

IS THERE A TYPICAL MODE OF INNOVATION TO LOW TECH COMPANIES?

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ABSTRACT

This paper intends to contribute to the discussion of innovation management in low-tech companies. The approach, here adopted, provides a broad view of innovation management, not restrict to the traditional approach focused on R&D intensive activities and product development. To do so, we conducted an exploratory research in 4 companies that, according to the OECD (2005) classification, are considered low-tech industries, and 1 High-tech company as a case referent. Through the multiple-case methodology was analyzed how large-sized companies manage and organize their innovation chains and investigated a possible convergence with the “typical low-tech innovation mode” diffused in the literature. Empirical evidences suggest the existence of something similar to a “typical innovation mode” for large companies low-tech”, quite different from that presented in the literature, innovation driven by suppliers. On the other hand, the results point to the existence of some similarities when compared with high-tech companies.

Keywords: *Innovation management; Value Chain, Low-Tech firms*

1. INTRODUCTION

The literature on management innovation and technology innovation has overestimated the role of internal R&D as a key determinant of firms’ innovative capacity, hence resulting in a disproportionate importance given to a small group of technology-intensive firms as innovation promoters (SANTAMARÍA et al., 2009).

According to Schmierl and Köhler (2005), Hirsch-Kreinsen et al (2006), Santamaría et al. (2009) and Barge-Gil et al. (2008) and others, this distorted view of the innovation process can be explained by the prominence of the linear model of innovation, the overuse of R&D statistics as a source of data, and the unfamiliarity of knowledge-based innovation strategies in low-tech companies.

Thus, as stated by Lima (2011), the innovative processes of low technology intensive companies, besides poorly understood and studied, are often underestimated as these firms are known (by definition) to have low-intensity formal R&D.

In this sense, the idea of low-tech innovation companies may seem controversial. When talking about low-tech companies, the idea related to low innovative practices, predominant process innovation and dependence on other sectors or suppliers to innovate still prevails.

We do not intend to question the importance and the key role R&D activities play as innovation promoters in certain industries or sectors, quite the contrary, it is to contribute to this discussion by incorporating other innovation forms rather than the traditional ones related to formal R&D activities, presumed to be important for companies in different sectors.

Thus, our goal is to contribute to understanding the innovative dynamics of low-tech companies in terms of the dynamics of high-tech companies. An empirical study was conducted to understand how the different activities and skills, as well as internal R&D activities, impact the innovation results of these companies. Therefore, we investigated how knowledge is generated, converted and disseminated throughout the innovation chains in order to understand the “innovation mode” of low-tech companies

The innovation concept used in this study is similar to that of the OECD (2005) Oslo Manual, in which innovation is the implementation of a new or significantly improved solution for the company, a new product, process, organizational method or marketing, in order to strengthen its competitive position, increase performance or knowledge. This work focuses on product innovation, proposed by Pintec (2005), which defines how new products are developed and whose key characteristics in terms of technical specifications, use and composition of inputs differ significantly from those previously produced by the company. Thus, these new products enable exploring new market segments in terms of technical specifications, technology, raw materials or intended applications. Therefore, to be considered a “new product”, it will have to meet the aforementioned characteristics and be new to the market and not only to the company.

Five low-tech companies and their different production units were studied. One high-tech company was also studied and, along with the literature, it served as a counterpoint to offset the others. All study cases are industrial companies that in the last five years showed good innovation performance by developing at least two new product designs considered significant in terms of increased sales, revenues, cost reductions, entering new markets or expanding existing markets. These projects were the subject of special attention during the interviews, as they were treated as a case study within each company studied.

Therefore, as it is relevant and pertinent to understand how the innovation value chains in low-tech companies are organized and managed, the objective of this work can be summarized as follows: analyze and describe how large low-tech companies structure, organize and manage their innovation value chains, in order to determine the existence or not of a typical innovation mode in low-tech companies.

Considering that Brazil has a prominent role among developing countries and has a significant industrial park, it is relevant to study the innovation in its Firms.

We stress that the reason for studying large low-tech companies was due to the fact that, despite ignoring the substantial heterogeneity of the sector described as low-tech, many of the research results have shown strong bias correlating the characteristics with the size of these companies (mostly small and medium-sized companies). As reported by Hirsch-Kreinsen (2008), “the limited resources and capacity for strategic actions by low-tech companies commonly reported in the literature, in most cases can be explained by the fact that this sector is dominated by small and medium-sized companies”, suggests that such characteristics for companies and the low-tech sector may be mostly associated to resource constraints, typical of small and medium-sized companies, for example, than to a stylized innovation form.

