CHANNELS OF INTERNATIONAL TECHNOLOGY TRANSFER IN BRAZILIAN INDUSTRIAL FIRMS

(PRELIMINARY RESULTS)

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1 VARIABLES AND CLASSIFICATIONS

This study used the second Brazilian technological Innovation Survey the period of 2001-2003 (PINTEC – 2003), conducted by the Brazilian Institute of Geography and Statistics (IBGE). The survey is a representative sample of manufacturing firms with 10 or more employees. In order to make the survey comparable to CIS we restricted our analysis to firms with 20 or more employees. In this sample there were more then 8,600 firms that, weighted, represent 43,595 firms[1].

The analysis of channels of international technology transfer in Brazil had to be adapted to the availability of information in the Brazilian Innovation Survey. This survey follows the principles of the Oslo Manual, but some of the indicators that exist in the Belgium CIS data do not exist in Brazilian survey. Thus, some of the indicators proposed by Cassiman and Veugelers (2006) and especially in Veugelers and Cassiman (2004) could not be reproduced.

Therefore, our Brazilian study adopted different criteria to define a firm that used international sources of technology. The variables and classifications used in the paper are explained below.

1.1 International involvement

According to their international involvement, companies were classified in three different and exclusive categories:

- **Foreign firm**: defined as a company with more than 50% of their capital controlled by an international group. It is the FSUB variable proposed in the preliminary background document which subsidizes the work on topic 3.
- **National exporter**
- **National non-exporter**

[1] In reporting all results, descriptive and econometric ones, we used the weighted values.

1.2 Innovation strategy

Innovative firms are defined as firms that have introduced new products or/and processes in the market. We can identify among these firms several different and exclusive innovation strategies, as proposed by Cassiman and Veugelers (2004):

- **Make only**: innovative companies are considered to have adopted the "make only" strategy if they were engaged in internal R&D activities in the period of the Innovation Survey - from 2001 to 2003 – and that had not bought technology through licensing, R&D contracting or consultancy services.
- **Buy only**: innovators are considered to have adopted the "buy only" strategy if they acquired technology through R&D contracting, licensing and/or consultancy services. In terms of the CIS questionnaire, these companies were engaged in extramural R&D and in acquisition of other external knowledge. At the same time, these companies showed no internal R&D activities.
- **Make and buy**: innovators are considered to have adopted the "buy only" strategy if they developed both of technological activities (internal and external) simultaneously.
- **No make and no buy:** Innovative companies that did not develop any kind of technological activities, except for acquisition of machinery (which was not used as a criterium of classification in the others categories) were considered to have adopted the "no make and no buy" strategy. In fact, most of the firms that declared not having engaged in other technological activities had acquired machinery in order to innovate.

Unfortunately, in Brazilian survey it is not possible to observe whether a firm has bought technology in domestic or in foreign markets. Hence, we had to adopt different criteria to classify firms that used foreign sources of technology. Similarly, the Brazilian survey did not inquire if the firm sold technology in internal or external markets. In other words, the variable SELL could not be reproduced and the variable BUY could not be separated into a national *versus* international level.

1.3 Cooperation

With regard to **cooperation**, our study identified companies with cooperation arrangements on innovation activities. The variable was constructed based on the type of partnership and whether this partnership occurred on the national or international level, as follows:

- **Link**: cooperation with clients or suppliers.
- **Comp**: cooperation with competitors
- **Intgr**: cooperation with other enterprises within the enterprise group
- **Science**: cooperation with universities and/or research institutes

1.4 Sources of information to innovate

In innovation surveys there are also data about sources of information for innovation that are considered important by innovative firms. In the Brazilian case, it is possible to know whether these sources are located in Brazil or in other countries. Therefore, firms were classified according to the importance of several sources of information for innovation:

- **Intern**: firms which declared that information within the firm was highly important for innovation.
- **Intgr**: firms which declared that information from another company of the same group was highly important for innovation.
- **Link, Comp, Science and Ginfo**: firms for whom the information from i) suppliers and clients; ii) competitors; iii) universities and research institutes and; iv) specialized conferences, meetings and publications or fairs and exhibitions were, respectively, the most important sources of information for innovation.

For each one of these categories, save the first, we identified the location of the source of information into two groups: Brazil *versus* other countries.

1.5 Those responsible for innovation

There is another question that may help to identify whether companies use foreign sources of technology. It is that of who mainly developed the innovation. Again, in the Brazilian case, it is possible to know the location of the main agent responsible for the innovation. Therefore, we also classified the companies according to who has developed the innovation, as follows:

- **Mainly the enterprise**
- **Other enterprise of the same group**
- **The enterprise in cooperation with other agent**
- **Other enterprises**

For each one of theses categories, we constructed a variable that indicates whether the agent responsible for innovation is located in Brazil or in other countries.

1.6 International technology acquisition

Finally, to define whether firms used or not foreign sources of technology three indicators were set: i) the main agent responsible for innovation; ii) cooperation and; iii) sources of information. The criteria to classify firms according to their international technological search was: if the main agent responsible for innovation was located abroad OR if the firm has cooperation agreements with other agents located abroad OR if the most important source of information for firm innovation was

located abroad. In such situations the firm was considered to have used foreign sources of technology in order to innovate.

