OWNERSHIP AND TECHNOLOGICAL CAPABILITIES IN BRAZIL

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1) The FDI Inflow into Brazil and the Thesis Question

The inflow of foreign direct investment (FDI) into Brazil has sharply grown since the beginning of the nineties, encouraged by the broad Brazilian economic liberalization and, mainly after 1994, due to the economic stabilization (Table 1).

TABLE 1 – FOREIGN DIRECT INVESTMENT IN BRAZIL – 1993-1998 (US$ billion)

1993	1994	1995	1996	1997	1998
0.71	1.87	5.09	9.98	17.08	26.11

Source: Central Bank of Brazil, 1998

Despite a large share of this FDI being related to the Brazilian privatization process (30-35 per cent in 1997), the amount guided to the industrial sector has been considerable. An important share of this FDI has been consolidated by mergers and acquisition of the biggest domestic firms by multinational corporations (MNCs), enlarging the denationalization of the Brazilian industrial chain. This intense FDI inflow to the Brazilian industry has been reflected by the central role played by MNCs in the industrial restructuring processes, which arose due to the intensified competition after the openness.

The economic debate about what the implications of the growing MNCs' stake in the Brazilian industry has been controversial. Generally, the main point of these discussions relies on the meaning and extent of productivity gains and their impacts on competitiveness. The simultaneousness of these factors has been identified as a result of a positive relationship between FDI and competitiveness in Brazil, even though that an intense FDI inflow increases modernization and competitiveness (BONELLI, 1998). Nevertheless, the meaning of this relationship is not very clear. Through a sectoral quantitative analysis, comparing indicators of competitiveness and FDI flow to Brazil during the nineties, BONELLI (1998) demonstrates that this relation is not positive in all industrial sectors. This, according to the author, confirms only partially the hypothesis that the growing industrial competitiveness in Brazil is due to the increasing FDI inflow.

MOREIRA (1998) argues that this increasing FDI implies quite a favorable cost-benefit balance to the Brazilian industry, as it stimulates technological progress and increases production scale gains and foreign trade. The information on technological progress considered by the author refers to specific aspects related to the modernization, for instance, the relation between productivity gains (added value/employees) and the presence of MNCs.

In most of these studies, innovation and technological upgrading are narrowly associated with modernization, and so concerning only to less complex technological capabilities. Therefore, the meaning of the growing FDI to more complex technological capabilities of the Brazilian industry are not brought to light. That has called our attention to the implications of the growing FDI to deepen technological capabilities (as well develop them), and so, improving the long-term competitiveness of the Brazilian economy. This is an important issue, as different levels of complexity of technological capabilities (TCs) can lead to different results in the short and the long-term economic development.

Guided by this issue, we are developing a thesis in which the main objective is to examine the long-term impact of the growing FDI upon the Brazilian industry, looking at the relation between ownership and TCs. The third section of this paper presents some indicators of technological capabilities by ownership (MNC and domestic firms) at sectoral level, which are proxies to different levels of complexity of TCs. In the second section, the concepts and classifications of TCs are identified. Also, some consideration about the role that MNCs have played to build and deepen technological capabilities in developing countries is presented. This literature review gives the theoretical background to developing and analysing the TCs indicators.

2) The Concept of Technological Capabilities and the Learning Process in Developing Countries

The process of technological change in developing countries was overlooked for a long time by the neoclassical school. That was due to the idea of technology prevailing in that approach as being: exogenous to the economic system; freely available to every economic agent; costless to reproduce, and explicit (i.e. codified by *designs*, manuals and so on). Due to conceiving technology in that way, the studies on neoclassical approach were led to consider developing countries as merely passive importers of technology. The technological progress in those countries should be limited to the "neoclassical question" of technical choice in between capital or labour-intensive (HERBERT-COPLEY, 1990). These countries should select from an "international technological shelf" the useful and appropriate technologies, which maximise their production function (LALL, 1992).

Fostered by the economic turbulence during the seventies and eighties, and by the intensive technological change taking place at that time, some non-orthodox approaches argued against these prevailing simplistic ideas of the technological progress. Initially considering the technological process in general (not specifically in developing countries), those unconventional approaches put the technical change in the centre of their analysis of economic change processes. Therefore, diverging from the neoclassical approach, these new approaches (among them the neoschumpeterian ones) have conceived the technological change as endogenous to the economic system, resulting from a cumulative process that demands efforts to be carried out and to produce results. As effort is required, the idea that developing countries are passive receivers of technology generated in developed countries was started to be questioned. The concern about many aspects of how technological capability is developed and supported in developing countries was increased. Therefore, the economic studies about technological change in developing countries changed from an assumption of passive import of technology to an examination of learning and technological change processes in these countries (FRANSMAN, 1984). In line with this, a vast set of micro-level studies from a non-orthodox point of view was developed, concerning the analysis of the nature of technological efforts in developing countries.

