RELATIONSHIP BETWEEN TECHNOLOGICAL ECO-INNOVATION CAPACITY AND INNOVATION PERFORMANCE: EVIDENCE FROM MOST INNOVATIVE FIRMS IN THE USA

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ABSTRACT
This research aims to verify the impact of technological eco-innovation capacity on innovation performance, from most innovative firms of different sectors: Biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA. This research was based on the model presented by Müller et al. (2005). Following it, a multiple case study was conducted in most innovative companies. The research had specialists' intervention. The data were extracted by a judging matrix with a scale type. This paper contributes to the discussion on influence of eco-innovation capacity and its impact on innovation performance. Furthermore, the results can help policy-makers improve the support for eco-innovations in innovative companies in the USA.

KEYWORDS: *technological eco-innovation capacity; innovation performance; most innovative companies in the USA*

1. INTRODUCTION

Recently, relevant changes have made organizational boundaries more fluid and dynamic in response to the rapid pace of innovation (Abrahamson, 1991; Griliches, 1990; Teece et al., 1997; Teece, 1986; Chesbrough and Rosenbloom, 2002; Christensen, 2003; Damanpour, 1996). It is widely acknowledged the essential role of innovation to survival of companies (Clark and Guy, 1998; Schumpeter, 1934; Baumol, 2002; Doran and Ryan, 2012; De Martino and Magnotti, 2017). There is a strong demand nowadays to make production processes as sustainable as possible (Birkie, 2018). In this sense, more emphasis is been placed on innovation, and in particular, on eco-innovation (Doran and Ryan, 2012). Implementing eco-innovations in products is one of the key factors for achieving sustainable development (Dangelico and Devashish, 2010). In this context, the success of business actions to combat climate change depends on a series of organizational resources and supports (Kolk and Pinkse, 2004; Schultz and Williamson, 2005; Hoffman, 2005; Weinhofer and Hoffmann, 2010) that generate competitive advantages when properly allocated (Hart and Dowell, 2011) (Neto et al., 2015). Eco-innovation can be characterized as technological, organizational, social and institutional (Panapanaan et. al., 2014)(Eryigit & Özcüre, 2015):

Technological Eco-Innovation: These technologies are both corrective and also preventive. They consist of measures to reduce the energy and material input and emissions (Eryigit & Özcüre, 2015).

- Organizational Eco-Innovation: Eco-audits are the examples for this type of eco-innovation. In services sector some material products are substituted with less-material services (Eryigit & Özcüre, 2015).
- Social Eco-Innovation: This is the patternal changes in consumer behaviour. People's life style changes result in social eco-innovation (Eryigit & Özcüre, 2015).

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- Institutional Eco-Innovation: Scientific and public institutions cooperate to make policies about eco-innovation (Eryigit & Özcüre, 2015).

This research focus on Technological Eco-Innovation. It is feasible to offer innovative products as it enables companies to have incremental gains and competitive advantage, in particular industries dealing with technological innovations. Technological eco-innovation is a dynamic process, and perhaps the most dynamic of all industrial activities (Schumpeter, 1943; Achilladelis and Antonakis, 2001). This requires the combined effort of various innovative activities, a condition of limited resources. Traditionally, the literature references two main types of innovation activities: internal and external (Cassiman and Veugelers, 2006). External activities are related to licensing knowledge access through external sources, R&D outsourcing, and hiring highly qualified researchers, with relevant knowledge (Arora and Gambardella, 1990), and others. Internal innovation activities use the firm's internal capacities (Vega-Jurado et al., 2009), where knowledge production is internalized (Frenz and Ietto-Gillies, 2009).

The state of the art has significant bearings on the advances of studies on the innovative technology capacity of firms. In a research conducted by Wang, Lu and Chen (2008), the technology capacity of firms under uncertainty was evaluated using the fuzzy set theory that adapts naturally to conditions of uncertainty produced in the decision-making processes. The results were plausible and enabled to assess the extent of high-tech firms' innovative technology capacity (R&D, manufacturing; marketing; learning, organizational; strategic planning and resource allocation). Lau et al. (2010) also conducted empirical studies to assess the technology innovation impact on the performance of innovation in Hong Kong. The results were satisfactory and enabled to show that the R&D capacities, resource allocation, strategy learning and planning, can significantly improve the results of the firms' business.

Moreover, it showed that R&D and resource allocation also have a significant effect on the introduction of new products. Yam et al. (2004) conducted an empirical study on technological innovation in the industrial enterprises in the Peking area (Guan et al., 2005, 2006; Guan and Ma, 2003) and the innovation capacity results (R&D, manufacturing, marketing, learning, organization, strategic planning and resource allocation) were inconsistent, as they did not yield propositions or hypotheses, which to a certain degree weakened the research findings (Lau, Yam and Tang, 2010).

Deciding on an ideal balance regarding innovation activities is a complicated issue (Chen and Yuan, 2007), there are barriers to be challenged and substantially reconfigured (Assink, 2006) in order to obtain an optimal and combined convergence of the various activities in confluence with the firms' desired and acceptable performance. Innovation activities are admittedly complex and risky. Thus, it is difficult to accurately assess (Afuah, 1998; García-Muin and Pez Navas-lo, 2007; Bellman and Zadeh; 1970) the innovation capacity and also discern the firms' range of acceptable performance.

