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Prioritization of green practices in GSCM: case study with companies of the peach industry

Priorização de práticas verdes em GSCM: estudo de casos com empresas da indústria do pêssego

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Abstract: This article aimed to define priorities for green practices that are observed in supply chains of the peach industry. The research method is the quali-quantitative modeling. The analyzed units are four focal supply chain companies of the peach industry in the region of Pelotas. From the literature on GSCM (Green Supply Chain Management), a model was elaborated for structuring green practices observed in the industry. The model includes three constructs: strategy, innovation and operations. Sixteen green practices present in the literature were distributed among the constructs. A focused group of three specialists adapted the model to the peach industry in Pelotas, eliminating three practices. The rest were prioritized by companies' managers with the support of AHP method of multicriterial analysis. Based on the result, five practices were considered priorities for the industry: Ecodesign, Cooperation, Performance Evaluation, Green Manufacturing and Green Purchases, in this order.

Keywords: GSCM; Sustainability; Multicriterial analysis; Greening of operations.

Resumo: *O objetivo deste artigo é definir prioridades para as práticas verdes que são observadas em cadeias de suprimentos da indústria do pêssego. O método de pesquisa é a modelagem qualiquantitativa. As unidades de análise são quatro empresas focais da cadeia de suprimentos da indústria do pêssego da região de Pelotas. Foi elaborado um modelo para estruturar práticas verdes observadas na indústria, a partir da literatura sobre GSCM (Gestão Verde da Cadeia de Suprimento). O modelo inclui três construtos: Estratégia, Inovação e Operações. Dezesseis práticas verdes presentes na literatura foram distribuídas entre os construtos. Um grupo focado de três especialistas adaptou o modelo à indústria do pêssego de Pelotas, eliminando três práticas. As restantes foram priorizadas por gestores das empresas com apoio do método AHP de análise multicriterial. Com base no resultado, cinco práticas foram consideradas prioritárias para a indústria: Ecodesign, Cooperação, Avaliação de Desempenho, Compras Verdes e Manufatura Verde, nesta ordem.*

Palavras-chave: *GSCM; Sustentabilidade; Análise multicriterial; Esverdeamento de operações.*

1 Introduction

Production strategies of manufacturing companies have been influenced by environmental requirements (Gmelin & Seuring, 2014). Factors such as limitation of raw material, depletion of natural resources and concerns about the disposal of industrial waste, associated with concerns about sustainability, have forced companies to review their production strategies (Dey et al., 2011). Another factor is the construction of a corporate image, which can be affected by poor performance in environmental and sustainability aspects (Zhu et al., 2008a).

In this sense, a significant change has been observed in the industry, and in its supply chains: focal companies have directed more efforts to meet environmental issues, reducing environmental risks and increasing their own eco-efficiency, as well as those of their business partners. Increasing eco-efficiency is more than mere compliance with current legislation, involving other aspects (Tseng et al., 2014). As a result, significant financial gains have been obtained by reducing consumption of raw materials and energy, as well as by recycling waste, or at least by reducing waste in the production process. In short, profit opportunities, social pressures by clients, and association of corporate image to environmentally sound practices have mobilized managers of supply

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chains for the study and adoption of environmental management techniques, the so-called Green Management Green Supply Chain (Green Supply Chain Management GSCM) (Zhu et al., 2008a; Zhu & Sarkis, 2006). Zhu et al. (2008b) use the term greening chain for integrated actions for sustainability in the supply chain.

According to Rao (2007), GSCM has been studied and adopted in various industries. One of the greening objectives of chains is related to the fact that companies want to go beyond the mere reduction of waste and energy and pollution control, but also include innovative actions to expand its market share (Paulraj, 2009). Additionally, green markets niche, where customers are willing to consider environmental aspects, not just price and quality in their purchases (Moraga-Gonzalez & Padron-Fumero, 2002), have been observed and their exploitation is an objective of focal companies and their respective supply chains (Rousseau & Vranken, 2013). In short, in addition to meeting the environmental regulations, companies with environmentally sound practices aim at greater long-term competitiveness, which includes goods and service to new markets (Sellitto et al., 2012).

One of the industries with significant potential for greening their supply chains is the food industry, given the intensive use of natural resources and the organic nature of the product (Chang et al., 2012). For this article, within the food industry, interests in particular the fruit growing industry and within this, the peach industry. The fruit industry includes planting activities, management, harvesting, processing (production of jams, preserves, and canned fruits in focal companies), distribution, and retail. The chain is supported by complementary service activities, such as the production of seeds, pesticides, packaging, logistics, financial services and advertising. This article devotes interest in the industrialization tier of the chain, which includes the focal companies: the object of study are four focal companies of the peach industry in Pelotas, in southern Rio Grande do Sul, southern Brazil. The focal company leads the SC analysis (Talamini et al., 2005) and has priority in the strategy formulation (Seuring & Müller, 2008a), influencing strategic definitions of the other members of the SC (Carvalho & Barbieri, 2013).

The purpose of this article is to define priorities for green practices that are observed in the peach industry supply chains. The research question is: how to prioritize green practices that can be adopted by focal companies of the supply chains of the peach industry? The specific objectives are: to define a model to structure green management practices observed in the industry; prioritize these practices from the perspective of the major companies in the industry; and define the practices that can be focused by companies in greening efforts of its chains. The research method is qualitative and quantitative modeling (Morabito & Pureza, 2010). The main contribution of this article is to provide to focal companies of the peach industry a tool for prioritizing green practices. Such prioritization can help directing greening efforts in order to improve the eco-efficiency of the entire chain. Such efforts can create an environmentally friendly corporate image and consequently help increase the competitiveness of the company and the chain. Eventually, with suitable modifications, the instrument can be applied to other industries, especially food industries.

