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Market Risk, Innovation Capacity and Value Creation In Brazilian Pharmaceutical Companies Listed on the B3

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INTRODUCTION

Innovation is an essential source of competitive advantage for companies that seek to maintain their performance in a dynamic economic environment (Koller, Goedhart & Wessels, 2015). Companies that operate in sectors characterized by the rapid and constant change have innovation as an ally in obtaining competitive advantages and improving organizational performance.

For example, companies in the pharmaceutical industry, while needing to innovate to remain competitive in the market, also face challenges in developing new drugs, which makes this innovation process risky (Grewal, Chakravarty, Ding & Liechty, 2008). Nevertheless, maintaining a diversified product portfolio is essential for maximizing shareholders' financial return (Cooper, Edgett, & Kleinschmidt, 2001).

The relationship between innovation and value creation is still a controversial topic in studies of the field. If, on the one hand, previous studies show a negative relationship between patenting activities and market value (Levitas & Chi, 2010), on the other hand, there is evidence that innovation, measured by the number of trademarks, has a positive impact on the value of companies (Teh, Kayo & Kimura, 2008). Some authors argue that this relationship indirectly creates competitive advantages (Tamayo-Torres, Gutierrez & Montes, 2016), which are reflected in the organizations' performance.

Therefore, this research aimed to verify whether, by assuming higher levels of market risk (Beta), pharmaceutical companies listed on B3 would be able to convert, with greater intensity, the resources and investments allocated in Research and Development (R&D), potentializing the value creation effect (Tobin's Q) over time. To this end, we used secondary data sources collected in Capital IQ referring to publicly traded companies in the pharmaceutical sector listed on B3 over a 10-year period, between 2010 and 2019, and the analyses performed with the aid of Stata IC 15.1 *software* (StataCorp, 2017) with the conjunction of the theoretical econometric models of Levitas and Chi (2010) and Teh, Kayo and Kimura (2008) and based on panel data with simultaneous equations (Haavelmo, 1943; Cornewell et al., 1992; Johansen, 1995).

The present study advances concerning the proposals of Teh, Kayo and Kimura (2008) and Grewal et al. (2008) since these authors used a temporal cutout. At the same time, this article proposes a longitudinal approach and the identification of time-lagged effects - more adequate to capture the fundamental relations of the pharmaceutical sector, which is known to take a long time to convert its investments into some kind of return.

On the other hand, few studies such as that of Teh, Kayo and Kimura (2008) and Pinheiro, Rapini, and Paranhos (2021) have been conducted to understand the peculiarities of the national pharmaceutical sector. A point that, partially, is supplied and encouraged by this article that focuses on the proposition of new studies and suggestions for advances in the literature and methodological aspects.

The structure of the article is organized in five parts, as follows: the present introductory chapter; the next one with the theoretical foundation and the hypotheses to be tested; then the methodological procedures are detailed, ranging from the initial stages of data collection and treatment to the details of the analytical strategies; in the next section, the analyses are divided

into three parts, the first being a brief description of the companies' profiles, the second containing the presentation of the initial model, and the third with the complete model; and, finally, the discussions, conclusions, and propositions for future studies.

THEORETICAL FRAMEWORK

This chapter aims to establish a logical sequence in the affinity between innovation and value creation, in addition to presenting the role of risk in the relationship between these two variables. The text is supported on the idea of resource allocation from *Resource-Based View* (RBV) in the national literature on markets and the performance of companies in the pharmaceutical sector - an essential point in the contextual discussion of this work.

Innovation, Risk, and Value Creation

Innovation is responsible for generating sustainable competitive advantages, which hinder the access of specific competitive threats. The sustainability of these competitive advantages can be made possible by the innovation capacity, an essential intangible asset of the organizations, stimulating entrepreneurial value creation. For example, in the pharmaceutical industry, these considerations become even more visible when one analyzes the patenting history of new drugs (Teh, Kayo & Kimura, 2008).

Innovation is considered one of the existing intangible assets (Teh, Kayo & Kimura, 2008). Higson (2001) mentions that Baruch Lev, in accounting, is one of the scholars on the theme. The author further points out that for Lev, the increase in interest concerning intangibles. However, this is not considered a new phenomenon is due to the fierce competition that has followed globalization and deregulation and the facilities provided by information technology (Higson, 2001).

