China and Brazil Productive Structure and Economic Growth Compared: 1980's to 2000's

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FIRST DRAFT

Abstract

China and Brazil are two countries with continental dimensions, with differences in availability of natural resources, population sizes, and which have adopted different strategies of economic growth in the past. China has been following consistently a strategy of Export Led Growth (ELG), while Brazil, until the mid 1990s had a strategy based on Import Substitution Industrialization (ISI) with a relatively closed economy to the external market; however, recently Brazil has been switching to a more open economy, based on primary goods exports. In the mid 1980s the Gross National Income measured in US$ using purchasing power parity rates (GNI-PPP) of China and Brazil were at approximately the same level, but by the mid 2000s the GNI-PPP of China was around 4 times greater than Brazil's. By looking at a series of input-output tables and their indicators, like multipliers and linkages, for China (1987, 1992, 1997, 2002, 2007) and Brazil (1985, 1992, 1997, 2002, 2007), we analyze, and compare the productive structures, and their changes over time, for these two countries. From the results, we are able to show the differences between these two countries and the results of the development strategies used by them.

Key words: China, Brazil, Input-Output, Productive Structure, Economic Growth.

1. Introduction

The economies in both the People's Republic of China (China) and Brazil have gone through many changes in last three decades. China and Brazil have differences in availability of natural resources, population sizes, and they have adopted different strategies of economic growth in the past. China has been following consistently a strategy of Export Led Growth (ELG), while Brazil, until the mid 1990s had a strategy based on Import Substitution Industrialization (ISI) with a relatively closed economy to the external market. Recently, however, Brazil has been switching to a more open economy, based on primary goods exports. And, although both China's and Brazil's seemingly miraculous growth in the 2000s has attracted the attention of many economists in the world, few analysts have examined the differences between these two countries' productive structures as well as their changes over time, and compared the results of the development strategies used by both countries.

From Figure 1 it can be seen that the mid 1980s the Gross National Income, measured in US$ using purchasing power parity rates (GNI-PPP), of China and Brazil were at approximately the same level, but by the mid 2000s the GNI-PPP of China was four times that for Brazil, during the same time frame, the Chinese population grew at a smaller rate than Brazilian one, such that at the beginning of the 1980's it was 8 folds greater than the one in Brazil and this difference was reduced to less than 7 folds in 2008. As a consequence of the above, the GNI-PPP per capita of China, that was 7% of the Brazilian level in 1980, is rapidly approaching the value presented by the Brazilian economy, being in 2008 at 60% of the Brazilian level.

Figure 2 shows the differences in percent points between the growth rates of China and Brazil, which were on average, on an yearly base, favorable to China, by 6.8 points in the 1980's, 8.3 points in the 1990's, and 6.3 points from 2000 to 2008. The same Figure also shows the differences between the shares of Gross Capital Formation and Exports in the GDP of these countries. It is striking the fact that despite the economic stabilization and the economic openness that took place in the Brazilian economy, the differences between the Chinese shares and the Brazilian ones have been consistently increasing since the 1980's. This is a point that will be further explored in this paper.

Figure 1: Relationship between China and Brazil for GNI-PPP, GNI-PP Per Capita, and Population, 1980 to 2008
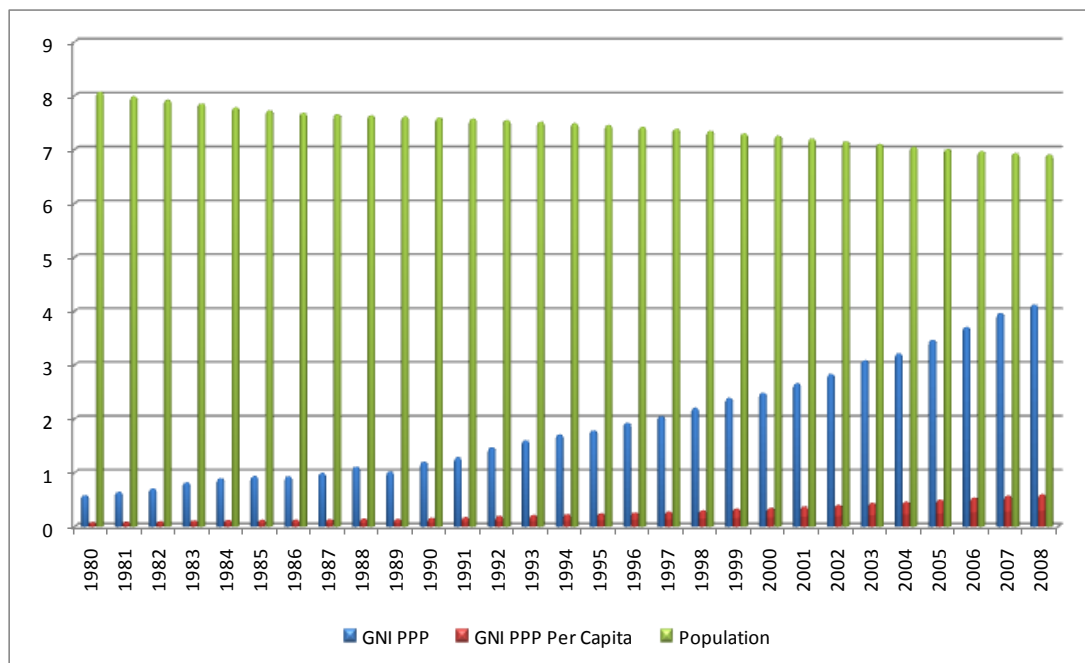
Source: World Bank Database

Figure 2: Differences, in percent points, between Yearly Growth Rates of GDP, Shares of Gross Capital Formation in GDP, and Shares of Exports and GDP of China and Brazil, 1980 to 2008
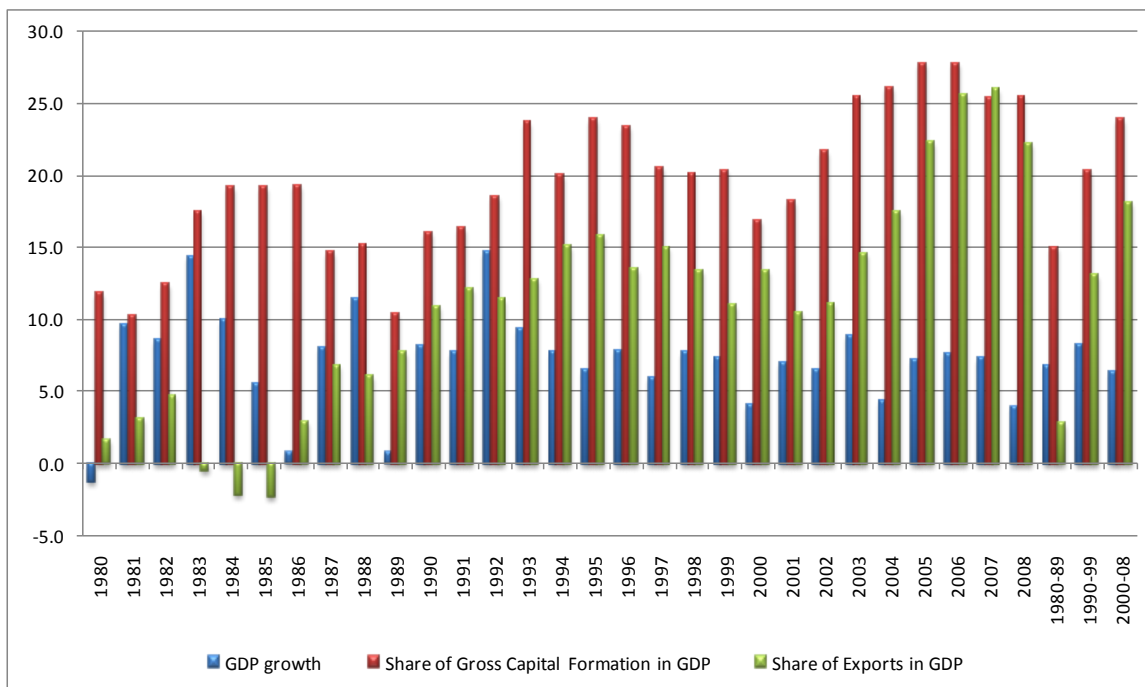
Source: World Bank Database

The analyze to be conducted in this paper, to better try to understand the differences between the economic results obtained by China and Brazil, will be based in a comparative analysis of their productive structures, and their changes over time. This will be done by looking at a series of input-output tables and their indicators, like multipliers and linkages, for China (1987, 1992, 1997, 2002, and 2007) and Brazil (1985, 1992, 1997, 2002, and 2007).