2 PRELIMINARY RESULTS

Once we have defined the variables and classifications to be used, this section describes some of the results obtained from Brazilian Innovation Survey.

2.1 Descriptive analysis

Around 36% of more than 43,000 Brazilian industrial firms with more than 20 employees implemented some kind of innovation (product or process) in the period 2001-2003. Among these firms, 14% implemented only process innovations, 6% only product innovations and about 15% developed both product and process innovations (table 1).

Regarding technological strategies, we can observe that the most part of innovative firms (72%) developed innovations without making in-house R&D investments and without buying disembodied technology outside of the firm – the "no make and no buy" strategy. The most important innovative expenditure of these firms was related to embodied technology acquisition, represented by the purchase of machinery and equipment for innovation. It is important to stress that, differently from Cassiman and Veugelers (1999), we are not able to identify firms that buy other kinds of embodied technology such as new personnel or other firms or part of them. Therefore, the number of firms which are categorized as "no make and no buy" is probably overestimated[2].

TABLE 1. NUMBER OF INNOVATIVE FIRMS AND INNOVATION STRATEGIES IN BRAZILIAN MANUFACTURING: 2001-2003.

Number of firms		% of total firms	% of innovative firms
Total	43,595	100%	-
Non-innovative firms	28,086	64%	-
Innovative firms	15,509	36%	100%
Type of innovation			
Only process	6,294	14%	41%
Only product	2,625	6%	17%
Product and process	6,590	15%	42%
Innovation strategy			
No make no buy	11,193	26%	72%
Only buy	915	2%	6%
Only make	2,353	5%	15%
Make and buy	1,048	2%	7%

Source: PINTEC (2003). Components may not sum up to totals because of rounding (the weight variable is not an integer in Brazilian survey).

[2] At least, when one compares the Brazilian figures with the Belgian ones, presented by Cassiman and Veugelers (1999).

The strategy of innovating through only internal R&D expenditures is one of most important innovation strategies: 15% of the innovative firms relied solely on in-house technology. Finally, 7% of innovative firms only bought technology from external sources and the remaining 5% made and bought their technology. It is interesting to notice that, despite the methodological differences, the comparison with Cassiman and Veugelers (1999) shows a different pattern of technological innovation in the Brazilian *vis a vis* the Belgian industry. In the latter case, most of firms simultaneously make and buy technology in order to innovate while in Brazil this strategy is the least used among innovative firms. Perhaps, this difference may be related to the characteristics of technological innovation in developing countries, where most of innovations are process innovations based on acquisition of embodied technology, such as machinery, rather than on in-house technological developments.

TABLE 2. INNOVATION STRATEGIES IN BRAZILIAN MANUFACTURING INDUSTRY ACCORDING TO THE INTERNATIONAL INVOLVEMENT OF FIRMS: BRAZIL, 2001-2003.

Innovation strategy	International involvement						Total	
	Foreign firms		National exporters		National non-exporters			
	number	%	number	%	number	%	number	%
No make and no buy (1)	351	41%	1,959	55%	8,882	80%	11,193	72%
Only buy (2)	43	5%	202	6%	670	6%	915	6%
Buy licenses and know how	*41*	*5%*	*163*	*5%*	*554*	*5%*	*758*	*5%*
Buy R&D	*5*	*1%*	*49*	*1%*	*148*	*1%*	*202*	*1%*
Only Make (3)	241	28%	936	26%	1,177	11%	2,355	15%
Make and buy (4)	211	25%	495	14%	343	3%	1,049	7%
Buy licenses and know how	*145*	*17%*	*312*	*9%*	*197*	*2%*	*654*	*4%*
Buy R&D	*119*	*14%*	*288*	*8%*	*171*	*2%*	*578*	*4%*
Innovative firms (1+2+3+4)	846	100%	3,592	100%	11,072	100%	15,512	100%

Source: PINTEC (2003). Components may not sum up to totals because of rounding (the weight variable is not an integer in Brazilian survey).

The innovative strategies were disaggregated according to their international involvement of Brazilian industrial firms (table 2). One can observe that, among foreign firms, the share of firms that made and bought technology is much greater than that of national firms, especially firms that are not involved in international markets. On the other hand, 41% of foreign firms did not make nor buy technology, while among national non exporting firms this share was around 80%.

TABLE 3. THE MAIN RESPONSIBLE FOR INNOVATION – NUMBER AND % OF FIRMS – ACCORDING TO THE TYPE OF INNOVATION MADE BY FIRMS: BRAZIL, 2001-2003.

The main responsible for innovation		Process innovators	%	Product innovators	%	Product and process innovators			
						product	%	process	%
		6,294	**100**	**2,625**	**100**	**6,590**	**100**	**6,590**	**100**
Own enterprise		326	5.2	2,389	91.0	5,927	89.9	458	6.9
Other enterprise of the same group	**Total**	**22**	**0.3**	**62**	**2.4**	**167**	**2.5**	**111**	**1.7**
	In Brazil	5	0.1	3	0.1	34	0.5	26	0.4
	In other countries	16	0.3	60	2.3	133	2.0	86	1.3
The enterprise in cooperation	**Total**	**92**	**1.5**	**66**	**2.5**	**254**	**3.9**	**150**	**2.3**
	In Brazil	78	1.2	52	2.0	187	2.8	87	1.3

	In other countries	15	0.2	14	0.5	67	1.0	64	1.0
Other enterprises	**Total**	**5,854**	**93.0**	**107**	**4.1**	**242**	**3.7**	**5,871**	**89.1**
	In Brazil	5,194	82.5	91	3.5	210	3.2	5,265	79.9
	In other countries	660	10.5	16	0.6	32	0.5	605	9.2

Source: PINTEC (2003). Components may not sum up to totals because of rounding (the weight variable is not an integer in Brazilian survey).

