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PRODUCT INNOVATION, MARKET STRUCTURE AND APPROPRIABILITY IN THE BRAZILIAN MANUFACTURING

Gílson Geraldino SILVA Jr[1]
Catholic University of Brasília, Brazil

ABSTRACT

This paper brings empirical evidence to the relationship among product innovation, market structure and appropriablility *at firm level* in Brazilian manufacturing. Our data base to 2003 and 2005 alows build a short unbalanced panel with 16.000 firms and use 10 appropriability mechanisms, since the traditional patents of invention to industrial secret and advertisement. We also consider a mix of appropriability mechanisms and distinguish product innovation to the firm and to the market. As we know, this is the first empirical study in this field to Brazil and some of the few at firm level in the literature.

Key words: product innovation, market structure, appropriability, Brazilian manufacturing

JEL codes: L10, L21, 032

ANPEC Área 8 - Economia Industrial e da Tecnologia

RESUMO

Apresentamos evidências empíricas para a relação entre inovação em produto, estrutura de mercado e apropriabilidade para empresas da indústria brasileira de transformação a partir de um painel curto e desbalanceado para 2003 e 2005 com 16.000 firmas e 10 mecanismos de apropriabiliadade, que vão desde as tradicionais patentes de invenção até segredo industrial e propaganda. Também consideramos um mix de mecanismo de apropriabiliade e distiguimos entre inovação em produto para a firma e para o mercado. Até onde sabemos, este é o primeiro estudo empírico desta natureza para o Brasil e um dos poucos para firmas na literatura.

Palavras chaves: inovação em produto, estrutura de mercado, apropriabiliade, industria brasileria de transformação.

Códigos JEL: L10, L21, 032

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1. INTRODUCTION

The relationship between innovation and market structure began with the Schumpterian hypotheses, which has two versions: 1) innovation increases more than proportionately with firm size and 2) innovation increases with market.

This discussion is probably one of the most extensively and intensively explored subjects in industrial organization. However, the empirical IO literature traditionally analyses R&D-market structure at industry level, and disaggregation varying from 2 to 5 SIC digit. And those studies use patents of invention as Scherer (1965) or appropriability indicators as Cohen, Levin and Mowery (1985). Most empirical studies failed in take systematic account of more fundamental sources of variation in the innovative behavior and performance of firms and industries.

In fact, innovation effort is traditionally measured as R&D expendures, basically because of technical difficulties to measure innovation. It focuses on the input of the innovation process (R&D) rather than the output (process or product innovation), as Cohen and Levin (1989) remark in their critical survey about innovation and market structure. However, there are significative objections to expendures on R&D as proxy to innovation. Geroski (1990) empirical study to innovation-market strucuture in UK industries is one remarkable exception; in spite he doesn't distinguish process and product innovation.

This paper brings empirical evidence to the relationship among product innovation, market structure and appropriablility *at firm level* in Brazilian manufacturing. We use 10 appropriability mechanisms, since the traditional patents of invention to industrial secret and advertisement. We also consider a mix of appropriability mechanisms and distinguish product innovation to the firm and to the market. It allows us take systematic account of more fundamental sources of variation in the innovative behavior and performance of firms and industries using firm level appropriability mechanisms. It is possible thanks to two detailed surveys conducted by Brazilian Census Office (IBGE) in 2003 and 2005: one about Brazilian industry, the Industry Annual Survey (PIA), and other about industry innovation, the Technological Innovation Survey (PINTEC).

Our main results are:

- Only one appropriability mechanism has always negative impact on product innovation decision (the opposite we expected), no matter if product innovation to the firm or to the market. As those appropriability methods have negative impact on firm's product innovation to the firm decision, it means those writing or strategic appropriability methods alone have low appropriabily effect.
- Our results also suggest that advertisement and a mix of appropriability methods are far efficient as product innovation to the firm protection option than only one writing or strategic appropriability mechanism. It makes sense once ad has an information split effect and a mix of appropriability options has a protection innovation effect far bigger than only one writing or strategic alternative.

However:

- Market share and it square doesn't have effect on firm's product innovation to the firm decision.
- Quite interesting, here market share and it interaction with only one appropriability mechanism have positive effect on firm's product innovation to the market decision, no matter it is writing or strategic. And market share square, negative impact, suggesting a conditional non-linearity. It makes sense as product innovation to the market is stronger than to the firm and certainly needs more protection

As we know, this is the first empirical study in this field to Brazil and some of the few at firm level in the literature.

