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Multi-criteria assessment of the benefits of a supply chain management training considering green issues

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ABSTRACT

Green Supply Chain Management (GSCM) is an important issue for organizations that spend considerable amounts of investments on personnel training annually. Although these investments present positive effects, the manner to assess the effectiveness of the training is unclear. Training, whose characteristics are intangible, is sometimes difficult to be assessed. This research has carried out a multi-criteria training assessment for GSCM through the four top-level processes of Supply Chain Operations Reference Model (SCOR) i.e., Plan, Source, Make and Deliver. Analytic Hierarchy Process was applied in the training assessment. In the chemical industry where our study was performed, the SCOR top-level processes were considered criteria, whereas Individual and Organizational Benefits alternatives. The modeling considered pairwise judgments for criteria, and ratings or absolute measure for alternatives. The analysis revealed that training essentially contributes to the organization, resulting in 87% for Organizational Benefits, and 77% for Individual Benefits. Organizational Benefits focused on the use of the best practices in GSCM and on the common understanding of vocabulary and processes. In addition, Individual Benefits increased knowledge and skills in GSCM. This result, presented to managers of the company, was validated as consistent and feasible.

1. Introduction

Once Supply Chain Management (SCM) is an important issue among researchers, many studies focus on the integration of Supply Chain (SC) through information and material flows (Prajogo and Olhager, 2012). Some important issues in SCM are performance, integration and sustainability. Some related approaches showed the relationship between higher level SCM practices, as well as Green Supply Chain Management (GSCM) practices that have been learned at some point in time (Zhu and Sarkis, 2004; Li et al., 2006).

In this direction, Das and Posinasetti (2015) presented evidence that components of the GSCM contribute to SC's performance. This is because GSCM reduces environmental impacts. GSCM is an important approach for improving environmental performance processes in terms of materials, resources conservation and waste elimination.

GSCM capability encompasses multiple functions to be learned by organizations over time. Training is a category of human resources that involves organization and career development (Shub and Stonebraker, 2009), while provides opportunities to learn and accumulate SCM capabilities to be mastered. GSCM is an important issue for organizations that spend considerable amounts of investments on personnel training annually. Although these investments present positive effects, the manner to assess the effectiveness of the training is unclear. In the company where this study was performed, the SCM training evaluation was based on the participant's perception, however, the benefits detected did not emerge from any structured model.

Training, whose characteristics are intangible, is sometimes difficult to be assessed. Therefore, a research opportunity to develop an assessment model with a strong influence of the resource and the capabilities of the firm is to be considered (Barney, 1991; Barney et al., 2001; Prahalad and Hamel, 1990). The purpose of the present article is to provide a model for GSCM training assessment, which incorporates elements from SCM Theory and Multi-Criteria Decision Making (MCDM). This study covers an important area to the industry, and its findings provide an insight

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into the Individual and Organizational Benefits from training and offer guidance for managers.

Several qualitative and quantitative methods to assess GSCM training are available, such as Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Multi-Attribute Utility Theory (MAUT), among others (Ishizaka and Nemery, 2013). The proposed procedure includes the application of AHP combined with Supply Chain Operations Reference Model (SCOR) in the assessment of training programs on GSCM.

AHP (Saaty, 2010) is an MCDM method which works with tangible and intangible factors using paired comparisons. AHP enables the decision maker to structure a complex problem in the form of a simple hierarchy and to evaluate on pairs of elements provided by experts.

AHP can be combined with different methods, as Fuzzy-AHP, to evaluate cooperation with green suppliers (Lu et al., 2007). Others combined methods are Neural Network, Genetic Algorithm, Grey Correlational Analysis to select green suppliers (Govindan et al., 2015). AHP is also combined with SCOR (Palma-Mendoza, 2014; Rabelo et al., 2007).

SCOR, a business process reference model proposed by the Supply Chain Council, is aimed at improving supply chain performance that links process elements, metrics, best practices and features associated with the execution of a supply chain in a unique format (Medini and Bourey, 2012). Ross (2015) defines SCOR as a cross-industry, standard SC model that forms analytical tools for SC on the basis of process, performance evaluation and best practices.

This article is organized as it follows: Section 2 introduces the Theoretical Background, mainly with concepts on SCM and GSCM, training and SCOR Model. AHP is described in Section 3. Section 4 presents the model to assess the training. In Section 5, we refer to the AHP applied in assessment of training considering green issues. The article ends with Conclusions and References.

2. Theoretical background

This section is organized into four different subsections. The first subsection provides an overview of SC and GSCM. We further extend the discussion with SCM training. The third subsection explores training issues in the existing literature on GSCM. Finally, in the fourth subsection, SCOR Model and its main processes are described.

2.1. Supply chain and Green Supply Chain Management

SCM includes the design, planning, execution, control, and monitoring of supply chain activities with the objective of adding net value (Blackstone, 2013). Some studies focus on the correlation between SC and internal integration, and on the degree of cooperation between SC parties through intra- and inter-organizational processes based on information technology (Flynna et al., 2010; Thun, 2010).