One important variable that will be used to set an indicator for the acquisition of foreign technology is related to the question about the main agent responsible for innovation in the firm. One can observe an interesting pattern with regard to this variable. Process innovations are mainly developed by other enterprises while product innovations are mainly developed by the enterprise themselves (table 3). Moreover, around 10% of process innovations are mainly developed by other enterprises outside Brazil. Finally, when the main agent responsible for innovation is another enterprise of the same group, generally this enterprise is located abroad.

Cooperation was also used as an indicator of international technology acquisition, when the cooperation partner is located abroad. Table 4 shows some indicators concerning the number of firms with cooperation and international cooperation agreements according to their international involvement.

TABLE 4. COOPERATION IN BRAZILIAN MANUFACTURING INDUSTRY ACCORDING TO THE PARTNER AND INTERNATIONAL INVOLVEMENT OF FIRMS: BRAZIL, 2001-2003.

Cooperation partners	International involvement						Total	
	Foreign firms		National exporters		National non-exporters			
	Number	%	number	%	number	%	number	%
Clients and suppliers	162	75%	283	80%	217	71%	662	76%
clients and suppliers abroad	29	13%	65	18%	12	4%	106	12%
Universities and research institutes (Science)	100	47%	192	54%	79	26%	371	42%
science abroad	2	1%	3	1%	6	2%	11	1%
Competitors	26	12%	55	15%	16	5%	97	11%
competitors abroad	2	1%	13	4%	1	0%	16	2%
Intra group	165	77%	71	20%	19	6%	255	29%
intra group abroad	154	72%	22	6%	3	1%	179	20%
International cooperation	162	75%	91	26%	21	7%	274	31%
Firms with cooperation agreements	215	100%	355	100%	304	100%	874	100%
% of innovative firms	25%		10%		3%		6%	

Source: PINTEC (2003). Components may not sum up to totals because of rounding (the weight variable is not an integer in Brazilian survey).

The first relevant information from table 4 is related to the share of firms that cooperate to innovate. Cooperation is more important to foreign firms than to local firms in Brazilian industry. Around 25% of foreign firms had, in the period 2001-2003, some kind of cooperation agreements in order to innovate and 75% of these firms had agreements with partners in other countries. Most of the international agreements of foreign companies were intra-group agreements, which means that headquarters or other subsidiaries of the same group are an important source of technology to these companies.

Regarding national firms, cooperation is a much less relevant activity. Only 10% of national exporters and 3% of national non-exporters had cooperation agreements. National exporters were more cooperative than non-exporters and they had more international partners than the latter.

Cooperation indicates how important foreign technology is to innovative firms in Brazil. However, there is another indicator that may be as important as cooperation. This indicator refers to the importance of several sources of information to innovation. As we have stressed before, there is a question in the Brazilian Survey about the location of information sourcers considered highly important by the innovative firm. Table 5 shows some results from the Brazilian Survey, again according to the international involvement of firms.

TABLE 5. SOURCES OF INFORMATION CLASSIFIED AS HIGHLY IMPORTANT BY BRAZILIAN MANUFACTURING FIRMS BY INTERNATIONAL INVOLVEMENT OF FIRMS: BRAZIL, 2001-2003.

Source of information classified as highly important by the firm	International involvement						Total	
	Foreign firms		National exporters		National non-exporters			
	number	%	number	%	number	%	number	%
Internal sources	538	64%	2,370	66%	5,608	51%	8,516	55%
Other enterprise of the same group	524	62%	225	6%	236	2%	985	6%
Group abroad	506	60%	92	3%	10	0%	608	4%
Clients and suppliers	550	65%	2,482	69%	7,090	64%	10,122	65%
clients and suppliers abroad	167	20%	514	14%	343	3%	1,024	7%
Competitors	145	17%	948	26%	2,788	25%	3,881	25%
competitors abroad	37	4%	158	4%	102	1%	297	2%
Universities and research institutes (Science)	173	20%	681	19%	1,453	13%	2,307	15%
science abroad	28	3%	22	1%	18	0%	68	0%
Conferences, publications, fairs (Ginfo)	303	36%	2,148	60%	5,166	47%	7,617	49%
ginfo abroad	149	18%	685	19%	488	4%	1,322	9%
International sources of information	598	71%	1,063	30%	812	7%	2,473	16%
Innovative firms	846	100%	3,592	100%	11,072	100%	15,512	100%

Source: PINTEC (2003). Components may not sum up to totals because of rounding (the weight variable is not an integer number in Brazilian survey).

First of all, the last two lines in the table show the share of innovative firms which declared that international sources of information were highly important for innovation. One can see that most of foreign firms (71%) considered these sources highly important, while just 16% of the Brazilian industrial firms declared the same: 30% of national exporters and 7% of national non-exporters.

