Technological Strategies of Transnational Corporations Affiliates in Brazil*
Estratégias Tecnológicas de filiais de Corporações Transnacionais no Brasil

RAC – Revista de Administração Contemporânea, vol 9, 1ª Edição Especial 2005

Eliane Franco
Doutora em Política Científica e Tecnológica pela Unicamp, com doutorado-sanduíche em Development Studies, University of Oxford, Inglaterra. Mestre em Política Científica e Tecnológica pelo Instituto de Geociências, Unicamp; Bacharel em Ciências Econômicas pela Faculdade de Ciências e Letras, Unesp; professora (PED) no curso de Graduação em Ciências da Terra, Unicamp; pesquisadora do Grupo de Estudos de Empresas e Inovação (GEMPI), Unicamp. Trabalhou como pesquisadora da Fundação Seade, onde participou da concepção, elaboração e análise de pesquisas estatísticas, bem como construção de indicadores econômicos para o Estado de São Paulo e Brasil. Suas principais áreas de interesse em pequisa são: políticas de desenvolvimento industrial e tecnológico, mensuração da inovação tecnológica e estratégias tecnológicas das empresas multinacionais (tese de doutorado).
Departamento de Política Científica e Tecnológica (DPCT)/IG/UNICAMP
Caixa Postal 6152
13.081-970
Campinas – SP
Telefones: (019) 3788-4555 (sec)
(011) 5058-6387 (res)
Emails: eliane_franco@uol.com.br
eliane@ige.unicamp.br

Prof. Dr. Ruy de Quadros Carvalho
Livre-docente pela UNICAMP; Doutor em Development Studies pela Universidade de Sussex, Inglaterra; Mestre em Ciência Política pelo IFCH, Unicamp e Bacharel em Administração de Empresas pela EAESP/FGV; Professor Associado (RDIDP) do quadro permanente do Departamento de Política Científica e Tecnológica do IG/UNICAMP e líder do Grupo de Estudos de Empresas e Inovação (Diretório de Grupos de Pesquisa/CNPq) - que se dedica à pesquisa da gestão, dos determinantes e das implicações do processo de inovação nas empresas industriais e de serviços brasileiras. Coordenador e professor responsável pelo curso de especialização "Gestão Estratégica da Inovação Tecnológica", do DPCT. Participou da equipe de concepção e redação do Livro Verde de Ciência, Tecnologia e Inovação (MCT 2001); foi um dos coordenadores do volume "Indicadores de Ciência, Tecnologia e Inovação do Estado de São Paulo - 2001"; foi consultor para o desenvolvimento metodológico das pesquisas estatísticas de inovação realizadas pela Fundação SEADE; realiza pesquisa sobre estratégias e atividades tecnológicas de multinacionais no Brasil e suas implicações para o desenvolvimento de competências nas empresas fornecedoreas locais. Lidera pesquisa sobre "Padrões de gestão estratégica da inovação tecnológica em empresas brasileiras", com apoio do CNPq. Vários artigos em periódicos referidos e capítulos de livro publicados, no Brasil e no exterior, sobre temas relacionados com inovação tecnológica.
Departamento de Política Científica e Tecnológica(DPCT)/IG/UNICAMP
Caixa Postal 6152
13.081-970
Campinas - SP
Telefones: (019) 3788-4557
(011) 3884-6197 (res)
Email: ruyqc@ige.unicamp.br

* Prêmio de melhor trabalho apresentado na área de Administração de C&T, Enanpad 2003

Technological Strategies of Transnational Corporations Affiliates in Brazil

Autoria: Eliane Franco, Ruy de Quadros Carvalho

Abstract

This paper presents an analysis of the technological efforts made by Transnational Corporations' (TNCs) affiliates in Brazil. Many studies have indicated that most TNCs concentrate their main technological activities in their home, developed countries. However, empirical investigation has shown TNCs affiliates in Brazil have presented a higher profile than local firms in terms of both innovative performance and R&D efforts. This study is an attempt to examine the technological efforts of TNCs affiliates in Brazil and their main determinants, considering the recent changes in TNCs' strategies of global organization of production and technological activities. The study is based on data analysis from 450 firms controlled by foreign capital operating in São Paulo State in 1996. The database was taken from the first PAEP – Pesquisa da Atividade Econômica Paulista –, which comprises not only economic indicators, but also includes an innovation survey, based on OECD guidelines. Using multivariate techniques we have identified distinct strategies of TNCs subsidiaries in regard to technological activities, which reflect different technological effort patterns. In addition, the article reveals that such diversity of technological strategies has been influenced by the size of firms, the industrial sector to which the firm belongs and the nationality of foreign capital, in this order.

Key-works: *technological strategies, transnational corporations, developing countries*

Resumo

Este trabalho apresenta uma análise sobre os esforços tecnológicos empreendidos por filiais de Corporações Transnacionais (TNCs) no Brasil. Vários estudos indicam que TNCs concentram suas principais atividades tecnológicas em seus países (desenvolvidos) de origem. Entretanto, pesquisas empíricas têm mostrado que no Brasil as filiais de TNCs vêm apresentando maior perfomance inovativa e esforço em P&D vis-à-vis as empresas locais. Este estudo pretende examinar os esforços tecnológicos de filiais de TNCs no Brasil e seus principais determinantes, considerando as mudanças recentes nas estratégias de produção e tecnológicas destas empresas no âmbito global. O estudo baseia-se na análise de 450 firmas com controle de capital estrangeiro em operação no Estado de São Paulo, em 1996. A base de dados foi extraída da primeira PAEP – Pesquisa da Atividade Econômica Paulista – que, além de informações econômicas, também contém questões relacionadas à inovação tecnológica, com base na metodologia da OCDE. Utilizando técnicas de análise multivariada foram identificadas estratégias tecnológicas distintas nas filiais de TNCs, que refletem diferentes padrões de esforço tecnológico. Além disso, os resultados sugerem que esta diversidade é influenciada pelos seguintes atributos: tamanho da firma, setor industrial a que ela pertence e nacionalidade do capital controlador, nessa ordem.

Palavras-chave: *estratégias tecnológicas, corporações transnacionais, países em desenvolvimento*

Introduction

This paper presents an analysis of the technological efforts made by Transnational Corporations' (TNCs) affiliates in Brazil. Many studies have indicated that most TNCs concentrate their main technological efforts in their home, developed countries. In home countries they have developed links with strong scientific and technological institutions; moreover, the most skilled researchers and production teams are located in developed countries. (DUNNING J., 1993; MOWERY D., 1999; KUMAR, N., 2001; CANTWELL J., 2001) On the other hand, most TNCs subsidiaries in developing countries are rather users of existing technologies than inventors of entirely new products and services. Indeed, with few exceptions, their technological efforts consist more of acquiring, adapting and improving technologies developed abroad rather than creating new technologies. Hence the TNCs affiliates in developing countries are more likely to transfer the results of innovation than transferring innovation capability (LALL, S., 1996), which can represent not an obstacle but a limitation for the deepening of local technological learning (ERBER F., 2000).

