The Influence of External Search Strategies on the Innovative Performance of Brazilian Firms

Carlos Arruda
E-mail: arruda@fdc.org.br

Anderson Rossi
E-mail: andersonrossi.associado@fdc.org.br

Gustavo Mendes
E-mail: gustavo.souza@fdc.org.br

Paulo Ferreira
Fundação Dom Cabral Business School, Belo Horizonte, Brazil
E-mail: paulo.ferreira@fdc.org.br

Abstract: In this paper we attempt to analyse the influence of three dimensions of external search strategies on the innovative performance of Brazilian firms. The dimensions analysed were: external search breadth, external search depth which deal with how firms access external knowledge and the types of external innovation partners that emphasize the "with whom" to interact. The underlying findings are mainly derived and based on conclusive descriptive research that utilized a survey as an instrument of data collection. In relation to external search breadth the results suggest that the variety of external actors produces a positive impact on the innovative performance of Brazilian firms. As regards external search depth a curvilinear relationship was observed −taking an inverted U-shape−. The empirical analysis also indicated that there was a difference in the impact of different external actors on the innovative performance of Brazilian firms, only customers and/or users and suppliers presenting significant impact.

Key Words: External search depth; External search breadth; External innovation partners; Innovative performance.

1 Introduction

The development of the theory of the firm from the neo-Schumpeterian perspective points to innovation as the fundamental element in explaining development and the generation of sustainable competitive advantage (NELSON, WINTER, 1982; DOSI, 1982; DIERICKX, COOL, 1989; TEECE *et al.*, 1997). In this sense, Chesbrough (2003) proposes the utilization of the term open innovation to refer to the inclusion of innovation as the strategic variable in the business

model and whose function is to create and capture value for the firm. In this approach the process of innovation is, above all, fed by the internal and external flow of knowledge and technology and, accordingly, dependent on the interaction of the company with external actors. It should be pointed out that the interaction with external actors throughout the innovation process is a question that has been debated for some time in the academic community (VON HIPPEL, 1988; NELSON, 1993).

In general, Child *et al.* (2005) suggests that there are a great number of motivations for the company to interact with external actors throughout its innovation process, ultimately all these motivations culminating in an increase in competitiveness and profitability. Nevertheless, there exists also a series of barriers that can diminish the effectiveness of an interactive innovation process, such as asymmetrical power relations, asymmetrical learning and cultural aspects, among others (HLADIK, 1988; HAMEL, 1991).

Keeping in view the motivations and barriers to companies interacting with external actors throughout their innovation process, it becomes important to analyse the external search strategy, which Laursen and Salter (2006) define as the use of external actors to achieve and sustain innovation. In analysing the external search strategy, Katila and Ahuja (2002) investigate the relevance of analysing deeply the intensity of the interaction with external actors (External search depth) and the diversity of the actors with which the company interacts (External search breadth). Belderbos *et al.* (2004) and Miotti and Sachwald (2003) on the other hand highlight the importance of the choice of which external actors to interact with. Thus, in this paper we analysed the impact of these three dimensions of external search strategy on the innovative performance of Brazilian firms. Therefore, we sought empirical evidence for the relationship between external search strategies and the innovative performance of Brazilian firms.

In addition to this introduction, the paper is structured into four topics of theoretical review, the first covering innovation process models and the importance of external search strategy, the second external search breadth, the third external search depth and the fourth the external innovation partners. Following this, the descriptive analysis of the variables analysed is presented, as well as the analysis of the impact of the three dimensions analysed on the innovative performance of Brazilian firms. Finally, in the conclusion, a discussion of the main results is given.

2 Conceptual Background

2.1 Innovation process and external search strategy

Authors such as Van de Ven *et al.* (1999) and Tidd *et al.* (2008) have maintained that innovation should be understood as a process, that is, as the sequence of events interconnected by causal relationships. The first innovation models proposed, that arose in the 40s, have become known as linear models and treated innovation as a linear sequence of activities, in other words, the development of innovations followed a rigid and sequential trajectory – basic research, applied research, development, production and launch of the product on the market - (GODIN, 2006; TIDD, *et al.*, 2008; SVETINA, PRODAN, 2008).