In this sense, This research aims to verify the impact of technological eco-innovation capacity on innovation performance, from most innovative companies of different sectors: biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA. This research was elaborated in light of theoretical excerpts, with foundation in the model presented by Müller et al. (2005), which considers the following metrics: resources, enablement and leadership. In this sense, deciding on an ideal balance regarding eco-innovation activities and innovation performance is a complicated issue, there are barriers to be challenged and substantially reconfigured in order to obtain an optimal and combined convergence of the various activities in confluence with the firms' desired and acceptable performance. Innovation activities are admittedly complex and risky. It is difficult to accurately assess (Afuah, 1998; García-Muin and Pez Navas-lo, 2007; Bellman and Zadeh; 1970) the innovation capacity and also discern the most innovative companies' range of acceptable performance. Given the importance of eco-innovation, to stimulate innovation, some studies investigated about eco-innovation: James (1997) detailed eco-innovation as process for development of new products, processes or services that offer value to clients and businesses with diminishment of environmental impact. Eco-innovation is an important driving force to support the sustainable development of companies (Kanda et al., 2015) (Li Cui, 2017). According Eryigit and Özcüre (2015). eco-innovation can be characterized as technological, organizational, social and institutional (Panapanaan, et. al., 2014):

•*Technological Eco-Innovation:* These technologies are both corrective and also preventive. They consist of measures to reduce the energy and material input and emissions.

•*Organizational Eco-Innovation*: Eco-audits are the examples for this type of eco-innovation. In services sector some material products are substituted with less-material services.

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Del Rio et al. (2010) reference that eco-innovation is innovation that increases the environmental performance of production and consumption activities. In this way, eco-innovation is analyzed as a new paradigm because it encompasses the growing importance of combining innovation and technologies developed with environmental protection. Incorporating this concept into new products, processes or services is a way of contributing to the promise that the demand for economic growth can be reconciled with sustainability (Weber and Hemmelskamp, 2005) (De Prá Carvalho, Zarelli, & Dalarosa, 2018). However, these studies examining the innovation have not given sufficient consideration to technological eco-innovation capacity. Therefore, responding to the calls made in the literature to verify the impact of technological eco-innovation capacity on innovation performance, the current study investigate the most innovative companies of different sectors: Biotechnology; chemicals & cosmetics; manufacturing & medical sectors in the USA. Within this spectrum, this study aims to assess the influence of technological eco-innovation capacity on the innovation performance of most innovative companies under resources, leadership and capability in different sectors in the USA.

This research was elaborated in light of theoretical excerpts, with foundation in the model presented by Müller et al. (2005), which considers the following metrics: resources, enablement and leadership. There is a gap in the literature concerning the eco-innovation capacity and innovation performance in most innovative companies of different sectors in the USA. This research can contribute to the eco-innovation capacity and literature with new empirical knowledge. Furthermore, the study illustrates that the eco-innovation capacity potential can be contribute provide key input to the decision-making process in this perspective of most innovative companies in the USA. According Li Cui (2017), the developing the appropriate indicator is the key to the evaluation of the eco-innovation ability (or performance) of a company. In this sense, this research aims to verify the impact of technological eco-innovation capacity on innovation performance, from most innovative companies of different sectors: biotechnology; chemicals & cosmetics; and manufacturing & medical sectors, in the USA. This research was elaborated in light of theoretical excerpts, with foundation in the model presented by Müller et al. (2005), which considers the following metrics: resources, enablement and leadership. The current research offers contribution to the literature: first, this study theoretically incorporates eco-innovation capacity. Second, empirical evidence concerning eco-innovation capacity in most innovative companies in the USA. Finally, this paper is structured in the following sections: Section 2 highlights background of the study and accordingly the study hypotheses. In Section 3, methodology used in the research is explained, elaborating on the sample, the variables and their measurement properties. Then, in Section 4, the results are presented and discussed. Conclusion, theoretical and practical implications, limitations and recommendations for further researches are provided in Section 5. Thus, this paper is structured in the following sections: theoretical background: issues of innovation and eco-innovation; methodology; conceptual model verification and underlying analyses; discussion and implications for management practice; and conclusions and limitations.

3. DESIGN OF RESEARCH

3.1. Conceptual Model framework: Constructs and hypotheses

This section examines the conceptual model (Figure 1) and presents the hypotheses to be tested throughout this work.

