R&D, MARKET STRUCTURE AND APPROPRIABILITY IN THE BRAZILIAN MANUFACTURING

Gílson Geraldino Silva Jr

Universidade Católica de Brasília
Programa de Pós-Graduação em Economia

ABSTRACT

In this paper I analyse the relationship among R&D, market structure and 10 appropriability indicators in the Brazilian manufacturing at firm level, linking an industry and an innovative survey for 2003 and 2005 for more than 16.000 companies. The main results are: market share has positive impact on the R&D expenditure decision, except if innovation patents and trade market are protection mechanisms; lagged profits have positive impact on R&D decision; writing or strategic appropriability mechanisms alone has negative impact on the R&D expenditure decision; and advertisement and a mix of appropriability mechanisms had positive impact on the R&D expenditure decision.

ANPEC Área 8 - Economia industrial e da tecnologia
JEL codes: L10, L21, 032
Key words: R&D, market structure, appropriability

RESUMO

Neste artigo analiso a relação entre P&D, estrutura de mercado e 10 indicadores de apropriabilidade a partir de dados por firma para a indústria brasileira de transformação, conectando informações de pesquisas industriais e de inovação tecnológica para mais de 16.000 empresas. Os principais resultados são: parcela de mercado tem impacto positivo na decisão de gastos com P&D, exceto quando patentes de inovação e marcas são utilizadas como mecanismos de apropriabilidade; lucros defasados tem impacto positivo na decisão de P&D; mecanismos de apropriabilidade estratégicos e por escrito, quando utilizados sozinhos, tem impacto negativo na decisão de gasto com P&D; e propaganda e mix de mecanismos de apropriabilidade têm impacto positivo na decisão de gastos com P&D.

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1. INTRODUCTION

A technological innovation can be a radical, an incremental or a revolucionary change through new product or process. Some of the main inputs to a successful technological innovation is research and development (R&D) expenditures – but it isn`t the only one. Low or high concentrated market structure and appropriability mechanisms are important innovation determinants as well.

In the beginning of the theoretical discussion about market structure and innovation, monopoly power and firm size were considered an extra advantage to innovation, as they reduce uncertainty (KAMIEN and SCHWARTZ, 1982). Just a few about other appropriability mechanisms than patent were examined. Quite recently research, however, show that protection to some inventions maximize innovation rate in some industries, but not in others (HUNT, 2004); and better advertisement incentive R&D (QI, 2008).

Empirical evidence from the 1950`s to the 1970`s suggested not conclusive relationship between market concentration and research effort, basically because of data quality available – few firms or just some industries, as chemistry and drugs (KAMIEN and SCHWARTZ, 1975). Empirical evidence from the 1970`s to the 1980`s suggested that patent were important to only a few industries. In others firms used others appropriability tools as trade mark and copyright. But it is not clear how each kind of appropriability mechanism impact on innovative activity (COHEN and LEVIN, 1989).

Further evidences showed that firms in the American manufacturing sectors protect their innovation`s profits not only through patents but using a mix of intellectual property mechanisms. Among them patents are the less used, while industry secret and leading time are the most applied (COHEN, NELSON and WALSH, 2000).And patent is not always the best appropriability option (HALL and ZIEDONIS, 2001), and others intellectual properties protection mechanisms that not patents can also have positive effects on the economy (MORTIMER, 2007).

Notwithstanding, patents have some limits as an appropriability mechanism in developing countries and R&D spend couldn't be the best measure to innovative effort in those kind of nations, where competition has a negative effect on innovation (GORODNICHENKO, SVEJNAR and TERRELL, 2008).

International comparisons show that, in 1997, R&D expenditure in Brazil was around 1.22% of it GDP, far below than the traditional innovative countries as Japan, whose R&D/GNP ratio was around 2.94%. And private firms spend around 0.39% of Brazilian GDP on R&D, while government spend 0.83%. (JENSEN, MENEZES-FILHO and SBRAGIA, 2004).

Some studies to Brazilian manufacturing sectors showed that net profit margins had no influence on R&D expenditures, may be because it is a long run investment (JENSEN, MENEZES-FILHO and SBRAGIA, 2004); that industrial firms reaction to trade openness in the 1990`s was rationalize productive process to improve manufacturing efficiency, but keeping them away from R&D activities, new projects and strengthen trade marks (DE NEGRI, SALERNO and CASTRO,2005) – results according to World Bank analysis, which

show that research projects are concentrated in developed countries (THE WORLD BANK, 2008).

In fact, understand the relationship among innovation, market structure and appropriability is really important, as those variables have strong impact on firms, sectors, regions and countries behaviour.

In this study I go beyond the traditional analysis among market structure, R&D and patents, as I will analyse nine others appropriability mechanisms than patents, as trade market and industry secret and advertisement – this one recently used by Lee (2005) in an empirical study to South Korea.

Our main results are not significant correlation among R&D expenditure and market share, lagged profits and appropriability mechanisms. However, we found some interesting results considering R&D expenditure decision: market share has positive impact on the R&D expenditure decision, except to innovation patents and trade market as protection mechanisms; lagged profits have positive impact on R&D decision; writing or strategic appropriability mechanisms alone has negative impact on the R&D expenditure decision; and advertisement and a mix of appropriability mechanisms had positive impact on the R&D expenditure decision.

