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OWNERSHIP AND TECHNOLOGICAL CAPABILITIES IN BRAZIL

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OWNERSHIP AND TECHNOLOGICAL CAPABILITIES IN BRAZIL[1]

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Abstract

Over the last fifty years, foreign-owned firms have played an important role in developing the Brazilian industry. The focus of debate on the impacts of these firms upon technical change in Brazil has been on the *use* of technology. However, a further understanding of how they can help to deepen local technological capabilities (TCs) is crucial. The research we are developing is an attempt to throw some light on this issue. As part of this task, this paper aims to present some proxies for TCs, comparing foreign- and domestic-owned firms. Farther demonstrating a low technological performance in the Brazilian industry, the figures point to a moderate TCs-building process, both by foreign- and domestic-owned firms. This suggests that foreign-owned firms do not *per si* mean local accumulation of deeper technological capabilities.

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1) Introduction

The inflow of foreign direct investment (FDI) into Brazil has sharply grown since the mid-1990s, encouraged by the broad liberalization and the stabilization of the Brazilian economic (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 is related to the Brazilian privatization process (30-35 per cent in 1997), the amount directed toward the industrial sector has been considerable. An important part of this FDI has been performed through mergers and acquisition of one the biggest domestic firms, enlarging the denationalization of the Brazilian industrial sector. This intense inward FDI is reflected on the central role played by multinational corporations (MNCs) in the industrial restructuring processes in the Brazil. These processes arise due to the intensified competition and the growing local market after the economic openness.

The policy and economic debate on the implications of the growing MNCs' stake in the Brazilian industry has been controversial. Generally, the central point of discussion is the meaning and extent of productivity gains and their impacts on competitiveness. As empirical studies have observed a simultaneousness of productivity gains and increased MNCs' stake, a positive relationship between FDI and Brazilian competitiveness has been suggested (BONELLI, 1998). However, so far the meaning of this relationship is not very clear. For instance, BONELLI (1998) notes, comparing indicators of competitiveness and FDI inflow in Brazil, that this relationship is not always positive. According to him, this observation suggests that the hypothesis that the growing Brazilian industrial competitiveness is due to the increasing FDI inflow is only partially confirmed.

In terms of technological development, the evidences of a positive influence of MNCs are much less clear. MOREIRA (1998) argues that the intensified FDI inflow implies a quite favorable cost-benefit balance to the Brazilian industry, as it stimulates technological progress and increases production scale gains and foreign trade. It is worth noting that Moreira measures "technological progress" through productive gains (value added/employee), and its statistical correlation to MNCs' stake. In fact, the introduction of new technology by MNCs has favored a so-called modernization of product and productive activities, resulting in productivity gains and growing competitiveness in the Brazilian industry.

However, this modernization, as it is characterized by use of updated technologies, does not necessarily imply that Brazil is evolving towards more complex levels of technological accumulation. That is, thus far, the meaning of the growing FDI in terms of a further technological accumulation in the Brazilian industry has not been brought to light. Considering this issue in terms of the technological capability approach, the point to be investigated is whether FDI can help to develop and deepen local technological capabilities.

From this perspective, we are developing a Ph-D thesis, as an attempt to throw some light on this issue. As part of this task, this paper aims to present some findings we have made so far, by comparing some proxies for technological capabilities between MNCs and domestic firms. The next section highlights some concepts and classification from the technological capability literature, which give the theoretical background for the proxies; and summarises some observations about MNCs' influence on technological change in developing countries. The third section outlines some methodological aspects for developing the technological capabilities proxies. Section 4 presents the proxies for technological capabilities, and draws some comparison between MNCs and domestic firms, at sectoral level. Finally, Section 5 makes some concluding remarks.

2) Technological Capabilities and 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 perceiving technology in this 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 between capital and 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 concerned with technological process in developed countries, these unconventional approaches put the technical change in the centre of their analysis of economical change processes. Therefore, diverging from the neoclassical view, these new approaches (among them the neoschumpeterian one) have conceived technological change as endogenous to the economic system, and as resulted from a cumulative process, which requires efforts to be carried out and to achieve results.