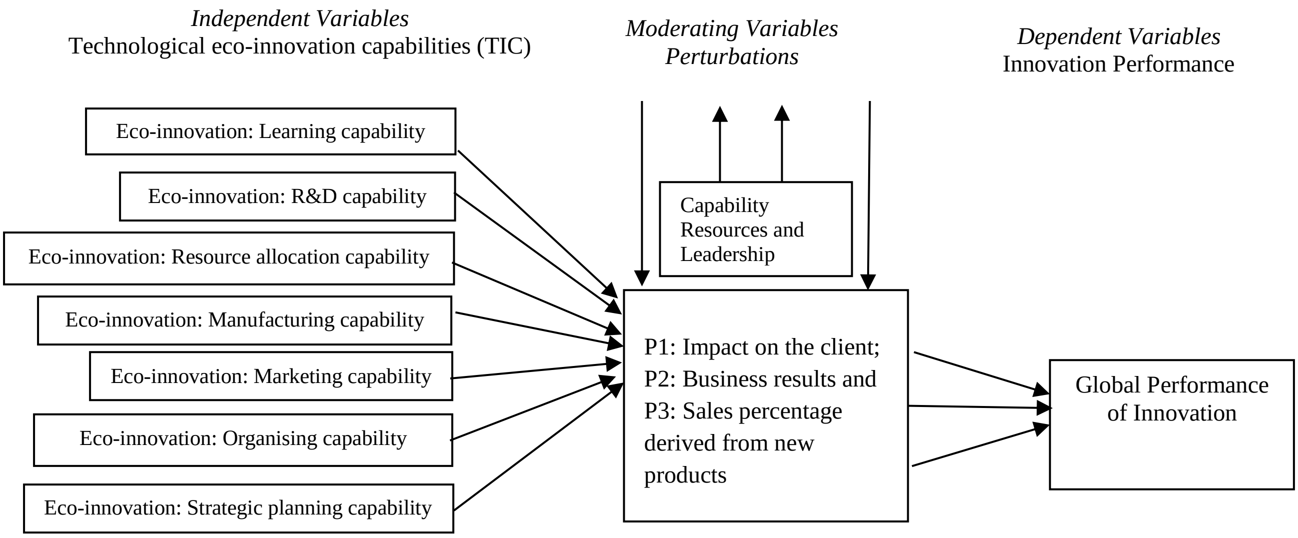

Figure 1: Framework Conceptual Model

From the conceptual model, the following independent variable, dependent variable and hypotheses were made:

Dependent variables: the following dependent variables were selected for this research innovation performance - P1: Impact on the client; P2: Business results and; P3: Sales percentage derived from new products.

Independent variables: the independent variables, companies' technological innovation capacities, were based on the literature. Therefore, the following dimensions were considered as independent dimensions: Firms' dimensions of technological eco-innovation capacities: eco-innovation - learning, R&D, eco-innovation - resource allocation, eco-innovation - manufacturing, eco-innovation - marketing, eco-innovation - organizing, and eco-innovation - strategic planning. The following hypotheses were formulated using the conceptual model:

H 1: Eco-innovation capacity has positive innovation performance in firms of biotechnology; chemicals & cosmetics; and manufacturing & medical sectors, in the USA

H2: Capacities, resources, and leadership influence to a greater or lesser degree the innovation performance in biotechnology; chemicals & cosmetics; and manufacturing & medical sectors, in the USA. The next section presents the scope of the study of case.

H3: The effectiveness rate global performance of innovation (ERGPI) of the firms in the three sectors: biotechnology; chemicals & cosmetics; manufacturing & medical, in the USA, depends on the combination and interaction of the eco-innovation capacities (activities of eco-innovation) on the firms (sectors) performance.

3.2 Sample and Data Collection

The population of this study was the most innovative factories in different sectors, in the USA, in the period from 2013 to 2017. The author investigates the impact of technological eco-innovation capacity on innovation performance, from most innovative companies of different sectors: biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA. This research was elaborated in light of theoretical excerpts, with foundation in the model presented by Müller et al. (2005), which considers the following metrics: resources, enablement and leadership. A questionnaire was used as a main instrument of this study (an assessment matrix). The actual survey was carried out between October, November, and December, 2017 which involved 79 specialists. The samples were selected by random sampling technique. Of the 79 specialists in our sample, 69 completed questionnaires were retuned. However, five cases had to be excluded from further analysis due to excessive missing data. Therefore, the present sample comprised of 64 specialists. The experts were issue their judgments through a scale questionnaire. The specialists have experience and innovation, production, technology, technical knowledge on product development in companies investigated, and with the following skills: Director Manufacturing Research & Advanced Engineering, Senior R&D Engineer, Director Research & Innovation, Director New Technologies & Innovation, others. Next, these procedures are detailed.

4. CONCEPTUAL MODEL VERIFICATION AND UNDERLYING ANALYSES

The results and underlying analyses are structured according to the following phases:
Phase 1: Evaluation of the technological eco-innovation capacities on innovation performance of the firms under perturbations (Capability, Resources and Leaderships) in three sectors - Biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA.
Phase 2: Effects of the perturbations (Capacity, Leardership and Research) on the innovation performance of firms in three sectors: Biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA. *How do the Resources, Capacity and Leadership support the innovation performance of the firms in three sectors:* Biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA, *based on the proposed of Müller, Va¨likangas, and Merlyn (2005)?*
Phase 3: Assessment of the effectiveness rate global performance of eco-innovation of the firms in three sectors: Biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA. The procedures are detailed as it follows.
Phase 1: Evaluation of the technological eco-innovation capacities on innovation performance of the firms in three sectors: Biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA, *under perturbations.*
This section presents the verification procedures for the conceptual model. In this spectrum, to solve the problem and achieve the intended research goal, the next step was to prioritize the dimensions (sub-components) (Figure 2) of the technological eco-innovation capabilities in relation to the global innovation performance of the business incubators from Chile, Israel and Italy. This procedure was developed using the multi-criteria analysis.

