Transnational corporations and patenting activities in Brazil: data description and statistical tests about the relative internalization of technological activities*

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RESUMO

Este artigo apresenta dados e testes estatísticos sobre um índice de "internalização relativa de atividades tecnológicas" (IRAT) de empresas transnacionais atuantes no Brasil. Esse indicador é calculado a partir das patentes de não-residentes das matrizes das multinacionais depositadas junto ao *Instituto Nacional de Propriedade Industrial* (INPI) e das patentes de residentes de suas subsidiárias (para o período de 1988 e 1996). Este artigo descreve as maiores empresas transnacionais em termos de patentes de não-residentes. Os dados são trabalhados para investigar a correlação entre o índice IRAT de cada corporação e características como: 1) setor industrial; 2) classe tecnológica; 3) nacionalidade; 4) tamanho. As relações estatísticas são calculadas utilizando a "análise do componente principal" e análise de regressão.

Palavras-chave: internalização de atividades tecnológicas, transnacionais, testes estatísticos.

ABSTRACT

This paper presents data and statistical tests about an index of "relative internalization of technological activities" (RITA, henceforth) of transnational corporations located in Brazil. This indicator is the ratio between the non-resident patents applied by the headquarters of the transnational corporations to the *Instituto Nacional de Propriedade Industrial* (INPI) and the resident patents applied by their subsidiaries. This paper describes the leading transnational corporations in non-resident patenting. The data are processed to investigate the correlation between the RITA indexes of each corporation and their characteristics such as 1) industrial sector; 2) technological class; 3) nationality; and 4) size. These statistical relations are calculated using Principal component analysis and regression analysis.

Key words: internalization of technological activities, transnationals, statistical tests.

JEL Classification: 030, F23, C10.

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* Support from CNPq and Fapemig is acknowledged. The authors acknowledge the research assistance from Ana Paula Verona, Márcia Rapini, Regina Fernandes, and Leandro Silva (FACE-UFMG) and would like to thank one anonymous referee for helpful comments and suggestions. The usual disclaimer holds.

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Recebido em agosto de 2000. Aceito em maio de 2001.

Introduction

The objective of this paper is to provide a tool for the evaluation of the contribution of foreign corporations to local technological activities using patent statistics.

This paper suggests an indicator for the evaluation of the technological activities of transnational corporations in Less-developed countries. This indicator, an index of "relative internalization of technological activities" (RITA, henceforth), is the ratio between the non-resident patents applied by the headquarters of the transnational corporations to the Brazilian Patent Office (*Instituto Nacional de Propriedade Industrial*, INPI henceforth) and the resident patents applied by their subsidiaries.

A methodological remark is important here: the contributions of transnational corporations to the international transfer of technology (Dunning, 1988; UNCTAD, 1998) certainly are greater than the patent statistics show. As Thomson & Nelson (1997) point, the foreign patenting follows (and are followed) by other means of technology transfer (equipment, training, flows of specialized workers, etc). The general limitations of patent statistics are well-known in the literature. (Griliches, 1990)

This paper is organized in five sections.

The first section surveys the literature about the internationalization of R&D by transnationals. The second section discusses why an index like RITA is necessary for the evaluation of transnationals operating in less-developed countries like Brazil. The third section describes the leading transnational corporations in non-resident patenting. Basic statistics are described and the RITA indexes for each corporation are calculated and presented. The fourth section performs statistical tests using these RITA indexes. These data are processed to investigate the correlation between the RITA indexes of each corporation and their characteristics such as 1) industrial sector; 2) technological class; 3) nationality; and 4) size. These statistical relations are calculated using Principal component analysis. The fifth section concludes this paper.

I The internationalization of R&D among developed countries

The literature about transnational and international distribution of innovative activities might be divided into two phases.

A first phase is surveyed by Caves (1996), including papers and investigations made until the beginning of the 1990s. These studies stress the strong correlation between R&D intensity

and multinationality (p. 163) and the lack of incentives for the corporations' headquarters to decentralize their production of innovative goods (p. 33).

A second phase begins in the 1990s, when the literature deals with the increasing internationalization of the transnationals' R&D activities. Examples of this line of research are the OECD's documents (OECD, 1998, 1999a, 1999b) and the special issues of the *Cambridge Journal of Economics* (Special Issue on Technology and Innovation, February 1995) and of the *Research Policy* (Internationalization of Industrial R&D, March 1999).

The degree of internationalization of R&D activities is described by these studies. Investigating 15 OECD countries, a study points that multinationals' subsidiaries represents 12% of their R&D expenditures. (OECD, 1999b, p. 11) In Europe, the contribution of transnationals' subsidiaries ranges from 60% in Ireland to 10% in Finland. In the United States, the multinationals' subsidiaries represent 10% of the national R&D expenditures, while in Japan these figures are lower, representing 2% of the national R&D. (OECD, 1999b) In some cases, the R&D intensity of foreign firms is greater than their national rivals, as shown by the pharmaceutical and chemical firms in the United States (p. 39); the food, beverage and tobacco firms in Japan (p. 49); "other industries" in Germany (p.53); and the manufacturing sector in the United Kingdom (p. 59).

For the developing countries, this literature has an important limitation: it is deeply focused in the developed economies. Focusing the internationalization of R&D among the developed countries, this literature describes the increasing sophistication of international networks and their growing interaction. Cantwell & Jane (1999), for instance, investigate the formation of technological systems internationally integrated and the strategies of geographical distribution of innovative activities. Patel & Varga (1999) examine corporate patterns of technological internationalization.

These studies evaluate interactions among countries with high technological capabilities. As these countries have mature systems of innovation (Albuquerque, 1999a), they share a common technological background and these studies describe relationships among equals. These studies use statistics adequate for these relationships among equals. For the evaluation of developing economies something different is necessary.

II Developing economies: arguments for an index of RITA

The Brazilian National System of Innovation may be characterized as immature. This characterization can be ascertained by statistical evaluation using patent data and scientific publications. (Albuquerque, 1999)

This level of economic and technological development has important implications for the country's integration in international technological flows. Evaluating the role of transnational corporations for the economic development, it is necessary to point that Brazil is mainly a host of foreign corporations, as the inward flows are greater than the outward flows. (UNCTAD, 1998) The direction and the unevenness of these flows have a technological meaning, as studies point that there is a strong relationship between technological capability, R&D activities and propensity to become transnational. (Caves, 1996; Chandler, 1992)

Barre (1996) has evaluated the relationship between transnationals and their subsidiaries, comparing the technological levels of their home country and their host country. The most sophisticated networks of research and innovation are established when the transnational operates in host countries with "strong" systems of innovation. The Brazilian case shows a co-action between firms from countries with a "strong" innovation system and their subsidiaries in a country with "weak" (immature) system. Instead of networks or division of labor between the headquarters and their subsidiaries, this relationship stresses the adaptive role of their technological activities.

Given this uneven relationship, the investigation of the contributions of transnational corporations in countries with immature systems do need new tools. The literature has used mainly patent data from the USPTO, investigating the inventors country to assess the international distribution of research and innovative activities by multinational corporations. (Cantwell, 1995; Patel e Pavitt, 1995)

These statistics are not well fitted for the case of developing economies. Although they (correctly) display a negligible participation of the Brazilian subsidiaries in the international networks of research and innovation, they are not able to grasp which role these subsidiaries perform within the Brazilian economy.

