Available online at www.sciencedirect.com

RAI Revista de Administração e Inovação 13 (2016) 176–189

http://www.revistas.usp.br/rai

Innovation development process in small and medium technology-based companies

Fabiana Matos da Silva [a], Edson Aparecida de Araujo Querido Oliveira [b,c], Marcela Barbosa de Moraes [c,d,*]

[a] *Management and Regional Development by the University of Taubaté (UNITAU), Taubaté, SP, Brazil*
[b] *Aerospace and Mechanical Engineering by Technological Institute of Aeronautics (ITA), São José dos Campos, SP, Brazil*
[c] *Graduate School of Management at the University of Taubaté (UNITAU), Taubaté, SP, Brazil*
[d] *Management by the University of Nove de Julho (UNINOVE), São Paulo, Brazil*

Received 29 October 2015; accepted 11 April 2016
Available online 19 June 2016

Abstract

Small and medium-sized technology-based companies are recognized as essential for the economy and business activity. The purpose of this article is to study how the technological innovation process occurs in small and medium technology-based companies located in the metropolitan region of the Paraíba Valley and North Coast – Brazil. The theoretical framework used is composed by six our models of innovation: the technology push, the market pull, the coupling innovation process, the functional integration innovation process, the systems integration and networking innovation process and open innovation. It was used in this research the multiple case studies with a qualitative approach. Data were collected through semi-structured interviews with owner-managers. The sample consisted of four small and medium technology-based companies of metropolitan region of the Paraíba Valley and North Coast – Brazil. In the data analysis, there was an intra and cross case analysis in order to verify the similarities and differences of the cases studied. As a result of observation of innovation development models adopted by companies, it appears that the model is closer to what was proposed in the chain interactions model. The development of innovation depends on the type of economic activity that is developed by the company and the interactions it has with internal and external environment. It was concluded that the small and medium-sized technology-based companies do not innovate in a systematic way, but intuitively and very focused on the ideas of its founders. They innovate focusing for meeting the requirements of customers and the needs observed in the market. The formation of partnerships is still viewed warily by the leaders and owners.

Keywords: Management; Development; Innovation; Small enterprise; Medium enterprise; Technology-based company

Introduction

For centuries, innovation has been a phenomenon that serves a single purpose: to make life more comfortable for humans (Kotsemir & Meissner, 2013). Complementing this idea, Leiponen and Helfat (2010) argue that many times the innovation contributes to the survival of not only individuals but also organizations as a whole.

Given this statement, innovation processes are fundamental to give competitive strength to companies. Innovations actions undertaken in this process can be motivated by entrepreneurial intentions as to meet new market demands; to add value to existing products and services; and to generate new products or services. Such actions reflect organizational competencies that renew the competitive vigor and contribute to the longevity of the enterprise (Freeman & Soete, 1997; Leiponen & Helfat, 2010).

To understand how innovation occurs in small and medium enterprises (SMEs), two essential processes are shown: the

* Corresponding author.
E-mail: fabianamatos.ali@gmail.com (F.M. Silva).
Peer Review under the responsibility of Departamento de Administração, Faculdade de Economia, Administração e Contabilidade da Universidade de São Paulo – FEA/USP.

http://dx.doi.org/10.1016/j.rai.2016.04.005

acquisition of new knowledge and design of new working method on the lines of production of goods and services. Therefore, for innovation to occurs, it is necessary to develop management systems and exploration of subjective capital, which is knowledge, which can be applied for use of organizational resources allowing a new production process (Leiponen & Helfat, 2010; Musiolik, Markard, & Hekkert, 2012).

To explain the occurrence of innovation based on these processes, some authors like Myers and Marquis (1969), Kline (1978), Rothwell and Zegveld (1985), Kline and Rosenberg (1986), Rothwell (1992) and Chesbrough (2003) developed explicative models made up of different stages, where knowledge is managed in order to facilitate such innovation. One of the advantages of working with these models is the possibility of detailed understanding of the origins of knowledge used as the basis for innovation, such as applied research, scientific research and market needs (Lobosco, Moraes, & Maccari, 2011; Viotti & Macedo, 2003).

Innovation development process can vary from enterprise to enterprise, being influenced by, among other things, by the sector of activity or by the size of the company (Conde & Araújo-Jorge, 2003). At this point, that emerges the focus of interest of this research, which comes to the innovation development processes in SMEs. SMEs present a leaner and more flexible structure when compared to large companies and can be considered more organic than mechanical (Mintzberg, 1989).

In the various classifications of SMEs that exist, there are calls small and medium technology-based companies, which serve up highly skilled workforce and few hierarchical levels, few departments, when these exist, and proximity to customers. This means that, in terms of innovation development process, present a potential to manage knowledge more quickly than large companies so that be created new production drawings (Moraes & Lima, 2014).

In the context of regional development, it should be emphasized the economic and social benefits that these companies provide to the region, especially with regard to the process of industrialization, search for competitiveness and scientific and technological development (Berté, 2006). Innovation also propitiates a new opportunity to influence the market direction in which the organization is inserted by different attributes developed in marketed products, which represent a new business perspective (Schreiber & Bohrer, 2014).

The literature review that supports the present paper did not allow us to identify research that explains the innovation development processes specifically of the small and medium technology-based companies. Given the importance of the subject and the apparent lack of treatment in both national and international literature, this study is justified by its potential to generate new knowledge relevant to the search for answers to the following research question:

How the innovation process occurs in small and medium technology-based enterprises located in Metropolitan Region of Paraíba Valley and North Cost – Brazil?

This paper is divided into 5 chapters. The first is about the introduction of the chapter in which highlights the research question that guided this research. The second chapter is a survey in the literature on the evolution of the understanding of the innovation process. The third explains the methodology used in the research. The fourth chapter highlights the analysis intra and cross cases following the precepts of Miles and Huberman (1994) and the last chapter deals with the discussion of the results and the conclusion of the study.

Evolution of comprehension of innovation process

The evolution of innovation is characterized by the high complexity of actions requiring an unorthodox and integrated thinking, which results in social acceptance (Kotsemir & Meissner, 2013). Thereby, the term innovation includes new technological, economic, social and organizational solutions that are not necessarily marketable, in the economic sense and direct monetary impact, but are applicable and are being used within organizations.

Some authors like Nobelius (2004), Ortt and Van Der Duin (2008) and Kotsemir and Meissner (2013) describe the processes of innovation in six generations of different models, as shown in Table 1. These models vary in the number and format of stages of the innovation process; however, in general, three main steps can be distinguished:

(a) Idea (or invention) of "something new (product, service or process (organizational or technological));
(b) Development (production, "doing") of "something new";
(c) Commercialization (diffusion, "selling") of "something new".

When analyzing Table 1, it was verified that the first model to arise is the technology push model, which is considered as the oldest model among models of innovation (Viotti & Macedo, 2003). In this model, the development, production and marketing of new technologies are seen as a well-defined sequence of time, which originates in research activities involved in product development and leads to the production phase and eventually the marketing (OCDE, 1992) exemplifies this model in Fig. 1.

Innovation is seen as a linear process and it is assumed that is by intensive scientific investments produce significant innovations. The challenge for managers is to invest more in research and development, which this generation works in isolation.

The market pull model can observe the existence of concern to the market need, and this is the main difference of the linear model. Fig. 2 illustrates the steps in the model.

The market pull model is born with the investigation of the needs market, pass through the responsible department for the research and development (R&D) that studies, analyses and the process of generating of new ideas and subsequently development of these ideas (Myers & Marquis, 1969).

What draws attention is the importance of market demand factor of this process, which is equivalent not ignore the influence of factors such as the scientific basis and the internal and external technological conditions to the firm on innovation. In the market pull model, there is a question of demand or supply of technical progress, absenting questions about other determinants of technological change.

Table 1
Evolution of innovation models.