This paper is organized as follows: section 2, divided into two major sections, addresses the theoretical framework regarding innovation management in low technological intensity firms, and discusses the innovation dynamics in these companies. The second section of the review focuses on the theme of innovation value chain management, a concept proposed by the researchers Hansen and Birkinshaw (2007), who analyze the innovation process within a structured and systemic perspective. Section 3 discusses two propositions that guided the development of this research. Next, the research methodology used in the work is explained, and the following sections present the analysis of the cases studied, the conclusions and proposals for new research themes.

2. THEORETICAL REFERENTIAL

2.1 Innovation In Low-Tech Firms

According to Tunzelman and Acha (2005), for low-tech companies that innovate, most of the innovations refer to processes or innovations conducted by third parties. Pavitt (1984) argues that such companies fall into the sectorial category, which he defines as “supplier-dominated”, this classification refers to an important aspect of the sector’s innovation pattern and mode, where change and innovation are conducted and driven by technology and equipment suppliers, supplies or materials, for example.

According to these authors, although these firms innovate, product innovation is typically incremental and/or results from the acquisition of new machinery or technology transfer from a supplier, customer or external consultant, which is characterized by low or nonexistent R&D investments and low internal competence to generate continuous innovation.

According to Hirsch-Kreinsen (2008), the international literature suggests that the way low-tech companies innovate is quite different from the stylized way high-tech companies innovate. Therefore, some features found in low-tech firms that account for this particular innovation are pointed out, such as:

- little structuring and systematization of innovation processes;
- few resources allotted to ongoing and systematic product development activities;
- low professional qualifications of those involved in the innovation process;
- limited process innovations, design and incremental innovations;
- extensive reliance on suppliers of machinery, technology and inputs as innovation drivers, among other factors.

With regards to the knowledge base of low-tech companies, Hirsch-Kreinsen et al. (2003), based on case studies of low-tech European companies that innovate, report that low-tech sectors are set apart by having complex knowledge bases that involve engineering, design and important knowledge dimensions.

Morceiros et al. (2011) show that technological innovation measured exclusively by traditional indicators (patent numbers or R&D expenditures) is insufficient to capture the innovative dynamics of various industries in the economy, as is the case of low-tech companies.

In the words of Schmierl and Köhler (2005), low-tech companies, by definition, produce very little scientific knowledge, but are large producers of practical knowledge. Like other companies or sectors, these firms are also constantly forced to increase and broaden their knowledge base, pressured to react to the market, customers, and internationalization standards.

Santamaría, Nieto and Barge-Gil (2009) show that many companies without formal R&D are innovative. These authors therefore believe that innovation studies have been excessively concerned with the role of R&D activities, while the main prerequisite for understanding the innovation process is to have a holistic view of the company.

Pavitt (1984) proposed four main categories of industrial standards: Science-based industries, Scale-intensive industries, Specialized suppliers industries, and Supplier-dominated Industries. Tidd, Bessant and Pavitt (2008) later added the class of information-intensive industries.

Pavitt's taxonomy (1984), proposes that "Supplier-dominated Industries" partly helps to locate the low-tech companies based on technology standards; yet ignores the low-tech companies that innovate and differentiate products by means of their own internal resources and innovation capabilities.

Pavitt's approach (1984) has been criticized by authors such as Teece and Pisano (1994) because it emphasizes on the company's external factors for building innovative capacity, ignoring the importance of knowledge and skills accumulated over time by companies, which according to the authors is of great importance to these companies.

Tunzelman and Acha (2005) believe that low-tech industries usually have little formal training based on science and technology, at least at the firm level, because these companies hardly practice R&D activities. According to the authors, these formal processes that use and generate knowledge play an unimportant role, making room to pragmatically learn by "doing and using". Thus, for these companies relevant knowledge does not come from formal activities such as R&D, considered as oriented-applications, practical knowledge.

The available literature is vast and to some degree contradictory. While some researchers argue that low-tech companies are capable of generating innovations through their own efforts (Smith, 2008; Bender, 2006; Robertson and Smith, 2005; Hirsch-Kreinsen, Hahn and Jacobson, 2008; and others), other authors are more restrictive about these companies' internal capacity to generate innovations, restricting them to depend on third parties to innovate, or incremental innovations, process and design (Heidenreich, 2008; Tunzelman and Acha, 2005, among others).