This paper has 4 sections further than this introduction: section 2 reviews recent theoretical and empirical analysis about R&D, market structure and appropriability, stressing recent approaches which consider advertisement as an appropriability mechanism; section 3, econometric models; section 4, results and interpretations; and section 5, conclusions.

2. RELATED LITERATURE

In this section I present recent theoretical and empirical analysis about R&D, market structure and appropriability, stressing the recent approaches which consider advertisement as an appropriability mechanism.

2.1 Recent theoretical analysis

The relationship among patentability, industrial structure and innovation become important in recently theoretical discussions. Some theoretical models find the patentability ratio which maximizes the innovative ratio. This analysis shows that some inventions maximize innovation ratio in some industries, but not in others. And that patentability standards affect expected profits as it influence firm`s probability to innovate be a competitive advantage, and the speedy at this advantage will reduce (HUNT, 2004).

Advertisement and innovation is a subject few analysed. Besides many formal and informal apropriability mechanisms, as patents and designing, advertisement is a protection option sometimes far efficient than formal ones.

In fact, either discover something new and register in a patent office or show it to as many potential buyers as possible, the second option could be financially better than the first one. And once something is associated to a company, competitors will have an extra difficult because more than imitate or create, they will need to persuade potential buyers that their products are as good or better than that company which first find something new and ad it.

According to Bagwell (2007), under economic point of view, there are three kinds of advertisement: persuasive, informative and complementary.

Persuasive ad has as objective change preferences, creating a spurious product differentiation and increasing fidelity. As a result, firm product demand becomes more inelastic, allowing firm charge higher prices. In this case ad means higher barriers to entry, which is more efficient if there are economies of scale in production and/or in advertisement. In doing so, persuasive ad has an anti-competitive effect once it has any real value to consumers but create only an artificial product differentiation, whose result is higher concentration, prices and profits (BAGWELL, 2007).

Informative ad consider that consumers has imperfect information, once there is search cost to find out relevant goods and services characteristics to decision making as price, quality and technical details. This imperfection can bring inefficiencies to the market. Informative ad would be a low cost solution to minimize asymmetric information. As a result, firm product demand becomes more elastic and makes firms entrant easier, once companies can being known easier, as well it prices and products. So, this kind of ad is pro-competitive (BAGWELL, 2007).

At least, advertisement complementary perspective suggests that ad does not change consumer preferences, as persuasive one. They assume a stable preference set and that ad complements goods and service, as social fashion one (BAGWELL, 2007).

But, does have ad dynamic effect on firms` competitive advantage (DORASZELSKI and MARKOVICH, 2007)? Using a dynamic game with perfect Markovian equilibrium, where firms advertise repeatedly, are rivals in product market and take entry and exit decisions, two advertisement standards are analysed: one affects consumers sympathy to firms and other influence consumers who knows this firm. This model shows that either strong regulation or forbidden advertisement have anticompetitive effects with negative impact on firms` competitive advantage.

Qi (2008) complements ad effects on innovation showing that, on one hand, ad also allows firms inform their consumers about something new on the market. In this sense, ad improvement means more R&D. On the other hand, intense ad about a known good suggests strong competition and it can reduce entrant innovative efforts. In this sense, innovation can reduce new firms entrance. To sum up, sectors where strategic interaction is higher, there is antagonist powers over how advertisement influences R&D.

Qi (2008) theoretical and numerical simulation analysis, both according to Doraszelski and Markovich (2007), shows how better advertisement technology (which means lowers cost) will increase or reduce R&D. Considering perfect price discrimination, goods not known to consumers but gradually being known through ad, each firm has goods with specific quality, and that each good is protected by patent, better ad increase entrance deterrence. So, worse ad technology (which means higher ad costs) could increase local innovation ratio. But any advertisement reduces sectorial growth as none information will be available to consumers.

2.2 Recent empirical evidence

Recently empirical analyses used better data base and computational and econometric methods, which allows check some details not usually considered, as advertisement impacts on R&D and others not patent appropriability mechanisms as copyright and leading time to competitor.

Data available informs that drug industry has high R&D expenditure but higher advertisement budget. It also informs that innovation and ad are complementary as a non price competition (CABRAL, 2000).

Expenditure on advertisement and R&D analysis of drug industry firms in eight therapy areas (asthma, migraine, obesity, Parkinson`s disease, seizure disorder, depression, lipid disorder, and gastric and duodenal ulcer) between 1995 and 2001 shows that technical advertisement has positive effect on new clinical products. The chronic disease market with high technical and detailed ad is more interesting to firms on drug industry. But the effects of advertisement on new products development were inconclusive (KWONG and NORTON, 2007).

Not only patents but also others intellectual protection tools have positive effects on the economy. Copyright laws, for example, incentive technological innovation and brought better price discrimination in the US VHS and DVD market (MORTIMER, 2007).