Generation	Period	Authors of fundamental ideas	Innovation model	Essence of the model
1	1950-s – late 1960-s	Usher (1954, 1955)	Technology push	Linear process
2	Late 1960-s – first half of 1970-s	Myers and Marquis (1969)	Market [Need] pull	R&D on customer wishes
3	Second half of 1970-er – end of 1980-s	Rothwell and Zegveld (1985)	Coupling model	Interaction of different functions
4	End of 1980-s – early 1990-s	Kline and Rosenberg (1986)	Integrated model	Simultaneous process with feedback loops; "Chain-linked" Model.
5	1990-s	Rothwell (1992)	Networking model	System integration and networks (SIN)
6	2000-s	Chesbrough (2003)	Open innovation	Innovation collaboration and multiple exploitation paths.

Source: Kotsemir and Meissner (2013).

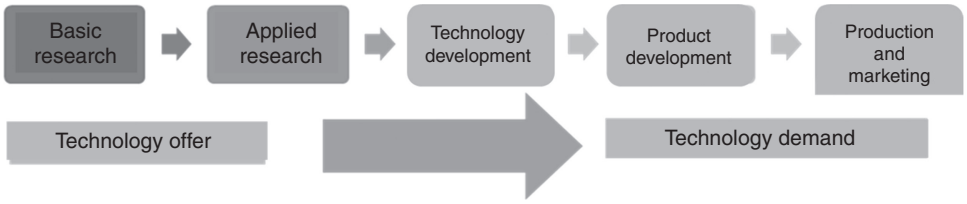

Fig. 1. Technology push model.
Source: Viotti and Macedo (2003).

Fig. 2. Market pull model.
Source: Barbieri (2003).

The third generation of the innovation process known as coupling model occurred in the 1970s to the 1980s and looks for the balance between research, development and market needs (Rothwell, 1994). Rothwell and Zegveld (1985) describe the coupling model as a logical, continuous sequential process, which can be divided into a series of distinct phases, but interact and have interdependent step.

The need identified in the market, added to a new technology of research centers generate a new idea, which in turn, is developed by researchers. Due to the constant monitoring of the state of the art in technology and production and, consequently, of the society and market needs, a new product is developed and put on the market as depicted in Fig. 3.

The linear model is theoretically exceeded as reporting Godinho (2003), but this remains unconscious, is often detected in measures, and programs focused for Science, Technology and Innovation (ST&I). Adopting this linear concept of innovation could induce to the conclusion that high investments in basic research would reflect positively on economic growth.

To overcome the limitations imposed by linear approaches, there are non-linear and interactive approaches, which emphasize the central role of design, the effects of feedback between the various stages of the linear model and the various interactions between ST&I in all phases, surpassing the more restricted view of the linear model of the innovative dynamics.

The fourth model is presented by Kline and Rosenberg (1986) and is known as functional integration innovation process, it is a logical sequence, but not necessarily continuous and linear where processes return whenever necessary in earlier or later stage, can be divided in functional series with interdependent and interactive steps.

The purpose of this model comes close to meeting the market needs or consumer satisfaction. It provides a reassessment of the importance of science and research in the innovation process, giving companies a central position in this process.

This model, on the other hand, emphasizes the effects of feedback between the phases of the linear model described above, as well as the numerous interactions that every step of the innovation process are established between innovative companies and other companies (competitors and suppliers) or between the first and industrial users, final consumers (Von Hippel, 2007) and organizations of the education system and the scientific and technological system.

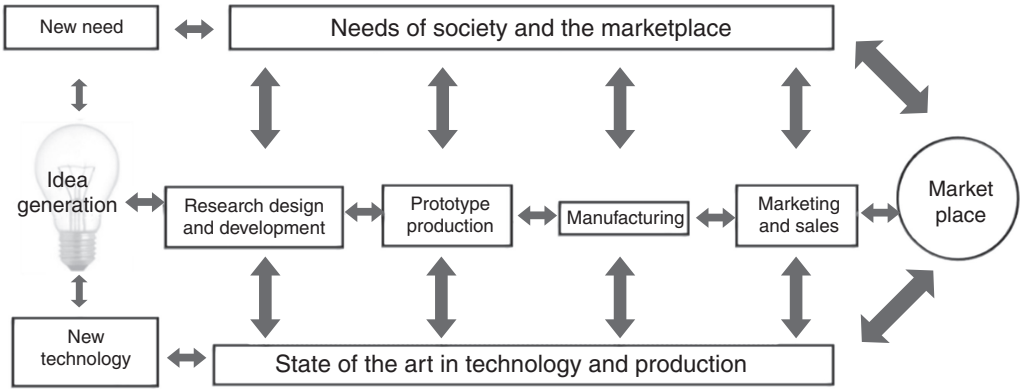

Fig. 3. Coupling innovation process model.
Source: Rothwell and Zegveld (1985).

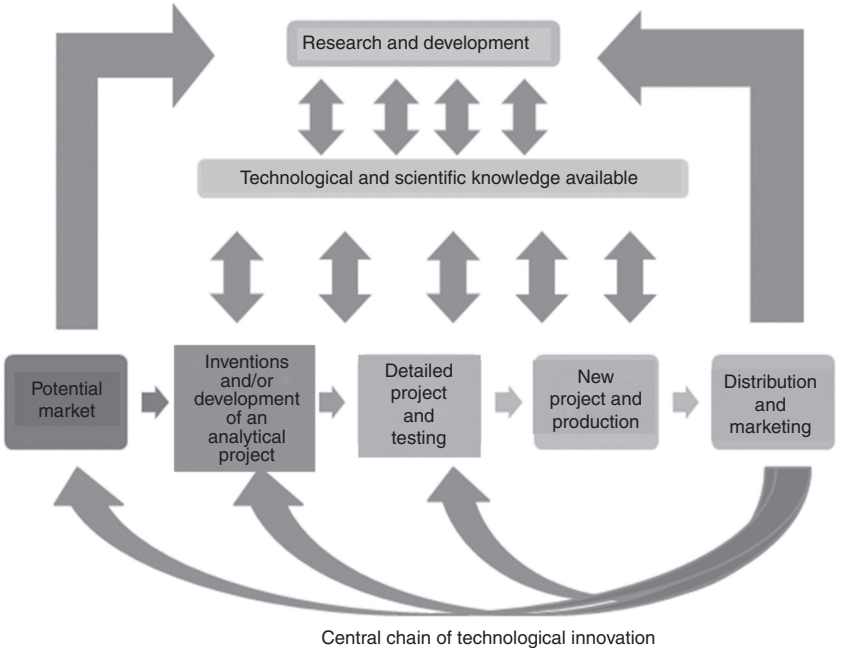

Fig. 4. The functional integration innovation process model.
Source: Kline and Rosenberg (1986).

It starts with an idea that materializes responding to a market need, and there is one point that feedback information, if not, investigates itself. There is a close connection between science and technology, which allows the exchange of experiences, knowledge and information, during its development, providing the necessary corrections in each stage and increasing the possibility of seeking good results. For Kline and Rosenberg (1986) to apply the knowledge in the process, it gives the model the logic of the chaining of ideas. Fig. 4 illustrates the model described.

This model aims to present the process of innovation of companies whose capacity for innovation resides in them. The way how this process triggers and unfolds, however, is different. In many companies, the incentive for innovation comes from the existing needs in the market, detected by marketing and distribution areas.

The fifth model is the systems integration and networking innovation process defined by Rothwell (1992) which brings the idea that companies do not innovate an isolated way, but is inserted in a context of relations network system with other companies (directly or indirectly) with the infrastructure of public and private research (universities and research institutes) and the national and international economy.

This model illustrated in Fig. 5 which is contrary to the models already presented, because they consider technological innovation as a set of steps (and these sequential or not). The central point of this model is inside the company focusing on the relationships between elements of the system as drivers of technological innovation process to consider several factors that have influence in the process, such as macroeconomic conditions, market conditions and communications infrastructure, and consider impacts caused by the process in the country's performance, as economic growth, job creation and competitiveness (Viotti & Macedo, 2003).