The paper is organized as follow, the next section will presented the theoretical background, while the results will be discussed in the third section and in the last section the final comments will be made.

2. Theoretical Background

From the basic Leontief model, the total output of an economy can be expressed as the sum of intermediate consumption and final consumption (Leontief, 1951) as

$$X = AX + Y \tag{1}$$

$$(I - A)^{-1} = B \tag{2}$$

$$Y = BX \tag{3}$$

where X is the $n \times 1$ total output vector, A is the $n \times n$ direct input coefficients matrix, describing the interindustry relationships between all sectors of the economy, Y is the $n \times 1$ final demand vector, and B is the Leontief inverse matrix ,$(I - A)^{-1}$. AX denotes the intermediate input vector, which can be obtained by multiplying the direct input coefficient matrix by the total output vector. The final demand vector, Y, can be treated as exogenous to the system, for example, the level of total production can be determined by the final demand.

From equation (3) one can estimate the output multipliers of type I for sector j (O_j), which shows the direct and indirect effects for a given sector (Miller and Blair 2009), i.e., the total amount of production generated in the economy to produce one unit of final demand of the given sector, and is given by:

$$O_j = \sum_{i=1}^{n} b_{ij} \tag{4}$$

Based on the Leontief system other indicators, like the Hirschman-Rasmussen and the Pure interindustry linkages presented bellow can be estimated and used to better understand the economic relations and the productive structure of a given economy.

2.1. Interindutsry Linkages

There is a lengthy literature devoted to the concept of key sector analysis, Rasmussen and Hirschman's notions have received widespread application and significant critical commentary (see, for example, McGilvray, 1977, Hewings, 1982). These debates will not be revisited in this paper; rather, the focus will begin with a brief presentation of the Rasmussen and Hirschman approach followed by a more detailed presentation of the work proposed by Guilhoto, Sonis e Hewings (2005).

The work of Rasmussen (1956) and Hirschman (1958) led to the development of indices of linkage that have now become part of the generally accepted procedures for identifying key sectors in the economy.

Define b_{ij} as a typical element of the Leontief inverse matrix, B; B^* as the average value of all elements of B, and B_{*j} the associated typical column sum, then the backward indices may be developed as follows:

$$U_j = \left[B_{*j} / n \right] / B^* \tag{5}$$

Defining F as being the matrix of the row coefficients obtained from the intermediate consumption matrix; G as the Ghosh matrix obtained from $G = (I - F)^{-1}$ (see Miller e Blair, 2009); G^* as the average value of all elements of G, and G_{i*} the associated typical row sum, then the forward indices may be developed as follows:

$$U_i = \left[G_{i*} / n \right] / G^* \tag{6}$$

One of the criticisms of the above indices is that they do not take into consideration the different *levels* of production in each sector of the economy, which is done by the Pure linkages

as developed and presented by Guilhoto et al. (1994) and by Guilhoto, Sonis and Hewings (2005), and summarized below.

Consider a technical coefficients matrix represented by the following block A matrix:

$$A = \begin{bmatrix} A_{jj} & A_{jr} \\ A_{rj} & A_{rr} \end{bmatrix} = \begin{bmatrix} A_{jj} & A_{jr} \\ A_{rj} & 0 \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ 0 & A_{rr} \end{bmatrix} = A_j + A_r \tag{7}$$

where A_{jj} is the matrix of direct inputs to sector j from itself; A_{rj} is the matrix of direct inputs that sector j acquires from the rest of the economy; A_{jr} is the matrix of direct inputs that the rest of the economy acquires from sector j; A_{rr} is the matrix of direct inputs that the rest of the economy acquires from itself; A_j refers to the sector j isolated from the rest of the economy; and A_r represents the rest of the economy.

From (7), one can generate the following expression:

$$B = (I-A)^{-1} = \begin{pmatrix} B_{jj} & B_{jr} \\ B_{rj} & B_{rr} \end{pmatrix} = \begin{pmatrix} \Delta_{jj} & 0 \\ 0 & \Delta_{rr} \end{pmatrix} \begin{pmatrix} \Delta_j & 0 \\ 0 & \Delta_r \end{pmatrix} \begin{pmatrix} I & A_{jr}\Delta_r \\ A_{rj}\Delta_j & I \end{pmatrix} \tag{8}$$

where:

$$\Delta_j = (I - A_{jj})^{-1}$$

$$\Delta_r = (I - A_{rr})^{-1}$$

$$\Delta_{jj} = (I - \Delta_j A_{jr} \Delta_r A_{rj})^{-1}$$

$$\Delta_{rr} = (I - \Delta_j A_{rj} \Delta_j A_{jr})^{-1}$$

From equation (8) it is possible to reveal the process of production in an economy as well as derive the Pure Backward Linkage (*PBL*) and the Pure Forward Linkage (*PFL*), i.e.,

$$PBL = \Delta_r A_{rj} \Delta_j Y_j \tag{9}$$

$$PFL = \Delta_j A_{jr} \Delta_r Y_r \tag{10}$$

where the *PBL* will give the pure impact on the rest of the economy of the value of the total production in region, i.e., the impact that is free from a) the demand inputs that region j makes from region j , and b) the feedbacks from the rest of the economy to region j and vice-versa. The *PFL* will give the pure impact on region j of the total production in the rest of the economy

Other advantage of the Pure linkages in relation to the Hirschman-Rasmussen linkages is that it is possible to get the Pure Total linkage in the economy (*PTL*) by adding the *PBL* and the *PFL*, given that this index are measured in current values, i.e.,

$$PTL = PBL + PFL \tag{11}$$

To facilitate a comparative analysis of the pure linkages with the Hirschman-Rasmussen linkages one can do a normalization of the pure linkages. This normalization is done by dividing the pure linkage in each sector by the average value of the pure linkage for the whole economy, in such a way that the pure linkages normalized are given by the following equations for the backward (PBLN), forward (PFLN) and total (PTLN) linkages:

$$PBLN_i = PBL_i \left/ \left(\sum_{i=1}^{n} PBL_i \middle/ n \right) \right. \tag{12}$$

$$PFLN_i = PFL_i \left/ \left(\sum_{i=1}^{n} PFL_i \middle/ n \right) \right. \tag{13}$$

$$PTLN_i = PTL_i \left/ \left(\sum_{i=1}^{n} PTL_i \middle/ n \right) \right. \tag{14}$$

3. The Chinese and Brazilian Economies Compared

As developing countries, both, China and Brazil, have as their main goal to achieve levels of development to provide their population with standard of living and wellbeing compared to the most developed nation. In their path to achieve this goal, different economic and political strategies were followed by these countries. While in the 1970´s and 1980's Brazil was struggling with the consequences of high external debt and inflation, China was putting forward a strategy of growth based on the exports of manufacture goods, taking benefit of its comparative advantage in the low cost of its labor force. In the 1990´s Brazil was able to bring down the inflation rate and to stabilize its economy, starting a process of opening it to the external markets. However, despite the progress made by the Brazilian Economy and its natural resources, so far it has been not able to catch up with the Chinese level of growth.

By applying the methodology presented in the previous section to make a comparative analysis of the productive structures of China and Brazil, and its changes through the growth process, we will try to shed some light in explaining the differences among these countries.