As effort is required, the view that developing countries were passive receivers of technology generated in developed countries was started to be questioned. The new approaches to technological change in developing countries was also fuelled by the economical and technological successful observed in some of these countries, named newly industrialised countries (NELSON, 1987). Thus, many questions about how technological capabilities are accumulated in developing countries were raised. Therefore, the focus of the debate on technological change in developing countries moved away from an assumption of passive importers of technology towards an examination of learning and technological change processes in these countries (FRANSMAN, 1984).

Following this new perspective, many empirical studies investigating the nature of this technological change in developing countries have been carried out; consolidating a broad field in the economic literature: the technological capability approach. The definitions of technological capabilities introduced by those studies are countless, as the processes of accumulating capabilities, named learning processes, demand efforts at many levels and directions of the productive activities. According to LALL (2000), the accumulation of capabilities “ (...) 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 accumulated depend on how explicit and conscious these efforts are.

The explicitness and consciousness of the technological efforts are given by the trajectory of learning process, which is cumulative and path-dependent. That is, 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 in LALL, 2000 : 17).

BELL (1984) calls attention different uses of the term “learning”. In the discussion on technological growth, learning is commonly described as varied processes through which individuals or organisations may acquire skills and knowledge. That is, broadly speaking, the technological capability accumulation process. The central mechanisms of these processes are “technological efforts”, which are any way through which a firm may increase its capability in dominating technology and achieving technical change. BELL underlines two kinds two mechanisms of learning: by-doing based and others. The by-doing mechanisms, as they are a by-product of production activity itself, are no explicit and virtually automatic. Other mechanisms of learning are more explicit and purposive. The literature has suggested that the more explicit the efforts, the more complex the TCs accumulated. Therefore, by-doing mechanism may lead to less complex TCs, while the more explicit ways of learning may lead to more complex TCs.

Considering these mechanisms of learning, and their different results in terms of the technological capabilities accumulated, there have been a variety of way to defined and classified these capabilities. One of the most usual definition of technological capabilities is ***skills, knowledge*** and ***experience*** required for 1) searching for available technological alternatives and selecting the most appropriate ones; 2) dominating the selected technologies, efficiently using them for transforming inputs into outputs; 3) adapting those technologies to specific conditions of production and local demand; 4) achieving subsequent improvements through incremental innovations; 5) institutionalising research and development (R&D) activities; and 6) carrying out more basic technological activities, that is basic research (FRANSMAN, 1984). The last two activities are associated with more complex capabilities, as they may create new technologies, while the first four do not necessarily present an ascendant order of complexity.

LALL (1992) suggests a broader classification for firm-level technological capabilities[1], in which the complexity degrees are systematically encompassed. According to this classification, these degrees can be basic, intermediate or advanced, what is defined by the levels of formality and purposefulness of the technological efforts. Hence, the basic capabilities are accumulated through simple production activity routines, that is, through doing-based or experience-based mechanisms; in turn, intermediate capabilities and advanced capabilities are developed through more explicit efforts. In addition to degrees of complexity,

[1] The technological capability approach has dealt with both firm-level and country-level TCs. However, most of the definition and classification of TCs is on a firm level.

the TCs are classified by LALL regarding their functions in facilitating particular productive activities. In this way, the there can have been three TCs functional dimension: 1) investment (which can be pre-investment and project execution), 2) production (production process engineering, product engineering and industrial engineering) and 3) linkage within the economy[2].

From this classification, LALL (2000) draws a distinction between operational and innovation capabilities. Operational capabilities (also called know-how) are the skills and knowledge required to use technologies developed by others. These are less complex capabilities, as they are accumulated mainly through doing-based efforts. In turn, innovation capabilities (or know-why) are related to more complex TCs (advanced capabilities), as they refer to the ability to understand the principles of technology.

The transition from less complex toward more advanced capabilities requires a qualitative leap, which is only possible through more explicit and purposive efforts. The skills and limitations for countries taking this leap are important determinants of their long-term development (FRANSMAN, 1984).