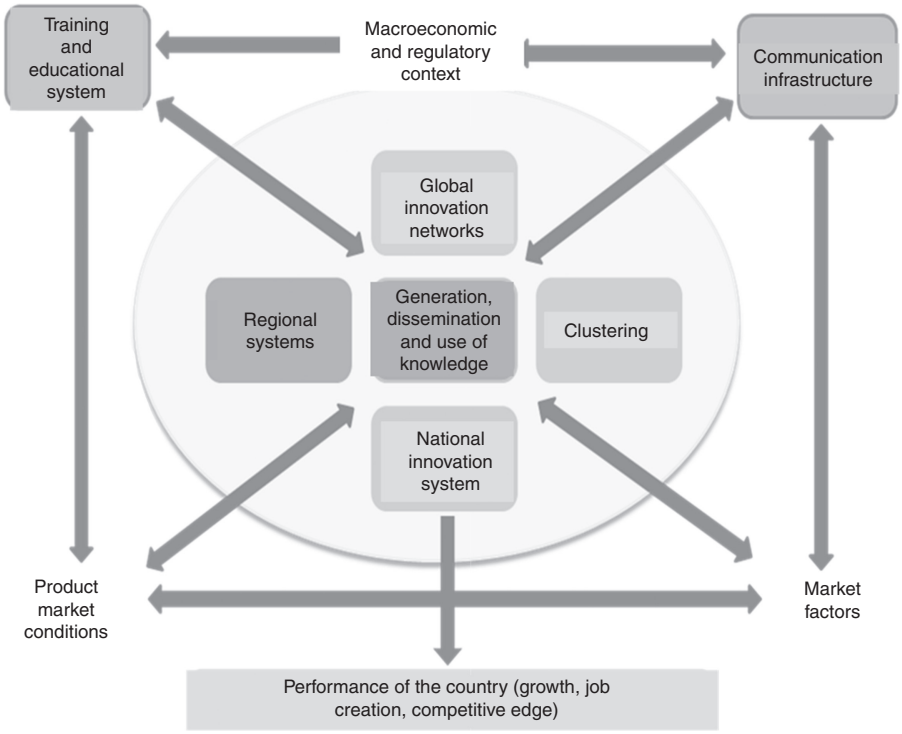

Fig. 5. The system integration and networking innovation process model.
Source: Viotti and Macedo (2003).

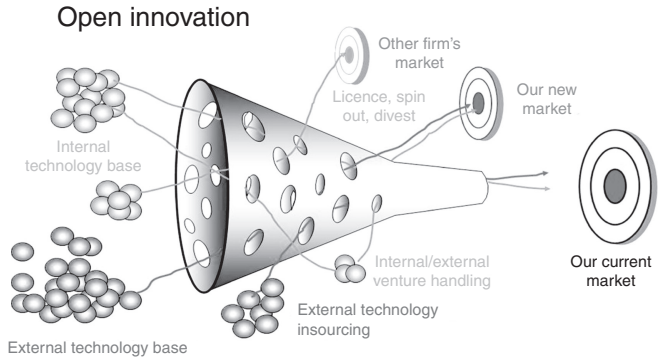

Fig. 6. Open innovation model.
Source: Chesbrough (2003).

From the systemic model of innovation described above, are considered universities as one of the pillars of the innovative process, which confirms the dynamics of the triple helix. To the extent that knowledge becomes an increasingly important input for socio-economic development, it is natural that the university whilst an institutional space of generation and transmission of knowledge, is seen and analyzed as a prominent social actor (Lobosco et al., 2011).

The sixth and last generation, developed by Chesbrough (2003), is the open innovation model that means a change in the traditional format of innovation. Chesbrough (2003, 2006) shows that this open format model that focuses on the use of external expertise to assist and accelerate internal innovation process, as shown in Fig. 6.

Rahman and Ramos (2010) explain that in terms of process, open innovation covers the management and the accumulation of ideas, knowledge, licenses, intellectual property, patents and inventions. The authors add that in terms of innovation, it can be considered user-innovation, marketing innovation, cumulative innovation and distributed innovation. Therefore, open innovation theory corresponds to a number of innovative approaches whose basic element is made innovation beyond the research and development departments of the organization.

In other words, open innovation incorporates joint efforts of internal initiatives to the organization and possible outsourcing or combination of multiple inputs coming from the external environment during the process of design and product development.

Noticeably, you see the transition from a closed system of innovation to open innovation system. In the closed system, the development of the idea rarely goes beyond the walls of companies; these seek to obtain competitive advantages, especially from the internal capabilities, and the R&D prominent place. The open system presents a model that not only allows other companies to internalize the knowledge and new technologies developed, creating new opportunities and new challenges, but also values the knowledge, experience and external creativity to the firm, giving rise to new business models.

To sum it up, the six generations of the development process of innovation indicate that linked innovative approach to research and development (R&D) is changing and adapting to the context of major organizational changes (Nobelius, 2004). We show that these models are an important source of competitive advantage for companies both large as medium and small sized.

Table 2
Sample of SMEs.

Name of SMEs	Economic activity	Number of employee	Year of foundation	Municipal district
ProShock	Their operation is associated to the cycling industry in Brazil. Manufactures bicycles and wheelchairs.	38	1993	São José dos Campos
TIQ	Manufacture of chemical products for textile industry.	55	1991	Tremembé
Troya	Production of aircraft structures and tools.	45	2005	São José dos Campos
Alltec	Development and manufacture of products and high performance structures in composite materials.	200	1995	São José dos Campos

Methodology

In order to develop a robust work and consistent with the research needs, we used a qualitative and descriptive approach, based on a multiple case study according to Eisenhardt (1989) recommendations. This methodological approach was chosen to adequately serve the purpose of research that is studying how the innovation process occurs in small and medium technology-based enterprises located in Metropolitan Region of Paraíba Valley and North Cost – Brazil.

The sample of this research is presented in Table 2. The cases have been chosen intentionally based on the contributions they could provide to the study, in other words, the study sample was characterized as non-probabilistic theoretical and intentional. The companies were selected according to their activities, size, year of foundation and developed some kind of innovation. Currently, cities located in Metropolitan Region of Paraíba Valley and North Cost – Brazil are recognized for their regional vocation linked to the sectors: aerospace, instruments, motor vehicles, mechanical metal and fine chemicals. These sectors are classified as high and medium-high technological intensity according to the OCDE (2011).

The data collection procedure was based on semi-structured interviews and in depth with the top managers who are directly linked with the innovation development process. The interviews lasted on an average duration of one hour and forty-five minutes.

To build the guidelines for the interviews was used as the basis he model of value chain of innovation developed by Hansen and Birkinshaw (2007). The model of the value chain of innovation, proposed by the authors, is to analyze innovation as an integrated process, from generation of concept to the diffusion of innovation among other areas of the organization. Table 3 shows the division of value chain in three phases and priorities.

The data analysis procedure was based on intra and cross case model set up by Miles and Huberman (1994). This analysis aims to describe, understand, explain and cross the conceptual content, processes and outcomes of a particular phenomenon in a context of multiple cases and hence develop a more detailed understanding of all cases in the sample (Miles & Huberman, 1994).

Complementing the analysis procedure also used two sense-making techniques: visual mapping and narrative. Hence, the narrative strategy aims to provide stories, meanings and mechanisms, while the visual mapping assists in forming patterns by graphical representations (Langley, 1999).

Analysis of results

This chapter presents the analysis intra and cross case of four companies of the research sample. In the analysis, they are depicted the main elements that helped to answer the research question, which is focused on generating new knowledge about the process of development of innovation in small and medium technology-based enterprises.

Intra case analyzes: PROSHOCK

ProShock is a company founded in 1993 and located in São José dos Campos (SP). Its founders used the wide experience to create bicycles suspensions. Initially, the company was focused on the manufacture of bicycles suspensions, as a supplier of Caloi. To study and observe the market began to devote himself to the manufacture of products with higher added value, and from internal research the company developed new products in different markets. It was noted that the company had the capacity and know-how to operate in the manufacturing hand bikes and wheelchairs, emerging a new product brand (Vemex) focused on assistive technology. The company's innovation model in question is shown in Fig. 7.

By analyzing, the model of innovation of ProShock observed the step of generating of ideas. Each project is defined in accordance with the focus to be developed, for example, development of a new product; improvement of the performance of a product already available for sale; and quality improvement project.