In fact, intellectual protection through patents is not always the best option for many firms. It motivates Cohen, Nelson and Walsh (2000) try explain why some American companies register patents and others not. Analysing data from 1478 R&D labs in the American manufacturing industry in 1994, they found that firms protect their innovation profits not only through patents but using a mix of intellectual property mechanisms, which include industrial

secret and leading time. Among those mechanisms, patents are the fewest used while industrial secret and leading time are the most common.

Hall and Ziedonis (2001) agree with Cohen, Nelson and Walsh (2000): patent is not always the best option. In some cases, there is a patent paradox, as illustrate an empirical study about 95 firms pattern standard in the US semiconductor industry between 1979 and 1995 – an industry whose main characteristic is fast technological change and cumulative innovation. It showed that those firms not always use patent to protect their R&D profits - which is a paradox in a high and fast technological change sector.

If patent sometimes is not the best option in developed countries, patents data limitations in developing countries became it not the best source of information about innovation. In general, data patents have three important restrictions: i) they measure inventions not innovation, ii) patents standard change according to country, industry and process and iii) companies frequently use alternative protection tools as industrial secret and leading time (GORODNICHENKO, SVEJNAR and TERRELL, 2008).

At least, R&D expenditure is not always the best measure to innovative effort in those countries because not all innovations are generated by R&D expenditures, R&D does not necessarily lead to innovation (they are an input rather than an output), and formal R&D measures are biased against small firms (GORODNICHENKO, SVEJNAR and TERRELL, 2008).

2.3 R&D, market structure and appropriability

Recently Lee (2005) analysed the relationship between market concentration and industry R&D intensity conditional to appropriability, inclusive advertisement, to South Korean manufacturing sector. His data base to 1983 had sectorial information about R&D and advertisement expenditures, revenue, concentration ratio and price-cost margin to 426 South Korean manufacturing sectors SIC 5 digit disaggregation level. Sectorial appropriability indicators were from The Yale Survey (LEVIN et alli, 1987) to USA. Sectors were classified as high (137) and low (289) appropriability levels.

Lee (2005) cross section empirical evidence to South Korean manufacturing sectors shows that market concentration and R&D expenditure are positively correlated in the low appropriability sectors, which suggests that market concentration supplements low R&D appropriability or that technological competence (or opportunities) may not be fully exerted (or exploited) when market structure remains atomistic. However, market concentration and R&D expenditure are negatively correlated in the high appropriability sectors, which suggests that high R&D appropriability supplements market concentration or that technological competence (or opportunities) may be fully exerted (or exploited) when market structure goes to oligopoly.

Lee (2005) cross section analysis also found that profit has not significative correlation with R&D expenditure, except in high appropriability sectors that showed weak negative correlation. The results have not substantial change if advertisement is considerer appropriability mechanisms.

As we said, patent is not always the best appropriability option (HALL and ZIEDONIS, 2001), patents information from developing countries has many restrictions and R&D

expenditure is not always the best measure to innovative effort in those nations (GORODNICHENKO, SVEJNAR and TERRELL, 2008). In this exercise I analyse firm and not sectorial data and there is 9 appropriability indicators further than patent.

3. ECONOMETRIC MODELS

In this section I present the econometric models used to analyse the relationship between R&D and market structure, conditional to appropriability.

I analyse a short and unbalanced panel data of information from innovative and industrial surveys[1] to 2003 and 2005. In all regressions I consider 10 appropriability mechanisms. According to IBGE, The Brazilian Census Bureau, five of them are writing protection mechanisms – patents of invention (PI), utility model patent (UMP), industry design register (IDR), trade marks (TM) and copyright (C) – and three of them are strategic protection mechanisms – design complexity (DC), industrial secret (IS) an leading time to competitors (LTC). This data base also has "others" appropriability mechanism category, which each firm specify, and advertisement expenditure (ADV). We also consider that a firm can use a mix of appropriability methods (MAM). In fact, a firm can, at the same time, register a patent, has a design complex and expend on advertisement.

I run two panel regressions, close to Lee (2005). Those panel regressions avoids endogenity problem, especially because of simultaneity between R&D expenditure and profitability. It also allows check lagged profitability impact on R&D expenditure and on R&D expenditure decision. The first one is a classical panel linear regression:

$$(1)\ lnred_{it} = \alpha_0 + \alpha_1 MS_{it} + \alpha_2 MS^2_{it} + \alpha_3 LNPCM1_{it} + \alpha_4 LNPCM2_{it} + \alpha_5 MS_{it}*AI_{it} + \alpha_6 MS^2_{it}*AI_{it} + \alpha_7 AI_{it} + \boldsymbol{\Psi}_{it} + \varepsilon_{it}$$

where $lnred_{it}$ is R&D expenditure /revenue ratio log to firm i at time t, MS_{it} is market share[2], MS^2_{it} market share square, $LNPCM1_{it}$ and $LNPCM2_{it}$ are the first and second price-cost margin[3] log lagged, AI_{it} is one of the ten appropriability mechanisms above used alone or mixed, $MS_{it}*AI_{it}$ is the market share-appropriability indicator interaction, $MS^2_{it}*AI_{it}$ is the market share square-appropriability indicator interaction, and $\boldsymbol{\Psi}_{it}$ is the firm fixed effects. It is important remark that market share measure market concentration and firm size at the same time.