Yet, it is important to regard recent changes in TNCs' strategies of global organization of production and technological activities. As part of the increasing production specialization and integration of TNCs activities in global networks, they have been more inclined to decentralizing R&D activities in order to tap host countries' comparative advantages. (CANTWELL J. and MUDAMBI R., 2001) In this process, host countries with a minimum level of local capabilities, which allow them to provide complementary assets to TNCs (skills, infrastructure, services, supply networks) can benefit from the spillovers of foreign corporations' presence. (LALL S. 1996; 2000)

This research is an attempt to examine technological efforts of TNCs affiliates in Brazil – one of the largest receptors of Foreign Direct Investment among developing countries (UNCTAD, 2000) – and their main determinants. The empirical study is based on factor

analysis of indicators of different types of technological inputs (activities) of TNCs subsidiaries; such indicators were taken from an innovation survey database, which has been based on the OECD guidelines for innovation surveys (Oslo Manual). We have identified distinct behaviours or strategies of TNCs subsidiaries, in regard to technological activities, which reflect different technological effort patterns. In addition, we show that such diversity of technological strategies has been influenced by the size of firms, the industrial sector to which the firm belongs and the nationality of foreign capital.

The paper is organized as follows. In section 2 we present some empirical evidences and the theoretical analytical framework, which will give support to the hypothesis of the existence of different technological orientations in TNCs subsidiaries and the influence of firms' economic attributes – sector, firm-size and nationality of foreign capital – on the diversity of strategies. Section 3 discusses the methodology used to explore the database and the results of research, that is, the patterns of technological effort found and how the selected economic determinants can affect them in different ways. The closing section 4 outlines the paper's concluding remarks.

Technological efforts of TNCs affiliates in developing countries: empirical evidences and analytical framework

Empirical Evidences

Even though TNCs concentrate technological activities in developed countries, there is empirical evidence that TNC subsidiaries in some industrializing economies like Malaysia, Singapore, India and Brazil are raising their local technological efforts and innovation capabilities.

Multinationals in the **Malaysian** electronic industry, for instance, have been upgraded from simple to advanced, complex process and higher value-added products. (ISMAIL M., 1999). This has been achieved not merely by way of transferring technologies developed by

parent firm to subsidiaries, but particularly by transferring learning and skills through collaborative innovation projects with their parent or sister firms. (ARIFFIN N. and BELL M., 1999) However, this process has not been linear and homogeneous and depends on several factors, such as government policy, parent corporate nationality, subsidiary strategy and type of product manufactured. (op.cit., p.181)

In **Singapore**, the increasing R&D efforts made by TNC subsidiaries in the electronic industry have been carried out basically due to pro-active government policies related to supplying experienced and highly educated personnel working in government-owned institutes and labs. Through joint public-private collaboration, research institutions and their experienced staff have been the most important local asset motivating TNC subsidiaries to undertake technological activities, from exploratory and advanced product and process development to applied and sometimes even basic research. (AMSDEN A., 2001)

The availability of R&D personnel has also been pointed out as the main reason for TNC subsidiaries establishing R&D units in **India**, across all types of industries, from conventional (chemical, pesticides, fertilizers, pharmaceutical, engineering and branded consumer goods) to new technologies (electronics, biotechnology and solar energy) (Reddy 1997). Another important result of Reddy' s research was the identification of differences between both kinds of industries (conventional and high-tech) in terms of local strategic assets acquisition for increasing their technological capabilities. Regarding this point, "…new technologies TNCs have established more linkages with the local industry than the conventional technologies TNCs. On the other hand TNCs dealing with conventional technologies have more linkages with local academic system." (REDDY P., 1997, p.182) Therefore, the empirical results showed heterogeneity of technological behaviors in TNCs affiliates and, in this case, it has been heavily influenced by the type of local assets in the host country as well as the industrial sector and technological nature of product.

In **Brazil**, empirical studies have also called attention to the influence of capital ownership on firm's technological effort. They have suggested that, in spite of the fact that R&D effort made by firms in São Paulo (Brazil) is relatively weak compared to industrialized countries, the R&D intensity[i] in the firms wholly or partially controlled by foreign capital is substantially greater than that of firms wholly owned by Brazilians. (QUADROS R. et al, 2001 p.213, Costa and Queiroz 2002). In fact, the results have shown not only that foreign firms in Brazil have developed higher R&D effort vis-à-vis the wholly Brazilian owned firms, but also that the former are more likely to innovate, i.e., they present higher propensity to introduce new products/processes in the market, when compared to locally controlled firms. With respect to the latter point, the innovative performance differences between both groups of firms (Brazilian and foreign owned) are more expressive among the larger firms, particularly in the group with 500 employees or more. (op.cit., p.210)[ii] It suggests that size-firm and capital ownership have significant importance in the innovative performance and technological effort.

Moreover, QUADROS and QUEIROZ (2001) found different strategies within the group of TNCs subsidiaries of auto assemblers in Brazil and Argentina. They emphasized that "the type of product policy adopted by assemblers, particularly their approach to the globalisation of plataforms and models, has important consequences on the tendency for increasing or decreasing local design activities." (p.12) To put it in detail, whereas companies such as General Motors and Fiat have adopted a more intensive local effort in designing regional derivatives of their global platforms, Ford and Renault have conduced a more centralized strategy to globalization, which search for a truly global car.

Analytical Framework

In synthesis, the empirical evidence about technological activities in TNCs located in developing countries suggests these firms have accumulated innovative capability in different ways. In other words, the subsidiaries have shown a diversity of strategies oriented to innovation. Such strategies vary according to the emphasis TNCs subsidiaries place on distinct elements of technological efforts, from physical investment and informal engineering activities to expenditures on formal R&D. Furthermore, the way affiliates have carried out technological efforts depends on some firm's attributes – such as the ownership (or nationality) of foreign capital and size (or scale) of operation – and economic aspects on the aggregate level, specially the technological nature of the industrial sector to which the firm belongs.

Therefore, in order to investigate what kind of technological effort strategies can be found in affiliates located in Brazil and their relationships with corporation strategy, firm-size and sector, this study have used a particular database and statistical techniques for analyzing the results. The methodology will be presented in the next section.

