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Innovation: case study among wood, energy and medical firms
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Abstract

Purpose – The purpose of this paper is to develop a best innovation practices framework analyzing the innovation process in firms from the most innovative and the less innovative sectors.

Design/methodology/approach – This case study uses an intense review of literature in the field of innovation practices inside organizations. The field work is based in direct observation of innovation practices intended to identify and select those practices that lead to successful implementation of the innovation process in the participating firms.

Findings – The study recognizes the need of innovation as a tool for sustainable growth for firms. The article also describes the current process used by US government and organizations to measure innovation and presents a list of innovation best practices that have been recognized by each participating firm as key practices to develop innovation.

Research limitations/implications – The framework allows a combination of practices from different industries however it has been studied in specific firms and a larger exploratory/explanatory process should be conducted to generalize the findings.

Practical implications – This paper offers practical insights about practices associated with the innovation process inside firms.

Originality/value – The study aims to develop a best innovation practices framework to be used by the less innovative sectors in order to become successful in the innovation development. These best innovation practices are identified from the most innovative sectors in the country.

Keywords Innovation, Manufacturing, Medical devices, Energy generation, Wood products, Manufacturing systems, United States of America

Paper type Case study

Introduction

It is commonly accepted that American society perceives wood as a high value among the raw materials used for manufacturing products (Ellefson *et al.*, 2010). The annual total consumption of roundwood to be used as raw material for the wood products industry in the USA has increased constantly from 12 billion cubic foot by 1965 to approximately 17.2 billion cubic foot by 2005 (Howard, 2007), representing a per capita usage of 255 board feet and also 1.75 percent of the GDP of the country. Yet still the wood products industry is a large business in the American economy. It is also a business sector which has been facing many challenges to maintain itself as a profitable sector (Hansen and Juslin, 2006; Hovgaard and Hansen, 2003; Crespel and Hansen, 2008; Hansen *et al.*, 2007; Zi and Bullard, 2008; Gazo and Quesada, 2005). This situation has opened up an opportunity to research for proposals aiming to help this industry to achieve sustainable growth. Innovation seems to be the right path especially for the wood products industry since, according to US economy indicators, this sector shows one of the less innovative performances based on the research and development expenditure compared to the company sales. Figure 1 shows

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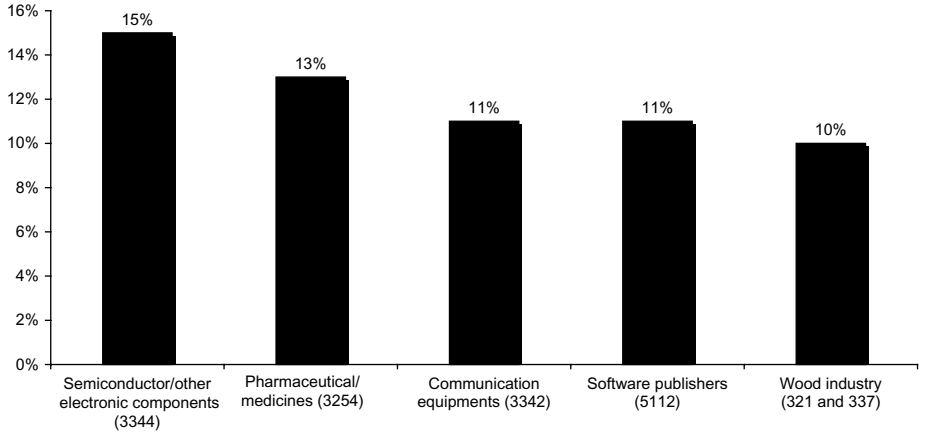


Source: Wolfe (2010)

Figure 1.
R&D expenditures as a ratio to company sales for different business sectors

a comparative chart for R/D expenditures as a ratio to company sales for different business sectors.

These proposals also have led researchers to a better understanding of the innovation process among industries in general since a better understanding of innovation is a crucial activity to develop sustainable growth and welfare in the world (Alsaaty and Harris, 2009; Stendhal and Roos, 2008).

This research about the innovation process inside the wood products industry can be divided in three large sections according to Hansen *et al.* (2006):

(1) organizational innovativeness, which concerns factors that influence innovativeness and the effect on financial performance;

(2) innovation systems, which focuses on studying the relationship between companies and regulations and policies in the innovation field; and

(3) new product development which researches about product development and all the involved stages.

Findings from literature shows some studies that were developed based on the previously discussed categorization, such as Crespel and Hansen (2008) who researched about work climate and its relationship with innovativeness inside wood industry firms. However, to the knowledge of the authors, no investigation inside successful innovative firms and a later comparison to wood industry firms has been previously developed, therefore the authors identified the need of a comparative study among the wood products industries and other industries aiming to answer the following research need:

RQ1. What common innovation practices can be identified in innovative industries such as energy and medical devices firms compared to wood products firms?