This paper has 4 sections further than this introduction: section 2 reviews empirical analysis about innovation, market structure and appropriability, stressing the evolution of the empirical literature and patents and R&D limits; section 3 shows our econometric models; section 4, results and interpretations; and section 5, conclusions.

2. EMPIRICAL ANALYSIS ABOUT INNOVATION, MARKET STRUCTURE AND APPROPRIABILITY

2.1 Empirical literature

The relationship between innovation and market structure began with the Schumpterian hypotheses, which has two versions: 1) innovation increases more than proportionately with firm size and 2) innovation increases with market concentration. This discussion is probably one of the most extensively and intensively explored subjects in industrial organization. As the goal of this paper is bring empirical evidence to the relationship among product innovation, market structure and appropriablility *at firm level* in Brazilian manufacturing, we should revise this subject.

The empirical IO literature traditionally analyses R&D-market structure at industry level, and disaggregation varying from 2 to 5 SIC digit. And those studies use patents of invention as Scherer (1965) or appropriability indicators as Cohen, Levin and Mowery (1985). An exception is Geroski (1990).

Scherer (1965) paper about "firm size, market structure, opportunity, and the output of patented inventions" is very influential and creative but also a good example of data and computational restrictions, not easily shifted until 1980's.

In spite Scherer's restrictions, his seminal methodology should be remarked. Scherer (1965) had as main sample 448 firms on Fortunes list of the 500 largest U.S. industrial corporations for the base year 1955. And 352 out of 448 (78%) spent on R&D. The dependent variable is the number of U.S. invention patents issued to the sampled firms in 1959. It is lagged because of office registration delay. The independent variables were three measures of firm size for 1955, profits for 1955 through 1960, liquid assets for 1955, an index of diversification, dummy variables differentiating industry and technology classes, and four-firm concentration ratios.

In the 1980's Cohen, Levin and Mowery (1985) study using data on R&D appropriability collected by Levin et al. (1984) in a survey of R&D executives in 130 industries shows we must look to underlying differences in appropriability conditions.

This long R&D-market structure relation debate is summarized by Cohen and Levin (1989) in their famous survey about empirical studies of innovation and market structure. Their analysis to the empirical evidences until 1980's suggest that empirical results bearing on the Schumpeterian hypotheses are inconclusive, in larger part because investigators have failed to take systematic account of more fundamental sources of variation in the innovative behavior and performance of firms and industries.

They also conclude that the empirical literature on Schumpeter hypotheses is pervaded by methodological difficulties as the data have often been inadequate to analyze the question at hand, and the econometric techniques employed were rather primitive. The empirical results concerning how firm size and market structure relate to innovation are perhaps most accurately described as fragile.

By way of synthesis, evidences about R&D and market structure consists of many diverse and often conflicting results, even though the majority of studies have found a positive correlation between seller concentration and industry R&D intensity. Several empirical studies show that controlling for

variables representing industry differences in technological opportunity, usually using industry dummy variables, considerably reduces the effect of seller concentration on industry R&D intensity, implying that market structure and technological opportunity are not mutually independent in their relationship with industry R&D performance.

Also, the conditions governing appropriability of the returns from innovation are among the fundamental determinants of differences in innovation and R&D efforts. In fact, the ability of the firms to appropriate the returns from innovation encourages R&D investment. A mix of appropriability mechanisms avoids appropriability predation or imperfect appropriability.

Cohen and Levin (1989) also remember us that economists have made relatively little progress in specifying and quantifying appropriability influence basically because the data necessary for empirical work are often unavailable or unreliable. Among the remarkable efforts to measure appropriability are Levin et al. (1987) with the Yale Survey and Cohen et al. (2000) with the Carnegie Mellon Survey.

Geroski (1990) empirical study about innovations-market strucuture relationhip in the UK industries is one of the few exeptions in this Schumpetrian tradition. The data on two 73 three digit industry cross-section panels covers the periods 1970-4 and 1975-9, using average values over the five year period for the independent variables. He also use qualitative response model.

He explores the correlation between innovativeness and monopoly power by examining the effect of rivalry using more information on market structure than just concentration ratios, by correcting for interindustry variations in technological opportunity, and by distinguishing the effect that rivalry has on innovativeness for a given level of post-innovation returns from the effect that rivalry has on innovativeness through its effects on post-innovation returns.