Table 3
Stages of value chain of innovation.

Generation of idea		Conversion		Diffusion	
Creation of idea within a unit.	Collaboration between units	Collaboration with actors from outside the company	Selection, screening and initial funding	Development and movement of the idea for a first result	Propagation and dissemination throughout the organization

Source: Hansen and Birkinshaw (2007).

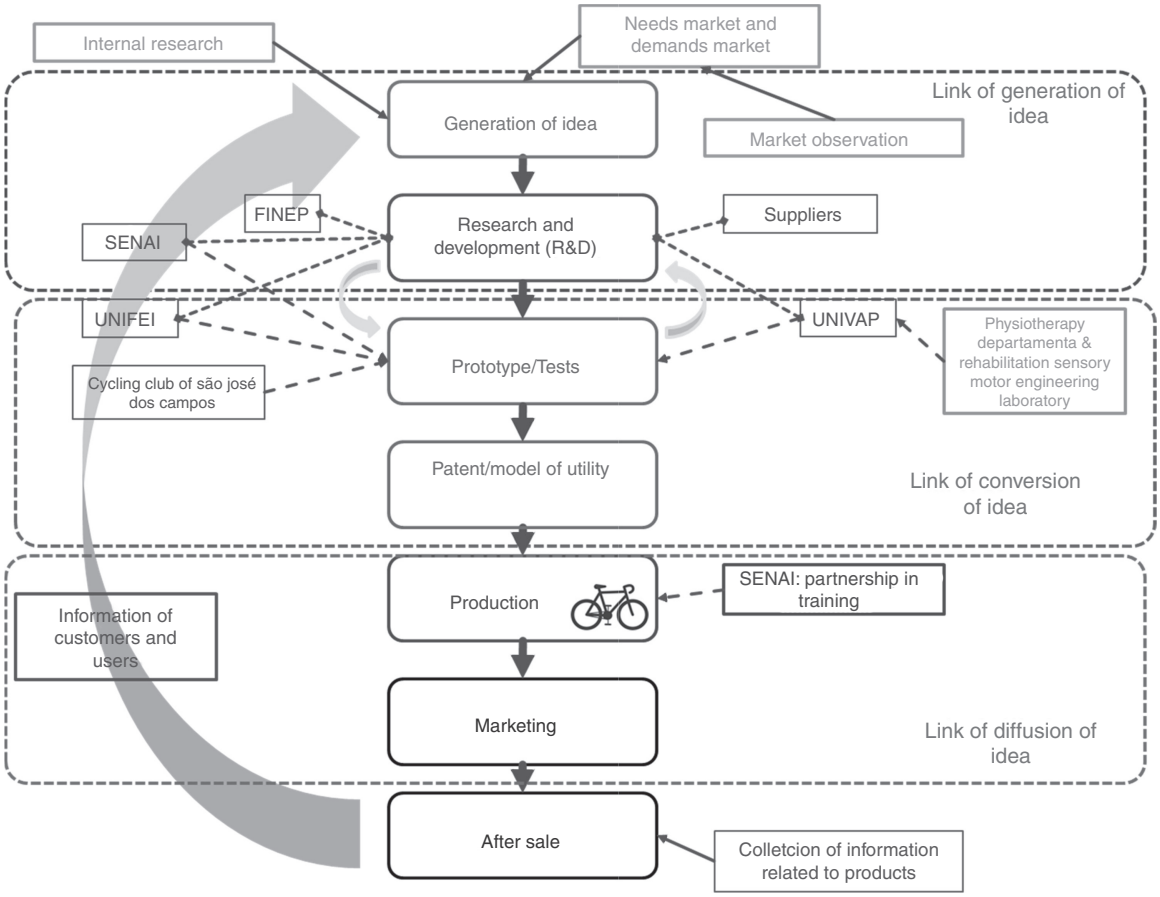

Fig. 7. Innovation model adopted by ProShock.

The definitions are made from information derived from customers, market analysis and internal research development. The company's efforts have recently focused on the development of internal projects, which are designed by the engineering team.

A lot of information that feed the step of generating of ideas are collected during the post-sale, which provides information for improvement and changes in products in the customer's vision. The projects of new products are balanced with the competitive strategy of the company.

The conversion phase of ideas is seen as the development process of products, which includes from the selection and prioritization of ideas until its commercialization. The engineering department discusses the technological requisites and checks the feasibility of the project development, in addition to considering the development goals, the application characteristics, the responsibilities of each area, and production parameters of each manufacturing area.

At this stage, the conversion of ideas is signed cooperation networks and information networks for the development of projects, in addition to funding for its implementation. There are also a partnership with Cycling Club of São José dos Campos and the University of Vale do Paraíba (UNIVAP), through the Physiotherapy Department & Rehabilitation Sensory Motor Engineering Laboratory (LERSM), to develop products focused on the market directed at para-cycling athletes in hand cycle category.

The development of assistive technology arises from a project of developing a wheelchair with damping and electronic control system. This project was supported financially when received approval in the public call of economic subsidy to innovation in 2008 the Funding Authority for Studies and Projects (in Portuguese: *Financiadora de Estudos e Projetos* – FINEP[1]).

After two years of the beginning was presented the first working prototype of the wheelchair suspension. The prototype was tested in the laboratory with fatigue test according to the standard ABNT NBR 7176 – WHEELCHAIRS, and field for two wheelchair users.

Based on the obtained findings, the company signed a partnership with SENAI in São Paulo Innovation Program, and in 2011 started the development of the second phase of the project: the prototype of the improvement to the design of a vehicle that includes all the above requirements.

In this context of innovative ideas, project with financial support from FINEP, partnership with SENAI, and findings reported in practice by the technical staff of the company with the monitoring, providing information and direct feedback from users' wheelchair partners arose the wheelchair. After the development and approval of prototypes began production in partnership with

[1] Funding Authority for Studies and Projects is an organization of the Brazilian federal government under the Ministry of Science of Technology, devoted to funding of science and technology in the country.

SENAI, which annually reserve vacancies for company employees in training courses.

Marketing is done at site and specialty shops, and a strong presence on social networks draws attention. The after-sales phase begins immediately after the time of acquisition of the product. With a focus on collection of information from customers for maintenance of post-purchase relationship and customer satisfaction and therefore the process of generating of ideas is feedback.

Hansen and Birkinshaw (2007) highlight the role of communication at any stage of the process. In the case of ProShock observed the intense internal and external information flow. It is observed that the ProShock not innovates alone and having an innovation model similar to Coupling Innovation Process Model. It is inserted into a networking relationship with universities (UNIFEI, UNIVAP), technical schools (SENAI), suppliers, cycling club in the city of São José dos Campos (SP) and general users.

In the construction of this model finds the sharing of information throughout the process. The relationships that integrate this model are built in order to meet market needs and consumer satisfaction.

Attention should be paid to the effects of feedback between the stages of development and interactions present in each stage of the process, because they allow the inclusion of information and adjustments required in addition to the constant development of knowledge.

Intra case analyzes: Tremembé Indústrias Químicas (TIQ)

TIQ was founded in 1991 in the city of Tremembé, and its performance is domestic and operates in the chemical segment with specialties developed mainly for textile industry and also participates in the sugar and ethanol industry and water and paper treatment, developing, continuously often in partnership with its customers, new products that respond to rapid changes in these sectors.

Based on interviews with the managers responsible for the development of products and processes of TIQ was presented graphically a model of innovation development, shown in Fig. 8.

For the construction of the model began the analysis by the stage of generating of ideas, which is fed by market needs, which are captured by a team of employees that is the Department of Applications.

This department is composed of professionals and board members, and is designed to control information that enters and leaves the company. There is a feedback and traffic information. Around two years ago, the generation of ideas is also fed by replacement of products, which for legal and environmental issues are required to be replaced.

With the approval of the directors, the idea is or is not continuity in the development process, afterward goes to research and development in which is tested and defined the parameters required for a complete specification. The department applications are present both at the stage of generating of ideas as the conversion of ideas phase. The R&D laboratory is responsible for the development of parameters and productive means.