More recently non-linear or interactive innovation process models have been proposed (TIGRE, 2006; TIDD, *et al.*, 2008), which, in general, try to emphasize, above all, the relationship between the stages, the effects of feedback and the relationship with external actors throughout the process. In this sense, Leonard-Borton (1995), Keil (2002) and Chesbrough (2003) emphasize

the use of external knowledge in the success of the innovation process. Kline and Rosenberg (1986) on the other hand state that the interactions of the firm with external actors and the relationships between the stages of the process can follow not only one, but various paths.

Thus, in analysing non-linear or interactive innovation process models it is observed that the strategy of external search for external ideas, knowledge and technologies assumes great importance (KATILA, AHUJA, 2002). The external search strategy can be defined as the set of decisions that the firm takes in relation to the manner of best exploiting external knowledge (LAURSEN, SALTER, 2006). In this sense, Chesbrough (2003) suggests that the adoption of an open innovation model necessarily involves the implementation of an external search strategy.

It is stressed that the external search strategy adopted by the firm is influenced by the characteristics of the external environment, such as, for example, the availability of technology, the degree of complexity and turbulence, the framework of the national innovation system, formal mechanisms of transfer, among others. Moreover, Laursen and Salter (2006) propose that the external search strategy is influenced by the past experiences and future expectations of the managers.

In addition to these factors, the effectiveness of the external search strategy depends on how the company manages the search processes for new combinations of ideas, knowledge and technologies. In this sense four capabilities are singled out that need to be developed by the companies. The first is the ability to work with different external actors (LUNDVALL, 1992; von HIPPEL, 1988). The second refers to the ability to build relationships and absorb and assimilate external knowledge (COHEN, LEVINTHAL, 1990). The third refers to the ability to understand the routines, standards and habits of how different external actors work (BROWN, DUGUID, 2000). And the fourth consists in the ability to build up networks of contacts and social capital (HAGEDOORN, DUYSTERS, 2002; POWELL *et al.*, 1996).

From the foregoing, Levinthal and March (1993) point out that it is difficult for organizations to determine what is the best external search strategy. Moreover, empirical evidence is observed that the best external search strategy varies in accordance with the firm's sector of activity, with the type of knowledge sought and with the type of innovation - incremental or radical - (CRISCUOLO et al. 2011; KÖHLER *et al.*, 2009). Nevertheless, companies that succeed in developing an effective external search strategy succeed in differentiating themselves and thus generating sustainable competitive advantages. Hence the importance of going deeper into the study of the variables that affect it.

In this sense Katila and Ahuja (2002) propose two dimensions to be analysed in developing an external search strategy. The first consists of the deepness or intensity of the interaction with the external actors (External search depth). The second dimension is the diversity of actors with which the company interacts (External search breadth). In addition, Miotti and Sachwald (2003) and Belderbos *et al.* (2004) highlight a third dimension, the choice of which external actors to interact with. These three dimensions constitute the focus of this paper, while the impact of the external search strategy on the innovative performance is analysed within the Brazilian context. In the topics that follow, conceptual and empirical aspects of these three dimensions are dealt with.

2.2 External search breadth

Laursen and Salter (2006) explore the necessity of the firm to analyse its external search strategy with the intention of making possible the absorption of new ideas, knowledge and technologies and thus making the innovation process more effective. One of the dimensions of analysis proposed for the external search strategy refers to the diversity of external actors with which the firm interacts (External search breadth). Katila and Ahuja (2002) make a point of this being the dimension of the external search strategy utilized by companies to explore new knowledge or access new solutions.

In a rapid review of the literature on the subject, it was found that there is a positive relation between the diversity of external actors that participate in the innovation process and the innovative performance (KATILA, AHUJA, 2002). As explanatory factors for this relationship the following are singled out: *i.* the enrichment of internal knowledge and the creation of new combinations that make it possible for the firm to deal with the problems identified (MARCH, 1991) and *ii.* the increase in the capacity of the firm to recombine internal knowledge, making possible the appearance of new products (FLEMING, SORENSON, 2001).

Nevertheless, Katila and Ahuja (2002) also argue that the interaction with a great number of external actors may cause a negative impact on the innovation process. This is because there exists a cost in the integration of knowledge that may from certain point on offset the benefit of the discovery of new knowledge. In this sense, Henderson and Clark (1990) stress that the interaction with each external actor demands changes in the form of communicating and also in the contacts network. In addition to this, the difficulty that companies encounter in responding to new information in the correct way and thus assimilating it into their innovation process is also pointed out. From this perspective, the interaction with external actors tends to present a saturation point, after which the entry of more actors produces a negative impact on innovative performance. Chen *et al.* (2008) calculate this saturation point at between 8 and 9 external actors in their analysis of Chinese companies.

