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How Can Green Supply Chain Management Contribute to the Product Development Process

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Abstract. The product development process has the following phases: concept, research, analysis, development and launch. At the same time, the supply chain management needs integrations with suppliers, manufacturers and customers. When a company develops a product, it is necessary to link the product development process to the supply chain management and think about how it can become greener. The aim of this article is to identify the main bibliography references about the product development, oriented towards the green supply chain management. For the literature review, efforts have been made to search the concepts of product development process, supply chain management, green supply chain management, sustainable supply chain management and triple bottom line. Methodology: For this bibliography, some articles were selected from the Periodical Portal available through Capes/MEC, using an advanced search. The result: The topic of product development oriented to the green supply chain management is still lacking consensus, being treated with a broad approach, and a model that orients the companies to develop a product aimed at the green supply chain management was not found yet.

Keywords. product development, supply chain management, green supply chain management, triple bottom line

Introduction

The product development issue is associated with several factors, such as design for quality and manufacturing. However, it is essential to recognize the importance of the product development associated with the supply chain, since the integration of multiple processes related to supplies, treated in the selection of suppliers, production processes and product distribution, should be considered. In this way, decisions are taken regarding the product aspect and the entire supply chain integrated in the product development [1].

Source [2] explains that, about 15 years ago, some authors started dealing with the need to manage the Supply Chain, rather than the individual work of the company. This

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individual work of companies made it difficult to achieve the desired results. Supply chain alignment occurs with the synchronization and integration of processes and activities between the links in the supply chain. The author cites examples of researchers who dealt with the theme [3], [4] and [5].

The companies in a supply chain need to be integrated, in order to share product design efforts, which should be linked to customer needs and operational processes, considering three domains: product, process and supply chain [11]. When developing a product, the company should consider the integration of the supply chain links: supplier, target company and customer.

Due to questions related to resource constraints and requirements bound by legislation in force, it is important to highlight the concept of green supply chain, which has been addressed in topics such as product line design, supplier selection, and logistic process [7]. The company should seek an environmental collaboration, which is the direct involvement of a company with other links in the supply chain, such as suppliers, customers and production process. This collaboration occurs in the joint planning, where the aspects for the reduction of environmental impacts of products and processes are taken into consideration [8].

This study has the general purpose of analyzing publications related to the topics of product development and green supply chain. As specific goals, this study aims to verify articles from journals, authors and topics about product development and green supply chain, as well as analyze the trend of topics of product development and green supply chain management.

1. Methodology

For the preparation of this bibliographic review, some papers were selected from the Periodical Portal available through Capes/MEC, through an advanced search using the following keywords: product development process, green supply chain management, sustainable supply chain management, and triple bottom line. In the advanced search, filters were not used in relation to the years of publication, thus, all articles published until 2017 were searched.

This is an exploratory research, developed on a research question or problem, with few or no previous studies that can bring further information about it [9]. The exploratory characteristic is evidenced in the study, since different keyword searches were carried out, with the intention of verifying the convergence on the researched subjects.

The research process is qualitative and therefore subjective, and involves the analysis and reflection on the perceptions and understanding of social and human activities [9]. The study is classified as qualitative, since it was performed based on reading and analyzing articles published in periodicals about the research topic.

The research result is classified as basic, since it is conducted to increase understanding on general issues, without emphasis on immediate application [9]. The keywords were researched and, afterwards, the subject in evidence was analyzed, in order to present the results of existing subject relationships in the literature.

2. Literature Review

The product development process is considered one of the critical processes for companies to grow and sustain themselves in the market. The process integration is considered a critical factor when the company is developing a new product, and the integration for the development of new products is possible when there is an integration of work teams, internal procedures, resources, as well as the external integration with the supply chain. The literature indicates that companies that can integrate with supply chain links, such as suppliers and customers, can improve the performance of new products and businesses [10].

With the reduction of the product life cycle and the pressure for increasing the global competitive market, the companies need to focus on the success of new product development. At the same time, the companies are dealing with regulatory and social demands for environmental awareness on a global scale. The complexity of global products challenges the companies to invest in high technology. The challenges have an impact on the entire product life cycle, forcing companies to invest in the concept of operations management, reducing the complexity and quantity of materials in a new product development [11]; [12].

The stages of the product development process have a direct influence on the final product, and the most critical decisions are in relation to production, costs, design, selection of materials, innovation, performance and quality [13].