It is essential to highlight here the characteristics that, according to Barney (1991), make intangible assets essential sources of competitive advantage for companies: they must be valuable, rare, imperfectly irreplaceable, and difficult to imitate. These characteristics are in line with the RBV, in which theorists argue that the basis of sustainable competitive advantage is possible to be formed from a junction of related capabilities and resources that possess the characteristics as mentioned earlier (valuable, rarity, inimitability, and imperfect irreplaceability) (Levitas & Chi, 2010).

Companies in the pharmaceutical sector deal with RBV factors in a very particular way since the time needed to generate value is very high. This is the classic example of patents and intellectual property disputes so fierce in this sector. From an economic point of view, the investment made by the company is high risk because several innovation processes may not actually be converted into innovation and value, in the form of return, for the companies. On the other hand, what was previously very rare after the innovation process can now be easily copied. Furthermore, with the expiration date, patents have their market reserve potential emptied (Kayo, Kimura, Martin & Nakamura, 2006).

According to Teh, Kayo, and Kimura (2008), the ability to innovate can be examined through two approaches: by the input and output values of the process. The process output values can be exemplified by items such as formulas, brands, and patents. The input values can be illustrated by expenditure on Research and *Development* (R&D) in companies, which are

sometimes used as indicators of innovation. Teh, Kayo and Kimura (2008) also point out that spending on R&D may indicate a predisposition of the company and even orientation of its strategy for innovation. However, it may not be a suitable parameter to signal the effectiveness of this process. On the other hand, this type of investment can be considered a source of intangible assets - in this case, and they may not be directly converted into results or economic-financial value (Kayo et al., 2006).

Still, when discussing innovation, it is essential to address the issue of market value creation. Levitas and Chi (2010) comment in their article that previous studies have shown that patenting activities may be unrelated or negatively related to the market value of companies. The authors also point out that these results do not mean that the market does not recognize the value that patents generate for companies, but rather that the market views these achievements as options of availability of future technologies for companies, valuing them in this way (Levitas & Chi, 2010).

Teh, Kayo and Kimura (2008) also analyzed patents and trademarks, one of the categories of intangible assets that can be considered a sustaining and an economic enabler of companies. When studying the relationship between these intangible assets and market value in Brazilian publicly traded companies, the authors found a positive relationship between the number of brands and value creation. However, they did not point out a significant relationship between patents and value creation in the companies in the study, and this last result could indicate that the efforts made by these companies in terms of creating new brands are not translated into market value (Teh, Kayo & Kimura, 2008).

Sectors such as the pharmaceutical industry frequently venture into the development of new products in order to remain competitive and sustainable in the market (Cooper, Edgett, & Kleinschmidt, 2004). Maintaining a diversified product portfolio is necessary for maximizing financial return and efficient resource allocation (Cooper, Edgett, & Kleinschmidt, 2001). Therefore, it is pertinent to understand the relationship between these firms' ability to innovate and their market value. Although the results of Teh, Kayo, and Kimura (2008) point to a non-significant relationship between patents (intangible asset) and value generation, it is expected that in the pharmaceutical sector, the results are divergent due to the constant need to develop new products and remain competitive in the market. Even the market value of companies directed to R&D activities tends to be higher than their peers who do not follow this path (Kayo et al., 2006). In this sense, the first hypothesis of the study is formulated:

H1: There is a positive relationship between innovation and value creation in pharmaceutical companies listed on B3.

The relationship between risk, innovation, and value is also remarkable in the pharmaceutical industry's drug development process. Grewal, Chakravarty, Ding, and Liechty (2008) address how expensive and risky drug development is: approximately between $800 million to $1 billion per drug, with only 1 in every 50,000 chemical entities created in the early stages of the process becoming able to move on to subsequent stages of the drug development process (Grewal et al., 2008, p. 261).

It is also possible to visualize the slowness of this process (Grewal et al., 2008) which, on average, takes 10 to 12 years for a drug to pass through the entire development chain. In this context, for the company to create value, to obtain results more significant than the opportunity cost of capital, it must select strategies that promote the maximization of its economic profit or the present value of its cash flows (Copeland, Koller & Murrin, 2002). Another point of view put forward by McTaggart, Kontes, and Manking (1994) is that for

these companies to maintain their strategies over a longer period of time it is necessary that they establish fundamental processes and capabilities that enable this.

Based on the above, for a company to remain longer in the market and create value, structured processes and capabilities that are in line with the characteristics proposed by Barney (1991) and that go in the same direction of the RBV Theory (Levitas & Chi, 2010) are required. In this way, these companies would be able to achieve sustainable competitive advantage. However, for these same companies to remain in the market, it is necessary to invest in innovation, such as spending on R&D (Teh, Kayo & Kimura, 2008) and/or developing new products, which can be costly, time-consuming, and risky for companies (Grewal et al., 2008).