SC design and integration depend on management strategies adopted by the business and are based on the corporation's core competence, involving decision-making processes to outsource SC activities, as manufacture, in order to achieve flexibility gain and cost reduction (Davenport, 2005; Prahalad and Hamel, 1990).

GSCM is an expansion of the SCM focusing on green issues as environmental sustainability practices, waste disposal and best use of resources (Zhu et al., 2012). Hervani et al. (2005) defined GSCM as green purchasing, green manufacturing and materials management, green distribution and marketing, and reverse logistics. Considered a typical supply chain, it includes reuse, remanufacturing and recycling of materials into new materials or products. GSCM is a widespread practice among companies seeking to improve environmental performance (Testa and Iraldo, 2010). The metrics to measure performance applied in GSCM such as quality, air emissions, energy use, gas emissions and others were identified (Ahi and Searcy, 2015).

Diabat and Govindan (2011) identified the main drivers involved in the implementation of GSCM as the integration of quality environmental management into the planning and operation process, reduction of energy consumption and the reuse and recycle of materials.

Beamon (1999) defined recycling, reuse and remanufacturing. Recycling is the process of collecting used products, components and materials from the field and processing them into recycled products. Reuse is the process of collecting used materials, products or components from the field and distributing them. The process of remanufacturing consists of collecting a used product from the field, assessing its condition, and replacing parts with new parts.

The elimination of waste through SC has provided companies with ways to gain profit and to regard sustainability as a competitive advantage (Kumar et al., 2012; Haanaes et al., 2012; Presley et al., 2007). The adoption of eco-friendly practices in production management includes the use of sustainable and cleaner technologies (Jabbour, 2010).

2.2. Supply chain management training

SCM elements contribute to value chains. Furthermore, due to its importance, training in SCM has been accounted for as one of the most relevant bases to be Certified in the Production and Inventory Management (CPIM) of the Association for Operations Management (shorted as APICS, formerly American Production and Inventory Control Society). The goal of APICS is to build and validate knowledge and operational management to provide certification programs, essential as a strategic advantage, in the present globalized world (Lummus, 2007).

The goal of the training program is to prepare employees to obtain the CPIM. It contributes to the field of terminology, concepts and strategies related to SCM, demand management, master and material planning, capacity management, sales and operations planning, production environment and process, purchasing, physical distribution, performance measures, supplier relationships, lean and JIT, quality systems and continuous improvement (Lummus, 2007).

Tramarico et al. (2015) evaluated two sets of benefits designated as Individual and Organizational based on training. Fig. 1 presents some benefits and their descriptions. The first four are Individual Benefits related to participants or trained people such as the individual recognition to maintain and motivate behaviors, and to improve and validate knowledge that can result in a sustainable competitive advantage to a company (Hansen et al., 2002; Van Zyl, 2003; Lummus, 2007; Treem, 2013; Gammelgaard and Larson, 2001). The last four benefits are Organizational Benefits such as the common understanding of vocabulary and concepts that would be consistent in the company; the use of best practices, and the improvement of the company's performance by sharing explicit and tacit knowledge (Gilbert, 2014; Bulkeley, 2006; Schoenherr et al., 2014; Khadivar et al., 2007).

Training programs provide the essential education that prepares professionals in the supply chain and operational management for today's fast-changing marketplace. However, some companies have conditioned the continuity of their training programs to the assessment of benefits.

2.3. Green Supply Chain Management training

GSCM has gained increasing attention within both academia and industry, once training is an important investment in internal capabilities (Sarkis et al., 2011). The capability dimensions as green manufacturing and packaging, green marketing, green suppliers,

Benefits	Description	Authorship
Individual recognition	Recognition is appropriate to motivate behaviors such as inventiveness, commitment, and initiative.	Hansen, Smith and Hansen (2002)
Improve SCM knowledge	The adoption and integration of what people know, how well people communicate what they know and how quickly people learn new things, can give a company a sustainable competitive advantage.	Van Zyl (2003)
Credential recognition	The credential allows certified individuals to demonstrate knowledge in the professional activities of SCM.	Lummus (2007)
Validate of knowledge and abilities	Assess a worker's knowledge and abilities; the status characteristic is perceived as relevant to an organizational task. In this case, SC managers need to demonstrate broad and deep knowledge and abilities.	Treem (2013), Gammelgaard and Larson (2001)
Common understanding of vocabulary and processes	Common understanding of a given concept and the terminology that would be consistent in the company.	Lummus (2007)
Use of best practices	Methods that have been found to be an effective mean for accomplishing goals and that can be used or adapted.	Gilbert (2014), Bulkeley (2006)
Improve company performance	The capability to share explicit and tacit knowledge for the company enables competitive performance.	Schoenherr, Griffith and Chandra (2014)
Proven knowledge and organizational skills	Focus on supporting an individual to be more effective at work and to operate better in groups and in the organization.	Khadivar et al. (2007)

Fig. 1. Individual benefits and organizational benefits.

green stock, and green eco-design have been investigated (Shang et al., 2010). Jabbour (2015) observed, in a case study conducted in four Brazilian market leaders in their segments, the adoption and evaluation of GSCM, offering training for suppliers and workshops for employees.