The definitions and classifications of technological capabilities developed through those studies are countless, since capability-building processes, named learning processes, demand efforts at many levels and directions of the productive activities. According to LALL (2000), the "capability building involves effort at all levels – shop floor, process and product engineering, quality management, maintenance, procurement, inventory control, outbound logistics, and relations with other firms and institutions" (: 18). Furthermore, the levels of complexity of the technological capabilities depend on the how explicit and conscious these efforts are.

The explicitness and consciousness of the technological efforts are defined by the trajectory of the learning processes. These are cumulative and path-dependent, meaning that firms "move along particular trajectories in which past learning contributes to particular directions of technical change, and in which the experience derived from those paths of change reinforces the existing stocks of knowledge and expertise" (BELL and PAVITT, 1993 : 168 *apud* LALL, 2000 : 17).

BELL (1984) highlights the existence of different uses of the term "learning". In the discussion on technological growth, learning means, commonly, varied processes through which individuals or organisations acquire skills and knowledge, i.e., widely considering, the acquisition process of technological capability. Therefore, learning is considered as any way through which a firm increases its capability in dominating technology and implementing technical change. BELL emphases the difference between learning-by-doing and the wider learning notions. The learning by-doing processes result passively (with no explicit actions); are virtually automatic, and have no costs, because they are a by product of the production itself. Other forms of learning do not present these three characteristics because they need more explicit efforts and investments in the acquisition of technological capability. The learning-by-doing processes should lead to less complex TCs, while the more explicit ways of learning should lead to more complex TCs. The more explicit the efforts, the more complex are the TCs.

Considering all of those directions and levels of technological efforts, FRANSMAN (1984) identifies six types of capabilities: 1) search for available technological alternatives and selection of the most appropriate ones; 2) domination of the technology, understood as its successful use when transforming inputs into outputs; 3) adaptation of the technology to specific conditions of production; 4) subsequent development through incremental innovations[1]; 5) institutionalisation of the research and development (R&D) activities; and 6) carrying out of basic research. The last two types are more complex, since they are related to the creation of technology, and the first four do not necessarily present an ascendant order of complexity.

Another classification of firm-level technological capabilities is presented by LALL (1992) through a matrix, considering both their levels of complexity and their functions. According to this matrix the levels of complexity could be basic, intermediate or advanced. Furthermore, considering their functions, technological capabilities could be analysed at three dimensions: (1) investment (which can be pre investment and project execution), (2)

[1] Since the learning processes are cumulative and continuous, in most of those studies, innovation is broadly understood. According to LALL (1992) "[o]nce firm-level technological change is understood as a continuous process to absorb or create technical knowledge, determined partly by external inputs and partly by past accumulation of skills and knowledge, it is evident that 'innovation' can be defined much more broadly to cover all types of search and improvement effort" (: 166).

production (process engineering, product engineering and industrial engineering) and (3) linkage within the economy. This is a broad classification as it covers all aspects of the technological capabilities building process.

Another way to classify TCs according their levels of complexity is through the distinction between know-how and know-why (LALL, 1994). LALL (2000) relates know-how to less complex capabilities, which he calls “operational capabilities”. These operational capabilities are the skills and knowledge needed to use technology developed by others. According to LALL (2000), the more complex and deep capabilities are related to the know-why, which is the ability to understand the principles of the technology. This ability he defines as “innovation capabilities”.

CHRISTENSEN (1994) presents another classification of technological capabilities according their levels of complexity: reproductive and dynamic capabilities. The first category is related to the ability to explore and use existing resources and capabilities, through experiential-based learning processes. The second category – dynamic capabilities – promotes innovation and create new routines and capabilities through experimental-based and R&D-based learning processes. Hence, the dynamic capabilities determine the long-term competitive advantage of the country.

The transition from the less complexity capabilities to the more advanced ones requires a qualitative leap, which is only possible by more explicit technological efforts and investments, which can occur by other forms of learning other than learning-by-doing. The skills and limitations to firms and countries to take this leap is an important determinant of their long-term development (FRANSMAN, 1984).