In addition to the facilities provided by technology mentioned by Higson (2001), Bardhan et al. (2013) empirically verified that Information Technology (IT) could act as a potentializer of the relationship between R&D and value generation (also measured by Tobin's Q). In the present study, a complementary hypothesis to that advocated by Higson (2001) and Bardhan et al. (2013) is being proposed by replacing IT with a more comprehensive proposition, market risk. For it is expected that risk should be proportional to the return to be obtained (Kayo et al., 2006) - therefore, by assuming higher levels of risk, it is expected that this effect could enhance value creation. However, this process would occur with the interaction of investment in R&D. Thus, and this study also becomes complementary to that proposed by Greenhalgh and Rogers (2006), who, instead of testing the role of market risk, used variables such as competition intensity and market size. Therefore, the following hypothesis is presented:

H2: Pharmaceutical companies listed on B3 that invest in innovation, measured by R&D, and have greater exposure to risk can achieve higher levels of value creation.

With the two hypotheses of this study, it is intended not only to test constructions made of theoretical origin empirically but also to enable new results that can serve as a basis for future studies. Other points consist of expanding to previous years and studying particular events and how companies in the pharmaceutical sector reacted. And, these may verify whether there is the influence of other variables in the context studied here, in addition to understanding the extrapolation of these hypotheses to other sectors of the companies listed on B3.

METHODOLOGICAL PROCEDURES

Secondary source data were collected from Capital IQ and are relative to publicly traded companies listed on B3 over a 10-year period - between 2010 and 2019. The data were analyzed in Stata IC 15.1 *software* (StataCorp, 2017) according to the pooling of two econometric theoretical models (Levitas & Chi, 2010; Teh, Kayo, & Kimura, 2008) according to several different estimations, but based on panel data with simultaneous equations (Haavelmo, 1943; Cornewell et al., 1992; Johansen, 1995). The reg3 command estimated the models, the fixed effects were defined by specifying *dummies* (*i.*) for the years and firm identifier variables, and the lagged variables were created by the specification described in the manual of time series operators (L. for those lagged in $t-1$, L2. for those lagged in $t-2$etc.).

INITIAL ANALYTICAL STEPS

The first step of the analyses was to perform univariate descriptive statistics with measures of dispersion, central tendency, and position of the variables studied (mean, median and standard

deviation) and bivariate (Pearson product-moment correlation coefficient). This step was complemented with the SW Test (Shapiro & Wilk, 1965) of normality, which null hypothesis the adherence to normality (N).

In the second step, the bivariate relationship between the variables was graphically observed, an analysis performed in parallel with Pearson's Product-Moment correlation coefficients (ρ). After the initial knowledge of the behavior of the variables and the relationship with their peers, it was possible to start the multivariate analysis. To this end, the Multiple Linear Regression Analysis (MLR) was also used by the Stata® *software* (StataCorp, 2017).

The third step used the strategy of comparing multiple models - competing models - and testing the assumptions of RLM. Based on the ρ coefficients described in the second step, it was possible to get an initial idea of the variability shared among the variables. However, no variable was removed for excessive collinearity (VIF > 10), except when there was a perfect linear combination (O'Brien, 2007). Then the tests to verify the homogeneity of variances were performed by the BP Test (Breusch & Pagan, 1979), CW Test (Cook & Weisberg, 1983), and complemented by other possible tests in order to obtain a complete diagnosis of heteroscedasticity (Brown & Forsythe, 1974). Suppose there was evidence for this, the robust correction for the standard errors (White, 1980). Still, the assumptions regarding the error term of the model would also be tested, such as the omission of variables by the RESET test (Ramsey, 1969) and its adherence to the normal distribution (Shapiro & Wilk, 1965).

Finally, the intensity and significance of moderation will be tested to identify whether it can be considered pure, quasi-moderative, homologative, or without effect (Sharma, Durand, & Gur-Arie, 1981). This test indicates whether the theoretical hypothesis of the study has empirical support within the context of the pharmaceutical industry.

COMPLETE MODEL

Model Specification and Identification Strategy

Although the two equations represent the viewpoint of the same unit of analysis, the decision-maker may aim to maximize the dependent variable of one equation to the detriment of the other. Because resources are scarce, it is also possible to point out an equilibrium condition between the two equations. The other aspects that support the identification conditions, such as the order condition and the rank condition, are also discussed below.