Mathiyazhagan et al. (2013) analyzed the barriers for the implementation of GSCM, and concluded that training for GSCM processes is not sufficient. The reduction of barriers when implementing GSCM was also analyzed by Jabbour and Jabbour (2016), who included the relationship between GSCM and Green Human Resource Management in a conceptual study.

Muduli et al. (2013) investigated behavioral factors in GSCM and considered training a process that leads employee's behavior towards accomplishing a set of desired organizational objectives. Perotti et al. (2012) studied the training costs of 15 third party logistic companies (3PLs) operating in Italy with medium economic impact. Zhu et al. (2007) studied training and operational costs in China, which revealed significant increase.

These referred articles took into account issues on training such as investment, evaluation, barrier to implement GSCM, lack of training, employee's behavior and training costs. There was limited discussion in the relevant works on how training evaluation or benefits can be structured.

2.4. Supply chain operations reference model

SCOR Model, the first process framework, was introduced in 1996. Frameworks provide a standard language for SC operations and the key activities to manage effective and efficient measures. The process reference model approach is unique in the way it joins business processes, performance metrics, practices, and people's skills into a unified structure (Ross, 2015).

The model describes business activities in order to meet customer demands, improving the performance of the SC to support the SCM strategy. Process reference models integrate the well-known concepts of business process of reengineering, benchmarking, process measurement, and organizational design into a cross-functional framework. The SCOR boundaries were defined from the supplier to the customer (Medini and Bourey, 2012).

Six distinct processes of SCOR Model (Ross, 2015) are:

- Plan – demand/supply planning and management.
- Source – sourcing stocked, make-to-order, and engineer-to-order product.
- Make – make-to-stock, make-to-order, and engineer-to-order production execution.
- Deliver – order, warehouse, transportation, and installation management, for stock, make-to-order, and engineer-to-order product.
- Return – return of raw materials and receipt of finished goods.
- Enable – represents integration of SCM.

Within all reference models, there is a specific scope addressed by the model; with SCOR it is not different and the model focuses on the following:

- Customer interactions – from order entry through invoice.
- Product – from your supplier's supplier to your customer's customer.

- Market interactions – from the understanding of aggregate demand to the fulfillment of each order.

The Model considered 10 metrics in level 1 including perfect order fulfillment, order fulfillment cycle time, cash-to-cash cycle time, and total cost to serve. SCOR-based model for the performance measurement of the maturity in SC's was applied and supported (Sellitto et al., 2015; Cai et al., 2009; Oliveira et al., 2012).

The SCOR framework was chosen to conceptualize the training assessment model (Section 4), owing to its process orientation and wide adoption by the supply chain academic and practitioner communities.

3. Method

AHP is one of the most common methods to solve MCDM problems. AHP was developed by Prof. Thomas Saaty in the 1970s while he was directing research projects for the Arms Control and Disarmament Agency at the United States Department of State (Saaty, 1980). Being very popular, AHP has been applied in a wide variety of areas of knowledge; the prominent decision areas in management were operation strategy, product and process design, planning and scheduling resources, project management and managing of SC (Sipahi and Timor, 2010). Modeling approaches for GSCM using AHP were also identified in MCDM literature (Seuring, 2013; Subramanian and Ramanathan, 2012).

The AHP application is often taken in two phases of the decision process: problem structuring and elicitation of priorities through pairwise comparisons (Ishizaka and Nemery, 2013). One characteristic of the AHP is the adoption of a fundamental scale. Saaty suggested a scale of 1–9 when comparing two components – numbers 3, 5, 7 and 9 correspond respectively to the verbal judgments of “moderately more dominant”, “strongly more dominant”, “very strongly more dominant”, and “extremely more dominant”.

In an AHP application, weights for criteria and priorities for the alternatives are obtained by means of expert judgments (Saaty, 2010), which must be inserted in the pairwise comparison matrix $\boldsymbol{A}$.

In the sequence, using Linear Algebra concepts, as the eigenvector ($\boldsymbol{w}$), and eigenvalue (λ_{max}), it is possible to get their relative priorities. The AHP priorities are obtained with an application of the Perron–Frobenius theorem, as presented in (1):

$$\boldsymbol{A}\,\boldsymbol{w} = \lambda_{max}\boldsymbol{w} \quad (1)$$

The consistency among the comparisons is an important propriety for $\boldsymbol{A}$. If $\boldsymbol{A}$ has consistent comparisons, then $a_{ij} = w_i/w_j$, for i, $j = 1, 2,\ldots n$, where n is the order of $\boldsymbol{A}$, and this way, $a_{ij} = a_{ik}\, a_{kj}$. Besides that, if $\boldsymbol{A}$ is a consistent matrix, then $\lambda_{max} = n$. The consistency index, CI, calculated by (2), is a measure of the distance between λ_{max} and n:

$$CI = (\lambda_{max} - n)/(n - 1) \quad (2)$$

If CI is lower than 0.10, the Matrix $\boldsymbol{A}$ is consistent. Otherwise, a review on the comparisons may be necessary.

