R&D Cooperation Between Firms and Universities: Some Quantitative and Qualitative Evidences from Brazilian Manufacturing. [1]

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The focus of this article is twofold. First, the econometric analysis draws a picture highlighting the main determinants that lead Brazilian manufacturing firms to undertake R&D and search for cooperation with universities. Second, the qualitative analysis narrows the focus presenting the views of entrepreneurs on these matters.

The econometric analysis aims to identify the determinants of firms´ decision to engage in R&D, intramural and through cooperation with universities and other research centers. It follows Piga and Vareli (2004) approach that jointly estimates the determinants of these two decisions through a bivariate probit model with censoring setting. The dataset used combines information, at a micro level of the main Brazilian industrial surveys: Brazilian Technological and Innovation Survey, for the period of 2001-2003, Annual Industrial Survey 2003, Foreign Trade Census of the Foreign Trade Secretary and Foreign Capital Census of the Brazilian Central Bank.

Its qualitative analysis attempts to answer the question of how entrepreneurs view and assessed the experiences of cooperation their firms went through. This is based on data from a qualitative research, carried out with a sample of entrepreneurs, and designed to capture their perspectives on a series of dimensions considered relevant for paving the way towards sustainable innovation in the firm.

In the econometric analysis the sample is restricted to manufacturing firms with more than 30 or more employees. In this sample there are 7537 firms (weighted total is 27634 firms), of which 1597 (weighted total is 3136 firms) declared itself to be engaged in any R&D activity during 2001-2003. Among these 1597 firms, only 190 (weighted total is 240) cooperated with universities in R&D activities.

Regarding to the decision to engage in R&D, the main results are:

- The variables ‘market share’, ‘size’, ‘market share of imported goods’ are all positive and significant variables.

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- The variables ‘scope’ and ‘international market’ are not a significant variable.

Regarding to the decision to engage in external cooperation in R&D with universities, the main results are:

- The variables ‘potential R&D intensity’, ‘group’ and ‘public subsidies’ are all positive and significant variables.
- The variable ‘size’ and ‘scope’ are not significant variables.

Regarding to sectoral dummies, firms from textile and leather sector have lower propensity to undertake R&D. However, firms from this sector are more likely to cooperate with university.

The qualitative research was based in depth interviews with 109 top national industrial entrepreneurs. This constitutes a representative sample of entrepreneurs of national manufacturing firms considered innovative or with a potential to innovate. The analysis of the interviews reveals that the importance of promoting internal R&D activities is acknowledged practically by all entrepreneurs. Most of the firms declared to have a R&D department since initial years of the firms. However it is observed that the size and nature of the activities developed in these R&D varies a great deal, depending not only in the size and sector of the firm, but also of the understanding of innovation. Regarding the latter it was observed that:

- When innovation was understood, by the entrepreneur or the group he represents, as an effort of producing new product to the market, the firms´ R&D department is structured as business unit with specific budget and qualified full time staff.
- Innovation used in a more loose sense, as improvement of processes or quality improvements R&D activities of the firm are usually linked to the production process or an external firm is hired to develop the product.

The interviews show a rather blurred picture when the issue was on R&D and Cooperation with Universities. At first sight one gets impressed by the proportion (73%) of entrepreneurs that reported their firms to cooperate with universities or research centers. However a closer look at the interviews reveals that cooperation is taken in a rather loose way. In fact most (57%) of this cooperation is occasional and oriented to solve specific problems, to test material or improve processes. Cooperation in a more permanent basis that could lead to information flow and knowledge integration between firms and universities was reported by 42% of the interviewees. The main reasons presented by those entrepreneurs whose firms had experienced only occasional or no cooperation at all with universities are as follows: the different pace of the work in the firm and academic world, the bureaucratic constrains to be faced when dealing with public institutions such as Brazilian universities and the different logic underlying the academic practices and the business world.

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APPENDIX 1 : Econometric Analysis

Methodology

The econometric specification follows Piga and Varelli (2004) approach by adopting a bivariate probit model with censoring setting.

In the model, there are two binary dependent variables denoted by ‘R&D’ and ‘Coop.Univ’. The variable ‘R&D’ indicates whether a firm has declared itself to be engaged in any R&D activity during 2001-2003 period or not. The variable ‘Coop.Univ’ indicates whether a firm has conducted R&D cooperation with universities during 2001-2003, or not. ‘Coop.Univ’ is only observed when a firm has indeed declared engagement in R&D, i.e. when ‘R&D’=1.