MNCs and the leap towards deeper and more complex TCs in developing countries

The conditions to take this leap have became even more complex given the current scenario of the world economy transformations, which has been indicated as a new stage of the economic internationalisation process, named globalisation (OECD, 1992). Amongst the movements characterising this process are: intensification of inter-firm co-operation and of international mergers and acquisitions; rise of FDI levels; increased intra-firm and intra-industrial trade; intense information technology advancements; introduction of new organisational methods; and so forth. These movements are changing the world economy in two directions: intensifying the international connections, defining globalisation as a stage of "deep international integration" (UNCTAD, 1994); and on the other hand, increasing concentration of the world supply structure, reflected by the consolidation of international mega-groups, the "global oligopolies" (OECD, 1992).

These global oligopolies are in the centre of the world transformations, as, in searching for a greater integration and control in all areas of their activities, they have pursued

[2] 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

world strategies and determined complex international networks (OECD, 1992, DUNNING, 1993). Due to their relevance as competitive factor, technological activities are a key element of these strategies.

The challenges imposed by this new scenario, as they have sharply affected the international technological accumulation, have raised many questions concerning the possibilities of bridging the technological gap between developed and developing countries. In other 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 internationalized than their productive activities, remaining concentrated in their home countries, it is worthwhile to understand the position to be occupied by developing countries in these strategies (OECD, 1992).

The discussion about the type of interaction established by MNCs with the host countries, and the implications of those interactions for the local technological capabilities-building process brings some light on this matter. According to FLORIDA (1997), this relationship depends on the FDI orientation, which can be: market-oriented and technological-oriented. The first type aims to adapt and manufacture products mainly to the local market, defining superficial technological interaction with the host country. The second type of FDI aims to obtain and ensure access to the host science and technology base, and to develop connections with the local scientific community, implying deep relationship between the MNC and the host country (INZELT, 1998 and 2000).

These notions of deep and superficial interactions can be connected to the degrees of TCs complexity: superficial interaction is related to less complex capabilities; while deep relationship to more complex ones. It is worth highlighting that each level of TCs complexity has different impacts on the economic development.

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and capabilities through experimental-based and R&D-based learning processes. Hence, the dynamic capabilities determine the long-term competitive advantage of the country.

Many empirical studies on developing countries technological change have suggested that greater part of the technological interaction established by MNCs with host countries is superficial, and then leading to less complex technological capabilities. For instance, 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 involves adapting imported technology to local conditions, resulting adaptive learning processes, and accumulation of less complex technological capabilities. KATZ and BERCOVICH stress that 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 limitation as a “truncation” of technological transfer by MNCs, which may limit positive effects through the host economy. Moreover, LALL notes that “a strong foreign presence with advanced technology can prevent local competitor from investing in deepening their own capabilities (...)” (1992: 179).

To conclude this section, the literature has suggested that developing countries need to carry out technological efforts to acquire, dominate, adapt, improve and create technologies. However, it has been highlighted some obstacles for those countries evolving towards more complex capabilities, which enable them to create new technologies for the world. That is, to reach the international technological frontier. Furthermore, notwithstanding the importance of MNCs for the developing countries learning process, the literature has warned some limitation of MNCs to induce deeper and more complex TCs in these countries.

3) Ownership and Technological Capabilities Proxies: methodological considerations

Having defined the conceptual background for our research, in this section we outline some methodological aspects to compute proxies for technological capabilities. The development of these proxies is intended to give some clues about the relative effects of MNCs for the technological development of the Brazilian industry.

Then, proxies are computed at sectoral level both for MNCs and domestic firms. The source of information to calculate the proxies is an innovation survey database[3], which is part of a broader Research of Economic Activity of State of the S. Paulo (PAEP/SEADE). PAEP comprises 10,453 industrial firms in the State of S. Paulo[4], the most industrially developed in Brazil. According to the Foreign Capital Census, 1995 (Central Bank of Brazil, 1998), this State concentrates 69 per cent of the total employees in, and 70 per cent of the net operating revenues of the foreign controlled firms in Brazil. Therefore, the analysis of technological capabilities according to ownership based on information for S. Paulo industry can be a reasonable proxy for the Brazilian industry as a whole.