Research and development does not have many partners for cooperation, for example, there is only a close relationship with suppliers and this thanks to the personal efforts of the team, and a proximity to the Lorena campus of University of São Paulo in involving the literature use directed the implementation of the company, acting as a source of information.

The team of R&D aims at create new products, developing formulations (laboratory scale) and applying the means of production (large-scale production). The TIQ maintains a minimum number of new products to be developed (6–10), which in the words of the respondents is easily overcome. Regarding the production process there is an internal focus on actions that focus on greater efficiency, quality, and reduction in production cycle.

Financial indicators that demonstrate process costs before and after the change continuously evaluate these actions: R&D not only engaged in the development, but also in continuous improvement processes. With regard to marketing, TIQ sought to circumvent the presence of a distributor and engaged in the sale to the end-user companies, giving the necessary technical support.

The company has an innovation model similar to chain interactions. During the construction of this model notes to the internal sharing of information throughout the process. Attention should be paid to the effects of feedback between the stages of development and interactions present in each stage of the process because it allows the inclusion of information and adjustments required in addition to the constant development of knowledge. This model of operation and development of innovation is still under construction, and its development is one of the goals of the company directors.

Intra case analyzes: TROYA

The beginning of the company took place in 2003, and initially participating in the incubation process of Incubaero,[2] was founded by three engineers who were already active in the aerospace segment as Embraer professionals.

The company is dedicated to the aeronautical market and specializes in the process of aircraft structures. It has a great knowledge in the drafting, design and manufacturing of tooling, but has developed projects for wind energy (design for Tecsis Company) and automotive industries, according to its know-how. Currently 90% of its activities are devoted to the aeronautical market.

Based on interviews with the Troya's top management drew up graphically the innovation development model, shown in Fig. 9.

The input of information in the generation of ideas is given by customer needs, which are captured and transformed into

[2] Incubaero is a business incubator and projects created by Casimiro Montenegro Filho Foundation to develop the aerospace industry, in partnership with the General Command of Aerospace Technology/Technological Institute of Aeronautics and technological finance agencies.

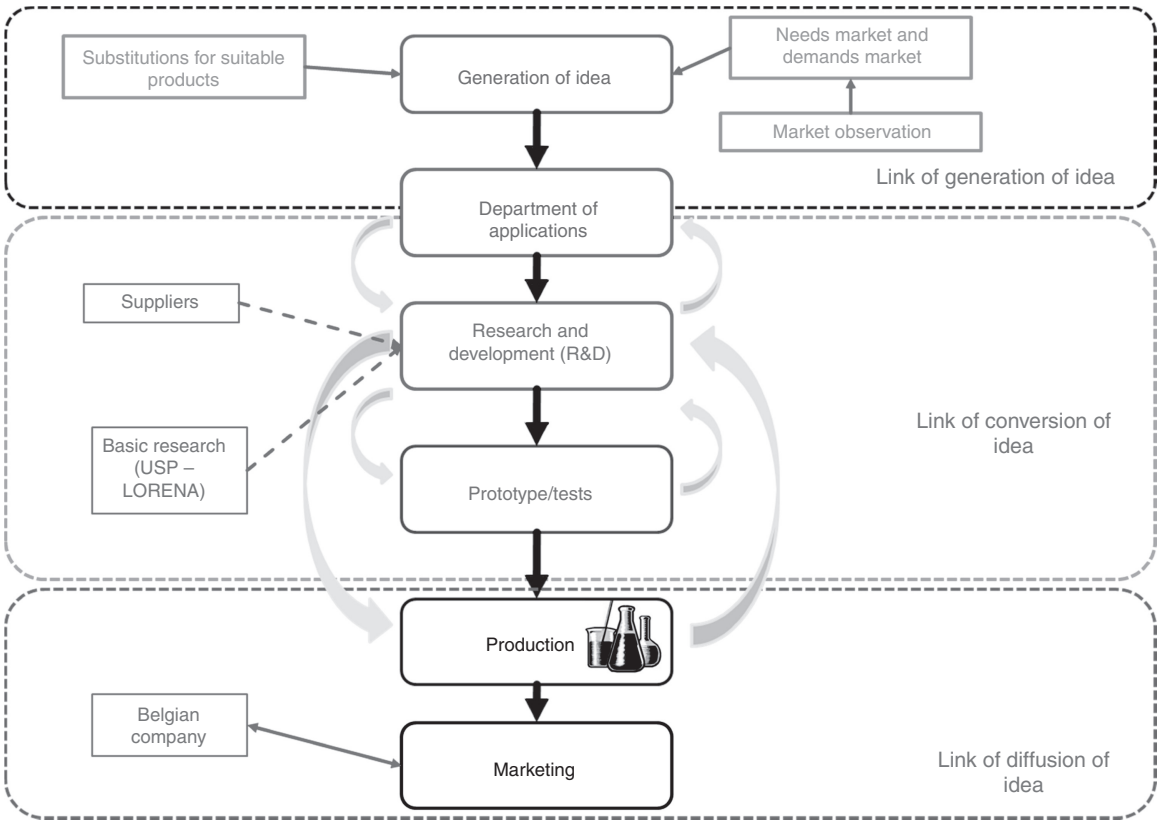

Fig. 8. Innovation model adopted by TIQ.

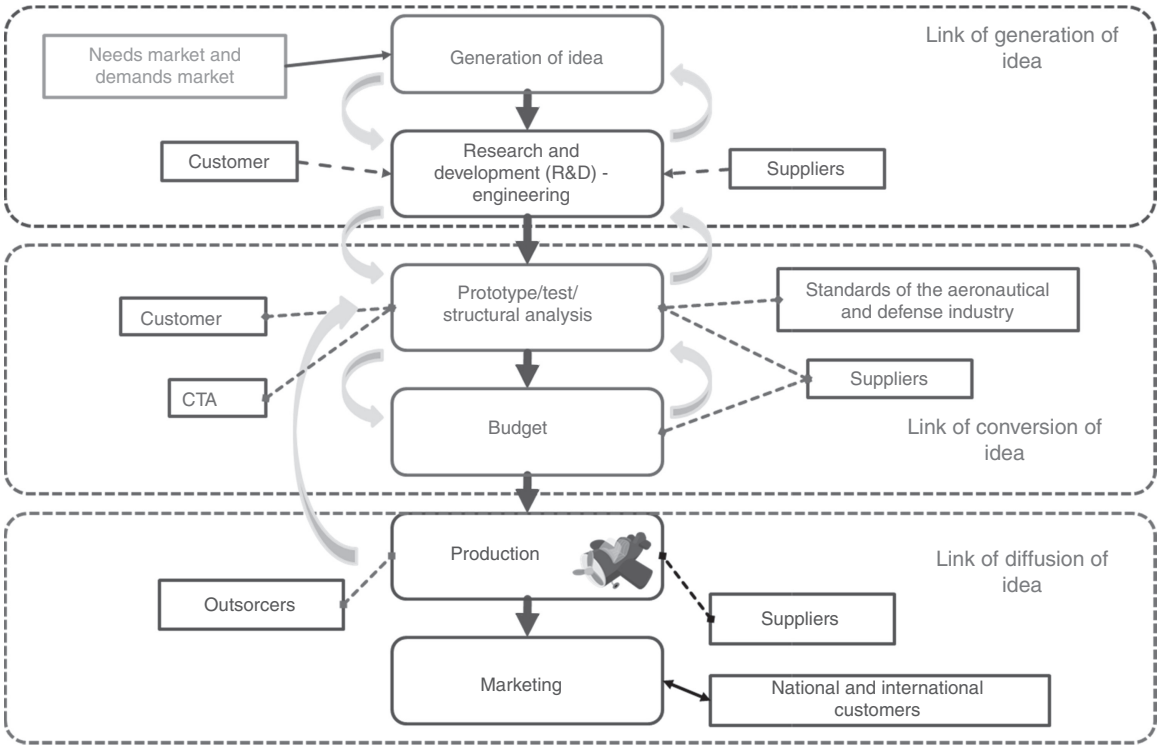

Fig. 9. Innovation model adopted by Troya.