The rest of the paper is organized in: review, methodology, research, results, and final considerations.

2 Green Supply Chain Management (GSCM)

According to Zhu et al. (2008a), the GSCM is the integration of environmental thinking applied to industrial management in its various facets, from design to the final destination of products, through the selection of raw materials, manufacturing processes, transportation and delivery, end user, and return waste. Bowen et al. (2001) define the GSCM as the integration of the company's purchasing plans with environmental activities in the SCM, in order to improve the environmental performance of suppliers and customers. GSCM aims at developing partners along the chain, seeking to encourage hiring of supplies and services from companies that have ISO 14000 type certification, or at least show concerns about the reduction of environmental impact in the chain (Sarkis, 2003). Large & Thomsen (2011) mention that the GSCM comprises at least the following typical activities: design, selection of raw material, green purchasing, green manufacturing, green distribution, monitoring of environmental impacts throughout the product life cycle, and reverse logistics. In reverse logistics, Green et al. (1996) highlight reuse, remanufacturing and recycling activities. According to Sarkis (2003), reverse logistics concerns are observed since the early product design process, including specs for the future disposal, dismantling, or reuse, as well as waste transportation and disposal.

Figure 1 shows a functional model of the GSCM, integrating typical activities of the supply chain with environmental concerns on the various types of returning wastes (Sarkis, 2003).

The main objective of GSCM is to make the chain eco-efficient, ie, meet both environmental and

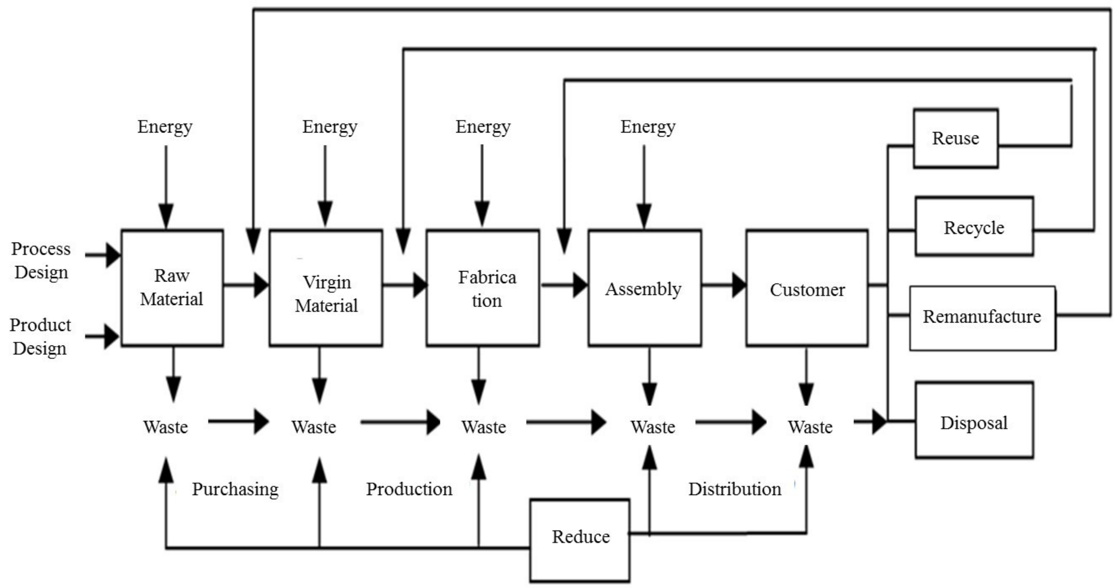

Figure 1. Functional model of the supply chain integrated with environmental practices. Source: adapted from Sarkis (2003).

economic requirements, increasing profits and market share while showing substantial improvement in environmental indicators of the company and chain partners (Sellitto et al., 2012). The implementation of GSCM includes environmental objectives, as well as primary objectives of supply chain management, such as profitability, quality, or cooperation. The GSCM includes the chain management a new goal: the eco-efficiency (ElTayeb et al., 2010).

According to Srivastava (2007), the main stimulus for the implementation of GSCM is economical. Usually, one can justify its adoption by the possibility of reducing the use of inputs, raw materials, and energy, and develop new market opportunities. Bowen et al. (2001) report that in the short term, financial performance may not be satisfactory, given the multiple systemic aspects that should be considered in deployments. In a strategic perspective, Srivastava (2007) states that GSCM can reduce the environmental impact of operations in the supply chain by integrating with other competing objectives, such as quality, cost, flexibility, services or deliveries. The adoption of techniques belonging to GSCM usually requires change management perspective: the company ceases to remedy problems at the end of the process (end-of-pipe) and passes to prevent them throughout the process. Finally, Holt & Ghobadian (2009) emphasize that compliance with environmental laws, consumer pressures or demands of new markets, in addition to economic motivators, can encourage the adoption of environmentally sound practices, the so-called green practices.

2.1 Theoretical support for the research: the GSCM structure

The research model proposed for this article organizes in three blocks the green practices observed in greening programs and in GSCM implementation programs: strategy, innovation, and operations, as in Figure 2 (Sellitto et al., 2013.). The model was used in full to measure the result of green practices in the automotive industry (Sellitto et al., 2015).