The first three steps to develop the proxies are: (1) define the quantitative method to be adopted and categories of analysis; 2) specify what is to be measured, and 3) identify how it can be done using the PAEP database.

The quantitative method adopted to compute the TCs-proxies is one of composite indices, ranging from zero to one[5]. That range helps to drawn comparisons amongst the categories of firm (MNCs and domestic). The 0-1 range has an attainment perspective, as it shows level reached by each category of firm in relation to a maximum target of "one"[6].

In addition to ownership, all proxies are computed by industrial sectors, classified according to their technological intensity. This classification (four levels: low-tech, medium-low-tech, medium-high-tech, high-tech) was suggested by OECD, according the criteria of overall R&D intensity (direct and indirect) (HATZICHRONOGLOU, 1997). Based on this classification, we are making a further aggregation into two groups: less technologically

[3] The innovation survey questionnaire followed the Oslo Manual (OECD) guidelines.

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

[5] To compose the indices, fixed minimum and maximum values have been established for each variable, which then 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; and $V_{i,max}$ = maximum V_i value.

[6] That is the same perspective of Human Development Index (HDI), developed by the United Nations. According to ANAND and SEN (1994), the HDI attainment perspective assess how well a country is doing in terms of the human development (:7).

intensive sectors (low-tech plus medium-low-tech), and more technologically intensive sectors (medium-high-tech and high tech) (Table 2).

TABLE 2 – INDUSTRIAL SECTORS AND THEIR TECHNOLOGICAL INTENSITY

Code	Industrial Sectors	ISIC Rev.3	Tech-Intensity[1]
	Less technologically intensive 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 intensive 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) low-technology; (2) medium-low-technology; (3) medium-high-technology and (4) high technology

The second step, specifying what is to be measured, means identifying the concepts and classification of TCs that better fit to the objective of our research. Based on literature review presented in the Section 2, and concerned with the TCs complexity degrees, we are making a distinction between ***operational*** and ***innovative capabilities***[7]. The first one is associated with basic and intermediate capabilities, and then it is taken here as proxy to less complex technological capabilities. Innovative capability is related to advanced capabilities, then it is taken as proxy for more complex capabilities. Both kind of TCs encompass some element of linkage capabilities: operational capabilities include linkages within the productive chain; while innovative capabilities linkages with universities and research institutes. Moreover, in terms of functional aspects, as in the LALL's (1992) classification, both

[7] This distinction is similar to the introduced by LALL (2000) between operational and innovation capabilities.

operational and innovative capabilities can be associated with the process, product or industrial engineering.

Having defined the categories and instrument of analysis, the next step is identify which elements can be somehow measured to be a proxy for technological capabilities. Given the information made available by Paep/Seade[8], the following proxies have been developed:

a) Linkage Index, based on the variables of external sources of information for innovation; and composed of two other indices:
   - Production Chain Linkage Index (suppliers of material/components, suppliers of equipment, clients and customers, competitors, patent disclosures and licences);
   - S&T System Linkage Index (universities and research institutes);
b) Process Engineering Index, based on variables related to use of techniques and equipment in the production process; as the former it is a composite index of two others:
   - Organisational Index (use of TQM, SPC; internal JIT and external JIT);
   - Automation Index (use of robots; CNC/DNC systems and CAD/CAM systems);
c) Systematic Effort Index; based on the variables R&D activities continuously and number R&D personnel;
d) Change Index, based on the variables "introduction of innovation[9]", and composed of:
   - Incremental Change Index;
   - Significant Change Index;
   - Process Change Index.

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[8] 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.

[9] It is important highlight that these indices cannot be taken as an output indicator, because they refer to the "introduction" of innovation, which is not exactly the result of some internal effort by the firm. Actually, in most of the case, it is associate to the "use" of technology generated by others, instead of creation of new technology.