1. Literature review

1.1 Innovation as a driver for success

Innovation as an economic activity has been widely studied by several authors; Schumpeter (1934) analyzed the impact of innovation and how innovation brings value

to the market since it creates working methods, products and material sources. Porter (1998) defined that innovation driven phase in a nation's economy as the last step to achieve a wealth driven phase in a nation's economy. Most recently, literature shows how innovation is well accepted as a tool for competitiveness, where companies are engaged in a continuous process of innovation to enhance more competitive environments for firms in all sectors (Mytelka and Farinelli, 2000; Muller *et al.*, 2005).

In past or present, there is always recognition of innovation; its contribution is clearly pointed out as a key element to help organizations capitalizing on knowledge and creating market opportunities by taking ideas into practice (Alsaaty and Harris, 2009). At the strategic level, Cooper and Edgett (2010) emphasized the importance of innovation goals inside business objectives. This approach directs businesses to ask themselves how innovation fits into the overall business plan and how innovation will contribute to the firm's growth.

1.2 The concept of innovation

Innovation has historically evolved and still today, innovation appears under several definitions which are more narrowly defined allowing a concept with more common elements between single statements.

Zaltman *et al.* (1973) defined innovation as any idea, practice or material perceived as new by the consumer, meanwhile, West and Farr (1990) have defined innovation as the introduction and application of any idea, process, product or procedure, relevant enough with an observable benefit to the individual, organization or society.

The Oslo Manual, defines innovation as:

> [...] the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations (Organization for Economic Co-operation and Development (OECD, 2005)).

According to Schramm (2008), innovation is defined as:

> [...] the design, invention, development and/or implementation of new or altered products, services, processes, systems, organizational structures, or business models for the purpose of creating new value for customers in a way that improves the financial return for the firm.

Despite the fact that there are several stated definitions for innovation in the literature, it is observed that they share common elements; essentially they recognize innovation as bringing new value to the consumer resulting from new or large changes in current product, process, business methods or marketing practices closely tied to an intrinsic benefit obtained from the innovation.

1.3 Innovation measurement

By measuring innovation, policy makers and business man are able to understand the hidden and exposed drivers that will help fostering a sustainable competitiveness in economies around the world (Porter and Stern, 1999).

Despite the well known complexity of measuring innovation performance, efforts have been made and an innovation index has been developed by tracking innovative capacity of 17 OECD economies since 1973, and eight emerging economies since 1990, where results show four main factors directly related to innovation performance:

(1) the amount of investment directed to research and development (R&D);
(2) the size of the labor force dedicated to R&D;
(3) the resources given to higher education; and
(4) the effort made in encouraging investment and commercialization by creating national policies (Porter and Stern, 1999).

These drivers are also impacted by the behavior of single firms and groups of similar firms, called clusters, and therefore public and private investments have to be analyzed as well to determine the conditions innovative capacity is facing. The sub indicators around public and private investments affecting the factors related to innovation index are:

- investment in basic research;
- R&D spending;
- supply of risk capital;
- aggregate level of education in the population;
- protection of intellectual property;
- openness to trade and investment; and
- changes in market demands (Rosenberg and Birdzell, 1987).

1.4 Research and development

Also known as R&D, research and development is "an activity involving significant transfers of resources among units, organizations and sectors and especially between government and other performers" (OECD, 2002). This innovation performance driver has been considered uncertain and sometimes unpredictable due to the complexity of its elements (Kerssen-van Drongelen and Cook, 1997), however it is recognized by the contribution brought to companies in terms of competitive advantage (Chiesa *et al.*, 2009).

R&D is commonly divided in three categories depending on the type of research and results obtained:

(1) Basic research covers all the experimental and theoretical work developing knowledge for the foundation of a topic but with no defined application or use.
(2) Applied research is knowledge developed through original investigation aiming an objective.
(3) Experimental development is created under a systematic work, developing knowledge or using existing knowledge, targeting improvement of current material, products, process and services or the development of new materials, products, processes and services (OECD, 2002).

In terms of economy for firms, R&D represents not only activities but expenditures that comprise 5.8 percent of annual firm expenditures and it is responsible for nearly 7 percent of the GDP of the US economy (Knott, 2009); this impact in economy has given R&D a role as an innovation measure that has been accepted among industry and government, helping firms to accomplish strategic positioning inside business sectors (Mitchel and Hamilton, 2007).

As specified by Chiesa *et al.* (2008) measuring R&D is the result of a mix of several complex and dynamic contributors, including firm's R&D strategy, R&D entities,

the type of R&D performed, and the resources involved, and this indicator is only a single component of the multi-dimensional measuring performance system for innovation.

1.5 Best practices benchmarking

Best practices are guidelines on how to perform an activity in a way that has successful results for other organizations. As Pertuzé *et al.* (2010) pointed out best practices are those activities that help organizations to ultimately reach their goals in the best known way.

Holloway *et al.* (1998) define best practice benchmarking as a technique through which firms are under a continuous review process of their outputs, and looking to identify ways to make changes to improve those results. Also in the literature is recognized four types of benchmarking, internal, competitive, functional, and generic benchmarking (Zairi and Leonard, 1994; Camp, 1995; Francis *et al.*, 1999; Holloway *et al.*, 1999; Hinton *et al.*, 2000), for this study the functional benchmarking, was applied to the innovation development and management process in the same function (manufacturing) but outside the industry as suggested by Francis and Holloway (2007) in order to understand the innovation development and management process, and also to identify those guidelines that will be useful to develop a framework for the wood industry in order to set innovation as a tool for sustainable growth.