Strategy in GSCM includes six dimensions: (i) Formulation, including methods and techniques for the formulation of goals and plans regarding environmental aspects that must be coherent with goals of the SCM (Seuring, 2013); (ii) Performance evaluation, including methods and techniques for the assessment of the degree of adherence of the GSCM to environmental goals (Seuring & Müller, 2008b); (iii) Cooperation, including the capacity of companies to cooperate and interact in the execution of green strategies (Sheu & Chen, 2012); (iv) Communication, which considers the type and methods to identify and promote communication in the chain; (v) Barriers, including the factors that block the implantation of GSCM such as operational costs for implementing green practices and conflicts with operational goals and priorities (Shi et al., 2012); and (vi) Drivers, including the factors that facilitate the implementation of GSCM, such as organizational support for green actions, fostering social capital (reciprocity and trust between the actors), government involvement and institutional pressures (Wu et al., 2012).

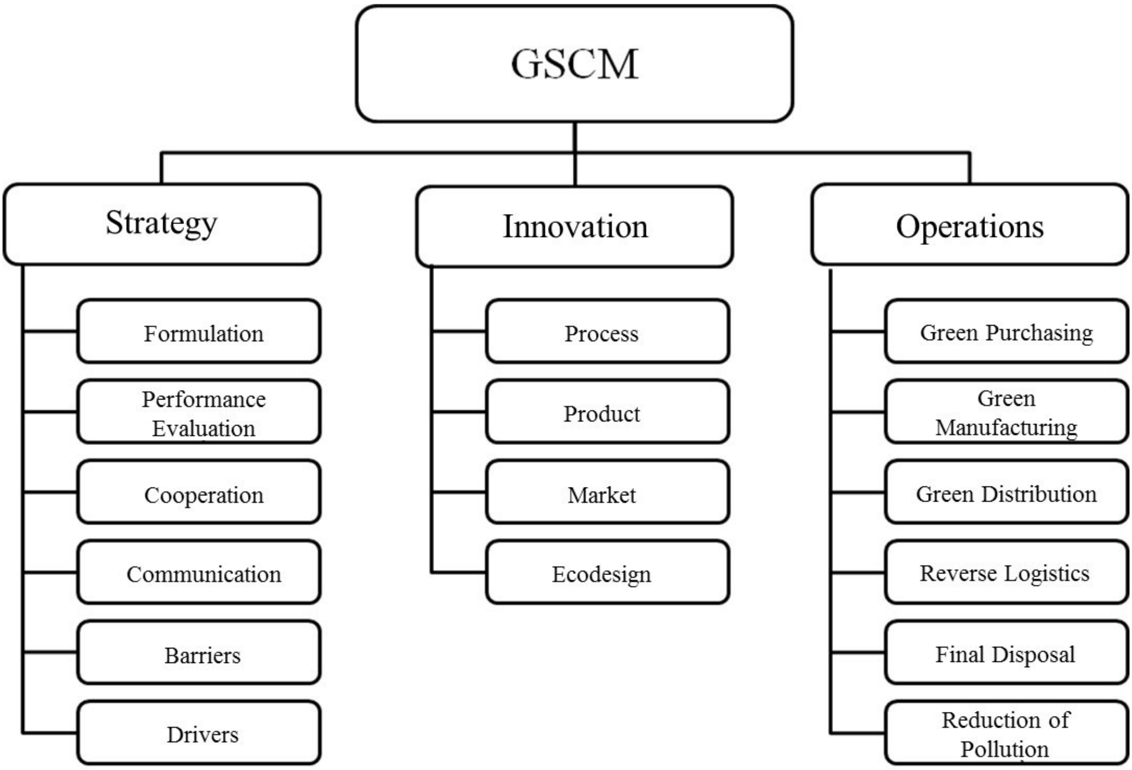

Figure 2. Organizational model of green practices in GSCM. Source: Sellitto et al. (2013).

Innovation in GSCM includes four dimensions: (i) product, including changes in product design, so that its use bring lower environmental consequences (Gupta & Palsule-Desai, 2011); (ii) process, including changes in production processes, causing lower environmental impact (Seuring & Müller, 2008a); (iii) market, including marketing actions to identify and develop customers willing to consume environmentally friendly products, not necessarily focused only on price and quality (Moraga-Gonzalez & Padron-Fumero, 2002), and considering approaches to network, i.e. relations between markets and the various tiers in the chain (Testa & Iraldo, 2010); and (vi) Ecodesign, including the product's relationship with the environment, according to a structured approach over the entire product life cycle from the raw material and energy to return after the use (Zhu et al., 2008a).

GSCM operations include six dimensions: (i) Green purchasing, which are characterized by the integration of environmental requirements to purchase policies (Shi et al., 2012) ; (ii) Green manufacturing, which implements practices that reduce the environmental impact of the manufacturing process (Srivastava, 2007); (iii) Green distribution, which implements practices that reduce the environmental impact of product distribution process (Wu et al., 2012); (iv) Reverse logistics, which manages closed cycles of materials and recovering value, returning waste as raw material or fuel (Srivastava, 2007); (v) Final waste disposal, referring to the construction and management of facilities for disposal or incineration of waste (Shi et al., 2012); and (vi) Reduction of pollution, modifying operating practices to reduce environmental attacks (Large & Thomsen, 2011).

3 The research

The research question is: how to prioritize green practices that can be adopted by focus companies of supply chains of the peach industry? The research method is the qualitative and quantitative modeling: we developed a prioritization support model that was applied to four focal companies of supply chains belonging to the peach industry. The construction of the models employed mainly the theoretical framework built on the literature reviewed, supported by data collected by direct observation of production processes and waste control; documentation analysis (evaluation report of suppliers and waste management); and meeting with managers of the studied focal companies, all belonging to the Pelotas peach industry.