Some of these proxies have been selected to operationalise the concepts of innovative and operational capabilities, composing to other indices. A proxy for innovative capabilities, and so for more complex TCs, is calculated by weighted average of the Systematic Effort (2/3) and the S&T System Linkage (1/3) indices. As proxy for less complex TCs, it is computed an Operational Capabilities Index through unweighted average of the Incremental Change Index, the Process Change Index, and the Organisational Index. The hypotheses behind these two composed proxies are that: 1) firms carrying out more systematic technological efforts may have higher technological capabilities than the others; and 2) having universities and research institutes as sources of information for innovations could indicate a deeper learning process.

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

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 Automation 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 of improving and deepening the technological capabilities;

4) MNCs' and domestic firms' TCs: drawing some comparisons

This section presents the proxies for technological capabilities both for MNCs and domestic firms. It is then drawn comparisons between these categories of firms, in an attempt to find out some signs of the relative effects of MNCs for the Brazilian technological accumulation.

Charts 1 and 2 sketch the average indices of the technological capabilities proxies for MNCs and domestic firms in two groups of sectors.

Generally, the figures suggest, at a glance, a more dynamic learning process by the MNCs. On all average indices, both in the less and in the more technologically intensive sectors, MNCs score better than domestic firms.

CHART 1 – AVERAGE INDICES - LESS INTENSIVE SECTORS

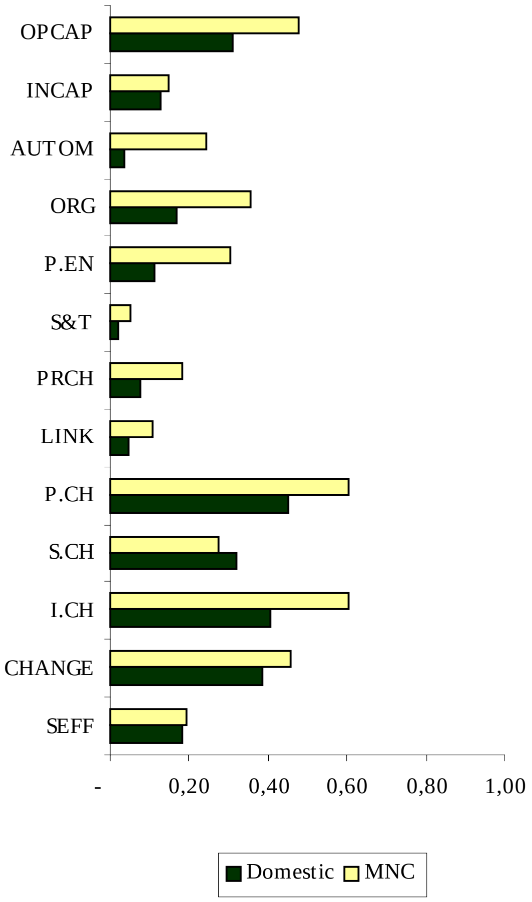
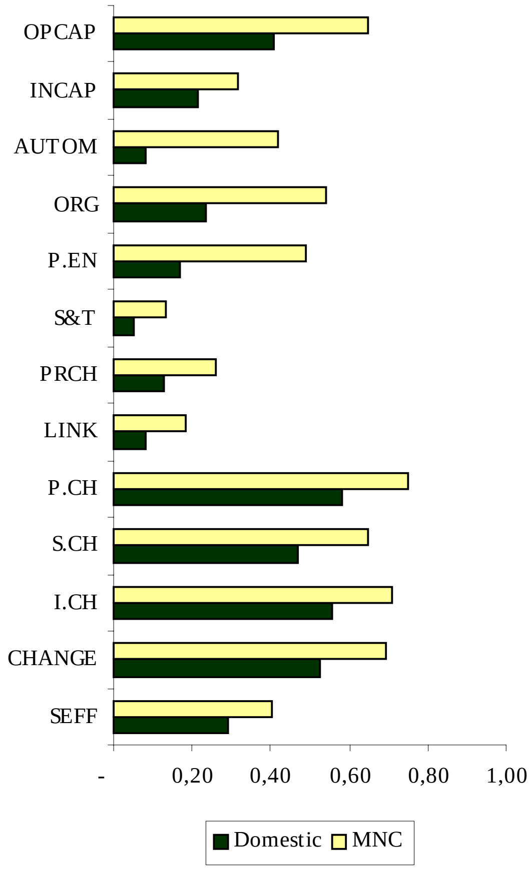