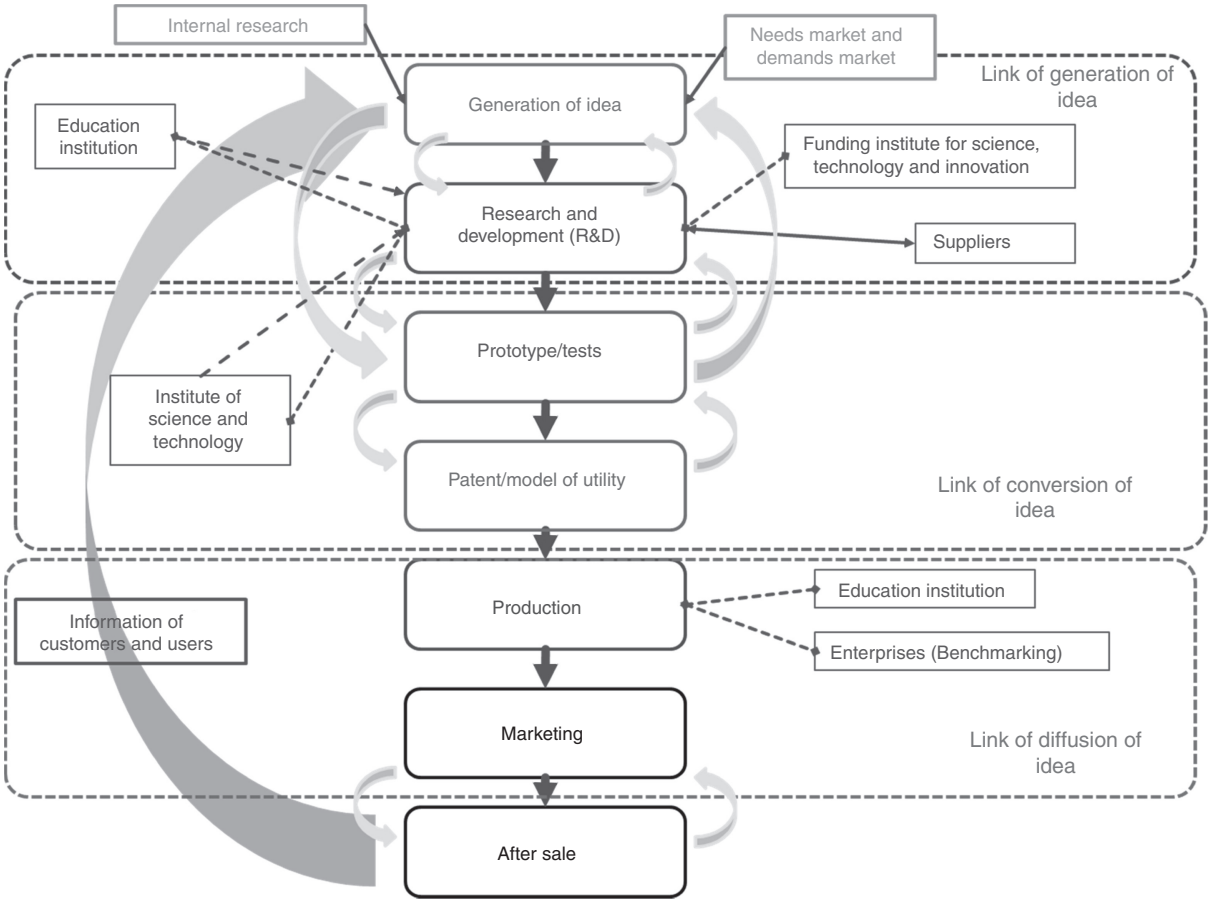

Fig. 10. Innovation model adopted by Alltec.

solutions for the Engineering Department, which is responsible for research and development of ideas and involve suppliers if necessary.

With the endorsement of managers and after critical analysis the idea has or has not continuity in the development process hence begins the conversion of ideas with the creation of the prototype, which initially consists in creating a virtual model modeled in CATIA software and structural analysis by Nastran software. With the customer's approval, the approved piece goes to budget and production department, and then the product returns to the prototype stage and physical tests.

The link diffusion of ideas starts with the production and involves suppliers and the need to outsource some stage of production is evaluated. This phase involves national and international stakeholders, located in Chile, Canada, Portugal and Spain.

After production has the commercialization. The Troya operates in the domestic and international market, serving, in Brazil, Embraer and all its suppliers, for example, Latecoere, Sobraer, and small enterprises. In the international market, it meets the medium and large companies, as Ogma in Portugal and Alestis Spain.

In relation to production processes, the internal focus is on actions that have reduced costs, maintaining quality and meeting deadlines. The company evaluates its development by financial indicators that prioritize revenues, in addition to indicators of Embraer's suppliers, seeking to supply index 98%.

During the interview, the top manager has made clear his concern with the training of staff with the intention of preparing them better to serve their customers, because in Troya view, quality of the workforce ensures product quality.

The Troya presents a functional integration innovation process model, which has internal and external feedback during the development process. Interactions should be highlighted because the company interacts with renowned institutions like ITA and CTA, and also interact with Embraer, which has an important position in the global aeronautical industry.

Intra case analyzes: Alltec composities

Two former employees of EMBRAER founded the Alltec Company in 1995 in São José dos Campos and has its activities focused on the manufacture of components in composite materials applicable to the aeronautical, aerospace and defense industry. In 2013, received of Embraer the award for best supplier of the year in the category Compounds Technology.

Based on interviews with top managers of Alltec, we presented graphically in Fig. 10, the model of development of innovation. The interview was conducted with two top

managers, and to prepare the construction of the model began by observing the idea generation stage.

The input information in the generation of ideas is given by customer needs. During the interview, the representatives of the innovation process make it clear that the company is focused on to meet these needs.

In the Engineering Department of the needs are identified, categorized, and formulates possible solutions. During this stage of development are involved suppliers and renowned educational institutions (ITA, UNIFESP, UFABC, UNITAU, FEG) and research (IPT and CTA). A relevant point in the Alltec model is the network of relationships that is formed by the company in all phases: are many higher education institutions, research institutes, and companies and partner laboratories.

Link of conversion of ideas is primarily engaged in the construction of prototypes and carrying out tests for approval of material as to its constitution, and physicochemical properties as to its application. At this stage they are involved partner laboratories and educational and research institutions.

Link of diffusion of idea begins with the production, which is directly involved in the innovation process, because it is the feedback for continuous improvement actions and reduction of lead-time, among others. After production has the commercialization, that serving Embraer in Brazil. The company has little international presence, and evaluates its development through financial measures that prioritize revenues.

The Alltec presents an innovation model similar to functional integration innovation process model, which has internal and external feedback during the development process. Interactions signed worth mentioning, because it is a well-developed focused on meeting customer needs.

Cross case analyzes

Companies present the phase of generating of ideas, their conversion into results, product development, until marketing, supported in their daily practices. It is not a consciously adopted and systemic model, with a well-defined goal.

The theory developed by Hansen and Birkinshaw (2007) decomposes the phase of generation of idea in three steps: (a) collaboration within the unit; (b) collaboration between units; and (c) collaboration with external parties. The companies studied have only one unit, and this characteristic cannot verify the collaboration between units.

Table 4 shows the comparison between the surveyed companies in the process of generating ideas, whose priority is the collaboration within the unit and with external parties. The companies' present cooperation within their units, but the big difference between them is how they do this collaboration.

In Proshock, collaboration occurs mainly by responsible between R & D, represented by the Engineering and Prototypes and Tests Department. There are a strong after-sales team's activities with respect the collection of information on traded products, thus feeding the process of generating of ideas.

In other companies, TIQ, Troya and Alltec, internal collaboration involves the sectors responsible for R&D, Prototyping and Testing, Production and Sales Department. In all companies surveyed, there are involved in all areas, be more direct or indirect way. In all, there is a concern of developing an enabling environment for innovation. This concern can be demonstrated by investments in employee training.