Furthermore, there is a possibility of using ratings or absolute measure in the AHP application, i.e., each alternative is compared with many other alternatives, while ratings compare each alternative with an ideal one (Saaty, 2006). A feature of absolute measurement in AHP is that the scale for each lowest level criterion consists of indicator categories (e.g., “very high”, “high”, “average”, “low” and etc.).

The AHP application can be summarized on few steps, including hierarchy construction, pairwise comparison, consistency verification, and results. In our research, the proposed flowchart (Fig. 2) by De Felice and Petrillo (2013) is adopted.

3.1. Case description

The research presented in this article was conducted, by assessment sessions with expert and SC managers, in a major chemical plant located in the State of Sao Paulo, Brazil. The plant belongs to a multinational group operating in 170 countries, with direct production in 40 countries. The studied plant has around 1000 employees, and is among the top 10 companies in the chemical and petrochemical sectors. Having a large portfolio of products, the company has offered important contributions to the segment of products for chemicals, plastic, oil and gas.

The company has been an active member of the United Nations Global Compact initiative since 2000, a strategic policy for businesses committed to align their operations and strategies with ten universally accepted principles in the areas of human rights, labor, environment and anti-corruption. The company's goal is to innovate, making customers more successful, driving sustainable solutions and forming the best team. Despite the alignment between this company's mission and the GSCM principles, training is a way to gather the best team.

A training program with 5 modules and 32 h each was implemented three years ago to prepare and obtain the CPIM. More than 100 employees participated in the training program.

4. Training assessment model

Most traditional methodologies for assessing investment returns for training initiatives utilize aggregated financial and non-financial measures that do not satisfy the company's need for more detailed information on their base of resource (Satiman et al., 2015; Bukowitz et al., 2004).

Training initiatives can provide employees appropriate environmental guidance. Therefore, companies wanted to see impact measures from a particular training program on the individual and organizational aspects. From a managerial point of view, training programs should develop GSCM skills.

Frequently asked questions regarding the gains of training are: “Does the training program deliver Individual Benefits based on GSCM?”, “Does the training program deliver Organizational

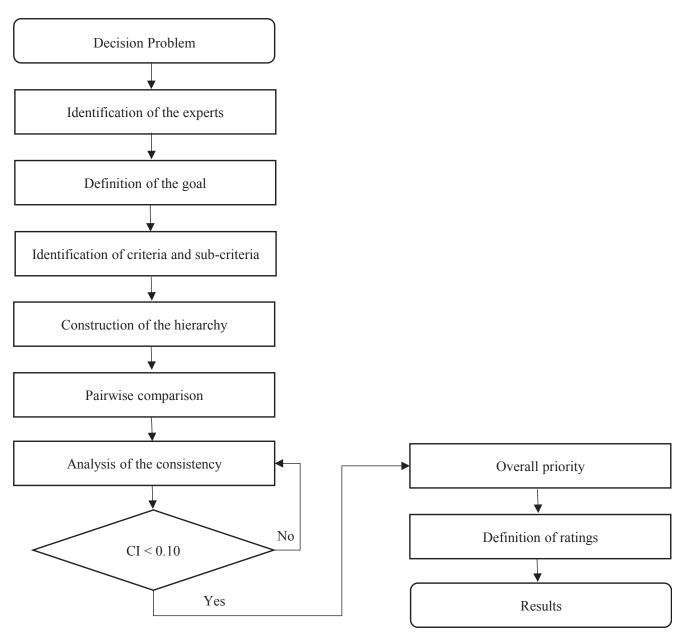

Fig. 2. The flowchart of methodological and research approach.

Benefits based on GSCM?" The answers to both questions will contribute to the development of the training assessment process.

This proposal is based on the four top-level processes of the SCOR Model, that is, Plan, Source, Make and Deliver. In this paper, twelve benefits were defined considering green issues in their components: "being on a long-term perspective", "best uses of resources", "avoiding rework and waste management", "recycled material", "renewable energy" and "scrap reduction" are among them. In this study, the SCOR sub-processes, with over twelve components, were not considered.

The Return was considered as part of the "transportation management with environmental impact reductions", which includes the logistics reverse category. These components are related to waste management, which is crucial to GSCM (Azzone and Noci, 1998; Digalwar et al., 2013). Fig. 3 presents the training assessment model.

The proposed model addressed GSCM components, provided internal knowledge and, at the same time, could adapt to changes in the company. The application details are presented in Section 5.

5. AHP applied in training assessment

The AHP applied in this study provided results through the steps which ensured the GSCM training assess. In the following paragraphs the training assessment is illustrated.

5.1. Identification of the experts

The expert who took part in the assessment has worked for the company for 20 years. He has been certified with the CPIM for over 10 years, is a regional coordinator of the training program, and was designed for our study by SC managers. Three SC managers also participated in the assessment and results validation.

