FDI AND TECHNOLOGICAL CAPABILITIES IN THE BRAZILIAN INDUSTRY

Authors:

Ionara COSTA

Ph-D Student

e-mail: ionara@ige.unicamp.br; ionara.costa@qeh.ox.ac.uk

Sérgio Robles Reis de QUEIROZ

Doctor Assistant Professor

e-mail: squeiroz@ige.unicamp.br

Institution:

Department of Science and Technology Policy – State University of Campinas - Brazil

Sponsors: Research Support Foundation of the State of São Paulo (Fapesp) and CAPES

* From October/2000 to June/2001, the first author has been a Visiting Student at the University of Oxford, supervised by Dr. Sanjaya Lall

Theme B: “Production and Use of Knowledge”

FDI AND TECHNOLOGICAL CAPABILITIES IN THE BRAZILIAN INDUSTRY

Ionara COSTA
Sérgio Robles Reis de QUEIROZ

1. Introduction

Over the last fifty years, multinational companies (MNCs) have played an important role in the development of the Brazilian industry. Moreover, since the import substitution period (in the sixties and the seventies), foreign direct investment (FDI) has been one of the main mechanisms for gaining access to industrial technology. This fact, together with the heavy dependence on imported technology, has been addressed by policy debate and by theoretical and empirical literature on industrial development in Brazil. With regard to technology, it has been argued often that MNCs positively affect the technical change process in the country. Generally, these firms are associated with easier access to foreign technologies, to scale and scope economies, and to productivity gains, and then to improvement of the competitiveness of the local industry (Bonelli, 1998; Moreira, 1998). In fact, introduction of new technologies by MNCs has currently favoured a so-called modernization process of products and productive activities in the local industry.

However, an important related issue remains not much addressed: the local generation of technology. That is, the meaning of the inward FDI in terms of creating new knowledge in Brazil. Generally, the studies on the influence of MNCs upon the Brazilian technological development have assumed by technical progress the local adoption and use of technology. Therefore, the focus of the debate has been on the use of technology. The importance of moving away from this narrowed focus towards a broader debate on the technological implications of the heavy presence of MNCs has been intensified since 1994, by a new wave of inward FDI, attracted by the stabilisation and the warm up of the huge Brazilian market[1].

Furthermore, in days when technological knowledge and learning have been recognised as one of the main sources of competitiveness and long-term economic development, a better understanding about what affects technological generation is a very critical issue (Lundvall and Johnson, 1994; Archibugi and Sirilli, 2000; Lundvall, 2000; Johnson and Lundvall, 2001,).

The research we are developing is an attempt to throw some light on this issue, dealing with it from the technological capability approach's perspective. Some writers of this approach have underlined the importance of investigating how the different ways of technological transfer (particularly FDI[2]) imply the technological accumulation in developing countries (Fransman and King, 1984; Dahlman and Westphal, 1982; Lall, 2000a and 2000b; Dunning, 1993). In this sense, this paper intends to bring some contributions to this issue. Based on an innovation survey database, it presents some proxies for technological capabilities, both for foreign- and domestic-owned firms. It then draws a comparison of those proxies, in an attempt to find out some signs of the relative effects of MNCs for the technological development of the Brazilian industry. The paper aims to contribute to a further understanding of the increased MNCs'

[1] According to the Central Bank of Brazil, the FDI in Brazil jumped from US$ 0.71 billion in 1993 to US$ 26.11 billion in 1998.

[2] Amongst other ways of technological transfer also mentioned by the literature are: capital good imports, technological licence, technical support and so forth.

stake for deepening and strengthening technological capabilities of the Brazilian industry, exploring how these firms can help the Brazilian industry to evolve from the main status of foreign technology user, towards a more active position as an original generator of knowledge.

Section 2 presents a review of the technological capabilities approach, highlighting the main concepts and aspects of the technological accumulation in developing countries. Special attention is given to the role played by MNCs. This literature review is a central aspect of the paper, as it is the base for the analytical framework outlined in Section 3. Guided by this framework, Section 4 describes the methodology for composing the technological capabilities proxies. Finally, adopting this methodology, Section 5 summarises the main findings which rise from the comparison between the technological capability proxies for MNCs and domestic firms, and also makes some concluding remarks.

2. Theoretical background

Around the mid-1950s, concerns about technical change again began to be present in economic literature[3] (Nelson, 1987). Moreover, by the late seventies and early eighties, the economic turbulence and the intensive technological change intensified this tendency, stimulating the emergence of new approaches for technology and its role in the economic development. Then, running counter to prevailing assumptions about the nature of technology and technical change[4], those approaches have conceived technology as endogenous to the economic system, resulting from a cumulative process, which demands effort to be carried out and to produce results. It has been stressed some peculiarities of the technology as a special production factor, for instance, its tacit and idiosyncratic aspects, what imply limitations to perfect imitation; and, on the other hand, its public features, that result in different degrees of appropriability. Amongst others, these aspects define technological accumulation as a very uncertain process (Nelson, 1987; Katz, 1987; Lall, 1994). One of the main intellectual inspirations for these new views came from Joseph Schumpeter, who considered the technological change (emphasising "major innovations") as the main driving force of the economic development. Amongst the approaches influenced by the Schumpeterian ideas, the evolutionary theory[5] stands out, defining technical change as an sequential process, in which minor or incremental innovations are very important[6].

These general ideas about technology and its role in economic development, especially the emphasis on incremental innovation, were of great importance in fuelling a growing interest in technical change in developing countries (Fransman, 1984; Lall, 1994). Moreover, by the late seventies, this interest was influenced by the success of some developing countries (named "new industrialising countries") in terms of their technological and industrial development (Fransman, 1984; Kim and Nelson, 2000). Up until then, developing countries had been considered by the economic literature as merely passive importers of technology,

[3] As emphasised by Nelson (1987: 2), this renewed interest of economists in technical change was a return to their intellectual origins, as the importance of technology was been already recognised by the great classical economists, as Adam Smith, Marx, Marshall.

[4] Up until then, among other aspects, technology was conceived as 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) (Lall, 1994).

[5] See Nelson and Winter (1982).

[6] In this sense, the evolutionary approach departs somehow from the original Shumpeter's ideas of major innovations and the economical cycle (Nelson, 1987; Fransman, 1984).

facing the only question of choosing between capital or labour-intensive technologies[7]. From this perspective, these countries should costlessly select, from an "international technological shelf", the more useful and appropriate technologies, which maximised their production function (Katz, 1987; Lall, 1992, Herbert-Copley, 1990; Dahlman and Westphal, 1982). In opposition to this premise of absence of any significant technical change in developing countries, some studies began to be concerned with what happened to the technology after being imported. The central idea of these studies is that, given the peculiar characteristics of technology (endogenous, cumulative, tacit, idiosyncratic and so forth), it cannot be passively imported, without any effort aiming to efficiently absorb it. It means that once imported, technology needs to undergo some changes – normally incremental innovations – for at least being adjusted to the local conditions of production and for meeting specific aspects of local demand. Therefore, the focus of the studies on developing countries shifted away from the technological transfer, and the inherent assumption of passive choices, towards the analysis of the technical change in these countries (Fransman, 1984). Following this new perspective, these studies consolidated a broad field in the economic literature on developing countries: the technological capability approach[8].

Technological capability approach: definitions and classifications

Rested on the view that technical change also happens in developing countries, the technological capability approach has tacked the nature and the determinants of this change. The basic hypothesis is that even as only importers of foreign technologies, developing countries should develop some capabilities for an efficient absorption of these technologies. In fact, empirical studies have showed that, in many cases, these "technological capabilities" are much more then just an ability to efficiently absorb foreign technologies. This observation has resulted in many different ways of defining and classifying technological capabilities in developing countries; as well as other related concepts, such as technological learning and efforts.

One of the most usual definitions of technological capabilities (TCs) is as ***skills, knowledge*** and ***experience*** required for firms to: 1) search for available technological alternatives and select the most appropriate ones; 2) dominate the selected technologies, successfully using them for transforming inputs into outputs; 3) adapt those technologies to specific conditions of production and local demand; 4) achieve subsequent improvements through incremental innovations; 5) institutionalize research and development (R&D) activities; and 6) carry out more basic technological activities, that is basic research (Fransman, 1984).

These skills, knowledge and experience are acquired and accumulated mainly through technological efforts, which can be more or less explicit and/or purposive. Therefore, technological efforts are mechanisms for accumulation of TCs. This accumulation process, also called the learning process, or technological capability-building process, is path-dependent, and so, it can consolidate different technological trajectories[9]. The trajectory's direction is given by the explicitness and consciousness of the technological efforts, which depend on technology-, firm-, industry- and country-specific aspects.

---

[7] Although from different perspectives, this perception was hold both by neoclassical economists and by authors of the dependence school of thought (Bell and Albu, 1999).

[8] This approach has had a strong empirical bias, mainly in the eighties, encompassing a heterogeneous set of studies.

[9] About technological trajectories see Dosi (1982).

The empirical literature has pointed to different kinds of technological efforts, that is mechanisms for learning and accumulating TCs. The distinction between by-doing mechanisms and others kinds of technological efforts has been very common. The by-doing (also called by-operating) mechanisms are not explicit and automatic, in the sense that TCs are accumulated as a by-product of the production activity (Bell, 1984; Dahman and Westphal, 1982). The other mechanisms for learning are more explicit and purposive, amongst those mentioned by the literature are: staff-training, staff-hiring, system performance feedback, interaction with external agents, agglomeration, networking, and research and development activities (R&D) (Bell, 1984; Freeman, 1994; Lundvall, 1984; Caniëls and Romijn, 2001).