The input-output data for China refers to the years of 1987, 1992, 1997, 2002 and 2007 while the data for Brazil this data is for the years of 1985, 1992, 1997, 2002 and 2007. These matrix, estimated at basic prices, were made compatible at the level of the 26 sectors, presented in Figures below. For each year, in each country, these input-output matrices were considered in two sets, one with only the domestic inputs in the intermediate consumption and final demand and other with total inputs, i.e., domestic plus imported inputs.

For China and Brazil's it was estimated the domestic and the total output multiplier of type I. Figure 1 shows the differences between the domestic multiplier of Brazil and China, while they are very close in the middle 1980´s, they are on average around 0.5 greater for China in 1992, 1997 and 2007, and 0.35 on average greater in 2002. The differences for the total output multiplier, as show in Figure 2, are even bigger, reaching on average 0.95 in 2008.

Giving the rapid growth of the Chinese economy and the above results one hypothesis that can be made is that as one economy grows faster than another, they economic multipliers, on average need also to be greater. If this hypothesis holds, it could be used as a way to help explaining the difference of growth among regions. However, further investigation is needed in this topic and no conclusive assertion can be made at this point.

The results for the Hirschman-Rasmussen backward and forward linkages for the economies of China and Brasil, as presented in Figures 5 to 8 for the years taken into consideration in this paper, are striking similar with one another, between both countries and through time. The fact that the relative importance of the sectors in both economies, with minor differences are the same is a reflex of the fact that it is the sector structure and not the level of the development of a country or region which should be the main reason in determining the results obtained from the Hirschman-Rasmussen approach.

As it was called attention in the methodological section, if in the analysis of the linkages one takes into consideration also the relative size of the sectors in the economy, as it is done by the Pure linkages approach, the differences between the relative importance of the sectors in the Chinese and the Brazilian economies become more clear.

Figure 3: Difference Between China and Brazil Domestic Multipliers for the Years of 1987(85), 1992, 1997, 2002, and 2007
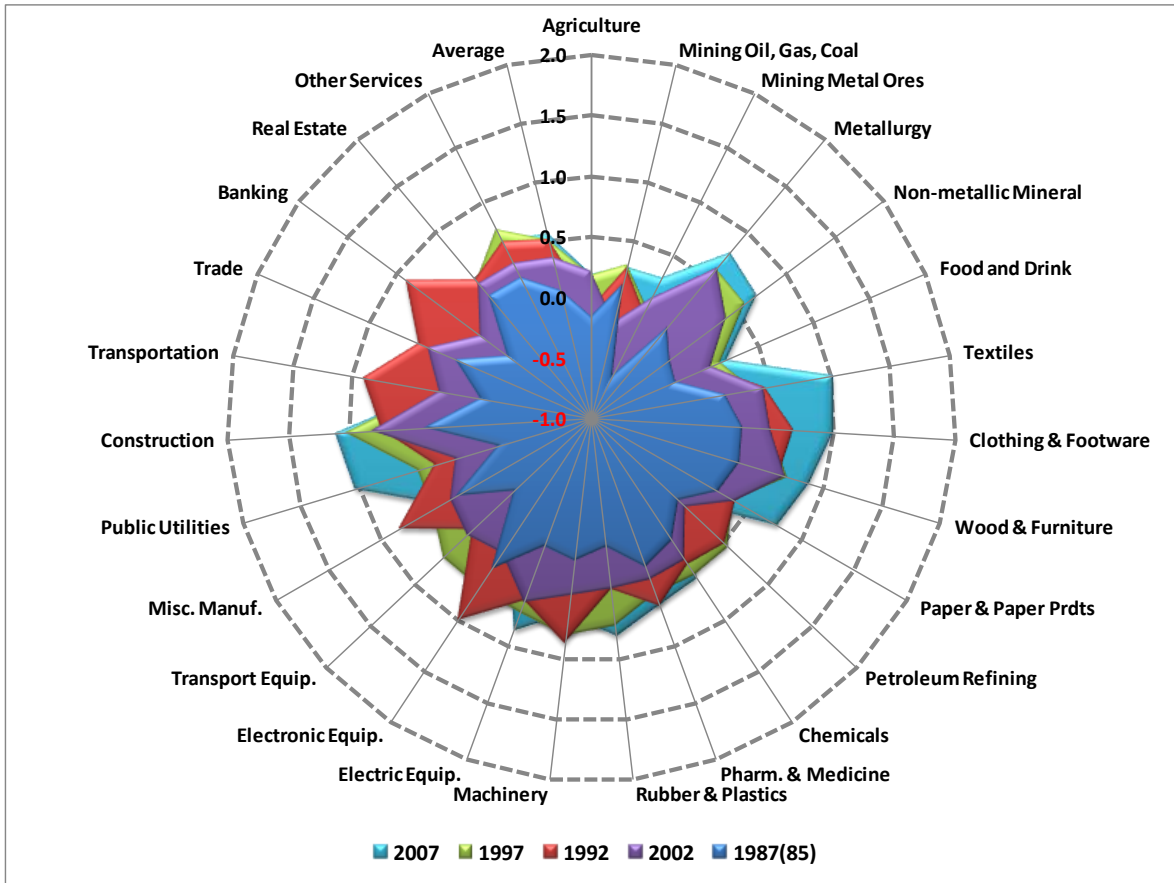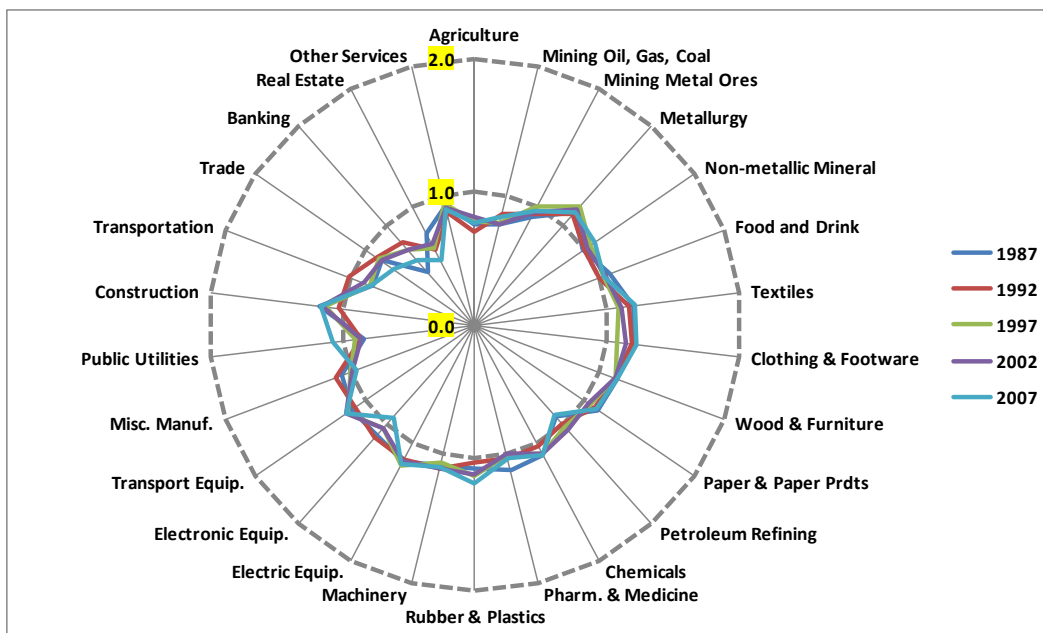