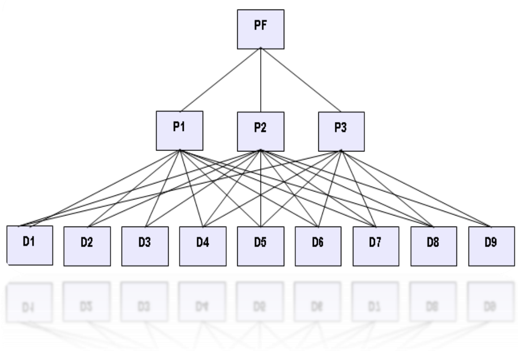

Figure 2: Evaluation of the technological eco-innovation capacities on innovation performance of the firms under perturbations

The methods used were *Compromise Programming, Electre III and Promethee II*. The results achieved confirm *H 1: Eco-innovation capacity has positive innovation performance in firms of biotechnology; chemicals & cosmetics; and manufacturing & medical sectors, in the USA.*
The results produced by this prioritization enable managers to better focus their efforts and resources on managing the capacities that perform best, which results in achieving the goals sought by the firms. The structure of this prioritization (classification by hierarchical analysis) is proposed at three planning levels in a judgment matrix, in which at the first hierarchical structure level it defines the goal, which is to achieve the performance of the firms that will feed the system; the criteria are in the second level, which are the innovation performance of the firms: P1: Impact on the client; P2: firms results (success) and; P3: Sales percentage derived from eco-innovation (new products). The dimensions of eco-innovation capabilities are in the third level, the alternatives, which are: Learning, R&D, Resource allocation, Manufacturing, Marketing, Organizing, and Strategic planning. The prioritization process obeys the judgment of the evaluators (experts). With the results of the judgment matrix, the methods were applied: *Promethee II, Electre III and Compromise Programming* to evaluate the eco-innovation capabilities in relation to the performance of the firms. Table 1 shows the results produced.

Table 1: Assessment of eco-innovation capacity of the firms on eco-innovation performance (impact on client, business results and sales percentage derived from eco-innovation) under perturbations (capacities, leadership and resources) – average: Biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA.

Biotechnology	**Eco-Innovation Capacity**	**Promethee II**	**Compromise Programming**	**Electre III**
	Strategic planning/ Organizing / Resource allocation	1ª	1ª	1ª
	R&D/Learning	2ª	2ª	3ª
	Marketing	3ª	3ª	2ª
	Manufacturing	4ª	4ª	2ª
chemicals & cosmetics	Eco-Innovation Capacity			
	Strategic planning/ R&D/ Organizing / Resource allocation	1ª	1ª	1ª
	Learning	2ª	2ª	3ª
	Marketing	3ª	3ª	2ª
	Manufacturing	2ª	2ª	1ª
manufacturing & medical sectors	Eco-Innovation Capacity			
	Strategic planning/ Organizing / Resource allocation	1ª	1ª	1ª
	R&D/Marketing	2ª	2ª	3ª
	Learning	3ª	3ª	2ª
	Manufacturing	4ª	4ª	2ª

The results produced by the methods demonstrate the eco-innovation capacities: Strategic/Planning/Organizing/R&D/Learning/Resources allocation, as the most significant ones to ensure the innovation performance of the incubators in the three sectors.

The essence of the technological innovation management is the accumulation of knowledge over time. The increase of the knowledge volume is produced by different mechanisms associated with different learning modes, such as: learning derived from R&D or Learning before doing (Pisano, 1997); Learning by doing, which arises spontaneously in the production process (Arrow, 1962); Learning by using, which is from observing the different ways in which customers use the company's products (Rosenberg, 1982); and Learning by failing, from the analysis of bad decisions by top managers (Maidique and Zirger, 1985). But traditionally the greatest importance goes to R&D than to the other learning modes (Nieto, 2004). Based on the specialized literature (Evangelista et.al., 1997) R&D has a strong impact on a firms' performance of innovation.

Thus, firms make use of its eco-innovation capacity (Activities of innovation) to achieve sustainable competitive advantage and value creation. Firms in all sectors have clearly defining the vision and mission of the business; the business's vision speaks of innovation; the business constantly looks for new ideas to improve services or processes; business constantly creates investment decisions (buying, renting equipment, etc.); business has a clearly defined innovative strategy; the business is a continuous process of learning; in the business there is a systematic approach for managing innovation. The business regularly carries out market research; the business continuously detects the needs of its customers; customer's demand for products and services are collected at each stage of the innovative process of the business, the business effectively uses its partnerships; the business regularly looks for new market opportunities. The business processes are able to efficient development of new products; the business establishes mechanisms for selection of good business ideas; the business processes are flexible enough to allow realize innovative projects. Employees in the incubators have sufficient knowledge to deal with innovation; the business structure creates suitable conditions for the development of innovation (Lendel and Varmus, 2013). Innovation performance of the business can help to business managers to effectively use the innovation potential of the business. Next, the degree of correlation between the dimensions of capability, resources and leadership and innovation performance was determined using Spearman's multivariate statistical technique. The technique adapts to the case in question.