Order Condition

The explanation why debt capacity is not a direct explanatory variable for value creation measured by Tobin's Q (Order Condition of Equation 2) consists of converting the funds raised through investment in research and development (R&D). For this reason, the process occurs indirectly. Although the process can also be carried out directly, the effect is only enhanced when there is the possibility of performing R&D more safely.

By mentioning security, it becomes possible to discuss the role of the exogeneity of market risk (Beta) in ensuring the order condition of Equation 1. This variable is composed of two components that capture the variability of the company in relation to market movements. This implies assuming that it is not entirely exogenous because part of its variability is due to its own decisions and can be simultaneous to others used as controls, for example. However, another part is exogenous because it also represents a market behavior and contains variability,

which is exogenous. It is this second part that is intended to be tested in the model as intervening between the relationship between q_{it} e $R\&D_{it}$.

Classification Condition

To meet the ranking condition for Equation 1, it can be expected that $z_{11}, \gamma_{11} \neq 0$ and, for Equation 2, at least one of $z_2 \neq 0$. These two expectations will be tested according to the probability value at three levels: p-value < 0.01, as strong evidence; p-value < 0.05, sufficient evidence; and, p-value < 0.1, as weak evidence. The two equations that deal with the simultaneity between q_{it} e $R\&D_{it}$are presented below:

Equation 1:

$$q_{it} = \beta_{10} + \beta_{11}LC_{it} + \beta_{12}LUCRAT_{it} + \beta_{13}ROA_{it} + \beta_{14}DVtoR_{it} + \beta_{15}Size_{it} + z_{11}Beta_{it} + y_{11}R\&D_{it} + \gamma_{11}R\&D_{it}Beta_{it}$$

$$+ \sum_{i} id_i + \sum_{t} year_t + \varepsilon_1$$

Equation 2:

$$R\&D_{it} = \beta_{20} + z_{21}END_{it} + z_{22}END_{it-1} + +z_{23}END_{it-2} + \beta_{22}Size_{it} + y_{21}q_{it} + z_{24}q_{it-1} + z_{25}q_{it-2}$$

$$+ \sum_{i} id_i + \sum_{t} year_t + \varepsilon_2$$

The subscript was i used to represent the variations between the units of analysis, the firms. On the other hand, the subscript t was used to represent the temporal variations. Different symbols were used to represent the coefficients of variation of the independent variables used as control (β), endogenous (y), exogenous (z), and to capture the moderating/interacting effect (γ). The first number in the subscript of the independent variables is used to point to the equation to which the coefficient of variation belongs and the second a symbolic order to which the variable was inserted in the equation.

RESULTS ANALYSIS

DESCRIPTION OF VARIABLES

Table 1 shows that, on average, the pharmaceutical companies on B3 invested R$132.71 million in research and development in the analyzed period, with a standard deviation of R$425.33 million. The average indebtedness of these companies was R$10,319.30 million,

obtaining a standard deviation of R$ 57,190.35. The average beta of these companies is 1.43 (s = 0.95), relatively high compared to other sectors, as expected. The average Tobin's Q is 1.43. This variable has a relatively high standard deviation of 4.6. The sample companies have high R&D investment and debt variability, and Tobin's Q. Beta is the only variable that has a standard deviation smaller than the mean. Moreover, this variable is closer between the mean and the median.

The highest correlation in the matrix is observed between debt and R&D ($\rho = 0.81$; p-value < 0.01). This result can be explained by the fact that companies that can assume higher debt levels are also those with greater ability to direct it to innovations (R&D). So, indebtedness becomes a key point to provide innovation. On the other hand, this variable has a very low correlation with value creation (Tobin's Q), after all ($\rho = -0.03$; p-value = 0.22). This provides empirical support for assuming that debt is not responsible for creating value directly but rather through higher R&D investments. As outlined in Equations 1 and 2, they were presented earlier.

Tobin's Q has correlations very close to zero (p-value > 0.1) with the other variables, except with market risk (Beta) - which despite being very close mathematically, it is still possible to assume this linear difference ($\rho = 0.05$; p-value = 0.01). Market risk also has non-zero correlations with R&E ($\rho = 0.15$; p-value < 0.01), with higher intensity and significance, and with debt ($\rho = 0.03$; p-value = 0.08), at lower intensity and significance.