The most relevant international source of information for foreign companies was another enterprise of the same group, followed by clients and suppliers. With respect to national firms, publications and participation in conferences and fairs were the most important international source of knowledge. For national exporters clients and suppliers were also relevant.

Finally, we can see in table 6, a synthesis of the results concerning the number of firms which acquired technology from sources abroad. First of all, we can observe that foreign companies are

much more innovative than national ones. 60% of foreign enterprises developed some kind of innovation in the period 2001-2003 while the average of the whole Brazilian industry is around 36% of innovative firms related to total. We can also observe that national exporters are closer to foreign companies than to national non-exporters in terms of innovation and international search for technology, despite the share of national exporters (17%) that acquired technology abroad is much less than the share of the foreign ones (47%). However, maybe the most preeminent difference between national and foreign firms is related to international cooperation. The share of national firms, even exporting ones, which had cooperation agreements with international partners is insignificant: around 1% of firms. On the other hand, 11% of foreign companies had international cooperation agreements in the period under analysis.

TABLE 6. NUMBER OF FIRMS ACCORDING TO THEIR INTERNATIONAL TECHNOLOGICAL SEARCH AND INTERNATIONAL INVOLVEMENT: BRAZIL, 2001-2003.

Type of firm	International involvement						Total	
	Foreign firms		National exporters		National non-exporters			
	number	%	number	%	number	%	number	%
Whole sample	1,420	100%	7,443	100%	34,732	100%	43,595	100%
Innovative firms	846	60%	3,592	48%	11,072	32%	15,510	36%
Firms with international cooperation agreements	162	11%	91	1%	21	0%	274	1%
Firms that declare International sources of information as high important to innovate	598	42%	1,063	14%	812	2%	2,473	6%
Firms that acquire technology abroad	666	47%	1,268	17%	1,022	3%	2,956	7%

Source: PINTEC (2003). Components may not sum up to totals because of rounding (the weight variable is not an integer in Brazilian survey).

After this preliminary description of the database, it is relevant to acknowledge some characteristics of Brazilian firms, according their international involvement and to the use of foreign sources of technology and knowledge. That is the subject of the next section.

2.2 Characteristics of firms

We chose some relevant indicators to analyze Brazilian industrial firms. First of all, it's important to stress that these indicators were calculated only for innovative firms. The reason is that we are concerned with the decision to search for technology internationally and the impact therein on the performance of these firms. Since the search of technology abroad is a feature of innovative firms or of firms with some kind of innovative activity, we decided to show the selected indicators only for this group of firms.

There are two variables that measure these firms' sizes: total turnover (US$) and number of employees, both in 2003. One can see that among innovative firms the foreign ones are on average larger than national firms and, among national innovative firms, those that export are in turn larger than non-exporters.

There are also some indicators related to the technological efforts of Brazilian industrial firms. The first of them is the total innovative expenditures as a share of the turnover in 2003. It's interesting to notice that this indicator goes in the opposite direction of the size of the firm, that is, foreign firms spent on average less in innovative activities (4.41% of their turnover) than the national exporting firms (7.57% of their turnover) and, in turn, the latter spent less than the national non-exporting ones (11.78%). However, the absolute value of innovative expenditures among foreign firms is greater than among the national ones. On average, foreign firms spent in 2003 more than US$ 3.25 million in innovative activities, while national exporters spent about US$ 812 thousand, and national non-exporters only US$ 65 thousand. The same ordering is also verified when it comes to the R&D expenditures of the firms.

TABLE 7. SELECTED INDICATORS OF THE INNOVATIVE FIRMS ACCORDING TO THEIR INTERNATIONAL INVOLVEMENT: BRAZIL, 2003.

Indicators (mean by firm)	International involvement			Total
	Foreign firms	National exporters	National non-exporters	
Total turnover (in US$)	100,020,514	31,155,855	2,239,446	14,266,271
Number of employees	733	379	69	177
Total innovation expenditure (in US$)	3,366,181	803,844	68,436	418,515
R&D expenditure (in R$)	985,920	246,403	8,182	116,649
Total innovation expenditure (% of turnover)	4.41	7.57	11.78	10.21
Intra and extramural R&D expenditure (% of turnover)	1.28	2.8	4.38	3.3
Acquisition of other external knowledge (% of turnover)	0.64	1.68	1.9	1.66
Acquisition of machinery and equipment (% of turnover)	3.4	6.21	11.27	9.51
Employees with higher education	217	57	6	29
Persons involved in intramural R&D activities	30	17	5	14
% of turnover of new or improved products (turning)	20.6	16.6	24.5	22.4
% of turnover of new or improved products to the market (turnmar)	5.8	2.5	0.8	1.5

Source: PINTEC (2003)

The number of employees with higher education and that of employees involved in R&D activities are also greater among foreign companies. There are, on average, around 217 employees with higher education and 30 specialists involved in intramural R&D activities in foreign companies. In the case of the national exporters, the number of employees with higher educations decreases to 57 and that of specialists involved in R&D activities falls to 17.