Investigating the statistics of patents granted to foreign subsidiaries (as Brazilian residents) between 1980 and 1995, their important role is clear: according to the ownership structure defined by the *Guia Interinvest 1992*, the foreign subsidiaries were granted 14,2% of the resident patents. (Albuquerque, 2000a) Franco (2000), using data from the Brazilian Central Bank (Banco Central do Brasil, 1999), calculates that the foreign firms contribute with 10% of the value added in the Brazilian economy. An investigation about the 85 larger subsidiaries in Brazil found that their average investment in R&D is 1,91% of their sales. (SOBEET, 2000) This figure is greater than the average for private domestic firms, according to research conducted by ANPEI. (Andreassi, 1999, p. 61) However, as Quadros *et alii* (2000, p. 26) remark, the larger involvement of foreign firms in technological activities vis-à-vis domestic firms might be an indicator of the weakness of the national technological capability.

Therefore, a tool able to capture and to qualify this participation is necessary: an index of "relative internalization of technological activities" (RITA, henceforth). (Albuquerque, 2000b) For this index, a new data compilation is necessary.

Using data provided by the INPI, a database is organized, with 57,640 resident patents and 54,480 non-resident patents applied between 1988 and 1996. This new database affords a comparison between non-resident patents applied by one transnational headquarters and the resident patents applied by its subsidiaries. The unity of analysis is the transnational corporation. Few steps are necessary for this comparison. First, information provided by the *Guia Interinvest 1998* enables the identification of the link between a transnational and its subsidiaries. Second, the database is searched to gather the non-resident patents applied by the headquarters and the resident patents applied by their subsidiaries. Third, the index RITA is calculated, dividing the subsidiaries' resident patents by the transnational's non-resident patents.

The intuition behind this index is two-sided. On one hand, the index RITA captures both the relevance of the Brazilian market for the multinational and its technological capability. If a multinational firm considers the Brazilian market important and if this multinational has a huge technological capability (with a big patent portfolio), it is supposed that this corporation applies a great number of non-resident patents at the INPI. On the other hand, if the subsidiaries perform significant technological activities in the host country, it has a significant number of resident patents.

Therefore, this index compares two magnitudes and permits a comparative analysis: the resident patents of the subsidiaries indicate the technological effort performed in the host country, and the non-resident patents indicate the potential contribution of the transnational to the host country. The RITA index, comparing the two magnitudes, hints whether or not the transnational is internalizing all their potential technological capability. The relative dimension of this index must be stressed.

Investigating the technological activities of the 500 biggest largest corporations (*Fortune 500,* 1998) and of the 100 most transnationalized corporations (UNCTAD, 1998), the RITA index for the firms operating in Brazil (respectively 152 and 69 global corporations with non-resident patents applied in the INPI) was 0.064 and 0.072. (Albuquerque, 2000b) These findings, at the firm level, are compatible with the overall figures for resident and non-resident patents (WIPO, 1999): the non-developed economies show a greater disparity between these two data sets, contrasting with more even figures for the developed countries.

III The transnationals leaders in non-resident patenting activities in Brazil

The role of transnational corporations in the Brazilian patenting activities is described by Tables I and II.

Table I
Resident And Non-resident Patents Applied in the INPI, According to the Assignee And Patent Type (1988-1996)

	Individuals	Firms/ Institutions	Total
RESIDENTS			
PI	14319	6943	21262
UM	17714	6383	24097
MI	6027	4818	10845
DI	742	694	1436
Total	38802	18838	57640
NON-RESIDENTS			
PI	3193	46584	49777
UM	138	241	379
MI	203	3690	3893
DI	23	367	390
Total	3557	50882	54439

Source: INPI, author's elaboration.

Table II
Firms and Institutions Residents in Brazil (number and share); Resident Patent (number and share), According to Their 1998 Ownership Structure (1988-1996)

Ownership structure	Number of firms	Share	(%)	Number of patents	Share	(%)
DOM	5759	0.898	89.76	14606	0.775	77.53
FOR	426	0.066	6.64	2571	0.136	13.65
FOP	82	0.013	1.28	508	0.027	2.70
RES	73	0.011	1.14	472	0.025	2.51
STA	43	0.007	0.67	632	0.034	3.35
OUT	25	0.004	0.39	32	0.002	0.17
GOV	8	0.001	0.12	17	0.001	0.09
Total	6416	1.000	100.00	18838	1	100

Source: INPI, Guia Interinvet 1998, author's elaboration

Table I shows the distribution of patents applied by residents and non-residents between 1988 and 1996, according to the assignee (individual or firms/institutions) and type of patent. There are important differences between resident and non-resident patenting: 1) the role of individuals is greater between residents (67,3%) than non-residents (6,5%); 2) the quality of non-resident patents is higher, as invention patents (PI) represents 91,4% of non-resident patents and only 36,9% of resident patents.

Table II shows the contribution of foreign firms (FOR, for foreign subsidiaries, FOP for Brazilian firms with foreign participation) to the patenting activities of firms and institutions: they sum 16,2% of the non-individual resident patents.

Two aggregate figures introduce the analysis of the internalization of technological activities by transnationals: Table I shows that non-resident firms/institutions own 50,882 non-resident patents and Table II shows that their subsidiaries (FOR) own 2,547 resident patents.[1]

A closer look in the internalization of technological activities is possible through the investigation of the leading firms in non-resident patenting activities.

The first step for this investigation is the identification of all transnationals with more than 20 patents: 189 transnationals (out of 9.190 firms with at least one non-resident patent), that applied 28,636 non-resident patents (out of 54,480 non-resident patents), representing 52.6% of non-resident patents.[2]

The second step is the identification of the Brazilian subsidiaries (FOR) of these transnationals. The *Guia Interinvest 1998* is the key reference, and the Internet homepages of these corporations are used too.[3]

Only 20 transnationals (representing 1,279 patents) with more than 20 non-resident patents do not have subsidiaries in Brazil. Investigating a database of contracts of technological transfer applied to the INPI between 1991 and 1997 (Silva, 1999), at least 5 of these 20 transnationals contracted some form of technology transfer with Brazilian firms.

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1 Other forms of ownership structure are DOM (domestic firms), RES (research institutions and universities), STA (state-owned firms), GOV (government agencies) and OTH (others).

2 The transnationals are grouped according to their headquarters. For instance, all non-resident patents applied by the IBM from United States, Switzerland, Germany are summed as one single corporation.

3 The figures for resident patents add patents applied by all subsidiaries of the transnational group. For instance, Rhodia and Rhodia-Agro etc are grouped as subsidiaries of the Rhône-Poulenc Group, as indicated by the *Guia Interinvest*.

The third step, using the transnational corporations as unity of analysis, is the compilation of their non-resident patents and their subsidiaries' resident patents.

The fourth step is the calculation of the index RITA. a division of the resident patents applied by the subsidiaries by the non-resident patents applied by their headquarters.