2. Methodology

Selecting the appropriate research methodology is, according to Yin (1984), based on three main conditions:

(1) the form of the research question;

(2) required control over the behavioral events; and

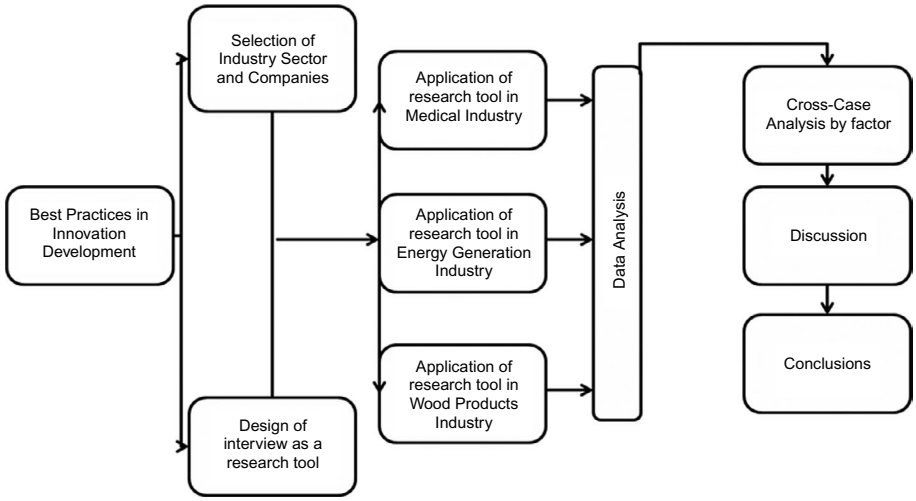
(3) how focused the study is on contemporary events.

In this research, authors analyzed the methodology for the innovation process inside three different companies from three different industry sectors; this analysis aims to identify which current practices lead to successful implementation of innovation inside the firm to ultimately develop a BIP summary applicable to the wood industry firms.

For this particular research, questions were written as explanatory questions (how and why) in order to understand the current practices (contemporary event) related to innovation management in the selected firms. These innovation practices are also known as the events and are not under the control of the researchers, leaving a scenario where multiple case studies are an accurate research methodology according to several authors (Yin, 1984; Lisl, 2006; Tellis, 1997).

2.1 Best practices in innovation development process

In order to collect relevant data about best practices in the innovation development process, the researchers reviewed existing literature about the topic to understand the innovation phenomenon inside selected organizations. From this literature review it was understood the concept of innovation, the methods that different companies use to implement and measure innovation, and how organizations see innovation as a part of its core strategy. Figure 2 shows the methodology used in this research.



Source: Adapted from Mohd (2008) and Yin (1984)

Figure 2.
Multiple case study methodology

2.2 Industry selection

The R&D process brings together all activities that involve transferring of resources among organizations, government and industries, to develop knowledge and/or uses for this knowledge (OECD, 2002). The R&D activity is a worldwide practice, and therefore, several efforts have been done in order to measure it and its impact as an economy driver. These measuring efforts became standard metrics, where R&D expenditure as a ratio of sales is worldwide accepted (OECD, 2002) and has been selected as the metric to define whether a company has a successful performance in innovation process or not.

For this case study, the innovation process was analyzed in selected companies within/and similar to semiconductor/other electronic (NAICS 3344) and pharmaceutical/medicines (NAICS 3254) because they have the largest R&D expenditure to company sales ratio, showing how innovation, measured as R&D expenditure, is a contributor to company performance (Subramanian and Nilakanta, 1996; Calantone *et al.*, 2002; Hult *et al.*, 2004) and wood products industry (NAICS 321 and 337) which shows the lowest R&D expenditure to company sales ratio. These ratios are shown in Table I.

Industry (NAICS code)	Sales worldwide ($ million)	R&D expenditure ($ million)	R&D as a share of sales (%)
Manufacturing industries, including (3,344)	192,258	28,812	15
Pharmaceutical/medicines (3,254)	529,601	69,516	13
Wood industry (321 and 337)	83,471	806	1

Source: Wolfe (2010)

Table I.
R&D expenses to company sales ratio

The first sector, medical devices industry is considered as a part of the US healthcare system and also is considered an industry with high manufacturing costs associated which also increase in a very fast rate; sales worldwide for this industry reach over $100 billion ($43 billion only in USA) and the sales rate increases at proximately 9 percent annually (Frost and Sullivan, 2005; DeFoggi and Buck, 2009). US healthcare expenditure, according to the US Department of Health and Human Services (2007), was 16 percent of the GDP ($2.3 trillion) in 2007 and the annual growth rate from 2007 to 2014 is expected to be 6.7 percent.

As a manufacturing industry, medical devices face a development cycle that takes between 18 and 24 months, and also they face regulations from Federal Drug Administration (FDA), which sets and controls the requirements for development, validation, manufacturing, and promotions of products. This highly regulated environment represents a risk management challenge for this industry which is not part of other manufacturing environments (FDA, 1999).