CHART 2 – AVERAGE INDICES - MORE INTENSIVE SECTORS



NOTE: **OPCAP** (Operational Capabilities Index); **INCAP** (Innovative Capabilities Index); **AUTOM** (Automation Index); **ORG** (Organisational Index); **P.EN** (Process Engineering Index); **S&T** (S&T System Linkage Index); **PRCH** (Productive Chain Linkage Index); **LINK** (Linkage Index); **P.CH** (Process Change Index); **S.CH** (Significative Change Index); **I.CH** (Incremental Change Index); **CHANGE** (Change Index); and **SEFF** (Systematic Effort Index).

However, both MNCs and domestic firms score quite low in all indices, both in the less and the more intensive sectors. The Systematic Effort Index is scored rather low for MNCs as well as for domestic firms. It is much lower than the Change and the Process Engineering indices. The high scores in these indices are probably associated with the current modernization process of the Brazilian industry. It is worth noting that the high Change indices should be carefully analysed, since the nature of the technological change is not enough picked up by the two-fold distinction: significative and incremental innovations.

Regarding the Linkage indices, both MNCs and domestic firms score rather low in the two groups of sectors, although MNCs score somewhat higher than domestic firms. Amongst the three partial Linkage indices, the S&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 S&T System Index against 0.13 on the Productive Chain Linkage Index. This figures reflect the tenuous connection between the industrial technological activities and the universities and research institutes in Brazil. The few exceptions among the more intensive sectors suggest the linkages depend on the technological characteristics of products and sectors.

Moreover, for domestic firms, the correlation between these Linkage indices and the Systematic Efforts is very low, contrasting to a high correlation observed for MNCs. This could be indicating that MNCs firms are more effective in establishing relations with other technological actors, mainly 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. Another interesting aspect in terms of the domestic firms' Linkage indices is a high correlation to the Process Engineering indices. As these indices are proxies to modernization, that high correlation should be explained by a strong pressures upon domestic firms (most of them small and medium firms) to speed up the upgrading of their productive activities.

Regarding the two main composite indices, the Operational Capabilities Index (OPCAP) is higher than the Innovative Capabilities (INCAP) one. Even though both of them are low, mainly in less intensive sectors. The analysis sector by sector suggests that both MNCs and domestic firms achieve their best scores in the more technologically intensive sectors (Charts 3 and 4).

Concerning the Operational Capabilities Index, the domestic firms have their best score in Office Machinery and Computing (0.51). The scores in the Electronic Material and Telecom Equipment sector are amongst the highest both for the MNCs and for the domestic firms: 0.81 the former and 0.36 the latter.

