32
c1	Agriculture, Hunting, Forestry and Fishing	4	32
c2	Mining and Quarrying	4	31
Mexico 2010			
Number	Sector	First Pseudo-Clousure	Clousure
c30	Renting of M&Eq and Other Business Activities	20	31
c20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	16	25
c9	Chemicals and Chemical Products	14	24
c21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	12	31
c12	Basic Metals and Fabricated Metal	7	9
c8	Coke, Refined Petroleum and Nuclear Fuel	5	30
c28	Financial Intermediation	5	26
c2	Mining and Quarrying	4	24
c10	Rubber and Plastics	4	30
c14	Electrical and Optical Equipment	4	31

Source: Own elaboration with WIOD data and the Pretopologie software.

Brazil

The most influential sectors, measured by its Connection Dynamism, for the Brazilian economy are shown in Table 2. In 1995 the influential sectors are rental of machinery and equipment and other business activities, retail and chemical industry; this relationship holds in 2010. In 2010 oil refining and nuclear fuel sector appears and the top ten influential industries, food and beverages disappear.

In 1995 the nine major sectors, four were related to the tertiary sector, three related secondary activities and two related primary activities, while in 2010,from the top ten sectors , five were related to tertiary activities , three as secondary activities and two primary activities. This indicates that for the most recent year the Brazilian market structure is more integrated sectors and greater influence are related to services.

Another element that we highlight is that from 1995 to 2010, the number of sectors that have most influence increased and the number of sectors influenced by them has increased, which indicates a trend towards diversification of the spread in a larger number of sectors.

In the year 1995, the most influential sectors, measured with its Connection Power, are the rental of machinery and equipment and other business activities with a closure of 32 sectors, while in 2010 is the real estate sector reached 33 sectors in its closure. The sectors that have most influence on this economy via its Connection Dynamism in 1995 were the rental of machinery and equipment, other business activities and financial intermediation. In the year 2010, the number of influential sectors grew up including the sectors of machinery and equipment rental and other business activities, chemicals, oil refining, financial services, among others. Between 1995 and 2010 increases the number of sectors that affect many sectors in its closure, which shows further integration and diversification effects in most sectors.

Table 2

Connection Dynamism for Brazil 1995 and 2010

Brazil 1995			
Number	Sector	First Pseudo-Clousure	Clousure
c30	Renting of M&Eq and Other Business Activities	21	32
c21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	11	20
c9	Chemicals and Chemical Products	9	31
c28	Financial Intermediation	9	21
c34	Other Community, Social and Personal Services	7	21
c12	Basic Metals and Fabricated Metal	6	10
c1	Agriculture, Hunting, Forestry and Fishing	5	33
c2	Mining and Quarrying	3	32
c3	Food, Beverages and Tobacco	3	31
c17	Electricity, Gas and Water Supply	2	20
Brazil 2010			
Number	Sector	First Pseudo-Clousure	Clousure
c30	Renting of M&Eq and Other Business Activities	19	32
c21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	15	32
c9	Chemicals and Chemical Products	10	32
c8	Coke, Refined Petroleum and Nuclear Fuel	9	32
c28	Financial Intermediation	8	32
c34	Other Community, Social and Personal Services	7	32
c12	Basic Metals and Fabricated Metal	6	32
c1	Agriculture, Hunting, Forestry and Fishing	5	32
c2	Mining and Quarrying	5	32
c20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	5	32

Source: Own elaboration with WIOD data and the Pretopologie software.

Korea

La economía coreana muestra una mayor integración en su economía, tanto en 1995 como en 2010. Se observan, sin embargo algunos reacomodos entre los sectores más importantes, los servicios de intermediación financiera pierden importancia relativa y los sectores de transporte terrestre, maquinaria, y electricidad, gas y agua mejoran su posición dentro de los sectores que más influencia ejercen desde su primera adherencia.