Despite the major challenges this industry faces DeFoggi and Buck (2009) pointed out that innovation is required to stay competitive and according to Wolfe (2010) the R&D expenditure of this sector was $69.5 billion in 2008 which makes this industry the second largest in R&D expenditure and the largest contributor for research and development in the chemical business sector (NAICS 325).

This leadership held by this business sector has also been analyzed to understand the innovation process and several conclusions have risen from these studies. For example, Ackerly *et al.* (2009) concluded that innovation inside the medical sector has been supported using venture capital practices which allow companies to get the needed capital to develop the ideas, especially in early stages of the innovation management process where medical devices firms have to face the high costs associated to FDA's development requirements.

Russell and Tippett (2008) performed a study were they identified the critical success factors (CSFs) that influence the most the selection on innovation projects in the medical devices industry. With this approach practitioners in this field are having a better understanding of front end CFS's developing also better criteria to select the most accurate project mix and achieving a higher consistency in meeting objectives.

DeFoggi and Buck (2009) constructed a framework that allows medical devices companies to identify unmet need of customers, in this way firms are able to foster innovation by applying a proactive marketing approach.

Worldwide there is an important effort made in the innovation field by the medical sector. This effort is the creation of the Medical Future Award which allows clinicians and academics to present the innovative ideas to a panel of experts who coach and mentor the development and validation process (Emerald Group Publishing Limited, 2009).

As is understood from the literature, the innovation process inside medical field is spread to several processes including product development, marketing strategies, financial support and more lately fostering forums for innovation where business people from the sector also can learn how to protect their ideas, write business plans or obtain funding for their ideas.

Based on the R&D expenditure to company sales ratio, the second sector is semiconductor/other electronic components (NAICS 3344); for this study the researchers were not able to obtain data from a company in this business subsector, therefore applying the same selection criteria described in the industry selection section of this

study, a company from the electrical equipment manufacturing business subsector (NAICS 3353) was selected. This company belongs to energy generation industry, and as the semiconductor/other electronics components are located in the under manufacturing sector (NAICS 33) which comprises establishments engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products.

According to researchers in the field by 2020 the electricity consumption will raised 75 percent compared to 2000. This large increment also raises concerns related to the impact of green houses gases produced by power plants, the imminent death of the actual transmission and distribution infrastructure and the variability of fuel prices which are used to generate electricity (Garrity, 2009).

These mentioned conditions leave the energy generation industry in a large urgency to develop new ways to produce electricity and also new ways to improve the current available resources ensuring also a sustainable development and growth.

To solve these needs, the US Government has spent since 1978 a total of $75 billion, of which $30 billion is for nuclear energy generation, $20 billion to coal, $13 billion for renewable energy and $4 billion to other fossil sources (Energy Information Administration, 2008). This expenditure is allowing the industry to develop several capabilities by 2015 where the focus has been raising efficiency in coal (up to 60 percent) and natural gas (up to 75 percent) as electricity sources; a second focus is DOE Advance Turbine System which aims to raise steam turbine efficiency to 60 percent. As a third target, the oil and gas extraction technologies has been speed up in order to look for domestic production, and finally, the expenditure is also supporting research to find ways to reduce transportation costs transportation for coal and natural gas fuels (Energy Information Administration, 2002).

As future innovation trends in the business sector Garrity (2009) points out that energy generation industry will be focusing in elevate efficiency of high voltage energy distribution, also expanding the renewable energy generation and consumption, also industry has to start looking into distribution automation to improve distribution systems in general; clean and lower emission sources will continue as the backbone of any new innovation in the energy sourcing and finally nuclear energy will grow despite the challenges in the industrialized countries.

The third sector selected is the wood products industry; this industry has faced challenges in order to remain as a profitable sector (Hansen and Juslin, 2006; Hovgaard and Hansen, 2003; Crespel and Hansen, 2008; Hansen *et al.*, 2007). This desired condition for the business performance can be achieved through innovation activity, which has been recognized as vital among the industry (Stendhal and Roos, 2008; Ellefson *et al.*, 2010; Alsaaty and Harris, 2009). However, it is also well known that for this particular industry, there is a modest amount of analysis about innovation, which also has been increasing in recent years (Ellefson *et al.*, 2010; Rametsteiner *et al.*, 2006). This gap in studies related to innovation inside the wood products industry results in a major research opportunity to contribute to a better understanding of this event inside this sector in order to come with outputs that help industry to obtain a sustainable and profitable growth.

2.3 Company selection

The methodology selected for this study allows analyzing every industry as an individual object of study, to understand a real-life phenomenon in depth and how

it behaves under that specific environment (Yin, 1984). This type of analysis is fundamental to obtain data for a later contrast between what literature suggests about innovation under certain conditions defined for industry selection, and also, is fundamental to compare the innovation development process through a cross analysis within the three chosen firms.

Among the selected industry sectors, the researchers chose the participating companies, based on the following factors:

(1) Companies with a strong quality oriented culture that pursues incremental improvements in existing systems (Alsaaty and Harris, 2009), for this specific case study the selected companies apply Six Sigma and Quality Control Techniques as part of their continuous improvement process.