Method and empirical results

The Sample and its economic representativeness

This study takes advantage of the PAEP database, which was produced by Foundation SEADE – Sistema Estadual de Análise de Dados.[iii] It is an economic survey, which was conducted among 10.600 industrial firms (with data referring to 1996) in the State of São Paulo (Brazil). The survey has also included innovation questions based on the Oslo Manual methodology, the main reference for developing international innovation surveys that are applied in member countries of OECD – Organization for Economic Co-operation and Development (OECD 1997)). For the purpose of our analysis, a sub-sample of the PAEP database was preliminarily selected. This has included the set of firms either wholly or

partially controlled by foreign capital, which will be named TNCs affiliates. The sub-sample comprises nearly 450 medium and large firms (with 100 or more employees) either wholly or partially controlled by foreign capital, which were operating in State of São Paulo in 1996.[iv]

The fact that the article draws on a database which is now considerably dated certainly raises doubts about how far ahead could the findings of research be extended. Yet, apart from the constraints imposed by the fact that at the time of research this was the only similar source of information available[v], there are good reasons to believe that such findings refer to structural features of firms, which do not change swiftly. Indeed, the year of 1996, which is the year of reference for data collected by the PAEP survey, was a year extremely important in terms of structural changes in Brazilian economy. Investment in the manufacturing industry increased, encouraged by internal stabilization, market liberalization, exchange rate appreciation and intensive FDI inflows.[vi] The latter contributed to the diffusion of new technologies and organizational methods in the manufacturing industry. Such firm restructuring translated into productivity rises, cost rationalization and expansion of profit margins. Since the restructuring process takes time to show results along supply chains, we assume the economy has been incorporating such changes until now, to a great extent. Moreover São Paulo state has also been the most representative region, not only in economic terms but also regarding to FDI participation, accounting for 70% of all TNCs affiliates in Brazil.

Despite the total number of firms controlled by foreign capital in the manufacturing industry in São Paulo (906) is much smaller than that of wholly Brazilian owned firms (40.527), they account for almost 40% of total industrial value-added in the state. Their significant economic participation can be seen in the largest sectors of Brazilian industry such as motor vehicles (72%), pharmaceuticals (65%), electronic and telecom (54%), electrical machinery (52%) and foods (49%). Moreover, the data of the sub-sample show that foreign

controlled firms' share in value-added increases in line with size group – the highest shares of firms with foreign participation are in the group of firms with 500 employees or more.

Identifying the PTEs

In order to identify different patterns or strategies of technological efforts in affiliates, five variables of technological inputs was selected in the database:

1) Royalties payments – that is, licensing expenses with patents, know-how, trademark and technical assistance –abroad;
2) Royalties payments in Brazil;
3) Investment in imported capital goods (machines and equipments);
4) Investment in Brazilian made capital goods;
5) Graduate employees engaged, full or part time, in internal R&D activities.

Variables **1** and **2** indicate the effort made by the firm in purchasing "codified information or disembodied technology", while variables **3** and **4** are a proxy of the effort made in purchasing "capital goods or embodied technology". (HAQUE I. et al, 1995; p.72) In other words, variables 1/2 and 3/4 express distinct kinds of efforts of firms in acquiring externally existing technologies as they are differenced on the bases of the age, complexity and packaging of technologies. (AGGARWAL A., 2002; p.124) In general terms, the non-formal technology transfer by acquisition of capital goods has cost advantages comparing to vis-à-vis disembodied technology acquisition, once specially contracts of patents and know-how licensing involve a more complex technology and tacit knowledge. (KIM et el, 1999; p.95)

Variable **5** represents the endogenous effort of the firm in technological learning by expenses in highly-skilled human capital. It covers systematic R&D efforts, which are usually developed by large companies in R&D laboratories, as well occasional product and process

engineering activities mostly made by smaller firms. Moreover, this variable could be considered a proxy for tacit technological learning, expressed in skills, experience and no-codified knowledge acquired by human resources in their linkages intra and inter-firms and with other institutions. (BELL M. and PAVITT K., 1993; 1995; FIGUEIREDO P., 2002; CANTWELL J., 2001)

In order to achieve a better understanding of the structure of the 5 variables above and explain the pattern of interrelationships between them, Factor Analysis was used. This is a technique in which multiple variables, each related to all other, can be simultaneously considered in attempt to summarize them in a smaller set of components (factors) with a minimum loss of information. (HAIR et al, 1998)

In addition, because of the large standard deviation in the distribution of the 5 variables – due to the occurrence of large number of firms with values near to "zero", on the one hand, and a small number of firms with high values, on the other – normalization were required. Then, the original variables of expenses in royalties (1 and 2) and investment in capital goods (3 and 4) were weighted by the net revenue[vii] of the firm, whereas variable 5 – personnel engaged in local R&D activities – was weighted by the total employment of the firm. The weights cover two strategies. One is analytical, providing a proxy for the intensity of expenses with embodied and disembodied technology (based on variables 1 to 4) and intensity of local and internal technological effort (based on variable 5). The second is statistical, reducing the dispersion coefficients of the variables and preserving the relation between them.

After the 5 variables have been weighted, Factor Analysis was applied. From the simultaneous correlation between the 5 variables 3 main factors were produced:

Table 1
Factor analysis of technological efforts variables in sample of firms controlled by foreign capital[1]
(Varimax Rotation/Principal Component Extraction)

Variables	Factor Loadings[2]

	FACTOR 1	FACTOR 2	FACTOR 3
Royalties payments (abroad)	**0,854**	0,032	-0,032
Royalties payments (Brazil)	**0,851**	-0,059	0,009
Investments in imported capital goods	-0,015	0,141	**0,859**
Investments in Brazilian made capital goods	-0,028	**0,839**	0,19
Graduated employees engaged in R&D	0,009	**0,586**	**-0,536**
% Variance (total=71,8)	29,3	22,0	20,5

Source: PAEP/SEADE, 1996
(1) Include only the foreign capital firms with 100 or more employees which have developed systematic or occasional R&D activities (454 cases)
(2) Indicate the degree of correlation between the variable and the factor.

The result of Factor Analysis (Table 1) shows 3 factors, which represent **3 PTEs – Patterns of Technological Effort –** found in the sample of affiliates:

- PTE 1: composed by high positive coefficient of correlation in royalties payments, abroad and in Brazil, expresses a pattern of **technological effort based on licensing or disembodied technology**;
- PTE 2: derived from positive correlations between investment in national machines/equipment and staff employed in R&D, indicates a pattern of **technological effort oriented to domestic assets acquisition** ;
- PTE 3: identified by the reverse correlation between acquisition of imported machines/equipments and staff in R&D, indicates a pattern of **technological effort oriented to imported capital goods acquisition**.

Based on the three main components (or factors) of correlations between the variables inserted in FactorAnalysis, all firms have received a "score" for the PTE identified. Such scores represent the level of correlation of each factor (or PTE) for each firm. Since there is a coefficient of correlation (or score) incident in each firm, the PTEs are not excluding between them. In other words, the PTEs scores are not constructed to compose groups or clusters of firms, but to indicate what is the predominant score (and therefore, the PTE) in each firm. For example, if firm 'X' receives 4.26 score in PTE1, 0.42 in PTE2 and 0.30 in PTE3[viii], the coefficients indicate that firm X is more engaged to carry out technological effort based on

licensing than others strategies (imported capital goods acquisition or domestic assets oriented) and so on.