Source: Research data

Figure 4: Difference Between China and Brazil Total Multipliers for the Years of 1987(85), 1992, 1997, 2002, and 2007
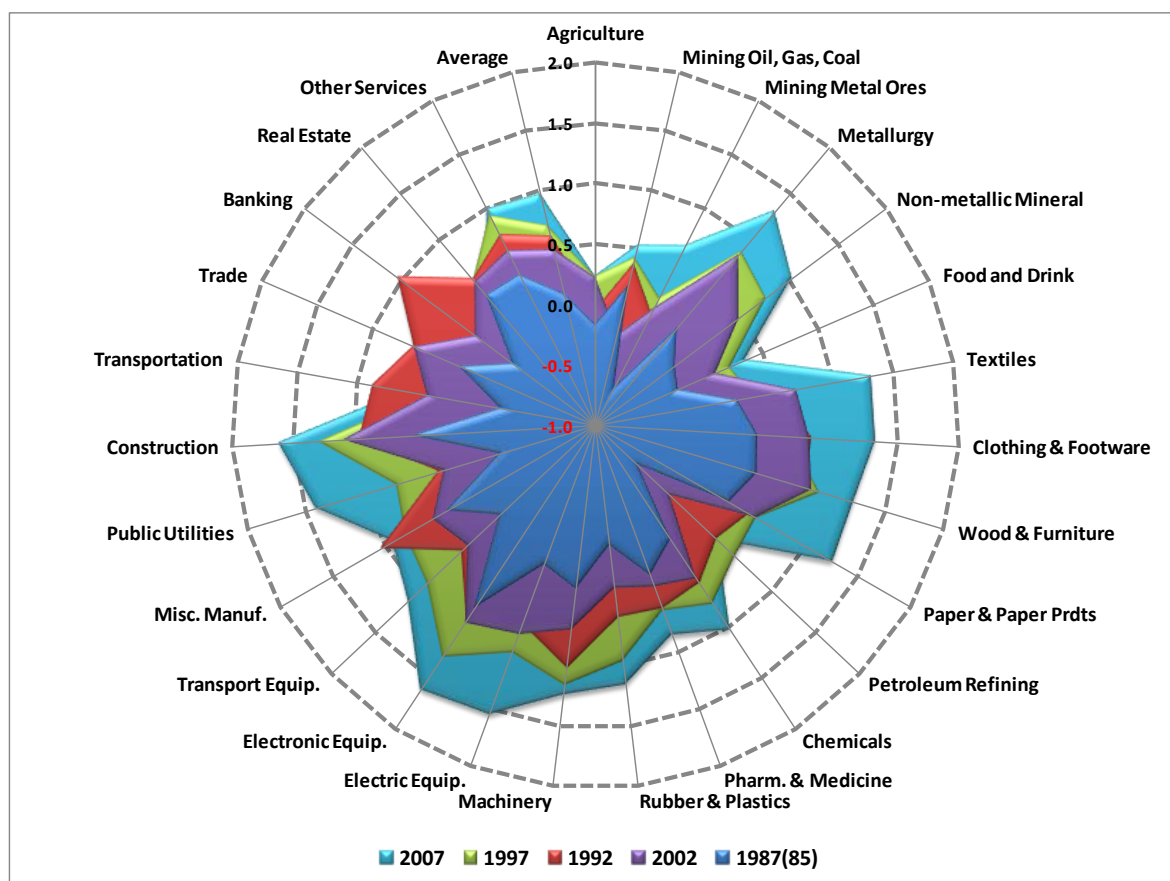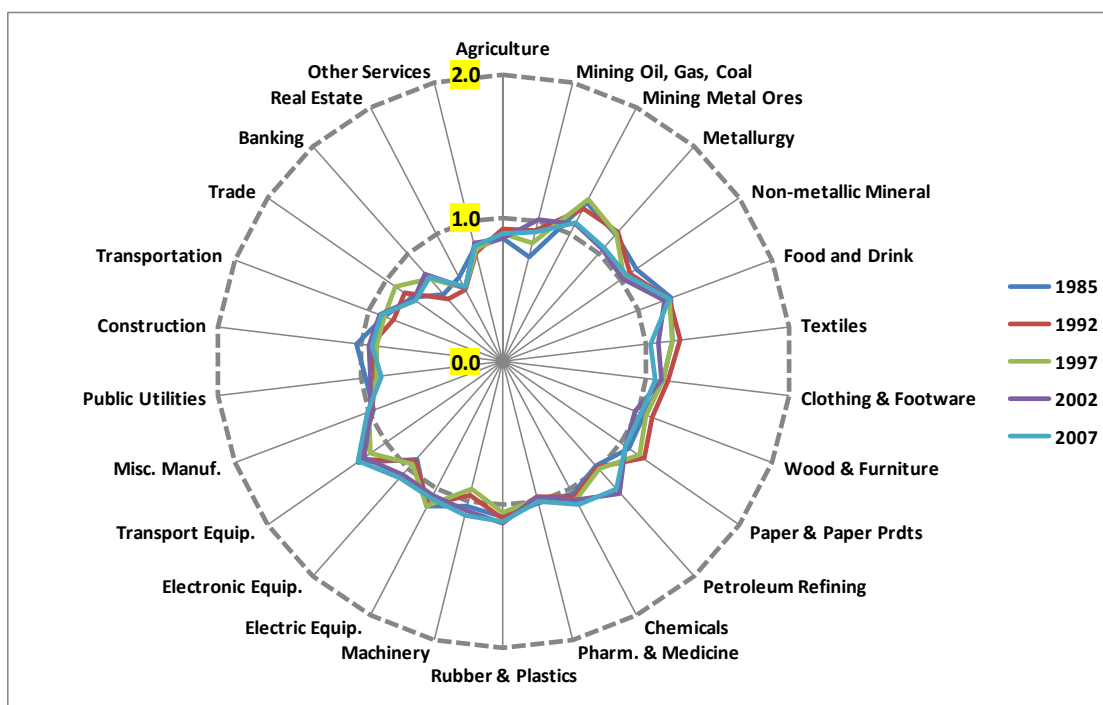

Source: Research data

Figure 5: Hirschman-Rasmussen Backward Linkages for China:
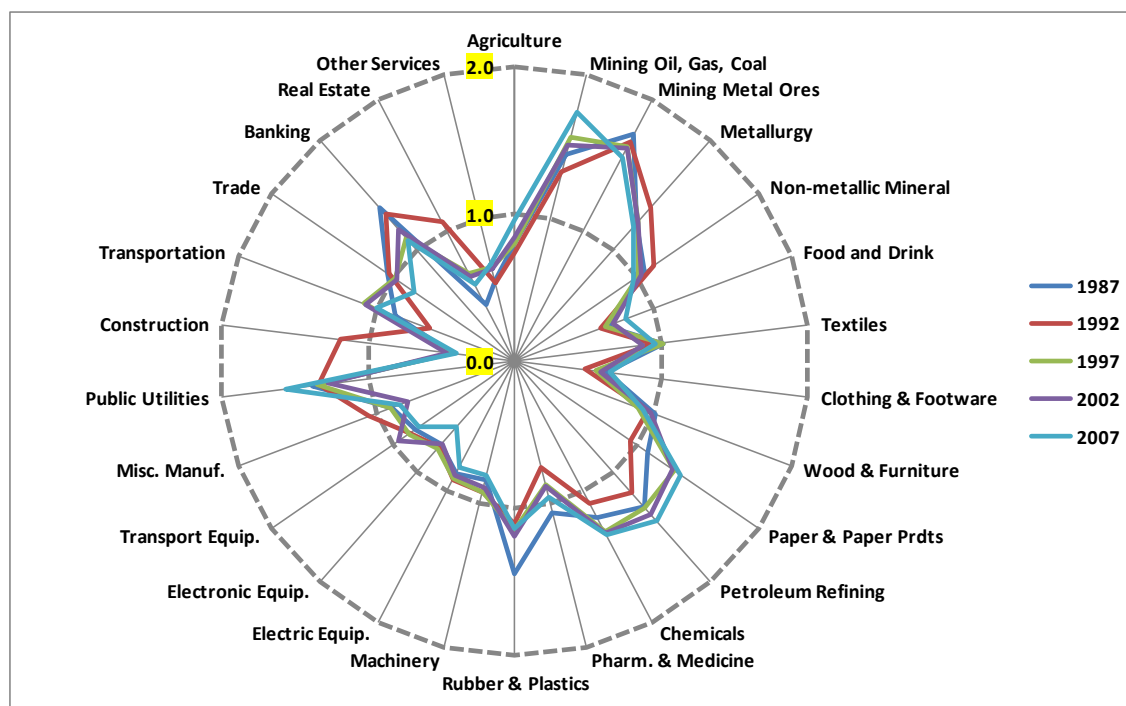1987, 1992, 1997, 2002, and 2007