The fifth step is the identification of the transnationals' size (using as proxy 1997 annual sales, when available: unfortunately, figures for 36 firms were not identified), nationality, industrial sector (using the *Fortune*'s 500 classification), technological class and orientation (according to OECD's criteria, OECD, 1996), and patents granted by the USPTO in 1998.

The mean value of RITA is 0.08108, with an standard-deviation of 0.27219.

There are 40 transnationals with indexes of RITA greater than the mean value, 59 with indexes less than the mean value and greater than zero, and there are 90 transnational corporations with no resident patent applied by their subsidiaries (therefore, RITA = 0), 20 of them without a Brazilian subsidiary.

Tables III and IV show the differences in the 20 leading firms, according to a ranking of non-resident patents applied for the INPI (Table III) and to the indexes of RITA (Table IV). Hoechst (Chemicals, Germany) is the leading firm in non-resident patents and Alcoa (Metals, USA) is the leading firm in the RITA ranking.

TABLE III

Twenty Leading Firms Ranked by Non-Resident patents Applied for INPI, with, Country of Origin, Total USPTO Patents, Total Non-residents Patents, RITA, Sales and Industrial Sectors (1988 - 1996)

Name	Country	USPTO Patents	Non-Residents Patents	Residents Patents	RITA	Sales U$ Billions	Industrial Sectors
Hoechst Aktiengesellschaft	DE	327	979	8	0.00817	30.0552	6
Unilever N.V.	NL	21	932	11	0.01180	48.7608	15
Norvatis AG (Novartis SA) (Novartis INC.)	CH	78	845	15	0.01775	21.4942	32
The Procter & Gamble Company	US	454	825	0	0.00000	35.764	38
Bayer Aktiengesellschaft	DE	381	730	10	0.01370	31.731	6
International Business Machines Corporation	US	2657	672	5	0.00744	78.508	8
Johnson & Johnson	US	41	665	15	0.02256	22.629	32
Minnesota Mining and Manufacturing Company	US	554	619	0	0.00000	15.07	36
The Dow Chemical Company	US	174	614	5	0.00814	20.018	6
Royal Dutch/ Shell Group	NL	143	593	5	0.00843	1281.472	31
E.I. Du Pont de Nemours and Company	US	393	555	0	0.00000	41.304	6
Rhône- Poulenc	FR	80	549	229	0.41712	15.413	6
Fiat Auto S.p.A	IT	8	548	63	0.11496	52.5687	30
Motorola, Inc.	US	1406	499	0	0.00000	29.794	10
The Goodyear Tire & Rubber Company	US	108	494	2	0.00405	13.1551	35
Basf Aktiengesellschaft	DE	399	407	2	0.00491	32.1781	6
Rohm And Haas Company	US	71	402	1	0.00249	4	6
Xerox Corporation	US	769	344	5	0.01453	18.166	8
Henkel Kommanditgesellschaft Auf Aktien	DE	85	338	2	0.00592	11.575	6
Philips Electronics N.V	NL	118	334	87	0.26048	39.1884	10

Source: INPI, Fortune (1998), Guia Interinvest (1998), author's elaborations.

Table IV
Twenty Leading Firms Ranked by the Indexes of RITA, with Country of Origin, Industrial Sectors, Technological Class and Orientation (1988 - 1996)

Individuals Titular	Country	RITA	Industrial Sectors	Technological Class	Orientation
Aluminum Company Of America	US	2.80000	28	3	4
Whirlpool Corporation	US	1.57627	10	1	3
British-American Tobacco Company Limited	GB	1.30189	41	3	1
L'Air Liquide, Societe Anonyme Pour L'Etude Et L'Exploit	FR	0.91667	6	2	4
Daimler- BenzDaimler-Benz Aktiengesellschaft	DE	0.80392	30	2	4
AMP Incorporated	US	0.44615	10	1	3
Rhône- Poulenc	FR	0.41712	6	2	4
Lucas Industries Public Limited Company	GB	0.40000	30	2	4
Moulinex	FR	0.36170	10	1	3
Ajinomoto Co, Inc.	JP	0.33333	15	3	1
Saint-Gobain Vitrage	FR	0.32046	6	2	4
Valeo	FR	0.30220	30	2	4
Pirelli Cavi S.p.A.	IT	0.30000	35	2	4
Philips Electronics N.V	NL	0.26048	10	1	3
Borden Chemical, Inc.	US	0.23810	15	3	1
Kimberly-Clark Corporation	GB	0.23308	17	3	1
Mannesmann Aktiengesellschaft	DE	0.16981	21	2	3
Philip Morris Products Inc.	US	0.16981	41	3	1
Reckitt & Colman Products Limited	GB	0.15686	38	2	4
Alcan International Limited	CA	0.15517	28	3	4

Source: Source: INPI, Fortune (1998), Guia Intervest 1998, OECD (1996) author's elaboration.

Tables V and VI present data according to the geographical origins of the transnational corporations (and Section IV.2, below, evaluates few variables according to their home country). The home base country of a transnational is an important variable, as countries differ in their propensity to transnationalize[4] and to distribute internationally their technological activities.[5] Therefore, it is interesting to investigate the geographical origins of the transnationals.

4 The World Investment Report 1999 (UNCTAD, 1999, p. 82) presents a country breakdown of the a "transnationality index" (TNI) calculated for the world's top100 transnationals. The average TNI for all listed transnationals is 55.4. Transnationals from Japan, United States, and Italy displayed the lowest TNIs. The highest TNIs are from Belgium, Canada, Netherlands, United Kingdom and Sweden.

5 Patel (1995) shows a ranking of countries according to the degree of internationalization of their innovative activities. The top countries are Belgium, Netherlands, Switzerland, UK and Sweden. And again, Japan and United States are the home countries of less internationalized corporations.

Table V
Number of Firms, Mean and St. Dev. of RITA, and Total and Mean of Patents per Country (1988 - 1996)

Country	Number of Firms	RITA		Patents	
		Mean	St. Dev.	Total	Mean
GB	9	0,23887	0,42170	964	107,1111111
FR	12	0,20444	0,27728	1729	144,0833333
CA	1	0,15517		116	116
IT	5	0,08299	0,13112	994	198,8
US	91	0,07957	0,33684	13812	151,7802198
NL	4	0,07017	0,12696	2015	503,75
DE	29	0,06007	0,15253	4773	164,5862069
JP	13	0,05053	0,09266	1184	91,07692308
ES	1	0,02380		42	42
SE	5	0,02089	0,03621	538	107,6
CH	9	0,01136	0,01846	1895	210,5555556
AU	1	0		38	38
BE	2	0	0	238	119
AT	1	0		62	62
NO	2	0	0	111	55,5
KR	2	0	0	97	48,5
LU	1	0		60	60
DK	1	0		109	109

Source: INPI, Fortune(1998), Guia Intervest 1998, author's elaboration.