Uniting the cases of positive and negative effects, empirical studies (LAURSEN, SALTER, 2006; LEIPONEN, HELFAT, 2010) have concluded that the diversity of external actors with which the firm interacts presents a curvilinear relationship (taking an inverted U-shape) with innovative performance. As, however, in this paper only 5 external actors were analysed, it is expected that the diversity of external actors (External search breadth) is positively related to the innovative performance of Brazilian firms. Accordingly, the hypothesis 1 can be stated as:

Hypothesis 1. *External search breadth has a positive effect on innovative performance of Brazilians firms.*

2.3 External search depth

The diversity of external actors with which the firm interacts has proved to be an important dimension of external search strategy. However, the external search strategy is not based only on finding the external actors that have knowledge, it is also important to analyse the interaction process with them. In this sense, the analysis of the depth of the interaction with each external actor (*External search depth*) becomes relevant. Katila and Ahuja (2002) suggests that this is the dimension of the external search strategy that makes it possible for the company to exploit the knowledge of the external actors with which it interacts in different ways.

Levinthal and March (1981) expand this analysis and conclude that the utilization of the same elements of knowledge intensively reduces the possibility of errors and facilitates the development of routines, which adds reliability to the process. In this context, the repeated utilization of knowledge gained from the external actors can lead to an understanding of the concepts that it involves, and help the company to adapt or expand its competencies (KATILA, AHUJA, 2002). Further, Eisenhard and Tabrizi (1995) describe that the depth of the interaction with external actors makes possible the decomposition of activities linked to innovation in a logical and well demarcated sequence, facilitating the elimination of dispensable stages, in this way associating dynamism to the process.

Nevertheless, Dosi (1988) suggests that there is a limit to the process of deepening of the interaction with the external actors. In this sense, Katila and Ahuja (2002) highlight two factors. The first refers to the existence of a point after which the innovation process based on the same knowledge becomes expensive, while the solutions to its problems become excessively complex. The second is connected to the fact of the deepening of the interaction with external actors making the innovation process more rigid, and thus the entrance of new knowledge less flexible (ARGYRIS, SCHON, 1978).

In this sense, Katila and Ahuja (2002) and Laursen and Salter (2006) propose that innovative performance will be positively affected in principle, but, after a certain point, greater deepening of the interaction with external actors generates a negative impact in innovative performance. Based on these authors hypothesis 2 has been framed:

Hypothesis 2. *External search depth is curvilinear (taking an inverted U-shape) related to innovative performance of Brazilian firms.*

2.4 External innovation partners

In this section we have tried to describe the specific contributions of five external actors in the sense of helping companies to attain superior performance in their innovation process. It should be pointed out that the five external actors selected were those analysed by the Industrial Research of Technological Innovation (PINTEC), carried out by the Brazilian Institute of Geography and Statistics IBGE) relative to the period 2008 (IBGE, 2010). They are: customers and/or users, competitors, firms within the holding, suppliers and universities and research institutes.

In general the customers and/or users constitute an external source of information about technologies, user's needs and market characteristics. In the specific analysis of the innovation process, interaction with the customers and/or users tends to speed up the process and also reduce the risk associated with the introduction of a new product or service in the market (von HIPPEL, 1988). Close contact with this actor can also make him an inventor or co-developer, principally in the initial phase of projects related to radical innovations, helping in the introduction of new concepts for the development of prototypes or of complex products (TETHER, 2002; LETTL *et al.*, 2006). In addition, von Hippel (1986) highlights the necessity of identifying and interacting with the lead users, which can be defined as users whose present needs can become the general need of the market in the future.