5.2. Definition of the goal

The goal of our model was to "Assess GSCM training". The company does not possess a structured model to assess the training effectiveness, which can provide Individual and Organizational Benefits for the day-to-day routine of employees.

5.3. Identification of criteria and sub-criteria

The set of criteria are Plan, Source, Make and Deliver. The Sub-criteria are P1, P2, P3, S1, S2, S3, M1, M2, M3, D1, D2 and D3. Individual and Organizational Benefits are the alternatives.

5.4. Construction of the hierarchy

Hierarchy containing goal, criteria and Sub-criteria. Fig. 4 presents the incomplete hierarchical structure.

5.5. Pairwise comparison

The pairwise judgments for the Plan, Source, Make and Deliver criteria were achieved. Table 1 presents the judgments for each criteria and priorities.

Make is the most significant priority result with 45%; Plan achieved 21%, Deliver 18%, and Source 16%.

5.6. Analysis of the consistency

The consistency can be considered as valid when the highest consistency index equals 0.09.

5.7. Overall priority

After the achievement of all judgments for criteria and Sub-criteria, the overall priorities were calculated by multiplying the priority values of each criterion by the Sub-criteria weight, for instance: P1 overall priority $= 0.21 \times 0.29 = 6\%$; P2 overall priority $= 0.21 \times 0.26 = 5\%$; P3 overall priority $= 0.21 \times 0.46 = 9\%$; The same procedure was performed to S1, S2, S3, M1, M2, M3, D1, D2, and D3. Table 2 shows the overall priorities of processes.

The overall priorities for the Sub-criteria M1, M2 and M3 associated to the Make criterion indicated the highest level of importance among the Sub-criteria of Plan, Source and Deliver. An interpretation of these results can indicate the characteristics desirable for the manufacturing capability to improve company's performance. The Sub-criteria P1, P2, P3, S1, S2, S3, D1, D2 and D3 are in a lower level, however, not too low (5%–9%).

Process	SCOR components	SCOR components adapted to GSCM
Plan	P1 - Plan Supply Chain	P1 - Demand planning on a long-term perspective
	P2 - Plan Source	P2 - Materials planning with the best use of resources
	P3 - Plan Make	P3 - Production planning avoiding rework and waste
Source	S1 - Source Stocked Product	S1 - Substituted or recycled raw material
	S2 - Source Make-to-Order Product	S2 - Merchandise based on renewable energy
	S3 - Source Engineer-to- Order	S3 - Services aligned with sustainability
Make	M1 - Make-to-Stock	M1 - Scrap reductions
	M2 - Make-to-Order	M2 - Greenhouse gas emission reductions
	M3 - Engineer-to-Order	M3 - Recycled and reused water
Deliver	D1 - Deliver Stocked Product	D1 - Distribution planning using full truckload
	D2 - Deliver Make-to-Order Product	D2 - Order management strives to exceed customer expectations without additional cost
	D3 - Deliver Engineer-to-Order Product	D3 - Transportation management with environmental impact reductions

Fig. 3. Training assessment model.

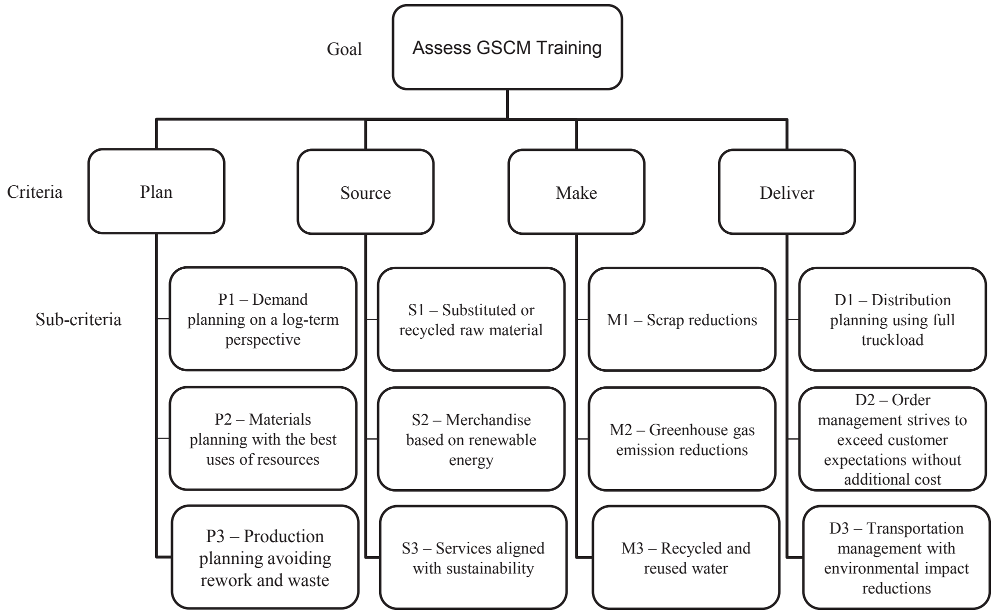

Fig. 4. Training assessment hierarchy.