In Table 3 can be seen the sectors that have a more direct influence on the market structure of the Korean economy. We see that in 1995 the most five prominent sectors were wholesale trade and commission trade, chemicals, financial intermediation, renting of machinery and equipment, and the retail trade. However, by the year 2010 the structure of the five sectors that have the greatest influence is changed, the trade-related sectors reduce their connectivity and others sectors emerge as prominent as oil refining and nuclear fuel, ground transportation and the electricity, water and gas which increase their influence in the Korean market structure.

As in the case of the other economies analyzed in this study, Korean economy also shows a trend to increase the importance of those sectors that are mostly related to services. For both

years of study, more than half of the sectors are engaged in tertiary activities. However, for 2010 the Connection Power of sectors such as oil, chemical and refining machinery have increased their prominence, they are key to the endogenous growth of the economy.

In comparison with Mexico and Brazil, the Korean economy shows more integration into its economy, both in years 1995 and 2010, However some rearrangements among the most important sectors are observed, the financial intermediation services lose relative importance and land transport sectors, machinery, and electricity , gas and water improve their position within the sectors most influential showing an improvement in its Connection Dynamisms.

Table 3

Connection Dynamism for South Korea 1995 and 2010

South Korea 1995			
Number	Sector	First Pseudo-Clousure	Clousure
c28	Financial Intermediation	19	32
c30	Renting of M&Eq and Other Business Activities	16	32
c9	Chemicals and Chemical Products	10	32
c20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	9	32
c29	Real Estate Activities	8	32
c8	Coke, Refined Petroleum and Nuclear Fuel	8	32
c10	Rubber and Plastics	6	32
c12	Basic Metals and Fabricated Metal	5	32
c23	Inland Transport	5	32
c1	Agriculture, Hunting, Forestry and Fishing	4	32
South Korea 2010			
Number	Sector	First Pseudo-Clousure	Clousure
c30	Renting of M&Eq and Other Business Activities	19	33
c8	Coke, Refined Petroleum and Nuclear Fuel	12	33
c9	Chemicals and Chemical Products	11	33
c23	Inland Transport	9	33
c17	Electricity, Gas and Water Supply	9	33
c28	Financial Intermediation	7	33
c12	Basic Metals and Fabricated Metal	6	33
c29	Real Estate Activities	6	33
c13	Machinery, Nec	5	33
c20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	5	33

Source: Own elaboration with WIOD data and the Pretopologie software.

The following minimum elementary sets, which are the sectors with little or minimal influence on the structure for the three economies are:

Mexico 1995: 5,16, 17,18,19,22,24,25,27,31,32,33,34

Mexico 2010: 5, 15, 16, 18, 19, 22, 24, 25, 27, 29, 31, 32, 33, 34.

Brazil 1995: 5, 15, 16, 18, 19, 22, 24, 25, 26, 27, 31, 32, 33.

Brazil 2010: 4, 5, 7, 13, 15, 19, 22, 24, 25, 26, 27, 31, 32, 33.

Korea 1995: 5, 16, 19, 24, 25, 31, 32, 33, 34

Korea 2010: 5, 7, 16, 19, 24, 25, 31, 32, 33.

Conclusions

We made a comparative analysis between the three economies that started from a similar development in the eighties, and through the years have had different performances. The pretopologic tools allowed us to perform a structural analysis of the economies of those economies and we were able to identify their key sectors and some features that point out its dynamics.

The contrast between the economies lead us to that in the case of Mexico, the economic policy has to be re-assed trying to unblock structural deficiencies related to the vertical specialization and the high concentration in a few sectors.

In Mexico and Brazil there are tendencies to induce a Structural Rigidity that is not observed in the case of Korea. Also in the case of Mexico and Brazil, the growing of tertiary activities does not seem relates to its industrial development. This is a serious problem for Latin American economies. We have reasons to believe that the structural rigidity of these economies tends to get worse over time. This could be an explanation for increased Connection Dynamism of elementary sectors.

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