He found fairly strong evidence against the hypothesis that increases in competitive rivalry decrease innovativeness. The calculations revealed that monopoly appears to inhibit the response to a given level of post-innovation returns, and that the indirect effects on innovativeness are relatively small. There is, in short, almost no support in the data for popular Schumpeterian assertions about the role of actual monopoly in stimulating progressiveness.

In the next section we show limits to R&D as proxy to innovation and patents limits as appropriability indicator.

2.2 Patents and R&D limits

At least since Scherer (1965) we know that a straight count of patents has two limitations: (1) the propensity to patent an invention of given quality may vary from firm to firm and from industry to industry; and (2) the quality of the underlying inventions varies widely from patent to patent.

Nowadays it is clear that 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, we should remark that 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 register an innovation 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 an innovation 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 as or better than that company which first innovate and ad it.

Advertising may serve as a signal of product quality or R&D effort; or both R&D and advertising are strategic investments and thus seem to affect each other. The relationship between advertising, R&D, and market structure advertising outlays aimed at increasing perceived quality (Shaked and Sutton, 1987).

About R&D expenditure, it is not always the best measure to innovative effort (Cohen and Levin, 1989), particularly in developing countries as Brazil once in those countries 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).

Using R&D expenditures may also be inappropriate 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. Perhaps most important for the purposes of this paper is the fact that in emerging market economies these types of innovations are less likely to be observed as firms are expected to engage more in imitation and adaptation of already created and tested innovations, rather than in generating new inventions and are less likely to expend resources on R&D (Gorodnichenko, Svejnar and Terrell, 2008).

In fact, innovation effort is measured by expendures on R&D, basically because of technical difficulties to measure innovation. It focuses on the input of the innovation process (R&D) rather than the output (process or product innovation), as Cohen and Levin (1989) remark.

In fact, it is heroic to assume that a properly measure R&D expenditure can fully summarize a firm's innovation effort. Moreover, many small firms simply have no formal R&D operation; and effort devoted to technological innovation is typically an unmeasured fraction of the time worked by the firm's engineers and managers. *At least, in most studies doesn't distinguish process and product innovation.*

In this study we consider direct measures to product innovation and a set of writing and strategic appropriability mechanisms and a mix of them inclusive advertisement. As far we know it covers a lack of empirical studies in the literature.

2.3 Empirical studies to Brazilian industry

Empirical studies about innovation in the Brazilian industrial firms could be grouped in two sets: before and after PINTEC (see details about this survey in the next section). Before PINTEC, those studies used R&D as proxy to innovation, following a long tradition. Among the main results, a negative relationship between R&D intensity and firm size for the years 1993 and 1994 (Hasenclever e Resende, 1998); R&D effort elasticity is size firm invariant (Macedo e Alburquerque, 1999); and concentration and advertisement expenditures are correlated (Resende, 2006).

After PINTEC, a set of empirical papers analyse the relationship among innovations, technological patterns and performance in the Brazilian industrial companies (De Negri e Salerno, 2005); technology, exports and employment (De Negri, De Negri e Coelho, 2006) and technological innovation in Brazilian and Argentine firms (De Negri e Truchi, 2007). In sum, they show that innovative firms with differentiated products have the biggest market share; innovative effort among Brazilian firms is higher than foreign ones in Brazil; Brazilian exports have technological intensity lower than world average; and that Brazilian firms have a technological performance better than Argentinean ones. However, those results are not enough. Innovative performance should increase and the global scenario gives Brazilian industry two options: innovation or innovation (Arbix, 2007)

In sipte many important empirical studies about innovation in the Brazilian industry, as far we know it is the first one that considers the relationship among product innovation, market share and appropriability in a broad sense.

Before we go ahead, let's give details about the data base and variables.

3. DATA BASE AND VARIABLES

Our data base are the Industrial Annual Survey (Pesquisa Industrial Anual, PIA) and the Technological Innovation Survey (Pesquisa de Inovação Tecnológica, PINTEC), both produced by Brazilian Census Office (Instituto Brasileiro de Geografia e Estatistica, IBGE).

