

## **The evolution of environmental practices in product development in Embraer: A longitudinal case study from 2007 to 2015**

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## **ABSTRACT**

The positive impact of market incentives in the development of the product has been documented in the last 200 years, and environmental practices have become an important topic of discussion. The purpose of this article is to identify the evolution of environmental practices in product development and the integration of these practices throughout the supply chain from 2007 to 2015. We did longitudinal case study in a Brazilian company, considered innovative, Embraer. The research method was qualitative and we conducted semi-structured interviews. We made Thematic analysis, categorizing the registration drives with the speeches of those surveyed and compared the results with those obtained by Morilhas (2007). The results indicate that there have been changes in environmental practices in product development at Embraer. The most important project was the creation of the DIPAS (integrated environmentally sustainable product development) and the external force that drives in highest proportions sustainable product development is still the law. Key words: Environmental practices, product development, supply chain management

## **INTRODUCTION**

On the issue of production there are significant evidence that some private sectors comes recently looking for new ways to generate greater value to the product, developing products that cause less pollution and emissions. The process emphasized more the environmental issues than the development of the product (PORTER, 1991; DESROCHERS, 2008).

Product development in the recent economy has a competitive pressure and is inserted in a profit-driven economy. However, as the study of Pagell and Gobelli (2009) points out that from the year 2000 companies began to consider the environment as an important variable in the developing of new products.

Morilhas (2007) created a framework for the development of sustainable products, based on the model of Wheelwright and Clark (1992), where in addition to engineering, marketing and manufacturing, the environmental variable is included in all stages of the product development process. The model was applied in several companies in 2007 and Morilhas (2007) concluded that the model should be validated in several segments and with different levels of environmental maturity to identify whether to suppress or add other environmental actions.

Schreiner, Morilhas e Melo (2014) replicated the model in a longitudinal study in two of the companies researched by Morilhas (2007) and found developments in environmental concerns. From the year of 2007 to 2014, the number of world conferences and events as Compenhage in 2009, Rio + 20 in 2012 shows the increasing of concern of companies with environmental management.

Studies such as Prajoro, Tang and Lai (2014) demonstrate that the extent of dissemination of the environmental management system within the organizations has a positive and significant effect on green management practices in terms of product, process and supply chain.

To do the supply chain management in a sustainable way (SSCM) means that organizations are responsible for the environmental and social results of its suppliers (WALKER and JONES, 2012).

The purpose of this article is to identify the evolution of environmental practices in product development and the integration of these practices throughout the supply chain from 2007 to 2015 of Embraer, a Brazilian enterprise of aviation.

Embraer develops aircrafts in Brazil, but around 80 of the pieces comes from suppliers in other countries as Germany, Spain, Belgium, United States, France and Japan. For this reason, there has been emphasis on theoretical framework in relation to sustainable supply chain management.

The specific objectives are to replicate the Morilhas framework (2007) contemplating the environmental variable in all stages of product development and identify the current environmental practices of Embraer in steps of product development.

We structured this article as follows: Introduction, literature review of product development, product management and sustainable supply chain management, methodology, presentation and data analysis, discussion of the results and conclusions.

## LITERATURE REVIEW

### Product Development

Wheelwright and Clark (1992) believe that the development and design of new products have their growing importance and related not only to new scientific and technological developments, but to the broader factors.

For a product development, it is required a project. In the project there are phases. Wheelwright and Clark (1992) present five stages for product development in three areas of functional activities. Starting from the stages presented by Wheelwright and Clark (1992), Morilhas and Nascimento (2007) built a model of product development with the environmental variable in all stages of development, as shown in Table 1. The proposed model presents the environmental variable interaction with other variables (engineering, marketing and manufacturing) proposed by Wheelwright and Clark (1992).

Table 1: Stages of development of a product in the areas of engineering, marketing, manufacturing and the environment.

Functional activities		Engineering	Marketing	Manufacturing	Environment
Concept Development		Proposes new technologies and new product ideas. Running simulations. Creates alternatives. Analyses opportunities and threats along with the marketing area.	Provides information on the market. Propose/product concepts investigates. Analyzes opportunities and threats along with the engineering area.	Propose/investigates process concepts	Proposes environmentally friendly concepts for the product and the process. Features environmental specifications, proposed by various stakeholders. Presents results of analysis of a reference product. Identifies opportunities for the development of environmentally friendly products. Discusses alternative products and production technologies.
Product Planning		Choose components. Interact with suppliers. Builds first prototypes. Define product architecture.	Sets parameters of target market. Estimates of sales and margins. Develops estimates of margin. Preliminary interactions with the market.	Cost estimate. Sets process architecture. Process simulation. Validates suppliers.	Analyzes the life cycle of the product. Aligns the environmental planning with organizational strategy. Examines external factors. Adopt appropriate environmental projects. Check the trade-offs between environmental and economic aspects.
Detailed Project And Development	Functional Project	Detailed design of the product. Interacts with the process. Builds on prototype scale. Conducts tests of prototype.	Tests of prototypes with customers. Participates in the evaluation of prototypes.	Draws up the detailed design process. Develops means of production. Participates in the development of prototypes in scale.	Apply project details and finalizes product specifications, including life-cycle considerations. Presents ideas of projects simplicity, facilitating the subsequent Assembly and disassembly of the product.