Table 1
Criteria priorities.

Criteria	Plan	Source	Make	Deliver	Priority
Plan	1	1	1/3	2	21%
Source	1	1	1/2	1/2	16%
Make	3	2	1	3	45%
Deliver	1/2	2	1/3	1	18%

5.8. Definition of ratings

The absolute model is used to rank independent alternatives one at a time in terms of rating intensities for each of the criteria. The level of performance corresponding to the attributes in linguistic scales varies from “Poor” to “Excellent”. The reason for the adoption of the absolute model is because it has the potential to significantly reduce conflicts in decision making processes (De Felice and Petrillo, 2013).

Table 3 presents the intensity levels or the quality degrees set for the training assessment alternatives.

Table 3
Training rating scale.

Intensities	Level
Excellent	1
Very good	0.83
Good to very good	0.67
Good	0.50
Poor to good	0.25
Poor	0

The criteria were pairwise compared and the alternatives were rated as illustrated in Fig. 4. The results of the alternatives indicate “Very Good” to P1, “Good” to P2, “Excellent” to P3 for Individual and “Excellent” to P1, “Good to Very Good” to P2 and “Very Good” to P3 for Organizational Benefits. Fig. 5 shows results for S1, S2, S3, M1, M2, M3, D1, D2, and D3.

The quantitative performance is based on the rating scale (Table 3), the qualitative performance (Fig. 5) for each benefits on Individual and Organizational and on overall priorities (Table 2). The priorities indicate the highest benefits, both individual and

Table 2
Overall priorities of criteria and Sub-criteria.

	Criteria and Sub-criteria	Local priorities	Overall priorities
Plan		**21%**	**21%**
	P1 – Demand Planning on a long term perspective	29%	6%
	P2 – Materials Planning with the best use of resources	26%	5%
	P3 – Production Planning avoiding rework and waste	46%	9%
Source		**16%**	**16%**
	S1 – Substitute or recycled raw material	32%	5%
	S2 – Merchandise based on renewable energy	33%	5%
	S3 – Service services aligned with sustainability	36%	6%
Make		**45%**	**45%**
	M1 – Scrap reductions	44%	20%
	M2 – Greenhouse gas emissions reductions	31%	14%
	M3 – Recycled and reused water	25%	11%
Deliver		**18%**	**18%**
	D1 – Distribution planning using truckload	32%	6%
	D2 – Order management strives to exceed customer expectations without additional cost	28%	5%
	D3 – Transportation management with environmental impact reductions	40%	7%

Alternative/Sub-criteria	P1	P2	P3
Individual Benefits	Very Good	Good	Excellent
Organizational Benefits	Excellent	Good to Very Good	Very Good

Alternative/Sub-criteria	S1	S2	S3
Individual Benefits	Good	Very Good	Good
Organizational Benefits	Very Good	Very Good	Very Good

Alternative/Sub-criteria	M1	M2	M3
Individual Benefits	Very Good	Very Good	Good to Very Good
Organizational Benefits	Excellent	Excellent	Good to Very Good

Alternative/Sub-criteria	D1	D2	D3
Individual Benefits	Very Good	Very Good	Very Good
Organizational Benefits	Good to Very Good	Excellent	Excellent

Fig. 5. Qualitative performance.

organizational for M1, M2 and M3. The individual benefits achieved 0.36 and the organizational benefits achieved 0.41. Table 4 presents the priorities for alternatives and Sub-criteria.

5.9. Results

The priorities for alternatives (Table 4) were added to aggregate the priorities: 87% for organizational benefits = 0.17 + 0.13 + 0.41 + 0.16, and 77% for Individual Benefits = 0.16 + 0.10 + 0.36 + 0.15 delivered by the training program.

In this application, priorities are not normally distributed, i.e., the sum of the vector components does not equal one.

In addition, the training program provided the opportunity to learn and accumulate GSCM capabilities. These results were presented to the managers of the company, who validated them as consistent and feasible.

6. Conclusions

A model was proposed to assess the benefits of a training program. The model and the results of the benefit assessment on the GSCM training were primarily developed and obtained in a global chemical corporation. Although only one plant had been surveyed, the model and the results can be adapted to other locations or industry branches.

The results for Sub-criterion Make are higher if compared to Plan, Source and Deliver Sub-criteria, being Source the lowest.

Comparing Sub-criteria Make and Source: Make achieved 26 percentage points over Source in terms of Individual Benefits and 28 percentage points over Source in terms of Organizational Benefits. Emphasis on Sub-criterion Make is on scrap reductions, greenhouse gas emission reductions and recycled and reused water.

On the priorities of alternatives, Organizational Benefits achieved 10 percentage points over Individual Benefits. Organizational Benefits focused on the use of best practices in GSCM, common understanding of vocabulary and process, and improved team integration. In addition, Individual Benefits increased knowledge and skills in GSCM.