CHART 3 – OPERATIONAL CAPABILITIES INDEX BY SECTORS – AVERAGE

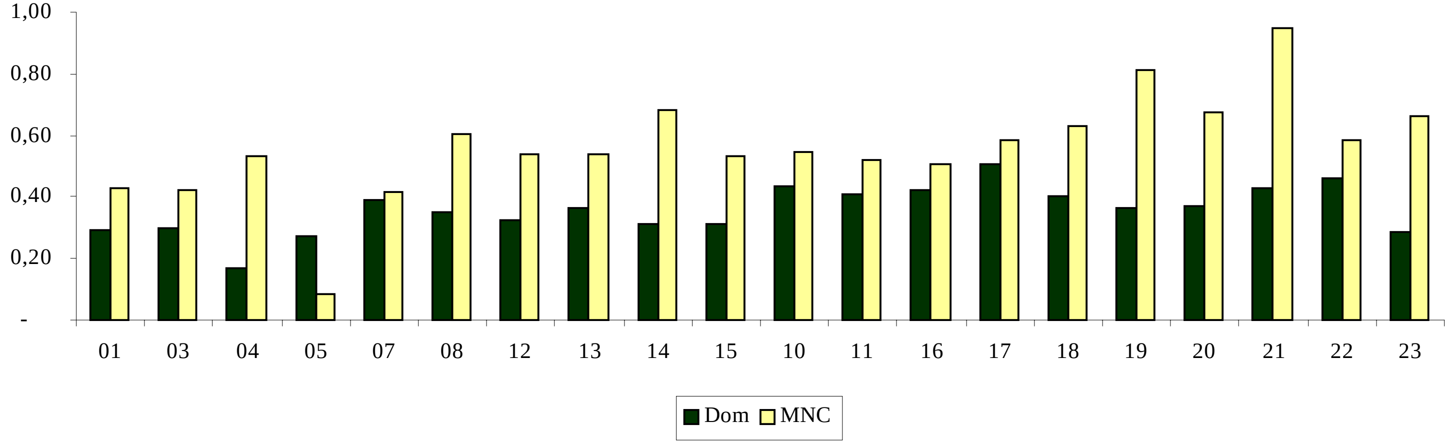
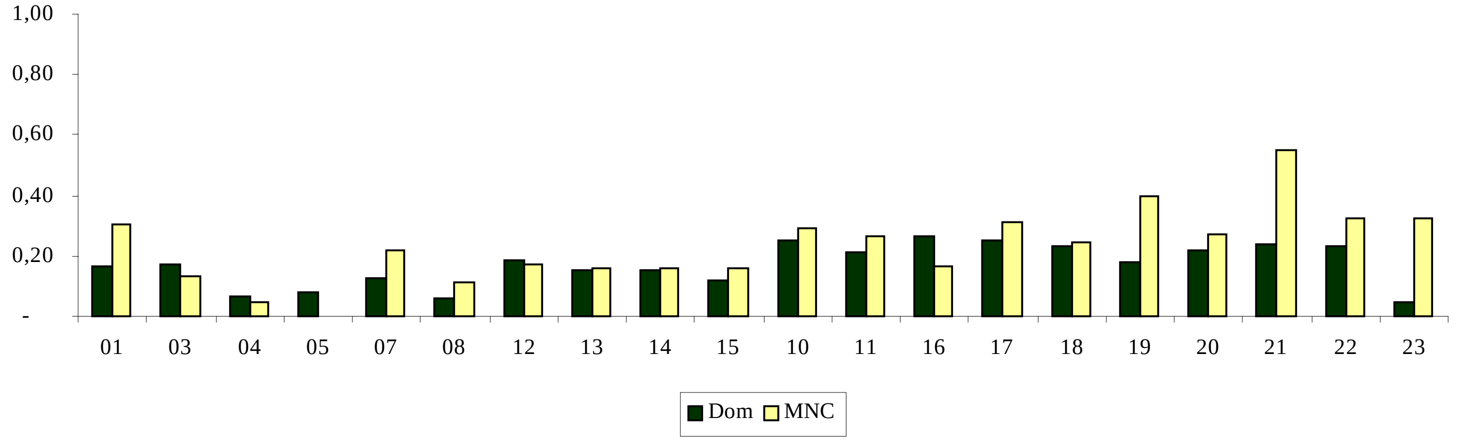


CHART 4 – INNOVATIVE CAPABILITIES INDEX BY SECTORS – AVERAGE



The higher scores reached in more intensive sectors reinforce the importance of technological complexity in shaping the technological dynamic of firms. What can also be observed through the high positive correlation between the technological complexity and the MNCs' indices. That can be associated with the fact that the MNCs are concentrated in these sectors: they account for nearly 51 per cent of the value added in the more intensive sectors and 20 per cent in the less intensive ones.

Furthermore, it is important take in account the firm size, as 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. Therefore MNCs are the biggest industrial firms in Brazil, what makes the indices developed only by ownership (domestic and MNCs) somehow biased, as larger firms tend to be more technologically dynamics. The simultaneous development of indices by firm size and ownership is the next phase of our research[10].

To sum up, 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.

5) Concluding Remarks

The figures presented in the previous section lead to the conclusion 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 intensive sectors. However, this relative higher performance by MNCs may indicate rather a weaknesses of domestic firms, than a MNCs' strength. As noted by AMANN and BAER (1998), amongst the domestic firms, the degree of formalisation of R&D activities (that is, more purposive and systematic efforts) has been quite low.