TABELA VI
Mean and Sta. Dev. of RITA, Number of Firms, Total and Mean of Patents per Group of Countries (1988 - 1996)

Class Country	RITA		Number of Firms	Patents	
	Mean	St.Dev		Total	Mean
G4	0,11307	0,23922	60	8862	147,7
G2	0,07957	0,33684	91	13812	151,8
G3	0,05054	0,09267	13	1184	91,1
G5	0,03879	0,07759	4	251	62,8
G1	0,02321	0,05834	21	4668	222,3

Source: INPI, Fortune (1998), Guia Intervest 1998, author's elaboration.

Table V displays the indexes of RITA according to the transnationals' home countries. Great Britain (9 transnational corporations) has the greater mean value of RITA (0.2389), followed by France, Canada, Italy, and United States. Seven countries (Austria, Belgium, Australia, Nor-

way, Korea, Luxembourg and Denmark) have transnationals with no resident patent (RITA =0). This Table V also shows that the United States is main the home country of the leading transnationals (91 firms), followed by Germany, (29), Japan (13), France (12) and Great Britain and Switzerland (both with 9 corporations).

Table VI aggregates these 18 countries in five groups: G1- dynamic small European economies (Sweden, Switzerland, Netherlands, Norway and Denmark); G2- United States; G3- Japan; G4- rest of Europe; G5- rest of the World. The leading group, ranked again by the mean of indexes of RITA, is G4 (rest of Europe), followed by the United States and Japan.

Table VII shows the RITA ranking according to firm size. Four groups are organized, according to the corporation's annual sales (1997): V4- 9 transnationals with sales greater than US$ 28 billions (corresponding to the 100th corporation of the Fortune 500); V3- 61 corporations with annual sales greater than US$ 8 billions (corresponding to the 500th corporation of the Fortune 500); V2- 57 transnationals with sales greater than US$ 1 billion; and V1- 26 firms with sales less than US$ 1 billion. There are 36 firms without data available. The leading group is the V3 (mean RITA = 0.1407); followed by the larger corporations group (V1, mean RITA = 0.1069).

Table VII
Number of Firms, Mean and St. Dev. of RITA, and Total and Mean of Patents per Group of Size (1988 - 1996)

Class Sales	Number of Firms	RITA		Patents	
		Mean	St. Dev.	Total	Mean
V3	57	0,14068	0,45043	10301	180,7
V1	9	0,10690	0,30403	838	93,1
V4	26	0,07747	0,16284	8978	345,3
V2	61	0,06629	0,11077	6174	101,2
Unidentified	36	0,00793	0,01960	2486	69,1

Source: INPI, Fortune (1998), Guia Intervest 1998, author's elaboration.

Table VIII shows the ranking according to Industrial Sectors. Only 6 sectors (out of 27) have indexes of RITA greater than the mean value (0.08108): Tobacco (41); Metals (28); Electronics, Electrical equipment (10); Motor Vehicles and parts (30); Food (15); and Electronics, Semiconductor (11).

Table VIII
Number of Firms, Total and Mean of Patents, and Mean and St. Dev. of RITA per Industrial Sector (1988 - 1996)

Industrial Sector	Classification	Number of Firms	Patents		RITA	
			Total	Mean	Mean	St. Dev.
41	Tobacco	2	106	53,0	0,73585	0,80050
28	Metals	8	564	70,5	0,38277	0,97805
10	Electronics, Electrical Equipment	21	3099	147,6	0,14668	0,35162
30	Motor Vehicles and Parts	18	2132	118,4	0,14304	0,19651
15	Food	7	1360	194,3	0,10649	0,12877
11	Electronics, Semiconductors	3	181	60,3	0,08569	0,05563
6	Chemicals	33	7708	233,6	0,06179	0,17853
1	Aerospace	2	437	218,5	0,05168	0,06833
5	Buildings Materials, Glass	3	230	76,7	0,04883	0,01324
42	Trading	2	254	127,0	0,04413	0,01867
35	Rubber and Plastic Products	8	1149	143,6	0,04168	0,10487
17	Forest and Paper Products	6	406	67,7	0,03885	0,09516
38	Soaps, Cosmetics	7	1651	235,9	0,03389	0,05665
31	Petroleum Refining	10	1370	137,0	0,02859	0,05217
13	Engineering, Construction	1	46	46,0	0,02174	
21	Industrial and Farm Equipment	17	1653	97,2	0,01985	0,04658
32	Pharmaceuticals	14	2809	200,6	0,01215	0,01488
27	Metal Products	5	464	92,8	0,00974	0,01357
40	Telecommunications	3	168	56,0	0,00794	0,01375
8	Computers, Office Equipment	3	1057	352,3	0,00733	0,00727
36	Scientific, Photo, Control Equip.	3	905	301,7	0,00610	0,01056
99	unidentified	6	433	72,2	0,00402	0,00984
14	Entertainment	3	321	107,0	0,00000	0,00000
34	Railroads	1	46	46,0	0,00000	
37	Securities	1	58	58,0	0,00000	
4	Beverages	1	127	127,0	0,00000	
29	Mining, Crude-Oil Production	1	43	43,0	0,00000	

Source: INPI, Fortune (1998), Guia Intervest 1998, author's elaboration.

Table IX aggregates the Industrial Sectors into three technological classes. (OECD, 1996) The 35 corporations classified as "low technology" class have the greater mean value (RITA = 0.16566), more than two times the indexes of the "high technology" class (RITA = 0.07618) and the "medium technology" class (RITA = 0.05997).

Table IX
Number of Firms, Total and Mean of Patents, and Mean and St. Dev, of RITA per Technological Class (1988 - 1996)

Technological Class	Classification	Number of Firms	Patents		RITA	
			Total	Mean	Mean	St. Dev
3	Low-technology	35	3976	113.6	0.16566	0.51155
1	High-technology	48	8011	166.9	0.07618	0.23924
2	Mean-technology	96	15984	166.5	0.05997	0.14490

Source: INPI, Fortune (1998), Guia Intervest 1998, OECD (1996) author's elaboration.

Finally, Table X reorganizes the Industrial Sectors according to their orientation. (OECD, 1996) The "scale-intensive" corporations have the higher mean (mean RITA = 0.10596), followed by "resource-intensive" orientation (mean RITA = 0.10133) and "specialized-supplier" (mean RITA = 0.08406). With means less than the general mean (0.08108) there are the "labor-intensive" (0.02411) and the "science-based" (0.04412) orientations.

Table X
Number of Firms, Total and Mean of Patents, and Mean and St. Dev. of RITA per Orientation (1988 - 1996)

Orientation	Classification	Number of Firms	Patents		RITA	
			Total	Mean	Mean	St. Dev
4	Scale-intensive	78	14155	181,5	0,10596	0,34719
1	Resource-intensive	27	3412	126,4	0,10134	0,25663
3	Specialized-Supplier	44	5080	115,5	0,08406	0,24983
2	Labour -intensive	9	740	82,2	0,02411	0,02224
5	Science-based	21	4584	218,3	0,01407	0,02352

Source: INPI, Fortune (1998), Guia Intervest 1998, OECD (1996) author's elaboration.

IV Statistical evaluation of the index of RITA

IV.1 Principal Component Analysis (PCA)

This section deals with 151 transnationals, each one with 5 variables (USPAT, NRESPAT, RESPAT, RITA and SALES). Each variable represents a characteristic of the global corpora-

tion, as size, patenting ability, interest in the Brazilian market, and internalization of technological activities.