The model can be described formally as follows:

$$R\&D_i^* = \beta_1 x_{i1} + \varepsilon_{i1}, \quad R\&D_i = 1 \quad if \quad R\&D_i^* > 0 \quad ,0 \quad otherwise.$$
$$CoopUniv_i^* = \beta_2 x_{i2} + \varepsilon_{i2}, \quad CoopUniv_i = 1 \quad if \quad CoopUniv_i^* > 0 \quad ,0 \quad otherwise.$$
$$(\varepsilon_1, \varepsilon_2) \sim BVN(0,0,1,1,\rho)$$
$$(CoopUniv_i, x_{i2}) \quad is \quad observed \quad only \quad when \quad R\&D_i = 1.$$

Below, the log-likelihood function that emerges from this model:

$$L_{ss} = \sum_{R\&D_i=1, CoopUniv_i=1} \ln(\Phi[\beta_1 x_{i1}, \beta_2 x_{i2}, \rho]) + \sum_{R\&D_i=1, CoopUniv_i=0} \ln(\Phi[\beta_1 x_{i1}, -\beta_2 x_{i2}, -\rho])$$
$$+ \sum_{R\&D_i=0} \ln(1 - \Phi_1[\beta_1 x_{i1}])$$

Where Φ denotes the normal bivariate cumulative distribution function with $\rho = \mathrm{cov}(\varepsilon_{i1}, \varepsilon_{i2})$ and Φ_1 denotes standard normal cumulative distributions function.

TABLE 1
The Explanatory Variables of the R&D Equation.

Variable	Proxy for	Definition	Expected sign
Size	Economy of scale.	Natural log of total of net sales revenue.	+
Scope	Economy of scope.	Level of firm product diversification. $Scope = \frac{1}{\sqrt{\sum_{i=1}^{3} s_i^2}}$ Where s_i represents the percentage of total sales from product category i.	+
Market Share	Market power.	Firm domestic market share. $MarketShare = \frac{R_i}{TR_i + IMP_i}$ Where R_i denotes firm i total gross domestic sale revenue, TR_i sum of total gross domestic sale revenue of all firms of the same sectoral activity of firm i and IMP_i denotes the value of all imported goods related with the same sectoral activity of firm i.	+
International Market	Competitive pressure.	Dummy variable that indicates whether the main market of the firm is the international one.	+
Market Share of Imported Goods	Competitive pressure.	Market share of imported goods. $MarketShare\_Ext = \frac{IMP_i}{TR_i + IMP_i}$ Where IMP_i denotes the total gross sales revenue of all imported goods related with the sectoral activity of firm i and TR_i sum of total gross sale revenue of all domestic firms of the same sectoral activity of firm i.	+
Regional dummies	Cross-sectional variation in technological opportunity available to firms in their geographical area.	Four dummies for Brazilian macro regions.	
Sectoral dummies	Cross-sectional variation in technological trajectories whose characteristics are common among firms belonging to different sectors.	Ten dummies for sectoral industry classification (namely CNAE code).	

TABLE 2
The Explanatory Variables of R&D Cooperation Equation.

Variable	Proxy for	Definition	Expected sign
Size	Economy of scale.	Natural log of total of net sales revenue.	+
Scope	Economy of scope.	Level of firm product diversification. $Scope = \frac{1}{\sqrt{\sum_{i=1}^{3} s_i^2}}$ Where s_i represents the percentage of total sales from product category i.[5]	+
R&D Intensity	Absorption capacity.	Firm total internal R&D expenditure per employee.	+
Group	Absorption capacity.	Dummy variable that indicates whether the firm belongs to a group.	+
Public Subsidies	Government financial subsidy for technological innovation.	Binary variable that indicates whether a firm receive government financial subsidy for technological innovation.	+
Regional dummies	Cross-sectional variation in technological opportunity available to firms in their geographical area.	Four dummies for Brazilian macro regions.	
Sectoral dummies	Cross-sectional variation in technological trajectories whose characteristics are common among firms belonging to different sectors.	Ten dummies for sectoral industry classification (namely CNAE code).	

[5] Notice that the minimum value of this index is 1, when the total sales of a firm comes from a single product.