(2) Company size.
For this research, large companies were selected since it implies also, a larger effort to develop and sustain an innovation culture among the company. Literature suggests that large firms are more productive and have a more aggressive approach to innovation since there is a larger amount of support activities between R&D and other functional departments, such as manufacturing and marketing. In addition to this it is also suggested that larger firms tend to obtain higher profitability since innovation costs are widely spread (Demircan and Ertürk, 2010; Wakasugi and Koyata, 2007; Cohen, 1995). In the medical device sector, the selected company has over 40,000 employees worldwide, the energy generation company has more than 400,000 employees worldwide and the selected company in the wood products sector has 56,000 employees worldwide.

(3) Their innovation process is performed under a systematic environment allowing also continuous innovation portfolio health which can allow strong results based on the fact that the scenario containing innovations with the higher returns is more clear (Kandybin, 2009).

(4) Company willingness to be part of the study, sharing information useful to accomplish the objectives.

2.4 Design and application of interview as a research tool

Using the definition of innovation given in the Oslo Manual (OECD, 2005), the researchers structured a survey; divided in four different parts as follows. This research tool was applied at the firm site in order to also perform direct observation of the innovation development activities that firms were able to share. The interviews were answered by personnel with the highest rank in the new technology, new product and processes and quality departments:

(1) *Demographic and general information.* Company name/location, employee job title, industry activity, number of employees. This first part of the interview is designed to collect information about the firm for a better understanding of the environment and conditions where the activities take place.

(2) *Innovation from a management perspective.* Definition of innovation based on the firm understanding, definition of innovation as part of the strategic objectives. Also firms were asked for the number of product, process, marketing and organizational innovation activities done in the past five years and

a description of the innovation development process and R&D expenditure as a financial indicator was emphasized based on literature findings that suggest a relationship between effective R&D expenditure and growth (Kandybin, 2009; Cooper and Edgett, 2010).

(3) *Innovation activities.* This third question analyzes the application of innovation as a standardized practice inside the firm process.

(4) *Factors affecting innovation.* Determine internal and external conditions affecting innovation through strengths, weaknesses, opportunities and treats (SWOT) analysis, where every firm was asked about at least two items in each category. This section of importance relys on the fact that researchers wanted to better understand factors that could be possibly affecting the innovation development process.

2.5 Data analysis

For studies where there is an evident need of a better understanding on how and why innovation takes place inside the firms, Yin (1984) suggests the use of Exploratory Multiple Case Study, which according to literature produces a more robust study (Herriot and Firestone, 1983; Tellis, 1997) and increasing the robustness of the theory being tested (Stake, 1995).

The data was analyzed using data displays in order to capture the findings separately and then through the use of tables to establish patterns among the three selected firms (Miles and Huberman, 1984; Yin, 1984).

3. Results

This section aims to present the inputs collected through the application of the interviews, and site visits as well as the analysis of those inputs. Information is presented based on the scheme developed for the interview as it was applied. The findings are compared to previous research and theory in the literature in order to contrast or compare with previous results.

3.1 Demographic and management perspective on innovation inside the firms

Table II shows a summary of the information collected from the participating firms. In this section researchers had the opportunity to apply the research tools in firms inside and outside the USA. This last factor is important since it allowed comparing literature against both, national and international sites.

Firms were asked to briefly describe what innovation means for them. The three firms defined innovation in terms of new or improved product or process, and none of them referred to marketing or organizational innovation as part of the definition of innovation. In addition, firms were also asked about innovation examples. Each firm was only able to identify innovation examples in the category of product and processes, where the energy generation firm pointed out three innovative products and three innovative processes, similar to the medical devices firm where the interviewed manager was able to identify 15 product innovations and around 30 process innovations in the past five years. And finally the cabinet manufacturer was able to identify ten product innovation and more than 40 process innovations in the past five years.

These definitions and examples are consistent with definitions given by several authors who usually do not consider marketing or organizational innovations among

Company business	Main activity	Location	Number employees	Employee interviewed	Definition of innovation
Energy generation	Research and development	North America	1,000	Engineering director Technology development manager Senior technology development engineer	New products or changes to improve them either make them cheaper or to last longer)
Medical devices	Manufacturing	Central America	1,100	New products and processes manager	New or improved product or processes that solves current or future needs
Cabinet manufacturer	Manufacturing	North America	300	Senior continuous improvement coordinator	New or improved products to offer to our clients or new or improved processes to be more profitable

Table II.
Demographics and general information summary

definitions of innovation found in the literature. For example, Schumpeter (1934) considers innovation as any major change in product, process or thinking. O'Sullivan and Dooley (2009) define innovation as something new that brings value to markets. Zaltman *et al.* (1973) state that innovation is any idea, practice or material perceived as new by the consumer, and West and Farr (1990) mention innovation as the introduction and application of any idea, process, product or procedure, relevant enough with an observable benefit to the individual, organization or society.