Each of these variables has a large variation, as follows:

VAR (USPAT) = 101254.90; $\overline{X}_{USPAT} = 152.19$;

VAR (NRPAT) = 37616.35; $\overline{X}_{NRPAT} = 172.43$;

VAR (RPAT) = 648.82; $\overline{X}_{RPAT} = 10.1$,

VAR (RITA) = 0.09114; $\overline{X}_{RITA} = 0.099$;

VAR (SALES) = 11125.69; $\overline{X}_{SALES} = 24.75$.

This large variation on the data suggests a search for the sort of distribution on how they are classified according to a common score.

A multivariate technique is useful to identify groups with similar aspects or even may suggest another aspect they have in common. (Mardia *et alii*, 1988) The idea is to use the principal component analysis (PCA) to reduce the number of original variables that need to be considered to a small number of indices Zi (i<5) (the principal components) that are linear combinations of the original variables.

Two principal components are chosen. The first variable explains 50% of the variation, and the second explains 20% of the total variation. Both accounts for 70%. A third component would increase the total variation to 80%, but it is let out since the first two components are very informative.

The two components are as follows:

Z1 = -0.1765 USPAT – 0,0487 NRPAT + 0.6847 RPAT + 0.7026 RITA – 0.063 SALES;

and

Z2 = 0.53 USPAT + 0.686 NRPAT + 0.226 RPAT + 0.00018 RITA + 0.44 SALES.

The first component is mainly a combination of RITA and RPAT (they are positively related). The coefficients for USPAT, NRPAT and sales are negative but not large enough, in absolute value, to be considered as going in the opposite direction of RITA and RPAT.

The second component indicates a direction where USPAT, NRPAT and SALES dominate.

The results for the 151 firms are plotted in Figure I against their values for the first two principal components, Z1 and Z2.

Figure I

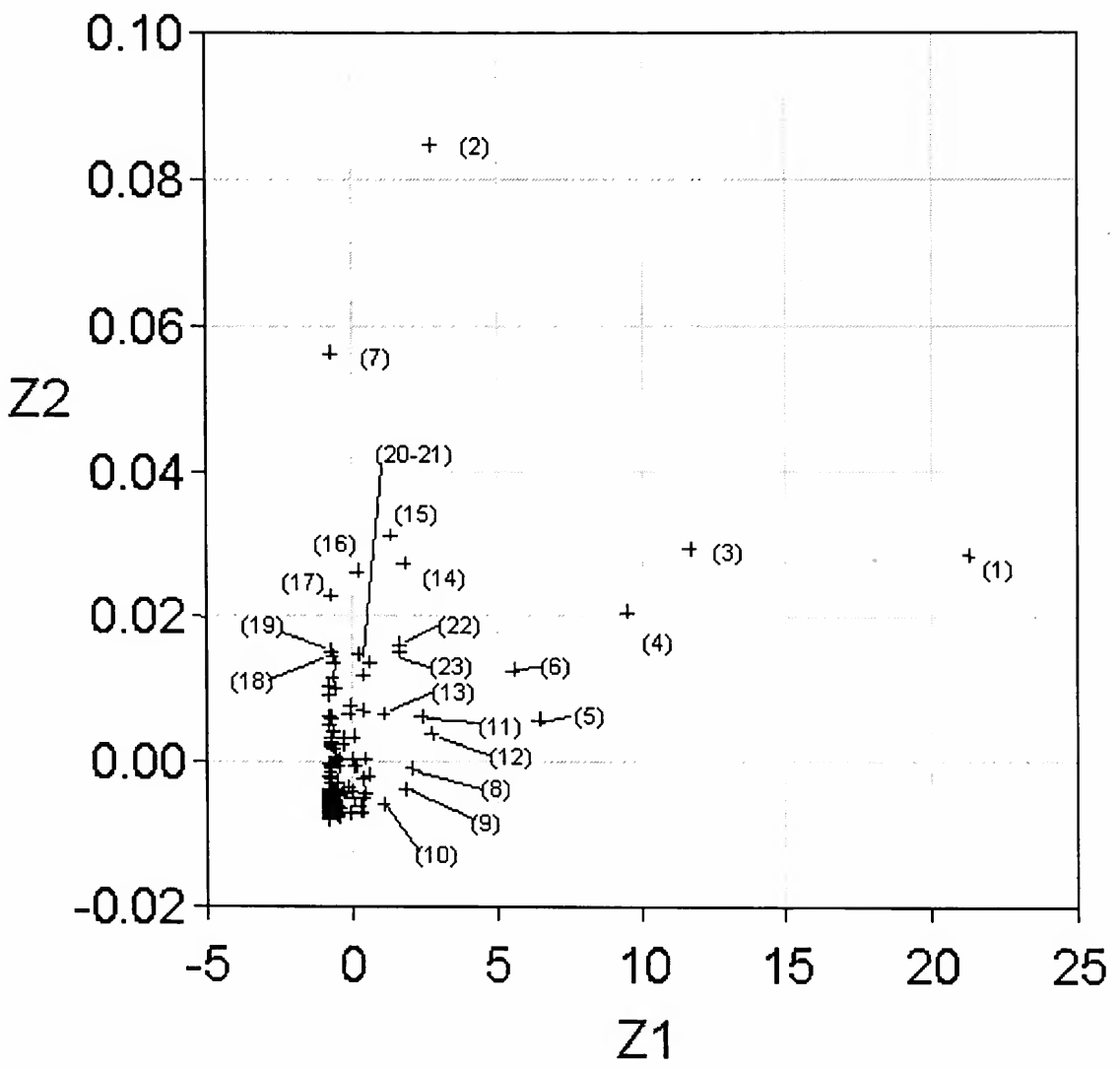


Figure I shows some isolated points and/or groups seen in Table XI, that have a different behavior from the others. This is due to a high index of RITA, as in the case of as Alcoa, or combines a high patenting activity in the USPTO and in the INPI (with resident and non-resident patents), as in the case of Rhône-Poulenc.