					Reduces the use of raw materials, recovers and reuses waste, reuses renewable materials. Designing packaging that can be recycled.
	Qualification	Refine product design details. Refines the prototypes.	Refine prototype tests. Define marketing plan. Define distribution plan.	Test of means of production. Prototypes in scale (process). Install production facilities and procedures.	Check specifications by testing prototypes. Reviews and makes considerations about the cycle of life through the prototype.
	Pilot production	Evaluate and test pilot units. Solves problems	Prepare marketing plan. Train sales force. Trains service personnel. Prepares sales process.	Build prototype units on a commercial scale. Refine process in scale. Trains staff. Checks for logistics channels.	Consider possible environmental statement and your requirements. Publish along with the marketing, communication material with environmental aspects, evidencing a better use and disposal of products.
Marketing		Evaluates field experience with the product	Fills distribution channels. Sells and promotes. Interacts with customers.	Take production to target levels. Hits performance targets.	Considers and evaluates environmental aspects and impacts experiences for prevention and or reduction of adverse impacts.
Disposal and post use		Plans to the discontinuance of the product and its replacement by new products. Proposes new technology and new product ideas. Constructs models. Running simulations. Creates alternatives. Analyzes opportunities and threats along with the marketing area.	Consider and approve the discontinuity in the marketplace. Brings new market information. Propose/product concepts investigates. Analyzes opportunities and threats along with the engineering area.	Get the receipt of the product along with the environment. Make a general assessment and ends the production. Proposes and investigates new concepts of process.	Get the receipt of the product along with the manufacture. Sets the post use of products: product disassembly, recycling, disposal, reuse of components. Retrieves packages for possible reuse. Proposes environmentally friendly concepts for new products and processes. Features environmental specifications, proposed by various stakeholders. Presents results of analysis of a product previously developed. Identifies opportunities to develop new environmentally correct products. Discusses alternative products and production technologies.

Source: Morilhas and Nascimento (2007)

## Sustainable Product Management

The literature deals with the concern of businesses in getting systems that can do the environmental management of the products manufactured. Studies such as Prajoro, Tang and Lai (2014) demonstrate that the extent of dissemination of the environmental management system within the organizations has a positive and significant effect on green management practices in terms of product, process and supply chain.

Alblas et al (2013) present a perspective on sustainability management in product development, defending the existence of external incentives enough to force companies to have greater sustainability doing three inferences for future research: organizing and filtering of the pressures on sustainability, to manage the sustainability in a more pro-active way, and incentives within the company.

The improvements in daily practices are tangible indicators that the EMS (Environmental Management Systems) is not only carried out superficially, for obtaining a certification, for example, but also deeply integrated into organizational routines. The deeper the diffusion of EMS,

the stronger will be the environmental management practices throughout the Organization (PRAJORO, TANG and LAI, 2014).

The EMS broadcast means making the internal marketing in the organization. Lai, Shang and Lu (2014) also identified environmental management practices, in terms of environmental awareness of manufacturing and product development alone do not bring the reputation for the organization. Therefore, based on the theory of communication, the findings extend the environmental management literature demonstrating the important role of the Green advertisement for environmental reputation. To share information related to corporate environmental protection efforts is a useful mechanism to inform consumers about the environmental impacts of products and organizational processes, generating a positive environmental reputation.

Praoro, Tang and Lai (2014) converges with Lai et al (2014) concerning communication and information sharing. The authors enhance the integration of a cross-functional team that is typically composed of members representing different organizational functions such as engineering, manufacturing and marketing, among others. This structure supports and integrates different ideas and sometimes contrasting different functions by promoting contributions in the design of a new product, which can lead to a better and faster process.

When positive thinking in relation to environmental practices or to the development of a green product is widespread in the organization between the various organizational functions, it will produce a shared vision among members of different functions and help them design new products or processes that are more environmentally focused (PRAJORO, TANG and LAI, 2014).

#### Sustainable Supply Chain Management

Sustainable integrated supply chain is the degree to which chain partners collaborate between and intra-organization for sustainability processes (WOLF, 2011).

To do the supply chain management in a sustainable way (SSCM) means that organizations are responsible for the environmental and social results of its suppliers (WALKER and JONES, 2012).

Wolf (2011) has identified the most important factors that encourage and that prevent the integrated supply chain management. To the author, the integration can be studied in two different ways: internal integration between different areas of the same organization and the external, which is the integration between organizations and covers part of the downstream and the upstream supply chain.

Pagell and Wu (2009) also suggest that there are two types of relationship of the company's strategy with sustainability: internal integration in the form of sustainable supply chain strategically, and external form with suppliers and customers.

Walker and Jones (2012) also grouped companies according to a typology of SSCM approach, based on barriers and motivation, external and internal. Several authors show the motivations and barriers to SSCM and how they can be internal and external, but it is not clear in the literature if certain types of organizations are more internally or externally motivated or engaged on SSCM.