Moreover, although MNCs score better than domestic firms on most indices, their scores on the proxy for more complex capabilities are quite low. This suggests that the technological activities carried out by MNCs are more related to operational than to innovative capabilities. Their technological linkages to the whole economy are quite low as

[10] The analysis of the TCs proxies by size is in the paper "FDI and Technological Capabilities in the Brazilian industry", to be presented at the Druid - Nelson and Winter Conference, June 2001.

well, and most of them are within the production chain. This means that the learning process in MNCs subsidiaries in Brazil may not lead to more complex TCs in the long-term, although the figures suggest the MNCs importance in upgrading the Brazilian industry.

Therefore, the low technological performance of MNCs suggests that the increased FDI inflow to the Brazilian industry do not *per se* ensure the TCs deepening. Then, the policy debate in Brazil should be concerned with this limitation of FDI in terms of technological learning process in the country. 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 S&T system as a whole.

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Danish **R**esearch **U**nit for **I**ndustrial **D**ynamics

The Research Programme

The DRUID-research programme is organised in 3 different research themes:

- The firm as a learning organisation
- Competence building and inter-firm dynamics
- The learning economy and the competitiveness of systems of innovation

In each of the three areas there is one strategic theoretical and one central empirical and policy oriented orientation.

Theme A: The firm as a learning organisation

The theoretical perspective confronts and combines the resource-based view (Penrose, 1959) with recent approaches where the focus is on learning and the dynamic capabilities of the firm (Dosi, Teece and Winter, 1992). The aim of this theoretical work is to develop an analytical understanding of the firm as a learning organisation.

The empirical and policy issues relate to the nexus technology, productivity, organisational change and human resources. More insight in the dynamic interplay between these factors at the level of the firm is crucial to understand international differences in performance at the macro level in terms of economic growth and employment.

Theme B: Competence building and inter-firm dynamics

The theoretical perspective relates to the dynamics of the inter-firm division of labour and the formation of network relationships between firms. An attempt will be made to develop evolutionary models with Schumpeterian innovations as the motor driving a Marshallian evolution of the division of labour.

The empirical and policy issues relate the formation of knowledge-intensive regional and sectoral networks of firms to competitiveness and structural change. Data on the structure of production will be combined with indicators of knowledge and learning. IO-matrixes which include flows of knowledge and new technologies will be developed and supplemented by data from case-studies and questionnaires.

Theme C: The learning economy and the competitiveness of systems of innovation.

The third theme aims at a stronger conceptual and theoretical base for new concepts such as 'systems of innovation' and 'the learning economy' and to link these concepts to the ecological dimension. The focus is on the interaction between institutional and technical change in a specified geographical space. An attempt will be made to synthesise theories of economic development emphasising the role of science based-sectors with those emphasising learning-by-producing and the growing knowledge-intensity of all economic activities.

The main empirical and policy issues are related to changes in the local dimensions of innovation and learning. What remains of the relative autonomy of national systems of innovation? Is there a tendency towards convergence or divergence in the specialisation in trade, production, innovation and in the knowledge base itself when we compare regions and nations?

The Ph.D.-programme

There are at present more than 10 Ph.D.-students working in close connection to the DRUID research programme. DRUID organises regularly specific Ph.D-activities such as workshops, seminars and courses, often in a co-operation with other Danish or international institutes. Also important is the role of DRUID as an environment which stimulates the Ph.D.-students to become creative and effective. This involves several elements:

- access to the international network in the form of visiting fellows and visits at the sister institutions
- participation in research projects
- access to supervision of theses
- access to databases

Each year DRUID welcomes a limited number of foreign Ph.D.-students who wants to work on subjects and project close to the core of the DRUID-research programme.

External projects

DRUID-members are involved in projects with external support. One major project which covers several of the elements of the research programme is DISKO; a comparative analysis of the Danish Innovation System; and there are several projects involving international co-operation within EU's 4th Framework Programme. DRUID is open to host other projects as far as they fall within its research profile. Special attention is given to the communication of research results from such projects to a wide set of social actors and policy makers.

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