Phase 2: Effects of the perturbations (Capacity, Leardership and Research) on the innovation performance of three sectors - Biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA- *How do the Resources, Capacity and Leadership support the innovation performance of the firms (sectors) based on the proposed of Müller, Va¨likangas, and Merlyn (2005)?* This section evaluates contribution of resources, capacity and leadership to support the innovation performance in *three sectors* - biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA, i.e. how do resources, capacity and leadership support the innovation performance in the three sectors? This procedure was developed in light of theoretical excerpts, with foundation in the model presented by Müller et al. (2005). The research had specialists' intervention. The data were extracted by a judging matrix with a scale type, in which the specialists gave their opinions, establishing priorities to the variables (resources, enablement and leadership), by level of importance.

Thus, combining the dimensions, we can say with all certainty that the dimensions capability, resource and leadership contribute significantly for achieving innovation performance in three countries. The results confirm the *H2: Capacities, resources, and leadership influence to a greater or lesser degree the innovation performance in biotechnology; chemicals & cosmetics; and manufacturing & medical sectors, in the USA.* However, capability and leadership represent the biggest contribution to client, business results and sales percentage derived from eco-innovation to biotechnology sector. On the other hand, resources represent the biggest contribution to client, business results and sales percentage derived from eco-innovation to manufacturing & medical sector. In other words, capabilities, leadership and resources contribute with maximum efficiency to the achievement of the innovation practice oriented to the technological strategies of firms in three sectors. In general, at firms, the dimensions are associated with resources, training, and leadership in which the Input focuses on incentives, team building, and personnel, which support the existing processes of innovation. The Processes in firms are related to the increase and the flow of innovation and to markets subject to budget constraints, and finally, Output is oriented towards reaching the goals of innovation.

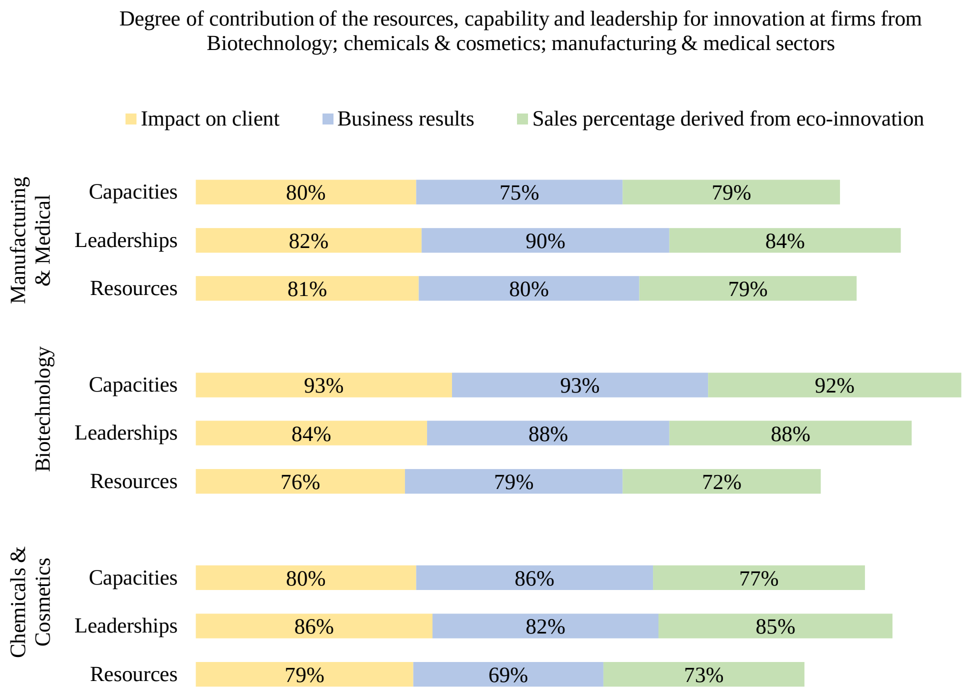

Figure 3: Degree of contribution of the resources, capability and leadership for innovation performance at firms from Biotechnology; chemicals & cosmetics; manufacturing & medical sectors

The portfolio of eco-innovation projects is generated from the strategic analysis of the company showing the importance of leadership in decision making, as proposed by Müller, Va ̈ likangas, and Merlyn (2005). Once the projects to be developed are selected, expense and investment budgets for each project are established, as well as the setting of the allocation of human and internal resources of the firms required for the project execution. The time management of the projects is implemented through time lines. Apart from the administrative management of the projects there is the technical management, in which the project objectives are established at the beginning of it and controlled throughout its implementation. Aspects such as product performance, durability, reliability and sustainability are evaluated against established goals. It was further observed that the business incubators ranks as medium/low degree of importance or adherence in the firms the internal corporate indicators of innovation in comparison to indicators of market performance, the impact of the use of internal indicators of innovation in improving the costs of products and services, the use of internal innovation indicators to assist in decision making about the sustainability policy of the firms and the cost reduction.
However, the reviews identified as medium / high relevance were the internal indicators associated with creative culture, such as approval of the employees regarding the evaluation of their personal metrics of innovation, the use of internal indicators of individual metrics of innovation as a motivator factor in the pursuit of improved personal skills. The assessment of Issues of innovation at firms in the light of the framework proposed by Muller et al. (2005) reveals that there are incentive schemes to support innovation, albeit in an incremental basis. However, there is not a formal mapping of the "champions of innovation" in the firms. An emphasis in the frequency in which strategic

considerations aimed at fostering innovation the study are performed has not yet been given. In view of the results (output), the firms controls the ratio of revenues from innovative projects in relation to the total billed. There is still control of the number of strategic projects of development in the Division, although a formal valuation of the expected revenue of eco-innovation projects in relation to the total turnover of the firms is not made.