Table XI
Transnationals With Different Behavior, According to PCA Analysis (Figure I)

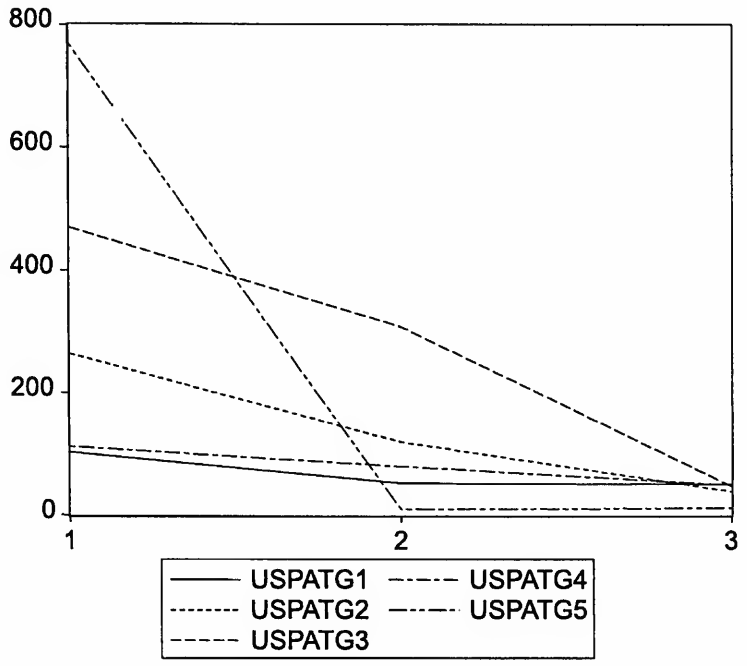
Number in Figure I	Firms	Country	Technology sector
1	Aluminum Company Of America	US	3
2	Rhône- Poulenc	FR	2
3	Whirlpool Corporation	US	1
4	British-American Tobacco Company Limited	GB	3
5	L'Air Liquide, Societe Anonyme Pour L'Etude Et L'Exploit	FR	2
6	Daimler- BenzDaimler-Benz Aktiengesellschaft	DE	2
7	Royal Dutch/ Shell Group	NL	3
8	Moulinex	FR	1
9	Ajinomoto Co, Inc.	JP	3
10	Borden Chemical, Inc.	US	3
11	Lucas Industries Public Limited Company	GB	2
12	AMP Incorporated	US	1
13	Kimberly-Clark Corporation	GB	3
14	Saint-Gobain Vitrage	FR	2
15	Philips Electronics N.V	NL	1
16	Fiat Auto S.p.A	IT	2
17	International Business Machines Corporation	US	1
18	Bayer Aktiengesellschaft	DE	2
19	Unilever N.V.	NL	3
20	Robert Bosch GMBH	DE	2
21	Mannesmann Aktiengesellschaft	DE	2
22	Pirelli Cavi S.p.A.	IT	2
23	Valeo	FR	2

Source: INPI, Fortune (1998), OECD (1996), author's elaboration.

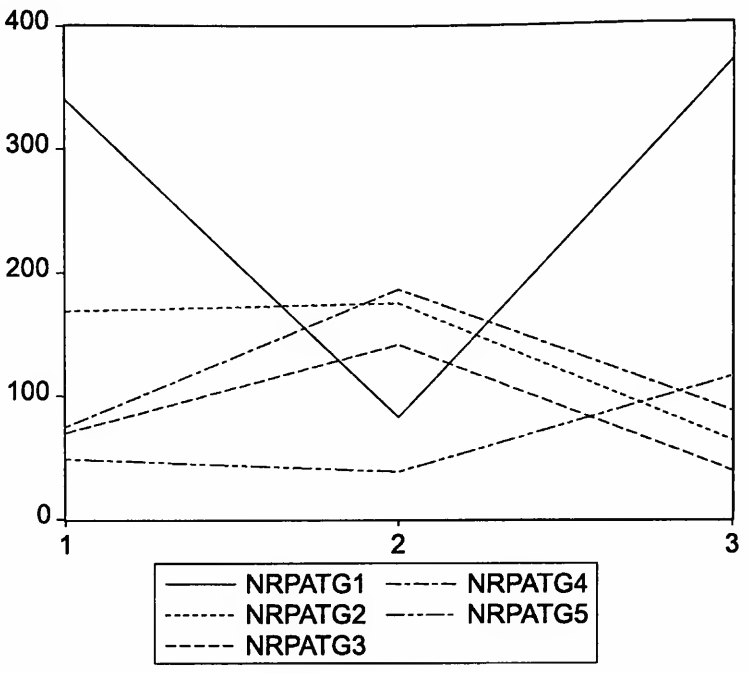
IV.2 A comparison between countries, classes and RITA

This subsection presents the Graphs 1 to 5. These Graphs organize the data according to technological classes (OECD, 1996): 1 for high-technology; 2 for medium technology and 3 for low technology. These Graphs show the different behavior of the following variables: USPAT (Graph 1), NRPAT (Graph 2), RPAT (Graph 3), RITA (Graph 4), and SALES (Graph 5).