Moreover, the empirical literature has suggested that, although important, the doing-mechanisms are not enough condition to strengthen the technological capabilities in all stages of the technological development, and so, move up the technological ladder (Bell, 1984; Lall, 2000a). It has been emphasised that the more explicit and purposeful the technological efforts, the deeper and more complex the capabilities accumulated (Bell and Pavitt, 1992, Lall, 2000a). Furthermore, it has been argued that different levels of TCs complexity can lead to different results in terms of short and long-term economic development. The more complex the capabilities accumulated, the deeper the positive impacts on the economic development (Lall, 2000a). Generally, it has been indicated that deeper and more complex technological capability is acquired by more explicit and purposive mechanisms, which may lead to more original and scientifically intensive results[10] (Lall, 2000a; Bell and Albu, 1999).

Taking into account this concern with TCs-complexity, Lall (1992) outlines a matrix of firm-level technological capabilities[11]. According to this matrix, the degrees of complexity may be basic, intermediate or advanced. These degrees are defined by 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 are built up upon adaptive duplicative activities, which are somehow purposely carried out; finally, advanced capabilities are developed through research-based activities, implying higher risk and uncertainty. In addition to the degree of complexity, Lall's matrix classifies technological capabilities with regard to their functions in facilitating particular productive activities. In this way, the matrix describes dimension of functional TCs: 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.

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 technology's principles[12].

---

[10] These ideas about originally, or novelty, and scientific intensity have been suggested in many studies about innovation in developed countries (Archibugui and Sirilli, 2000; Albaladejo and Romijn, 2000)

[11] 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. We will deal with this aspect later on in this paper.

[12] Both terms "know-how" and "know-why" have been broadly adopted by the literature, sometimes with subtle meaning difference. In addition to these terms, it has been also made reference to other kind of knowledge, such as know-who (information about who knows what); know where; Know-what (knowledge about facts) (Johnson and Lundvall, 2001).

One could ask what defines the kind of knowledge accumulated, the degree of complexity of the technological capabilities? Which level of complexity have the developing countries reached? How could they develop more complex capabilities? These questions have been tackled through studies on the nature of, and the factors affecting the technological accumulation in these countries.

Nature and determinants of TCs accumulation

The empirical studies on TCs have reported some specific traits of the technical change in developing countries, such as its incremental aspect and the importance of the doing-based learning mechanisms (Bell, 1984). The observation of these peculiarities have suggested that the developing countries have to overcome some obstacles for reaching higher steps of the technological ladder and so, getting closer to the international technological frontier. In that issue, Lall (2000a) notes that the "process of technological change in developing countries is one of acquiring and improving on technological capabilities rather than of innovation at frontiers of knowledge. This process essentially consists of learning to use and to improve on technologies that already exist in advanced industrial economies" (:13).

Some authors have dealt with this issue in terms of technological-users and technological-generators agents (Bell and Albu, 1999). It has been assumed that a generator of knowledge may find deeper results regarding its industrial dynamic, and so, its long-term economic development. For instance, working on the Korean semiconductor industry, Choung, Hwang, Choi and Rim (2000) investigate the rate and direction of both technological-using and technological-generating capabilities, emphasizing the importance of the latter ones to create and to sustain new competitive advantage[13].

After all, what is important to enable a country to evolve into a successful learning trajectory? How can a developing country take the qualitative leap from imitator towards true innovator, and so catch up with developed countries?

Some elements which help to answer these questions can be found in the factors influencing the accumulation of deeper and strengthening technological capabilities. Both the TCs-approach on developing countries and the innovation theory on developed ones have been concerned with the determinants of the technological accumulation. While the latter has focused mainly on the determinants of innovation itself (or level of innovativeness); the former has concentrated on the factors affecting the technological efforts broadly speaking (Caniëls and Romijn, 2001). Although differences regarding the nature of technological change in developed and developing countries have been recognised, there have been some overlaps in analysing the factors exerting influence upon the rate, direction and intensity of

[13] Also, the learning economy literature brings some lights on this issue. The learning economy is a convergent field from the TCs literature on developing countries and the innovation theory on developed countries. That new field is mainly concerned with the learning and the knowledge accumulation processes and their implication for narrowing the gap between developed and developing countries (Caniëls and Romijn, 2001). Lundvall (2000) asserts that in the learning economy "it is the capability to access and create new knowledge that determines the process of individuals, firms, and countries" (:101). See also Lundvall and Johnson, 1994).

this process[14]. The literature has pointed to a plenty of these factors. Generally, from a firm-level technological capability view, two main groups of factors have been identified: the internal and the external ones, which can still be economics or technical determinants (Fransman, 1984). Amongst the internal factors, it can be mentioned the characteristics of the firm (such as: size, ownership, production organisation); and the product and technology features (Lall, 1992 and 1994, Katz, 1985). Amongst the external factors are, for instance, the macroeconomic environment; the commercial regime[15]; the competitive pressure; the size and level of diversification of the local industrial sector; the technological opportunity and appropriability regimes; the skill endowments; and so forth (Nelson, 1987; Lall, 1992 and 1994, Katz, 1985). These external factors have been also analysed from a national-level technological capability perspective (Lall, 1994). Lall (2000a) suggests that the "national boundary defines a common set of incentives and factor markets, attitudes, and business systems within firms learn" (:15)[16].

The national aspect of the TCs accumulation process, and its inherent market failures, impose a crucial role to be played by national policies in stimulating the technological capability development (Lall, 2000a). In this way, holding that technological capabilities are not spontaneously accumulated, many authors have stressed the importance of explicit technological policies (Bell and Pavitt, 1992; Bell and Albu, 1999). Another argument on behalf of selective and explicit policies is that the learning process of firms in developing countries should be somehow protected[17] (Bell, 1984; Fransman, 1984; Lall, 1992 and 1994). The basic idea is that selective learning protection is crucial for evolving into more complex levels of the technological accumulation process (Lall, 1992; Katz, 1985). Lall (1992, 2000a and 2000b), investigating the technological learning of some Asian NICs, named "Asian tigers", emphasizes that a key element of the policies adopted by these countries, which helps to explain their different levels of TCs accumulation, is their attitude to foreign capital. The Asian tigers' experience gives a case for investigating the impact of foreign and domestic capital ownership upon the technological accumulation in developing countries. Given this is a central issue to our research, we shall comment on it.

---

[14] Many empirical studies on developed countries have investigated classical assumptions about the determinants of innovation. Amongst those assumptions, it has been much addressed the Schumpeter's hypothesis of a positive impact of market power and large sized-firm upon the levels of innovativeness; the technology-push assumptions; and the Schmookler (1966)'s demand-pull assumption. For instance, see the statistical analysis by Brower and Kleingknecht (1996); Arvanitis and Hollersteing (1996); Crepon, Duget and Kabla (1996) and Felder, Licht, Nerlinger and Stahl (1996). Those analysis are based on the first innovation survey carried out in Europe (I Community Innovation Survey). We will come back to this point later on in this paper.

[15] Regarding this issue, there has been the long debate about the inward- *versus* export-oriented economies and the debate about the protection to the infant industry (Lall, 1992)

[16] The national aspects of the TCs accumulation has been approached by the "national innovation system" literature (see Lundvall (1992); Nelson (1993); Freeman (1987)).

[17] In the seventies and eighties, this idea was somehow incorporated by the debate on the import substitution strategies and the importance of the protection against the imports of similar products (Bell, 1984).

MNCs and TCs in developing countries

The access to foreign technology by, and the foreign-owned firms (MNCs) role in developing countries has been an important issue addressed by the technological capability approach. A common concern comes from the presumption that MNCs tend to concentrate more complex technological efforts (like R&D activities) in their home countries (Prasada Reddy and Sigurdson, 1994; Dunning, 1993; Archibugui and Pianta, 1996). Moreover, these firms are the main generator of industrial technology, accounting "for the great bulk of expenditure on knowledge-creating and skill-enhancing activities, and for trade in technology or technology-intensive products" (Dunning, 1993: 288). As a result, some technological limitations of relying on MNCs have been stressed. For instance, Katz (1976) and Katz and Bercovich (1993), based on a number of firm-level empirical works on technical change in Latin American countries, suggest that the majority of technological efforts undertaken by MNCs involve adapting imported technology to local conditions. This leads to adaptative learning processes, and so to limited accumulation of more complex technological capabilities. For this reason, the literature has suggested some shortcomings of MNCs-dependent strategies with regard to the technological development in developing countries. In this way Lall (1992) observes that

> 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 may limit positive effects through the host economy; and adds that "a strong foreign presence with advanced technology can prevent local competitor from investing in deepening their own capabilities (...)" (: 179).

According to Lall (2000b), such drawback to FDI in terms of technological development of the host countries may be overcame through selective policies aiming to protect the learning process of domestic firms and to attract high quality FDI. It means FDI characterized by: advanced MNCs activities and technologies, stimulus to locally use and create sophisticated skills; orientation towards international markets and so, deeper participation of the host economy into dynamic systems of international production (Lall, 2000b: 338). In the same way, Cantwell (1989) argues that FDI "can boost local know-why if induced to do so by appropriate policy interventions (...), or when there is already a substantial base of local research capabilities" (in Lall, 2000a: 21).

Lall (2000b) distinguishes four modes of FDI policy-strategies which have been adopted by developing countries: 1) autonomous: based on technological capabilities of domestic firms and, on strong exporting-orientation (strategy adopted by Korea and Taiwan); 2) strategic FDI-dependent: based on a combination of FDI attraction and efforts to upgrade local MNCs activities (Singapore's policy); 3) passive FDI-dependent: based on FDI, however, the upgrading of technological activities is left to the marked (this "welcome FDI-strategy" has been pursued by Malaysia, Thailand and Philippines, and, to some extent, by China and Mexico); 4) ISI restructuring[18]: based on MNCs or domestic firms, and characterized by trade

[18] Moreover, Lall (2000b) mentions that the main difference between the ISI restructuring and the "autonomous" strategy is that the latter one is characterised by "lack of clear, co-ordinated industrial policy to develop competitiveness, with haphazard (generally weak) support for skills, technology, institutions and infrastructure" (:337).

liberalization and strong export incentives (strategy followed, with some differences, by China and India, and by most of the Latin American countries). Lall (2000a) emphasizes that the autonomous strategy has more positive implications for building-up deeper technological capabilities, as illustrated by the cases of Korea and Taiwan. In these two countries, autonomous strategy has worked as a mechanism for protecting the learning process of domestic firms, enabling some of them to become MNCs in their own right (Lall, 2000a and 2000b). The second best strategic option for strengthening technological capabilities is the "strategic FDI-dependent". Pursuing this strategy, Singapore, with heavy dependence on MNCs, has been strong in a narrow range of high-tech products. While Hong Kong, adopting the third strategy, "has good operational capabilities in light industry but little technological depth" (:39).