Phase 3: Assessment of the effectiveness rate global performance of eco-innovation of the firms in three sectors: Biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA *(ERGPI)*

This phase focuses on determining effectiveness rate global performance of innovation of the firms in the three sectors, using neuro-fuzzy modeling. It is a process whose attributes usually possess high subjectivity capabilities of eco-innovation, in which the experience of the decision maker is very significant. Thus within this spectrum there is the need for a tool that allows adding qualitative and quantitative variables that converge towards a single evaluation parameter (Oliveira and Cury, 2004; Von Altrock, 1997). Here this model supports the management of firms in the three, as it allows to evaluate the desirable rate toward the firms performance of innovation from interation among eco-capabilities (activities of eco-innovation), *in three sectors:* Biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA.

The model shown here uses the model of Oliveira and Cury (2004). The model consists of qualitative and quantitative variables, based on information from the experts. The neurofuzzy model is described below.

Stagy 1: Determination of Input Variables (IV) and Linguistic Terms: This section focuses on determining the qualitative input variables (IV). These variables (9) were extracted from conceptual model (Figure 1), results of effects of the capabilities of eco-innovation on the firms innovation performance. The linguistic terms assigned to each IV are: High, Medium and Low. Accordingly, Figure 4 shows the IVs in the model, which are transformed into linguistic variables with their respective Degrees of Conviction or Certainty (DoC), with the assistance of judges opining in the process. The degrees attributed by the judges are converted into linguistic expressions with their respective DoCs, based on fuzzy sets and aggregation rules and composition rules). The IV are (eco-innovation capacities): learning capability, R&D capability, resource allocation capability, manufacturing capability, management capacity, marketing capability, organizing capability, management capacity, and strategic planning capability.

Stage 2: Determination of the Intermediary Variables and Linguistic Terms: The qualitative input variables go through the inference fuzzy process, resulting in linguistic terms of intermediate variables (IVar). Thus, the linguistic terms assigned to IVar are: Low, Medium and High. The intermediate variables were obtained from: eco-learning capability performance/ eco-Strategic planning capability performance – LCP/SPCP; eco-R&D capability performance/ eco-marketing capability performance – RDCP/MKCP/MCP; eco-resource allocation capability performance/ organizing capability performance/ management capability performance – RACP/OCP/MCP. The architecture proposed is composed of eleven (6 IB) expert fuzzy system configurations, 9 IV (input variables), 5 IVar (Intermediate variables) and 1 OV (Output variables), i.e., qualitative input variables that go through the fuzzy process and through the inference block, thus producing an output variable (OV), called intermediate variable (IVar). Then, the IVars, which join the other IVar form a set of new IVars, thereby configuring a sequence until the last layer in the network. In the last layer of the network the output variable (OV) of the neurofuzzy is defined. This OV is then subjected to a de-fuzzification process to achieve the final result: effectiveness rate global performance of innovation (ERGPI) in sectors: biotechnology; chemicals & cosmetics; manufacturing & medical.