2.2 Managing Innovation and Innovation Value Chain

The concept of innovation value chain, suggested by Hansen and Birkinshaw (2007), offers a broad and integrated view of a company's innovation process, not restricted to the product development process, considering innovation within a nonlinear and systemic "chain" logic, involving three distinct and interconnected chain links: generate ideas (internal to departments/units, between departments/units and

between different institutions), conversion (selection – classification and funding, development) and dissemination, according to Figure 1.

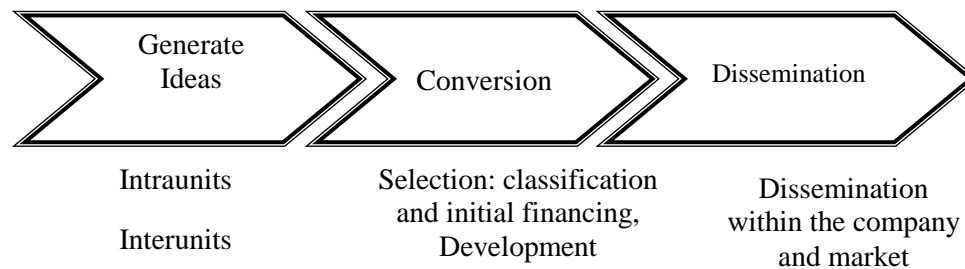


Figure 1 – Innovation Value Chain, based on Hansen and Birkinshaw (2007)

This concept is not about a linear logic for innovation or emphasizes a single process such as Product Development Process (PDP), on the contrary, Hansen and Birkinshaw (2007) proposed the systemic idea where PDP (Product Development Process), despite being an important activity, coexists with other also important activities. This representation allows to encompass the strategic and operational dimensions. In this logic, priority managerial action should be given to the weakest link in the chain, and the authors state that “the chain is only as strong as its weakest link”.

2.2.1 *Generate Ideas Link*

The purpose of this link is to generate ideas from various sources: from the team’s own business unit, from other business units or from other teams, from the company, customers, end users, competitors, universities, inventors, consultants, and etc. offering something which, in a broader sense, resembles the Open Innovation context suggested by Chesbrough, (2003). However, Hansen and Birkinshaw’ proposal to interact with various actors is essentially mostly centered in the Link “Generate Ideas”.

2.2.2 *Converting Ideas Link*

The new ideas generated need to be properly evaluated and selected, and then classified to determine the degree of technical difficulty to develop them in terms of technical, commercial and economic feasibility, and also return of investment time, required resources, etc. However, in between the lines, the authors suggest that the project analysis during this “conversion” should not be limited to the immediate objectives, but rather to the business strategy, analyzing the potential benefits of this new idea. For example, it may be that the new idea does not bring a direct and immediate commercial success to the company or business unit, but may help the company to enter new markets or develop a new resource, helping to maintain or increase the company’s competitive product advantage in the medium and long term.

2.2.3 *Disseminate Ideas Link*

The ideas that were generated, selected, coordinated, financed and developed also need to be “bought-accepted” by the company’s internal and external parties. Not paying attention to this could jeopardize and put at risk the whole innovation process, as for instance the intentional or unintentional boycotting of important actors within and outside the company.

According to the Innovation Supply Chain logic, there can be one or more activities along the chain in which a company excels, that is, stronger links in the company. Conversely, there may be one or more activities in which the company has difficulties, which are the weakest links in the chain. According to Hansen and Birkinshaw (2007), different from common sense, the company should pay more attention to its weakest links as these will influence the performance of the entire chain. When companies only pursue the strongest links in the innovation chain, they often promote the weakening of the weakest parts of the chain, compromising their ability to innovate, given that the capacity to innovate is as good as the weakest link in its innovation value chain.

3. RESEARCH PROPOSALS

Based on the literature, two research propositions to discuss innovations in low-tech companies are shown as follows:

Proposition 1

Low-tech companies have a more participatory innovation system, while high-tech companies systematically take advantage of the broad practical and tacit knowledge base of its employees at different levels.

Given the low technological complexity of the innovation product/process and low R&D intensity, low-tech companies tend to have a more participatory innovation process that is more accessible to a larger group of people by better using the employees' tacit knowledge, for example.