Table 3
Descriptive Statistics for Selected Variables According to Different Sample Restrictions [a]

Variables	All Firms (n=27634)		Firms with R&D Activities (n=3136)		Firms with R&D Cooperation Agreement with Universities (n=240)	
	Mean	SD	Mean	SD	Mean	SD
Net sales revenue (R$ 10^6)	31.75	969.05	177.26	2081.33	1089.08	5714.96
Number of Employee	155.44	1157.26	529.50	2227.14	2008.81	4506.75
R&D (R$ 10^6)	0.20	12.80	1.80	27.72	13.17	75.79
Internal R&D (R$ 10^6)	0.18	11.24	1.58	24.33	11.28	65.84
External R&D (R$ 10^6)	0.02	2.02	0.22	4.38	1.89	11.43
R&D / Net sales revenue	0.54%	0.37	4.70%	0.80	2.22%	0.04
Internal R&D / Net sales revenue	0.51%	0.37	4.50%	0.80	1.90%	0.03
External R&D / Net sales revenue	0.03%	0.01	0.20%	0.02	0.29%	0.01
Foreign Capital	0.03	0.28	0.08	0.37	0.13	0.35
Group	0.07	0.48	0.18	0.53	0.44	0.56
Public Subsidies	0.004	0.062	0.028	0.229	0.190	0.442
Scope	1.30	2.54	1.39	2.21	1.24	1,77
Market Share	0.01	0.07	0.03	0.11	0.10	0.17
International Market	0.05	0.42	0.07	0.39	0.10	0.34
Market Share of Imported Goods	0.07	0.21	0.13	0.20	0.17	0.20

[a] Weighted numbers.

Table 4
Bivariate Probit Estimates with Sample Selection

	R&D			CoopUniv		
Variables	Parameter	SE	P value	Parameter	SE	P value
Market Share	1.275	0.274	0.0001			
International Market	-0.062	0.049	0.2061			
Market Share of Imported Goods	0.440	0.106	0.0001			
Scope	0.004	0.007	0.5553	-0.013	0.021	0.5380
Constant	-5.953	0.139	0.0001	-3.001	2.228	0.1780
Size	0.287	0.007	0.0001	0.106	0.092	0.2512
North	-0.376	0.109	0.0060	-0.552	0.422	0.1913
Northeast	-0.117	0.084	0.1645	0.174	0.326	0.5933
Southeast	0.091	0.073	0.2850	0.207	0.294	0.4822
South	0.336	0.074	0.0001	0.212	0.313	0.4973
Food and Tobacco	-0.058	0.057	0.3062	0.208	0.242	0.3915
Textile and Leather	-0.302	-0.057	0.0001	0.455	0.252	0.0713
Wood and Paper	-0.479	0.067	0.0001	0.298	0.293	0.3086
Petroleum and Chemical	0.450	0.059	0.0001	0.171	0.274	0.5323
Plastics and Rubber	0.064	0.062	0.3045	-0.080	0.297	0.7863
Non- Metallic	-0.058	0.070	0.4030	0.618	0.274	0.0243
Primary Metal	0.081	0.058	0.1623	0.123	0.261	0.6365
Machinery	0.468	0.060	0.0001	0.002	0.283	0.9953
Electronic and Electrical	0.845	0.064	0.0001	0.098	0.349	0.7795
Transportation	0.353	0.065	0.0001	-0.238	0.270	0.3781
Group				0.237	0.085	0.0053
Public Subsidies				0.812	0.166	0.0001
Potential R&D Intensity[6]				0.024	0.010	0.0143
ρ	-0.581	0.219	0.0079			
Log Likelihood	-8072					
Number of Observations	7535					

[6] In order to deal with endogeneity problem, this variable corresponds to the predicted value from the first stage.

APPENDIX 2: Qualitative Analysis

Methodology

The qualitative research was based in depth interviews with 109 top national industrial entrepreneurs. This constitutes a representative sample of entrepreneurs of national manufacturing firms considered innovative or with a potential to innovate.