As well as the customers and/or users, the suppliers can also contribute to speeding up the innovation process, reduce costs, improve the quality of the product or service and, consequently, generate competitive advantages (CLARK, 1989; DYER, 1996; RAGATZ *et al.*, 1997). It should be mentioned that interaction with suppliers, also called vertical cooperation, was extensively analysed in

the context of supply chain management. Concerning the innovation process, Bidault *et al.* (1988) stress the benefits of the involvement of suppliers in the initial stages of the innovation process, more specifically in relation to conceptualization and design. In addition, Handfield *et al.* (1999) highlight the possibility of accessing the technological roadmap of the supplier and the greater facility and flexibility in integrating technological changes by means of longer term interaction with the suppliers. On the other hand, Mikkola and Larsen (2006) highlight a substantial increase in the risk of the competitor having access to the knowledge developed.

Concerning the interaction with universities and research institutes, this is seen to be an important external actor for accessing new scientific and technological knowledge and also, understanding new scientific developments (KLEVORICK et al., 1995; BELDERBOS *et al.*, 2004). Based on this information Belderbos *et al.* (2004) highlights the fact that interaction with universities and research institutes tends to facilitate the process of the development of radical innovations.

In relation to the Brazilian context, Benedetti and Torkomian (2009) suggest that in the interaction between universities and research institutes and companies, although the main objectives of the parties diverge, there is a complementarity of the objectives and capacities with the characteristic of co-development. This is because the result desired by the universities and research institutes serves, with great frequency, as input for the company to reach the results planned. Nevertheless, Segatto-Mendes (2001) suggests that the existence of divergent interests and the information asymmetry between the parties tends to generate an agency cost, while it demands the utilization of monitoring and control mechanisms which itself tends to jeopardize the interaction.

In addition to the customers and/or users, suppliers and universities and research institutes, Chesbrough (2003) argues that ideas, knowledge and technologies can be found in companies of all sizes. In this sense, interaction with firms within the holding is presented as an important external source in obtaining superior performance in the innovation process. Cooperation in R&D is held to be one of the principal mechanisms for the company to succeed in increasing its innovation process by means of the recombination of its own resources with the complementary resources of other actors (TEECE, 1986; MITCHELL, SINGH, 1992).

Prominence is given to the fact that companies can also interact with their competitors to learn more about the technology and mainly to reduce costs and risks in large projects and seek solutions to common technological problems, to the extent that they possess complementary R&D resources (TETHER, 2002; MIOTTI, SACHWALD, 2003). However, it can be seen that interaction with competitors tends to be limited to a few situations, such as those cited above, due to the fact that the inherent risk is significantly high. In the Brazilian context, Leão (2005) highlights the relevance of the Theory of Coopetition in understanding the dynamic of interaction among competitor companies.

Based on the foregoing, it was possible to observe the specific factors inherent to interaction with each of the five external actors throughout the innovation process. Thus, it is proposed in this paper that there is a heterogeneity in the impact of different external actors in innovative performance, as outlined by Belderbos *et al.* (2004), and a reply was sought to the following question:

Question: *Which types of external innovation partners have a positive effect on the innovative performance of Brazilian firms?*

The following presents the method adopted for measuring the impact of the three dimensions of external search strategy on the innovative performance of Brazilian firms. Subsequently the results obtained are presented and discussed.

3 Data and Methodology

With the intention of replying to the guiding question of this paper, a work of a conclusive descriptive nature was carried out, which according to Malhotra (2006) proves adequate when one possesses a *priori* knowledge of the problem investigated and seeks to describe the existence of relationships between variables. To this end, the quantitative approach was chosen utilizing a survey as an instrument of data collection.

In the first place, a prior test was performed with 3 specialists of the area and 2 companies to analyse the conformity of the instrument of data collection, some alterations being made with a view to simplifying understanding, and in addition two new questions were included. Subsequently, the survey was undertaken during the period July to September 2011, the questionnaire being applied in person when possible and by e-mail to an available database. At the end of this period 72 valid questionnaires were collected for companies operating in Brazil, filled out by executives from the Research and Development areas and Planning.

The survey prepared possesses three parts. The first covers descriptive information about the companies, such as invoicing and investment in R&D. The second seeks to map the inbound and outbound of knowledge and technology throughout the stages of the innovation process. And the third presents a series of questions focused on the problem of this paper, covering: *i. Types of external innovation partners; ii. External search breadth; iii. External search depth; iv. Innovative performance.* In this part of the survey the Likert scale of seven points was used. In topic 3.1 the operationalization of each of the variables examined in this paper is presented.