Source: Research data

Figure 6: Hirschman-Rasmussen Backward Linkages for Brazil:
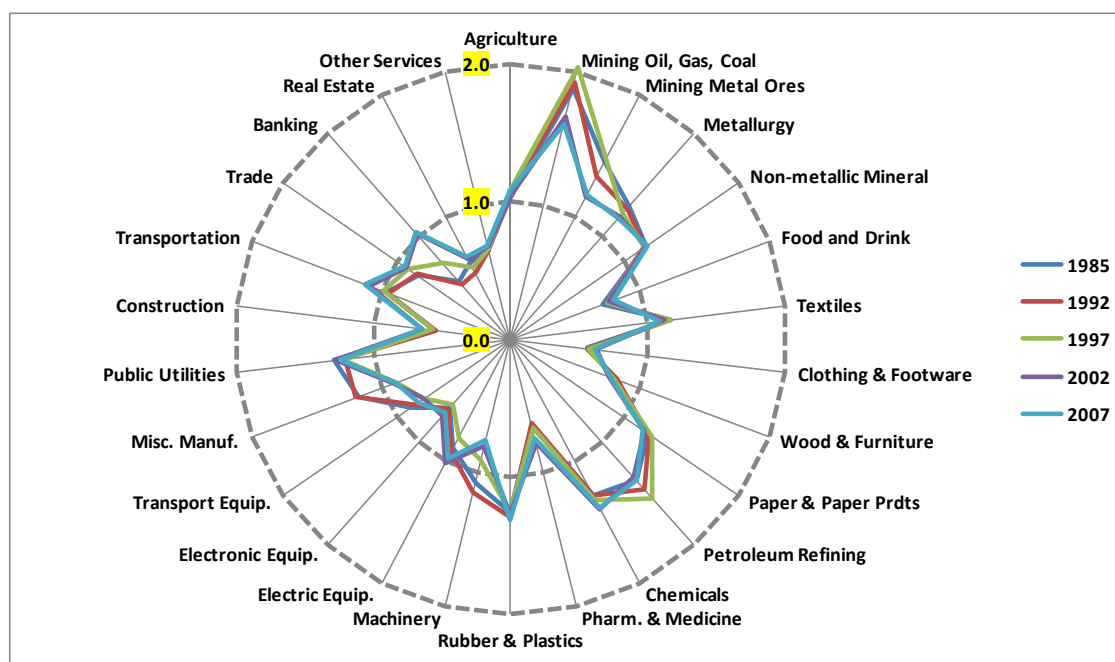1985, 1992, 1997, 2002, and 2007

Source: Research data

Figure 7: Hirschman-Rasmussen Forward Linkages for China:
1987, 1992, 1997, 2002, and 2007

Source: Research data

Figure 8: Hirschman-Rasmussen Forward Linkages for Brazil:
1985, 1992, 1997, 2002, and 2007
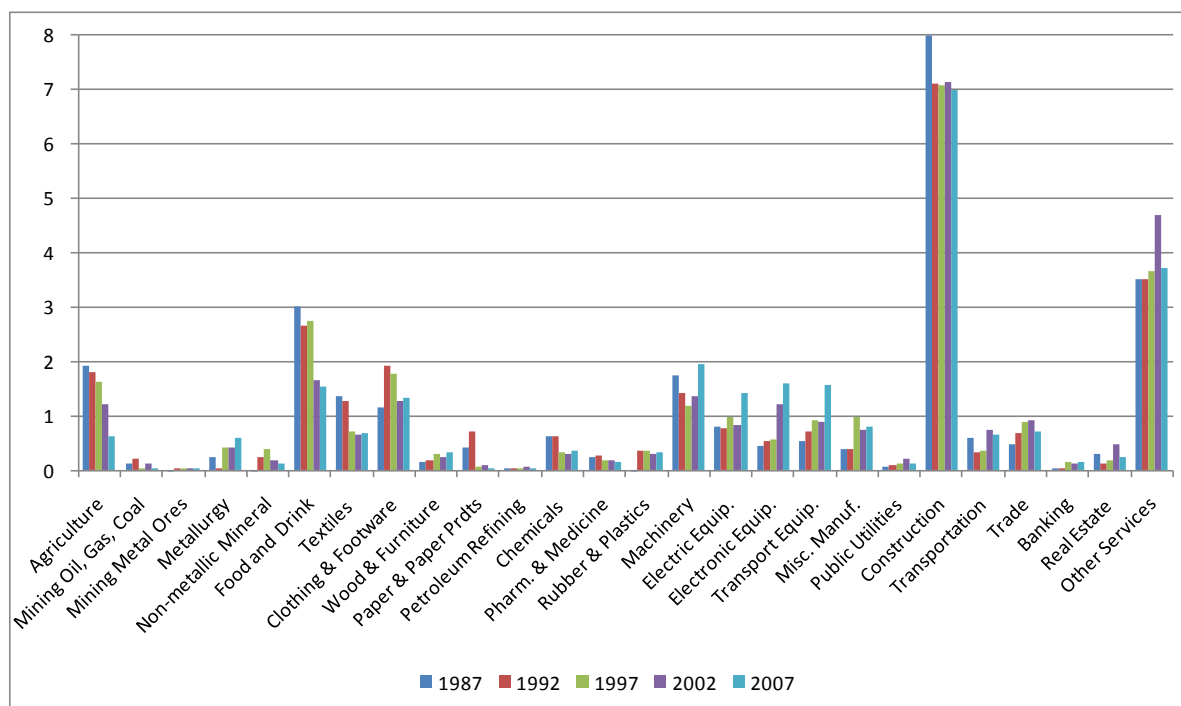

Source: Research data

Figures 9 to 14, and Tables 1 to 3, present the Pure Linkages - backward, forward, and total – for the Chinese and the Brazilian economies.

For the Chinese Pure backward linkages it is possible to see that, overall the most important sectors are Construction, Other Services, Food and Drink, Clothing and Footwear, and Machinery. While the relative importance of sectors like Electric Equipment, Electronic Equipment, Transportation Equipment, Miscellaneous Industries, Transportation, and Trade are increasing, the relative importance of more traditional sectors like Agriculture, Textiles, and Food and Drink are decreasing. In the Brazilian case the most important backward linkages are found in the sectors of Other Services, Food and Drink, Construction, Transportation Equipment, Trade, Transportation; sectors on the rise are Petroleum Refining, Machinery, and Electronic Equipments while declining sectors are Agriculture, Clothing and Footwear, and Banking.

For the Pure forward linkages, the most important for the Chinese economy are Construction, Other Services, Agriculture, Metallurgy, Chemicals, Machinery, Transportation, Trade, Electric Equipment, Electronic Equipment, Transportation Equipment, Clothing and Footwear; declining sector in importance are Agriculture, Non-Metallic Mineral, Textiles, and Food and Drink. For the Brazilian economy the most important sectors are Other Services, Food and Drink, Agriculture, Construction, Public Utilities, Trade, Transportation, Petroleum Refining, Transportation Equipment, Banking, Mining of Metal Ores, Metallurgy, and Chemicals.