Therefore, the considerations about the limitations of MNCs in accumulating deeper technological capabilities in the host countries make room for the claims on behalf of the selective policies to protect the learning. This does not mean close the doors to the foreign capital, since, as suggested by the literature, the competition plays an important role in stimulating technological development (Bell, 1984). As Lall (1992) notes "[c]ompetition (...) is probably the most potent inducement to skill and technology upgrading" (in Caniëls and Romijn, 2001:13).

Furthermore, as MNCs are the central agents generating industrial technology at the world level, FDI is still one of the main ways to gain access to foreign technology. However, as long as ownership matters, targeting policies in relation to MNCs should be focused on the attraction of good quality FDI, which can induce more complex technological capabilities in the host countries.

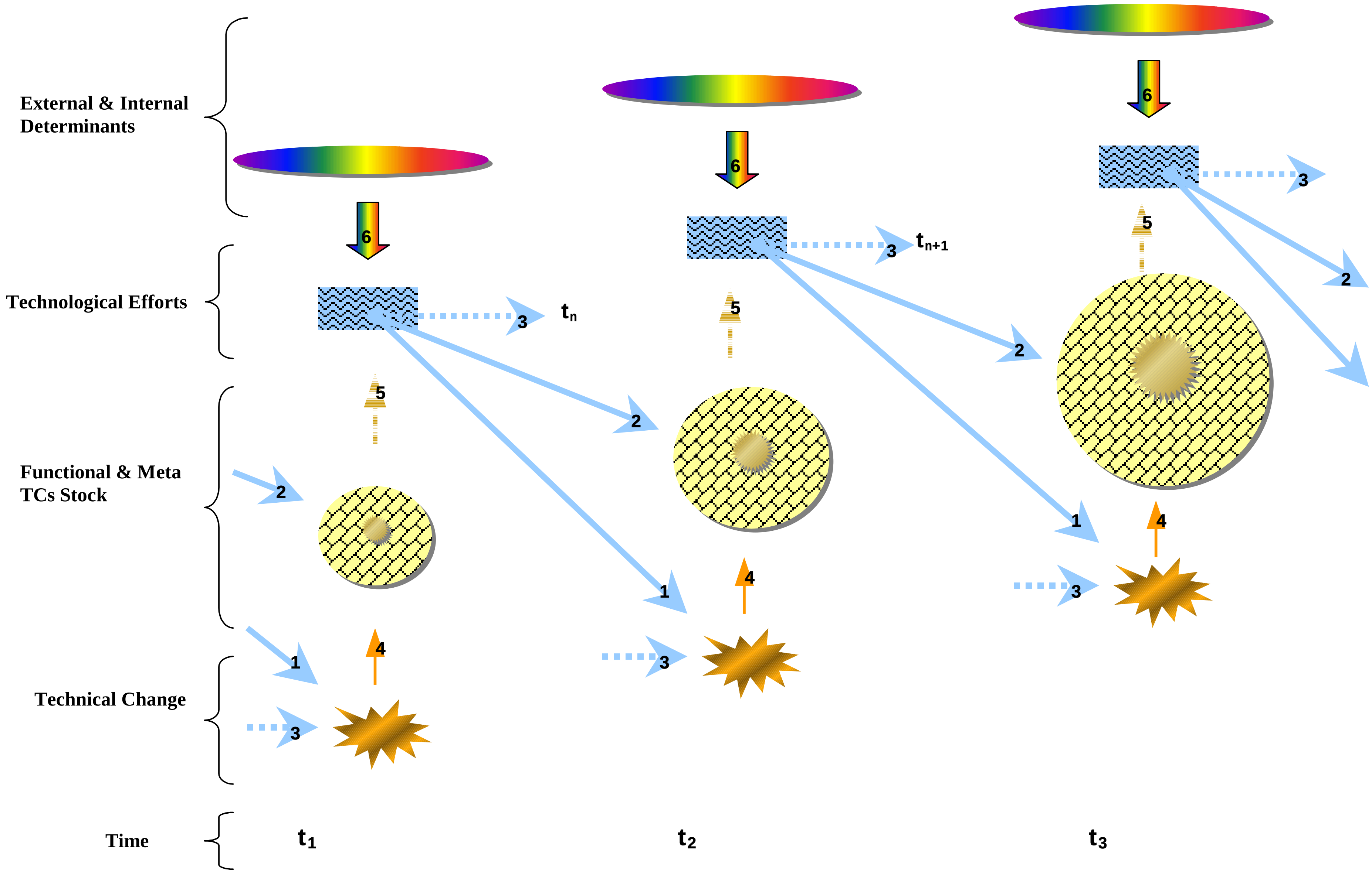
3. The framework adopted

Having highlighted the main aspects of the technological capability literature on developing countries, we now proceed to outline the analytical framework, which will provide the base for the methodology adopted to operationalise the concepts of technological capabilities, and to compute the TCs-proxies.

Figure 1 summarises the main elements and the basic dynamics of the learning process, and the technical change at the firm-level, as discussed in the previous section.

Five elements are sketched in Figure 1: technological capabilities stock, technological efforts, internal and external determinants of these efforts, technical change and time. This latter is intended to demonstrate the cumulative and path-dependent aspect of the learning process. So that, the technological events in t_n will exert influence on t_{n+1}. The direction and the rate of this process shape the technological trajectory (for instance, the Figure 1 illustrates an ascendant one). Along this trajectory, technological capabilities are accumulated and technical change may be achieved.

Figure 1 – Learning Process and Technical Change: Elements and Dynamics



Basically, two types of technical change may occur: imitation and innovation. These are two ends of a complexity spectrum[19]; for instance, it can be identified: pure duplicative imitation, minor creative imitation, major creative imitation, and so forth. This is based on a three-level distinction introduced by Kim and Nelson (2000): duplicative imitation, creative imitation, and innovation.The first one is the pure copy of technology developed by others; while the second aims "at generating imitative products but with new performance features" (:5). Innovation, by its turn, is the development and introduction of a new process or product technology into the market for the first time[20]. In addition to the degree of complexity, it is important to note a time-lag treat of the technological change, which is illustrated in the Figure 1 by the dotted-line arrow 3. This time-lag means that efforts carried out in t_n may induce technical change both in t_n (arrow 1 in the figure) and in the future (dotted-line arrow 3). It may happen, as well, that efforts in t_n induce technical change either in t_n, or in the future; or even that they achieve no technical change at all[21].

With regard to the stock of TCs, although accumulated over time, it is not directly exposed to this time-lag. This is due to the fact that, as technological efforts are being performed, skills and knowledge are being accumulated, increasing the TCs stock (arrow 2 in the Figure). That is, a firm may learn (and accumulate TCs) while it is carrying out technological efforts. Nevertheless, some indirect time-lag may be observed through the influence of the technical change upon the accumulation of TCs (arrow 4). It is worth highlighting that the TCs accumulation process is rather a dynamic one, what attributes the stock-variable feature to TCs, which is illustrated in the Figure 1 by the increasing-size over time of the TCs' circle. Then, as a dynamic process, in the same manner the TCs stock is increased by technological efforts, they are affected by the TCs accumulated up until then (arrow 5). It means, the more TCs are accumulated, the more efforts are undertaken. This defines such a virtuous cycle of the TCs accumulation. It should be noted that this is not a quantitative process, as the quality of the TCs accumulated (as well of the technical change achieved) acts upon this cycle. The quality means the depth and the complexity of the technological capability. This takes us back to the issue of the degrees of consciousness and explicitness of the technological efforts, and their direct and positive correlation to the degree of complexity of the TCs accumulated.

Moreover, as mentioned in the previous section, those levels, as well as the performance of technological efforts by itself, are affected by internal and external factors (arrow 6), which are technology-; firm-; sector- and country-specific. As it will be better described in the next section, in this paper we are concerned with three factors influencing the TCs-accumulation: ownership and size (internal factors), and industrial sector (external one). The first one (foreign and domestic ownership) is central for the purpose of our research. As emphasised in the Section 2, the literature has demonstrated that origin of capital does matter for the

[19] This term is introduced by Bell and Albu (1999) to refer to the range of TCs complexity, which ends are "routine production capabilities" and "innovative capabilities".

[20] Many empirical studies on innovation measurement (mainly in developed countries) have underlined the importance of have a clear definition of innovation, in terms of the market into which it is introduced; its degree of novelty or originality, and its scientific intensity. For instance, the Community Innovation Surveys (CIS) has distinguished innovation to the world from innovation to the firm, industry or country (Archibugui and Pianta, 1996). Based on the I CIS, Arvanitis and Hollenstein (1996) define four categories of products: 1) unchanged products; 2) improved products; 3) fundamentally improved product or new products; 4) world novelties. And, also based on the I CIS, Brouwer and Kleinknecht (1996) identify: 1) essentially unchanged products; 2) incrementally improved products, and 3) radically changed or totally new products. Albaladejo and Romijn (2000) adopt a broad classification of innovation according to its degree of novelty and science intensity.

[21] The literature on innovation process in developed countries has mentioned the implication of this time-lag in measuring the output ("innovation") of this process (Brower and Kleinknecht, 1996).