Firms were also asked about their perspective about innovation and how this perception is linked to their strategic goals. The energy generation firm indicated that innovation is a key factor for a sustainable profitable growth. As part of the strategic plan for a profitable growth, the firm set a return on investment (ROI) rate between 10 and 15 percent for every innovation project in order to sustain a constant growth.

In the case of the medical devices company, a similar answer was found. In this case, innovation is considered also a fundamental driver for the company's growth. This firm requires a higher ROI for innovation projects in order to accomplish incremental revenue of 10 percent.

These findings are similar to previous research, where several authors have indicated that organizations use their strategic goals and objectives to prioritize their improvement activities such as innovation (Mitchel and Hamilton, 2007; Kandybin, 2009; Alsaaty and Harris, 2009; Mankin, 2007; Corso and Pavesi, 2000).

In contrast with the findings in the energy generation and medical devices firms, the cabinet manufacturer firm presents a different situation. This firm recognizes the importance of being sustainable and profitable to stay competitive but innovation projects are not used as a growth strategy for the company. This firm requires a variable growth, which changes upon the yearly company budget and therefore there is no standard ROI for projects or a similar defined company growth goal.

3.2 Innovation activities (describing the innovation development process)

Nieto and Santamaría (2010) and Conforto and Capaldo (2010) suggest that innovation can be developed using different methodologies despite company size or other characteristics. These methodologies according to Corso and Pavesi (2000) are usually systematic approaches developed inside firms and also are the result of alliances with external sources such as universities and research centers.

In this study it was observed that energy generation firms and medical devices firms are consistent with the approach suggested before. These two firms have defined innovation as a growth strategy and use structured methodologies for tracking innovation performance. These methodologies are described below.

Energy generation firm develops innovation projects using three main sources:

(1) Customer feedback, which can be obtained directly from the customer or through the monitoring services installed products in customer facilities.

(2) Employee's creativity which reinforces idea generation. This source follows a defined methodology that takes every idea, to the next management level to be approved and entered into an innovation portfolio. This portfolio contains all those ideas that have large potential to become an innovative product or innovative process.

(3) Cooperation between the firm and research centers such as universities, where basic research is developed and becomes useful for the new technology development process.

This cooperation among the firm and third parties is included in the company budget and it reaches a third of the total new technology development yearly budget.

The energy generation firm also shows a very clear methodology to follow up on portfolio health known as technology readiness levels (TRL). TRL is a systematic metric-measurement system, adopted from NASA, which supports assessment of a particular technology. A general model includes five large steps subdivided in nine different levels. These five steps are:

(1) basic research in new technologies without a specific goal;

(2) focused technology development for a specific goal;

(3) technology development and demonstration for each specific application before the full development of the application;

(4) system development; and

(5) system launch and operations.

The medical devices firm also obtains part of its innovation opportunities from feedback from customers. This feedback is handled by the customer service department, who receives the information and generates the feedback to the corresponding area. A second innovation source, is an internal program developed as part of the continuous improvement culture, where employees bring innovative ideas that are analyzed by the next management level and based on its feasibility and innovation potential are taken into an innovation portfolio. For this firm there is also a clear methodology to develop innovation at the product and process level. This company uses a systemic methodology known as 7 M's which consists of seven steps

where every innovation project has to go through in order to maintain its feasibility and achieve goals.

M0 phase includes the idea generation. M1 and M2 are activities aiming to fulfill any required regulation. M3-M5 cover the different stages of production, starting with the production launch, followed by production based in forecast and finally production based on demand. M6 and M7 are steps where deployment occurs since there is a new innovation available to substitute current technology. This methodology allows the firm to move forward on every innovation under a systematic approach, which also, makes innovation visible at every step and feasible to be controlled, improved or discarded if it is found that feasibility is not as required by the firm.

The wood products industry also uses feedback from customers to look at innovation opportunities. This information is collected through customer service and is directed to the marketing department, who joins efforts with the design department to develop answers to customers' needs. Employees have also an active role in the feedback process by providing innovative ideas; however there is no systemic approach for communicating innovation opportunities. The wood products industry deals with innovation in a very different way since this firm does not have a systematic methodology to generate ideas and or develop these ideas. Innovation for this industry arises from employees and customer feedback, but there are no standardized steps to follow up and start the innovation development process. In this case, innovation seems to be more the result of a random situation instead of being the result of a planned strategy embedded in the business strategic growth.

4. Discussion

4.1 Strengths, weaknesses, opportunities and treats

Table III shows the results of the SWOT analysis performed in the case study firms with the goal to understand what internal and external factors might be affecting the innovation process.