Finally, the share of the turnover derived from new products or from new products to the market is an indicator of the output of innovative activities. It's worthy to stress that this share takes into account only the revenues derived from the domestic market. The share of revenues from new

products is around 20% for foreign firms, 17% for the domestic exporting ones and 24% for domestic non-exporting firms. Regarding the share of revenues derived from new products to the market, it is larger in foreign companies than in national ones, suggesting that the formers introduce more new products in the domestic market than national companies.

The same indicators from table 7 were disaggregated according to cooperation agreements and according to the use, in some way, of knowledge from abroad in order to innovate. Such results are showed in table 8.

Regarding cooperation, firms that cooperated to innovate are, on average, larger than firms which did not. There were few innovative firms with international cooperation agreements (274 according to table 6) and these firms are much larger than the rest of Brazilian industrial firms: they employed, on average, more than 2,000 employees and their turnover was around US$ 300 million. Moreover, their expenditures in innovative activities were around 38 times the average of the whole industry (table 7) and the R&D expenditures of these firms are around US$ 5 million, whilst the average of the whole Brazilian industry is near US$ 130 thousand. However, perhaps due to their size, the innovative expenditures of the firms which had cooperated to innovate corresponded to a lower share of their turnover than that of the firms with no international cooperation. The same happened to others technological expenditures as R&D, machinery and acquisition of external knowledge.

TABLE 8. SELECTED INDICATORS OF INNOVATIVE FIRMS ACCORDINGO TO THE INVOLVEMENT IN COOPERATION AGREEMENTS AND INTERNATIONAL TECHNOLOGICAL SEARCH: BRAZIL, 2001-2003.

Indicators (means by firm)	Firms by cooperation			International technological search	
	no	yes	international cooperation	no	Yes
Total turnover (in US$)	6,396,832	63,201,644	363,643,383	4,304,026	174,103,126
Number of employees	123	751	2097	102	495
Total innovation expenditure (in US$)	178,158	1,276,568	12,470,183	102,158	1,761,988
R&D expenditures (in US$)	27,327	297,149	4,895,487	16,349	542,593
Total innovation expenditure (% of turnover)	10.4	8.2	5.1	10.64	8.54
Intra and extramural R&D expenditure (% of turnover)	3.6	2.1	1.6	3.94	2.08
Acquisition of other external knowledge (% of turnover)	1.9	0.8	0.5	1.6	1.77
Acquisition of machinery and equipment (% of turnover)	9.9	3.5	2.5	10.19	6.84
Employees with higher education	16	138	584	11	108
Persons involved in intramural R&D activities	7	19	83	6	27
% of turnover of new or improved products (turning)	22.6	16.8	24.1	24.0	15.6
% of turnover of new or improved products to the market (turnmar)	1.2	5.3	10.7	1.0	3.7

Source: PINTEC (2003)

The number of employees involved in R&D activities and that of those with higher education were also greater in firms with international cooperation agreements and in firms with some cooperation agreement on the national level than in firms which lacked such cooperation. One may suggest that cooperation improves the results of innovative activities, based on the share of revenue derived from new products and new products to the market. Both output indicators are greater in firms with international cooperation agreements than in other types of firms. Notwithstanding, the share of the revenue derived from new products which were not new to the market is lower in firms with some kind of cooperation agreement than in firms with no cooperation, perhaps, again, due to their size.

Finally, regarding international technological search, the results are very similar. Firms that used sources of knowledge abroad are larger than those which did not use them, and also spent more in innovative activities. However, the share of these expenditures in their turnover is lower than in firms with no international search for technology, suggesting that these two activities (foreign technology acquisition and internal R&D expenditures) may not be complementary.

Despite the fact that these preliminary results showed some interesting features about the use of international sources of technology in Brazilian industry, there are some questions that need to be investigated. The econometric strategy developed in our study aims to answer 3 basic questions:

(i) Which factors determine international technology acquisition (or search) and international cooperation?

(ii) What are the effects of international technology acquisition and cooperation on R&D spending? Or, alternatively, are there complementarities or substitution effects between intramural technological efforts and international technological acquisition?

(iii) What are the effects of international technology acquisition and cooperation for innovation on the turnover derived from a new product?

3 PRELIMINARY ECONOMETRIC RESULTS

We employed two-stage Heckit in our estimates in order to deal with the selection bias imposed by the questionnaire. The selection bias derives from the fact that only innovative firms answer the parts of the questionnaire which we are especially interested in. In some cases, truncating the missing values to zeros may be misleading. A good example is the variables related to the hampering factors for innovation. Attributing zero to non-innovative firms in these variables may be misleading because zero means no difficulty to innovate. In other words, the hampering factors to innovate can only be correctly assessed by those firms which effectively innovated or tried to do so.

We preferred Heckit estimates rather than other alternatives such as Tobit estimates because the Heckit modeling strategy allows the researcher to set different covariates to each stage of the estimation. For instance, when one analyses the R&D spending of firms it is possible to notice a great number of zero values and a share of firms having positive R&D spending. The zero values are a result of firm's decisions of investing or not in R&D. So, it is necessary to model this investment decision due to the non randomness of it. According to Maddala (1992), when "(…) *the observed zero values are due not to censoring, but due to the decisions of individuals (…) the appropriate procedure would be to model the decisions that produce the zero observations rather than use the Tobit model mechanically*" (Maddala, 1992).