On the typology offered by Walker and Jones (2012), we can observe four types of companies:

1. Internally focused – organization more influenced by domestic factors. We classified the industry investigated in this study within this typology.
2. Reserved players – they are motivated by external factors, although there are internal barriers.
3. Set schedule – they are affected by the company's internal motivation, and external barriers less influence them.
4. External responders – They are more influenced by external factors, including clients, NGOs, and Government pressures.

Companies differ in the cause of their engagement or motivations; some say it is internally as the management and commitment of top managers in relation to sustainability, leadership, company culture, employee involvement, EMS-Environmental Management System or practices of CSR-Corporate Social Responsibility (WALKER; JONES, 2012).

Converging with Walker and Jones (2012), Prajoro, Tang and Lai (2014) identified in their research that when the diffusion of environmental initiatives, including the EMS (environmental management systems) and ISO 14001 certifications, they are extended to the supply chain of partners, the environmental effects are also significantly larger and more extensive than when confined within an organization only.

Concerning the barriers, they can also be external, such as regulations, consumers' desire for low prices, lack of commitment from suppliers, industry and cultural barriers between different locations, such as different patterns of countries.

The internal barriers can be listed as: pressure for cost, results, lack of commitment, and lack of management knowledge (WALKER; JONES, 2012). In the companies researched by Wolf (2011) it was found the lack of experience and knowledge in sustainability as factors that hinder the SSCM. For the author, elements as how to create a new position, invest in training, and look for an external consulting help to integrate the traditional chain with integrated sustainable chain.

External factors of motivation were listed as a re-activate reply to the external influence as the pressures of stakeholders or customers, NGOs, the Government through laws and policies and regulations (WALKER; JONES, 2012). The findings of Wolf (2011) revealed a more positive vision in relation to external stakeholders. Sustainability complements the traditional supply chain management in several ways and the ability to develop a more sustainable chain is linked to the understanding of the expectations of multiple stakeholders, and not the mere understanding of client (WOLF .2011).

In addition, how can the integration of internal and external chain be conquered? To Wolf (2011) strategic goals need to be integrated with the functional goals. All the managers interviewed in the research of the author reported that there was a gap between the partners of all the four German companies surveyed and in particular, the sustainable supply chain strategies. The answer is in the information gain of the stakeholders needs by integrating this information into strategic formulation and including in the channels of communication along the supply chain (WOLF, 2011).

External partner integration of the chain can be downstream or upstream. On the integration of downstream chain, perceived pressure is one of the factors that leads to sustainable chain integration. External pressure encountered by Wolf (2011) with respect to customers, and 3 of 4 respondents stated that they are not sure if customers would pay higher prices for sustainable products. In the external integration of upstream chain partners, the goal is to generate innovative products and processes in the issue of sustainability.

In addition, in the literature it is discussed if SSCM can generate competitiveness (WALKER; JONES, 2012). There is a debate and controversy about the impact of environmental regulations on the economic performance of companies. Some scholars suggest that the regulations make companies generate innovative responses that can generate earnings, competitiveness and profitability, known as "win-win" (DESROCHERS, 2008).

Researches as the one of Porter and Kramer (2006) suggest that the sustainable supply chain management is positively related to the performance.

Environmental regulations can increase competitiveness and contribute to the environment through the innovation "win-win". It means to have the environmental gain while it generates profit. For Desrochers (2008), government regulations occasionally result in the development of "green" practices. In the hypothesis of Porter (1991), the environmental regulations will encourage

companies to reduce waste, increase efficiency, use better technologies and become more competitive and profitable than their rivals who do not follow the rules, and still reduce the environmental impact.

This hypothesis was approached by Porter (1991) and Desrochers (2008) and contributes to this debate, concluding that inflexible laws do not generate competitiveness and even profitability. Porter (1991) suggests the flexibility and freedom to be motivated for the profit and competitiveness, and so the company can maximize their resources.

## **METHODOLOGICAL PROCEDURES**

The method of this research is qualitative and exploratory, whereas the environmental variable in product development is still an unexplored subject. This is a case study, which, according to Yin (2001) consists of a deep and detailed study, allowing its extensive knowledge.

### **The company**

For this study, we chose one of the companies searched by Morilhas (2007) for the possibility of a longitudinal study. The company researched is the Embraer, which was established in 1969 and privatized in 1994. The company has several business segments, including the manufacture of commercial, executive, training and military attack aircrafts, and the Embraer Systems with a focus on Systems development and systems integration. With more than 17 thousand employees, the mission and value of the company are directed to commitments to sustainability.

Morilhas (2007) has selected the company because it constantly developed new processes and products and declared their environmental concern.