In this part of the study, the key characteristics of the firms in the sample are described and the demographic profiles of the entrepreneurs traced as a means of contextualizing the perceptions of those interviewed in relation to projects undertaken in collaboration with centers of excellence. It should be emphasized that the sample is representative in both regional and sectoral terms and that it covers industrial firms that innovated products and processes and exported at premium prices during the period 2001-2003.[7]

Table 5
Descriptive Statistics for Selected Variables According to Different Sample Restrictions[a]

Variables	All Firms		Firms with R&D Activities		Firms with R&D Cooperation Agreement with Universities	
	(n=74)		(n=60)		(n=18)	
	Mean	SD	Mean	SD	Mean	SD
Net sales revenue (R$ 10^6)	342.67	1294.80	429.58	1423.98	1299.53	2383.26
Number of Employee	969.70	2141.50	1105.67	2291.90	2523.86	3582.34
R&D (R$ 10^6)	9.90	83.39	12.97	92.47	41.95	167.78
Internal R&D (R$ 10^6)	9.02	74.14	11.81	82.20	37.60	148.97
External R&D (R$ 10^6)	0.89	9.31	1.16	10.34	4.35	18.84
R&D / Net sales revenue	3.20%	6.70%	4.20%	7.00%	3.10%	4.00%
Internal R&D / Net sales revenue	3.00%	6.50%	3.93%	6.90%	2.70%	3.40%
External R&D / Net sales revenue	0.22%	0.96%	0.29%	1.05%	0.41%	0.70%
Group	0.29	0.54	0.36	0.55	0.63	0.52
Public Subsidies	0.09	0.34	0.10	0.35	0.31	0.49
Scope	1.48	1.50	1.16	0.36	1.04	0.13
Market Share	0.06	0.12	0.07	0.12	0.12	0.17
International Market	0.16	0.21	0.16	0.22	0.18	0.23
Market Share of Imported Goods	0.04	0.23	0.04	0.22	0.16	0.39

[a] Sample of interviewed firms.

[7] According to data from the National Innovation Survey (PINTEC) conducted by the Brazilian Geographic and Statistical Institute (IBGE).

The Firms

The firms in the sample are all domestically owned (majority control in Brazilian hands) and most were founded prior to 1970. This means they have over 30 years of experience in the market (20 years or more when referring to those opened between the late 1970s and 1990, few in the sample having been founded thereafter).The great majority (73%) are family firms that continue to be operated by the families that founded them (90%). Family control has not, however, kept these enterprises from promoting structural changes in the last two decades. In fact, approximately 48% claim to have made some type of change—the most common being via acquisitions in the 1990s.

In terms of size, measured by number of employees in 2005, the firms in the sample are distributed as follows: nearly half the sample (45%) is comprised of firms with 500 employees or more, while 35% have 100 to 499 employees and only 21% have fewer than 100 employees. In terms of revenue, approximately 23% earned over US$ 214 million in 2005, 20% between US$ 43 and 214 million and 30% from US$ 21 to 43 million. All these enterprises belong to innovative segments within the domestic industrial framework and, as expected, are mainly in the medium to large range with respect to both size and revenues.

The Entrepreneurs

The entrepreneurs interviewed are in the upper ranks of their respective firms, 50.6% holding the position of president, 33% being directors and 17% managers. This is relevant insofar as it guarantees that the study embraces the opinions of the individuals responsible for setting the agendas and making the investment decisions of the enterprises in question. Those interviewed are predominantly male. Most (73%) are under 55 years of age and only 4% are over 70. The majority have been in the firm for more than10 years.

The age of the entrepreneurs and their time with the firm indicate that this generation was already in control at the end of the 1980s, when subsidies and protectionist measures were being questioned and economic policy was being directed towards opening the market so as to modernize the domestic industrial sector and enhance its competitiveness.

Another characteristic typical of those interviewed is their high educational level. The great majority (89%) hold undergraduate degrees, especially in Engineering (46%), followed by Administration (25%) and Economics (14%). A significant proportion (58%) also have MBAs or Master's degrees—or even PhDs—in other disciplines; of these, 26% are from foreign universities. Most of the executives and managers interviewed also speak another language, with English (93%) and Spanish (43%) being the most common.

The importance of seeking information abroad was also underlined by the majority of those interviewed (86%), who stated their firms participated in industrial fairs and congresses at least once a year. These data suggest that the entrepreneurs linked to the more innovative Brazilian firms perceive the need to insert their firms into the foreign market on a more competitive basis, which was not the case prior to 1980, up to which time protectionist policies shielded the domestic market.