In each of the following subsections we detail our results.

3.1 Which factors determine international technology acquisition (search) and international cooperation?

In order to tackle this question, we followed two different approaches: (i) in the first approach, we estimated a Heckit model for innovation (first stage) and for the international technological search (second stage) and, (ii) in the second approach, we estimated a bivariate Probit for national or international cooperation in the second stage of the Heckit model. The main feature of the second approach is that the bivariate Probit modeling not only accounts for the isolated probabilities of cooperating in the national and international levels, but also for the joint probability of cooperating in both levels. The dependent variable was already defined in section 1.6.

TABLE 9. SELECTION EQUATION: PROBIT MODEL FOR FIRM INNOVATION, BRAZIL: 2001-2003.

Dependent variable: innovate X not innovate			
Explanatory variables	**Coefficient**	**Std**	
Intercept	-0.523	0.019	***
Foreign firm	0.058	0.040	ns
Export firm (lagged)	0.199	0.019	***
Share of employees with higher education	0.346	0.060	***
Market share	0.089	0.024	***
Size 2: number of employees in [100 ; 250)	0.206	0.021	***
Size 3: [250 ; 500)	0.242	0.034	***
Size 4: [500; 1000)	0.745	0.051	***
Size 5: [1000; 2000)	0.865	0.078	***
Size 6: >=2000 employees	0.999	0.106	***
Number of observations	8,687(not weighted)	43,277 (weighted)	
Log likelihood	-27,012		

Source: PINTEC (2003). Obs. Industrial dummies (NACE – 2 digits) not reported.

Table 9 shows the results of the Probit selection equation that models the innovation decision in the period 2001-2003. The explanatory variables are: i) a dummy for foreign firms; ii) a lagged dummy for exporting firms; iii) the share of employees with higher education; iv) the market share of firms calculated on the NACE 2-digits industrial level and; v) 5 size dummies based on the

number of employees. The results were coherent with other previous papers about innovation in the Brazilian industry, and the only non-significant variable was the foreign firm dummy.

This is the selection equation for both the Probit model for a firm to acquire technology abroad and for the bivariate Probit model for a firm to cooperate and to cooperate internationally. In both second stage models, we have avoided the selection bias by adding the Mill's inverse ratio (obtained in the selection equation) to the explanatory variables. Based on the Probit model, the estimates of the Mill's inverse ratio are obtained for each innovative firms from the sample as shown by:

$$\lambda_{i1}(Z_i\gamma) = \frac{\phi(Z_i\gamma)}{\Phi(Z_i\gamma)}$$

where $\phi(.)$ is the density function and $\Phi(.)$ is the cumulative distribution function of the standard normal distribution N(0, 1). Therefore, the Mill's inverse ratio works as an instrument to correct the selection bias in the second stage, estimated only for innovative firms.

TABLE 10. PROBIT MODEL WITH CORRECTION FOR SELECTION BIAS FOR A FIRM TO ACQUIRE TECHNOLOGY ABROAD: ONLY INNOVATIVE FIRMS IN BRAZILIAN INDUSTRY, 2001-2003.

Explanatory variables	Model 1			Model 2		
	Coef.	Std		Coef.	Std	
Intercept	-0.56	0.34	***	-2.41	0.33	***
Size (log of number of employees)	0.37	0.08	***	0.36	0.08	***
Size²	-0.01	0.01	Ns	-0.01	0.01	ns
Foreign firm	1.20	0.06	***	1.01	0.06	***
Export firm (lagged)	0.39	0.05	***	0.40	0.05	***
Firm with public funding of innovation	-0.02	0.03	Ns	0.01	0.04	ns
Share of employees with higher education	0.84	0.13	***	0.90	0.13	***
Hampering factors for innovation:						
High Costs	0.18	0.03	***	0.20	0.03	***
Qualified personnel	-0.06	0.05	ns	-0.04	0.05	ns
Information	0.13	0.05	**	0.15	0.05	***
Customer responsiveness	0.07	0.07	ns	0.08	0.07	ns
Sources of information:						
Internal sources	0.06	0.03	*	-	-	
Link (competitors, clients and suppliers)	0.16	0.03	***	-	-	
Research/Science	0.06	0.04	ns	-	-	
Others	0.57	0.03	***	-	-	
Innovation strategy:						
Only make	-0.04	0.04	ns	-0.04	0.04	ns
Only buy	0.00	0.06	ns	0.03	0.05	ns
Make and buy	0.21	0.05	***	0.22	0.05	***
Lambda (Mill's inverse ratio)	-0.56	0.26	**	-0.58	0.25	**
Number of firms (weighted)	15,489					
Firms that acquire technology abroad (weighted)	2,951					
Log likelihood						

Source: PINTEC (2003). Obs. Industrial dummies (NACE – 2 digits) not reported.

Table 10 presents the results of the Probit estimation for a firm to acquire technology abroad in the period 2001-2003. In the above equation the variables size, share of employees with higher education and public funding may be considered controls, since we are interested in factors like international involvement and innovation strategy and their impact on the international technology search.

Particular attention must be paid to the variables related to the international involvement of the firms, namely, the exporting firm and the foreign firm dummies. One can see that the involvement in international markets, through foreign direct investment or trade, have positive effects on the likelihood of searching technology abroad.