As R&D expenditure is not always the best measure to innovative effort, a probit panel regression is an option to R&D expenditure data problems. So, our second regression is:

$$(2)\ R\&D_{it} = \alpha_0 + \alpha_1 MS_{it} + \alpha_2 MS^2_{it} + \alpha_3 LNPCM1_{it} + \alpha_4 LNPCM2_{it} + \alpha_5 MS_{it}*AI_{it} + \alpha_6 MS^2_{it}*AI_{it} + \alpha_7 AI_{it} + \boldsymbol{\Gamma}_{it} + \varepsilon_{it}$$

where $R\&D_{it}$ is a dummy variable, which is 1 if firms had expended on R&D and 0 on the contrary. It represents the firm R&D expenditure options. $\boldsymbol{\Gamma}_{it}$ is the firm random effect as any probit panel regression. All other variables are like (1) above.

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[1] The innovative survey is Pesquisa de Inovação Tecnológica (PINTEC) and the industrial survey is Pesquisa Industrial Anual (PIA), both of them by The Brazilian Institute of Geography and Statistics (IBGE).

[2] MS_{it}= firm i at year t revenue/sector revenue at year t, where sector is SIC 4 digit disaggregation level.

[3] PCM_{it}= (net $revenue_{it}$ + Δ $inventories_{it}$ – $payroll_{it}$ – operational $costs_{it}$)/(net $revenue_{it}$ +Δ $inventories_{it}$), as suggested by Domowitz, Hubbart and Petersen (1986).

4. RESULTS

In this section I show the results and interpretations to empirical evidence got from the econometric models showed in the last section. I begin showing the descriptive statistics, which gives a good picture of our data base, which has information from 2003 and 2005 for more than 16.000 companies. Just after, I show and interpret the regressions results.

4.1 Descriptive statistics

The descriptive statistics to continuous variables (TABLES 1 and 2) show us that among 16626 firms, 3823 (23%) spent in R&D and that the R&D/net revenue ratio (R&D) average is 4%.The standard deviation (38.3%) and percentiles shows substantial dispersion. 75% of the firms in this sample had R&D/net revenue ratio lower than 1.4%. R&D/net revenue ratio median 0.4% is close to 0.39% aggregated spending found by Jensen, Menezes-Filho e Braga (2004).

Market Share (MS) average is 0.9%, with standard deviation 3.9% and 75th percentile 1.4%. Price cost-margin (PCM) average is 64%, with median 71%, standard deviation 23.7% and percentiles 5th 23% and 75th 82%. At least, the advertisement/net revenue ratio (ADV) average is 0.3%, median 0.02%, standard deviation 1.2% and 75th percentile 0.3%

To sum up, those descriptive statistics show us that R&D/net revenue ratio is bigger than the ad/net revenue ratio, market share is lower than 1.5% for at least 75% of the firms in this sample, and at least 50% of them have price cost-margin bigger that 71%. They also show us a significant dispersion of all variables described.

TABLE 1 – continuous variables descriptive statistics

Variable	Observations	Average	Standard Deviation
R&D	3823	0.04	0.46
MS	16626	0.009	0.041
MS^2	16626	0.0018	0.023
PCM	16626	0.64	0.237
ADV	16626	0.003	0.012

Source: Our tabulation from 2003 and 2005 PIA and PINTEC surveys

TABELA 2 – continuous variables percetiles

Variable	P5	P25	P50	P75	P95
R&D	0	0.001	0.004	0.015	0.07
MS	0.0001	0.0007	0.0034	0.014	0.11
MS^2	0	0	0	0.0002	0.012
PCM	0.23	0.57	0.71	0.82	0.93
ADV	0	0	0.0002	0.003	0.028

Source: Our tabulation from 2003 and 2005 PIA and PINTEC surveys

Let`s have a look on discrete variables frequencies. TABLE 3 show us that among the five writing protection mechanisms, patents of invention (PI) was used by 6.22% of the firms in our sample, utility model patent (UMP) by 5.47%, industry design register (IDR) by 4.98%, trade marks (TM) by 22.97% and copyright (C) by 2.44%. Among the three strategic

protection mechanisms, design complexity (DC) was used by 2.59% of the firms in our sample, industrial secret (IS) by 10% and leading time to competitors (LTC) by 5.74%. Other appropriability mechanisms, which each firm specify, by 2.8%, and a mix of appropriability methods (MAM), which include advertisement, by 49.74% of the firms in this sample. As we said, a firm can, at the same time, register a patent, has a design complex and expend on advertisement. It justifies use MAM.