PIA is a firm level industrial annual survey to Brazilian manufacturing. It began in 1966 and change completely in 1996 to be according to modern survey technology. It is drawn according to concentration industrial. All industrial firms with more than 30 employees are in this survey. As smaller firms are the majority in number but the minority in economic activity, PIA has a sample to industrial firms with more than 5 and less than 30 employees. From PIA we get annual information about advertisement expenditure, net revenue, inventories, payroll, and operational costs.

Those information allow us calculate at firm level market share as MS_{it}= firm i at year t revenue/sector revenue at year t, where sector is SIC 4 digit disaggregation level; price cost margin as PCM_{it}=(net revenue_{it} + $\Delta\text{inventories}_{it}$ – payroll_{it} – operational costs_{it})/(net revenue_{it} +$\Delta\text{inventories}_{it}$), as suggested by Domowitz, Hubbart and Petersen (1986); and advertisement intensity as ADV_{it} = advertisement expenditure_{it} /net revenue_{it}.

PINTEC is a firm level technological innovation survey that began in 2000 following Oslo Manual 3rd edition methodology. It is not annual and has until now three editions available: 2000, 2003 and 2005. However, only the second and third editions have information about appropriability mechanisms. So we focus on 2003 and 2005 surveys.

From PINTEC we get annual information about product innovation (to the firm or to the market) and if the firm use (or not) at least one of the following protection mechanisms: patents of invention (PI), utility model patent (UMP), industry design register (IDR), trade marks (TM) and copyright (C) (those 5 are writing appropriability mechanisms), design complexity (DC), industrial secret (IS) an leading time to competitors (LTC) (those three are strategic protection mechanisms). This data base also has “others” appropriability mechanism category. It allows us build indicator variables about R&D activity and use of protection mechanisms.

It is important remark that we have a direct measure of appropriability at firm level from PINTEC. As acknowledged by Cockburn and Griliches (1987), despite the richness of some surveys as the Yale Survey, it is not easy to derive a single measure of innovation appropriability.

PIA and PINTEC are connectable through a common firm identification number. However, as they are surveys, some firms in the PIA are not necessarily in the PINTEC and *vice-versa*. We match PIA and PINTEC 2003 and 2005 editions and get a short unbalanced panel with 16.000 firms.

4. ECONOMETRIC MODELS

As or innovation produt dependent variable is a binary one, we must use a binary response model. Probit is the binary response models most commonly used in applications. It is typically estimated by maximum likelihood which has good properties in large samples. In particular, it is asymptotically efficient (Horowitz and Savin, 2001).

Generally, a probit model can specified as

(1) $P(Y=1|X) = G(X\beta_k) = G(\beta_0 + \beta_1 X_1 + (\ldots) + \beta_k X_k)$, where G(.) is a normal cdf.

The β_k gives the signs of the partial effect of each x_k on the response probability; and the statistical significance of x_k is determined by whether we can reject H_0: $\beta_k = 0$. In sum, the signing of β_k determines whether the independent variables had a positive or negative effect on the binary depend one (Wooldridge, 2002).

However, there is neglected heterogeneity problem. The consequences of omitting variables when those variables are independent of the included explanatory variables are bias and inconsistence coefficients estimation. The omitted variables set could have many variables as management ability, technological opportunity and feeling to innovation. The fixed effects probit analysis treats fixed effects as parameters to be estimated along with β. And treat fixed effects as parameters to estimate lead to potentially serious biases. But it doesn't happen if we consider random effects (Wooldridge, 2002).

In the general form our specification is

(2) $P(I=1|MS, LNPCM_{it-1}, LNPCM_{it-2}, AI) = G(X\alpha_k) = G(\alpha_0 + \alpha_1 MS_{it} + \alpha_2 MS^2_{it} + \alpha_3 LNPCM_{it-1} + \alpha_4 LNPCM_{it-2} + \alpha_5 MS_{it} * AI_{it} + \alpha_6 MS^2_{it} * AI_{it} + \alpha_7 AI_{it})$

This can be re-written as

(3) $I_{it} = \alpha_0 + \alpha_1 MS_{it} + \alpha_2 MS^2_{it} + \alpha_3 LNPCM_{it-1} + \alpha_4 LNPCM_{it-2} + \alpha_5 MS_{it} * AI_{it} + \alpha_6 MS^2_{it} * AI_{it} + \alpha_7 AI_{it} + \mathbf{\Gamma}_{it} + \varepsilon_{it}$, where:

I_{it} is a dummy variable to firm i at time t, which is 1 if firms had product innovation (to the firm or to the market) and 0 on the contrary.