### **Data collection**

We collected the data from primary form through interviews. We conducted three interviews that lasted on average 2 hours each, and all of them were recorded. Three researchers participated of the interviews. We used a questionnaire to conduct the semi-structured interview (Appendix 1). The first interviewee is a mechanical engineer, who works in the company for 24 years, and he is responsible for project DFE (Design for environment) and DIPAS Project Manager (integrated product Development environmentally sustainable). The second interviewee is a civil engineer, master in environmental engineering and a Ph.D. in environmental engineering in evaluation of life cycle of the product. He is a sustainability analyst at Embraer for 3 years, and before working in Embraer, the respondent was an employee of Natura, in the area of sustainability. The third respondent is a mechanical engineer, he works at Embraer for 16 years, and he is responsible for quality corporate.

For the construction of the theoretical framework, we searched at web of science with the key words: "green practices on products development", and we found 266 documents. We selected the research period from the year 2007 until 2015, and the number of documents has reduced to 190. Subsequently we selected the field of research as "Social Science", and deleted the "Technological Sciences" and "humanitarian arts", and we found 78 documents. For the 78 documents, we selected three research areas: "Engineering", "Government laws", and "business economy", and we found 66 documents. We refined the search for the document type "article", and we found 45 articles. Of the 45 articles, there were no articles in the Portuguese language, and we selected for reading only the articles in English, which totaled 38 articles to the review of the literature of the period. We read the abstract of the 38 articles and we selected 20 articles

## DATA ANALYSIS

The first phase of the processing of data was to relate the environmental product development practices, listed by the three respondents. We presented in Table 2 the environmental practices listed by the three respondents, categorized the practices made by Embraer for the thematic units. We selected the thematic units according to the literature.

Table 2: Analysis of environmental practices in product development.

Thematic Units	Embraer Practices
Innovations Management	<ul style="list-style-type: none"> <li>- Coordinated by Directorate of technical development.</li> <li>- Learning across the enterprise with the University to generate new knowledge through courses and lectures on life cycle of products.</li> <li>-Replacement of paper by electronic means (manuals, etc) on planes</li> <li>-INNOVA Project encourages employees' participation in innovation.</li> <li>-Partnership with Braskem and Natura to share knowledge on sustainable environmental management;</li> <li>-69 implementation ideas (on average) per day/ by employees for KAIZEN;</li> <li>-Sustainability issues became part of business decisions;</li> <li>-Anticipation to changes in legislation;</li> </ul>
Product Development	<ul style="list-style-type: none"> <li>-The Legacy 500 was developed with a noise level lower than required by the law;</li> <li>-DIP (integrated development) enables integration with other areas in the process of product development.</li> <li>-Methodology for product development: High level requirement; environmental contract, in general, laws and documentation annex with the environment.</li> <li>-Technological development area in relation to the AVC (plane flying with 30 years with efficiency);</li> <li>-Focus on safety first.</li> <li>-DFE (Design for Environment);</li> </ul>
Sustainable product development	<ul style="list-style-type: none"> <li>-Implementation of DIPAS (Integrated Development of environmentally sustainable products) – 2009;</li> <li>-Airplane manufactured with composite (lighter, less fuel, less emissions)</li> </ul>
Environmental management – CSSM External Pressure –	<ul style="list-style-type: none"> <li>-Special attention to external and internal noise;</li> <li>-Replacement of paper by tablets in the check-list;</li> <li>-Evaluate contract suppliers in relation to environmental practices (in conjunction with the area of quality, manufacture and engineering);</li> <li>-Problems with disposal of composite;</li> <li>-Dispose of aircraft in the desert;</li> </ul>
Certifications (CSSM)	<ul style="list-style-type: none"> <li>-First company certified with ISO 14001 (the largest to the smallest plants) and their suppliers;</li> <li>-REACH (European legislation)</li> <li>-Increase of note in the product stewardship.</li> </ul>
Recycling – CSSM	<ul style="list-style-type: none"> <li>-Use of products which can be recycled and avoid future risk.</li> <li>-Partnership with AFRA (Aircraft Fleet Recycling Association);</li> </ul>
Reverse Supply Chain –CSSM	<ul style="list-style-type: none"> <li>-Return of packaging to the manufacturers;</li> </ul>
Disposal and after use - CSSM	<ul style="list-style-type: none"> <li>Technical manual for customers with disposition instruction..</li> </ul>
Environmental Concern – CSSM	<ul style="list-style-type: none"> <li>-Awareness of people;</li> <li>-DIPAS</li> <li>-Sustainability campaigns in newspapers.</li> <li>-Flight Trials (many items tested simultaneously)</li> </ul>
Social Responsibility	<ul style="list-style-type: none"> <li>-Reduction of noise to affect least the local community;</li> </ul>
Legislation	<ul style="list-style-type: none"> <li>-Regarding to noise reduction (Legacy 500, 33 decibels less noisy than the legislation requirement);</li> <li>-Pro-activity with respect to legislation, mainly in Europe;</li> </ul>



	-Observation of candidate substances to be tracked, seeking alternatives;
Marketing	Intern – DIPAS for engineers; External – Dow Jones – financial performance-oriented valuation of shares – shareholder stakeholder.

Source: Data of the research

In the second phase of the analysis, we related to the company's environmental practices concerning the survey of Morilhas (2007) with current environmental practices, reaching thus the aim of analysis of longitudinal form. We used the same thematic units of Morilhas (2007) which we present in Table 3.