With regard to collaboration with external parties, the cooperation relations between companies and other institutions play a significant role with regard to learning, dissemination of knowledge, innovative capacity, and therefore competitiveness.

Cooperation between companies seeks to meet certain needs that would hardly be satisfied acting individually, the need to combine skills and use know-how of other companies; share the burden for carrying out technological research, development and sharing the knowledge gained; offer higher quality products and more diversified lines; increase the competitive strength of action for market of external insertion; strengthen the purchasing power; share resources, especially those underutilized; and share risks and costs to generate new opportunities.

It is noteworthy that the companies surveyed have some relationship with external sources. Some present this point more clearly and with greater intensity, like ProShock and Troya while the TIQ presents initial way but with the intention of expansion.

Table 5 shows the phase of conversion of idea; it evaluates its priorities, and compares the companies. At the stage of conversion (selection, prioritization and funding ideas), companies are found structured by aligning its activities with its strategic needs.

The ProShock, TIQ and Troya are remarkable for a structure that uses multidisciplinary teams and a high standardization of processes. Only ProShock and Troya redefine its competitive strategy, operating and developing its know-how in the development of new products and activities in other markets.

In the conversion of idea can find a common barrier to all companies, which is the funding of ideas. To strengthen this stage is necessary to encourage the use of government funds in addition to the use of special credit lines for small business.

Of the companies surveyed, the ProShock and Alltec have projects funded by FINEP. The Troya signalled interest in the economic subsidy of its projects, but did not finalize the paperwork for public notices and does not have expected to do it.

Of the companies surveyed, the ProShock presented resulting patents of its development, and a total there are six patent applications. Already the TIQ and Troya did not have this concern. Table 6 shows the comparison of companies in the phase of diffusion of ideas.

In this phase of diffusion of ideas, dissemination in the organization and in the market, ProShock and Troya developed new business models from developed products, although Troya has preferred to keep in the aeronautical market for tradition and stability of relations providing the business. The TIQ offers a wide range of products and services and operates in outsourcing services to other companies.

Regarding the dissemination of the project and of new knowledge is a necessary routine followed by all companies, especially to fulfill the requirements of regulatory standards and also by customer participation in the innovation process.

Table 4
Comparison of phase of generation of ideas.

Phase	Priorities	ProShock	TIQ	Troya	Alltec
Generation of Idea	Collaboration within the unit	Internal collaboration is made between the sectors, especially among those responsible for R&D (Engineering), Prototypes, and tests. The after sale acts feeding the process with ideas collected with customers and users.	Search the collaboration between all sectors involved with processes and products, such as R&D, production or sales.	There is collaboration between the Engineering responsible for R&D (Engineering), and Prototypes and Testing and Production.	The collaboration takes place between all sectors involved with processes and products, such as R&D, Production.
	Collaboration with external parties	There is external collaboration (customers, users, universities and others). It is signed cooperation networks and information.	There is the start of an external collaboration with respect to basic research (USP-Lorena), and there is interest in expanding these networks.	There are external collaboration (Customers, users, CTA, national and international companies and others), and are signed cooperation networks and information.	There is external collaboration (customers, users, universities, institute of science and technology and others), and are signed cooperation networks and information.

Table 5
Comparison of phase of conversion of idea.

Phase	Priorities	ProShock	TIQ	Troya	Alltec
Conversion of Idea	Evaluation and Funding	The new product designs are balanced with the competitive strategy of the company. There are development projects with economic subsidies (FINEP).	The projects are developed with own resources, working within the chemical segment for the textile industry, which proved to be very wide.	The new product designs are balanced with the company's competitiveness strategy, working in product development in other sectors, if its market to show lazy (automotive, energy).	The new product designs are balanced with the competitive strategy of the company. There are development projects with economics subsidies (FINEP).
	Development of ideas into products, services or new business	The company is dedicated to the manufacture of products with higher added value, conduction internal research. Developed new products in different markets. It identified the capacity and know-how to be making hand bikes and wheelchairs. Appeared a new brand of products (Vemex) focused on assistive technology.	The company is dedicated to the chemical segment in the textile market, but its R&D team works on several fronts, ranging from the creation of new products, adequacy due to legislation changes, continuous improvement; development processes; and outsourcing manufacturing to the other markets.	The company is dedicated especially to the aerospace industry and may realign its competitive strategy, if necessary. The activities are global. The focus of development is the attention to customer needs.	The company is dedicated especially to the aerospace industry and can align their competitive strategy, if necessary. The focus of development is the attention to customer needs.

Table 6
Comparison of phase of diffusion of idea.

Phase	Priorities	ProShock	TIQ	Troya	Alltec
Diffusion of Idea	Disseminate and apply the ideas inside and outside the organization	It is inserted into a relationship with universities networking (UNIFEI, UNIVAP), technical schools (SENAI), suppliers, cycling club located in São José dos Campos – Brazil and users in general.	The company's focus is on the internal development of its processes, and the creation of new products.	The company belongs to an important regional context, relating to various external actors. Its focus is the development of solutions for the aeronautical industry, but because of its know-how has worked on other fronts while needed.	The company belongs to an important regional context, relating to various external actors.

Discussion and conclusion

Innovation is a widespread issue, particularly with regard to competitiveness and tool for business survival, since being able to do something that no one else can, and do it better than the other. This represents a significant competitive advantage.

The central objective of this paper was to understand how the innovation process occurs in small organizations. With the results, we conclude that small enterprises do not innovate alone, because they have an established contact network that have a strong connection with the activities developed by the companies surveyed. Despite all the obstacles, there is the relationship with universities, technical schools in the region and other companies, both large and small and medium-sized.

The development of innovation is strongly influenced among other things by industry sector and by the size of the company (Conde & Araújo-Jorge, 2003). It is possible to observe that the companies of the aeronautical industry, the development of innovation mainly gives because of the customer requirements, while in other sectors seeks to meet new markets as a way of survival.

Innovation is driven by the ability to establish relationships, opportunity detection and take advantage of them (Tidd, Bessant, & Pavitt, 2008), and this was observed in four companies surveyed. Innovation processes of companies are usually supported by their relationships with other companies and organizations. Relations of competition and conflict or trust and partnership on different levels can represent these ways of interaction of local actors with external actors.

The authors also argue that the type of interaction also requires information on the number and types of actors involved; motivations and objectives; frequency; intensity and duration; problems and difficulties of the interactions (Cassiolato & Lastres, 2005).

Through analysis, we can see that companies provide to the aeronautical and defense industry have as a starting point the compliance with the requirements specified by customers. Every process is unleashed before the customer needs, while companies selling products themselves are concerned to collect information on the market.

Companies linked to defense and aeronautical form partnerships, especially the requirement of the region's industry and geographic proximity to CTA, ITA, and Army aviation. The other companies have their starting point both internal research, and the observed needs in the market.

These companies have more difficult in its activities and development of products and processes. Such difficulty is because they are not within an activity that characterizes the region, hence it is more difficult to establish partnerships and develop technologies.

Hansen and Birkinshaw (2007) emphasize the importance of the role of communication at any stage of this process, confirming the idea that innovation does not happen in isolation. The larger the network of relationships of SMEs will be the largest development achieved (Cross, Hargadon, Parise, & Thomas, 2007).

Ideas emerge and turn a project in development when the various opinions are integrated, but they often arise from unstructured way or observation of market needs. Even if unintentionally, companies build external networks of relationships and involve their employees in multidisciplinary groups.

Other factor that it is equally important is the institutional environment, which these companies operate, because it affects the innovation (Albagli & Maciel, 2004). If there is no integration between the technical, marketing, R & D, and others involved in the innovation process, the groups promoted internally will generate many ideas that will be evaluated in isolation after a long process, instead of being immediately vetoed earlier.

Hamel (1999) shows how the models of temporary participation in projects can contribute to the exchange of knowledge and generation of ideas, and to Cross et al. (2007) innovations are created through networks and groups of persons who work harmoniously.

This statement was proven in the numbers of generated ideas and projects in companies and how employee participation is active mainly in the stages of generation and development of ideas. Another important point concerns the iteration between stages of the model. This topic was not addressed in Hansen and Birkinshaw's article (2007), but it was found in the study that the diffusion phase can feed back into the product development phase.