It is assumed that the low complexity of the product/production process, as it does not require large amounts of technical and codified knowledge or intensive R&D activities, could allow those not directly involved with production and product development to also contribute to the process innovation. Thus, efforts to generate innovations would not be limited to the group of experts, scientists and technical staff of a department or R&D unit.

Thus, what at first glance could be viewed as disadvantages to these companies, low technology intensity, lack of R&D and encoded scientific knowledge in a broader sense, can be important competitive advantage sources as it could allow to significantly broaden the use of their employees' tacit knowledge to a greater extent to generate ideas.

Proposition 2

There is a specific mode of innovating for large low-tech companies that is quite different from the traditional mode widely touted in the literature.

Are there empirical evidences that suggest the existence of difference between the traditional "innovation mode" and the innovation way found in large enterprises surveyed?

This proposition holds that the form of innovation among small and large low-tech companies may be different.

For the companies studied, the evidence found point to the existence of a typical innovation mode by large low-tech companies when compared to the typical low-tech innovation mode.

Furthermore, large-sized companies low-tech organize and manage their innovation value chains differently from high-intensity technology companies, which points to a "typical low-tech way to innovate" within the context of large companies.

This proposition has been raised based on the understanding that these companies innovate and differentiate their products despite having different demands and resources from typically innovative companies (as for instance high-tech companies), such as large R&D investments, modern laboratories, investment in basic research, scientifically capable personnel, and other resources, therefore these companies manage, organize and structure their innovation chains differently in terms of systematization and formalization of processes, work organization, organizational arrangements and resources employed, which points to the existence of a "typical low-tech way to innovate" within the context of large companies.

As pointed out by Robertson, Smith and Tunzelman (2009) and Malerba (2005), science-based innovations (common in high-tech companies) are very different from non science-based innovations and guided by accumulated experience and expertise (common in low-tech companies), it is then assumed they should be treated differently. Therefore, if these companies innovate and differentiate their products despite not having the same demands and resources as companies in high-tech sectors, for example, they organize and manage their innovation chains in a different and unique manner, somewhat similar to a typical low-tech innovation mode.

This typical mode, besides being different from the typical high-tech innovating mode, based on intensive R&D activities, also greatly differs from the low-tech mode reported in the literature, strongly biased by the representativeness of small and medium-sized companies that make up the sector and which are generally associated with discontinuous innovations, innovations with small strategic representativeness and conducted by suppliers.

4. RESEARCH METHOD

Given that the understanding of the innovation phenomenon in low-tech companies, particularly with regards to understanding how low-tech companies manage, organize and structure innovation is incipient and their variables and theoretical constructs are not yet well defined and consolidated in the literature, an exploratory research approach seems suitable for this work. It can be argued that this issue is still in the construction phase of the theory.

The research methodology used is the traditional one used in studies such as this one, similar to the works of Hirsch-Kreinsen et al. (2003), Köhler (2008), Salerno et al. (2010) and several other studies on management, organization and innovation. The methodological approach adopted here is exploratory and qualitative, conducted by the multiple-case methodology, which authors such as Salerno et al. (2010) and Eisenhardt (1989) consider as one of the best research options in similar areas and topics.

The analysis units studied are the companies, represented by those who work in the departments or related areas and who are responsible for developing the innovation projects.

The interviews took place between 2009 and 2010, following a semi-structured in situ interview, in which 19 people were individually interviewed. The interviewees held different posts: presidents, directors, managers, analysts, project managers, and each interview lasted approximately two hours. Five people were interviewed in CanSteel: President, Chief Financial Officer (who is also HR manager), Product Development Manager and Program Coordinator of Generating Ideas; Three people were interviewed in Sanit-plastic: President, HR manager and Commercial Manager; Four were interviewed in Biscuit-Braz: Production/Commercial Manager, HR Manager, Quality Engineer and Product Development Manager; Two people were interviewed in Plastic-Pipe: Commercial Director and Product Manager; Three people were interviewed in Hometal-ware: Product Development Manager, HR Coordinator and New Business Coordinator; Two people were interviewed in PharmaTechs: Commercial Manager and R&D Researcher.

In addition managers of areas such as human resources or marketing involved in the design of new products were also interviewed. In each company at least three people were interviewed.

Regarding the documentary analysis, for each case and prior to the interviews, document qualitative research regarding the company was carried out (Internet, company websites, competitors, customers, management reports, etc.) to collect information and to prepare the researcher. The document analysis was also performed after the interviews, using documents and reports provided by the respondents (such as annual reports and organizational charts).