For the Pure total eight sectors of the 26 sectors listed in Table 1 are key sectors for both China and Brazil. From the perspective of pure linkage, we can see some clear trends, for some of the sectors, taking place both in China and Brazil. As presented in Figures 13 and 14, the sectors of Agriculture, Processing and Manufacture of Food and Drink, and Construction, have decreased their total pure linkage from 1985(87) to 2007 both in China and Brazil although they are key sectors for both countries' economies. The sector Construction has the largest total pure linkage in China, which means this sector plays the most important role in China's economy. The sectors of Manufacture of Transport Equipment, Transportation, Storage, Postal, and Telecommunication Services, and Other Services have increased their total pure linkage from 1987 to 2007 for both China and Brazil. On one hand, the sector Metallurgy has increased its total pure linkage in China, while on the other hand it has decreased its total pure linkage in Brazil.

Figure 9: Pure Backward Linkages for China: 1987, 1992, 1997, 2002, and 2007
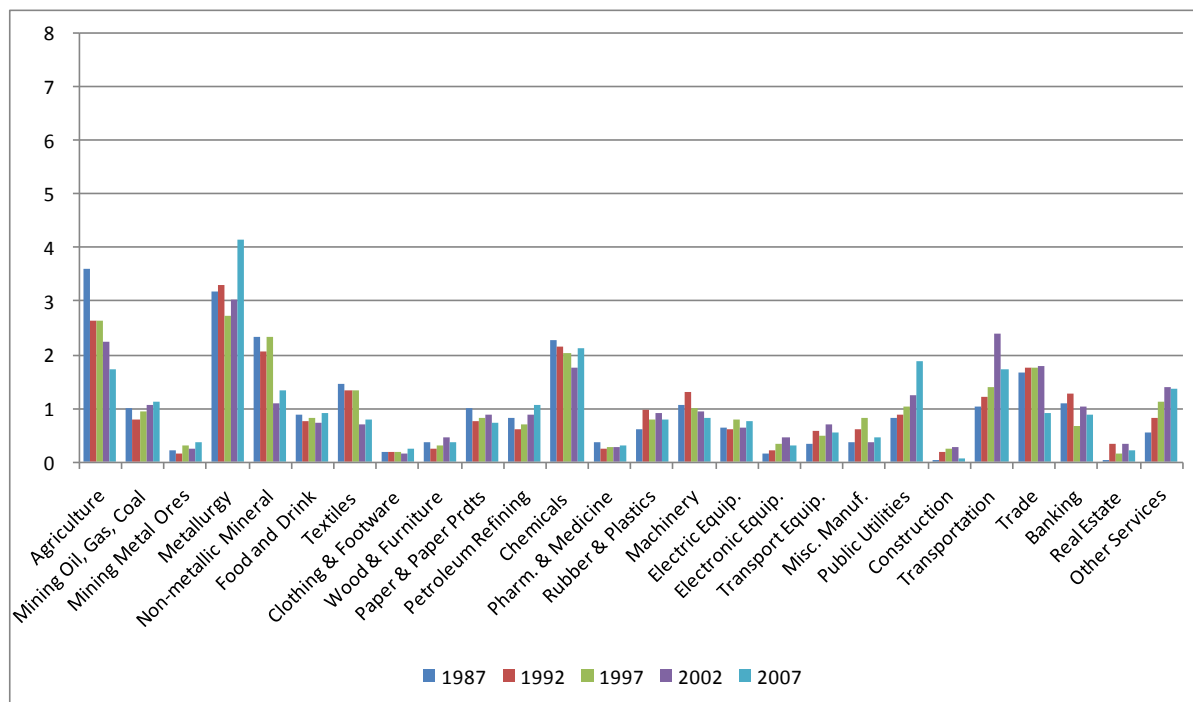

Source: Research data

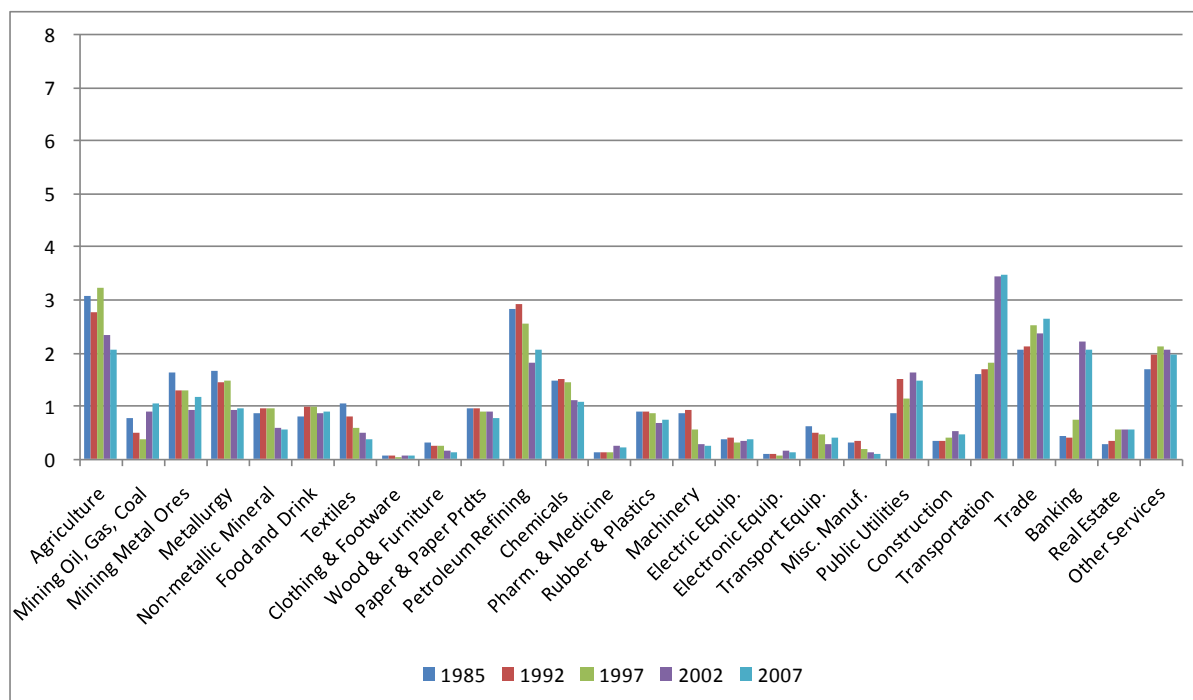Figure 10: Pure Backward Linkages for Brazil: 1985, 1992, 1997, 2002, and 2007
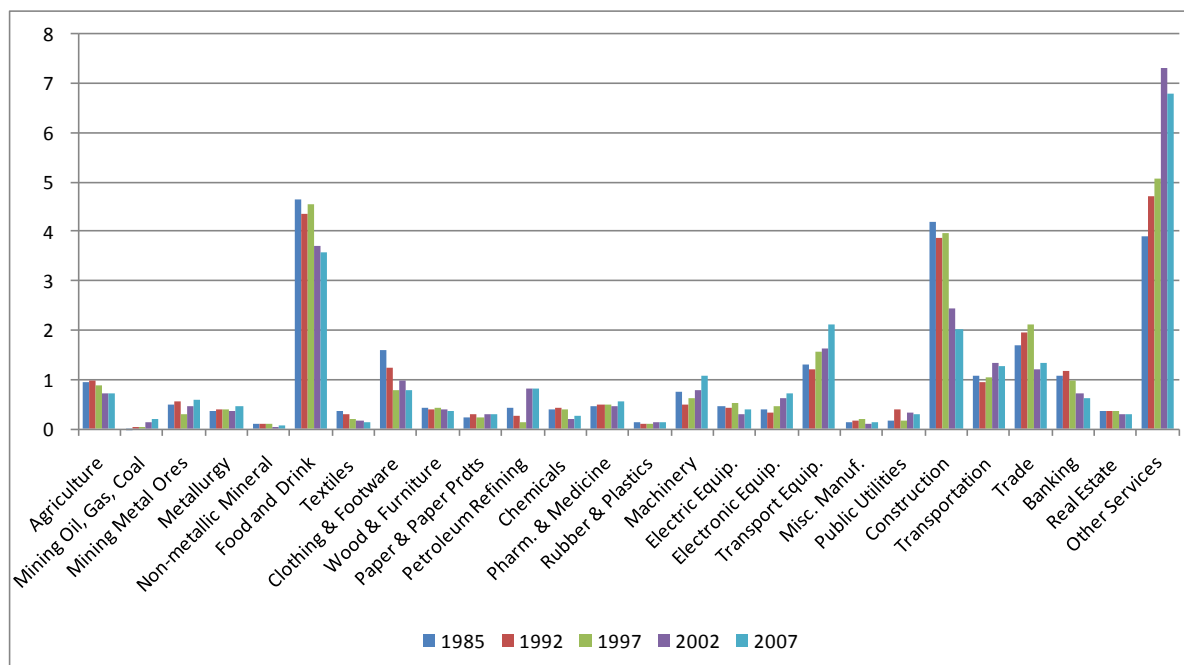
Source: Research data