After the PTEs were composed for each firm in the sample of affiliates, an aggregate analysis will test the influence of size, sector and nationality of the foreign controller on the PTEs of foreign-controlled firms. This has been done by using the Answer Tree technique. It is a classification system, which selects the best predictors for a target variables based on summary statistic (F-statistic).ix Simultaneously, it creates groups or clusters (named "nodes"), which are the best sub-sets of cases within each selected predictor. The exogenous variables (or predictors) selected to explain the PTEs (dependent variables) were the following:

- Number of employees, which will indicate the firm SIZE;
- Two digital level of CNAE – Classificação Nacional de Atividades Industriais, based on ISIC (rev-3) – which will represent the industrial activity SECTOR of the firm;
- Country of foreign controller or partner, which will indicate the NATIONALITY of affiliates.

The Answer Tree technique has some advantages for analyzing the sample of affiliates and the influence of selected determinants on the PTEs. Firstly, the segmentation can identify witch group of sectors, firm-size or nationality of capital is more associated with the highest scores of PTEs. The results should operate as an accurate policy instrument, since focus on aggregate of enterprises, which are more oriented to undertake a specific technological strategy. Secondly, it can combine and analyze simultaneously a diversity of explanatory variables, including multiple-category nonmetric variables, like groups of industries (19 categories).[x]

Empirical results

With reference to the segmentation tree for PTE 1 (Figure 1), all the exogenous variables (size, sector and nationality) have been elected as significant to explain differences in licensing-oriented strategy in affiliates.

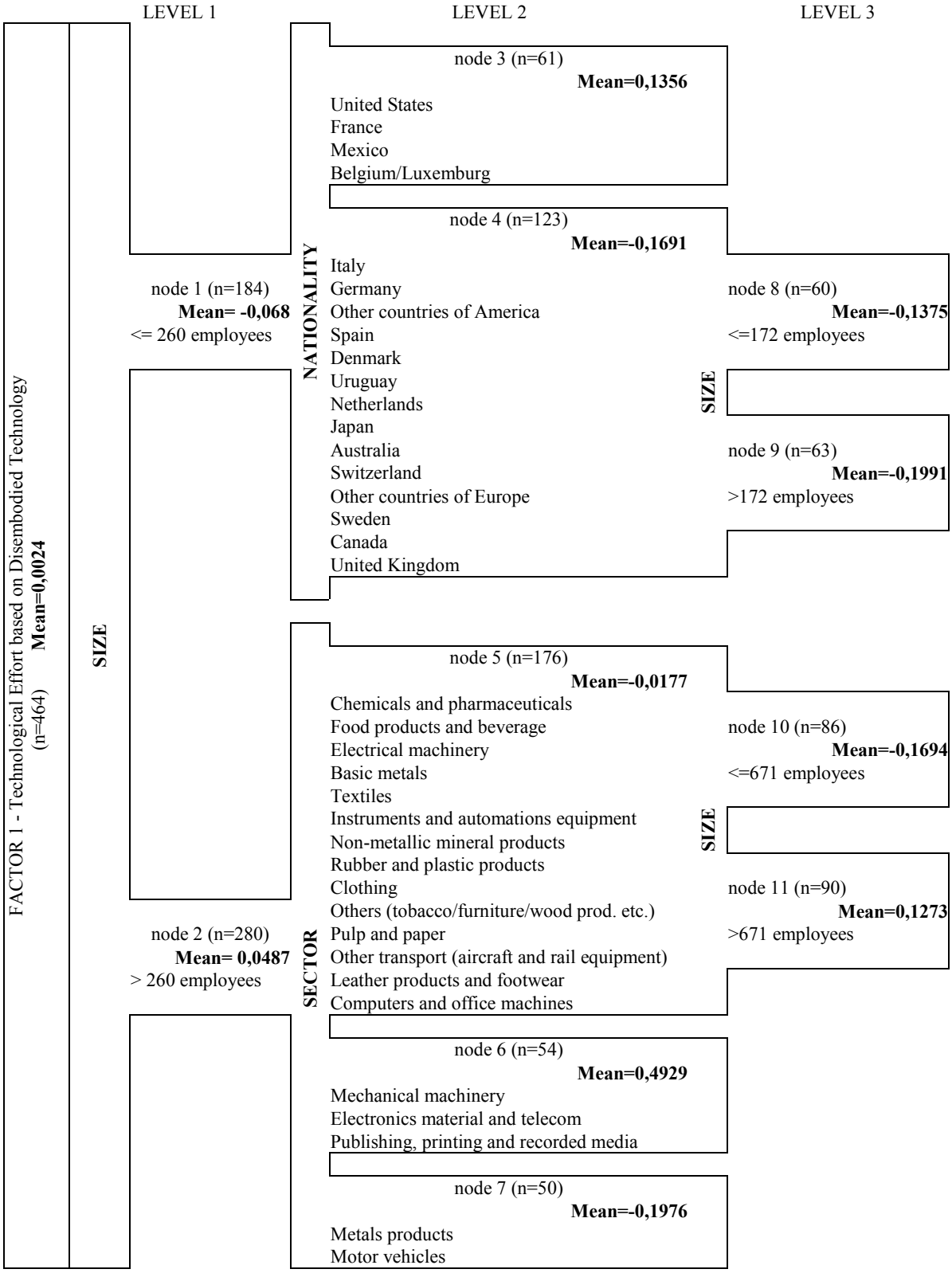
However, Figure 1 shows that the main predictor for PTE 1 was firm size. The positive scores suggests that foreign firms with more than 260 employees, are more likely to carry out expenses in disembodied technology (local or foreign). On the other hand, the negative scores indicate that smaller firms are more engaged in acquiring one of them. This is a trend more stressed in the group of intermediate firms, with more than 172 employees, from a diversity of countries (node 9), as well as in two sectors – metal products and motor vehicles – of firms with more than 260 employees (node 7). Similar score can also be found in the group of firms with 671 employees or less from the most part of manufacturing sectors (node 10).

In contrast, into the group of firms with more than 260 employees it can be seen three sectors – **mechanical machinery**, **electronics material and telecom** and **publishing, printing and recorded media** – accounted for the highest positive node (6) and, because of this, they were elected as the most representative group of pattern of technological effort based on disembodied technology (PTE 1).

This result is consistent with the nature of these industries, which require strong volume of process engineering to increase their productivity levels and innovative capacity. In fact, process technology seems to be transferred on licensing basis more than product technologies. (KUMAR N., 1997) Based on this achievement, it can be inferred that capital-intensive industries tend to rely heavily on licensing and technical assistance than other industries.