In the energy generation firm SWOT analysis pointed to highly skilled personnel as a valuable strength, where graduate students and professionals with doctoral degrees are in charge of R&D activities and highly involved in the steps to develop innovation. Interviewed managers also stated that collaboration with external organizations such as research centers and universities allows them to have access to the latest knowledge and high level scientists. As one of the weaknesses, this firm mentioned that communication among other divisions is not constant and structured, therefore; innovation activities that take place in different divisions are not shared resulting in an extra effort in knowledge or practices that are already tested and approved inside the firms other divisions. This firm also mentioned that because it takes up to ten years to develop some products, the product development cost is extremely high, therefore the use of a methodology to track the development process is crucial to control the execution of selected projects and reduce waste of resources. As part of the opportunities, this firm mentioned that having high skilled employees would be critical to sustaining highly competitive work. Cooperation with universities and research centers would let them decrease the cost of innovation projects because research expenses are shared through this collaboration. The firm also identified that its sector is highly competitive and it makes innovation a difficult target to achieve because new technologies are developed also by major competitors at the same speed they develop

Industry	Energy generation	Medical devices	Wood products
Strengths	Highly skilled personnel	Strong improvement culture based on lean manufacturing techniques	Strong improvement culture based on lean manufacturing techniques
	Research partnership with universities and governmental research centers	High motivation of employees towards Innovation development	Resources availability that could be allocated towards innovation development
Weaknesses	Communication gap among other divisions about innovation developments that could be useful for this firm	Existing gap among innovation performance and innovation measurement	Lack of formal innovation development methodology
	Innovation development time up to ten years	Not all functional areas are aligned with innovation development as a growth strategy	Innovation is not promoted as everyone's job
Opportunities	Partnership with universities and research centers contributes to research cost reduction	Develop metrics based on data available to measure innovation performance	Lean manufacturing offers a strong training system useful towards innovation training
	Access to high skilled personnel inside and outside the firm	Lean manufacturing offers a strong training system useful towards innovation training	Large mix of organizational cultures coming from different sites that allows sharing a wider scope of knowledge
Threats	High competence among the business sector which make innovation hard to develop	High regulated environment creates a negative perception about change	The product is a commodity product therefore economic conditions have a direct impact on availability of resources
	Innovation is mainly developed as top secret therefore cannot be publicly announced	High technology requirements could make creativity to be seen as unnecessary	Set innovation as a corporate growth strategy to align all site and assure resources

Table III.
SWOT analysis results

their own causing every innovation project to be treated as top secret to avoid new technologies being shared before its implementation.

The medical devices firm pointed out as strength the firm's strong process improvement system, which leads employees to identify improvement opportunities. This system is also reinforced by the high motivation level that employees have towards this improvement culture setting an open mind environment for innovation inside the firm. This firm mentioned that using the continuous improvement methodology allows to capture data that could be used for measuring innovation; however it is pointed out as a first weakness that innovation measurement is not performed at every department. A second weakness is the different levels of involvement where not every department perceives innovation as part of their daily routine. As opportunities the manager mentioned that even though innovation measuring was not clearly performed, the firm has a good improvement opportunity because data is available and metrics can be

developed as required. Also, it was mentioned that a strong training system through lean manufacturing methodology is in place and can be used as the platform to train individuals inside the organization towards innovation making innovation a vital part of the firm culture. This strategy has been mentioned by Hoerl and Gardner (2010). Two threats were identified inside this firm:

(1) low openness for process and product changes since the firm belongs to a highly regulated sector which requires strict validation processes for changes in current products or processes; and

(2) also the perception about the high technology requirement.

Employees from areas different than engineering might perceive that innovation is only for scientific job positions that are able to develop large improvements or changes based on their technical skills.

The wood products firm mentioned that lean manufacturing methodology has helped to develop an improvement culture, where employees see opportunities to improve as part of their job. This situation which is similar to the one found in medical devices, helps the firm to involve employees in the innovation process by taking advantage of the training system and the open mind culture towards improvement that is already in place. This firm also recognized that inside the organization there are resources and a training structure that can be used to promote innovation inside the firm. As weaknesses, the firm mentioned that there is no formal innovation process where employees can transmit their ideas, which is observed in the other two firms where formal processes are established for creativity and idea generation. This situation is also related to a second weakness which was identified by the manager interviewed as a weak perception of innovation as part of everyone's job.

Two opportunities in the wood products firm were identified: the use of the current training system to develop innovation training, and being part of a large corporation with extensive knowledge in different disciplines that can be used for creativity and idea generation. As threats, the firm recognized that they manufactured a commodity product therefore; this organization is more sensitive to market fluctuations than other types of industries such as energy generation and medical devices, this condition has a direct impact on the budget available to develop innovation projects. A second threat is related to organizational management since the firm has not defined innovation as a growth strategy and therefore is not perceived as a company goal and consequently; is not developed at every level of the organization and resources are not accordingly assigned.

4.2 BIPs from energy generation, medical devices industries

Based on the previous discussion, authors observed that energy generation, medical devices and wood products firms share critical activities such as liaisons, resources availability, strong continuous improvement culture, using lean manufacturing techniques, which help to build the basics for developing the innovation process as a company strategy.

Researchers were also able to identify, through weaknesses and threats, that energy generation and medical devices firms have a different scenario from the one observed in the wood industry firm. In the first two firms, the weaknesses and threats are strongly related to factors affecting the current innovation development process such as communication gaps, the impact of high competence among industry and the presence

of high regulated environments which according to firms' representatives could have a negative impact on innovativeness since these conditions might lead employees to discouragement towards innovation initiatives. However, in the wood products firm the scenario shows very different elements. This firm's representative clearly recognized as a first element that innovation has not been set as strategy for sustainable growth at the top management. As a second element, the firm also recognized that innovation is not promoted as everyone's job and is not developed through a formal methodology, even though the firm recognized that they possess a strong continuous improvement system useful to support and stimulate the innovation process. As a third element, the company pointed out the fact that the wood products are commodity products, highly dependable on the market's conditions and therefore the economy has a high impact on monetary resources. According to the representative, low cost strategies are developed using continuous improvement and are set as company goals. However, there is no budget assigned for innovation activities, which is consequently because of the fact that innovation is not a strategy used as part of the strategic planning, and therefore resources assignments are not discussed for this topic.