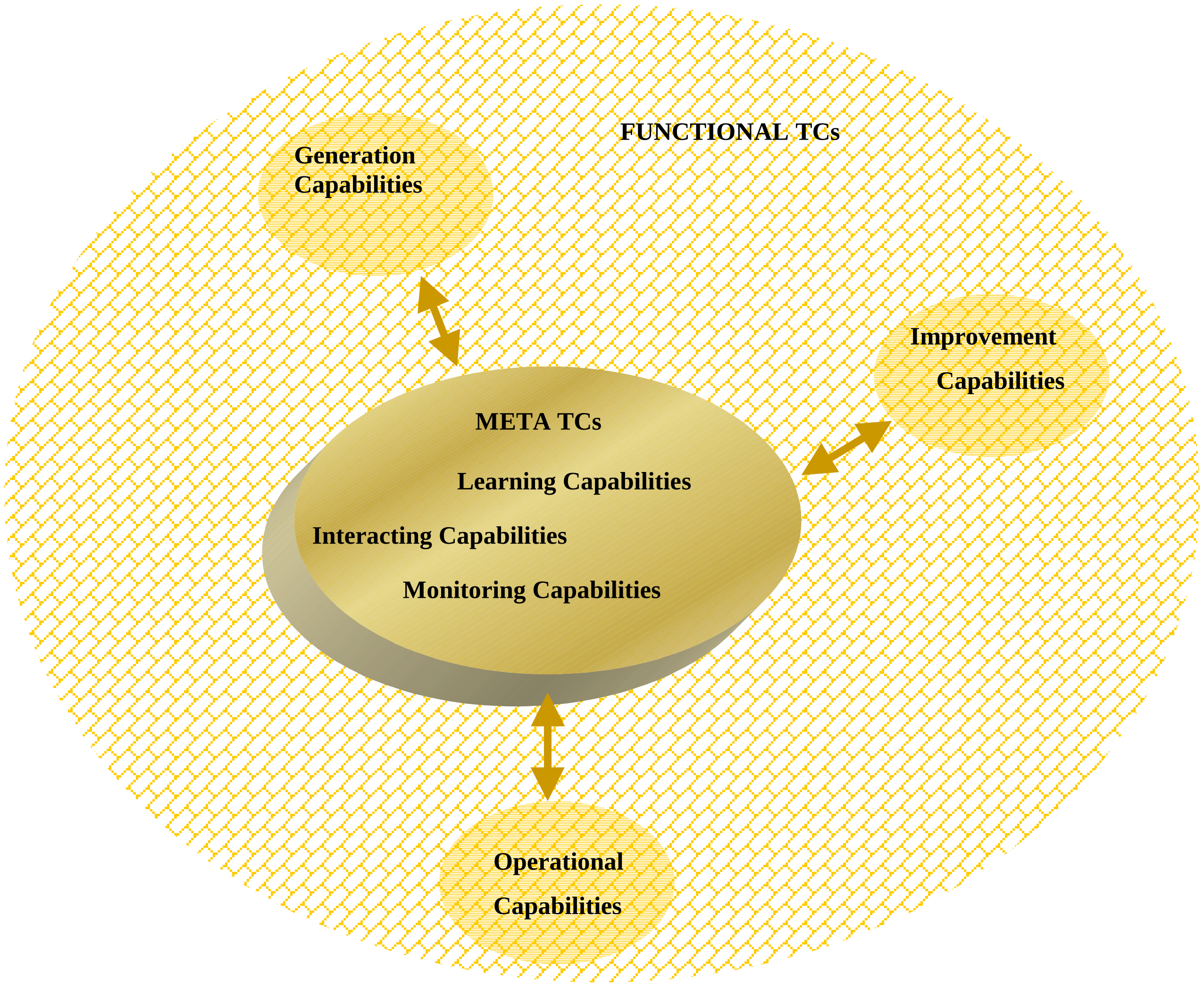
dynamic of the learning process. Likewise, the importance of both size and sector have been much stressed by the empirical and theoretical literature.

Another essential element of the learning process sketched by Figure 1 is the meta-technological capabilities (represented by the central round-star within the TCs-cycle). That special type of TCs is incorporated into a classification we are suggesting bellow, and outlined in Figure 2. Then, before dealing with those meta-TCs, we should firstly make some comments on this classification.

A central aspect of the classification is the distinction between those meta-TCs and the functional-TCs. As proposed by the literature, the functional capabilities are associated with different aspects of the productive activity they facilitate (Bell and Albu, 1999). For instance, as noted in Section 2, in the Lall (1992)'s matrix, these aspects are investment, process, product and industrial engineering, and linkages within other agents. The classification proposed in Figure 2 includes three types of functional TCs: 1) operational, 2) improvement and 3) generation capabilities. They are capabilities, respectively, to operate, improve, and generate product and process technologies. The criteria adopted to define these categories of TCs is the kind of technical change (duplicative imitation, creative imitation, or innovation) they may influence, through the technological efforts. Then, operational capabilities are TCs related to an efficient performance of the productive activities. They encompass skills, knowledge and experience to search, acquire, assimilate, use, dominate, and make minor adaptation on important technologies (product, process and engineering). So that, their effects upon technical change are more associated with a duplicative imitation of technology generated by other agents, and somewhat creative imitation. The TCs approach has addressed these capabilities in different ways. Usually, they are defined as a set of core information required for undertaking the production activity (Katz, 1985; Lall, 1994). The concept adopted herein follows the idea of "operational capability" (also called know-how) introduced by Lall (2000a).

Improvement capabilities, in their turn, are skills and knowledge associated with major imitation creative of the technologies adopted. Then, these capabilities refer to creative skill and knowledge required for the firm to improve upon the technologies it acquire from external agents. As mainly creative TCs, instead of just duplicative, they are more complex capabilities. Likewise, generation capabilities is characterised by technologically creative skills and knowledge. Nevertheless, these capabilities are a further step in the TCs-building process, as they are required for achieving significantly more original results, which are "innovations". Some authors have dealt with these improvement and generation capabilities as being "innovation capabilities", which are associated with know-why (Lall, 2000a). Caniëls and Romijn (2001) observe that innovation capabilities are the skills and knowledge required to make independent adaptation and improvement technologies, and ultimately to create entirely new technologies" (:17). In the same way, Albaladejo and Romijn (2000) suggest that innovation capability is the "ability to make major improvement and modification to existing technologies and to create new technologies" (:5).

Figure 2 – TCs Classification – Functional and Meta TCs



Before we turn to the meta-TCs, the inclusion of improvement and generation TCs in the functional category deserves some further comments. The distinction by Bell and Albu (1999), between production and knowledge system, is useful for this purpose. As well their observations about the categorisation of "innovation capabilities" and the degree of complexity of the technical change induced. Bell and Albu underline that this degree of complexity (that is, degree of "innovativeness") is "a quality or depth which may be achieved to different extents in all functional areas" (:1724). In this sense, as generation capabilities and improvement capabilities accumulated are deeper than operational ones[22], they may facilitate the performance of some production functions by inducing more complex technical change. It should be easier to get this point if this technical change is viewed as a change in the types of goods produced and in the methods adopted to produce them. That is, change in the production system level, induce by the knowledge system level (Bell and Albu, 1999).

Furthermore, it is worth emphasising that the level of complexity is an inherent aspect of the functional-TCs, as it is associated with the type of technical change that may be induced by these categories of TCs. In this sense, functional-TCs and meta-TCs cannot be compared in terms of degrees of complexity. It means we cannot say that meta-TCs are more complex than functional-TCs, and vice-versa. So, what exactly are these meta-TCs about? They are skills and knowledge not directly related to the production system level, as they facilitate the TCs-accumulation process itself. That is, while the functional-TCs facilitate activities on the production system, the meta-TCs facilitate the dynamic of the knowledge system level.

To a certain extent, many authors have acknowledged the importance of these meta capabilities. For instance, Caniëls and Romijn (2001) note that the dynamic of the learning process is based not only on the accumulation of TCs connected with the productive activity, but also it is based on "an increasing capability to manage the technological learning process efficiently. This capability, the capability to learn, is built up as a by-product of the technological learning process (...)" (:18). It means, as noted by Stiglitz (1987), that "learning itself often has to be learned" (in Lall, 2000a: 17)[23].

Moreover, the concept of absorptive capacity by Cohen and Levinthal (1990) brings some contribution to this issue. They define absorptive capacity as the "ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends (...)" (:128). In addiction, they note that the development of this ability is affected by prior accumulated knowledge. Cohen and Levinthal's absorptive capacity concept raises regards about two other meta-elements of the technological capabilities accumulation process, namely: 1) the ability to interact with external agents, and hence, 2) the ability to identify and localize the main sources of external technological knowledge. Many authors have pointed out the relevance of the first one for the technological accumulation, analyzing the different ways of interaction, and agents involved. The central idea is that the external sources of knowledge are crucial for the technological change process. According to Cohen and Levinthal (1990), this is explained by the fact that "(...) most innovations [or broadly speaking technical change] results from borrowing rather than inventions" (:128). This idea is somehow

[22] That is due to, as discussed in Section 2, the two first are accumulated primarily through more systematic and purposive efforts, while the latter mainly though operational mechanism (doing-based).

[23] Dealing with the literature on cognitive structures of learning in a broad meaning (not only technologically), Cohen and Levinthal (1990) attribute to Elis (1965) and Estes (1970) the idea of "learning to learn", as being a "progressive improvement in the performance of learning tasks in a form of knowledge transfer" (:130).

incorporated in the Lall's matrix as "linkage capability", which is the ability to transmit and receive information, skills and technologies (Lall, 1992: 168)[24].

Having made a case for the importance of learning to learn, and interacting with external sources of technological knowledge, we distinguish three meta-TCs in our classification: learning, interacting and monitoring capabilities. The first one refers to abilities to manage the learning process, that is, the learning-to-learn ability. The mechanism for accumulate this capability is the learning process itself, that is learning-by-learning. The interacting capability is associated with abilities to interact and exchange knowledge external agents. The more a firm interacts with other technological system's agents, the higher its ability to interact with. Thus, the mechanism for accumulate interacting capabilities is the interaction itself. This idea fits into the concept "learning by interacting" introduced by Lundvall (1988). Finally, monitoring capability is the skill and knowledge required to identify, to localise and to keep abreast of the relevant knowledge in the firm's technological field. The influence of the meta-TCs goes across the functional TCs, for this reason they are called here "meta" capabilities.