Figure 1

Answer Tree segmentation for PTE 1 (Pattern of Technological Effort based on Disembodied Technology)

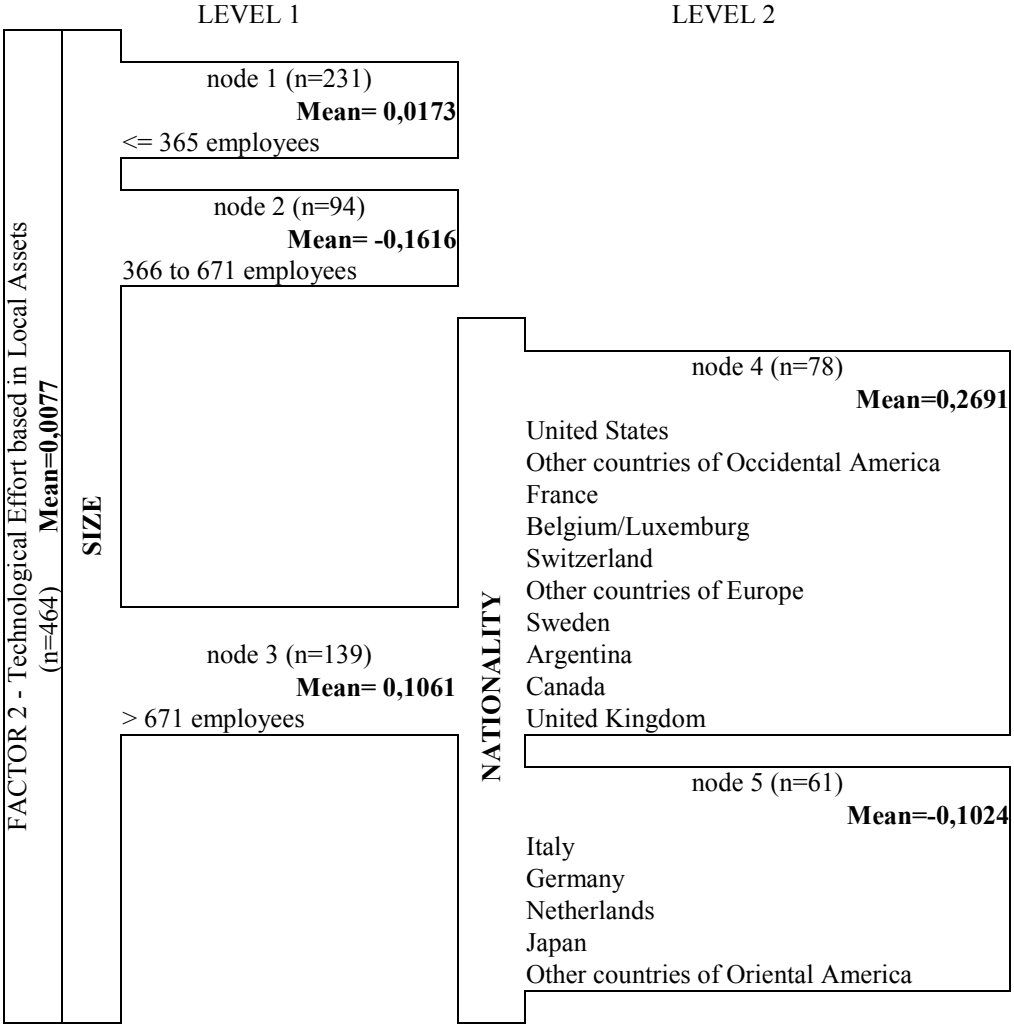


Source: PAEP/SEADE, 1996

Regarding PTE 2 (Figure 2), i.e., the pattern of technological effort based on local assets, firm size is also the first predictor ranked. Significant negative score is shown in the intermediate size firms (node 2) indicating that this group has basically practiced one of the strategies, which compose the PTE 2 (national capital goods acquisition or indigenous R&D). On the other hand, the positive score in node 3 suggests that only in the group of the **largest firms** (more than 671 employees) the technological behavior based in domestic innovative effort is more evident. Further, inside that group significant differences are shown by Answer Tree: largest firms with foreign controlled capital from US, France, Belgium/Luxemburg, Switzerland, Sweden, Argentine, Canada and UK have the highest scores (node 4). Curiously, none industrial sector has appeared in the tree segmentation. It suggests that instead of type of industry, the **scale of operation** – expressed by the large size of firms – was the main determinant to explain technological strategy in TNCs affiliates based on local technological assets seeking.

Figure 2

Answer Tree segmentation for the PTE 2 (Pattern of Technological Effort based on Local Assets)



Source: PAEP/SEADE, 1996

However, since the identification of sector is a crucial indicator for policy making, specially regarding the technological behavior of multinationals based on local assets, a simple crossings between mean score of PTE 2 and industrial sectors was carried out. The ranking correlation discloses substantial differences of PTE 2 across industries (Table 2). However, because of the greater statistical significance of size firm in Answer Tree aggregate analysis (Figure 2), the sector effect was annulated. As can be seen in Table 2, five industries have presented the highest positive scores: instruments and automation equipment, basic metals, computers and office machines, electronics material and telecom and aircraft and rail

equipment. Excepting basic metal, the other four sectors are considered "science-based", according to Pavitt's classification (PAVITT K., 1984; *apud* BELL M. and PAVITT K., 1993), and heavily dependent on knowledge and skills to develop technological learning and innovation capacity.

Conversely, the higher negative Factor 2 scores in textiles, publishing, printing and record media, clothing and other industries (tobacco, furniture, wood products) should be attributed to their greater propensity in acquiring national capital goods and lower effort in R&D activities. In other words, according to the same taxonomy, sectors like textiles, clothing, furniture, wood products are characterized as "supplier-dominate" and heavily dependent on suppliers of machinery and other production inputs in order to improve and modified products and production methods. (op.cit., p.178)

Table 2
Mean scores of PTE 2 (Technological Effort based in local assets) in foreign firms (1), by industrial sectors

Sector	PTE 2 (mean score)
Instruments and automations equipment	**0,759**
Basic metals	**0,487**
Computers and office machines	**0,429**
Electronics material and telecom	**0,387**
Other transport (aircraft and rail equipment)	**0,317**
Motor vehicles	0,087
Chemicals and pharmaceuticals	0,066
Electrical machinery	0,041
Pulp and paper	0,039
Mechanical machinery	0,025
Food products and beverage	-0,061
Non-metallic mineral products	-0,080
Rubber and plastic products	-0,094
Metals products	-0,149
Others (tobacco/furniture/wood products etc.)	**-0,346**
Clothing	**-0,431**
Leather products and footwear	**-0,617**
Publishing, printing and recorded media	**-0,635**
Textiles	**-0,646**