Regarding cooperation, table 11 presents the results of the bivariate Probit model, using the same variables of the previous equation. We can see that foreign firms and exporting ones are more likely to have cooperation agreements to innovate. However, contrary to what has been observed in terms of the international technology search, exporting firms are not more likely to have international cooperation agreements. The foreign firm dummy, in turn, had a positive impact on international cooperation.

TABLE 11. BIVARIATE PROBIT MODEL WITH CORRECTION FOR SELECTION BIAS FOR A FIRM TO COOPERATE AND TO COOPERATE INTERNATIONALLY: ONLY INNOVATIVE FIRMS IN BRAZILIAN INDUSTRY, 2001-2003.

Explanatory variables	Cooperation			International Cooperation		
	Coef.	Std		Coef.	Std	
Size (log of number of employees)	-0.262	0.11	**	0.590	0.09	ns
Firm with public funding of innovation	0.339	0.11	***	0.286	0.12	**
Foreign firm	0.179	0.11	*	0.899	0.12	***
Export firm (lagged)	-0.381	0.14	***	-0.025	0.16	ns
Share of employees with higher education	-0.299	0.23	ns	0.590	0.28	ns
Innovation strategy						
Only buy	0.351	0.26	ns	0.070	0.31	ns
Only make	0.373	0.12	***	0.210	0.21	ns
Make and buy	0.904	0.13	***	0.680	0.19	***
Hampering factors for innovation						
High Costs	0.051	0.11	ns	0.430	0.12	ns
Qualified personnel	0.007	0.18	ns	-0.359	0.26	ns
Information	0.374	0.16	**	0.641	0.30	**
Customer responsiveness	0.217	0.30	ns	0.048	0.29	ns
Sources of information						
Internal sources	0.168	0.12	ns	0.020	0.18	ns
Link (competitors, clients and suppliers)	0.159	0.11	ns	0.240	0.13	*
Research/Science	0.399	0.12	***	0.270	0.13	**
Others	-0.077	0.09	ns	-0.063	0.10	ns
Lambda (Mill's inverse ratio)	-3.879	0.64	***	-2.230	0.61	***
Rho	14.660	6.22	**			
Number of firms (weighted)	15,489					
Firms that cooperate						
Firms that cooperate internationally						
Log likelihood						

Source: PINTEC (2003). Obs. Industrial dummies (NACE – 2 digits) not reported.

We are also especially interested in the impact of the "Buy only", "Make only" and "Make and buy" strategies on international cooperation. In both equations of direct interest (shown in tables 10 and 11, respectively), the adoption of the "make and buy" strategy seemed to be a boosting factor for international cooperation in Brazilian industrial firms. Alternatively, neither the "make only" nor the "buy only" strategies showed to be significant determinants of the probability of international cooperation. Brazilian firms which followed the "make only" strategy sought for cooperation only on the national level, according to the national cooperation equation depicted in table 3.

It is worthy to notice that some hampering factors for innovation served as motives for the international search for technology. Indeed, the lack of information for innovation showed to be significant in all estimates. Similarly, high importance attributed to some sources of information also seemed to be an important factor for the probability of searching for international cooperation, especially when it comes to the research/science source. Finally, the significance of the lambda indicates that estimates without the Mill's inverse ration correction are inconsistent because of the selection bias.

3.2 What are the effects of international technology acquisition and cooperation on R&D spending?

In order to estimate the impact of international cooperation on R&D expenditures of Brazilian firms (or, alternatively, the complementarities or substitution effects between intramural technological efforts and international technological acquisition) we also used the Heckit strategy and two equations in the second stage. The first stage Probit is shown in table 12.

TABLE 12. SELECTION EQUATION: PROBIT MODEL FOR A FIRM TO SPEND IN R&D, BRAZIL: 2003.

Dependent variable: to spend in R&D or not		
Explanatory variables	**Coefficient**	**Std**
Intercept	-1.95	0.03 ***
Foreign firm	-0.22	0.05 ***
Export firm (lagged)	0.33	0.02 ***
Share of employees with higher education	0.97	0.07 ***
Market share	0.18	0.04 ***
Size 2: number of employees in [100 ; 250)	0.34	0.03 ***
Size 3: [250 ; 500)	0.52	0.04 ***
Size 4: [500; 1000)	1.29	0.05 ***
Size 5: [1000; 2000)	1.50	0.08 ***
Size 6: >=2000 employees	1.53	0.11 ***
Number of observations	8,687	43,277 (weighted)
Log likelihood	-9,547	

Source: PINTEC (2003). Obs. Industrial dummies (NACE – 2 digits) not reported.

In the second stage there were two equations for R&D spending of Brazilian industrial firms (table 13). In the first equation, the dependent variable is the log of the total R&D spending, whilst in the second equation the dependent variable is the log of the R&D/turnover ratio.

TABLE 13. OLS MODEL WITH CORRECTION FOR SELECTION BIAS FOR R&D SPENDING OF BRAZILIAN INDUSTRIAL FIRMS: ONLY FIRMS WITH POSITIVE R&D SPENDING, 2003.