Table 3: Longitudinal study – Embraer 2007 to 2015

<b>Environmental Management</b>	<b>Embraer 2007 (MORILHAS, 2007)</b>	<b>Embraer 2015</b>
Realization or not of integration with other areas in product development process participation and decision criteria	Mainly the area of engineering and manufacturing. The area of the environment does not perform. The environmental practices are adopted from the master plan.	-Implementation of DIPAS (2009); -decision criterion: security; authorization of the Board to take decisions, but the issue of sustainability is part of business decisions;
Environmental Management Model	ISO 14000; SIG-MASSQ. (environment, health, safety and quality).	-DFE (Design for environment) -ISO 14001 -Product stewardship
Environmental Practices	ISO 14000, customer requirements, life cycle assessment, preservation of material resources, energy efficiency.	-Noise and emissions; -Replacement of paper by tablets in the check-list; -Use of composite;
Motivations to adopt environmental practices	Customers requirements, preservation of material resources, re-use, energy efficiency.	-Take account of the legislation; -Marketing-media pressure; -Competitive advantage – long-term thinking.
Decision before the process	There are no decision making of environmental management	High Level Requirement (contractual and environmental) laws; -DFE;
Changes in the process of product development after the adoption of environmental practices	Greater level of environmental awareness of those involved in the development process.	-Amendment of the packaging; -Less noise than required; -Sustainability issues are part of business decisions;
Results obtained to ensure the continuity of environmental practices	Improving the company's image for the consumers.	To be competitive in European and American market.
Reverse Logistics	No	-Return of packaging manufacturers; -Partnership with AFRA

Most important agents for the product development process	Nine tied as the most important items, including shareholders, top management, end user and legislation. Does not include the environment as the most relevant.	From eleven items, nine considered as the most important, including the environment. Society and NGOS' agents were considered less important.
Integration with customers and suppliers-supply chain management	With clients, the company seeks to meet customers ' requirements. With suppliers, the company is who determines some environmental requirements.	-Evaluation and contracts with suppliers concerning environmental practices (set of the areas of quality, manufacturing and engineering);
Stages of the product development process in which environmental aspects have been considered.	In the process of development, environmental aspects are considered only in the validation of suppliers and in control and noise emissions, and recycling only in factory rejects and not at disposal and after use.	All. DIPAS and DFE; SSCM; Emissions and noise; Discard; post-use: products which can be recycled and avoid future risks; Dispose of the aircraft in the desert; Disposal of the components (e.g., composite)
Environmental experts in the development process	No. The Department is starting now, it the department that causes such concerns. Materials engineering is concerned, not projects.	Yes, in all the stages (DIPAS and DFE)
Moments when environmental aspects are considered in relation to the development of products made by the company	In the raw material and manufacturing (water jet cutting)	-Raw materials, manufacturing, suppliers; -Focus on awareness of employees; -Tests (flight tests);
Moments when environmental workers are consulted during the product development process	At the stage of raw material.	-All phases – DIPAS; Since the conceptual definitions through verification, testing and certification
Disposal and post-use	Not found in the Morilhas study (2007)	-Technical Manual for customers with disposition instruction;
Reasons for which they decided to adopt ISO 14000	Best environmental processes.	-First aircraft company certified in ISO; -Marketing;
Evidence of actions and environmental practices developed by the company	It is starting to do it	There is concrete evidence.

Source: survey data.

## DISCUSSION OF RESULTS

The first thematic unit is the integration of environmental management with other areas in product development process. In Morilhas (2007) the area of the environment was not integrated with other areas. With the creation of the DIPAS (integrated development of environmentally sustainable product) in 2009 the environmental criterion is taken into account in all stages of product development, showing a great evolution in relation to environmental practices.

On the issue of environmental management Model in 2007 the company only owned ISO 14000 certification. In 2015 the company has ISO 14001, in addition the DFE (Design for environment) and note the certificate Product Steward Ship. Product Steward Ship certificate is a certificate that measures the impact reduction, environmental health and safety. This certificate

also aims to identify and graduating from the company that seeks to develop products redrawn to be more durable, re-usable, which are made with recycled materials and causing less damage to the environment. Therefore, about the company's environmental management Model, it presented evolution during the period researched.

Studies such as the one of Prajoro, Tang and Lai (2014), show that the diffusion of ISO 14001 is reflected in a cross-functional improvement in organizations, which do not only focus on certification, but more importantly, they look towards environmental management practices. The DFE is regarded as a tool of sustainable innovation essential to relate design with environmental sustainability of products (EPPINGER, 2011).

In relation to environmental practices, Morilhas (2007) found the customers' requirements and energy efficiency in response of his respondents. In 2015, the customers' requirements and energy efficiency were not mentioned as environmental practices, but effective action in relation to noise and emissions. Furthermore mentioned the replacement of paper by tablets in the checklist, which benefits the company in environmental terms and in terms of shared responsibility.