The peach industry has economical, historical, cultural, and social importance in Pelotas. Peach cultivation occupies about 1,200 farms, more than

98% belonging to family farming, occupying thirteen thousand hectares. The region is responsible for more than 95% of the production of the state and more than 60% of the country. The industry is represented by SINDOCOPEL (Union of the Candy and Food Preserves Industry), which brings together thirteen producers that benefit peach. The production is about 70 million cans per year, representing more than 50 tons of peach. Out the thirteen companies, three are large and take strategic decisions that influence the entire industry. The three large companies agreed to participate. Not to disregard the other ten, most of them also participated. The sample produces about 71% of the canned peach of Rio Grande do Sul and 53% of Brazil (APL Alimentos Sul, 2015a).

Peach supply chain consists of three productive tiers and two contexts of service. The tiers are: (i) farms in which the fruit is produced and are supplied with seeds, fertilizers, pesticides and agricultural machinery; (ii) the manufacture or processing, which is supplied with fruit, packaging and industrial machinery; and (iii) retail, serving the final consumer. The service contexts are: (i) transport, storage and waste management; and (ii) financial support, scientific, technological and training, and advertising agents. The producer can deliver fruit in natura direct to the retail or can deliver to manufacturing, which benefits, packages and also delivers to retail, in the form of jams and preserves (APL Alimentos Sul, 2015b). Although it is known as peach industry, the chains also produce other fruits such as pineapple and figs, in smaller quantities.

The companies were selected based on the potential to contribute to the research, in what the company represents in the Brazilian peach market, and in the ease to collect data (Endacott & Botti, 2007). The contact was made via SINDOCOPEL and reinforced via the Governance of the Local Productive Cluster. Respondents were senior executives of the industrial area of the companies. The data generated in the interviews were videotaped and transcribed. The recordings allowed the capture of oral and body language that helped in the interpretation of data.

Chart 1 shows the main characteristics of the studied companies, based on data provided by the Union or by the companies themselves.

3.1 Methodology

The methodology involved two parts, one theoretical, the other empirical. The first part adapted, to the peach industry, a model already published, reaching a referential framework for the research. The adaptation was made in focus group, mediated by the researchers, with three experts. Experts have doctorate respectively in Chemical Engineering, Agribusiness, and Civil Engineering with significant academic achievement and consulting in environmental management and food industry (15, 10, and 20 years respectively of experience). Among the sixteen dimensions of the original model, the group selected those that interest for the peach industry, using Fuzzy Delphi Method:

- **Step 1:** k experts manifest preferences on the importance of constructs and dimensions, in a range from 1 to 5 (graduation = R_i, $\in S$);
- **Step 2:** The opinions were organized and fuzzy triangular numbers (NFT_S) calculated, forming the index $O_i = (L_i, M_i, U_i)$ for each construct and dimension i. L_i indicates the minimum value of classification of the k experts, according to the Equation 1. M_i is the geometrical mean of the classification of k experts for the construct i, given by Equation 2. U_i indicates the maximum value of the classification and is calculated by Equation 3.

$$L_i = Min(L_{ik}) \tag{1}$$

$$M_i = \left(R_{i1} \times R_{i2} \times \cdots \times R_{ik}\right)^{\frac{1}{k}} \tag{2}$$

$$U_i = Max(L_{ik}) \tag{3}$$

- **Step 3:** Given the NFT_S for all constructs, we used the centered area approach (CA) (Hsieh et al., 2004) for the defuzzification of

Chart 1. Companies that participated of the study.

Company	Structure	Market
A	Midsize familiar company located at Pelotas, founded in 1940, with 43 employees, processing peaches and figs.	National
B	Very large company, located at Pelotas, with 2,300 employees, exporting to 48 countries, processing peach, pineapple, and fig.	National – International
C	Large company, located at Morro Redondo, founded in 1974, with 480 employees, processing peach, pineapple and fig.	National
D	Large company, located at Morro Redondo, founded in 1900, with 900 employees, processing peach, pineapple and fig.	National

the NFTs of the constructs, as defined by the value of G_i, given by Equation 4. We accepted dimensions with $G_i \geq 3{,}0$:

$$G_i = \frac{(U_i - L_i) + (M_i - L_i)}{3} + L_i \quad (4)$$

Table 1 presents the resulting *Gi*.

Dimensions Market (Innovation construct) and Green Distribution (construct Operations) were removed from the analysis. The main reasons for withdrawal were: (i) the experts discarded a green market in peach industry, as defined in other industries: it is not clear in this industry the difference between green market and green product; and (ii) exclusive distribution does not exist in the industry, because it relies on logistic providers that share the channel with other industries that supply the retail.

Experts helped defining the final framework, including a short definition of the dimensions and a question to be used as a lead in the interviews of the empirical part of the research. The framework is shown in Chart 2. The last column presents the main references used in the review of the dimensions.

In the second part, the researchers interviewed practitioners of four focal companies of the industry, discussing point by point the structure of Chart 2.

After discussion, the respondents, supported by researchers, prioritized constructs and dimensions of the framework, based on the methodology proposed by the AHP. Respondents built matrices of preferences (positive reciprocal square matrices) whose c_{ij} cells are calculated by pairwise comparison between constructs and dimensions a_i according to the fundamental scale [1-9] of Saaty (2006). For the construction, n (n-1) / 2 comparisons are necessary, n being the size of the matrix (Vaidya & Kumar, 2006). The choice of scale [1-9] and pairwise comparison are historically justified in Ishizaka & Labib (2011). The fundamental scale is presented in Table 2.