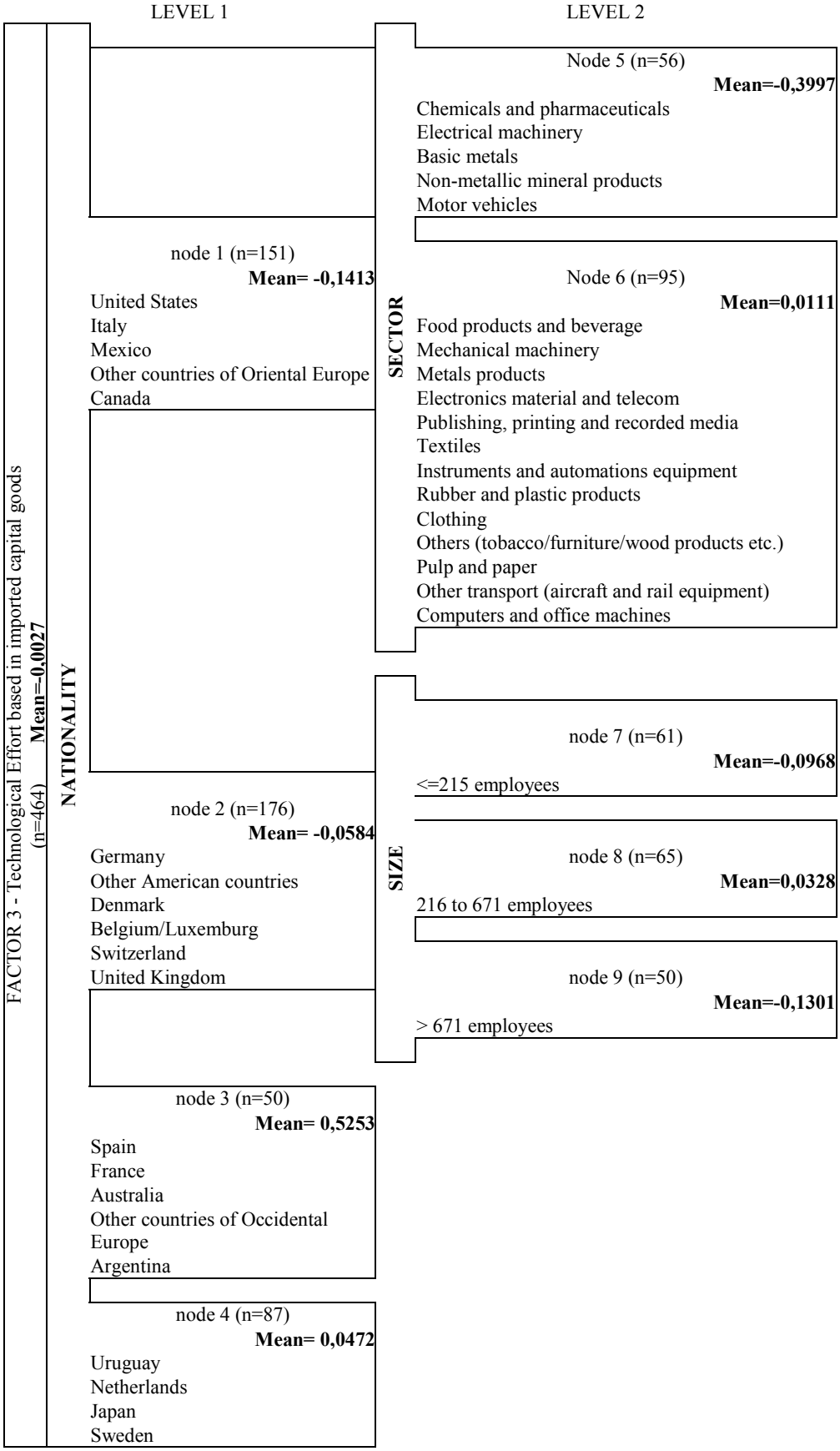
Source: PAEP/SEADE, 1996
(1) Only firms controlled by foreign capital, with 100 or more employees, which carried out systematic or non-systematic internal R&D activity

In contrast to the former Answer Tree configurations, where the firm size was considered the main determinant to explain different behaviors in PTE 1 and PTE 2, the first predictor for PTE 3 was the **nationality** variable (Figure 3). It suggests that foreign firms with diverse sizes and sectors used to develop technical changes based in imported capital goods. Such result is totally in line with the general strategy of TNCs, i.e., they have taken advantage of trade liberalization to carry out technological transfer based on the importation of equipment.

In spite of this general trend, the highest positive score showed in "node 3" indicates that the affiliates from **Spain**, **France**, **Australian** and **Argentina** are more likely to import capital goods than the affiliates from other countries. Yet, the high positive coefficient may indicate the contrary: that this group has been increasing the local technological capability based on internal R&D activities. However, a more detailed exam of the determinants of PTE 3 showed the high positive correlation in node 3 is more related to equipment import rather than R&D effort.

It has also called attention the high negative score in the "node 5" (Figure 3), which indicates a reverse correlation between the imported technology and R&D activity in a specific group of sectors and nationality of multinationals. In essence, their capital came from US, Italy, Mexico or Canada and they are concentrated in the **chemical**, **electric machinery**, **basic metals**, **non-metallic minerals** and **motor vehicles sectors**. This result may be suggesting two different technological strategies within this group of firms: on the one hand, they may be investing proportionally more in foreign capital goods rather than in R&D personnel, a situation that puts them as more representative of PTE 3; on the other hand, this group may be undertaking proportionally more R&D technological effort rather than importing embodied technology, condition that would put them as more representative of PTE2.

Figure 3
Answer Tree segmentation for the PTE 3 (Pattern of Technological Effort based on Imported Capital Goods)



Source: PAEP/SEADE, 1996

Therefore, in order to check what is the predominant technological pattern in this group of affiliates, it was verified the distribution of graduated employees in R&D activities, as well as the investment in national and foreign capital goods, by industrial sectors in this group of firms (of the above mentioned countries).

Table 3
Distribution of Staff in R&D, investments in national and foreign capital goods in firms controlled by foreign capital (1), by industrial sectors

Industrial Sectors	% Staff in R&D	% Investment in National Capital Good	% Investment in Imported Capital Goods
Food products and beverage	2,9	19,5	56,5
Textiles	0,0	0,0	0,0
Clothing	0,0	0,0	0,0
Pulp and paper	0,6	9,7	9,8
Publishing, printing and recorded media	0,1	0,0	0,0
Chemicals and pharmaceuticals	**19,1**	**10,9**	**6,0**
Rubber and plastic products	5,1	6,3	4,1
Non-metallic mineral products	**1,6**	**0,9**	**0,3**
Basic metals	**10,1**	**9,0**	**2,0**
Metals products	0,8	0,4	0,6
Mechanical machinery	5,1	5,1	4,6
Computers and office machines	0,6	0,0	0,0
Electrical machinery	**1,7**	**0,5**	**0,1**
Electronics material and telecom	0,6	3,1	7,2
Instruments and automations equipment	2,9	1,1	0,3
Motor vehicles	**48,8**	**33,4**	**7,9**
Other transport (aircraft and rail equipment)	0,1	0,0	0,6
Others (tobacco/furniture/wood products etc.)	0,0	0,1	0,0
Total	100,0	100,0	100,0

Source: PAEP/SEADE
(1) Only firms with 100 or more employees, whose controller foreign capital are from US, Italy, Mexico, Canada or other countries of Oriental Europe

Table 3 shows the distribution of staff allocated in R&D activities and investment in national and imported capital goods, by sector, only for the set of affiliates of "node 1" of Figure 3. The results suggest that the high negative score of PTE 3 found in **chemicals**, **electrical machinery**, **basic metals**, **non-metallic minerals** and **motor vehicles** (from the mentioned countries)(node 5) is more related to their R&D effort instead the imported technology acquisition strategy. The same industries have also presented significant rates in

national capital acquisition, a situation which put them in the group of industries more engaged to adopt a domestic assets seeking strategy (PTE2).