<u>MNCs and the leap to deeper and more complex TCs in developing countries</u>

The conditions to take this leap have became more complex given the current scenario of transformations of the world economy, which has been identified as representing a new stage of the economic internationalisation process, defined as globalization (OECD, 1992). Among the movements that characterise this process are: the intensification of inter-firms cooperation and international mergers and acquisitions, the rise of the FDI levels, the increase of intra-firm and intra-industrial trade, the advancements in the information technologies, and the introduction of new organisational methods. These movements are changing the world economy in two senses: on the one hand, intensifying the international connections, defining globalisation as a stage of “deep international integration” (UNCTAD, 1994); on the other hand, increasing concentration of the world supply structure, reflected by the consolidation of international mega-groups, the world or global oligopolies (OECD, 1992).

These global oligopolies are in the centre of the world transformations, since, in searching for a greater integration and control in all areas of their activities, they have pursued world strategies and determined complex international relation networks (OECD, 1992, DUNNING, 1993). The technological activities are an important element in these strategies due to their relevance as a competitive factor.

The challenges imposed by this new scenario have lead to issues concerning the possibility of reducing the technological gap between developed and developing countries, as they have sharply affected the TCs building process. In others words, the current transformation processes in the world economy have implied the need to reconsider the role of developing countries in the technological change process and the impacts of this process on their learning and technological capabilities (DUNNING, 1993).

According to ARCHIBUGI and PIANTA (1996), "the characteristics of countries and their national systems of innovation, namely their industrial strengths and field of excellence, remain important for moulding the direction taken by international flows of innovative activities and the strategies of multinational companies" (: 462). Moreover, since the technological activities of the MNCs have been less internationalised than their productive activities, remaining concentrated in their home countries, it is worthwhile to understand the position to be occupied by the developing countries in these strategies (OECD, 1992).

The discussion about the kind of interaction established by MNCs with the host countries, and the implications of these interactions for the local technological capabilities-building process brings some light on this matter. According to FLORIDA (1997), there are two types of FDI, which define different relations between the MNC and the host country: market-oriented and technological-oriented. The first type has the objective of adapting and manufacturing of products to local markets. It is motivated overall by the demand side and defines superficial relations with the host country in terms of technological change (skin-deep collaboration). The second type of FDI aims to obtain and ensure access to the science and technology base, to the human capital and to develop connections with the local scientific community. Therefore, it is motivated by the supply side and implies deep relations (soul-deep collaboration) with the host country (INZELT, 1998 and 2000).

These concepts of deep and superficial relations can be compared to the concepts and classification of technological capabilities according to their levels of complexity: the superficial relations, which can result in reproductive capabilities, should be related to the less complex capabilities; and the deep relations, which can result in dynamic capabilities, should be associated with the more complex ones. It is worth highlighting that each one has different impacts in the economic development, as they have different implications to the short and long-term competitiveness.

The literature about technological changing in developing countries has been concerned about the role played by MNCs in the learning and technological capabilities-building process in those countries. In general, it has suggested that the greater part of the technological relations established by MNCs with the host countries is superficial, leading to less complex technological capabilities.

KATZ (1976) and KATZ and BERCOVICH (1993), basing on a number of firm-level empirical studies on technical change in Latin American countries, suggest that the majority of technological efforts undertaken by MNCs involve adapting imported technology to local conditions. These resulting adaptive learning processes, imply less complex technological capabilities in these countries. According this author, MNCs subsidiaries in developing countries, in spite of undertaking adaptive activities, rarely, "engage [in these countries] in more complex activities of R&D, close to the state of the art" (1993 : 470).

LALL (1992) makes similar observation

> FDI can in appropriate conditions, be a very efficient means of transferring a package of capital, skills, technology, brand names and access to established international networks. It can also provide beneficial spillovers to local skill creation and, by demonstration and competition, to local firms. (...). The very factor however, that FDI in such an efficient transmitter of packaged technology based on innovative activity performed in advanced countries has serious implications. With few exceptions, the developing country affiliate receives the results of innovation, not the innovation process itself (...). The affiliate, in consequence, develops efficient capabilities up to a certain level, but not beyond (...). (: 179).

LALL (1992) identifies this as a "truncation" of the technological transfer by FDI, which can limit the positive effects through the host economy. In addition, "a strong foreign presence with advanced technology can prevent local competitor form investing in deepening their own capabilities (...)" (: 179).

To conclude this section, the literature has suggested that developing countries need to carry out some technological efforts to acquire, dominate, adapt, improve and create technologies, even though it has recognised the limits to those countries to create new technologies, in such way that radical innovations to the world would be developed by them. Likewise, the important role played by MNCs in the technological learning process of developing countries has been recognised. However, the literature has highlighted the limits of these economic agents to induce more deep and complex TCs in developing countries.