The training program improved the GSCM knowledge based on human resources as gains on Individual Benefits, besides recognizing the skills of individuals certified by the company. Knowledge is accumulated and incorporated to the organizational systems in a collective dimension. Therefore, the assessment has offered guidance to managers on GSCM training, measured in terms of benefits. We believe to have made significant contributions to the GSCM literature both in theory and in practice.

Finally, by means a real application, this article has illustrated how a training assessment model should be applied to appraise performance of a particular training program. Nonetheless, the model was applied in one company only and, therefore, all the employees who attended the training program should be considered for a research to be carried on. A long-term evaluation, based on training tangible aspects of efficacy and efficiency, should be considered as next steps. Moreover, a new approach based on Benefits, Opportunities, Costs and Risks is suggested as a further research. Another consideration is about other frameworks on GSCM practices and process as suggested by an anonymous reviewer.

Table 4
Quantitative performance.

Alternative/Sub-criteria	P1 6%	P2 5%	P3 9%	Priority
Individual benefits	0.83	0.5	1	0.16
Organizational benefits	1	0.67	0.83	0.17
Alternative/Sub-criteria	**S1 5%**	**S2 5%**	**S3 6%**	**Priority**
Individual benefits	0.5	0.83	0.5	0.10
Organizational benefits	0.83	0.83	0.83	0.13
Alternative/Sub-criteria	**M1 20%**	**M2 14%**	**M3 11%**	**Priority**
Individual benefits	0.83	0.83	0.67	0.36
Organizational benefits	1	1	0.67	0.41
Alternative/Sub-criteria	**D1 6%**	**D2 5%**	**D3 7%**	**Priority**
Individual benefits	0.83	0.83	0.83	0.15
Organizational benefits	0.67	1	1	0.16