This previous analysis had strongly demonstrated a lack in the innovation process development inside the participating wood industry firm compared to the innovation process development held in the participating energy generation and medical devices firms. Based on this finding and fulfilling the objective of this research, authors have also identified four major guidelines known as BIPs. These best practices were identified using tools previously explained in the methodology section, which also is supported by similar methods used by studies found in the literature such as Walter (2010), who identified best practices in ergonomics for construction businesses through survey of several contractors among the USA and Pertuzé *et al.* (2010) who identified best practices for collaboration among universities and industries using interviews (surveys) with managers from aerospace, information technology, materials, consumer electronics, automotive, biomedical, mining, paper and petrochemical industries.

The BIPs were identified as remarkable since they help both, medical devices and energy generation firms, to develop and implement the innovation process and therefore, authors agree that they will also help in the successful implementation and development of the innovation process among the wood products industry. Table IV shows a summary of the BIPs identified and the positive impact observed inside the organizations.

5. Conclusions and future research

This multiple case study was designed to understand current practices related to the innovation development process in three industries from different sectors and develop a BIPs framework useful for the wood products industry. This framework is shown in Figure 3.

In this research it was found that innovation development as a process is affected by internal and external factors. Also, it was identified that customer satisfaction is a very reliable source to generate ideas that could eventually become innovations among the firms. Innovation development is also recognized among two out of the three firms as a process with a direct impact on company performance. Therefore, in energy generation and medical devices firms innovation development is used as a profitable growth strategy.

BIP's	Positive impact
1. Define innovation as a strategic goal for sustainable and profitable growth	This BIP will allow the company to understand and use innovation as a tool through all the organization, making resources available and measuring its impact on the firm's objectives
2. Cooperation among firm, customer and research centers	It was observed that obtaining feedback from customers becomes a very ideal generation source where needs are evaluated and solved, also cooperation with research partners allows the firm access to the latest knowledge and cost sharing decreasing the research expenditure
3. Use of structured methodology to develop innovation project	This practice aims to project feasibility evaluation and further performance tracking to ensure a healthy innovation portfolio
4. Use of improvement process methodologies	The use of these methodologies allows companies to reach personnel through previously developed structures making it easier for the firm to spread innovation as part of everyone's job since elements such as training systems and feedback processes can be used towards innovation development

Table IV.
Best innovation practices

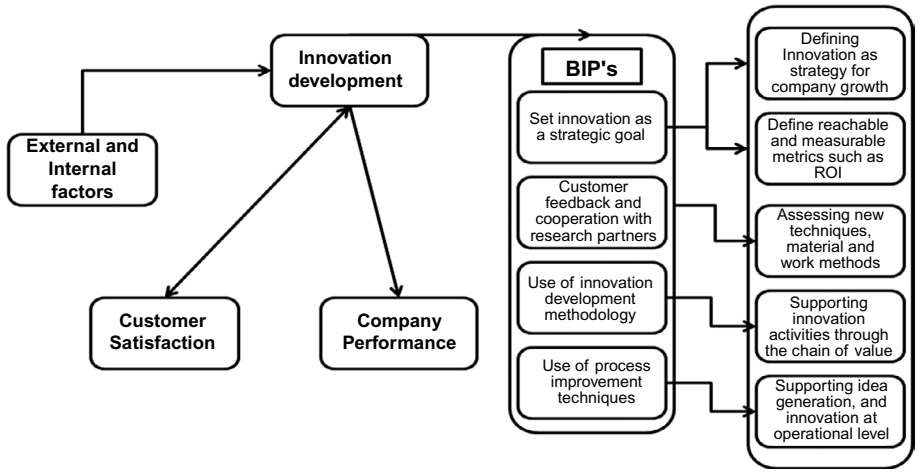


Figure 3.
Best innovation practices

These best practices identified in the previous section of this research will contribute to industry and education institutions to adopt a general understanding that leads to the use of innovation as a company growth strategy based on successful results in both, energy generation and medical devices. Also, these findings aim to contribute remarking the importance of feedback from the customer and the cooperation among industry-research centers. Since this will fulfill the innovation development pipeline with several ideas to innovate, they also aim to contribute by setting the path for future research about further understanding how innovation could become part of a learning process for individuals inside universities, developing the necessary set of skills for future professionals to become more innovative in daily tasks, contributing also to

achieve the firm's growth through the innovation process. For this future research, the authors identify that obtaining data relevant to innovation learning and innovation teaching using tools as laboratories and surveys to evaluate these topics among industry will bring valuable information to support the innovation development process inside the industry and cooperation among research centers.

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