Figure 11: Pure Forward Linkages for China: 1987, 1992, 1997, 2002, and 2007
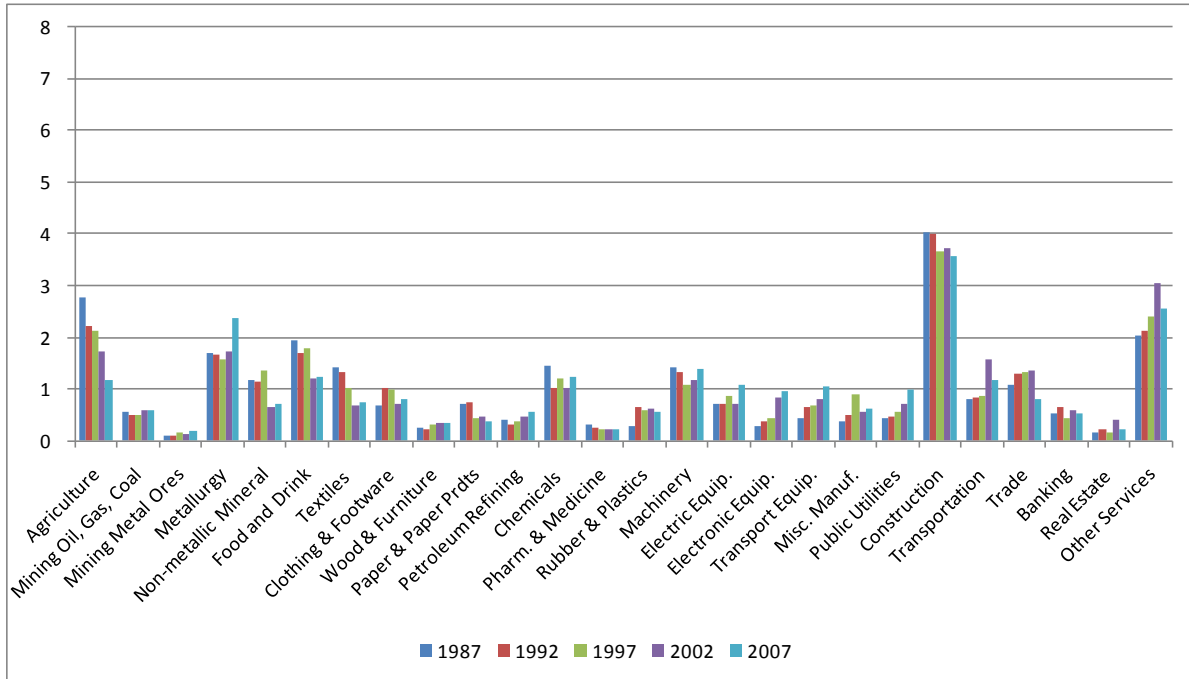

Source: Research data

Figure 12: Pure Forward Linkages for Brazil: 1985, 1992, 1997, 2002, and 2007
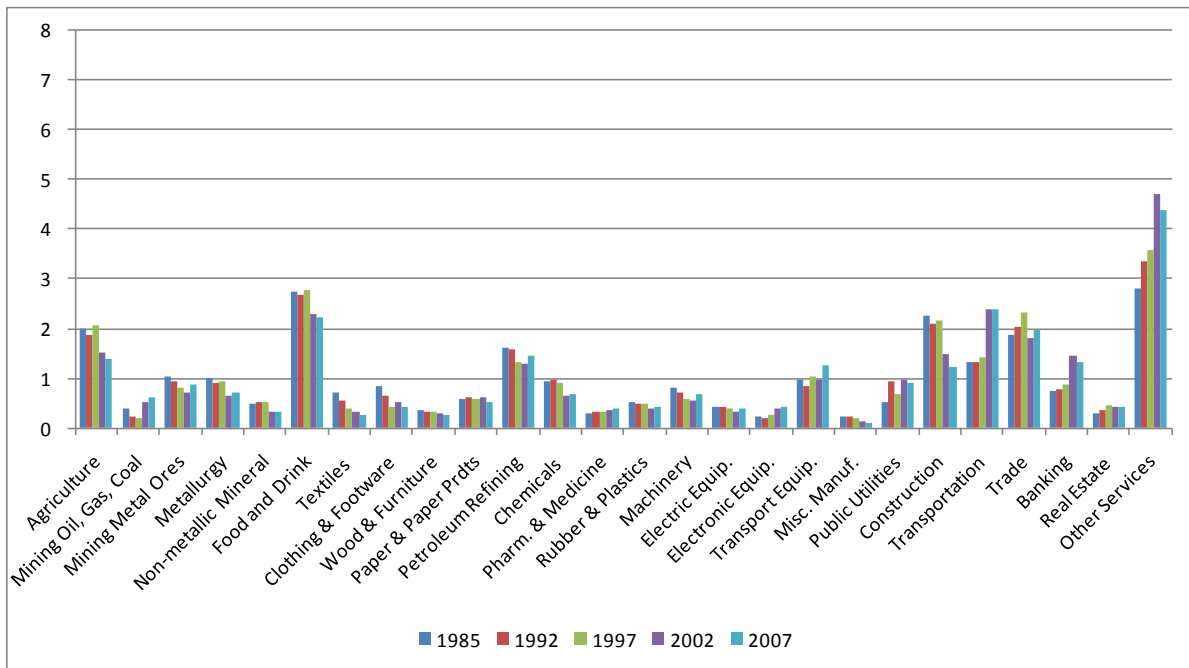

Source: Research data

Figure 13: Pure Total Linkages for China: 1987, 1992, 1997, 2002, and 2007

Source: Research data

Figure 14: Pure Total Linkages for Brazil: 1985, 1992, 1997, 2002, and 2007

Source: Research data

For China, there are six more key sectors except for these listed in Table 1. They are listed in Table 2. Among these six sectors, Non-metallic Mineral Industries sector and Manufacture of Textiles sector both decreased their importance, but Electric Equipment Industries sector and Electricity, Gas, and Water Supply sector both increased their importance in China's economy.

For Brazil there are three more key sectors listed in Table 3. Among these three sectors, Mining and Processing of Metal Ores sector has decreased its total pure linkage and has been not a key sector since 1992, and Financial and Insurance Services sector has increased its importance in the economy and become a key sector since 2002.