Once built the preference matrix, the vector of priorities is given by the normalization of the eigenvector of maximum eigenvalue (main eigenvector). The calculation of this vector requires numerical methods. The method indicated by Saaty (1990) is to raise the preference matrix to the nth degree (starting with = 2), multiply the result by a unit vector column and normalize the result. Then, raise the matrix to the power (n + 1) and repeat the procedure. If the result did not change, this is the priority vector. If there are differences, raise to (n + 2) and continue until the result has converged. In practice, it has been observed that n = 3 is sufficient if the matrix is not too inconsistent. Examples of application that converges in the third power are found in Sellitto et al. (2006) and Rosa et al. (2006).

Calculations can be extensive. To reduce stress without significant loss of accuracy, Saaty (1990) presented four approximate methods. We chose one. The a_{ij} element of each column are summed, divided each a_{ij} value of the matrix by the sum of the column to which it belongs (resulting in a normalized matrix whose column sums are equal to one) and finally we extract the mean value p_i of each row of the normalized matrix. The vector comprises by the p_i is the priority vector of the original preference matrix (Equations 5 to 7).

$$Sum = \sum_{i=1}^{n} a_{ij} \quad (5)$$

Table 1. Possibility degree of the dimensions of the framework.

Constructs and *Gi*	Dimensions	G_i
Strategy in *GSCM I* – 4.50	Formulation – A1	5.00
	Performance evaluation – A2	4.75
	Cooperation – A3	5.00
	Communication – A4	4.25
	Barriers – A5	4.00
	Drivers – A6	4.75
Innovation in *GSCM* – 4.75	Process – B1	5.00
	Product – B2	4.00
	Market – B3	2.50
	Ecodesign – B4	5.00
Operations in *GSCM* – 4.75	Green purchasing – C1	5.00
	Green manufacturing – C2	4.50
	Green distribution – C3	2.25
	Reverse logistics – C4	4.50
	Final destination of waste – C5	4.50
	Reduction of pollution – C6	5.00

Chart 2. Framework and questionnaire for the research.

Construct	Dimension	Content	Lead for the interviews	References
Strategy in *GSCM*	Formulation – A1	Method and techniques for the formulation of environmental goals and plans	The company has goals for the environmental aspects related to the processes and activities associated with the business?	(Bai & Sarkis, 2010; Large & Thomsen, 2011)
	Performance evaluation – A2	Quali-quantitative methods to evaluate environmental performance	The company has methods that employees can use to understand the importance and critically evaluate the environmental performance?	(Large & Thomsen, 2011; Sellitto et al., 2010, 2012)
	Cooperation – A3	Typology and methods to identify and promote cooperation in GSCM	The company maintains cooperative relations with consumers and suppliers to evaluate all issues about the production process?	(Wu et al., 2012; Zhu et al., 2008c)
	Communication – A4	Typology and methods to identify and promote communication in GSCM	The company has channels that allows communication with partners in the chain?	(Bai & Sarkis, 2010; Large & Thomsen, 2011)
	Barriers – A5	Factors that can block the implementation of environmentally friendly initiatives in companies	The company has met the regulations imposed by the government or the demands of organized consumers?	(ElTayeb et al., 2010; Testa & Iraldo, 2010)
	Drivers – A6	Factors that can facilitate the implementation of environmentally friendly initiatives in companies	The strategic environmental management of the company has been driven by the actions of competitors or consumers?	(Wu et al., 2012)
Innovation in *GSCM*	Process – B1	Innovations in production processes: new technologies, new materials, new methods	The company invests in technologies that reduce emissions or use fewer natural resources?	(Bai & Sarkis, 2010; Large & Thomsen, 2011; Marchi, 2012)
	Product – B2	Innovations in product development: new products, new methods, life cycle analysis	The product design was considered to improve the packaging and marketing of the product?	(Bai & Sarkis, 2010; Zhu et al., 2008a; Gmelin & Seuring, 2014)
	Ecodesign – B4	Promotion of the use of environmentally friendly techniques in new products´ development	The company has promoted actions in product design in order to increase the reuse, recycling or recovery of parts or components?	(Wu et a al., 2012; Zhu et al., 2008c)

Chart 2. Continued...

Construct	Dimension	Content	Lead for the interviews	References
Operations in *GSCM*	Green purchasing – C1	Imposition and control of environmentally friendly requirements to suppliers	The company has partnerships with or make demands to suppliers in order to improve the environmental performance?	(Bai & Sarkis, 2010; Wu et al., 2012)
	Green manufacturing – C2	Manufacturing practices that reduce the environmental impact in the chain	Are there procedures and internal audits to assess the environmental impact of manufacturing processes and the fulfilment of environmental objectives of the management system?	(Bai & Sarkis, 2010; Darnall et al., 2008)
	Reverse logistics – C4	Closed-loop and value recovery: return of materials or waste to the same chain or other chains as raw material or fuel	Is there cooperation with other companies for reuse or recycling waste?	(Sarkis et al., 2011; Srivastava, 2007)
	Final destination of waste – C5	Construction and management of recycling or disposal of solid waste facilities	Are there evaluation and control of the recycling and waste disposal?	(Large & Thomsen, 2011; Sarkis et al., 2011)
	Reduction of Pollution – C6	Imposition and control of requirements for reduction of environmental attacks	Is there monitoring of products and processes that may cause harmful impacts to the environment?	(Large & Thomsen, 2011; Zhu et al., 2008b)

Table 2. Fundamental scale (Saaty, 1990).