In the companies studied details related to the formal structure of the company for PDP/P&D activities, organization and interfaces between areas were analyzed (marketing, finance, R&D and production); the project's "history"; identification and configuration of the innovation chain, focusing on the generation, conversion and idea dissemination links; the different modes and stimuli to generate ideas and the selection criteria for these ideas; how the idea progressed to the development stage, among other factors.

Regarding on-site observation, upon the researcher's request, the interviews were preceded by "technical visits" to the product production and development sector, in order to understand (observe) the different internal processes, the work environment, production processes, among others, to assist carrying out and interpreting the interviews, as well as for the analysis and insights of the researcher.

For the companies studied, the selection criteria used was as follows: innovative low-tech companies in various industrial segments; companies with attributes and indications of emphasis on continuous innovation activity; large-sized Brazilian companies (according to SEBRAE classification, with more than 499 employees) and established firms with at least five years in the market, to use as a basis for analyzing the past events, evolution and development of innovations in recent years.

Table 1 shows the data regarding the companies studied (fictitious names).

Companies (fictitious names)	Year founded	Approximate No. of employees	No. directly involved with PD	Main products
CanSteel	1955	900	9	Metal packaging for food and chemicals
Hometal-ware	1947	1200	17	Metal and sanitary wares
Plastic-Pipe	1941	1500	25	Construction pipes and equipments
Biscuit-Braz	1953	3200	11	Food Products: cookies, biscuits, and "salty crackers"
Sanit-plastic	1957	N/R	15	Toilet seats, frames and bathroom and kitchen accessories
PharmaTech (reference case)	1965	3000	N/R	Synthetic drugs and herbal medicines, generic molecule products and biopharmaceuticals

Table1 – List of companies prepared by the author. N / R = Not reported

5. ANALYSIS AND DISCUSSION OF RESULTS

This topic addresses the joint analysis of the companies studied.

6. INNOVATION VALUE CHAIN ANALYSIS OF LOW-TECH COMPANIES

To answer the main question of this study: “how do low-tech companies organize and manage their innovation value chains?” the main characteristics and organization forms of these chains were raised in the different companies to understand their innovation process and also the configuration of each chain and the activities related to each link

Link 1: Generating Ideas

As for generating ideas, in practice, proposing ideas is restricted to small groups of people or specific units involved in the product development process (R&D management, product development consulting, product committee, marketing, sales and etc.). Through weekly or monthly meetings the members can present from abstract and incipient concepts up to initial concepts of a product or even prototypes. However, although proposing ideas is usually restricted to small groups or relatively closed departments, CanSteel and Sanit-plastic were the exceptions as these companies have programs to generate ideas open to all employees.

As CanSteel and Sanit-plastic are not structured for large amounts of resources available to invest in Research and Development, they develop their own internal capabilities based on constant innovative knowledge creation by using ideas from their employees, encouraging tacit knowledge dissemination and valuing practical experience, similar to the DUI innovation - Doing, Using and Interacting – as described by Jensen et al. (2007). According to these authors, DUI considers that tacit knowledge flows through interactions between different social actors, through learning processes that occur through products, processes, techniques and new uses of machinery.

CanSteel, for instance, uses the “Generating Ideas Project”, an important management tool that promotes creating and disseminating knowledge by using employees’ ideas at different levels. In a structured and systematic way, this program encourages employees to make suggestions, criticize, and create new ideas for products, operational routines, processes and management.

As an example, in the past three years (2009, 2010 and 2011) the average number of ideas per employee was over 100 ideas, with an average utilization rate higher than 30%. Of these, the vast majority of ideas correspond to specific and incremental improvement ideas in processes, routines, among others. However, there are numerous reports of successful cases where ideas were used for substantial changes to existing products or proposed new products. Of the many examples, a key commercial success of this company came from this program to generate ideas. The initial idea, the development of a new closing system for solid canned food came from an employee of the administrative area.

After the employee’s idea was approved, the OPD (Office of Product Development) submitted it as a pre-project for approval by the Executive Committee, which led to an international patent and an important innovation for the company, expanding to several new products and international licensing.

This program, in addition to receiving many ideas in terms of innovations in products, processes or management practices, creates a direct communication channel between the company’s employees and management.

Parallel to the program, the company has managing policies that are not usual in similar companies, such as job security, workers’ participation in management and broad profit participation policies.