Table 1: Sectors that are Key Ones in the Economies of China and Brazil,
Using the Pure Total Linkage Approach: 1985(87), 1992, 1997, 2002, and 2007

Sectors		1985/1987	1992	1997	2002	2007
Agriculture	China	2.76	2.22	2.13	1.73	1.18
	Brazil	2.01	1.87	2.05	1.53	1.39
Metallurgy	China	1.70	1.67	1.57	1.72	2.36
	Brazil	1.01	0.92	0.94	0.63	0.71
Processing and Manufacture of Food and Drink	China	1.94	1.71	1.79	1.20	1.22
	Brazil	2.73	2.68	2.76	2.28	2.23
Manufacture of Transport Equipment	China	0.43	0.64	0.69	0.79	1.06
	Brazil	0.96	0.85	1.03	0.96	1.25
Construction	China	4.02	3.98	3.67	3.72	3.56
	Brazil	2.27	2.11	2.18	1.48	1.24
Transportation, Storage, Postal, and Telecommunication Services	China	0.81	0.83	0.87	1.57	1.18
	Brazil	1.34	1.32	1.42	2.39	2.38
Wholesale and Retail Trade	China	1.07	1.31	1.33	1.35	0.80
	Brazil	1.88	2.04	2.31	1.80	1.98
Other Services	China	2.03	2.14	2.39	3.05	2.54
	Brazil	2.79	3.35	3.60	4.69	4.38

Source: Research data

Table 2: Sectors that are Key Ones Only in the Economy of China,
Using the Pure Total Linkage Approach: 1985, 1992, 1997, 2002, and 2007

|	1987	1992	1997	2002	2007
Non-metallic Mineral Industries	1.16	1.16	1.37	0.64	0.72
Manufacture of Textiles	1.41	1.31	1.02	0.68	0.73
Chemicals	1.45	1.03	1.19	1.02	1.24
Machinery and Tractor Industries	1.40	1.32	1.08	1.16	1.39
Electric Equipment Industries	0.72	0.70	0.87	0.72	1.08
Electricity, Gas, and Water Supply	0.44	0.48	0.57	0.72	1.00

Source: Research data

Table 3: Sectors that are Key Ones Only in the Economy of Brazil,
Using the Pure Total Linkage Approach: 1987, 1992, 1997, 2002, and 2007

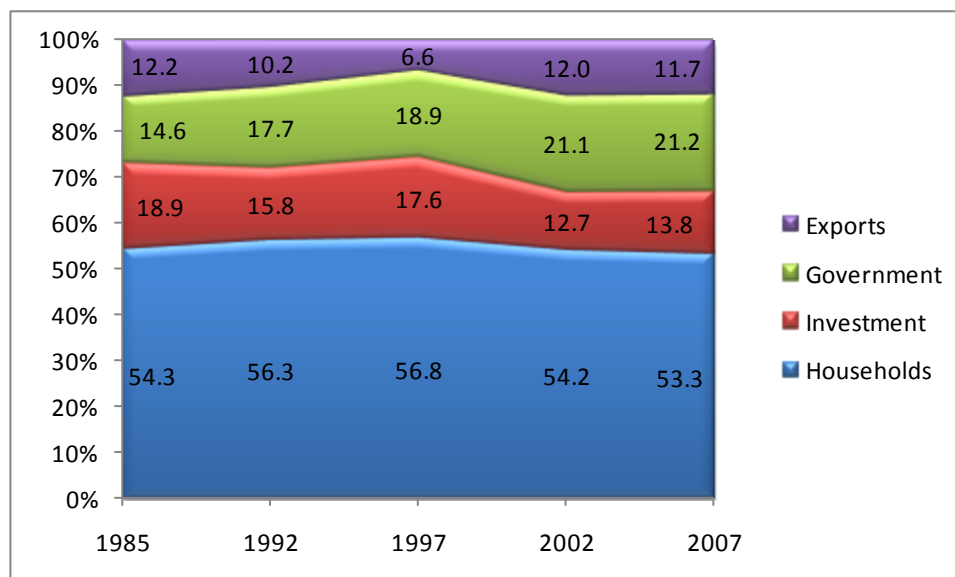|	1985	1992	1997	2002	2007
Mining and Processing of Metal Ores	1.05	0.92	0.80	0.70	0.88
Petroleum Refining	1.62	1.58	1.34	1.30	1.45
Financial and Insurance Services	0.76	0.79	0.87	1.46	1.34

Source: Research data

Based on the Leontief inverse matrix, we also calculated the contribution to GDP (Gross domestic production) by sector from the four final demand components, which are Households consumption, Investment, Government consumption and Exports (Figures 15 and 16). The results indicate that in 1985/1987, households' consumption plays the most important role in GDP; however, its importance has decreased significantly in China while in Brazil, its importance just had a very little change. On the other hand, in Brazil only government spending has a clean increasing trend during this period, which means that Brazilian GDP growth is mainly driven by its domestic market; but in China both investment and exports have contributed more and more in terms of GDP growth, which means that China's economy has been driven by the external market and its level of investment that are leading the Chinese economy to become the most important economy in the World.

Figure 15: China – GDP Dependence on the Components of the Final Demand (Exports, Government, Investment and Households): 1987, 1992, 1997, 2002, and 2007
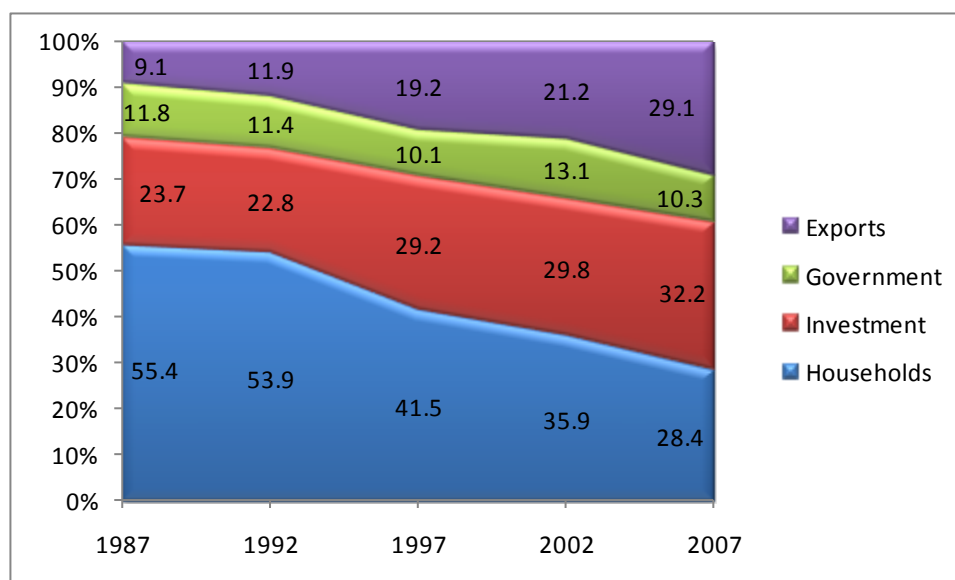
Source: Research data

Figure 16: Brazil - GDP Dependence on the Components of the Final Demand (Exports, Government, Investment and Households) : 1985, 1992, 1997, 2002, and 2007

Source: Research data

4. Final Comments

In this paper, working with a series of input-output tables for China - 1987, 1992, 1997, 2002, 2007 - and for Brazil - 1985, 1992, 1997, 2002, 2007 – it was possible to analyze and to compare these economies and the relative importance of their sectors to the production process as well as the contribution of each component of final demand to their GDP.

The results show that Brazil is still a relatively closed economy with the growth of its GDP being mainly driven by its domestic market, which by its turn is highly depended in the household (54%) and the government spending (21%). The relative importance of the sectors in the Brazilian economy shows that this economy is based on the Service activities and on the commodity sectors, like Agriculture, Mining of Metal Ores, Metallurgy, Food and Drink, Petroleum Refining, and Chemicals, with the more high technology sectors being less important. On the other and the results for the Chinese economy shows that this economy has been driven by the external market (29%) and its level of the investment (32%) with the most important sectors being the Construction sector, which is direct related to the level of investment in the economy, and the sectors related to high technologies like Electronic Equipments, Electric Equipments, Transportation Equipment, and Machinery, while the sectors linked to commodities are losing in importance and becoming only "supporting" sectors in the economy.

A important question that was not dealt in this paper, and needs further research, is the role that natural resources and the environment will play in the future development of the Chinese and Brazilian economies.

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