Further, the inverse technological pattern can be seen in **food and beverage** industry in the same group of affiliates (Table 5). This sector shows an effort rate in imported disembodied technology (56,5%) extremely superior comparing to their investments in R&D activities (2,9%). It suggests that food and beverage foreign companies, despite have been undertaking efforts in adaptation of products – including to building regional R&D centres in state of São Paulo (FRANCO E., 1998; QUADROS R. et al, 2001) –, remain adopting technology transfer based on imports of equipment as the predominant technological strategy in Brazil.

Concluding remarks

The statistical results showed a diversity of patterns of technological efforts (PTEs) among TNC subsidiaries in Brazil. To put in detail, we could identify tree different strategies of technological inputs seeking for developing innovation capacity in these firms: *licensing seeking* (PTE 1), *domestic assets – R&D in-house and local capital good suppliers –seeking* (PTE 2) and *imported capital goods seeking* (PTE 3). Further, the empirical findings have shown that each technological orientation has been affected by firm-size, sector and firm-nationality, in different ways, with a clear predominance of firm size as the attribute with greater explanatory influence. For affiliates which are more engaged in PTE 1 and PTE 2 firm-size and, in turn, production scale matters, specially in the largest firms belonging to sectors like, on the one hand, mechanical machinery and electronicas material and telecom equipment (PTE 1) and, on the other hand, aircraft and basic-metal (PTE 2). On the other hand, for firms more oriented to adopt PTE 3, nationality of their foreign capital (that is, the corporation and firm strategy) was the most important determinant to explain significant

variations in this technological behavior, rather than production scale. The main results of this study can be summarized in Figure 4, bellow:

Figure 4
Synthesis board of the main representative groups of TNCs affiliates for each PTEs

PTEs	Construction	Main Determinant	Main Representative Industries/firm-size/nationality
PTE 1 (Technological Effort based on Disembodied Technology)	Positive correlation between national and imported royalties expenses	SIZE	Mechanical machinery/Electronics material and telecom/Publishing, printing and recorded media (260 employees or more)
PTE 2 (Technological Effort based on Domestic/Internal Assets)	Positive correlation between national capital goods and R&D	SIZE	- Aircraft/Basic Metal (more than 679 employees); - Instruments and automation equipments/Computers and office machines/Electronics material and telecom (100 employees or more); - Motor Vehicles/Chemical and pharmaceutical/Basic Metals (100 employees or more; from US, Italy, Mexico or Canada)
PTE 3 (Technological Effort based on Imported Capital Goods)	Negative correlation between R&D and imported capital goods	NATIONALITY	Chemical and pharmaceutical (from Spain, France, Australia or Argentina)/ Food and beverage (from US, Italy, Mexico or Canada)

Source: PAEP/SEADE, 1996

Regarding the PTE 1, Figure 4 shows that the industries appointed as most typical of such pattern were mechanical machinery, electronic material and telecom and publishing, printing and record media. Once this group is composed not only by large but also intermediate firms (with more than 260 employees), it could be inferred that this strategy is more affected by sector and size rather than nationality of foreign capital.

Moreover, the empirical results showed that the affiliates technological behaviour based in local assets (PTE 2) is extremely concentrated in the largest companies (with more than 670 employees). Aircraft equipment and basic metals were the most representative industries into

this group, suggesting these sectors (specially the former) is largely scale dependent to undertake and deep their technological capabilities.

Further, disregarding the size influence, industries like instruments and automation equipments, computers and office machines and electronics material and telecom could also be included into the PTE 2 group. Such industries are technology-intensive. Hence, their technological behaviour is more affected by other competitors and velocity they must introduce new products in market rather than by the scale advantages. To put in other terms, they demand fast renovation of products, efficiency productive and deeper efforts in order to increase their innovation capacity and competitiveness in the global market.

Since motor vehicles (specially), chemical and pharmaceutical and basic metals showed the highest inverse correlation between imported technology and R&D activities, they were also included as representative of PTE 2, i.e., group of firms which have undertaken technological strategies based in domestic assets. However, such behaviour just can be attributed only for multinational with foreign capital from US, Italy, Mexico and Canada.

To summarize, the first general important conclusion was the high concentration of any kind of technological efforts in a few groups of industrial firms in State of São Paulo and, consequently, in all Brazilian economy. Yet, that condensed technological effort is a produce of two major structural features of the Brazilian manufacturing industry, that is, the continuing growth and market concentration of large TNCs, which have increased their dominance and scale advantages in the most dynamic industrial sectors (Lall 1996) and the weakness of national firms in undertaken technological activities. (Quadros et al 2001)

Secondly, it is not by change that the absolute size of the affiliates was elected the main determinant explanatory attribute for R&D-strategy. This relation was also suggested in more recent aggregate studies. For instance, analysing the technological behaviour in 85 foreign

industrial firms operating in Brazil in 1998[xi], MATESCO (2000) found that firm size (measured by sales turnover) has exerted strong influence on the quantity and quality of expenses with innovation and technological capacity. To put in detail, since larger firms have higher capacity for investment and accumulation, they are able to using internal assets (high skill personal, R&D labs, marketing, etc.) and external networks for diversifying their product lines. As a consequence, the scale advantages strengthen entrance barriers for new competitors and market structure becomes more concentrated. Since internal R&D activities involve high costs and risks, larger firms have more conditions to finance this activity systematically.

Overall, the main propose of this study was to identify patterns relating to how foreign firms looking for technologies abroad or develop them internally in order to increase their local innovative capacity. We also associate the technological strategies found with some specific driving forces (size, sector and nationality). Once this is an aggregate study, we believe the empirical results can contribute for new designs of industrial and technological policies specially oriented to multinationals and their specific demands for technologies. This paper hopes to have contributed to strengthening the growing perception, amongst Brazilian policy makers, that industrial policy should not consider TNCs and their affiliates as a monolithic bloc. We argue that a better understanding about TNCs technological strategies could help policy makers to develop instruments for intensifying linkages between foreign affiliates and local suppliers (firms or institutions) of more value-added and technological products, components or services. That synergy could generate a diversity of spill-overs for the whole economy benefiting both sides, foreign and local investors and the national competitiveness.