When dealing with product development and the search for process integration, some topics arise in this context, such as Supply Chain Management, defined as the integration of business processes from the end user to the original (primary) suppliers that provide products, services and information, adding value to customers and stakeholders [14].

A supply chain is formed by suppliers, target company and customers. The target company is evidenced centrally, flanked by suppliers who work directly with it — these are called first tier suppliers. There is another set of suppliers, called the second-tier supplier or the supplier of the suppliers. The target company has a set of customers with which it interacts in a direct way, symbolized by the distributors; and another, with which it interacts in an indirect way, that is, the set of retailers and the final customer. The two commercial relationship ways are called upstream way, towards the suppliers, and downstream way, towards the end customer, as it is shown in Figure 1 [14].

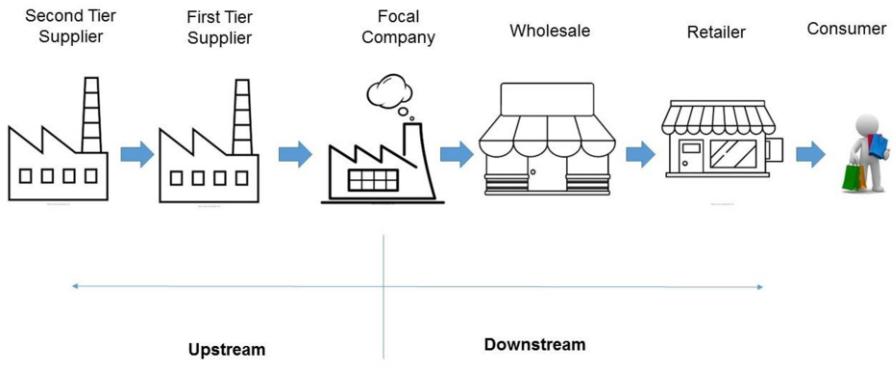

Figure 1. Representation of a supply chain.

The beginning of Supply Chain studies occurred between the late 1980s and the early 1990s, when researchers analyzed the principles of the supply chain management and identified the importance of this management, in the pursuit of cost reduction, information flow improvement, production, products and customer services. As a focus, it is necessary to find the right supply chain for the product, industry, production and product lifecycle. The supply chains are considered complex and expensive systems when not managed in a connected and effective way, and when not established the communication between the links [15].

The focus of Supply Chain Management is the relationship management, in order to achieve a more cost-effective result for all links in the chain. The aim of the supply chain is to meet the needs and expectations of clients with the best cost-benefit ratio. Supply chain management contributes to leverage resources and knowledge in companies that face a competitive and technological development environment [16].

The relational view of the supply chains suggests that the capabilities may be developed by combining the existing resources in different links of supply chain, such as the integration of supply chain links to improve the performance, production time, productivity, and on-time deliveries. The value of collaboration in the supply chain enables inter-organizational learning, implying solving the company's daily problems involving suppliers and/or customers [17].

Source [18] relate the topic of product development and supply chain as one of the eight supply chain business processes. The product development and marketing process show that, for companies be competitive, they must develop and launch new products in an increasingly shorter term, because the product life cycle is short. As already mentioned, [10], [18] also consider the product development process as a critical part for the companies and corroborate that the involvement of the main customers and suppliers in the development of new products is essential to reduce time-to-market. The eight processes are shown in the Figure 2.

With the advance of the supply chain management theme since the late 1980s, new demands, scenarios and legislative pressures have emerged for companies' adequacy. Among these demands, we have issues related to legislation and focused on the producer responsibility, returning to the need of recycling systems in supply chains [19].

[12] published about the process of environmentally responsible manufacturing and the development of new products. In the publication, it was discussed if development process of new products has a positive or neutral impact on cost and timeliness but, at the same time, evaluates the environmental goals and their improvements. The study was carried out using the concept of three-dimensional concurrent engineering (3DCE). The concept of 3DCE is "…the simultaneous development of products, processes and supply chains".

In addition to handle the 3DCE concept, it also treats the environmentally responsible manufacture that integrates product and design issues, with production planning and control and supply chain management, aiming to identify, quantify, assess, and manage the flow of environmental waste seeking to reduce and minimize its impacts on the environment, maximizing the resource efficiency [12].