3) Ownership and Technological Capabilities Proxies

This section presents some indicators of technological capabilities by ownership (MNCs and domestic firms) at sectoral level. The development of these indicators has been based on data collected by an innovation survey, which is part of the broader Research of Economic Activity of State of S. Paulo (PAEP/SEADE). The innovation survey was carried out as it is stated in the Oslo Manual (OECD) and it covers all industrial sectors according to the International Standard Industrial Classification (ISIC Rev. 3). The PAEP comprises 10,453 industrial firms of the State of S. Paulo[2], the most developed in Brazil. According to the Foreign Capital Census, 1995 (Central Bank of Brazil, 1998), this State concentrates 69 per cent of the total of employed individual and 70 per cent of the net operating revenues of the foreign controlled firms in Brazil. Therefore, the analysis of technological capabilities by ownership to the State of S. Paulo should be a good proxy to the Brazilian industry as a whole.

Regarding the main question of our research, that is, what are the long term impacts of growing FDI upon Brazilian TCs, the first two steps to develop the indicators are: (1) to specify what is to be measured, and (2) to identify how it can be done using the PAEP database.

Specifying what is to be measured means identifying the concepts and classification of TCs that are more fitting to the objective of our thesis. The literature review, presented in the previous section, provides the required background. Based on this literature, we are highlighting the concept of technological capabilities as the ***skills, knowledge*** and ***experience*** required for firms to carry out technological efforts to: 1) search and select (acquire) the most appropriate technologies and assimilate and use (dominate) these technologies (basic capabilities); 2) adapt them to specific conditions of production and market and improve them through incremental innovations (intermediate capabilities) and 3) create technology and carry out of basic research (advanced capabilities).

To develop the indicators, so that they can be proxies to different levels of complexity of these TCs, we are distinguishing between ***operational*** and ***innovative capabilities***. That distinction is similar to the one done by LALL (2000). The first one is associated with the basic and intermediate capabilities, and so it is taken here as a proxy of less complex

[2] Using statistical tool, the sample was expanded by Seade Foundation, becoming to cover about 40,000 industrial firms.

technological capabilities. The second one is related to advanced capabilities, being a proxy of the more complex ones. Both include some kind of linkage capabilities: the operational capabilities include the linkages within the productive chain, and the innovative capabilities include the linkages with universities and research institutes. The concepts of operational and innovative capabilities could be related to the production capabilities presented in the matrix of TCs, developed by LALL (1992), and so, they should be related to the process, product or industrial engineering.

Once the concepts of TCs, in which the indicators will be based, are determined, the second step is to identify which of those capabilities could be measured using the PAEP innovation survey. That is a two-fold task. Firstly, the methodology to be adopted must be defined. Given the amount of available variables[3], **compose indices** have been constructed to summarise in a simple number the different kinds of technological capabilities. To construct the indices, fixed minimum and maximum values have been established for each variable. Then every variable is normalised according to the general formula:

$$\mathbf{Index_{ij} = (V_i - V_{i,min})/(V_{i,max} - V_{i,min})}$$

V_{ij} = Actual V value in the sector "j"
$V_{i,min}$ = minimum V_i value
$V_{i,max}$ = maximum V_i value.

The normalisation process is used to range each variable from 0 to 1, which is an important step to compare the variables involved in setting up the indices. The index value for a sector/group of enterprises (domestic and foreign one) shows the distance from 0 towards the maximum possible value of 1. That methodology is based on the Human Development Index (HDI), which was developed by UNDP.

[3] There are, basically, three types of variables. 1) Variables answered in terms of yes/no: R&D activities (intramural, continuously, occasionally); Product innovation (incremental and significant); process innovation; product or process innovation; product and process innovation; product innovation; process innovation; use of robots; CNC/DNC systems (computer numerical controlled machine tools); CAD/CAM/CAE systems; Total Quality Management (TQM); Statistical Control Process (SPC); internal just-in-time; external just-in-time; teamwork of continuous improvement; cellular production; mini-factories.2) Variables answered in terms of the degree of importance (not relevant, slightly important, moderately important, very important, crucial): internal sources of innovation (R&D department; other departments and other enterprises within the enterprise group); external sources (suppliers of materials/components; suppliers of equipment; clients or customers; competitors; universities; research institutes; patent disclosures and licences; fairs and exhibitions; other sources; professional conferences and meetings). 3) Variables answered in terms of absolute value: number R&D staff and number of firms which have R&D staff. All variables are related to 1996. The information made available was the number of firms what answered the questions and the per cent of added value by firms what answered yes.