The data collected were then analysed using the software: SPSS (Statistical Package for the Social Sciences). Univariate and multivariate statistical techniques were utilized, among them the analysis of central tendency measures and dispersion and multiple regression. It is stressed that linear and curvilinear models were tested with a view to verifying which presents a better fit in the Brazilian context.

As already pointed out the sample utilized in this survey consists of 72 companies that operate in Brazil. Concerning revenue 43% of the companies invoice over R$ 1 billion, 21% between R$ 100 million and R$ 1 billion, 29% below R$ 100 million and 7% did not provide information on revenue. In relation to shareholding control, it is observed that 53% of the companies are Brazilian owned, 39% have foreign capital, 4% are state-owned Brazilian companies and 4% did not reply.

In relation to the approximate percentage of the 2010 revenue invested in R&D and innovation, for the 56 companies that replied an average rate of investment of 4.57% was obtained, 50% of these companies investing up to 2%. On the other hand concerning the percentage of the revenue arising out of the innovation process carried out over the last 3 years, for the 47 companies that replied, an average of 16.58%, was obtained, the revenue brought about by the innovation process over the last 3 years for 50% of these companies being below 10%.

3.1 Measures

Types of external innovation partners

The question of the external actors was tackled through questions relative to the interaction of the company with each of the five external actors analysed in its innovation process. The following external actors were analysed separately: customers and/or users, competitors, firms within the holding, suppliers and universities and research institutes, whose importance in the process of innovation was stressed in topic 2.4. For these indicators the Likert scale of 7 points was utilized, 1 being "I disagree totally" and 7 "I agree totally". Cronbach's alpha for these five external sources is 0.615, which indicates internal consistency and adequate reliability of the questionnaire. On the occasion of the regression analysis we chose to use the binary scale, so that values of 1 to 4 were codified as 0 and values of 5 to 7 were codified as 1, as Leiponen and Helfat (2010) propose.

External search breadth

The Breadth variable represents one of the dimensions of the external search strategy. This indicator was operationalized in accordance with the works of Laursen and Salter (2006) and Chen *et al.* (2008). Thus, it was chosen to codify the interaction with the 5 external actors using a binary scale, values of 1 to 4 on the Likert scale being codified as 0 and values of 5 to 7 as 1. Following that the results obtained for each of the 5 external actors were summed. The firms present Breadth equal to 0 when they do not possess a consolidated relationship with any of the 5 external actors analysed, and present Breadth equal to 5 when they possess a consolidated relationship with the five external actors. Accordingly, the greater the value for the variable Breadth the greater will be the diversity of partners with which the company interacts during its innovation process.

External search depth

The Depth variable also represents one of the dimensions of the external search strategy and refers to the intensity of the interaction with the 5 external actors analysed in aggregate. This variable was operationalized as the average of the interaction with the 5 external actors measured on a Likert scale of 7 points, as Chen *et al.* (2008) proposes. Higher values for this variable indicate that the firm possesses an intense relationship with a larger number of external actors, indicating that it exploits the knowledge of the external actors with which it interacts in greater depth, a question dealt with in section 2.3.

Innovative performance

The measurement of innovative performance was theoretically based on the work undertaken by Griffin (1993), Rindfleisch and Moorman (2001) and Knudsen and Mortensen (2011), which utilize development cycle time measures in the place of financial measures, which permits the comparison between different innovation processes, even when the companies analysed are active in different sectors. The following dimensions were analysed: *i.* superior quality of the product or service generated; *ii.* greater speed of the innovation process; *iii.* less cost of the innovation process. It must be pointed out that these three dimensions were compared with the average of the market in which the company is active. For operationalization of these indicators the Likert scale of 7 points was utilized that goes from 1 "I disagree totally" to 7 "I agree totally". Cronbach's alpha for these three variables is 0.660, which indicates internal consistency and adequate reliability of the questionnaire. In the regression analysis we chose to use the average of these three variables to represent the innovative performance of Brazilian firms.

4 Results

4.1 Descriptive statistics

Based on the sample of 72 large Brazilian companies we sought to explore the impact of the Breadth and Depth variables and of each of the 5 external actors on the innovative performance of Brazilian firms. Table 1 presents the descriptive statistics of each of the variables. It should be pointed out that before these analyses were effected, 5 companies of the sample were excluded due to the fact that they had a high percentage of missing values, which could cause some type of bias in the research.