Intensity of importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favor one activity over another
5	Strong importance	Experience and judgement strongly favor one activity over another
7	Very strong importance	An activity is favored very strongly over another; its dominance demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6 and 8	Intermediate values	Used for graduation in slightly different judgments
Reciprocals	If *i* has one of the above numbers assigned to it when compared with *j*, then j has the reciprocal when compared with *i*	

$$a'_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \quad (6)$$

$$\text{Mean } i = p_i = \frac{\sum_{i-1}^{n} a_{ij}^{l}}{n} \quad (7)$$

The resulting priorities only make sense if they come from consistent matrices. Accordingly, Saaty (1990) proposed to apply a consistency check, by calculating the consistency ratio *CR*, based on the *IC* consistency index (Equations 8 and 9).

$$IC = \frac{\lambda \max - n}{n-1} \tag{8}$$

$$CR = IC/IR \tag{9}$$

in which n is the dimension f the matrix; λ_{max} is the amount obtained by multiplying the line (sum of pairwise comparison of columns) by weights derived from normalized matrix and IR is the randomic index reached by simulation and shown in Table 3 (Saaty, 1990).

4 Results

Figure 3 represents the modeled structure of the problem, including overall target, constructs and respective dimensions, hierarchically.

Next, respondents were presented to the AHP. With researcher mediation, respondents compared pairs of constructs and dimensions, according to its strategic preferences, that is, according to the capacity of the construct or dimension to influence the environmental performance of the industrial activities of the company. The CR were calculated. All remain below 8.35%. All four hierarchy CR (Park & Han, 2002) (global consistency for the companies) remain between 4.9% and 5.3%, which allows accepting the priorities (Vargas, 1982). With this, the analysis proceeds without reviewing any judgment.

Data on Company A are shown in Table 4. Columns contain the constructs and their priorities, dimensions and its partial priorities (within the construct) and final (absolute, obtained by multiplying the priority of the construct by partial dimension priority) and the dimension order. Further, Tables 4-7 show the priorities respectively of B companies to D. All the tables are homologous.

5 Discussion

Table 8 shows the ranking of priorities assigned to the constructs.

In order to standardize the comparison, we adopted a Merit Factor FM for the constructs. If we have n factors, first order gives n points, second order (n – 1) points and so on. The two last rows of the table show raw and normalized FM for the constructs. The rest of the tables are homologous.

The Innovation construct has the highest priority in all companies and is the only one whose importance is greater than if the distribution was uniform (33.4%). The Strategy construct had three second places and a third. Finally, in only one out of the companies construct Operations has not the lowest priority. This means that the companies of the sample consider investments in innovative practices as the most promising in going towards the GSCM. Such prioritization meets Gupta & Palsule-Desai (2011): the prevention of pollution caused by industrial activity can be achieved more effectively through innovation in the design of processes, products and management of waste. As an example of innovation, the companies B, C, and D adopted a new model of can, called Easy Open, releasing openers hand, reducing

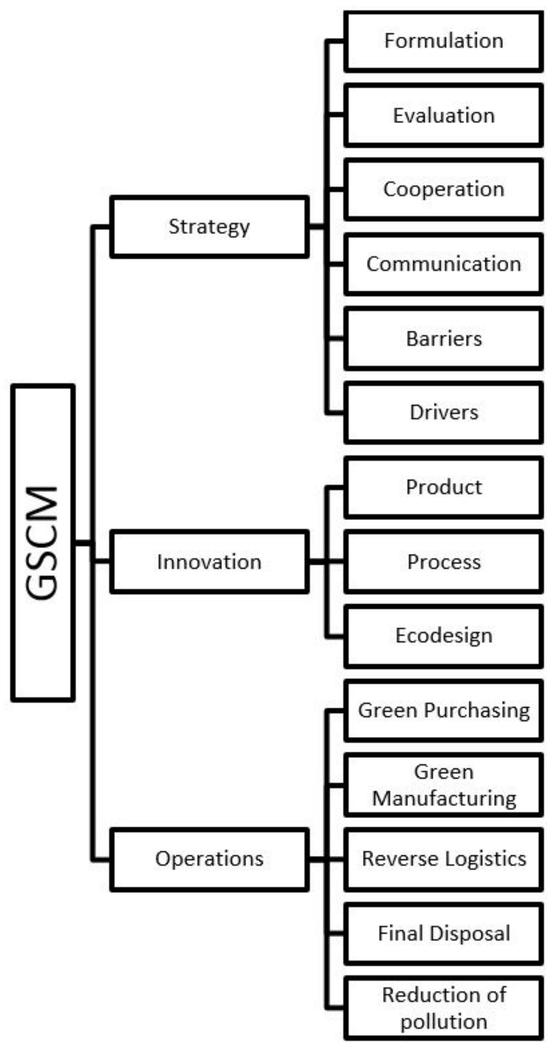

Figure 3. Model for the problem. Source: elaborated by the authors.

Table 3. Randomic index (Saaty, 1990).

n	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
IR	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Table 4. Structure of Priorities for the company A.

Construct	Priorities %	Dimensions	Partial Priorities %	Final Priorities %	Ranking
Strategy	26.05	Formulation	8.36	2.18	9
		Evaluation	14.66	3.82	7
		Cooperation	41.25	10.75	**3**
		Communication	5.42	1.41	11
		Barriers	2.90	0.76	12
		Drivers	27.41	7.14	4
Innovation	63.33	Process	10.62	6.72	5
		Product	26.05	16.50	**2**
		Ecodesign	63.33	40.11	1
Operations	10.62	Green Purchasing	50.28	5.34	6
		Green Manufacturing	26.02	2.76	8
		Reverse Logistics	13.44	1.43	10
		Final Disposal	3.48	0.37	14
		Reduction of Pollution	6.78	0.72	13
			total	100	

Table 5. Structure of Priorities for the company B.