MS_{it} is market share[2], MS^2_{it} market share square, $LNPCM_{it-1}$ and $LNPCM_{it-2}$ are the first and second price-cost margin log lagged, AI_{it} is one of the ten appropriability mechanisms described in section 3 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.

AI_{it} allows us control for systematic firm differences in appropriability on product innovation firm decision. $MS_{it} * AI_{it}$ tell us if market structure and appropriability are (or not) mutually independent in their relationship with industry product innovation performance, i.e., it controls market share effects on product innovation firm decision for systematic firm differences in appropriability.

[2] It is important remark that market share measure market concentration and firm size at the same time.

The tension between the often-cited inverted-U hypothesis and the diverse empirical results indicates that the available empirical evidence is inconclusive, and thus much remains to be learned regarding the relationship between market structure and industry innovative performance. MS^2_{it} provide support for the inverted-U hypothesis. And $MS^2_{it}*AI_{it}$ it allows us check if appropriability strategy influence inverted-U relationship. At least, Γ_{it} is the firm random effect and avoid neglected heterogeneity problem.

We expect that α_1, α_3, α_4, α_5, α_7 have positive sign as market share, lagged profit and appropriability mechanisms should have positive effect on product innovation decision. And we expect that α_2 and α_6 could be positive or negative as is possible a U or U-inverted market share-product innovation relationship are possible.

At least, those panel regressions with lagged variables avoids endogenity problem, especially because of simultaneity between product innovation and profitability.

5. RESULTS

5.1 Descriptive statistics

TABLE 1, which sould be read through collums, give us some information about firm's innovative profile, our dependet variable. Around 21% of the firms in our sample have done product innovation to the firm (IP1), and just 4.5% to the market (IP2).

TABLE 1 - product innovation share

PRODUCT INNOVATIVE PROFILE (%)	**IP1**	**IP2**
YES	21.13	4.57
NO	78.87	95.43
TOTAL	**100**	**100**

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

Let's check the descriptive statistics to our explicative variables.

The continuous variables (TABLES 2 and 3, that should be read through lines) show us that among 16626 firms 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 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 than 71%. They also show us a significant dispersion of all variables described.

TABLE 2 – continuous variables descriptive statistics

Variable	Observations	Average	Standard Deviation
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 3 – continuous variables percetiles

Variable	P5	P25	P50	P75	P95
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 4, that should be read through columns, 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%.

A firm can, at the same time, register a patent, has a design complex and expend on advertisement. So it makes sense consider a mix of appropriability methods (MAM). We create MAM qualitative variable that is one to firms that used *more than one* appropiability mechanism, include advertisement and 0 on the contrary. By 49.74% of the firms in this sample used a mix of appropriability methods (MAM).

TABLE 4 – 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

Let's check the regression results.

5.2 Regressions results

Tables 4 and 5 have the probit regression results.

Table 4 have results to 11 regressions like equation (3) to process innovation to the firm. In general, we have two patterns: t-2 lagged profit has always positive impact on product innovation decision (as expected) and only one appropriability mechanism has always negative impact on product innovation decision (the opposite we expected). Market share and it square doesn't have effect on firm's product innovation decision to the firm.The exception is maket share negative effect on product innovation decision to the firm if industry design register (IDR) is the only one appropriability mechanism. Market share and it squares interactions with appropriability have any effect on product innovation.

As those appropriability methods have negative impact on firm's product innovation to the firm decision, it means those writing or strategic appropriability methods alone have low appropriabily effect.

Advertisement as the only appropriability mechanism option has positive effect on on firm's product innovation to the firm decision, which suggests it is a protection option more efficient than only one writing or strategic. As Shaked and Sutton (1987) suggest, advertising is as a signal of product quality or innovative effort; or both. If fact, advertising and innovation are strategic investments and one affect each other. Firms with high ad investment can increase their market share.

At least, we consider a firm use a mix of appropriability methods (MAM). It has positive effect on product inoovation to he firm decision, which suggests it is a protection option more efficient than only one writing or strategic and at least as efficient as advertisement.

Interestingly, when we consider advertisement as the only firm's product innovation to the firm option or MAM market share has positive effect on innovative decision. As those appropriability methods have positive impact on innovation decision, it means ad alone and mix of appropriability methods have high appropriabily effect.