Before turning to the methodology, we should make a last consideration about the learning process dynamic. The literature has suggested that TCs are accumulated rather by a sequence (Caniëls and Romijn, 2001). Bell and Albu (1999) define this sequence as a "continuous of accumulation" of knowledge and skill. Applying this to the classification proposed herein, this continuous starts from the accumulation of less complex TCs (that is operational TCs), which first may induce merely duplicative imitation, and in a next time, as the process evolves, it may induce some minor creative imitation. In a next stage, the firm can accumulate some more complex capabilities (improvement TCs), which can allow it to achieve major creative imitation. Then, a further step is the accumulation of generation capabilities, which may leads to innovations. This sequence is only applied to the functional-TCs, since the meta-TCs are accumulated along all continuous.

[24] One can find a plenty of studies on this aspect of the technological development: user-producer interaction, relation with suppliers, interaction with universities and other scientific institutions, linkages within technological parks and industrial clusters, and so forth.

4. Methodology

Having outlined the analytical framework, we turn now to describe the methodology adopted to operationalise the concept of technological capabilities. The main aim is to develop proxies for the different levels of technological capabilities complexity, which can allow us to draw some considerations regarding the implications of foreign ownership for a deeper technological accumulation by the Brazilian industry.

The proxies are composed from information of an innovation survey carried out in the State of São Paulo, by the Seade Foundation[25]. This innovation survey (named Paep) followed the Oslo Manual guidelines. Thus, the Paep, and consequently the proxies we are suggesting, takes part in the international efforts to measure innovation and technological activities[26].

As an attempt to examine the impact of MNCs upon the TCs accumulation, these proxies are computed by two groups of firms, according to the origin of their capital, that is domestic and foreign. Also, the proxies are develop according to size of companies and industrial sector. These two other factors influencing the technological accumulation are taken into account for helping to overcome two difficulties. The first is associated with the database itself. As up to now Paep has been carried out only for 1996, we cannot get a time perspective of the technological accumulation process. Therefore, it is important try evaluate as much as possible different aspects of the learning process for this specific year. The second reason, as noted by Dunning (1989), is due to the difficulties of isolating ownership-effects from other aspects associated with the firms (as size), and also of making comparisons between firms involved in a similar set of value-added activities.

Then, regarding the size, it is defined two groups of firms (small and medium, and large firms). These, combined to the two ownership groups, result in four categories of analysis:

1) small and medium domestic (SME domestic): group of firms with less than 250 employees and, which origin of capital is 100% local;
2) large domestic: group of firms with more than 250 employees and, which origin of capital is 100% local;
3) small and medium MNCs (SME MNCs): group of firms with some foreign’ stake, and employing less than 250 workers;
4) large MNCs: group of firms with some foreign’stake, and employing more than 250 workers.

[25] That is the most industrialised State in Brazil. It accounts for about 35% of the Brazilian GDP, and for 70% of the turnover of all MNCs in Brazil. Therefore, the São Paulo’s industry is a good proxy to the Brazilian industry as a whole.

[26] From the late seventies and the early eighties, at the same time that the economic literature began again to be more concerned with the technical change process, there has been much efforts to develop indicators of this process, specially in developed countries. Among these efforts, there are many empirical work on trying measure R&D and patents (respectively, input and output approach); firm-based surveys, and innovation surveys (Arguibugi and Sirilli,(2000). Regarding the latter ones, the OECD and the EU have joined efforts to harmonise a questionnaire, which could allow to draw international comparisons. These efforts resulted in the Oslo Manual, which has given the guidelines for two Community Innovation Surveys (CIS I-1993 and CIS II-1996), and a third CIS is to be launched in 2001. The difficulties to measure the different aspects of the technical change, and thus, the indicators shortcomings, have been much addressed by the literature (for instance, see Archibugui and Pianta, 1996; Archibugui and Sirilli, 2000; Kleinknecht (1996); Acs and Audretsch (1993); Kleinknecht and Bain (1993)).

Concerning the sector of activity, the proxies are computed for 22 industrial sectors at two levels of ISIC Rev.3 (Table 1). These sectors are classified according to their technological intensity, based on a four-level classification (low-tech, medium-low-tech, medium-high-tech, high-tech) developed by OECD. The criteria adopted by this classification is of overall R&D intensity (direct and indirect) (Hatzichronoglou, 1997). In an aim to help analyse the proxies, these sectors are further aggregated into two groups: 1) technologically less intensive sectors (low-tech plus medium-low-tech); and 2) technologically more intensive sectors (medium-high-tech and high tech) (Table 2).

Table 1 – Industrial Sectors according to their technological intensity

Code	Industrial Sectors	Tech-Intensity[1]
	Less technologically intense sectors	
1	Food Products and Beverage	1
3	Textiles	1
4	Clothing	1
5	Leather products	1
7	Pulp and Paper	1
8	Publishing, Printing and Recorded Media	1
12	Rubber and Plastic Products	2
13	Stone, Clay and Glass (non-metalic Mineral)	2
14	Basic Metals	2
15	Fabricated Metal Products (except Machinery)	2
	More technologically intense sectors	
10	Chemical Products (except Pharmaceutical Products)	3
11	Pharmaceutical Products	3
16	Mechanical Machinery	3
17	Office Machinery, computing	4
18	Electrical Machinery and Components	3
19	Electronic Material and Telecom Equipment	4
20	Medical, Precision and Optical Instruments	3
21	Motor Vehicles	3
22	Autoparts	3
23	Other Transport (aircraft, shipbuilding, etc.)	3

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

The quantitative method adopted to compute the TCs-proxies is one of composite indices, ranging from zero to one[27]. This range helps to drawn comparisons amongst the categories of firms and groups of sectors. The range 0-1 has an attainment perspective, as it shows the level reached by each category of firm in relation to a maximum target of "one"[28].

[27] 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.

[28] 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).

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

1) Organisational Index and Automation Index, based on variables related to the use of techniques and equipment in the production process (TQM, SPC; internal JIT; external JIT and robots; CNC/DNC systems and CAD/CAM);
2) Incremental Change Index, Significant Change Index and Process Change Index, based on the variables "introduction of innovation";
3) Systematic Effort Index; based on the variables "R&D department as source of information for innovation" and the "R&D personnel";
4) Production Chain Linkage Index and S&T System Linkage Index, computed from the variables of "external sources of information for innovation" (suppliers of material/components, suppliers of equipment, clients and customers, competitors, patent disclosures and licences; and universities and research institutes).

The indices groups 1 and 2 are somehow a measure of the type of technical change achieved by the firm in 1996, which according to the framework adopted can be: imitation duplicative, imitation creative and/or innovation. Moreover, this change was achieved through some effort (explicit or not), which required some previously accumulated technological capabilities. Therefore, we are taking for granted that measuring this change we can have a proxy for some TCs. Then the next question is: which TCs? As we cannot distinguish the type of change, we are taking those indices as proxy for operational capabilities[29]. The two basic assumptions for doing this are that: 1) most of "innovation" in the surveyed firms is in fact imitation (either duplicative or creative); and so 2) for introducing and using a "new" product or process, the firm probably had accumulated some previous TCs to search for, acquire, assimilate, use, dominate an make minor adaptation upon it, that is "operational capabilities". Then, 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. It should be noted that we have chosen not to include the Significant Change and the Equipment Index in the Operational Index. This methodological option is due to the first may include some creative input by the firm, associated with more complex capabilities, which we cannot identified in the Paep database. The Equipment Index, by its turn, is not taken into the Operational Capabilities, as the adoption of some equipment (like robots), is highly associated with the kind of process technology adopted, which depends rather on the good being produced, than on the complexity of TCs accumulated.

The systematic effort index, as it is a measurement of the more explicit technological efforts, it is taken as a proxy for the improvement and generating capabilities. The basic assumption is as these efforts may lead to further results regarding technical change and TCs accumulated, for being performed they require some previous accumulation of more advanced TCs, that is creative capabilities.

[29] In Paep questionnaire the surveyed firms were asked to answer whether they had introduced or not any "innovation" in the period 1994/1996. Innovation was defined as the introduction of technologically new or improved products and/or processes (Quadros et al., 1999). This perspective of innovation do not allow us identify the type of technical change it is about, that is, in terms of its degree of originality and/or scientific intensity.

The last two indices (Production Chain Linkage Index and S&T System Linkage Index) are taken as proxies for the monitoring and interacting capabilities, both meta-TCs. That is based on the assumption that for having external sources of information for technical change, the firm should have accumulated some capabilities to acquire and assimilate technology and knowledge from external sources.

It should be noted that the proxies are an attempted to measure some TCs already accumulated, and not the process of accumulation itself. Moreover, as indirect proxies they are not a perfect measure of each TCs. That is, as we are composing the proxies through information on the efforts and technical change, we cannot perfectly isolated each capability involved. However, as proxies the indices can give some idea about the TCs previously accumulated.

There is another important observation we should mention, before turn to analyse some findings we have made so far. This is the need to carry out some statistical tests to better examine the influence of ownership, size and sector upon the level of technological capabilities accumulated. These tests are going to be carried out in the next stage of our research. Also, as a further stage, we intend to draw some comparison between our findings based on the Paep database, and the information about other examples of innovation surveys, basically, the Community Innovation Surveys. By this international comparison, we intend to create a yardstick, which can help us to better analyse the TCs proxies.

5. Main Findings and Concluding Remarks

This section is an analysis of some findings we have made up to now, by adopting the methodology previously described. A comparison is drawn between technological capability proxies for MNCs and domestic firms. Also, in both categories, the proxies are computed for small-medium-, and large-size groups of firms. By making this comparison, the main aim is to get some clues about the relative contributions of the foreign capital for the Brazilian technological development.

Charts 1 and 2 sketch the average indices of the technological capabilities proxies for the four categories of firms and the two groups of sectors.