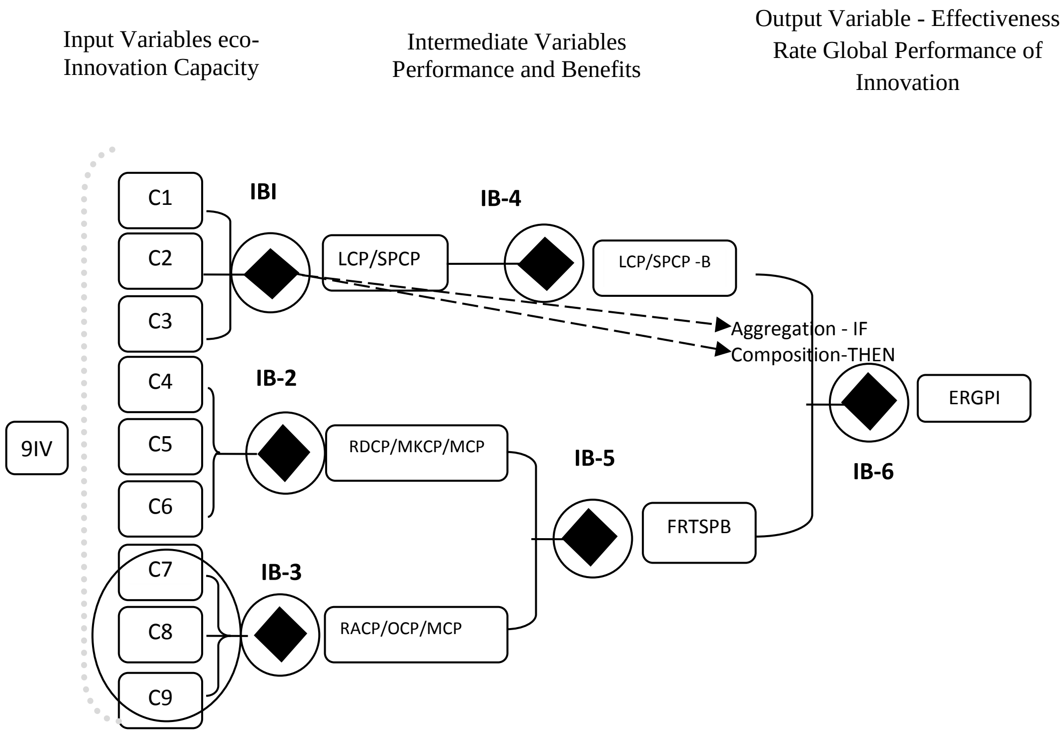

Figure 4: Assessment of the effectiveness rate global performance of eco-innovation (ERGPI) in three sectors: Biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA

The results confirm the *H3: The effectiveness rate global performance of innovation (ERGPI) of the firms in the three sectors: biotechnology; chemicals & cosmetics; manufacturing & medical, in the USA, depends on the combination and interaction of the eco-innovation capacities (activities of eco-innovation) on the firms (sectors) performance* (IV- results of the Phase 1).

Stage 3: Determination of Output Variable – Effectiveness Rate Global Performance of innovation (ERGPI) in three sectors: biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA

The output variable (OV) of the neurofuzzy model proposed was called effectiveness rate global performance of innovation (ERGPI) of the firms (sectors), resulting in the processes of:

Fuzzyfication: The fuzzification process determines the pertinence functions for each input variable.

Fuzzy Inference: The fuzzy inference rule-base consists of IF-THEN rules, which are responsible for aggregating the input variables and generating the output variables in linguistic terms, with their respective pertinence functions.

Defuzzification: For the applications involving qualitative variables, as is the case in question, a numerical value is required as a result of the system, called defuzzification. Thus, after the fuzzy inference, fuzzification is necessary, i.e., transform linguistic values into numerical values, from their pertinence functions (Von Altrock, 1997). To illustrate this, assuming that the study-object business incubator demonstrate the following performance rates for of the firms in three sectors - biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA - 0,8891; 0.7134; and 0.6728. The expected reference for performance for all incubators is 0.5527 (hypothetical). It is concluded that the effectiveness rate global Outcomes of the three sectors depends of the combination and interaction of the eco-innovation capacity of the firms in the three sectors. The effect of the eco-innovation capacities on the firms (all sectors) global performance is dynamic and dependent on constraints and uncertainties that come from the environment at any given time. The environmental contingencies are crucial and essential to adapt the eco-innovation activities.

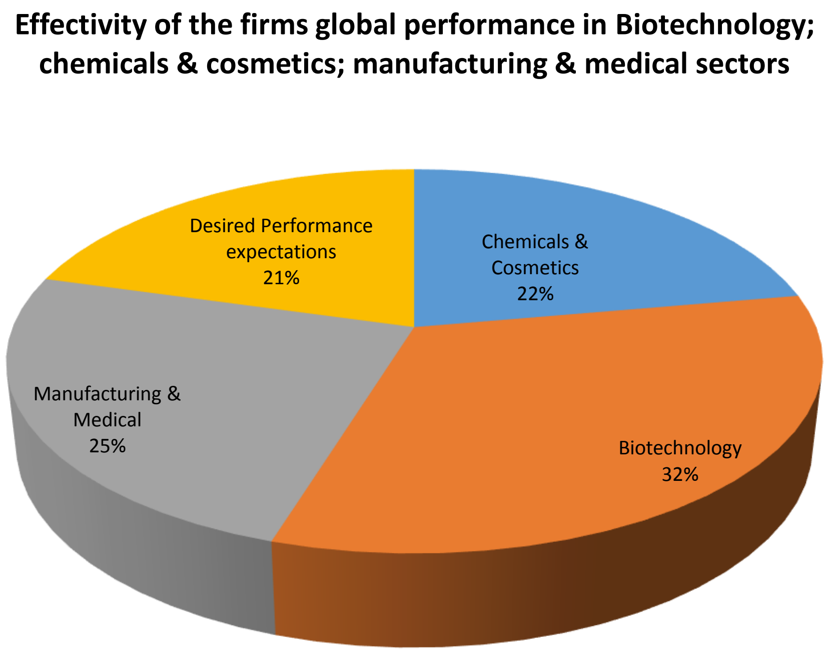

Figure 5: Effectivity of the firms global performance of eco-innovation in biotechnology; chemicals & cosmetics; manufacturing & medical sectors

The effectiveness rate global performance (ERGP) of the firms in three sectors: biotechnology; chemicals & cosmetics; manufacturing & medical sectors (USA) depends of the combination and interaction of the eco-innovation capacities of firms (sectors). Sector of biotechnology (32%) shows efficiency in the combination of their capacities. The effect of the eco-innovation capacities on the firms (sectors) global performance is dynamic and dependent on constraints and uncertainties that come from the environment at any given time.