Those results also suggest that advertisement and a mix of appropriability methods are far efficient as product innovation to the firm protection option than only one writing or strategic appropriability mechanism. It makes sense once ad has an information split effect and a mix of appropriability options has a protection innovation effect far bigger than only one writing or strategic alternative.

In ad and MAM regressions t-1 and t-2 lagged profit have positive effect on innovation decision as well market share.

Table 4: Product innovation to the firm, appropriability and market share - 2003- 2005 probit painel

IP1	PI	UMP	IDR	TM	C	DC	IS	LTC	OTHERS	LNADV	MAM
CONSTANT	0.25(0.16)	0.78(0.17)***	0.99(0.189)***	0.70(0.096)***	0.057(0.26)	0.29(0.26)	0.44(0.134)***	-0.065(0.178)	0.12(0.269)	0.06(0.086)	-1.52(0.056)***
MS	-0.10(2.19)	-1.95(2.58)	-5.08(3.02)*	0.106(1.67)	-1.87(3.16)	0.67(3.56)	-0.697(1.84)	1.054(2.34)	-0.065(4.95)	2.93(1.70)*	5.99(2.31)*
MS^2	2.86(3.57)	2.89(4.31)	8.51(5.67)	2.41(2.87)	4.45(4.80)	-1.56(6.22)	1.34(2.93)	-0.737(4.00)	1.64(10.71)	-1.81(3.29)	-10.33(7.01)
$LNMPC_{t-1}$	0.10(0.089)	0.11(0.088)	0.10(0.088)	0.084(0.088)	0 .11(0.089)	0.11(0.089)	0.10(0.089)	0.11(0.089)	0.11(0.089)	0.35(0.10)***	0.27(0.071)***
$LNMPC_{t-2}$	0.26(0.085)***	0.26(0.085)***	0.26(0.085)***	0.234(0.084)***	0.265(0.085)***	0.265(0.085)***	0.26(0.085)***	0.27(0.086)***	0.267(0.085)***	0.387(0.109)***	0.237(0.071)***
MS*AI	0.79(1.22)	1.68(1.37)	3.30(1.57)**	0.607(1.07)	1.78(1.64)	0.37(1.83)	1.04(1.07)	0.224(1.267)	0.76(2.507)	-0.23(0.28)	-1.37(2.35)
MS^2*AI	-2.89(2.03)	-2.50(2.28)	-5.36(2.92)*	-3.04(2.02)	-3.51(2.52)	-0.20(3.19)	-1.86(1.78)	-0.74(2.16)	-1.85(5.40)	0.63(0.56)	4.62(7.06)
AI	-0.16(0.084)**	-0.44(0.09)***	-0.55(0.096)***	-0.455(0.053)***	-0.065(0.13)	-0.18(0.131)	-0.271(0.070)***	-0.0016(0.09)	-0.09(0.135)	0.10(0.012)***	0.86(0.048)***
LOG VERO	-5419.96	-5410.81	-5406.01	-5368.36	-5424.36	-5424.08	-5415.89	-5425.31	-5425.10	-5423.05	-7512.52
TEST χ^2											
All variables	χ2 (7)=49.45***	χ2 (7)=67.60***	χ2 (7)=74.87***	χ2 (7)=140.31***	χ2 (7)=41.58***	χ2 (7)=42.18***	χ2 (7)=57.47***	χ2 (7)=39.83***	χ2 (7)=40.24***	χ2 (7)=248.18***	χ2 (7)=618.56***
MS,MS^2	χ2 (2)=3.36	χ2 (2)=0.57	χ2 (2)=2.83	χ2 (2)=3.74	χ2 (2)=1.21	χ2 (2)=0.08	χ2 (2)=0.21	χ2 (2)=0.54	χ2 (2)=0.15	χ2 (2)=7.30	χ2 (2)=8.43
MS*IA,MS^2*IA	χ2 (2)=4.12	χ2 (2)=1.49	χ2 (2)=4.43	χ2 (2)=4.78*	χ2 (2)=2.09	χ2 (2)=0.14	χ2 (2)=1.09	χ2 (2)=0.23	χ2 (2)=0.12	χ2 (2)=1.36	χ2 (2)=0.43
MS*IA,MS^2*IA,IA	χ2 (3)=10.62***	χ2 (3)=28.86***	χ2 (3)=36.75***	χ2 (3)=106.38***	χ2 (3)=2.10	χ2 (3)=2.67	χ2 (3)=18.82***	χ2 (3)=0.23	χ2 (3)=0.65	χ2 (3)=98.26***	χ2 (3)=358.06***
OBSERVATIONS	8073	8073	8072	8073	8073	8073	8073	8073	8073	9276	14379

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

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

Note: IP1 is product innovation to the firm *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).