Generally, both for MNCs and domestic firms, the indices show that the less complex technological capabilities are higher than the more complex ones. That is immediately observed when the Operational Capabilities Index is compared to the Systematic Effort Index. One factor that helps to explain the relative higher level reached on the Operational TCs Index is the strong modernization process of the Brazilian industry, and the fact that the Paep refers to the period 1994/1996, which was the peak time of this process. Thus, in response to increasing competition, combined with market growth, industrial firms introduced many technologies, both for updating products and production processes (Quadros et al., 1999). This can be picked up from the high scores on the Incremental, Significant, and Process Change Indices[30].

[30] It is interesting to not that these indices are composed by the variables “introduction of innovation”, as the Paep questionnaire asked firms to answer whether they had or not introduced any “innovation” in the period 1994/1996.

Chart 1: Average Indices – Less technologically intensive sectors

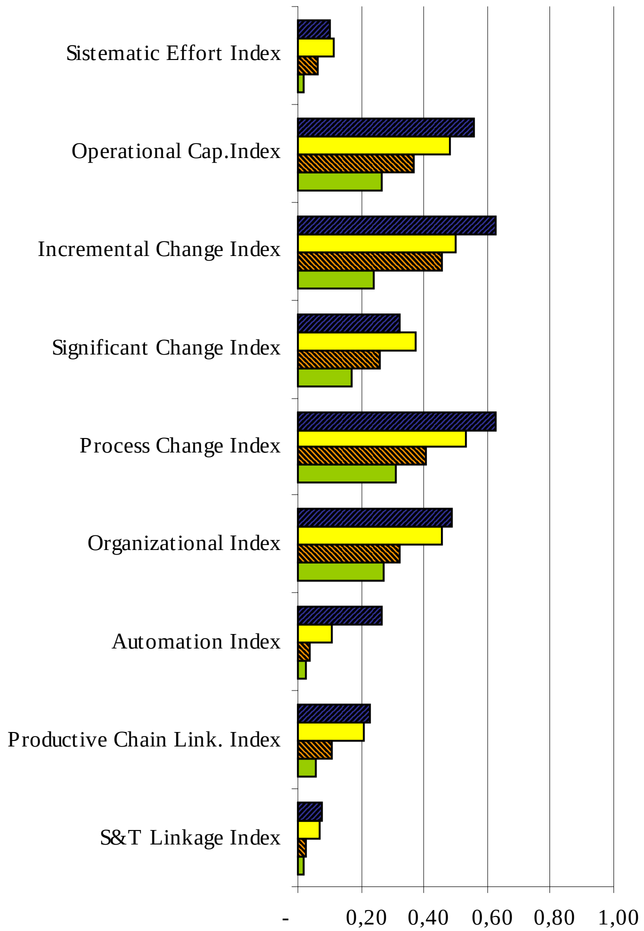
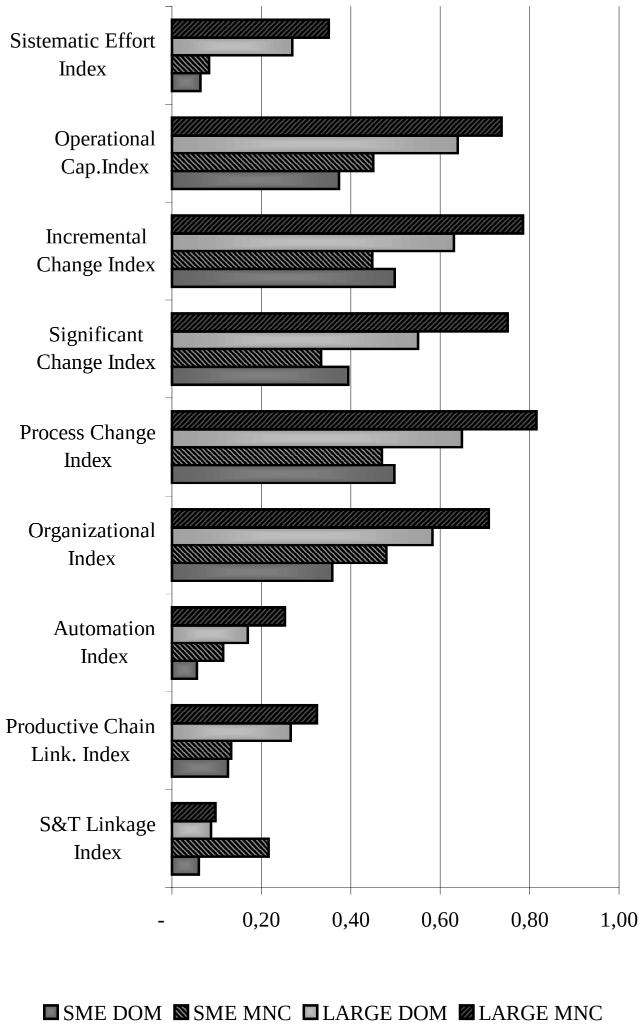


Chart 2: Average Indices – More technologically intensive sectors



This contrast between the less (Operational) and the more complex TCs (Systematic Effort) suggests a Brazilian industry weakness in accumulating deeper and further technological capabilities. It is worth noting, as well, that such weakness is observed both among MNCs and domestic firms, almost in all sectors of activity and in all categories of size.

With regard to sector and size, the sharpest differences among the categories are observed. That is, in most cases, the highest indices are reached in the more technologically intensive sectors and by the larger firms. As pointed out by the literature, that is due to the importance of these two factors as determinant of the firms' technological activities. The influence of sector and size upon the technological accumulation implies some difficulties in analysing the impact of the ownership upon this process, which is the main concern of this paper. The statistical tests, which will be carried out in a next stage of our research, are intended to help to overcome this shortcoming.

In spite of this shortcoming, the indices suggest a better technological performance by MNCs than by domestic firms, in both group of sectors. Amongst the SME-firms, SME-MNCs score better on most indices, both in the less and the more technologically intensive sectors. With the exception of the Process, Incremental, and the Significative Change Indices in the more technologically intensive sectors, where SME-domestic firms score better than SME-MNC.

Amongst the larger firms, Large-MNCs score better than Large-domestic firms on all indices in the more technologically intensive sectors, and on most indices in the less technologically intensive sectors. The only exemptions are the Systematic Effort and the Significative Change indices, on which large-domestic firms score better than large-MNCs.

Furthermore, the relative higher score by MNCs may indicate rather a weaknesses of domestic firms, than a MNCs' strength. As noted by Amann and Baer (1998), among the Brazilian domestic firms, the degree of formalisation of R&D activities (that is, more purposive and systematic efforts) has been quite low. Also, although MNCs (SME and large) 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 the operational than to the creative capabilities. In addition, their technological linkages to the whole economy are quite low as well, and most of them are within the production chain.

Some elements to explain such a not very favourable technological picture of the Brazilian industry should be found in its historical trajectory of development. In this sense, the FDI policy-strategies adopted by Brazil, both during import substitution period and since the early nineties, may, as suggested by the literature[31] be implying this drawback to the technological accumulation in the country.

To summary up, farther demonstrating a low performance of technological activities in Brazil, the figures point to a moderate TCs-building process, both by MNCs and by domestic firms. Going back to the main objective of our thesis, this suggests that the increased FDI inflow into the Brazilian industry do not *per se* means the local accumulation of deeper technological capabilities.

[31] See Section 2.

References

ACS, Zoltan J. and AUDRETSCH, David B.(1993). Analysing innovation output indicators: the US experience. In: KLEINKNECHT, Alfred and BAIN, Donalt (Eds). New concepts in innovation output measurement. New York : St. Martin's Press, 1993, p. 10-41

ALBALADEJO, Manuel and ROMIJN, Henny (2000). Determinants of innovation capability in small UK firms: an empirical analysis. ECIS Working Papers Series, n.13. (29p).

AMANN, Edmund and BAER, Werner (1998). From technology absorption to technology production: industrial strategy and technological capacity in Brazil's development process. University of Oxford - Center for Brazilian Studies - Working Paper, CBS-01-98.

ANAND, Sudhir and SEN, Amartya K. (1994). Human development index: methodology and measurement. Human Development Report Office, Occasional Papers, n.12, New York : UNDP, Jul., 1994.

ARCHIBUGI, Daniele and PIANTA, Mario. (1996): Measuring technological change through patents and innovation surveys. Technovation. v. 16, n. 9, p. 451-468.

ARCHIBUGI, Daniele and SIRILLI, Giorgio (2000). The direct measurement of technological innovation in business. National Research Concil, Rome, Italy, 2000 (photocopy).

ARGHIBUGI, Daniele e IAMMARINO, Simona (1999). The policy implications of the globalisation of innovation. Research Policy (Special Issue: The Internationalization of Industrial R&D). Amsterdam, v. 28, nrs. 2 e 3, mar., 1999, p. 317-336.

ARVANITIS, Spyros and HOLLENSTEIN, Heinz (1996). Industrial innovation in Switzerland: a model-based analysis with survey data. In: KLEINKNECHT, Alfred (Ed.) Determinants of Innovation: the message from new indicators. London : Macmillan Press Ltd., 1996, p.13-62.

BANCO CENTRAL DO BRASIL (1998): Censo de Capitais Estrangeiros – 1995. Brasília : Banco Central do Brasil (http://www.bcb.gov.br/htms/censo).

BARANSON, Jack e ROARK, Robin (1985). Trends in North-South transfer of high technology. In: ROSENBERG, Nathan. e FRISCHTAK, Claudio (Eds.). International Technology Transfer: concepts, measures and comparisons. London : Praeger, 1985, p. 24-42.

BELL, Martin (1984). Learning and accumulation of industrial and technological capability in developing countries. In: FRANSMAN, Martin e KING, Kenneth (Eds.). Technological capacity in the Third Word. London : Macmillan, 1984. p. 187-209.

BELL, Martin and ALBU, Michael (1999). Knowledge systems and technological dynamism in industrial clusters in developing countries. World Development, v.27, n.9, p.1715-1734.

BELL, Martin and PAVITT, Keith (1992). Accumulating technological capability in developing countries. Proceedings of the World Bank Annual Conference on Development Economics, p. 257-281.