TABLE 3 – firms that used appropriability protection mechanisms

(%)	PI	UMP	IDR	TM	C	DC	IS	LTC	others	MAM
Yes	6.22	5.47	4.98	22.97	2.44	2.59	9.99	5.74	2.80	49.74
No	93.78	94.53	95.02	77.03	97.56	97.41	90.01	94.26	97.20	50.26
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Our tabulation from 2003 and 2005 PIA and PINTEC surveys

TABLE 4 show us that 11% of the firms in our sample spent on (internal)[4] R&D and TABLE 5 inform us that 53% of that firms had continuous (internal) R&D activity and 47% occasional.

TABLE 4 – firms that spent on R&D

R&D	%
Spent	10.89
Not spent	89.11
Total	100.00

Source: Our tabulation from 2003 and 2005 PIA and PINTEC surveys

TABLE 5 – firms that had continuous or occasional R&D activity

R&D activity	%
Continuous	53.21
Occasional	46.79
Total	100.00

Source: Our tabulation from 2003 and 2005 PIA and PINTEC surveys

4.2 Regressions

Here I show the results and interpretations based on the panel regressions, which are adapted from Lee (2005). A short and unbalanced panel avoid endogeneity because of simultaneity between R&D expenditure and profits, and allow us check how lagged profits influence on R&D expenditure. It will be check through a regression like (1) described in the econometric models section.

Our results to R&D expenditure, market structure and appropriability (TABLE 6) show us that R&D expenditure and market share are not correlated, except in the regression that consider advertisement as an appropriability mechanism, which has a negative correlation. It suggests that ad as appropriability mechanisms supplements market share.

[4] According to IBGE, internal R&D means R&D from firm`s own resources. It does not include spend on adoption of technology, for example.

The relation between R&D expenditure and lagged profits is close R&D expenditure and market share: there isn`t significative correlation among them, except to the second lagged profit in the regression with ad as appropriability mechanism, where it is negative.

The relation among R&D expenditure and appropriability mechanisms here is also quite interesting: except to trade market (TM), there isn`t significative correlation among R&D expenditure and appropriability mechanisms. R&D expenditure and TM have negative correlation, which suggests that TM is substitute strategic investment to R&D expenditure. As market share means firm size and market concentration at the same time, this result also suggests that smaller firms that used TM as appropriability mechanisms spent more on R&D.

Market share square (MS^2) and it interaction with appropiability mechamisms (MS^2*IA), and MS*IA are not correlated with R&D expenditure. F tests also suggests that appropriability mechanisms are not important to market share, expect to trade mark.

According to recent literature (GORODNICHENKO, SVEJNAR and TERRELL, 2008) developing countries have R&D expenditure levels far lower than developed. It is particularly low in Brazil, as show the descriptive statistics above, which inform us that the R&D expenditure/revenue ratio median is 0.4% and that 75% of the companies have R&D expenditure/revenue ratio below 1.4%. This low R&D expenditure/revenue could be influencing the results above.

An alternative to low R&D expenditures should be check market share and appropriability mechanisms impact on R&D expenditure decision, which can be analysed using an R&D expenditure dummy variable, which is 1 to companies that have been spent on R&D and 0 to that have not. It will be check through a probit panel regression like (2) described in the econometric models section above. The results are in the TABLE 7.

TABLE 6: R&D expenditure, appropriability and market structure - panel regressions