Table 5 have results to 11 regressions like equation (3) above to firm's product innovation to the market decision.Here the results are more interesting.

Again, we have two patterns: t-2 lagged profit has positive impact on product innovation decision (as expected, except to ad regression) and only one appropriability mechanism has always negative impact on product innovation decision (the opposite we expected). As those appropriability methods have negative impact on firm's product innovation to the firm decision, it means those writing or strategic appropriability methods alone have low appropriabily effect.

Market share and it square doesn't have effect on firm's product innovation to the market decision, except if trade market is the only one appropriability option. In this TM regression, MS have positive effect and it square negative, i.e., there is a non-linear relationship between innovation and market share if trade market is the appropriability mechanism.

Quite interesting, here market share and it interaction with only one appropriability mechanism have posite effect on firm's product innovation to the market decision, no matter it is writing or strategic. And market share square, negative impact, suggesting a conditional non-linearity. It makes sense as product innovation to the market is stronger than to the firm and certainly needs more protection.

Advertisement as the only appropriability mechanism option has positive effect on firm's product innovation to the market decision, which suggests it is a protection option more efficient than only one writing or strategic. Market share have positive effect and there is non-linearity innovation-market share relation as MS^2 has negative impact on product innovation to the market decision. Market share and it square interactions with other appropriability machanisms (MS*ad and MS^2*ad) has the oposite MS and MS^2 sign, i.e., advertisement dominates market share effect. As Shaked and Sutton (1987) suggest, advertising is as a signal of product quality or innovative effort; or both. If fact, advertising and innovation are strategic investments and one affect each other. Firms with high ad investment can increase their market share.

At least, we consider a firm use a mix of appropriability methods (MAM), and the result is basically the same ad regression. As those appropriability methods have positive impact on innovative decision, it means ad alone and mix of appropriability methods have high appropriabily effect. In those cases market share is more largely influenced by the level of technological competence.

Those results also suggests that advertisement and a mix of appropriability methods are far efficient as product to the market innovation protection option than only one writing or strategic appropriability mechanism. It makes sense once ad has an information split effect and a mix of appropriability options has an innovation protection effect far bigger than only one writing or strategic alternative.

Table 5: Product innovation to the market, appropriability and market share - 2003- 2005 probit painel