Once the methodology was defined and the available variables considered, the following proxies to technological capabilities it have been developed:

a) Linkage Index as proxy of linkages capabilities; it is constructed from the variables of external sources of information for innovation. It is composed by three other indices:
   - Production Chain Linkage Index (suppliers of material/components, suppliers of equipment, clients and customers, competitors, patent disclosures and licences);
   - C&T System Linkage Index (universities and research institutes);
   - Others Linkage Index (fairs and exhibitions, others sources, professional conferences, meetings);
b) Process Engineering Index, based on variables related to the use of techniques and equipment in the production process; as the former it is a compose index of two others:
   - Organisational Index (use of TQM, SPC; internal JIT and external JIT);
   - Equipment Index (use of robots; CNC/DNC systems and CAD/CAM systems);
c) Occasional Effort Index;
d) Systematic Effort Index; it is based on the R&D activities continuously and number R&D personnel;
e) Output Index, composed by:
   - Incremental Innovation Index;
   - Significant Innovation Index;
   - Process Innovation Index.

All proxies have been developed by industrial sectors, classified according to their technological intensity. That classification (four levels: low-tech, medium-low-tech, medium-high-tech, high-tech) was developed by OECD, adopting the criteria of overall R&D intensity (direct and indirect) (HATZICHRONOGLOU, 1997). Based on this classification, two groups of sectors can be considered: the less technologically complex sectors (low-tech plus medium-low-tech) and the more technologically complex sectors (medium-high-tech and high tech) (Table 2).

TABLE 2 – INDUSTRIAL SECTORS AND THEIR TECHNOLOGICAL COMPLEXITY

Code	Industrial Sectors	ISIC Rev.3	Tech-Complex[1]
	Less technologically complex sectors		
1	Food Products and Beverage	15	1
3	Textiles	17	1
4	Clothing	18	1
5	Leather products	19	1
7	Pulp and Paper	21	1
8	Publishing, Printing and Recorded Media	22	1
12	Rubber and Plastic Products	25	2
13	Stone, Clay and Glass (non-metalic Mineral)	26	2
14	Basic Metals	27	2
15	Fabricated Metal Products(except Machinery)	28	2
	More technologically complex sectors		
10	Chemical Products (except Pharmaceutical Products)	24 less 2423	3
11	Pharmaceutical Products	2423	3
16	Mechanical Machinery	29	3
17	Office Machinery, computing	30	4
18	Electrical Machinery and Components	31	3
19	Electronic Material and Telecom Equipment	32	4
20	Medical, Precision and Optical Instruments	33	3
21	Motor Vehicles	Part 341+342	3
22	Autoparts	343	3
23	Other Transport (aircraft, shipbuilding, etc.)	35	3

Note: (1) Technological complexity: (1) low-technology; (2) medium-low-technology; (3) medium-high-technology and (4) high technology

In trying operationalise the concepts of innovative and operational capabilities, some of these proxies have been selected to build up two further compose indices. Then, a proxy to innovative capabilities is calculated as the simple average of indices which could indicate more complex capabilities, namely: Systematic Effort Index, Significant Innovation Index and C&T System Linkage Index. The Operational Capabilities Index is calculated as the simple average of Production Chain Linkage Index, Process Innovation Index and Organisational Index. The hypotheses behind these two composed proxies are that: 1) firms that have carried out more systematic technological efforts and have been more successful in doing this (i.e: have found more significant innovation), should have higher technological capabilities than the others; 2) having universities and research institutes as sources of information for innovations could indicate a deeper learning process. Therefore, the Innovation Capabilities Index is a proxy to more complex TCs and the Operational Capabilities Index is a proxy of the less complex ones.

Besides the two hypotheses above, others can be used to help the analyse of the indices:

a) The higher the Linkage Index, the larger the spillovers and externalities to the local economy;
b) The higher the Process Engineering Index and its components (Organisational and Equipment Index), the more intense the modernization process; and the more intense the modernization process, the larger the productive efficiency gains;
c) The higher the Systematic Effort Index, the larger the possibility to improve and deepen the technological capabilities;
d) A higher Output Index and its components (Incremental Innovation Index, Significant Innovation Index and Process Innovation Index), could indicate a higher effectiveness of the efforts carried out.

Technological capabilities of MNCs and domestic firms: drawing some comparisons

This sub-section draws some comparisons between MNCs and domestic firms, regarding their technological activities. Though this is still a partial analysis, it represents an important step to evaluate the role that have been played by MNCs in the Brazilian TCs-building processes. Therefore, it helps to evaluate the long-term implications of the increasing FDI inflow into Brazil.

The comparison between the average technological capabilities proxies for MNCs and for domestic firms suggests, at a glance, a more dynamic learning process by the former. On all average indices, both in the less and in the more technologically complex sectors, MNCs score better than domestic firms. Yet, in less technologically complex sectors, the differences between MNCs and domestic firms are smaller than that observed in the more complex ones. Insomuch the average Significant Innovative Index (S.IN) for domestic firms (0.32) is higher than that for MNCs (0.27). As it is one of the partial indices that compose the Innovative Capabilities Index (INCAP), this contributes to MNCs and domestic firms, therefore, resulting in the same innovative capabilities score (0.17) in the less complex sectors (Charts 1 and 2).