lnred	PI	UMP	IDR	TM	C	DC	IS	LTC	others	lnadv	MAM
CONSTANT	-4.72(0.30)***	-4.93(0.32)***	-4.95(0.34)***	-4.51(0.26)***	-4.77(0.487)***	-4.58(0.44)***	-4.87(0.27)***	-4.74(0.32)***	-4.83(0.45)***	-4.96(0.40)***	-5.18(0.33)***
MS	-5.36(3.61)	-3.60(3.58)	-5.53(3.68)	-3.00(3.06)	-5.40(4.53)	-7.36(5.07)	-6.04(3.26)*	-9.22(3.63)***	-8.09(6.68)	-7.43(4.11)*	-14.14(16.76)
MS^2	6.74(5.31)	3.66(4.84)	4.08(5.33)	-0.60(4.68)	4.23(6.30)	10.26(8.51)	6.06(5.05)	12.13(5.47)**	5.83(13.53)	9.08(6.30)	59.82(90.97)
LNPCM1	0.05(0.34)	0.091(0.34)	0.086(0.34)	0.16(0.33)	0.08(0.34)	0.10(0.34)	0.087(0.34)	0.07(0.34)	0.07(0.34)	0.197(0.443)	0.10(0.34)
LNPCM2	-0.29(0.39)	-0.31(0.39)	-0.31(0.39)	-0.23(0.39)	-0.30(0.39)	-0.29(0.39)	-0.30(0.395)	-0.285(0.39)	-0.305(0.39)	-1.26(0.51)**	-0.32(0.39)
MS*AI	0.14(1.96)	-0.94(1.74)	0.12(1.69)	-1.81(1.73)	-0.04(2.11)	0.85(2.44)	0.478(1.80)	2.23(1.75)	1.36(3.19)	-0.60(0.72)	8.51(16.58)
MS^2*AI	-1.75(3.31)	0.39(2.53)	0.28(2.57)	4.02(3.11)	0.32(3.04)	-2.55(4.20)	-1.05(3.46)	-4.64(3.03)	-0.61(6.72)	1.10(1.23)	-54.83(90.83)
AI	-0.15(0.14)	-0.028(0.15)	-0.022(0.158)	-0.26(0.12)**	-0.11(0.23)	-0.20(0.21)	-0.066(0.126)	-0.13(0.146)	-0.080(0.21)	0.07(0.06)	0.206(0.314)
total R^2	0.0789	0.0731	0.0698	0.0585	0.0727	0.0765	0.0704	0.0623	0.0696	0.0672	0.0132
within groups R^2	0.0179	0.0147	0.0117	0.0305	0.0119	0.0148	0.0118	0.0147	0.0126	0.0194	0.0136
between groups R^2	0.0874	0.0832	0.0802	0.0632	0.083	0.0873	0.081	0.0716	0.08	0.072	0.0106
Test F											
All variables	F(7,758)=1.98*	F(7,758)=1.61	F(7,757)=1.28	F(7,758)=4.41**	F(7,758)=1.31	F(7,758)=1.63	F(7,758)=1.29	F(7,758)=1.61	F(7,758)=1.39	F(7,649)=1.83	F(7,758)=1.49
MS,MS^2	F(2,758) =1.14	F(2,758) =0.64	F(7,757)=2.17	F(2,758) =2.69*	F(7,758)=1.20	F(7,758)=1.12	F(7,758)=2.28	F(7,758)=3.27	F(7,758)=2.44*	F(7,649=)1.67	F(7,758)=0.50
MS*AI, MS^2*AI	F(2,758)=0.83	F(2,758)=0.67	F(2,757) =0.09	F(2,758)=0.89	F(2,758) =0.02	F(2,758) =0.37	F(2,758) =0.05	F(2,758) =1.24	F(2,758) =0.50	F(2,649) =0.41	F(2,758) =0.21
MS*AI, MS^2*AI, AI	F(3,758)=1.72	F(3,758)=0.87	F(3,757)=0.06	F(3,758)=5.03**	F(3,758)=0.17	F(3,758)=0.92	F(3,758)=0.13	F(3,758)=0.88	F(3,758)=0.36	F(3,649)=0.56	F(3,758)=0.60
Observations	3106	3106	3105	3106	3106	3106	3106	3106	3106	2633	3106

Source: Our tabulation from 2003 and 2005 PIA and PINTEC surveys

***,**,* means 1%,5% and 10% significance level, respectively

Note: lnred is R&D/net revenue ratio log, MS is market share, MS^2 is market share square, LNPCM1, LNPCM2 is price cost margin log lag 1 and 2, MS*IA is market share- appropriability indicator interaction, MS^2*IA is market share squared- appropriability indicator interaction. PI is patent of invention *dummy* (1 if firm had patent of invention, zero on the contrary), UMP is utility model patent *dummy* , IDR is industry design register *dummy*, TM is trade market *dummy*, C is copyright *dummy*, DC is design complexity *dummy*, IS is industrial secret *dummy*, LTC is a leading time to competitors *dummy*, "others" is other appropriability machanisms used by the firms *dummy*, lnadv is advertisement/net revenue ratio log, and MAM is a mix of appropriability mechanisms *dummy* variable, which includes advertisement (it is one of a firm used one or more appropriability mechanism, inclusive ad, and zero on the contrary).

The results in the TABLE 7 suggest that market share has positive impact on the R&D expenditure decision, except to innovation patents (IP) and trade market (TM) as protection mechanisms, where they are not significative. It means that, in general, market share supplements those appropriability mechanisms (except to IP and TM as appropriability mechanism), or that technological competence (or opportunities) may not be fully exerted (or exploited) when market structure remains atomistic.

Lagged profits have positive impact on R&D decision in all regressions, which suggests that firms use private financial source to R&D activities.

Writing or strategic appropriability mechanisms alone has negative impact on the R&D expenditure decision. It means that firms choose between writing or strategic appropriability mechanisms alone and R&D expenditure decision, or they are substitute strategic investment. As market share means firm size and market concentration at the same time, this result also suggests that the smallest firms that used writing or strategic appropriability mechanisms alone as appropriability mechanisms spent more on R&D.

Nonetheless, advertisement – a kind of appropriablility mechanism - and a mix of appropriability mechanisms (MAM) had positive impact on the R&D expenditure decision. It means that firms choose both those appropriability mechanisms and R&D expenditure decision, or they are complementary strategic investment. As market share means firm size and market concentration at the same time, this result also suggests that the biggest firms that used ad and MAM as appropriability mechanisms spent more on R&D.

Market share square (MS^2) and it interaction with appropiability mechamisms (MS^2*IA), and MS*IA are not correlated with R&D expenditure (except to others, ad and MAM). χ^2 tests to panel regression subset of variables suggests that appropriability mechanisms have significative impact on market share.