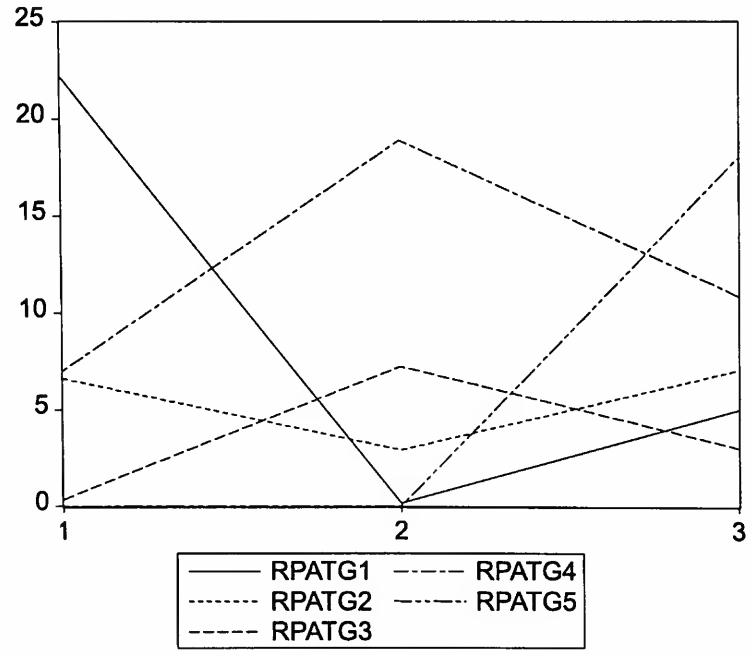
Graph 1



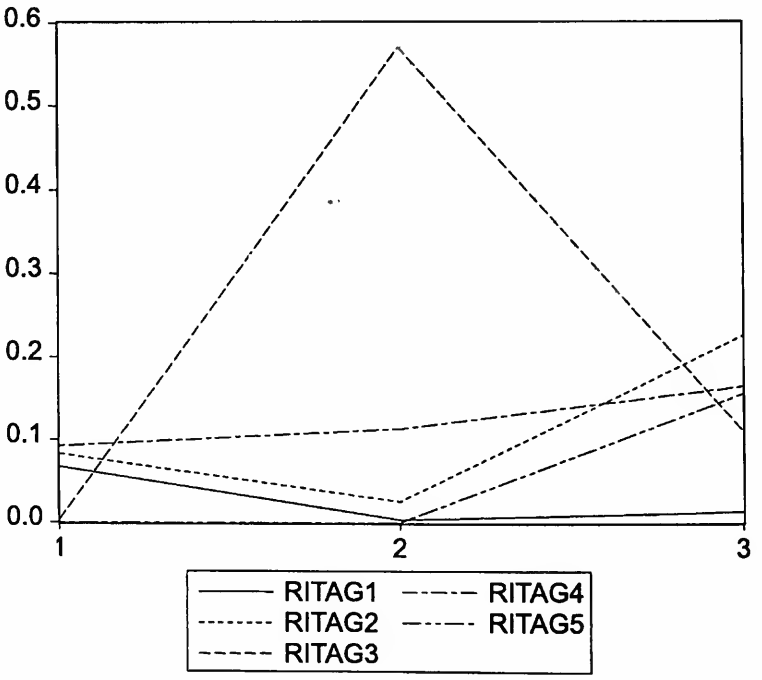
Graph 2



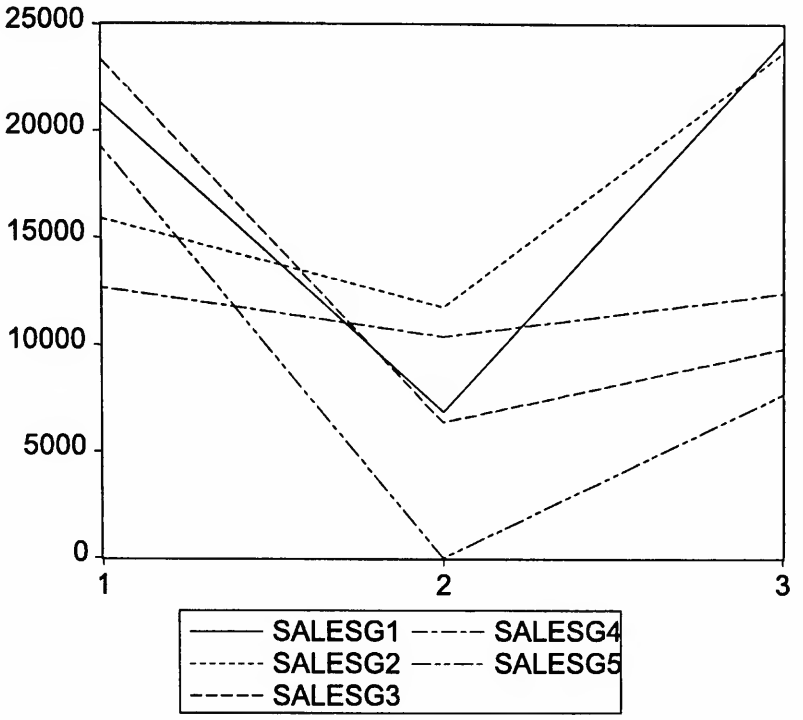
Graph 3



Graph 4



Graph 5



First, the USPAT displays a pattern predicted by the literature on patents: the higher technological class has the higher USPAT means.

Second, the NRPAT displays a differentiated pattern. Groups G1 and G5 show a U-shaped pattern: the higher means are in the high and low technology groups. The other groups (G2, G3 and G4) show an inverted-U-shape: the higher means are in the medium technology class. These differences hints the different attraction that the Brazilian market and resources represent to different transnationals. In other words, these differences stress that technological reasons are not operating alone.

Third, the RPAT patterns are similar to the NRPAT patterns in the case of groups G1 and G5 (U-shaped) and of groups G3 and G4 (inverted U-shape). Only the United States transnationals display different patterns: inverted U-shape in NPAT and U-shape in RPAT. G1 and G2 show an interesting pattern: their RPAT means are higher in the case of high technology.

Fourth, the indexes of RITA summarize different patterns among the five groups of countries. Only the group G1 show a pattern with the greater mean with the high technology class. The groups G2, G4, and G5 have the greater means with the low technology class. The G3 has the higher mean with the medium technology class.

An interesting comparison between the pattern displayed by the G4 (rest of Europe) in USPAT and RITA: the former increases as the level of technology becomes higher, while the latter decreases. However, the indexes of RITA of this group are always greater than the general mean (0.08), even the mean for the high technology class (0.09213).

Finally, the variable SALES shows an systematic pattern: all groups of countries present a U-shaped form, with the greater sizes in the high and low technology classes.

These data support the ability of the index of RITA to capture the potential contributions of transnational corporations. For instance, Graph 3 shows that the G1 group has the higher mean for the RESPAT variable, and that this mean is in the high technology class. However, Graph 4 shows that the index of RITA for the G1 group is lower than the general mean (0.08108). Graph 2 shows that the NRPAT for the G1 in this class is high. Therefore, the index of RITA indicates that the potential contribution of the transnationals of this class is not completely exploited by their subsidiaries (high RESPAT mean, but low RITA index, caused by high NRESPAT).

IV.3 Regression analysis

The RITA index, being a "quotient" relating the two independent variables NRPAT and RPAT, is therefore closely related to each one of them isolated, but not with both. However, as one analyses few observations in the data set using a sensitivity analysis (Biazi, 1996), in a multivariate context, it was identified that these observations could be treated as outliers. The model chosen for the regression analysis includes these two variables and a dummy variable (TEC1, for high technology, TEC2, for medium technology) for technological class (OECD, 1996). The regression results are shown in Table XII. The inclusion of a dummy associated to nationality was tried, but surprisingly this was not significant.

From this sensitivity analysis ten points (representing transnational corporations) were kept out of the set. They have a different behavior from the others in the regression context, being very influential for the fit. In general these points have a large value for RITA (examples of these firms are Alcoa, Ajinomoto, Moulineux).

Table XII
Regression Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.046852	0.007902	5.929237	0.0000
NRPAT	-8.59E-05	1.68E-05	-5.104908	0.0000
RPAT	0.004028	0.000228	17.66118	0.0000
TEC1	-0.025096	0.009614	-2.610299	0.0101
TEC2	-0.018723	0.008764	-2.136310	0.0344

R-squared	0.700793	Mean dependent var	0.039673
Adjusted R-squared	0.691993	S.D. dependent var	0.068039
S.E. of regression	0.037761	Akaike info criterion	-6.518152
Sum squared resid	0.193919	Schwarz criterion	-6.413586
Log likelihood	264.4594	F-statistic	79.63367
Durbin-Watson stat	1.304997	Prob(F-statistic)	0.000000

The main result of this regression is the statistical significance of the different classes of technology (high tech, medium tech and low tech) pointed out by the dummies.

Although the RITA index is statistically related to the set of variables (NRPAT, RESPAT, and TEC), the model described by Table XII is still not well-fitted. It was suspected that the RITA index should be grouped in classes according to their magnitudes and included in the model through a dummy variable (DD1, for RITA > 0.4; and DD2 for 0 < RITA < 0.4). There are still few influential points spotted out: 2, 4, 5, 8, 9 and 10. The model now becomes very well fitted, as shown by Table XIII.

Table XIII
Regression Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.025300	0.008784	2.880144	0.0046
NRPAT	-9.45E-05	1.74E-05	-5.439901	0.0000
RPAT	0.002362	0.000148	15.96995	0.0000
TEC1	-0.019585	0.009747	-2.009292	0.0465
TEC2	-0.013478	0.008936	-1.508226	0.1338
DD1*NRPAT	-0.062968	0.001569	-40.13842	0.0000
DD2	0.049720	0.006939	7.164781	0.0000
DD1	4.465009	0.083072	53.74856	0.0000

R-squared	0.979606	Mean dependent var	0.072821
Adjusted R-squared	0.978564	S.D. dependent var	0.263643
S.E. of regression	0.038600	Akaike info criterion	-6.455411
Sum squared resid	0.204125	Schwarz criterion	-6.291177
Log likelihood	270.2712	F-statistic	940.0934
Durbin-Watson stat	0.683561	Prob(F-statistic)	0.000000

V Conclusion

The initial results of this investigation, about the transnationals and their contributions to the technological activities of the host countries, indicate that in general the figures are not high: the general mean of the index of RITA is 0.08108.