Corroborating with the findings of Wolf (2011), when there are internal organizational integration, high levels can be achieved through shared responsibility between functions, what happens in the case of the checklist made in Embraer and referred to by interviewed number three. However, the four companies researched by Wolf (2011), in general, believe they have earned with sustainable supply chain management, but all reported that find it difficult to quantify, as was described by interviewed number two of Embraer as the amount of paper saved mentioned in the replacement of paper by the tablet.

Another environmental practice is the use of composite material for aircraft manufacturing. Composite generates environmental gains for being a lighter material, which lets the airplane lighter and consequently, it requires less fuel for the flight.

As for the motivations for adoption of environmental practices, Morilhas (2007) found again the requirements of customers and energy efficiency, the preservation of material resources and re-use. However, we did not managed to relate the findings of Morilhas (2007) when it concerns to product development. In the present study, it was observed that the compliance is the greatest motivation to adopt environmental practices, as well as the competitive advantage of being proactive on the issue of compliance, where the company is seen as an "early rider" presented by Porter and Van der Linde (1995). The marketing was also mentioned as motivating for one of the three respondents in this study.

In 2007 there was no environmental management decision-making before the process, but in 2015 there was, with two tools: the DFE and the "High Level Requirement", which analyzes contracts with suppliers and environmental issues before the decision-making process.

Morilhas (2007) mentions a greater level of environmental awareness of those involved in the development process in relation to changes after the adoption of environmental practices. In 2015, two of three interviewees mentioned that sustainability issues are part of business decisions, and that the company has lower noise aircraft of that required by law, which shows a change of awareness in the development process of the product not focusing only on the legislation. In addition, today the company counts with the change of packaging, which are all returned.

To ensure the continuity of environmental practices, in 2007 the company believed in improving the company's image for the consumers. In 2015, the company wants to be competitive in the European and American market. This is due to the fact of Embraer be a smaller company compared to Boeing and Airbus.

As for the most important agents for the development process of the product the findings in 2015 were similar to the findings of Morilhas (2007). In 2007, nine items were tied as the most

important, among them shareholders, top management, end user and legislation, stating that the environment was not included as the most relevant.

However, checking Morilhas's dissertation (2007), the environment had the score 9 of 10, of a scale from 0 (less important) to 10 (very important), IE, it was considered an important agent for the product development process, although it was not considered by the author. In 2015, of eleven items, nine items were considered as the most important, including the environment, whereas scores above 8 are considered as an important agent.

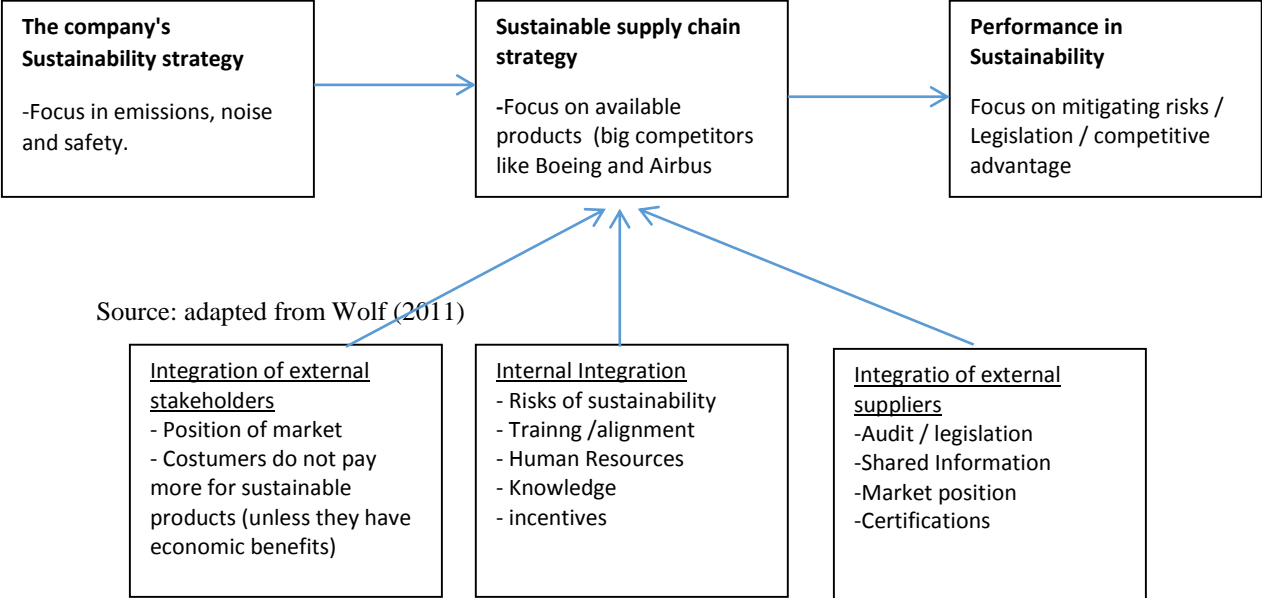
Society and NGOs were considered the less important agents getting the scores 3 and 4, converging with the findings of Walker and Jones (2012), where NGOs were not listed as external factors of pressure of the integrated development of environmentally sustainable product, and diverging from the results found in this study. Schneider et al. (2014), in their longitudinal study, found different weights in the areas over the years, and the environment, for one of the companies surveyed, was behind the final consumers. However, the authors did not mention the criterion used for the classification of importance.