IP2	PI	UMP	IDR	TM	C	DC	IS	LTC	OTHERS	LNADV	MAM
CONSTANT	0.95(0.16)	0.35(0.18)**	-0.012(0.197)	-0.482(0.106)***	-0.11(0.278)	0.55(0.262)**	0.43(0.135)***	1.28(0.175)***	-0.068(0.28)	-1.02(0.107)***	-2.98(0.10)***
MS	-1.17(2.20)	1.96(2.61)	0.457(3.42)	9.28(1.67)***	3.46(3.37)	2.27(3.96)	2.71(1.88)	0.877(2.35)	9.95(5.11)*	6.71(1.63)***	26.39(5.46)***
MS^2	4.61(3.69)	-0.096(4.52)	6.72(7.620	-8.43(2.72)***	0.615(5.46)	2.27(7.86)	2.66(3.16)	-0.798(4.03)	-14.59(10.89)	-5.83(2.74)**	-102.5(33.76)***
$LNMPC_{t-1}$	0.12(0.12)	0.156(0.12)	0.148(0.117)	0.109(0.115)	0.15(0.116)	0.15(0.117)	0.106(0.12)	0.16(0.119)	0.15(0.11)	0.32(0.14)**	0.17(0.10)*
$LNMPC_{t-2}$	0.23(0.11)**	0.23(0.11)**	0.22(0.114)**	0.185(0.112)*	0.22(0.113)**	0.22(0.114)**	0.204(0.11)*	0.24(0.116)**	0.226(0.11)**	0.097(0.13)	0.24(0.108)**
MS*AI	5.46(1.22)***	3.98(1.39)***	4.78(1.77)***	-0.115(1.04)	3.25(1.74)*	3.70(2.02)*	3.54(1.13)***	3.99(1.27)***	-0.105(2.59)	-0.62(0.26)**	-16.02(5.47)***
MS^2*AI	-7.37(2.06)***	-4.88(2.38)**	-8.36(3.88)**	-0.40(1.76)	-5.40(2.84)*	-5.91(3.99)	-7.29(2.016)***	-3.82(2.177)*	2.55(5.49)	0.75(0.42)**	92.16(33.76)***
AI	-1.30(0.086)***	-0.97(0.09)***	-0.78(0.10)***	-0.625(0.06)***	-0.72(0.14)***	-1.05(0.132)***	-1.05(0.073)***	-1.45(0.092)***	-0.74(0.14)***	0.13(0.015)***	1.24(0.09)***
LOG VERO	-3177.93	-3253.05	-3280.54	-3233.35	-3300.31	-3275.27	-3169.73	-3145.97	-3294.35	-3068.99	-3756.33
TEST χ^2											
All variables	χ2 (7)=633.81***	χ2 (7)=541.24***	χ2 (7)=498.58***	χ2 (7)=558.77***	χ2 (7)=471.57***	χ2 (7)=507.64***	χ2 (7)=638.76***	χ2 (7)=675.15***	χ2 (7)=482.98***	χ2 (7)=562.82***	χ2 (7)=833.55***
MS,MS^2	χ2 (2)=3.63	χ2 (2)=2.82	χ2 (2)=5.53*	χ2 (2)=47.19***	χ2 (2)=6.97**	χ2 (2)=4.26**	χ2 (2)=24.56***	χ2 (2)=0.28	χ2 (2)=5.24*	χ2 (2)=27.53	χ2 (2)=38.95***
MS*IA,MS^2*IA	χ2 (2)=21.05***	χ2 (2)=9.70***	χ2 (2)=7.74**	χ2 (2)=0.52	χ2 (2)=3.74	χ2 (2)=3.52	χ2 (2)=13.12***	χ2 (2)=17.31***	χ2 (2)=1.24	χ2 (2)=6.28**	χ2 (2)=8.58**
MS*IA,MS^2*IA,IA	χ2 (3)=269.99***	χ2 (3)=129.02***	χ2 (3)=69.82***	χ2 (3)=163.88***	χ2 (3)=32.98***	χ2 (3)=84.06***	χ2 (3)=285.86***	χ2 (3)=324.18***	χ2 (3)=45.95***	χ2 (3)=76.57***	χ2 (3)=223.66***
OBSERVATIONS	8073	8073	8072	8073	8073	8073	8073	8073	8073	9276	14379

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

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

Note: IP2 is product innovation to the market *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).

6. CONCLUSION

By way of synthesis, the relationship between product innovation (to the firm or to the market) and market structure (conditional to appropriability) among Brazilian manufacturing firm's empirical evidence to 2003 and 2005 unbalanced panel suggest that:

Our main results are:

- Only one appropriability mechanism has always negative impact on product innovation decision (the opposite we expected), no matter if product innovation to the firm or to the market. As those appropriability methods have negative impact on firm's product innovation to the firm decision, it means those writing or strategic appropriability methods alone have low appropriabily effect.
- Our results also suggest that advertisement and a mix of appropriability methods are far efficient as product innovation to the firm protection option than only one writing or strategic appropriability mechanism. It makes sense once ad has an information split effect and a mix of appropriability options has a protection innovation effect far bigger than only one writing or strategic alternative.

However:

- Market share and it square doesn't have effect on firm's product innovation to the firm decision.
- Quite interesting, here market share and it interaction with only one appropriability mechanism have positive effect on firm's product innovation to the market decision, no matter it is writing or strategic. And market share square, negative impact, suggesting a conditional non-linearity. It makes sense as product innovation to the market is stronger than to the firm and certainly needs more protection

Our results about product innovation and market structure (conditional to appropriability) is not only are according to the debate about this subject but also bring some contributions. In fact, most of the literature is about R&D and market structure, not about innovation and market structure.

In this study we consider direct measures to product innovation and a set of writing and strategic appropriability mechanisms and a mix of them inclusive advertisement. As far we know it this is the first empirical study in this field to Brazil and some of the few at firm level in the literature. It also covers a lack of empirical studies in the literature.

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