Though the smaller differences observed in less complex sectors, both domestic firms and MNCs score quite low on all indices. That is probably related to the mature technological stage of these sectors. The characteristics of their markets, products and technology itself imply a less dynamic technological process, as they require less technological efforts.

CHART 1 – AVERAGE INDICES - LESS COMPLEX SECTORS

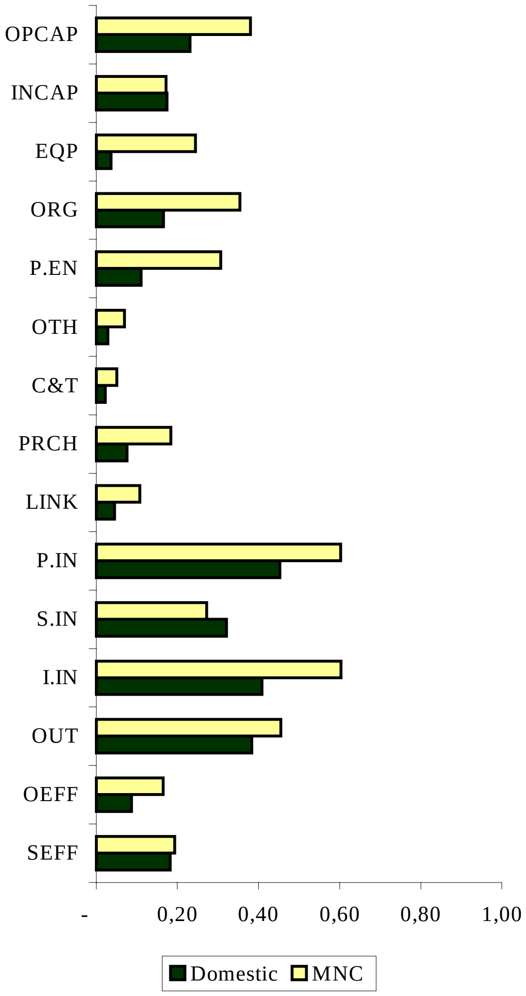
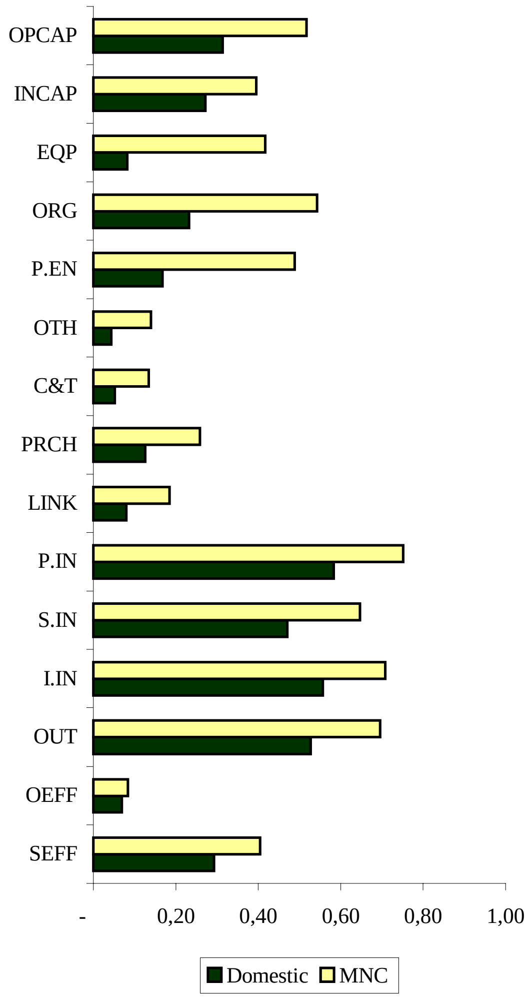


CHART 2 – AVERAGE INDICES - MORE COMPLEX SECTORS



NOTE: **OPCAP** (Operational Capabilities Index); **INCAP** (Innovative Capabilities Index); **EQP** (Equipment Index); **ORG** (Organisational Index); **P.EN** (Process Engineering Index); **OTH** (Others Linkage Index); **C&T** (C&T System Linkage Index); **PRCH** (Productive Chain Linkage Index); **LINK** (Linkage Index); **P.IN** (Process Innovation Index); **S.IN** (Significative Innovation Index); **I.IN** (Incremental Innovation Index); **OUT** (Output Index); **OEFF** (Occasional Effort Index) and **SEFF** (Systematic Effort Index).