Table 1 - Descriptive Statistics

	No. of firms	Mean	S.D.	Minimum	Maximum
Breadth	67	2.70	1.21	0	5
Depth	67	4.02	1.10	1.2	6.8
Innovative performance	67	4.38	1.32	1	6.33
Customers and/or users	61	3.92	1.74	1	7
Suppliers	60	4.94	1.68	1	7
Universities and research institutes	64	4.72	2.02	1	7
Firms within the holding	67	4.43	1.74	1	7
Competitors	67	1.98	1.46	1	7

In relation to the Breadth variable it was observed that Brazilian companies on average present a deeper relationship with 2 to 3 external actors to provide support for their innovation process. It was observed that only 5 companies analysed noted that they had a deep relationship with the 5 external actors and 12 companies with 4 external actors. It should be pointed out that Chen *et al.* (2008), in analysing 10 potential external partners of Chinese companies observed that on average these companies present a deep relationship with 7 external actors.

For the Depth variable this has an average of 4.02, a result that demonstrates that in general Brazilian companies present a moderate and not very intensive relationship when analysing the five external actors in aggregate. It can be seen also that on average the relationship of the Brazilian companies is more intense with suppliers, university and research institutes and with firms within the holding. On the other hand, the lower intensity of the relationship with customers and/or users should be pointed out and the low intensity with competitors, illustrated by the low average of the study. In relation to the innovative performance variable a middling performance of Brazilian companies is observed on average in relation to the speed, to the cost of the innovation process, and to the quality of the product or service provided.

4.2 Results of the regression analysis

In the first place the correlations are presented between the variables that are to make up the regression analysis. As can be seen there is a positive and strong correlation between the variables Breadth, Depth and the innovative performance. Nevertheless, the correlation between the variables Breadth and Depth is very strong, which could cause problems of multicollinearity in the regression analysis. In this sense, we chose to analyse the impact of these variables on innovative performance separately.

Table 2 - Correlations

	1	2	3
1. Breadth	1		
2. Depth	0.856*	1	
3. Innovative performance	0.510*	0.570*	1

*Correlation is significant at the 0.01 level (2-tailed)

Table 3 presents the results of the impact of the variables Breadth and Depth and of the 5 external actors on the innovative performance of Brazilian firms. In models 1 and 3 the linear and positive relationship between the variables Breadth and Depth and innovative performance is tested. In models 2 and 4 the curvilinear relationship (taking an inverted U-shape) between these variables is tested, to identify the existence or not of "over-search". In Model 5 we try to identify which external actors have a significant impact on the innovative performance of Brazilian firms.

Table 3 - Determinants of Innovative Performance in Brazilian Firms

	Model 1	Model 2	Model 3	Model 4	Model 5
Breadth	0.559***	0.857*			
	(0.117)	(0.479)			
Breadth²		-0.054			
		(0.085)			
Depth			0.683***	1.890***	
			(0.122)	(0.714)	
Depth²				-0.143*	
				(0.083)	
Customers and/or users					0.734**
					(0.296)
Suppliers					0.770**
					(0.350)
Universities and research institutes					0.455
					(0.300)
Firms within the holding					0.487
					(0.323)
Competitors					0.301
					(0.437)
Number of observations	67	67	67	67	67
R-squared	26%	26.4%	32.5%	35.5%	27.2%
F-test (sig.)	22.793	11.499	31.337	17.605	4.569

Notes: Standard error between brackets
***p < 0.001; ** p < 0.05; * P < 0.10

Model 1 shows that the variable Breadth presents a positive and significant impact on the innovative performance of Brazilian firms, confirming hypothesis 1. In this sense, it is observed that an external search strategy that involves a greater variety of external actors tends to result in better performance in the innovation process.

In Model 2 we sought, by means of the inclusion of the square of the Breadth variable, to analyse if there exists an optimum point after which work with a greater variety of external actors starts to cause a negative impact on the innovative performance (taking an inverted U-shape). This resulted in the coefficient of the square of the Breadth variable presenting a negative sign, which would indicate a tendency to fall after the optimum point, nevertheless this coefficient is not significant. Such a result demonstrates that the variety (Breadth) of external actors is a relevant factor in explaining innovative performance and that in analysing 5 sources of knowledge a point of inflection was not observed after which Brazilian companies would present a decrease in their innovative performance in relating to one more external actor.