Innovation in small and medium technology-based companies occurs in a very particular way and adapts according to the characteristics and its leaders of company's own. The relationships established in this process differ and those established in large companies and it is necessary to understand them, since their importance is mainly recognized with regard to socioeconomic benefits brought to the region.

The Metropolitan Region of the Paraíba Valley and North Coast – Brazil presents several interaction possibilities, such as the significant number of public research organizations, technology mediation organizations, incubators, political institutions, regional development agencies, and educational organizations, as well as a large number of companies.

Briefly, we concluded that the small and medium technology-based companies not innovate in a systematic way, but an intuitive way and focused on the ideas of its founders. Innovation is developed mainly focused on meeting the requirements of customers and market needs. The formation of partnerships is primarily by market requirements or development of products and processes, but is viewed with fear by managers and entrepreneur.

The small and medium technology-based companies proved highly adaptable and flexible in their management practices and innovation, even though it has few resources to invest in R&D. On the other hand, these organizations use the various positive aspects that have to launch innovations that do not require large financial expenditure, especially in innovating their processes and products, and seeking alternative ways to launch innovations that increase their competitive performance.

The contributions of this paper were both in the academic context and in the corporate. In the academic context, the study has contributed to advances in research carried out in Brazil

in the innovation field of knowledge. Thus developed the systematization of an analysis model, which contributed to the better understanding of how occurs the process of innovation in small and medium technology-based companies. In the corporate context, the models presented will contribute to improving the innovation management analyzed companies, helping to maximize results.

Finally, although it has been achieved the objective proposed in this paper, the survey has limitations. A limiting factor was the accessibility of company information was restricted because some top managers did not feel comfortable to disclose data treated as confidential, mainly related to strategy and financial issues. Another limitation was the small number of selected cases, with information that reflect, for the most part, the point of view of the top managers.

Conflict of interest

The authors declare no conflicts of interest.

References

Albagli, S., & Maciel, M. L. (2004). Informação e conhecimento na inovação e no desenvolvimento local. *Ciência da Informação*, *33*(3), 9–16.

Barbieri, J. C. (2003). *Organizações inovadoras: Estudos e casos brasileiros*. FGV Editora.

Berté, É. C. O. P. (2006). *Contribuições ao processo de formulação estratégica de pequenas empresas de base tecnológica-PEBT'S*. (Doctoral dissertation, Universidade de São Paulo).

Cassiolato, J., & Lastres, H. (2005). *Sistemas da Inovação: Políticas e perspectivas. Parcerias estratégicas, n.8, maio*.

Chesbrough, H. (2003). The logic of open innovation: Managing intellectual property. *California Management Review*, *45*(3), 33–58.

Chesbrough, H. W. (2006). The era of open innovation. *Managing Innovation and Change*, *127*(3), 34–41.

Conde, M. V. F., & Araújo-Jorge, T. C. D. (2003). Modelos e concepções de inovação: A transição de paradigmas, a reforma da C&T brasileira e as concepções de gestores de uma instituição pública de pesquisa em saúde. *Ciência & Saúde Coletiva*, *8*(3), 727–741.

Cross, R., Hargadon, A., Parise, S., & Thomas, R. J. (2007). Together we innovate-how can companies come up with new ideas? By getting employees working with one another. *MIT Sloan Management Review*, http://sloanreview.mit.edu/wsj/insight/innovation/2007/09/

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, *14*(4), 532–550.

Freeman, C., & Soete, L. (1997). *The economics of industrial innovation*. Psychology Press.

Godinho, M. M. (2003). Inovação: Conceitos e perspectivas fundamentais. In *Para uma Política de Inovação em Portugal*. pp. 29–51. Dom Quixote, Lisboa: Biblioteca de Economia & Empresa.

Hamel, G. (1999). Bringing silicon valley inside. *Harvard Business Review*, *75*(5).

Hansen, M. T., & Birkinshaw, J. (2007). The innovation value chain. *Harvard Business Review*, *85*(6), 121.

Kline, S. J. (1978). Innovation is not a linear process. *Research Management*, *28*(4), 36–45.

Kline, S. J., & Rosenberg, N. (1986). An overview of innovation. In R. Landau, & N. Rosenberg (Eds.), *The positive sum strategy: Harnessing technology for economic growth*. National Academies Press.

Kotsemir, M. N., & Meissner, D. (2013). *Conceptualizing the innovation process – Trends and outlook. Higher School of Economics Research Paper No. WP BPR, 10*.

Langley, A. (1999). Strategies for theorizing from process data. *Academy of Management Review*, *24*(4), 691–710.

Leiponen, A., & Helfat, C. E. (2010). Innovation objectives, knowledge sources, and the benefits of breadth. *Strategic Management Journal*, *31*(2), 224–236.

Lobosco, A., Moraes, M. B., & Maccari, E. A. (2011). Inovação: Uma análise do papel da Agência USP de Inovação na geração de propriedade intelectual e nos depósitos de patentes da Universidade de São Paulo. *Revista de Administração da UFSM*, *4*(3), 406–424.

Miles, B. M., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded source book* (2nd ed.). Sage: Oaks, CA.

Mintzberg, H. (1989). *Mintzberg on management: Inside our strange world of organizations*. Simon and Schuster.

Moraes, M. B. M., & Lima, E. (2014). Empreendedorismo Estratégico em Pequenas e Médias Empresas Brasileiras e Canadenses do Setor Aeronáutico. In *Anais do XXXVIII Encontro da Anpad*.

Musiolik, J., Markard, J., & Hekkert, M. (2012). Networks and network resources in technological innovation systems: Towards a conceptual framework for system building. *Technological Forecasting and Social Change*, *79*(6), 1032–1048.

Myers, S., & Marquis, D. G. (1969). *Successful industrial innovations: A study of factors underlying innovation in selected firms*. Washington, DC: National Science Foundation., 69-17.

Nobelius, D. (2004). Towards the sixth generation of R&D management. *International Journal of Project Management*, *22*(5), 369–375.

Organização para Cooperação e Desenvolvimento Econômico – OCDE. (1992). *. Development. Technology/Economy Programme. Technology and the Economy: The key relationships* (42) Organization for Economic.

Organização para Cooperação e Desenvolvimento Econômico – OCDE. (2011). *Diretrizes da OCDE*. http://www.oecd.org/innovation

Ortt, J. R., & van der Duin, P. A. (2008). The evolution of innovation management towards contextual innovation. *European Journal of Innovation Management*, *11*(4), 522–538.

Rahman, H., & Ramos, I. (2010). Open innovation in SMEs: From closed boundaries to networked paradigm. *Issues in Informing Science and Information Technology*, *7*(4), 471–487.

Rothwell, R. (1992). Successful industrial innovation: Critical factors for the 1990s. *R & D Management*, *22*(3), 221–240.

Rothwell, R. (1994). Towards the fifth-generation innovation process. *International Marketing Review*, *11*(1), 7–31.

Rothwell, R., & Zegveld, W. (1985). *Reindustrialization and technology*. ME Sharpe.

Schreiber, D., & Bohrer, K. (2014). Influência da Cultura Organizacional na Gestão da Inovação em Indústria Calçadista. *CONNEXIO*, *3*(2), 31–48. CONNEXIO-ISSN 2236-8760.

Tidd, J., Bessant, J., & Pavitt, K. (2008). *Gestão da Inovação* (3rd ed.). Porto Alegre: Bookman.

Usher, A. P. (1954). *A History of Mechanical Inventions. Revised edition*. New York: McGraw Hill.

Usher, A. P. (1955). *Technical Change and Capital Formation, in National Bureau of Economic Research, Capital Formation and Economic Growth*. pp. 523–550. Princeton: Princeton University Press.

Viotti, E. B., & Macedo, M. D. M. (2003). *Indicadores de ciência, tecnologia e inovação no Brasil*. Unicamp.

Von Hippel, E. (2007). *The sources of innovation*. pp. 111–120. Gabler.