Regarding the integration with customers and suppliers, in 2007 the company sought to meet customers' requirements, but with suppliers, the company is the one which determines some environmental requirements. In 2015, we found divergence in the findings. An assessment is made of contracts with suppliers concerning environmental practices, together with the areas of quality, manufacturing and engineering. However, one of the interviewees mentioned that with some suppliers they had no "power", since these vendors work with much bigger companies like Boeing and Airbus.

The findings of Wolf (2011) suggest that the sustainable integrated supply chain is stronger when the corporate sustainability strategies give empowerment decision makers decide to supply chain, which does not happen with the case study in question, where the suppliers are the same as the major airlines as Boeing and Airbus and there are few suppliers.

In order to enhance the discussion of results, and since the company researched uses around 80 suppliers, we found necessary to make a figure showing the Sustainable supply chain Management of Embraer (Figure 1).

Figure 1: Sustainable supply chain management of Embraer



In the external integration of upstream chain partners, the goal is to generate innovative products and processes in the issue of sustainability, for example, the aeronautical company wants to manufacture planes emitting less carbon during its life cycle (WOLF .2011).

Concerning the barriers, these can also be external, such as regulations, consumers' desire for low prices, lack of commitment from suppliers and the type of industry, all of them applicable to Embraer.

In the analysis of the stages of the product development process in which environmental aspects were considered, there were also developments. In Morilhas (2007), environmental aspects were considered only in the validation of suppliers and control of emissions and noise. Recycling was made only of factory rejects and there was no environmental practice in the disposal and post-use. In 2015 the findings were different. Environmental aspects are considered in all stages, and as proof of that, all respondents cited the DIPAS and DFE when questioned. In addition, the disposal of the aircraft is done in the desert due to climatic conditions, which increases too much the oxidation time of the plane. The composite material chosen recently for the manufacture of the plane is also used to make building countertops.

One of the interviewees mentioned that one of the aircraft was manufactured with inferior noise legislation. When asked why, he said the company wanted to be ahead of competitors, as a benefit to the consumers. The findings reinforce the views of the literature, that environmental considerations should go beyond a particular stage, focusing on the importance of cross-functional management environmental management decisions (PRAJORO; TANG; LAI, 2014).

When they were asked about the presence of environmental specialists in the development process, and if the same are consulted, Morilhas (2007) found that there were not, that is different from what happens today with the DIPAS and DFE.

In the Morilhas' research (2007), he noted that only during the process of choosing the raw materials and manufacturing is that environmental aspects were considered. In 2015 we noted that in addition to the choice of raw materials, environmental aspects are also considered in the selection of suppliers, in the awareness of employees and even in tests done on aircraft, called flight tests, which is regarded as the last stage of product development. One of the interviewees mentioned that several tests are made simultaneously to decrease the amounts of required flights, thereby reducing the emission of gases during this process.

There was no reverse logistics in the company in 2007, according to Morilhas (2007). However, in 2015 the company has partnership with AFRA-Aircraft Fleet Recycling Association-which has as its slogan "REsale, REcycle and REtired". This means that when a plane is no longer fit to fly, everything inside the plane goes to this Association that recycles, resells or retire everything inside the plane. So, the plane part to be thrown in the desert is quite empty, which reduces the environmental impact. Another reverse logistics is in relation to the return of the packaging of large pieces, such as packaging of wings and aircraft turbines to the manufacturers, which before 2007 they were not returned.

In the discard and post use, there was evolution between 2007 and 2015. Before, there was no information, but at the beginning of 2015, the company began supplying for buyers of aircraft, technical manual with instruction for disposal.

Finally, the paper presented by Morilhas (2007) have not been included within the environmental management, the Innovation Management and Marketing.

In the management of innovation, we observed, by the answers of the interviewees, that there is learning across the enterprise with the University to generate new knowledge through courses and lectures on life cycle of products. In addition, Embraer has a project called "Project INNOVA" that encourages employees' participation in innovation. There are also Embraer's

partnership with Braskem and Natura to share knowledge on Sustainable environmental management through regular meetings.

These actions, considered innovative in the context of environmental companies, was approached by Wolf (2011), who noted the lack of experience and knowledge in sustainability as factors that hinder the SSCM. For the author, elements as to create a new position, invest in training, and look for an external consulting help to integrate the traditional chain with integrated sustainable chain.

Concerning the external marketing, the company participates in the Dow Jones Sustainability Index, and concerning the internal marketing, with the release of DIPAS, mainly for employees who are engineers.

It was clear in the interviews, that the participation of the company in the Dow Jones Sustainability Index is facing the financial performance, since the objective is the recovery of the stock, in other words, the concern with the shareholder expectations. These findings corroborate with those of Wong (2014), indicating that environmental reputation is positively related to the financial performance in terms of ROA (return on assets), profit margin and EPS (earning per share). The findings of Wolf (2011), also suggest that the integration of external stakeholders, the publication of the company in the Dow Jones Sustainability Index, get good results in marketing terms.