Construct	Priorities %	Dimensions	Partial Priorities	Final Priorities	Ranking
Strategy	10.62	Formulation	9.07	0.96	11
		Evaluation	24.73	2.62	8
		Cooperation	42.17	4.48	6
		Communication	3.09	0.33	14
		Barriers	5.58	0.59	13
		Drivers	15.36	1.63	10
Innovation	63.33	Process	26.05	16.50	**2**
		Product	10.62	6.72	5
		Ecodesign	63.33	40.11	**1**
Operations	26.05	Green Purchasing	50.28	13.10	**3**
		Green Manufacturing	26.05	6.78	4
		Reverse Logistics	6.78	1.77	9
		Final Disposal	3.48	0.91	12
		Reduction of Pollution	13.44	3.50	7
				100	

the amount of metal in the package and requiring less electrical power for welding. The development of the product was set by cooperation between the focal company and suppliers.

Table 9 orders the priorities in strategy.

Cooperation was the higher priority in three out of the four companies and the second highest priority in the fourth company. In the second position, environmental performance evaluation, with a first, two second, and a third place. This means that, in green strategy, companies believe they should prioritize cooperation activities and methods for evaluating environmental performance. For example, A and B cooperate in joint purchases and exchanging market information, even as competitors. Such cooperation between competitors in the industry is not new, having been studied, among others, by Dubois & Fredriksson (2008). Regarding the evaluation of environmental performance, it was observed in interviews that companies have structured methods, evaluating and systematically measuring the impact of its main activities. Drivers may also be considered, since its importance (19%) is higher than it would be if the distribution was uniform (16.7%). Communication and Barriers can be disregarded, which does not mean that companies do not value these dimensions of the strategy, but these problems do not exist or are well resolved in the industry.

Table 10 orders the priorities in innovation.

Ecodesign was the highest priority in three out of the four companies and has the second highest priority in the fourth company. Product obtained a first, two

Table 6. Structure of priorities for the company C.

Construct	Priorities %	Dimensions	Partial Priorities %	Final Priorities %	Ranking
Strategy	26.05	Formulation	15.36	4.00	7
		Evaluation	42.17	10.98	**3**
		Cooperation	24.73	6.44	5
		Communication	5.58	1.45	10
		Barriers	3.09	0.81	12
		Drivers	9.07	2.36	9
Innovation	63.33	Process	10.62	6.72	4
		Product	26.05	16.50	**2**
		Ecodesign	63.33	40.11	**1**
Operations	10.62	Green Purchasing	26.02	2.76	8
		Green Manufacturing	50.28	5.34	6
		Reverse Logistics	13.44	1.43	11
		Final Disposal	3.48	0.37	14
		Reduction of Pollution	6.78	0.72	13
				100	

Table 7. Structure of Priorities for the company D.

Construct	Priorities %	Dimensions	Partial Priorities %	Final Priorities %	Ranking
Strategy	10.62	Formulation	9.07	2.36	9
		Evaluation	24.73	6.44	5
		Cooperation	42.17	10.98	**3**
		Communication	3.09	0.81	12
		Barriers	5.58	1.45	11
		Drivers	15.36	4.00	7
Innovation	63.33	Process	10.62	6.72	4
		Product	63.33	40.11	**1**
		Ecodesign	26.05	16.50	**2**
Operations	26.05	Green Purchasing	47.31	5.02	6
		Green Manufacturing	26.91	2.86	8
		Reverse Logistics	14.09	1.50	10
		Final Disposal	7.16	0.76	13
		Reduction of Pollution	4.52	0.48	14
				100	

Table 8. Ranking of priorities for the constructs.

Company	Rank		
	Operations	Innovation	Strategy
A	3º	1º	2º
B	2º	1º	3º
C	3º	1º	2º
D	3º	1º	2º
Raw FM	5	12	7
Norm. FM	21%	50%	29%

seconds and a third position. Finally, Process was the less prioritized. The main difference between Ecodesign and other improvement methods is that, in the Ecodesign, environmental performance goals are more important than other goals. Therefore, the companies believe that, in order to achieve advances in GSCM, the environmental objectives of innovation projects should has at least (preferably more) the same importance than other goals, which is guaranteed by a structured adoption of Ecodesign techniques.

Table 9. Priority ranking of the dimensions of construct Strategy.

Company	Rank					
	Formulation	Evaluation	Cooperation	Communication	Barriers	Drivers
A	4º	3º	1º	5º	6º	2º
B	4º	2º	1º	6º	5º	3º
C	3º	1º	2º	5º	6º	4º
D	4º	2º	1º	6º	5º	3º
Raw FM	13	20	23	6	6	16
Norm. FM	15%	24%	27%	7%	7%	19%

Table 10. Priority ranking of the dimensions of construct Innovation.

Company	Rank		
	Process	Product	Ecodesign
A	3º	2º	1º
B	2º	3º	1º
C	3º	2º	1º
D	3º	1º	2º
Raw FM	5	8	11
Norm. FM	21%	33%	46%

This belief is in line with findings by Wu et al. (2012) that suggest ongoing evaluation and modification of products and processes from the viewpoint of the Ecodesign, in order to obtain energy efficiency and reduction of inputs in industrial activities.

Finally, Table 11 orders the priorities in operations.