According to technological classes, this index shows that the main contributions of the transnationals to the internalization of technological activities are in the "low technology" class. Regarding the orientation of the industrial sector, this index indicates that the contribution of transnationals are greater in the "resource-intensive" and "scale-intensive" sectors. The indexes of RITA for the "high technology" class and for the "science-based" sectors are lower than the general mean.

The Graphs 1 to 5 are indicating the existence of some effects of groups or classes. Further work, using panel analysis, might explain the effect of such groups interacting with each other.

The large variation in the indexes of RITA reveals the diversity of transnationals' behavior. For instance, the motors and part industrial sector has an above the average RITA (0.14304), while the pharmaceutical sector has an under the average RITA (0.01215).

The descriptive statistics and the principal component analysis demonstrate the large variations in variables like size, nationality, patents applied to the USPTO, and indexes of RITA. Different countries (and groups of countries) have different characteristics (number of global corporations per technological class, size, etc). Different combinations of these variables (size, nationality, industrial sector) explains the large variation in the indexes of RITA.

The regression analysis shows that the technological classes are relevant for the results, improving the regression fit. The regression analysis shows that the high technology class (TEC1 in Tables XII and XIII) is correlated with lower indexes of RITA. This result is consistent with the descriptive statistics presented at Table IX (the low-tech class has the higher RITA mean).

On the one hand, these results could link the discussion of Sections I and II with the statistical analysis of Sections III and IV. The literature suggests that an immature system of innovation (the Brazilian case) would not attract (predominantly) sophisticated foreign investment (that connect the country to the international technological flows), as these transnational corporations seek for strong technological and scientific capabilities in their locational choices. The results from Sections III and IV would support this interpretation.

On the other hand, these results should be carefully compared with other variables, specially with a variable that capture the age of the subsidiaries. Probably, more established foreign firms would have time, knowledge and trust for investing in local technological activities.

This is a key issue for further research, and a cautious note for the interpretation of this paper data and results.

References

Albuquerque, E. National systems of innovation and non-OECD countries: notes about a rudimentary and tentative typology. *Revista de Economia Política*, v. 19, n. 4, p. 35-52, out-dez. 1999.

_____. Patentes, empresas transnacionais e atividades tecnológicas: uma avaliação da contribuição tecnológica das empresas transnacionais instaladas no Brasil a partir de estatísticas de patentes. *Revista Economia Aplicada*, v. 4, n. 2, p. 367-377, abr.-jun. 2000a.

_____. Empresas transnacionais e suas patentes no Brasil: resultados iniciais de uma investigação sobre a internalização de atividades tecnológicas. *Revista de Economia Contemporânea*, v. 4, n. 2, jul-dez. 2000b.

Andreassi, T. *Expenditures in technological innovation: a study in Brazilian companies*. 1999. (MSc Dissertation), Brighton: SPRU.

Banco Central do Brasil. Censo de capitais estrangeiros. Disponível em: http://www.bacen.gov.br. Acesso em: 20/08/1999.

Barre, R. Relationships between multinational firms' technology strategies and national innovation systems: a model and an empirical analysis. *In*: *Innovation, Patents and Technological Strategies*. Paris: OECD, 1996.

Biazi, E. *Some aspects of influence analysis and a new approach*. 1996. (DPhil Thesis) Coventry: University of Warwick.

Cantwell, J. The globalization of technology: what remains of the product cycle model? *Cambridge Journal of Economics*, v. 19, n. 1, 1995.

Cantwell, J.; Janne, O. Technological globalisation and innovative centres: the role of corporate technology leadership and locational hierarchy. *Research Policy*, v. 28, n. 2-3, p. 119-144, 1999.

Caves, R. *Multinational enterprise and economic analysis*. Cambridge: Cambridge University, 1996.

Chandler Jr., A. Organizational capabilities and the economic history of the industrial enterprise. *Journal of Economic Perspectives*, v. 6, n. 3, p. 79-100, 1992.

Dunning, J. H. *Explaining international production*. London: HarperCollins Academic, 1988.

Fortune. *1998 Global 500.* 03/08/1998.

Franco, G. O capital estrangeiro. Revista *Veja* 2/02/2000, p. 129

Griliches, Z. Patent statistics as economic indicators: a survey. *Journal of Economic Literature*, v. 28, Dec. 1990.

Guia Interinvest. *O Brasil e o capital internacional*. 9ª ed. Rio de Janeiro: Interinvest, 1998.

Mardia, K. V., Kent, J. T., Bibby, J. M. *Multivariate analysis*. London: Academic Press, 1988.

OECD. *L'internationalisation de la R&D industrielle: structures et tendances*. Paris: OECD, 1998.

_____. *Technology and industrial performance*. Paris: OECD, 1996.

_____ *Globalisation of industrial R&D: policy issues*. 1999a. Disponível em: em http:/ www.oecd.org. Acesso em: 15/12/1999.

_____.*The globalisation of industry in OECD countries* (STI Working Papers), 1999b. Disponível em: http:/www.oecd.org. Acesso em: em 28/02/2000.

Patel, P.; Pavitt, K. Patterns of technological activity: their measurement and interpretation. *In*: STONEMAN, P. (ed.), *Handbook of the economics of innovation and technological change*. Oxford: Blackwell, 1995a.

_____. The localised creation of global technological advance. *In*: MOLERO, J. *Technological innovation, multinational corporations and new international competitiveness: the case of intermediate countries*. Singapore: Harwood Academic Publishers, 1995b.

Patel, P., Varga, M. Patterns of imnternationalisation of corporate technology· location vs. Home country advantages. *Research Policy*, v. 28, n. 2-3, p. 145-156, 1999.

Penrose, E. *La economia del sistema internacional de patentes*. México: Siglo XXI, 1974.

Quadros, R., Furtado, A.; Bernardes, R., Franco, E. *Technological innovation in Brazilian Industry: an assessment based on the São Paulo Innovation Survey*. Campinas: Unicamp, 2000. Mimeografado.

Silva, L. Transferência de tecnologia: um estudo dos contratos de importação de tecnologia averbados no INPI entre 1991 e 1997 (Monografia de Graduação). Belo Horizonte: FACE-UFMG, 1999.

SOBEET. Comportamento tecnológico das empresas transnacionais em operação no Brasil. *Conjuntura Econômica*, março de 2000 (encarte).

Thomson, R., Nelson, R. *The internationalization of technology, 1874-1929: evidence from US, British and German patent experience*. New York: Columbia University, 1997 Mimeografado.

UNCTAD. *World investment report: trends and determinants*. New York: United Nations, 1998.

_____ *World investment report: foreign direct investment and the challenge of development*. New York: United Nations, 1999.

WIPO. *International patent statistics*. Disponível em: http://www.wipo.org. 1998.