## **CONCLUSION**

The present study aimed to identify the evolution of environmental practices in product development and the integration of these practices throughout the supply chain.

It is a longitudinal study and for this reason, the comparison has been made with regard to practices in 2007 and the practices in 2015.

We identified developments in environmental practices in product development in Embraer during the period from 2007 to 2015. Therefore, there is evidence of environmental practices within the company currently, while in 2007, the same were starting (MORILHAS, 2007).

According to Morilhas (2007), environmental practices related to the process of development of products made by Embraer are mainly related to the legislation, requirements of clients, funders (World Bank), preservation of natural resources and increased energy efficiency.

Regarding the environment, in the Morilhas study (2007), he reported that they used to invest in the environment, but the area that needed to develop more was the product development. In 2009, according to the interviewed number one, the company created the DIPAS, generating a significant change in the evolution of environmental practices and integration with other areas.

The legislation, which was one of the main concerns of the company in 2007, remains in 2015, as well as customers` requirements. In this research, the four main criteria listed by the respondent number one were safety, weight, cost, and manufacture. The variable technology continues to be valued by the company, how it was in the findings of Morilhas (2007). Different from what was found in the search of Wolf (2011), the technology of information was not seen as a major factor that prevents or inhibits sustainability.

The greatest contribution of this research was to identify the evolution of environmental practices and highlight the importance of these measures in the development of the product. It is still an exploratory subject and for this reason, we suggest for future surveys to be made other longitudinal studies in other companies studied by Morilhas (2007).

## **BIBLIOGRAPHICAL REFERENCES**

- ALBLAS, A.; PETERS, K.; WORTMANN, J.C. Fuzzy sustainability incentives in new product development: An empirical exploration of sustainability challenges in manufacturing companies. **International Journal of Operations & Production Management**, v. 34, n. 4, 2014.
- DESROCHERS, P. Did the invisible hand need a regulatory glove to develop a green thumb? Some historical perspective on market incentives, win-win innovations and the Porter hypothesis. **Environ Resource Econ**, 2008.
- EPPINGER, S. The Fundamental Challenge of Product Design. **Journal of production and innovation management**, 2011, pp. 399–400.
- FUENTES, C. Green Materialities: Marketing and the socio-material construction of green products. **Business Strategy and the Environment**. Sweden, 2014.
- MORILHAS, L. **O estágio emergente das práticas ambientais no desenvolvimento de produtos das organizações inovadoras: um estudo exploratório**. Dissertação de Mestrado. FEA-USP. 2007.
- MORILHAS, L.; NASCIMENTO, P. T. A Construção de Um Modelo de Desenvolvimento de Produto Com a Variável Ambiental. **XIV SIMPEP**, 2007.
- PAGELL, M.; GOBELI, D. How Plant Managers' Experiences and Attitudes Toward Sustainability Relate to Operational Performance. **Production and Operation Management**, v 18, n. 3, May–June 2009, pp. 278–299.
- PAGEL, M.; WU, Z. Building a more complete theory of sustainable supply chain management using case studies of ten exemplars. **Journal of Supply Chain Management**, 2009, pp. 37- 56.
- PRAJORO, D.; TANG, A. K. Y.; LAI, K. H. The diffusion of environmental management system and its effect on environmental management practices. **International journal of operations and production management**. V. 34, n. 5, 2014.
- PORTER, M. E. **Estratégia competitiva: técnicas para análise das indústrias e da concorrência**. 7. ed. Rio de Janeiro: Campus, 1991.
- PORTER, M. E.; KRAMER, M. R. Strategy and Society: The Link between Competitive Advantage and Corporate Social Responsibility. **Harvard Business Review** 84, no. 12, 2006.
- PORTER, M. E.; VAN DER LINDE, C. Toward a New Conception of the Environment-Competitiveness Relationship. **The Journal of Economic Perspectives**, v. 9, n. 4, 1995.
- SCHREINER, L. C.; MORILHAS, L. J.; MELLO, A. M. A evolução das práticas ambientais no desenvolvimento de produtos nas organizações no período de 2007 a 2014. **ENGEMA – Encontro internacional sobre gestão empresarial e meio ambiente**. São Paulo, 2014.
- WALKER, H.; JONES, N. Sustainable supply chain management across the UK private sector. **Supply Chain Management: An International Journal**, 2012, pp 15-28.
- WHEELWRIGHT, S. C.; CLARK, K. B. **Revolutionizing product development: quantum leaps in speed, efficiency, and quality**. New York: The Free Press, 1992.
- WOLF, J. Sustainable supply chain management integration: A qualitative analysis of the german manufacturing industry. **Journal of Business Ethics**, 2011, pp. 221-235.
- WONG, C. W. Y.; LAI, K. H.; K. C. CHANG; LU, C. S. Uncovering the value of green advertising for environmental management practices. **Business strategy and the environment**, 2014, pp. 117-130.
- YIN, R. K. **Estudo de caso – planejamento e métodos**. Porto Alegre: Bookman, 2001.