Green Purchasing was the higher priority in three out of the four companies and the second highest priority in the fourth company. In the second position, Green manufacture, with a first and three second places. Together, they obtained all the first and second priorities. They are the only dimensions with importance greater than 20%, which would be the priority if the distribution was uniform. They can be treated together, because there are mutual influences: controlling the environmental performance of supplies makes it easier controlling the environmental performance in manufacturing. All companies declared that they monitor quality and the environmental impact of raw materials and production processes of suppliers. The main raw material is the fruit and its most important environmental impacts can be observed both in the processes of suppliers as in the manufacture of focal companies. In addition, partnerships with suppliers to monitor the peach fly may be mentioned, which led to significant reduction of pesticides and elimination of intermediate control activities with significant environmental gain. Waste Management and Pollution Reduction are at the other end of priorities. As in the strategy construct, this low priority does not mean that the dimensions are not important, but that they are well resolved in companies and chains. This observation is not surprising, since the managers and the companies themselves have backgrounds in earth sciences, including management and recovery of waste and pollution reduction practices. Major problems such as proper disposal of waste and coat lumps have been well resolved over time in the industry.

5.1 Implications of the GSCM in industry

The study concluded that, according to the studied companies, the construct with higher priority for actions to greening the supply chains in the peach industry is innovation. Innovative actions are the most promising regarding environmental advances. This conclusion does not mean that Strategy and Operations constructs are negligible: only means that actions in these constructs are less promising, either because they doesn´t resolve the existing problems, either because the actions that are possible have yet been taken.

Within the scope of innovation, the dimension more likely to bring environmental advances is the practice of Ecodesign. The main feature of innovation projects based on Ecodesign is that the main objectives of the project are related to environmental objectives. Functional improvements, performance or cost reduction in products or processes occur as a desirable side effects of the achieved environmental objectives. For example, innovative projects aimed at reducing materials, energy or other environmentally hazardous inputs such as pesticides, may result in cost reduction or increase in food security, but these, although desirable, are not the main objectives, which are reducing environmental attacks and increased eco-efficiency.

Although not priorities, it´s worth considering the other constructs.

Regarding strategy, the most important dimensions were Cooperation, Performance Evaluation and Drivers. If the companies want to use strategy to improve its environmental management, the most promising actions are cooperation with other members of the

Table 11. Priority ranking of the dimensions of construct Operations.

Company	Rank				
	Green Purchasing	Green Manufacturing	Reverse Logistics	Final Disposal	Reduction of Pollution
A	1º	2º	3º	5º	4º
B	1º	2º	4º	5º	3º
C	2º	1º	3º	5º	4º
D	1º	2º	3º	4º	5º
Raw FM	19	17	11	5	8
Norm. FM	32%	28%	18%	8%	13%

supply chain and to develop performance evaluation systems for monitoring and control of strategy effectiveness. Finally, in general, it is possible that the industry is not taking full advantage of available drivers. Among these, can be mentioned: (i) receptivity of consumers, particularly in large urban centers, to the greening actions of industrial operations and to increase food security; (ii) incentive programs for the purchase of machinery and technology needed to greening processes; (iii) centers of excellence in environmental technology available in universities and institutions in the region; (iv) access to government programs, such as PNAE (National Plan for Food for School Food); or (v) create designation of origin (DOC) and major role in Fenadoce, international trade fair that takes place in the city.

Finally, regarding Operations, the most important dimensions were Green Purchasing and Green Manufacturing. Both are correlated, because the fulfillment of environmental requirements by suppliers usually means better conditions in manufacturing. An integrated action example is the requirement that manufacturers have made to producers about the reduction in the use of pesticides. With this, washing processes were reduced partially in manufacturing, with significant environmental gain. Another example was the standardization requirement in fruit size, which has led to significant reduction of fruit disposal in natura in production and manufacturing, with environmental gain by reducing the organic solid waste and the better use of packaging and transportation. Finally, a major problem in manufacturing is excessive loss and disposal of raw materials in waiting lines for the discharge because the vehicles are not refrigerated. The same applies to the lack of synchronization between the demands of manufacturing and the shipping of producers. Qualification actions in storage facilities, just-in-time supplies and milk-run delivers could eliminate this type of environmental attack.

In summary, we concluded that, to make progress in GSCM on the peach industry of Pelotas, green practices that should be prioritized are: Ecodesign, Cooperation, Performance Evaluation, Green Procurement and Green Manufacturing, in this order.

6 Final remarks

The purpose of this paper was to define priorities for green practices that are observed in the peach industry supply chains. Priorities were set for four focal companies of the industry that, by their leading position, can influence the entire industry. For so, a theoretical model was built, organizing the green practices observed in the industry. With the support of AHP, these practices were prioritized in companies and the aggregate result was used for analysis. In the end, five practices should be prioritized in greening efforts in the industry: Ecodesign, Cooperation, Performance Evaluation, Green Purchasing and Green Manufacturing, in this order.

The article resulted from a study in four focal companies in the peach industry supply chains with operations in Pelotas area. The industry, for handling products and organic raw materials, has high potential risk, not only environmental considerations related to food security. Therefore, it is of strategic interest in the industry, the development and prioritization of environmental issues such as green practices observed in GSCM. By creating positive image in relation to the environment and food safety, the industry can become more competitive and grow sustainably.

As alternatives for future studies we suggest: (i) a census in the entire industry, because it is limited geographically and there are few companies affiliated to the employers' association; (ii) extension of the research to the adjacent links, the producer of fruit and retailing, analyzing how the priorities evolve along the chain; (iii) extension to service providers of the chain, such as carriers, retailers and reverse logistics operators; (iv) case studies in depth in the three large companies on one or more of the priorities chosen, for example, Ecodesign; and (v) use of the questionnaire developed to evaluate, supported by a Likert scale, the degree of application in companies of the developed model.

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