Table 1:
Descriptive statistics and correlation matrix of the main study variables.

	Average	Median	Standard Deviation	Correlation Matrix (ρ)			
				R&D	Indeb.	Beta	Tobin's Q
R&D	132.71	18.48	425.33	1			
p-value							
n				498			
Indebtedness	10319.30	829.82	57190.35	0.81	1		
p-value				0.00			
n				494	2860		
Beta	1.46	1.44	0.95	0.15	0.03	1	
p-value				0.00	0.08		
n				497	2767	2988	
Tobin's Q	1.43	0.73	4.60	-0.07	-0.03	0.05	1
p-value				0.12	0.22	0.01	
n				457	2291	2412	2458

INITIAL MODEL

The M0 model presents the result only with the constant and when compared to the others, is the one with the weakest fit (AIC = 1177.6; BIC = 1181.7). The M1 model adds the fixed effects of the firms and years used in the panel. This change alone accounts for explaining 74.5% of the total variability in Tobin's Q. Models M2 and M3 adds the control variables and

the variables of interest, respectively, separately. These models are only presented in unified form in M6 and M7.

Until this representation, there is no significant jump in explaining the total variability. Nevertheless, two variables that show a strong relationship with the dependent variable are Profitability (M2: *prof*, p-value < 0.01) and Market Risk (M3: *beta, p-value* < 0.01). When adding the Return on Assets (ROA), there is a significant change in the explanation of Tobin's Q, going to approximately $R^2 = 81\%$.

Initially, the simple moderation of Beta risk is not significant to support the value generation hypothesis (p-value > 0.1) in any of the models (M3 to M7). On the other hand, the moderation of ROA is shown to be quite significant (p-value < 0.05). This result shows the existence of significant return invested in Research and Development (R&D) in value generation according to the intensity of ROA. Nevertheless, this result can be observed only as complementary and is not the core of the research.

The Market Risk presents high collinearity with the other variables, but this fact is due to the inclusion of other variables that are originated from a linear combination of this variable - the moderations. Another point is the issue of homoscedasticity, not achieved until M6 (p-value < 0.01) but corrected for robust standard errors at M7. Furthermore, strong evidence of omitted variables was also found (p-value < 0.01) - a solution that can be found by adding non-linear terms of the variables employed in the model (Ramsey, 1969). However, this is already an expected result. For this reason, one of the most appropriate techniques for dealing with this type of problem is simultaneous equation modeling.

Table 2:
RLM models with the moderations.

Models	M0	M1	M2	M3	M4	M5	M6	M7
LC			0.0164*				0.005	0.005
			0.056				0.495	0.745
prof			1.062***				-0.968***	-0.968*
			0.002				0.008	0.083
dvtor			0.000				-0.001	-0.001
			0.711				0.395	0.267
size			0.000				0.000	0.000
			0.639				0.195	0.124
beta				-5.543***	-4.625***	-6.043***	-3.385**	-3.385**
				0.002	0.004	0.000	0.040	0.047

red				0.000	0.000	0.001	0.001	0.001
				0.679	0.388	0.261	0.306	0.226
redbeta				0.000	0.000	0.000	0.000	0.000
				0.753	0.967	0.950	0.863	0.772
roa					4.187***	4.626***	4.890***	4.890***
					0.000	0.000	0.000	0.000
redbetaroa					-0.00229**	-0.00217**	-0.00303**	-0.00303*
					0.035	0.045	0.027	0.059
redbetaroaln						-0.0748**		
						0.027		
Constant	1.132***	2.564***	2.040***	11.21***	8.873***	10.81***	7.427***	7.427***
	0.000	0.000	0.000	0.000	0.000	0.000	-0.003	0.001
n	457	457	456	456	456	436	455	455
AIC	1177.6	739.5	727.7	741.1	624.3	588.5	617.1	593.1
BIC	1181.7	1127.2	1131.7	1132.7	1024.2	963.6	1033.3	959.9
F	0.0	11.4	11.4	11.2	15.3	16.1	15.1	.
R^2	0.000	0.745	0.755	0.744	0.804	0.810	0.810	0.810
p-value	.	0.00	0.00	0.00	0.00	0.00	0.00	.

Legend: *** p-value < 0.01, ** p-value < 0.05 and * p-value < 0.1; p-values in parentheses.