It should be stressed that this result differs from that obtained by Chen *et al.* (2008) for Chinese companies, as these start to present a negative return in interacting with more than 9 external actors. The work of Laursen and Salter (2006) demonstrated that UK companies present a decreasing return after the point of interaction with 11 external actors. As only 5 external actors were analysed in this paper it was already expected that the existence of "over-search" for the Breadth variable would not be observed.

Model 3 shows that the Depth variable presents a positive and significant effect on innovative performance. Such a result demonstrates that a strategy that seeks to deepen the relationship with external actors tends to increase innovative performance. In complementary fashion, in Model 4 hypothesis 2 is tested, that there is a point beyond which it is not more advantageous for the company to intensify the relationship with its external partners. The coefficient for the square of the Depth variable was negative and significant. Consequently, the curvilinear Model presents better fit in the Brazilian context considering the 5 external actors analysed, which indicates the existence of "over-search" in the Brazilian context when the variable Depth is analysed. This implies that there is a point, in this survey between 5 and 6 (see Figure 1), beyond which the company, in deepening its relationship with more external actors, starts to present a negative return. In practical terms, we have that the strategy that seeks to deepen interaction with the 5 external actors analysed has a saturation point.

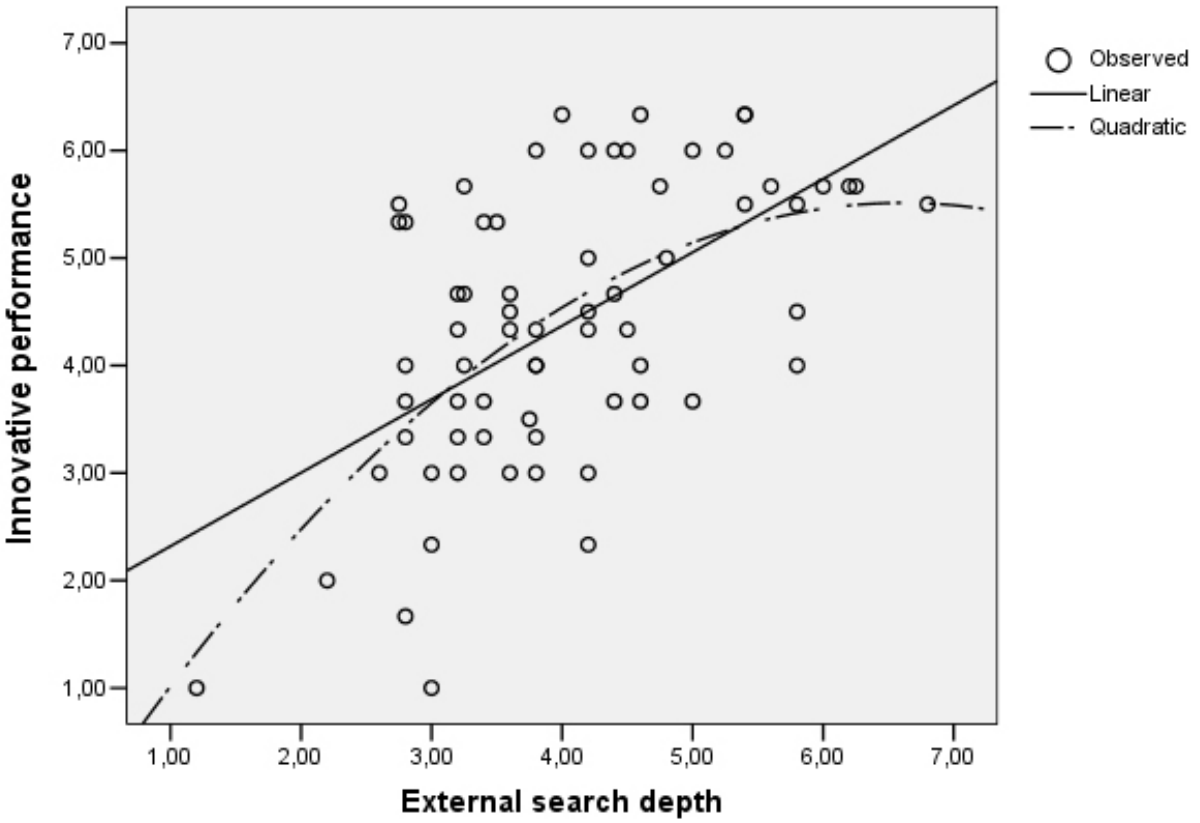

Figure 1 - Predicted Relationship Between Innovative Performance and External Search Depth