TABLE 7 : R&D *dummy* appropriability and market structure - probit panel regressions

DR&D	PI	UMP	IDR	TM	C	DC	IS	LTC	others	lnadv	MAM
CONSTANT	1.78(0.178)***	1.45(0.19)***	1.39(0.22)***	0.51(0.105)***	0.39(0.29)	1.147(0.287)***	1.18(0.143)***	1.62(0.20)***	1.21(0.31)***	0.037(0.1)	-2.26(0.072)***
MS	6.85(2.961)	13.34(3.88)***	8.06(5.48)	16.92(2.15)***	8.21(4.30)**	9.40(4.60)***	10.90(2.47)***	8.40(3.10)***	25.18(7.91)***	9.41(1.82)***	10.42(1.80)***
MS^2	-4.42(5.015)	-14.11(6.05)***	-0.47(17.53)	-16.85(3.23)***	-5.67(6.42)	-11.20(7.25)	-6.36(3.86)*	-9.59(5.068)*	-44.95(15.79)***	-10.17(3.06)***	-6.85(2.72)***
LNPCM1	0.32(0.10)***	0.348(0.106)***	0.345(0.109)***	0.32(0.11)***	0.357(0.11)***	0.36(0.11)***	0.31(0.10)***	0.36(0.107)***	0.361(0.11)***	0.54(0.125)***	0.41(0.095)***
LNPCM2	0.32(0.098)***	0.314(0.10)***	0.317(0.103)***	0.276(0.101)***	0.32(0.10)***	0.312(0.103)***	0.27(0.09)***	0.31(0.10)***	0.317(0.103)***	0.27(0.123)***	0.304(0.09)***
MS*AI	1.96(1.56)	-0.978(1.989)	1.96(2.78)	-3.26(1.23)***	2.19(2.19)	1.42(2.346)	-0.106(1.35)	1.31(1.63)	-6.48(3.97)*	-0.605(0.285)**	2.91(1.86)
MS^2*AI	-3.68(2.65)	1.054(3.11)	-6.07(8.80)	2.73(1.93)	-3.90(3.31)	-0.82(3.70)	-3.27(2.19)	-0.986(2.66)	16.12(7.92)**	0.70(0.46)	-7.967(2.868)***
AI	-1.22(0.092)***	-1.06(0.099)***	-1.03(0.11)***	-0.66(0.059)***	-0.516(0.147)***	-0.895(0.145)***	-0.94(0.07)***	-1.14(0.10)***	-0.93(0.15)***	0.17(0.014)***	1.22(0.062)***
Log Vero	-4672.20	-4712.00	-4732.70	-4676.42	-4796.52	-4777.70	-4663.37	-4706.20	-4762.28	-4728.55	-6063.90
Test χ^2											
All variables	χ^2 (7)=611.11***	χ^2 (7)=522.43***	χ^2 (7)=489.74***	χ^2 (7)=522.54***	χ^2 (7)=436.54***	χ^2 (7)=456.76***	χ^2 (7)=610.52***	χ^2 (7)=526.50***	χ^2 (7)=464.71***	χ^2 (7)=690.16***	χ^2 (7)=1164.20***
MS,MS^2	χ^2 (2)=10.94***	χ^2 (2)=13.83***	χ^2 (2)=7.87**	χ^2 (2)=72.51***	χ^2 (2)=7.12**	χ^2 (2)=4.86*	χ^2 (2)=37.23***	χ^2 (2)=9.27***	χ^2 (2)=10.21***	χ^2 (2)=32.54***	χ^2 (2)=49.21***
MS*AI, MS^2*AI	χ^2 (2)=1.94	χ^2 (2)=0.28	χ^2 (2)=0.53	χ^2 (2)=10.04***	χ^2 (2)=1.41*	χ^2 (2)=1.07	χ^2 (2)=9.38***	χ^2 (2)=1.39	χ^2 (2)=4.57	χ^2 (2)=4.97*	χ^2 (2)=9.40***
MS*AI, MS^2*AI, AI	χ^2 (3)=247.74***	χ^2 (3)=172.67***	χ^2 (3)=131.04***	χ^2 (3)=226.62***	χ^2 (3)=16.01***	χ^2 (3)=52.40***	χ^2 (3)=263.46***	χ^2 (3)=180.89***	χ^2 (3)=75.49***	χ^2 (3)=171.09***	χ^2 (3)=471.96***
Observations	8073	8073	8072	8073	8073	8073	8073	8073	8073	9276	14379

Source: Our tabulation from 2003 and 2005 PIA and PINTEC surveys

***,**,* means 1%,5% and 10% significance level, respectively

Note: DR&D is R&D *dummy* variable (1 if firm spent on R&D, 0 on the contrary), MS is market share, MS^2 is market share square, LNPCM1, LNPCM2 is price cost margin log lag 1 and 2, MS*IA is market share-appropriability indicator interaction, MS^2*IA is market share squared- appropriability indicator interaction. PI is patent of invention *dummy* (1 if firm had patent of invention, zero on the contrary), UMP is utility model patent *dummy* , IDR is industry design register *dummy*, TM is trade market *dummy*, C is copyright *dummy*, DC is design complexity *dummy*, IS is industrial secret *dummy*, LTC is a leading time to competitors *dummy*, "others" is other appropriability machanisms used by the firms *dummy*, lnadv is advertisement/net revenue ratio log, and MAM is a mix of appropriability mechanisms *dummy* variable, which includes advertisement (it is one of a firm used one or more appropriability mechanism, inclusive ad, and zero on the contrary).