BONELLI, Régis e GONÇALVES, Robson R (1998). A note on foreign direct investment and industrial competitiveness. Rio de Janeiro : IPEA, ago. 1998. (29 p),(Textos para Discussão, n. 584).

BRAGA, Helson C. e MATESCO, Virene (1989). Desempenho Tecnológico da Indústria Brasileira: uma análise exploratória. Rio de Janeiro : IPEA, fev.. 1989. 37 p.(Textos para Discussão Interna, n. 162).

BROUWER, Erik and KLEINKNECHT, Alfred (1996). Determinants of innovation: a microeconometric analysis of three alternative innovation output indicators. In: KLEINKNECHT, Alfred (Ed.) Determinants of Innovation: the message from new indicators. London : Macmillan Press Ltd., 1996, p.99-124.

CANIËLS, Marjolein and ROMIJN, Henny (2001). Small-industry clusters, accumulation of technological capabilities, and development: a conceptual framework. In: International Workshop on "Small Enterprises in Global Markets: internationaltisation, clustering, innovation", University of Molise, Campobasso, Italy, 22-24, March, 2001.

CANTWELL, John (1990). Technological innovation and multinational corporations. Oxford : Basil Blackwell, 1990 (first published 1989). 239p.

CANTWELL, John e JANNE, Odile (1999). Technological globalisation and innovative centres: the role of corporate technological leadership and locational hierarchy. Research Policy (Special Issue: The Internationalization of Industrial R&D). Amsterdam, v. 28, nrs. 2 e 3, mar., 1999. p. 119-144.

CHOUNG, Jae-Yong; HWANG, Hye-Ran; CHO, Jin-ho, and RIM, Myung-Hwan (2000). Transition of latecomer firms from technology users to technology generators: Korean semiconductors firms. World Development, v.28, n.5, p. 969-982.

CHRISTENSEN, Jean Froslev (1994). Analyzing the technology base of the firm: a multi-dimensional resource and capability perspective. In: EUNET/*IC Conference. Evolutionary economics of technological change: assessment of results and new frontiers. Eunetic Conference, v. 3. Strasbourg : European Parliament, out.,1994. (p. 1717-1740).

COHEN, Wesley M. and LEVINTHAL, Daniel A. (1990). Absorptive capacity: a new perspective on learning and innovation. Administrative Science Quartely, v.35, n.1, Mar, 1990, p. 128-152.

CRANE, Diana (1977). Technological innovation in developing countries: a review of literature. Research Policy, Netherlands, v. 6, n.4, p. 374-395, out. 1977.

CREPON, Bruno; DUGUET, Emmanuel and KABLA, Isabelle (1996). Schumpeterian conjectures: a moderate support form various innovation measures. In: KLEINKNECHT, Alfred (Ed.) Determinants of Innovation: the message from new indicators. London : Macmillan Press Ltd., 1996, p. 63-98.

DAHL, Michael S (2001). Overview of the theories of geographical clustering and agglomeration. In: DRUID Winter Conference (Vol.I), Jan. 18-20, 2001. (preliminary draft)

DAHLMAN, Carl e WESTPHAL, Larry (1982). Technological effort in industrial development - an interpretative survey of recent research. In: STEWART, Francis. e JAMES, Jeffrey. (Eds.). The economics of new technology in developing countries, Londres : Frances Pinter, 1982. p. 105-137.

DOSI, Giovanni (1982). Technological paradigms and technological trajectories. Research Policy, v.11, p.147-162.

DUNNING, John H (1993). Multinational enterprises and the global economy. [s.l.] : Addison-Wesley P., 1993 . p.287-330/599-617.

ERBER, Fabio S. (1983) Technological dependence and learning revisited. Rio de Janeiro : IEI/UFRJ, 1983. 40p.(Textos para Discussão, n.34).

FAJNZYLBER, Pablo (1993). A capacitação tecnológica na indústria brasileira de computadores e periféricos: do suporte governamental à dinâmica de mercado. Campinas, 1993. Dissertação de Mestrado (Economia). Instituto de Economia, Universidade Estadual de Campinas.

FELDER, Johannes; LICHT, Georg; NERLINGER, Eric and STAHL, Harald (1996). Factors determining R&D and innovation expenditure in German manufacturing industries. In: KLEINKNECHT, Alfred (Ed.) Determinants of Innovation: the message from new indicators. London : Macmillan Press Ltd., 1996, p.125-154..

FLORIDA, Richard (1997). The globalization of R&D: results of a survey of foreign-affiliated R&D laboratories in the USA. Research Policy. Amsterdam, v. 26, n. 1, mar., 1997. p. 85-103.

FRANSMAN, Martin (1984). Technological capability in the Third World: an overview and introduction to some of the issues raised in this book. In: FRANSMAN, Martin e KING, Kenneth (Eds.). Technological capacity in the Third Word. London : Macmillan, 1984. p. 3-30.

FREEMAN, C.(1995) The national system of innovation in historical perspective. Cambridge Journal of Economics, v.19, p. 5-24, 1995.

FREEMAN, Chris (1994). The economics of technical change. Cambridge Journal of Economic (Critical Survey), [s.l.], n. 18, 1994. p.463-514.

FREITAS, Adriana Gomes de (1993). Capacitação tecnológica em sistemas de produção para águas profundas. Campinas, 1993. 158p. Dissertação de Mestrado (Política Científica e Tecnológica). Departamento de Política Cientifica e Tecnológica, Universidade Estadual de Campinas.

GASSMANN, Oliver e ZEDTWITZ, Maximilian von (1999). New concepts and trends in international R&D organization. Research Policy (Special Issue: The Internationalization of Industrial R&D). Amsterdam, v. 28, nrs. 2 e 3, mar., 1999. p. 231-250.

GERTLER, Meric S (2001). Best Practice? Geography, learning and institutional limits to strong convergence (2001). In: DRUID Winter Conference (Vol.III), Jan. 18-20, 2001. (to be published in the Journal of Economic Geography, 1 (2001).

GONÇALVES, Reinaldo (1991). Internacionalização da produção e empresas transnacionais: uma abordagem teórica. Rio de Janeiro, 1991. 64p. Tese de Livre-docência (Economia). Departamento de Economia, Universidade Federal do Rio de Janeiro.

HATZICHRONOGLOU, Thomas (1996). Globalisation and competitivenes: relevant indicators. Paris : OCDE, 1996. 61 p.(GD, STI Working Papers, n. 43). (http://www.oecd.org/dsti/sti/prod/sti_wp.htm)

HATZICHRONOGLOU, Thomas (1997). Revision of the high-technology sector and product classification. Paris : OCDE, 1997. 25 p.(GD, STI Working Papers, n. 216, unclassified). (http://www.oecd.org/dsti/sti/prod/sti_wp.htm)

HERBERT-COPLEY, Brent (1990). Technical change in Latin American manufacturing firms: review and synthesis. World Development, Oxforf, v.18, n 11, p. 1457-1469, nov. 1990.

INZELT, Annamária (1996). Science and technology statistics in the partners in transition countries and the Russian Federation. Paris : OCDE/GD 56, 1996.

INZELT, Annamária (1998). Transformation role of FDI in R&D; analysis based on a databank. Hungarian : Innovation Research Centre, 1998. (paper).

INZELT, Annamária.(2000). The FDI in R&D: skin-deep and soul-deep co-operations. Journal Technology Transfer, August, 2000 (forthcoming).

JOHNSON, Bjorn and LUNDVALL, Bengt-Ake (2001). Why all this fuss about codified and tacit knowledge? In: DRUID Winter Conference (Vol.III), Jan. 18-20, 2001.

KATZ, Jorge M (1976). Importación de tecnología, aprendizaje e industrialización dependiente. Mexico : Fundo de Cultura Económica, 1976. p. 52-75.

KATZ, Jorge M (1985). Domestic technological innovations and dynamic compartative advantages: further reflections on a compartative care-study program. In: ROSENBERG, Nathan. e FRISCHTAK, Claudio (Eds.). International Technology Transfer: conceps, measures and comparisons. London : Praeger, 1985. p. 127-166.

KATZ, Jorge M (1987). Domestic technological generation in LDCs: a review of research finding. In: ________ (Ed.). Technology generation in Latin American manufacturing industries. London : Macmillan, 1987. p. 13-55.

KATZ, Jorge M. e BERCOVICH, Nestor (1993). A. National systems of innovation supporting technical advance in industry: the case of Argentina. In: NELSON, Richard R. (Ed.). National Innovation Systems: a comparative analysis. New York : Oxford University Press, 1993. p. 451-475.

KIM, Linsu and NELSON, Richard R. (Eds.) (2000). Technology, learning & innovation: experiences of newly industrializing economies. [s.l] : Cambridge Univ. Press, 2000.

KLEINKNECHT, Alfred (1993). Testing innovation indicators for postal surveys: results form a five-country project. In: KLEINKNECHT, Alfred and BAIN, Donalt (Eds). New concepts in innovation output measurement. New York : St. Martin's Press, 1993.

KLEINKNECHT, Alfred (1993). Why do we need new innovation output indicators? And introduction. In: KLEINKNECHT, Alfred and BAIN, Donalt (Eds). New concepts in innovation output measurement. New York : St. Martin's Press, 1993.

KLEINKNECHT, Alfred (Ed.) (1996). Determinants of Innovation: the message from new indicators. London : Macmillan Press Ltd., 1996.

KLEINKNECHT, Alfred and BAIN, Donalt (Eds) (1993). New concepts in innovation output measurement. New York : St. Martin's Press, 1993.

KUEMMERLE, Walter (1999). Foreign direct investment in industrial research in the pharmaceutical and electronics industries: results from a survey of multinational firms. Research Policy (Special Issue: The Internationalization of Industrial R&D). Amsterdam, v. 28, nrs. 2 e 3, mar., 1999. p. 179-193.

KUME, Honório (1996). A política de importação no plano real e a estrutura de proteção efetiva. Brasília : IPEA, 1996. (Texto para Discussão, n. 423).