Thus, in a broader sense, that which at first glance could be a disadvantage for non technology-intensive and encoded scientific knowledge companies, the low technological intensity/complexity of the product/production, although not a sufficient condition, can be a source of great opportunities or even competitive advantage for these companies, in that the absence of scientific and codified knowledge can be a facilitator and be compensated through management initiatives that seek to better use internal resources, the employees’ practical and tacit knowledge to greater degree.

Even in a smaller dimension at the companies studied, not including all employees, it was found that initiatives that facilitate and encourage the contribution from people outside the relatively closed “circle” of product development can greatly contribute to developing new ideas.

Regarding the internal sources of ideas, for the high-tech company studied, it appears to be very different. It would be very difficult for any new product idea to come from someone who is not involved with the product development process or within a high hierarchical position in the company.

With regards to the external sources of generating ideas in low-tech companies, there are no formal mechanisms that include the effective participation of members outside the company in the process of generating ideas.

On the other hand, the reference case of a high-tech company (PharmaTech) has within this mechanism an important source of new ideas. The company advances partnerships with laboratories, R&D centers and universities in search of new development ideas.

For the cases studied, the evidence suggest that the complexity and technological intensity of projects or innovations intended have a direct relationship with the company's propensity to set systematic search mechanisms of external sources for new ideas.

The results found herein provide evidence that firms which are not very intensive R&D and technology driven, which in theory would have greater research limitations and therefore should be very interested in seeking the external expertise they lack, in practice use few external sources to "generate ideas".

Thus, a more active attitude by the low-tech companies studied to systematize the search for new external knowledge, seems to be suitable for the pursuit of positive results with regards to the Link generating ideas.

The generation of ideas is closely related to the different learning forms these companies use. Especially with regards to internal generation of ideas, initiatives in human resources management, knowledge management and work organization, which could implement greater importance to innovation management.

Although it could be said that the low-tech companies studied are "poor-ideas generation companies" as proposed by Hansen and Birkinshaw (2007), the constraints related to the generation of ideas in a restricted manner to few internal groups show that this Link can be significantly improved (both internally and externally).

Link 2: Conversion of Ideas

To select the ideas that were generated in these low-tech companies, traditional market and financial criteria are used to prioritize projects, using indicators for control and performance evaluation of the conversion process, such as estimates of return on capital, results of market research, traditional financial indicators such as time of return on investment, costs, risks, etc. In other words, criteria tied to technical, economic and commercial feasibility.

While the processes recommend that the selection of projects should be usually carried out by committees or teams, what prevails in practice is the strong interference by senior management in the selection, as well as in the strategic decisions of continuity or letting go of these projects.

The companies have formal product development processes, with their own laboratories and technical staff dedicated to the project, organized as managers, departments or consultants, with the manager of the area responsible for conducting, managing, controlling, with accountability of projects, communication and schedule.

As for project resources, the respondents from the low-tech companies showed no dissatisfaction. However, evidence showed that the characteristics of the projects selected and developed have a direct relationship, although we cannot say that low-tech companies are companies with "poor-generation" of ideas. There is a predominance of projects with incremental and less complex features, which normally require fewer resources and are characterized by a lower risk than the more innovative and radical designs, which can partially explain this "satisfaction" with regards to the resources available.

Overall, in all of the companies studied, there are resources foreseen in the annual budget for product development. External funding sources are used by CanSteel and Plastic-Pipe, however these are not frequent financing forms, and it can be said that there are no financing multi-channels. In the high-tech companies, the funding of some projects is shared with its development partners, and for partnership projects with universities and research centers, it is the company that usually does the funding.

The cases studied show some shared practices with the Funnel Development and Stage-Gate® models proposed by Clark and Wheelright (1993) and Cooper (1993), respectively, with stages that resemble the stages proposed in these methodologies.

However, although these low-tech companies use methods that have these characteristics, none use them in their pure form because many adaptations are made to their specific product development form. For example, although there are formal meetings for project selection, decision points, portfolio analysis, with criteria generally linked to technical, economic and commercial feasibility, for some companies what prevails in practice is the decision of the directors regarding strategic matters, though not necessarily guided by technical criteria. Especially if the idea comes from top management, some projects may even start without thoroughly analyzing their feasibility.

Even though there are departments or product development managers, in some situations systematic interventions are common and key decisions are made by individuals at higher hierarchical levels, without adequate involvement with the development team, with no technical background, with interests overlapping the goals of the development team, and so on.