It is important remark that our results about innovation and market structure (conditional to appropriability) are according to the debate about this subject.

In the beginning of theoretical analysis about concentration and market structure, market power and firm size were considered an extra advantage to innovation, as they reduce uncertainties (KAMIEN and SCHWARTZ, 1982). However, appropriability mechanisms, especially those not patent, were not part of the discussion. Recently, some theoretical analysis predicts that protect some inventions maximize innovation ratio in some industries, but not in others (HUNT, 2004); and that better advertisement improve R&D (QI, 2008).

Earlier empirical evidence to concentration and innovation relationship found between 1950`s and 1970`s were not conclusive because of the kind of data available – to a few companies or to selected sectors, as chemistry and drugs (KAMIEN and SCHWARTZ, 1975). Empirical evidence found between 1970`s and 1980`s show us that patent were important just to some industries, but in others firms choose others kind of appropriability mechanisms, as trade mark or copyright (COHEN and LEVIN, 1989).

Recent evidence suggested that American manufacturing companies protect their profits from innovation using not only patents but also a mix of appropriability mechanisms. Among the appropriability mechanisms used, patents are on the lowest used and industry secret and leading time are among the top used (COHEN, NELSON and WALSH, 2000). And more: patent is not always the best appropriability mechanism (HALL and ZIEDONIS, 2001) and not only patents but others appropriability mechanisms have positive effects on the economy (MORTIMER, 2007). At least, additional research found that patents have strong limitations as appropriability mechanism in developing countries, and that R&D expenditure is not the best measure to innovative effort in those nations (GORODNICHENKO, SVEJNAR and TERRELL, 2008).

International comparisons show that R&D expenditure in Brazil was around 1.22% of it GDP in 1997, far below the traditional innovative countries as Japan, whose R&D/GNP ratio was around 2.94%. And private firms spend around 0.39% of Brazilian GDP, while government spend 0.83% (JENSEN, MENEZES-FILHO and SBRAGIA, 2004).

Some studies to Brazilian manufacturing sectors showed that net profit margins had no influence on R&D expenditures, may be because it is a long run investment (JENSEN, MENEZES-FILHO and SBRAGIA, 2004); that industrial firms reaction to trade openness was rationalize productive process to improve manufacturing efficiency, but keeping them away from R&D activities, new projects, stronger trade marks (DE NEGRI, SALERNO and CASTRO,2005) – results according to World Bank analysis, which show that research projects are concentrated in developed countries (THE WORLD BANK, 2008).

Our results show not significant correlation among R&D expenditure and market share, lagged profits and appropriability mechanisms. However, we found some interesting results considering R&D expenditure decision: market share has positive impact on the R&D expenditure decision, except to innovation patents and trade market as protection mechanisms, where they are not significative; lagged profits have positive impact on R&D decision in regressions; writing or strategic appropriability mechanisms alone has negative impact on the R&D expenditure decision; and advertisement – a kind of appropriablility

mechanism - and a mix of appropriability mechanisms had positive impact on the R&D expenditure decision.

5. CONCLUSION

It is the first analysis I know about R&D and market struture conditional to appropriability to Brazilian manufacturing firms. Our results bring new evidence to this important subject to one of the BRICs. The main are:

i) not significant correlation among R&D expenditure and market share, lagged profits and appropriability mechanisms.

ii) Market share has positive impact on the R&D expenditure decision, except to innovation patents (IP) and trade market (TM) as protection mechanisms, where they are not significative. It means that, in general, market share supplements those appropriability mechanisms (except to IP and TM as appropriability mechanism), or that technological competence (or opportunities) may not be fully exerted (or exploited) when market structure remains atomistic.

iii) Lagged profits have positive impact on R&D decision, which suggests that firms use private financial source to R&D activities.

iv) Writing or strategic appropriability mechanisms alone has negative impact on the R&D expenditure decision. It means that firms choose between writing or strategic appropriability mechanisms alone and R&D expenditure decision, or they are substitute strategic investment. As market share means firm size and market concentration at the same time, this result also suggests that the smallest firms that used writing or strategic appropriability mechanisms alone as appropriability mechanisms spent more on R&D.

v) Advertisement – a kind of appropriablility mechanism - and a mix of appropriability mechanisms (MAM) had positive impact on the R&D expenditure decision. It means that firms choose both those appropriability mechanisms and R&D expenditure decision, or they are complementary strategic investment. As market share means firm size and market concentration at the same time, this result also suggests that the biggest firms that used ad and MAM as appropriability mechanisms spent more on R&D.

To sum up, or results suggests that the mix of appropriability mechanism effect and market share are important to firm`s R&D expenditure decision in the Brazilian manufacturing sector.

Recent literature register that R&D is not the best innovative effort measure. May be better check market share and appropriability mechanisms impact on process and product innovative decision process, either to the firm or to the market. It is going to be our next empirical analysis.

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