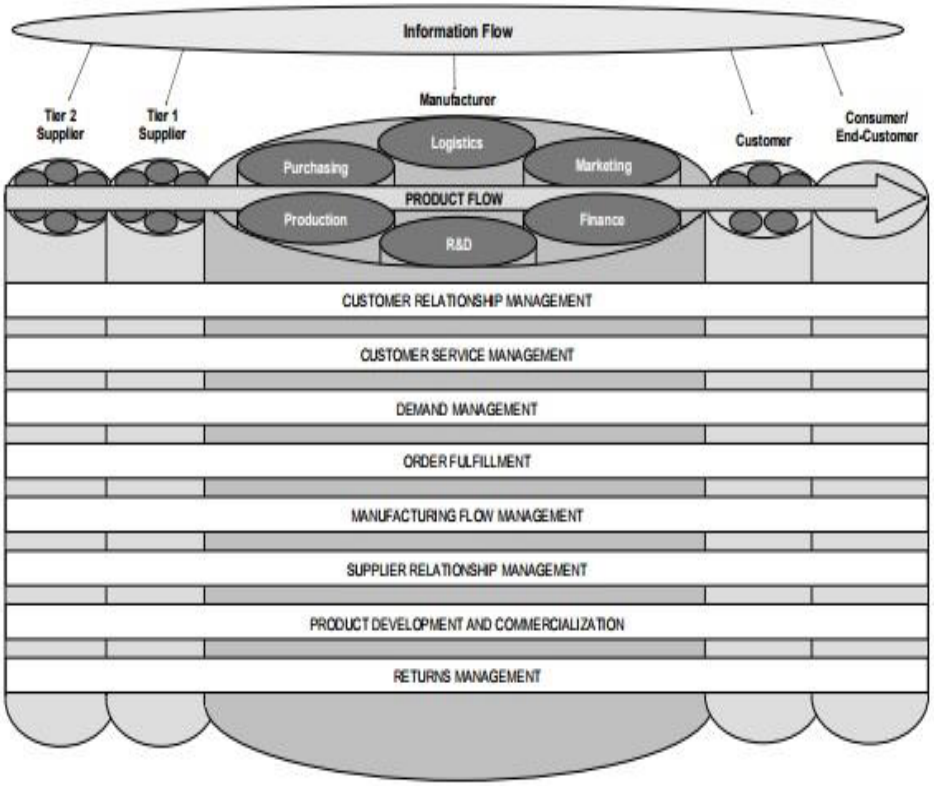

Figure 2. Supply chain management: integrating and managing business process across the supply chain.

The study addresses ERM topics such as product design, process design, supply chain design and integration of product, process and supply chain. In addition, the authors made a comparison between NDP and ERM practices, using the dimensions of 3DCE practice: key metrics, time-to-market, view of life cycle costs, logistics, quality, product design, supply chain management, voice of customer, supplier integration, internal functional involvement, managerial involvement and product, process, and supply chain integration. It is important the understanding of the development integration of new products and environmentally responsible manufacturing, aligned with the development goals of environmental-friendly products. These goals must also be aligned with the decrease of environmental waste, time-to-market reduction, low cost, and quality improvement [12]

In Brazil, Law number 12,305 of August 2nd, 2010 presents the guidelines for the integrated management and the management of solid waste, including hazardous waste, as well as guidelines for the responsibilities of generators and public power and applicable economic instruments. This law regulates aspects related to products, processes and environment, instituting the National Solid Waste Policy [20].

Sustainable initiatives have been considered by companies when they are developing more sustainable methods. The companies are interested in product and service improvements from the sustainable standpoint, to stimulate innovation

opportunity, product quality and potential market opportunities. In order to develop effective products and services, it is necessary to integrate the supply chain [21].

Topics related to environmental issues in the supply and production chain have been considered in several perspectives. Some studies focus on reverse logistics, considering activities such as recycling, remanufacturing and impacts, in order to reduce environmental damage. Other studies focus on transport activities and environmental impacts, mainly in terms of carbon emissions. Similarly, there are studies that characterize and classify supply chains based on environmental performance [22].

The demand from customers, nongovernmental organizations and legislations pressure the companies to develop sustainable activities, increasing the complexity of product design. Some studies on the development of new green products have emerged in pursuit of the sustainability approach to supply chain management, as well as to operations, engineering, supplies and sustainable products. Consequently, the development of new green products needs to be directed towards the development of new sustainable products [11].

In this context, the theme Green Supply Chain Management gained a greater prominence between the years 2011 and 2012, being emphasized in the academic and industrial spheres. The theme highlights the importance of environmental collaboration, which is the target company's direct involvement with suppliers and customers, in order to plan the environmental management and solutions, looking for the reduction of the environmental impact in the production of products and processes and information integration [8].