Link 3: Dissemination of Ideas

The evidence points to the “dissemination” Link as the least problematic or strongest in the innovation value chain of the low-tech companies studied.

Although the companies studied have different production units, in each unit with more than 100 employees and a local management team, a striking feature is the strong centralization of strategic decisions at the headquarters of these companies.

This centralization has a direct effect on the dissemination of ideas within and with the units, which through its local managers no barriers are usually created to accept and disseminate the ideas generated and then converted. Thus, this centralization facilitates disseminating the ideas given that it inhibits possible resistance within and between units. Due to the fact that the idea has already been “bought” or even suggested by the company’s top management, no strong effort is usually needed to “convince” its dissemination.

However, what also shows an important role for the internal dissemination strategy is the adoption of a set of management practices in work organization, human resource management and knowledge management. The adoption of these management practices demonstrates it significantly contributes to reduce possible resistance, even if unintended, to the changes inherent in new ideas or the innovation proposed, and contributes to the development of an organizational environment that is conducive to innovation. For instance, companies develop training programs for the areas, teams and units that will have contact with the new technology, manufacturing process or product that will be produced by the company, thereby reducing anxiety and resistance to what is “new”.

As for external dissemination, in all companies studied, the product development teams are closely related to the company’s marketing and sales areas, during the previous innovation chain stages (generation and conversion), which also facilitates its dissemination.

On the other hand, for those low-tech companies, the existence of a stronger Link may indicate imbalances in the innovation value chain. For example, the fact that the dissemination of ideas seems to be the strongest Link in the innovation value chain can be an indication of difficulties in other links, as the generation and conversion of ideas with more incremental characteristics tend to be easier for internal dissemination.

7. CONCLUSIONS

The following are the conclusions of this study, based on the analyses conducted and compared with the propositions used from the literature review. The contributions of this paper to the literature on Innovation Management, its limitations and directions for future studies are investigated.

It is noteworthy that although the methodology used was found to be adequate, the results found, while important and able to assist in broadening the discussions for a greater number of companies, are not generalized to all large low-tech companies.

7.1 Verification of Research Proposals

Proposition 1

Low-tech companies show a more participatory innovation system, in comparison to high-tech companies, by systematically utilizing their employees' practical and tacit knowledge basis at different levels.

Proposition 1 is accepted.

The empirical results strongly indicate that the decision to better use the employees' internal tacit knowledge base tends to be more accessible for low-tech companies.

Due to the fact that these companies' product developments are not primarily guided by technical and codified scientific knowledge, because their production processes and products are not typically complex and are not based on intensive technology and science (compared to high-technology companies), low-tech companies tend to benefit from an important source of knowledge and learning by systematically intensifying and extending the advantage of tacit knowledge and creativity of a larger number of employees.

The logic is based on the understanding that technical barriers and specific skill requirements to provide new ideas and solutions tend to be lower for these companies and therefore more accessible to a larger number of people.

For the high-tech company analyzed, which has its product innovation process guided by scientific and codified knowledge, the required technological complexity and scientific and technical knowledge are seen as the major barriers for people without such knowledge to effectively contribute to new developments (even for incremental product innovations).

However as reported, although this Proposition is accepted, it can be said that the low-tech companies studied take little advantage of this possibility.

Although the respondents claimed these companies use multiple internal sources to generate ideas, so that any employee or company area can propose ideas for products, with the exception of CanSteel and Sanit-plastic, the Proposition of ideas for new products in practice is narrowed to small groups of people involved in the product development process (R&D management, product development advisory, product committee, marketing, sales etc.).

The results point to the possibility of improving the Link "generating ideas" in the low-tech companies studied. They could benefit from a broader internal knowledge base for generating ideas by using formal mechanisms through which those not formally involved in the product development process could contribute to this.

However, as noted in these companies, a straightforward formal mechanism for generating ideas is certainly not enough for improving the internal generation of ideas. It would be necessary to adopt different management mechanisms to support this process, such as implementing modern personnel management policies, knowledge management and management practices that could create conditions similar to the Capacitating context described by Von Krogh, Ichijo and Nonaka (2001), in which the organizational learning process can be developed from individual and group learning.

Proposition 2

There is a specific mode of innovating for large low-tech companies that is quite different from the traditional mode widely touted in the literature.

Proposition 2 is accepted.