The different initial specifications of the research model point out that the constant alone is not sufficient to explain value creation. Some marginal value is only added by including ROA, which, in turn, shows significant results in moderating the Risk-Innovation relationship with value creation. In contrast, firm-specific variations over the 10 years studied explain much of the variability in value creation. Nevertheless, there is evidence of endogeneity, which will be proposed in the following discussion.

COMPLETE MODEL

Five different estimation methods have been tested for simultaneous equations 1 and 2. In general, their results are quite similar. Two information criteria were used to choose the best model: Akaike (AIC) and Bayesian (BIC). The 3SLS estimation (Zellner & Theil, 1992) was the one that achieved the lowest levels in both information indicators and, for this reason, was

chosen to be interpreted. It is worth noting that the fixed effects of firms (i) and years (t) were omitted to maintain the parsimonious size of Table 3. The total explained variability of the dependent variable in Equation 1 = 58% and in Equation 2 = 94%.

The main results (Table 3) consist of 358 observations over the 10 years studied; this number is relatively small in relation to the descriptive statistics and the total number of companies listed on B3 due to the low frequency of supplying the total invested in R&D. The results also satisfy the identification strategy, as at least one exogenous variable in each equation has a coefficient statistically different from zero (rank condition) for the variables unique to each (order condition). The relevance condition can also be considered as satisfied because when analyzing the equations separately, (1) debt has no direct influence on Tobin's Q (p-value < 0.1) and (2) risk moderation (beta) only occurs in the simultaneous equations model, not significant when the equations are considered separately. Result consistent with observed in the initial RLM model.

It is possible to conclude that higher levels of investment in R&D are associated with higher levels of value creation measured by Tobin's Q (p-value < 0.1). On average and analyzing contemporaneously, each R$ 100.00 investment in R&D is associated with the immediate conversion of 0.821 units of the value creation. With this, it is possible to point out that there is strong evidence for the confirmation of H1: There is a positive relationship between innovation and value creation of pharmaceutical companies listed on B3.

This relationship is controlled to some degree by market risk. Under the condition of higher risk levels, it is possible to observe that if the company chooses to invest in R&D, lower levels of value creation are observed. In this case, despite the strong statistical significance (p-value < 0.001), it is not possible to point confirmation to H2: Companies in the pharmaceutical sector listed on B3 that invest in innovation, measured by R & D, and that have greater exposure to risk, manage to achieve higher levels of value creation.

This fact described in the results can perhaps be explained by choice to disinvest in R&D to obtain more short-term liquidity, in cash, for example. Under conditions where market risk is equal to zero, it is possible to observe that higher levels of R&D are associated with higher value creation.

Initially, when testing the correlation pairs, it was possible to observe that value creation is not linearly related to the amount of R&D investment but is significantly related to market risk (Beta). This result is repeated in the regression model but has no support in the full model of simultaneous equations. In this case, the moderation relation not only showed significance, but the market risk became non-significant, and so did the R&D investment. In this case, the literature (Sharma, Durand, & Gur-Arie, 1981) points to this type of relationship as pure moderation, more intense than quasi-moderation, because it changes the parallel relationships present in the nomological network.

The results of Equation 2 indicate that the current indebtedness is not related to the current level of investment in R&D (p-value > 0.1). This fact can be interpreted as the companies' debt capacity only influences the level of investment in R&D in future moments, as presented in the research model itself. The lagged variables present an extremely strong relationship (p-value < 0.01), whether referring to the previous period or two periods. On average, each R$ 1,000.00 investment capacity that the company has can be responsible for decreasing R$ 1.7 in future periods.

This relationship is contrary to Tobin's Q, which has a contemporaneous but not lagged effect, where each unit of value generated is immediately converted into an average of R$ 117.00 of investment in R&D.

Table 3:
Different estimators for the simultaneous theoretical model.