In Model 5 we sought to identify which of the 5 external actors analysed presented a positive and significant impact on the innovative performance of Brazilian firms. As a result it was observed that the interaction of Brazilian firms with actors of their value chain, namely: their customers and/or users and suppliers, presented a positive and significant impact on innovative performance. It must be stressed that although Brazilian firms demonstrate a high average for their relationship with universities and research institutes and with firms within the holding, these two external actors were not statistically significant in explaining innovative performance, as neither were competitors.

5 Conclusion

The more recently proposed non-linear or interactive innovation process models emphasize the necessity of firms to interact with external actors in the search for ideas, knowledge and technologies that help to increase the innovation process, either accelerating the process, reducing the cost or improving the quality of the product or service. From this perspective, Katila and Ahuja (2002) highlight the importance of formulating an external search strategy which makes the interaction process with the external actors throughout the innovation process more effective.

It has therefore been our aim in this paper to analyse the influence of three dimensions of external search strategy on the innovative performance of Brazilian firms. The following dimensions were analysed: external search breadth, external search depth which deals with how

firms access external knowledge, and the types of external innovation partners that emphasize whom they interact with. In relation to external search breadth and external search depth the results suggest that the variety and depth of the interaction with external actors presents a positive impact on the innovative performance of Brazilian firms, as found by Katila and Ahuja (2002) and Laursen and Salter (2006).

Also examined in this paper was the existence of "over-search", that is, a point beyond which an increase in the diversity and depth of the interaction with external actors starts to affect the innovative performance negatively as Katila and Ahuja (2002) and Laursen and Salter (2006) suggest. In relation to the external search breadth the presence of "over-search" was not observed. It should be pointed out that this result was expected since only 5 external actors were analysed, they being: customers and/or users, competitors, firms within the holding, suppliers and universities and research institutes. This result indicates that Brazilian companies tend to succeed in improving their innovative performance by the interaction with these 5 actors. Nevertheless the interaction with additional actors, like virtual community and of technologically based start-ups can result in the generation of counterproductive results beyond a certain point, in that it becomes more complicated for the firm to internalize and integrate all the ideas, knowledge and technologies in its innovation process.

In relation to external search depth the hypothesis was corroborated that there is a point beyond which "over-search" is observed. This indicates that Brazilian companies that exploit in depth the interaction with the 5 external actors tend to display inferior results to the companies that exploit in depth the interaction with less external actors. This indicates that the decision to deepen the interaction with a determined external actor should be pondered through an analysis of the associated costs and benefits. In this sense, Almirall and Casadesus-Masanell (2010) highlight that interaction with external actors throughout the innovation process should be analysed in terms of the trade-off between the benefit of the discovery and the cost of the divergence.

The empirical analysis also indicated that there is a difference in the impact of different external actors on the innovative performance of Brazilian firms, corroborating the heterogeneity among the external sources proposed by Belderbos *et al.* (2004). In addition, the results demonstrated that learning in Brazilian companies is more associated with learning by doing and learning by using, than with learning by searching. This is because the external actors that present a significant impact on innovative performance are the suppliers and the customers and/or users, universities and research institutes showing no significant result.

According to Bittencourt (2012), this means that the learning typically utilized by Brazilian companies comes from the accrual of knowledge obtained from firms' production routines and search processes not associated with codified knowledge. It is pointed out that the learning mechanisms used to a greater degree by Brazilian firms tend to change in accordance with the sector of activity, technology intensive sectors being more attuned to learning by searching.

In general the results obtained demonstrate that open innovation practices, more specifically the interaction with external actors throughout the innovation process, are found within the context of large Brazilian companies. Which according to Chesbrough (2003) indicates greater ability of these in exploring external opportunities and attaining greater innovative performance.

In addition to this, it is observed that a large part of the companies can increase the diversity and depth of interaction with the external actors, and should take the presence of “over-search” into consideration when formulating their external search strategy.

As a limitation of the work special mention should be made of the reduced size of the sample, although significant, which reduced the force of the statistical analyses and made it impossible to undertake sectoral analyses, as well as testing other variables that influenced the formulation of external search strategy.

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