Indeed, as the figures suggest, the technological activities are not much expressive, both in less and more complex sectors. The Systematic Effort Index is low for MNCs as well as for domestic firms. It is lower than the Output indices, on which, despite MNCs score better than domestic firms, the differences between them are not so significant. Among the Output indices, the high Incremental and Process Innovation indices could be associate with the current modernization process. Nevertheless, these high Output indices should be carefully analysed, since the technological nature and intensity of the innovations are note enough picked up by the two-fold distinction: significative and incremental innovations[4].

Regarding the Linkage indices in the two groups of sectors, both the MNCs and the domestic firms are score quite low. While, the Linkage indices scored by MNCs are somewhat higher than that scored by domestic firms. Amongst the three partial Linkage indices, the C&T System Linkage is the lowest. Excepting for the Office Machinery and Computing sector, where MNCs score 0.20 against 0.08 to Productive Chain Linkage Index. For the domestic firms, the exception is the Pharmaceutical Products sector: score 0.14 on the C&T System Index against 0.13 on the Productive Chain Linkage Index.

This figures on the C&T Linkage Index reflect the tenuous connection between the industrial technological activities and the universities and research institutes in Brazil. The few exceptions among the more complex sectors suggest the dependence of linkages on the technological characteristics of products and sectors.

In addition, the correlation between the Systematic Efforts and the Linkage indices is quite low for the domestic firms, contrasting to the high correlation observed for MNCs. That could indicate that MNCs firms are more effective in establishing relations with other technological actors, meanly within the productive chain. That means that the technological activities carried out by MNCs could be resulting in more spillovers to local economy than those carried out by domestic firms.

Considering domestic firms, another significant aspect in terms of the Linkage indices is their high correlation to the Process Engineering indices. As these indices are proxies to modernization, that high correlation should be associated with the strong pressures over domestic firms (most of them small and medium firms) to speed up the upgrading of their productive activities.

[4] ALBALADEJO, Manuel and ROMIJN, Henny (2000) developed an interesting classification of innovations according to their degree of novelty and to their degree of science intensity.

Regarding the two main compose indices, the Operational Capabilities Index (OPCAP) is higher than the Innovative Capabilities (INCAP) one. Even though, both of them are low, mainly in less complex sectors. The analysis sector by sector shows that both the MNCs and the domestic firms reach their best scores in the more technologically complex sectors (Charts 3 and 4). Concerning the Operational Capabilities Index, for instance, the domestic firms have their best score in Office Machinery and Computing (0.42), by the way the same reached by MNCs. The scores in the Electronic Material and Telecom Equipment sector are among the highest both for the MNCs and for the domestic firms: 0.66 the former and 0.29 the last. Regarding the Innovative Capabilities Index, domestic firms reach their best score in the Office Machinery and Computing sector (0.36) again. That score is close to that reached by the MNCs in this sector: 0.40.

The higher scores reached in more complex sectors reinforce the importance of technological complexity in shaping the technological dynamic of firms. What could also be confirmed through the high positive correlation showed by MNCs between the technological complexity (based on four levels of complexity) and the indices. That is related to the best performance of MNCs in more complex sectors. This should be associated with the fact that the MNCs are concentrated in these sectors: they account for nearly 51 per cent of the added value in more complex sectors and 20 per cent in the less complex ones.

In addition, it is important take in account the firm size, since, MNCs represent only 5.5 per cent of the total number of firms of the PAEP database, while account for 40.5 per cent of the total added value. That means MNCs are the biggest industrial firms in Brazil. It makes the indices developed only by ownership (domestic and MNCs) somewhat biased, as larger firms tend to be more innovative. However, the simultaneous development of indices by firm size and ownership is the next phase of our research.

To conclude, farther demonstrating a low performance of technological activities in Brazil, the figures suggest a moderate deepening of the Brazilian TCs, both by MNCs and by domestic firms. In view of the cumulativeness of the learning process, this could jeopardise a virtuous cycle of TCs-building and industrial development at the long-term in Brazil.