Estimation		3SLS	2SLS	OLS	SURE	MVREG
Equation 1						
	LC	0.00449	0.00610	0.00688	0.00693	0.00693
		(0.463)	(0.454)	(0.377)	(0.303)	(0.373)
	lucrat	-1.117***	-1.227***	-1.124**	-1.123***	-1.123**
		(0.002)	(0.009)	(0.012)	(0.004)	(0.012)
	roa	3.428***	4.206***	4.099***	4.085***	4.085***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	dvtor	0.00000613	-0.000432	-0.000712	-0.000711	-0.000711
		(0.994)	(0.694)	(0.494)	(0.430)	(0.494)
	size	-0.0000161*	-0.00000801	0.00000302	0.00000324	0.00000324
		(0.054)	(0.408)	(0.692)	(0.623)	(0.671)
	beta	-1.076	-2.490	-2.763*	-2.654*	-2.654
		(0.463)	(0.145)	(0.090)	(0.059)	(0.103)
	red	0.00821***	0.00278*	0.0000252	0.000191	0.000190
		(0.000)	(0.061)	(0.963)	(0.687)	(0.727)
	redbeta	-0.00480***	-0.00191*	0.0000675	0.0000196	0.0000197
		(0.000)	(0.076)	(0.874)	(0.958)	(0.963)
	Constant	4.253*	6.482**	6.932***	6.761***	6.761***
		(0.055)	(0.012)	(0.005)	(0.001)	(0.006)
Equation 2						
	endiv	0.000904	0.00100	0.00120	0.00119*	0.00119
		(0.135)	(0.220)	(0.107)	(0.065)	(0.111)
	L.endiv	-0.00179***	-0.00210**	-0.00190**	-0.00189***	-0.00189**

	(0.006)	(0.016)	(0.017)	(0.006)	(0.017)
L2.endiv	-0.00171***	-0.00142**	-0.00159**	-0.00158***	-0.00158**
	(0.001)	(0.040)	(0.011)	(0.003)	(0.012)
size	0.00179	0.00149	0.00255	0.00244	0.00244
	(0.418)	(0.576)	(0.287)	(0.238)	(0.308)
q	117.0***	128.9***	13.85	21.62	21.63
	(0.003)	(0.005)	(0.376)	(0.110)	(0.167)
L.q	4.705	-8.423	10.32	9.911	9.911
	(0.729)	(0.641)	(0.498)	(0.452)	(0.515)
L2.q	0.816	-9.848	5.331	5.161	5.160
	(0.947)	(0.550)	(0.706)	(0.673)	(0.715)
Constant	-336.9***	-308.1***	-74.03	-94.09	-94.13
	(0.001)	(0.008)	(0.294)	(0.123)	(0.182)
n	358	358	358	358	358
AIC	4885.10	.	4937.20	4934.80	4934.80
BIC	5583.60	.	5635.70	5633.30	5633.30
F	.	10.24	11.17	.	11.18
p > F	0.00	0.00	0.00	0.00	0.00

Legend: *** p-value < 0.01, ** p-value < 0.05 and * p-value < 0.1; p-values in parentheses.

DISCUSSIONS AND CONCLUSIONS

This paper advances the literature by studying in a combined manner the effects of the relationship between market risk, investment in research and development, and value within the context of the pharmaceutical industry of companies listed on B3 over the last decade. As seen in the descriptive analyses, even at B3, there is great variability in the profiles of pharmaceutical companies when it comes to R&D investment - with some of them closer to the reality of privately held companies and others larger and internationalized. These results may be helpful for small and medium entrepreneurs, laboratory franchisees, research institutes, and others active in their market expansion process.

All models analyzed in this research presented high values of explained variability of the dependent variable. In the initial model, values close to 80% were reached, while in the equivalent equation in the complete model, values close to 60% were reached. This may indicate that the independent variables used are sufficient to explain satisfactory levels of value creation in the pharmaceutical sector.

As predicted in the literature, there is strong evidence for confirming hypothesis H1: There is a positive relationship between innovation and value creation of pharmaceutical companies listed on B3. This result can be confirmed in studies such as the one conducted by Bardhan et al. (2013) for the technology sector. As a result that emerged from the observations, it is possible to observe the contemporaneity of the relationship outlined in H1. The results from previous periods were consistent in pointing out that the value previously generated is not responsible for being converted into R&D investment capacity. Unlike indebtedness, which can impact decreasing the ability to invest in longer-term R&D. In this case, evidence was found for periods more extended than one year of lag.

Unlike H1 and despite pointing to vital statistical significance, it was not possible to confirm hypothesis H2: Companies in the pharmaceutical sector listed on B3 that invest in innovation, measured by R&D, have greater exposure to risk management to achieve higher levels of innovation.

This hypothesis can be rediscussed from the viewpoint that pharmaceutical companies, along with technology companies, may occupy a place considered to be the market's risk ceiling. Under such conditions, the risk may have different behaviors that are highlighted in the general literature or other sectors. It turns out that this sector has high-risk characteristics and a high need for R&D investment. These conditions need to be taken into account when they are present simultaneously. As predicted in the literature (Kayo et al., 2006), the risk should be proportional to the return to be obtained. However, these may be at different moments in time, and the maintenance of competitive advantage is linked at some level to innovation processes, whether they come from investment in R&D, development of new processes, projects, products, or even the brand (Kayo et al., 2006) - variables that may complement the results observed in this study.