References

AGGARWAL, A. (2002). "Liberalization, multinational enterprises and export performance: evidence from Indian manufacturing", **The Jornal of Development Studies**, Vol.38, No.3, February 2002, pp.119-137

AMSDEN, A., TSCHANG T. e GOTO, A. (2001) "Do foreign companies conduct R&D in developing courtiers?: a new approach to analyzing the level of R&D, with an analysis of Singapore", **ADB Institute Working Paper**, cod. 14 March.

ARIFFIN, N. e BELL, M. (1999). Firms, politics and political Economy, In: Yomo, K. S., Felker, G. & Rasiah, R. (eds.), **Industrial Technology Development in Malaysia**, London and New York.

COSTA, I. And QUEIROZ, S. Foreign direct investment and technological capabilities in Brazilian industry, **Research Policy**, 31, 2002.

BELL, M. and PAVITT (1993). Technological accumulation and industrial growth: contrasts between developed and developing countries, **Industrial and Corporate Change**, Vol.2, No.2, pp.157-210

CANTWELL, J. (2001). "Innovation and information technology in MNE", In: **The Oxford handbook of International Business**, RUGMAN, T. and BREWER, Oxford University Press

CANTWELL, J. and MUDAMBI, R. (2001). **MNE competence-creating subsidiary mandates: an empirical investigation**, University of Reading, UK, *draft*

DUNNING, J.H. (1993). "MNEs, Technology and Innovatory Capacity: A Host Country Perspective", In: **Multinational Enterprises and the Global Economy**, Wokingham, United Kingdom and Reading, Mass.: Addison Wesley, 1993.

ERBER, F.S. (2000) "O padrão de desenvolvimento industrial e tecnológico e o futuro da indústria brasileira", IE/**Universidade Federal do Rio de Janeiro**, *draft*.

FIGUEIREDO, P. (2002). "Does technological learning pay off? Inter-firms differences in technological capability-accumulation paths and operational performance improvement". **Research Policy**, n.31, pp.73-94

FRANCO, E. (1998) **Novas práticas organizacionais, inovação e competitividade no mercado global: um estudo sobre uma empresa transnacional do setor de bens de consumo**, Campinas, UNICAMP (Dissestação de Mestrado)

HAIR et al (1998). **Multivariate data analysis**, fifth edition, Prentice Hall, New Jersey.

HAQUE I. et al (1995). "Trade, technology and international competitiveness", **Economic Development Institute of the World Bank**, Washington

ISMAIL, M.N. (1999). "Foreign firms and national technological upgrading: the eletronics industry in Malaysia", In: JOMO K.S., GREG FELDER and RAJAH RASIAH (eds.), **Industrial Technology Development in Malaysia**, London and New York

KIM Y., KIM L. and LEE J. (1999). "Innovation strategy of local pharmaceutical firms in Korea: a multivariate analysis, Technology Analysis and Strategic Management", Vol.1, No.1, 1989, In: KIM L. (org.), **Learning and Innovation in Economic Development**, Great Britan, Bodmim, pp.93-108.

KUMAR, N. (1997). "Technology generation and technology transfer in the world economy: recent trends and implications for developing countries", **INTECH**, Discussion Paper Series, September, no.9702

KUMAR, N. (2001). "Determinants of location of overseas R&D activity of multinational enterprises: the case of US and Japanese corporations", **Research Policy**, 30, 159-174

LALL, S. (1996). "Transnational corporations and economic development", In: **Transnational Corporations and World Development**, UNCTAD, Division on Transnational Corporations and Investment, London, pp. 44-72

LALL, S. (2000). "FDI and development: policy and research issues in the emerging context". **QEH Working Paper Series**, n.43, June 2000

MATESCO, V. (2000). "Comportamento tecnológico das empresas transnacionais em operação no Brasil", **SOBEET**, março.

MOWERY, D. (1999). Technological Innovation in a Multipolar System: Analysis and Implications for US Policy, paper presented in **Third International Conference in Innovation and Science Policy**, Austin, August-September

OECD (1997). "Oslo Manual – the measurement of scientific and technological activities", Eurostat, European Commission

PINHEIRO, A.C., GIAMBIAGI, F. and GOSTKORZEWICZ, J. (1999). "O desempenho macroeconômico do Brasil nos anos", cap.1, In: GIAMBIAGI, F. e MOREIRA, M. (orgs.), **A economia brasileira nos anos 90**, BNDES/DEPEC, Rio de Janeiro, 1a. edição

QUADROS, R. et al (2001). "Technological innovation in Brazilian industry: an assessment based on the São Paulo innovation survey", **International Journal** of **Technological Forecasting and Social Change**, nº 67, pp. 203-219, New York, 2001.

REDDY, P. (1997). "New Trends in globalization of corporate R&D and implications for innovation capability in host countries: a survey from India", **World Development**, vol.25, nº 11, pp. 1821-1837

UNCTAD (2000). **World Investment Report – cross-border, mergers and acquisitions and development** (overview), New York and Geneva, 2000.

---

[i] As measured by the ratio of the number of graduate staff employed in R&D to the total employment of firms engaged in R&D activities.

[ii] Costa and Queiroz (2002), drawing on results of the same database, arrived to similar conclusions.

[iii] Fundação SEADE is the government agency for the production of statistics in the state of São Paulo.

[iv] The set of smaller firms controlled by foreign capital (5 to 99 employees) will not be analyzed in this study because the variable which represents internal Research and Development (R&D) activity – one of the information used to compose the indicator of technological effort in affiliates – is available only for enterprises with 100 or more employees. Since the small affiliates have accounted for only 7% of value-added within this group of firm-size, the reduction of the number of affiliates in the sub-sample could be done with a minimum loss in terms of economic weight.

[v] Only in the middle of 2003 IBGE has started to release the results of PINTEC 2000, a database also constituted by information from na innovation survey.

[vi] In fact, comparing with earlier period of 'Plano Real', FDI inflows drop from US$ 1 billion per year between 1981-1994, to US$ 2 billion in 1994, US$ 9 billion in 1996 and US$ 26 billion in 1998 (considering US$ 6 billion from privatizations). (BACEN database, in: PINHEIRO, GIAMBIAGI and GOSTKORZEWICZ, 1999, p.35)

[vii] The best weight in this case should be the total cost of the firm with technology acquisition, but such information was not provided by the PAEP.

[viii] The respective scores were extracted from the original database of affiliates.

[ix] It consists of the mean square between groups by the mean square within group.

[x] Despite of multiple regression technique can reflect precise causality relations comparing to answer tree descriptive technique, the former is more complex the more categories "dummy" variables have in the model.

[xi] The sample of TNC affiliates comes from a research-panel conducted by SOBEET – Sociedade Brasileira de Estudos de Empresas Transnacionais e da Globalização Econômica.