Explanatory variable	Model 1			Model 2		
	Dependent variable: Log of internal R&D spending			Dependent variable: Log of internal R&D spending / turnover		
	Coef.	Std		Coef.	Std	
Intercepto	7.23	0.70	***	-3.13	0.78	***
Size (log of number of employees)	0.55	0.15	***	-1.22	0.17	***
Size²	0.01	0.01	ns	0.08	0.02	***
Foreign firm	0.21	0.11	*	-0.38	0.12	***
Market share	0.07	0.02	***	0.01	0.02	ns
Export firm (lagged)	0.28	0.09	***	0.10	0.10	***
Firm with public funding of innovation	0.38	0.07	***	0.14	0.08	*
Share of employees with higher education	1.73	0.22	***	0.21	0.25	ns
Firm that acquire technology from foreign sources	0.44	0.07	***	0.12	0.08	ns
Firm that cooperate to innovate	0.28	0.09	***	0.16	0.10	ns
Lambda	0.15	0.21	ns	0.69	0.24	***
R2 adj	0.57			0.36		
F	70.02	***		30.44	***	
N	1627			1623		

Source: PINTEC (2003). Obs. Industrial dummies (NACE – 2 digits) not reported; the number of firms in the two models are different because of the lack of information about turnover for four firms.

We are especially interested in the effects of both cooperation and the search for technology internationally on the R&D effort of firms. According to the equations shown in table 13, there's no trade-off between technological acquisition from foreign sources and intramural R&D. In fact, technology acquisition on the international level positively influenced the level of R&D spending. However, when it comes to the innovative effort measured by the R&D/turnover ratio, international acquisition of technology did not show to be a relevant factor. The same pattern was observed regarding cooperation for innovation.

It is worthy to notice that the Mill's inverse ratio is significant in the second equation but not in the first one, suggesting that selection bias is an issue to be considered in the R&D/turnover ratio but not in the level of R&D.

3.3 What are the effects of international technology acquisition and cooperation on innovation?

Lastly, are Brazilian firms that acquire technology internationally able to make more money from the innovative product than the innovative firms that do not? We assessed this issue by, again, estimating a Heckit model with two equations in the second stage. The first stage, in this case, is a Probit model for a firm that has developed new products in opposition to firms that have not

innovated or that have developed only new productive processes. The results of the Probit are exposed in table 14.

TABLE 14. SELECTION EQUATION: PROBIT MODEL FOR A FIRM TO INNOVATE IN PRODUCT, BRAZIL: 2001-2003.

Dependent variable: innovate in product or not			
Explanatory variables	**Coefficient**	**Std**	
Intercept	-0.990	0.020	***
Foreign firm	0.058	0.040	ns
Export firm (lagged)	0.139	0.019	***
Share of employees with higher education	0.572	0.061	***
Market share	0.099	0.023	***
Size 2: number of employees in [100 ; 250)	0.099	0.022	***
Size 3: [250 ; 500)	0.121	0.036	***
Size 4: [500; 1000)	0.646	0.049	***
Size 5: [1000; 2000)	0.798	0.073	***
Size 6: >=2000 employees	0.955	0.100	***
Number of observations	8,687	43,277 (weighted)	
Product innovators	9,199 (weighted)		
Log likelihood	-21,007		

Source: PINTEC (2003). Obs. Industrial dummies (NACE – 2 digits) not reported.

In the first equation of the second stage, the dependent variable was the share of the new product in the total turnover, whilst in the second equation the dependent variable was the share of new products that are new to the market in the total turnover. These variables correspond to the *turnin* and *turnmar* variables in the CIS questionnaire, respectively.

TABLE 15. OLS MODEL WITH CORRECTION FOR SELECTION BIAS FOR SHARE OF NEW PRODUCTS IN TURNOVER OF BRAZILIAN INDUSTRIAL FIRMS: ONLY PRODUCT INNOVATORS, 2001-2003.

	Share of new products			Share of new products to the market		
Intercepto	0.399	0.174	**	0.127	0.048	***
Size (log of number of employees)	-0.135	0.047	***	-0.020	0.013	ns
Size²	0.012	0.005	**	0.002	0.002	ns
Foreign firm	0.149	0.033	***	0.007	0.009	ns
Market share	0.012	0.006	*	0.002	0.002	ns
Export firm (lagged)	-0.113	0.022	***	0.000	0.006	ns
Firm with public funding of innovation	0.011	0.018	ns	0.002	0.005	ns
Share of employees with higher education	0.001	0.075	ns	0.033	0.021	ns
Firm that acquire technology from foreign sources	-0.072	0.020	***	0.020	0.006	***
Firm that cooperate to innovate	-0.059	0.028	**	0.025	0.008	***
Lambda	0.184	0.122	ns	-0.047	0.030	ns
R2 adj	0.15			0.08		
F	15.53	***		8.01	***	
N	2459			2459		

Source: PINTEC (2003). Obs. Industrial dummies (NACE – 2 digits) not reported.

It is very interesting to notice that international acquisition of technology, as well as cooperation for innovation, are only important to raise the share of the new products that are new to the market. When one considers solely the share of the new product, regardless or whether it is new to the market or for the firm only, both variables seemed to have a negative impact. These results suggest that international acquisition of technology and cooperation to innovate are important factors only for innovative firms that are committed with a higher degree of innovativeness.