CHART 3 – OPERATIONAL CAPABILITIES INDEX BY SECTORS – AVERAGE

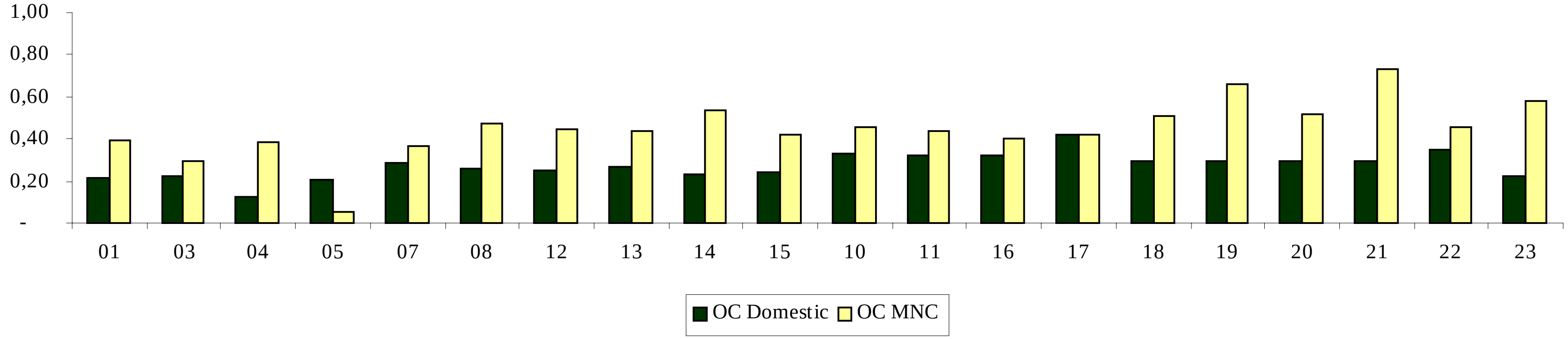
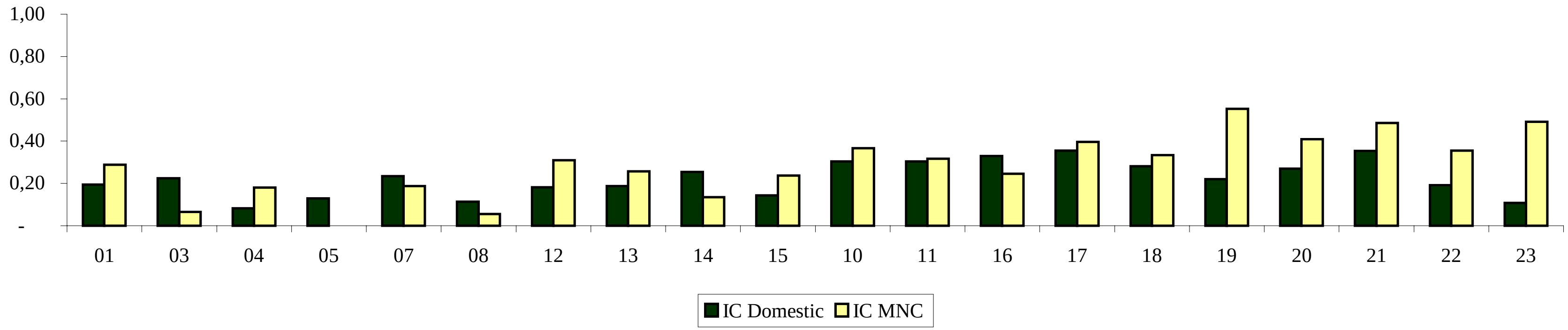


CHART 4 – INNOVATIVE CAPABILITIES INDEX BY SECTORS – AVERAGE



4) Conclusions

The indices presented in the previous section led to conclude that MNCs have a better technological performance than domestic firms. That is probably due to the fact that the former are amongst the biggest firms in Brazil and are concentrated in more technologically complex sectors.

Nevertheless, in spite of MNCs show a better performance, their TCs-building process is quite limited. What means that the learning process in MNCs subsidiaries in Brazil should not lead to more complex TCs in the long-term. The technological activities carried out by MNCs are more related to the operational capabilities than to the innovative ones.

Their technological linkages to the whole economy are quite low as well. The majority of them are within the production chain, what reinforce the operational character of the technological efforts carried out.

The indices indicate the gains induced by MNCs in terms of operational capabilities, that means productive efficiency gains. MNCs are important actors in upgrading the Brazilian industrial chain, however, as pointed by the literature, they are not the best agent to deepen TCs in Brazil by themselves.

The low technological performance of MNCs suggests that the increased FDI inflow into the Brazilian industry do not *per si* ensure the deepening of TCs. Therefore, the debate about FDI in Brazil should consider this limitation of FDI regarding the technological learning processes of the country. Then, it should start to consider how MNCs could be induced to develop more complex technological activities in Brazil, and how the spillovers of these activities could be maximised to the whole local economy. That means found a way to develop and to drive the Brazilian technological learning process, involving all potential technological actors: domestic firms, MNCs and C&T system as a whole.

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