Contributions

It is possible to point out that there is strong evidence that the relations established in Equations 1 and 2 met the identification requirements of the simultaneous equations technique and statistical significance. It was using the technique of the simultaneous equation, especially with the presentation of multiple estimates, making it possible to take a step forward concerning linear regression models and panel data with fixed effects. It was possible to bring empirical evidence that would not be revealed with the aggregate data of more traditional regression estimators by controlling for endogeneity.

Besides this methodological contribution, it was also possible to advance theoretically in the discussion of hypothesis H2, which despite bringing a controversial result, can serve as a basis for future research, as discussed below, whether case studies or even counterproposals the one presented in this article.

It is worth noting that the relations observed within the pharmaceutical sector should be analyzed with time lags since generating innovations, creating patents, and other R&D activities take a long time from conception to reaching the markets in an accessible manner (Ge & Xu, 2020). For this reason, performing temporal cut-offs, as present in the research of Teh, Kayo, and Kimura (2008) and Grewal et al. (2008), may present spurious results with estimation bias. A strength in conducting this research is the results that bring new knowledge of the average effect over time, such as the one discussed value creation and investment in R&D.

Suggestions for Future Studies

Since the pharmaceutical sector is very dependent on the innovations it produces, it would be possible to draw a parallel with the technology sector - also abundant in this aspect. Some research in this sector can already be observed in the literature (Bardhan et al., 2013), but not exactly as designed in the present research. Future studies may test the relationships observed in the pharmaceutical sector in other sectors or even outline comparative hypotheses. Competing models with other variables representing innovation could also be tested, like the variables used by Teh, Kayo and Kimura (2008) and Greenhalgh and Rogers (2006).

Although Teh, Kayo and Kimura (2008) have not observed any significant results with the number of patents, for example, it can be seen that many companies in the pharmaceutical sector invest in R&D but choose not to patent the innovation. Mainly due to the exposure brought to the product, which can be easily copied in places with few protectionist barriers. On this point, companies can build different strategies to protect or make available their intellectual properties. On the other hand, empirical results point out that the legal mechanisms created have a negative impact on the pharmaceutical industry (Eger & Mahlich, 2014), for example.

The number of researchers or the proportions of researchers, especially those with PhDs and high qualifications, may be a *proxy* variable that better represents the company's commitment to promote innovation than the one used in this study or the one also used by Teh, Kayo and Kimura (2008). This discussion is already being held within the context of firms in the pharmaceutical sector, Ge and Xu (2020) for the reality of Chinese firms and Greenhalgh and Rogers (2006) for those in the United Kingdom. Still, on the role of qualification, Ge and Xu (2020) suggest that there should be an increase in cooperation between companies operating domestically and research institutions. Something that can be easily adapted to the Brazilian reality.

From an analytical perspective, future studies could compare different endogeneity control strategies, such as the Gaussian copula (Malevergne & Sornette, 2003), for example, in order to identify whether the chosen technique may be influencing the empirically observed results. One of the findings of the present research.

From the perspective of developing a research field, few studies are directed to understanding the market mechanisms of the national pharmaceutical sector. The great majority of research studies study the market as a whole and control it by sector. In this way, the specific cases of each sector can evade theoretical predictions that consider the global movements of the stock market.

Limitations

As mentioned at some points earlier, the availability of some variables acts as a limiting factor. The database available to collect data published by companies has few variables that can be used as *proxies* for innovation. It would be desirable to perform different tests, such as those performed by Teh, Kayo, and Kimura (2008). Other variables can not only capture a broader spectrum of what innovation means but can also be used to bring new empirical insights, as was done in this chapter of discussion and conclusions.

Another point of these limitations, but also related to the previous one, is the availability of R&D investment levels for companies in other sectors. These data are available only for those in the pharmaceutical sector. This factor makes cross-sectoral comparative studies impossible,

but they can be accessed in several ways through other databases - as performed by Teh, Kayo, and Kimura (2008).

According to the discussion held on the total explanation level of the variability of value creation and the variable limitations mentioned above, it is possible to conclude that the addition of new variables is welcome both to complement the explanation level of the dependent variable and to improve the measurement precision of the variables that explain it. These may be two ways of acting in future studies, but they are based on the limitations of the results found here.

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