Empirical evidences suggest the existence of something similar to a "typical innovation mode" for large companies low-tech, quite different from that presented in the literature, innovation driven by suppliers.

For the companies studied, the evidence found point to the existence of a typical innovation mode by large low-tech companies when compared to the typical low-tech innovation mode. On the other hand, the results point to the existence of some similarities when compared with high-tech companies. The results indicate that although these companies have different strategies, technologies, intensity in R&D, resources and demands, contrarily to the literature and common sense, these companies organize and manage their innovation value chain very similarly to high-tech companies.

Some differences were found among the low-tech companies and high-tech companies studied regarding how they organize and manage the innovation value chain (in view of the literature and reference case), it can be stated that low-tech companies as well as high-tech companies organize and manage their innovation value chains very similarly.

The international literature, as for example Tunzelman and Acha (1985), Hirsch-Kreinsen (2008), suggests the existence of a typical low-tech innovation mode based on the differences between low-tech and high-tech innovations. These authors argue that the way low-tech companies innovate is very different from the innovation management paradigm of high-tech companies.

Thus, some features found in the low-tech companies account for this typical low-tech innovation mode, as for instance the lack of internal R&D capacity and specific knowledge base of low-tech companies, lack of strategic direction for innovation, little structuring and systematization of innovation processes, few resources for the ongoing and systematic development activities, limited innovation process, design and incremental innovations, restricted use of practical local knowledge base, extensive reliance on machinery and technology suppliers as drivers of innovation, and other examples.

However, even disregarding the great heterogeneity of the sector characterized as low-tech, it can be said that these characteristics point to a strong bias related to the size of companies, usually related to small and medium-sized companies. As reported by Hirsch-Kreinsen (2008), the limited resources and capabilities for strategic undertakings by low-tech firms, usually reported in the literature, can be explained in most cases by the fact that this sector is dominated by small and medium-sized companies.

It can be argued that the low-tech innovation mode reported in the literature, which focuses on the companies' limitations, underrepresented strategic innovations and driven by suppliers, does not apply to the large low-tech companies studied in this work.

All of the companies studied have formal processes, systematic and continuous product development, they have specific areas or departments with ongoing activities aimed at product development, managerial maturity, significant budgetary resources designated for projects, ongoing product development teams, good qualification level of the workforce involved in product development activities, use partnerships and external research development, use multiple sources of ideas, and other features.

Consistent with the literature, for the cases studied here in, the argument taken into consideration regards that low-tech and high-tech companies differentiate from one another by the fact that the former mostly relies on tacit knowledge, while the latter relies on scientific and codified knowledge.

However, the results showed that both types of companies use knowledge and multiple and complementary learning forms at different levels, for example, the "learning by doing and learning by interacting" are important for both types of companies.

Although science-based learning is key to the high-tech company studied, the "learning by doing and learning by interacting" also proved to be very important, given that it is its competence in the pharmacological processes crucial for developing new research routes for new drugs, generics and so on.

In the low-tech companies studied, it can be said that there is no defined innovation development process – it is an "ad-hoc" process, changing according to the different needs of each project. It is likely that innovation, while desired, is not strongly "sought after" as a competitive strategy. It can also be said that there is no formal systematized structure to develop and implement more dynamic and radical innovations.

7.2 Synthesis of The research Contributions

This work does not intend to generalize concepts; however in the companies studied the results found deserve attention and these findings could be used in future works to contribute to advancing the subject "Innovation Management Low-tech Companies". The main findings are summarized below:

- Although the literature claims the existence of a typical low-tech innovation mode, innovation driven by suppliers, for large companies this was not perceived in the companies studied. No meaningful differences were perceived between the organizing and managing mode of the innovation value chain when compared to high-tech companies.
- The low complexity and technological intensity of low-tech companies' innovations, when associated with management practices, can enable increasing the number of people to generate ideas internally.

- Innovation management contributes to managing innovation. In recent years all companies have developed some changes or have introduced new management practices, organizational forms, organizational restructuring and etc., which have produced effects on the innovation processes.

As proposals for future works it would be interesting to comparatively and broadly analyze, for instance through a research survey, innovation patterns and management practices found in both low-tech and high-tech companies in order to find the contributions in terms of possible similarities and differences in order to achieve generalized results, which was not possible in this work given the resource constraints and methodological choice, and especially because it was deemed necessary to first understand the business environment of low-tech companies, still understudied and relatively ignored by the literature and public policies.

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