The Green Supply Chain Management approach is concerned with aspects related to the use of materials and resources such as water and energy. Environmental impacts on air, water and soil can be considerably reduced, by reducing energy consumption, toxic waste generation and gas emissions. Significant savings in energy consumption, water use, and waste and gas generation can occur in the supply chain. These results can be obtained through the reconfiguration of the supply chain and the efficient management of the material flow, achieved through an effective integration of logistics with the production process throughout the supply chain, as can be seen in Figure 3 [23].

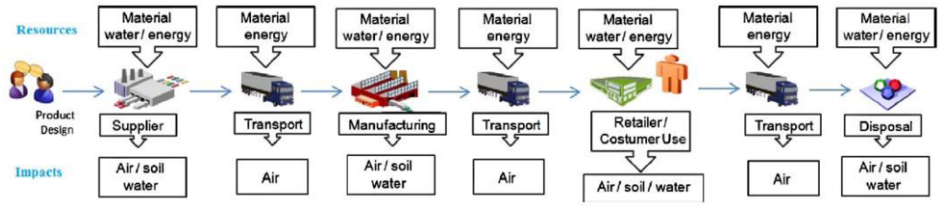

Figure 3. Use of supply chain resources and environmental impact.

A business process more concerned with environmental management can be achieved through environmental pollution prevention technologies, assessment and impact procedures, and pollution control. The target company's practices should be extended to the other links, such as suppliers and customers. Upstream of the green supply chain, we have the impact on procurement policy and eco-design. Downstream,

the collaboration with customers, in relation to packaging, logistics systems that can help in an efficient and effective network of distribution and delivery systems [24].

Considering the topic of the development of green products and supply chains, it is important to analyze the development process of a sustainable product, which requires modifications of the traditional linear process. The design choices are made on the product components to be dismantled and reused, as well as the materials that can be recycled, that is, processed into new ones [13].

The products with sustainable features require interaction and collaboration in the development process. The collaboration in the development processes of new products should occur in internal processes, but also in external relations. The theme of green product development was created from the importance of environmental responsibility [5].

When dealing with product developments, it is worth remembering the resource constraints and the importance of companies thinking about new supply chains or transforming the existing ones, in search of solving this problem that affects companies and infrastructure. The result of these supply chains is the conservation of critical resources such as energy, fuel, inventory and storage losses. Environmental sustainability should be considered, since there is a restriction on non-renewable resources and/or developments of best practices in handling, distribution and recycling of products. The strategies for product development with resource constraints enable the production of affordable and environmentally sustainable products, due to the greater efficiency of the supply chain compared to the traditional view of the product development [22].

Although the management of the green supply chain is important for the economy, we can verify that the research about the theme is in a pre-paradigmatic state. Most of the research has a prescriptive tone, which warns that the environmental impacts should be considered in the management of the supply chain and little attention is still given to the environmental performance and the competitive dimension of operations occurring in the supply chain. In the last decade, the theme has raised in researches, it is possible to perceive this gap. The author has classified five categories that have been explored on the subject: complexity and conflict, uncertainty and investment, antecedents and decisions, characteristics and decisions, characteristics and performance, partiality and discretion [10].

3. Conclusions

This study contributed to show the trends about the concept of green supply chain management and product development process. Although publications have been found on other topics, namely product development, supply chain management, green supply chain management and triple bottom line, these are treated in a broad and general way, not in a more in-depth and integrated approach.

In order to understand the relationship between product development and green supply chain management, it is necessary to develop further study, with an integrated approach, since there is an existing gap.

The proposal for a more in-depth study is based on consultations in search in the Periodical Portal available through Capes/MEC, from where the following results were obtained:

- The topic of product development and supply chain had the first publications in the 1990s, since the theme Supply Chain began to be discussed at the end of 1980;
- The topic of green supply chain management had no publications until 2001 and the largest number of publications occurred in the period between 2012 and 2016;
- The term sustainable supply chain management had some publications between 2002 and 2004 but the largest number of publications is concentrated in the period between 2011 and 2017.

Green supply chain management is a recent theme for the academic and business environment and, at the same time, a concern, as companies need innovation processes, new demands from consumers, pressures in relation to costs and legislation, concerns with non-renewable resources. These needs emerge in depth studies about the subject, related to green products, processes and supply chains.

As a suggestion for future research, it is possible to develop a study that reflects on the development of products oriented to the green supply chain, evidencing the integration of all links: suppliers, target company and distribution, and that worries about the impacts upstream and downstream of a supply chain.

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