6 IMPLICATIONS FOR MANAGEMENT PRACTICE

Contextual innovation management implies that an innovation manager makes different decisions in different contexts (Ortt and van der Duin, 2008). Thus, combining the dimensions, from the interface between eco-innovation capabilities and the innovation performance based on the dimensions Resources, Capability and Leadership, there is significant predominance of the learning capacities, R&D and planning. R&D efficiency reflects the product development process dynamics, reduces time-to-market, improves product profitability, increases productivity, as well as other benefits for firms Studies on R&D efficiency have many applications as a management tool. R&D is strong performance measure, similar to ROI. It can also be used as a means of comparison (benchmark). R&D efficiency is also an aggregate measure of the overall success of a company's product in the development effort. The presence of R&D creates an organizational setting that is favorable to questioning, promoting corporate/company flexibility, with an ability to integrate new concepts and adaptability to market changes (Freel, 2000). R&D and innovation are susceptible to sectorial influences [...] (Becheikh et.al., 2006). Product innovation is considered stronger in high-technology sectors [...] (Subrahmanya, 2005).

A firms' strong customer-focus can lead to an emphasis on innovation that is derived from the desire to continually adapt to customer needs (Santos-Vijande and Alvarez-Gonzalez, 2007). Rowley (2002) calls attention to the fact that client knowledge enables the companies' regrouping and creation of incremental value. However, learning is often used to describe the innovation process. It is true that incubators innovate through constant learning processes that generate new technological knowledge (Nonaka and Takeuchi, 1995). The essence of the technological innovation process is the accumulation of knowledge over time. The increase of the knowledge volume is produced through different creative mechanisms associated with different learning modes, such as: learning from R&D or "Learn before doing" (Pisano, 1997); "Learning by doing", which arises spontaneously in the production process (Arrow, 1962); "Learning by using" (Rosenberg, 1982); and "Learning by failing", from the analysis of bad decisions by top managers (Maidique and Zirger, 1985). And the capacities are generated for the companies to mobilize and expand their technology, human and financial resources in the eco-innovation process. Resources are always a critical factor for all kinds of activities and processes. Evangelista et al. (1997) propose that technology resources will increase its importance as a strategic factor for the firms' performance in the near future.

7. CONCLUSIONS AND LIMITATIONS

This research aims to verify the impact of technological eco-innovation capacity on innovation performance, from most innovative firms of different sectors: Biotechnology; chemicals & cosmetics; manufacturing & medical sectors, in the USA. This research was elaborated in light of theoretical excerpts, with foundation in the model presented by Müller et al. (2005), which considers the following metrics: resources, enablement and leadership. The results obtained were satisfactory, validating the proposed process. In this scenario our contribution is highlighted, because it provides support to the critical priorities in order to implement this innovation project. There is a gap in the literature concerning the innovation capacity performance assessment on the eco-innovation performance, in firms. It is hoped that this study will stimulate a broad debate on the issue and it is acknowledged that more studies are needed to build more robust results in the near future. Innovation has become the primary basis of productivity improvements, sales volume growth, and firms' competitiveness. Increased global competition pressures are also forcing firms to continuously adopt, develop and innovate to enhance product competitiveness such as product design and quality, technological service and reliability. For these reasons, a firms must upgrade its eco-innovation capability […]. These firms are not only expected to create products meeting customers' needs for high quality and low price but also provide environmental solutions for consumers and society.

In fact, successful technological eco-innovation depends on both technological eco-capability and other critical capabilities, such as organizational, marketing, capital funds, manufacturing, strategic planning, and resource allocation (Yam et al., 2004). Such manufacturing capabilities determine a firms' ability to transform R&D into products and processes. Cooperating R&D, manufacturing, and capital capabilities provide effects of complement to accelerate successfully technological innovation activities (Wang and Cheng, 2008). Thus, the results demonstrate that eco-innovation capacity impact is positively related to innovation performance in most innovative companies. By eco-innovation capacity the companies can focus on holistic corporate performance, efficiency, and business value. Eco-innovation thus becomes a collective achievement that allows practitioners to appraise and critique the performance of their environmental practices, and that thereby allows them to constantly refine those practices. In fact, a companies's capabilities will influence their ability to develop eco-innovations (Florida et al., 2001). This is because of the firm's human capital and financial resources being important for eco-innovation. More eco-innovations are requiring technology because of the new knowledge involved in the processes. Firms that are more knowledge intensive are better able to develop eco-innovations (Doran and Ryan, 2012).

Regarding this effort, the research on such priorities should be applied permanently and periodically. Of the findings of the state of the art and state of practice, it is reasonable to state that this research is vulnerable to criticism. In the research, cross-sectional data used in this study may not be appropriate to establish fundamental relationships between variables. Furthermore, a study was developed for firms in three sectors in a static context, which may represent a limiting factor. Therefore, it is recommended to reproduce and replicate the model in firms from other countries or sectors in order to confirm the results. Of the different dimensions, the results show a predominance of R&D efforts. However such eco-innovation capabilities have to keep up with up-to-date changes and should be viewed as a priority of the present moment, with regards to systemic efforts guided by defining and redefining the performance of the firms of the study over time. It is plausible that building capacities occur over a continuous process and converge to the desired performance, which is in constant transformation through the new demands. Therefore, the innovation policy for firms in this category should be anchored by efficient planning.

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