LALL, Sanjaya (1992). Technological capabilities and industrialization. World Development, v.20, n.2, 1992, p.165-186.

LALL, Sanjaya (1994). Technological capabilities. In: SALOMON, Jean-Jacques, SAGASTI, Francisco R. e SACHS-JEANTET, Céline (Eds.). The uncertain quest: science, technology, and development. [s.l.] : United Nations University Press, 1994. p. 264-301.

LALL, Sanjaya (2000a). Technological change and industrialization in the Asian newly industrializing economies: achievements and challenges. In: KIM, Linsu and NELSON, Richard R. (Eds.). Technology, learning & innovation: experiences of newly industrializing economies. [s.l] : Cambridge Univ. Press, 2000. p. 13-68.

LALL, Sanjaya (2000b). The technological structure and performance of developing country manufactured exports, 1985-98. Oxford Development Studies, v.28, n.3, 2000, p.337-369.

LALL, Sanjaya and WIGNARAJA, Ganeshan (1992). Foreign involvement by European firms and garment exports by developing countries. QEH, International Development Centre, Centre Studi Luca d'Agliano, University of Oxford, Development Studies (Working Papers), n.54, nov. 1992.

LAPLANE, Mariano F.; SARTI, Fernando (1997). Competition, policy and growth in the brazilian automobile industry. In : GERPISA, CINQUIÈME RENCONTRE INTERNATIONALE, 1997. The trajectories of internationalization of automobile industry firms. Paris, jun., 1997a. p.239- 251.

LAPLANE, Marilano F. e SARTI, Fernando (1997). Investimento Direto Estrangeiro e a retomada do crescimento sustentado. Economia e Sociedade. Campinas, v. 8, jun., 1997. p. 143-181.

LUNDVALL, Bengt-Ake. Commentary about chapters 2 and 3 (2000). In: KIM, Linsu and NELSON, Richard R. (Eds.). Technology, learning & innovation: experiences of newly industrializing economies. [s.l] : Cambridge Univ. Press, 2000. p. 13-68.

LUNDVALL, B. A. (1988). Innovation as on interactive process: from user-producers interaction to the national system of innovation. In: Technical change and economic change. London: Frances Printer Publishers, 1988.

LUNDVALL, B. A. (Ed.) (1992). National system of innovation: towards a theory of innovation and inteactive learning. London : Pinter Publishers, 1992.

LUNDVALL, B.-A and B. JOHNSON (1984). The learning economy. Journal of Industry Studies, v.1, n. 2, p.23-42.

MASON, Robert D.; LIND, Douglas A. and MARCHAL, Willian G (1999). Statistical techniques in business and economics. Mc Graw Hill, 1999. (10^{th}. Ed)

MATESCO, Virene Roxo e HASENCLEVER, Lia (1996). Indicadores de esforços tecnológico: comparações e implicações. Rio de Janeiro : IPEA, out.. 1996. 29 p.(Textos para Discussão, n. 422).

MERCADO, Alexis (1992). Capacitação tecnológica na indústria de química fina no Brasil: uma taxonomia das empresas nacionais. Campinas, 1992. 222p. Dissertação de Mestrado (Política Científica e Tecnológica). Departamento de Política Cientifica e Tecnológica, Universidade Estadual de Campinas.

MOLIN, Mans J (2001). Dynamic capabilities: how can we make them work? In: DRUID Winter Conference (Vol.III), Jan. 18-20, 2001.

MOREIRA, Maurício Mesquita. (1998): Estrangeiros em uma economia aberta: impactos recentes sobre produtividade, concentração e comércio exterior. Brasília : BNDES/DEPEC.(Textos para Discussão, n.67). (http://www.bndes.gov.br)

NARULA, Rajneesh (1996). Multinational investment and economic structure: globalisation and competitiveness. London : Routledge, 1996. 217p.

NEGRI, João Alberto De (1997). Impactos das multinacionais na reestruturação da indústria: uma proposta metodológica. Brasília : IPEA, maio 1997. 45 p.(Textos para Discussão, n. 474).

NELSON, R. (Ed.) (1993) National system of innovation. Oxford Univ. Press. : Oxford, 1993.

NELSON, Richard (1987). Understanding technical change as an evolutionay process. In: Professor Dr. F. de Vries Lectures in Economics: Theory, Institutions, Policy, v.8. Amsterdan : Elsevier Science Publishers.

NELSON, Richard R. and WINTER, S. (1982). An evolutionary theory of economic change. Cambridge, Massachusetts ; Harvard University Press, 1982.

NIOSI, Jorge (1999). The internationalization of industria R&D: from technology transfer to the learning organization. Research Policy (Special Issue: The Internationalization of Industrial R&D). Amsterdam, v. 28, nrs. 2 e 3, mar., 1999. p. 107-117.

OCDE (1992). Technology/ Economy Programme. Paris : OCDE, 1992. P. 209-236 (Cap. 10).

OCDE (1997). National Innovation Systems. Paris : OECD, 1997. (http://www.oecd.org).

OCDE (1998). Measuring Intangible Investment: intangible investment in the statistical frameworks for the collection and comparison of science and technology statistics. Paris : OCDE Secreariat, 1998. 49 p. (http://www.oecd.org/dsti/sti/prod/sti_wp.htm)

PACK, Howard (2000). Research and development in industrial development process. In: KIM, Linsu and NELSON, Richard R. (Eds.). Technology, learning & innovation: experiences of newly industrializing economies. [s.l] : Cambridge Univ. Press, 2000. p. 68-94.

PASSOS, Maria Cristina Araujo (1996). Capacitação tecnológica na indústria de máquinas-ferramentas no Rio Grande do Sul. Campinas, 1996. 273p. Tese de Doutorado (Economia). Instituto de Economia, Universidade Estadual de Campinas.

PATEL, Pari e VEGA, Modesto (1999). Patterns of internationalisation of corporate technology: location vs. Home country advantages. Research Policy (Special Issue: The Internationalization of Industrial R&D). Amsterdam, v. 28, nrs. 2 e 3, mar., 1999. p. 145-155.

PAVITT, K. (1984). Sectoral patterns of technical change: towards a taxonomy and a theory. Researcy Policy, v.13, p.343.

PEARCE, Robert D (1989). The internationalisation of research and development by multinational enterprises. London : Macmillan, 1989.

PEARCE, Robert D (1999). Decentralised R&D and strategic competitiveness: globalised approaches to generation and use of technology in multinational enterprises (MNEs). Research Policy (Special Issue: The Internationalization of Industrial R&D). Amsterdam, v. 28, nrs. 2 e 3, mar., 1999. p. 157-178.

PRASADA REDDY, A. S. e SIRGUDSON, Jon (1994). Emerging patterns of globalization of corporate R&D and scope for innovative capability building in developing countries. Science and Public Policy, England, v. 21, n. 5, p. 283-294, out. 1994.

QUADROS, Ruy; FURTADO, André; BERNARDES, Roberto and FRANCO, Eliane (1999). Technological innovation in Brazilian industry: an assessment based on the São Paulo innovation survey. In: 3rd. International Conference on Technology Policy and Innovation, Austin, US, 30 Aug. – 2 Sept., 1999.

QUEIROZ, Sérgio R. R (1993). Os determinantes da capacitação tecnológica no setor químico farmacêutico brasileiro. Campinas, 1993. 219 p. Tese de Doutorado (Economia), Instituto de Economia, Universidade Estadual de Campinas.

RANIS, Gustav (1984). Determinants and consequences of indigenous technological activity. In: FRANSMAN, Martin e KING, Kenneth (Eds.). Technological capacity in the Third Word. London : Macmillan, 1984. p. 95-112.

REICH, Robert B (1991). Who do we think they are? The American Prospect, [s.l.], n. 4, 1991. p. 49-53. (http://epn.org/prospect/04/04reic.html).

ROSENBERG, Nathan. e FRISCHTAK, Claudio (1985). Preface. In: ________ (Eds.). International Technology Transfer: concepts, measures and comparisons. London : Praeger, 1985. p. vii-xvii.

SEN, Amartya Kumar (1999). Development as freedom. Oxford : Oxford University Press, 1999.

STIGLITZ, J. E. (1987). Learning to learn, localized learning and technological progress. In: DASGUPTA, P. and P. STONEMAN (Eds.). Economic policy and technological performance. Cambridge : Cambridge University Press, p.123-153.

TEECE, David J (2000). Firm capabilities and economic development: implication for newly industrializing economies. In: KIM, Linsu and NELSON, Richard R. (Eds.). Technology, learning & innovation: experiences of newly industrializing economies. [s.l] : Cambridge Univ. Press, 2000. p. 105-124.

TYSON, Laura D'Andrea (1991). They are not us - Why american ownership still matters. The American Prospect, [s.l.], n. 4, 1991. p. 37-49. (http://epn.org/prospect/04/04tyso.html).

UNCTAD. Globalization, integrated international production and the world economy(1994). In: UNCTAD. Transnational corporations, employment and the workplace. World investiment Report, 1994. p. 117-160 (cap. 3).

VINDING, Anker Lund (2001). Absorptive capacity and innovative performance: a human capital approach. In: DRUID Winter Conference (Vol.II), Jan. 18-20, 2001 (first draft).

VOSSEN, Robert W. and NOOTEBOOM, Bart (1996). Firm size and participation in R&D. In: KLEINKNECHT, Alfred (Ed.) Determinants of Innovation: the message from new indicators. London : Macmillan Press Ltd., 1996, p.155-168.

WILLMORE, Larry N (1987). Controle estrangeiro e concentração na indústria brasileira. Pesquisa e Planejamento Econômico. Rio de Janeiro, v. 17, n. 1, abr., 1987. p. 161-190.

ZANDER, Ivo(1999). How do you mean ‘global’? An empirical investigation of innovation networks in the multinational corporation. Research Policy (Special Issue: The Internationalization of Industrial R&D). Amsterdam, v. 28, nrs. 2 e 3, mar., 1999. p. 195-213.