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References

Ahi, P., Searcy, C., 2015. An analysis of metrics used to measure performance in green and sustainable supply chains. J. Clean. Prod. 86, 360–377.
Azzone, G., Noci, G., 1998. Identifying effective PMSs for the deployment of green manufacturing strategies. Int. J. Oper. Prod. Manag. 18 (4), 308–335.
Barney, J.B., 1991. Firm resources and sustained competitive advantage. J. Manag. 17 (1), 99–120.
Barney, J.B., Wright, M., Ketchen Jr., D.J., 2001. The resource-based view of the firm: ten years after 1991. J. Manag. 27 (6), 625–641.
Beamon, B.M., 1999. Designing the green supply chain. Logist. Inf. Manag. 12 (4), 332–342.
Blackstone, J.J.H. (Ed.), 2013. APICS Dictionary, fourteenth ed. APICS, Chicago.
Bukowitz, W.R., Williams, R.L., Mactas, E.S., 2004. Human capital measurement. Res. Technol. Manag. 47 (3), 43–49.
Bulkeley, H., 2006. Urban sustainability: learning from best practice? Environ. Plan. A 38 (6), 1029.
Cai, J., Liu, X., Xiao, Z., Liu, J., 2009. Improving supply chain performance management: a systematic approach to analyzing iterative KPI accomplishment. Decis. Support Syst. 46 (2), 512–521.
Das, K., Posinasetti, N.R., 2015. Addressing environmental concerns in closed loop supply chain design and planning. Int. J. Prod. Econ. 163, 34–47.
Davenport, T.H., 2005. The coming commoditization of processes. Harv. Bus. Rev. 6, 2–9.
De Felice, F., Petrillo, A., 2013. Absolute measurement with analytic hierarchy process: a case study for Italian racecourse. Int. J. Appl. Decis. Sci. 6 (3), 209–227.
Diabat, A., Govindan, K., 2011. An analysis of the drivers affecting the implementation of green supply chain management. Resour. Conserv. Recycl 55 (6), 659–667.
Digalwar, A.K., Tagalpallewar, A.R., Sunnapwar, V.K., 2013. Green manufacturing performance measures: an empirical investigation from Indian manufacturing industries. Meas. Bus. Excell 17 (4), 59–75.
Flynna, B.B., Huob, B., Zhaod, X., 2010. The impact of supply chain integration on performance: a contingency and configuration approach. J. Oper. Manag. 28 (1), 58–71.
Gammelgaard, B., Larson, P.D., 2001. Logistics skills and competencies for supply chain management. J. Bus. Logist. 22 (2), 27–50.
Gilbert, L., 2014. Social justice and the Green city urbe. Rev. Bras. Gest. Urb. 6 (2), 158–169.
Govindan, K., Rajendran, S., Sarkis, J., Murugesan, P., 2015. Multi criteria decision making approaches for green supplier evaluation and selection: a literature review. J. Clean. Prod. 98, 66–83.
Haanaes, K., Reeves, M., Strengvelken, I., Audretsch, M., Kiron, D., Kruschwitz, N., 2012. Sustainability nears a tipping point. MIT Sloan Manag. Rev. 53 (2), 69–74.
Hansen, F., Smith, M., Hansen, R.B., 2002. Rewards and recognition in employee motivation. Comp. Benefits Rev. 34 (5), 64–72.
Hervani, A.A., Helms, A.A., Sarkis, J., 2005. Performance measurement for green supply chain management. Benchmarking Int. J. 12 (4), 330–353.
Ishizaka, A., Nemery, P., 2013. Multi-criteria Decision Analysis: Methods and Software. John Wiley & Sons, West Sussex.
Jabbour, C.J.C., Jabbour, A.B.L.S., 2016. Green human resource management and green supply chain management: linking two emerging agendas. J. Clean. Prod. 112, 1824–1833. http://dx.doi.org/10.1016/j.jclepro.2015.01.052.
Jabbour, A.B.L.S., 2015. Understanding the genesis of green supply chain management: lessons from leading Brazilian companies. J. Clean. Prod. 87, 385–390.
Jabbour, C.J.C., 2010. In the eye of the storm: exploring the introduction of environmental issues in the production function in Brazilian companies. Int. J. Prod. Res. 48 (21), 6315–6339.
Khadivar, A., Zadeh, A.R., Khani, M., Jalali, S.M.J., 2007. A conceptual model for knowledge flow in supply chain. Int. Eng. Manag. Conf. IEEE 352–356.
Kumar, S., Teichman, S., Timpernagel, T., 2012. A green supply chain is a requirement for profitability. Int. J. Prod. Res. 50 (5), 1278–1296.
Li, S., Ragu-Nathan, B., Ragu-Nathan, T.S., Rao, S.S., 2006. The impact of supply chain management practices on competitive advantage and organizational performance. Omega 34 (2), 107–124.
Lu, L.Y.Y., Wu, C.H., Kuo, T.C., 2007. Environmental principles applicable to green supplier evaluation by using multi-objective decision analysis. Int. J. Prod. Res. 45 (18–19), 4317–4331.
Lummus, R.R., 2007. The role of APICS in professionalizing operations management. J. Oper. Manag. 25 (2), 336–345.
Mathiyazhagan, K., Govindan, K., NoorulHaq, A., Geng, Y., 2013. An ISM approach for the barrier analysis in implementing green supply chain management. J. Clean. Prod. 47, 283–297.
Medini, K., Bourey, J.P., 2012. SCOR-based enterprise architecture methodology. Int. J. Comp. Integr. Manuf. 25 (7), 594–607.
Muduli, K., Govindan, K., Barve, A., Kannan, D., Geng, Y., 2013. Role of behavioural factors in green supply chain management implementation in Indian mining industries. Resour. Conserv. Recycl 76, 50–60.
Oliveira, M.P.V., McCormack, K., Trkman, P., 2012. Business analytics in supply chains—the contingent effect of business process maturity. Expert Syst. Appl. 39 (5), 5488–5498.
Palma-Mendoza, J.A., 2014. Analytical hierarchy process and SCOR model to support supply chain re-design. Int. J. Inf. Manag. 34 (5), 634–638.
Perotti, S., Zorzini, M., Cagno, E., Micheli, G.J., 2012. Green supply chain practices and company performance: the case of 3PLs in Italy. Int. J. Phys. Distrib. Logist. Manag. 42 (7), 640–672.
Prahalad, C., Hamel, G., 1990. The core competency of the corporation. Harv. Bus. Rev. 68 (3), 79–91.
Prajogo, D., Olhager, J., 2012. Supply chain integration and performance: the effects of long-term relationships, information technology and sharing, and logistics integration. Int. J. Prod. Econ. 135, 514–522.
Presley, A., Meade, L., Joseph Sarkis, J., 2007. A strategic sustainability justification methodology for organizational decisions: a reverse logistics illustration. Int. J. Prod. Res. 45, 4595–4620.
Rabelo, L., Eskandari, H., Shaalan, T., Helal, M., 2007. Value chain analysis using hybrid simulation and AHP. Int. J. Prod. Econ. 105 (2), 536–547.
Ross, D.F., 2015. Distribution Planning and Control. Springer, N. York.
Saaty, T.L., 2010. Principia Mathematica Decernendi: Mathematical Principles of Decision-making. RWS, Pittsburgh.
Saaty, T.L., 2006. Rank from comparisons and from ratings in the analytic hierarchy/network processes. Eur. J. Oper. Res. 168 (2), 557–570.
Saaty, T.L., 1980. The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. McGraw-Hill, New York.
Sarkis, J., Zhu, Q., Lai, K.H., 2011. An organizational theoretic review of green supply chain management literature. Int. J. Prod. Econ. 130 (1), 1–15.
Satiman, L.H., Abu Mansor, N.N., Zulkifli, N., 2015. Return on Investment (ROI) training evaluation in Malaysian SMEs: factors influencing the adoption process. Dev. Learn. Organ 29 (2), 18–21.
Schoenherr, T., Griffith, D.A., Chandra, A., 2014. Knowledge management in supply chains: the role of explicit and tacit knowledge. J. Bus. Logist. 35 (2), 121–135.
Sellitto, M.A., Pereira, G.M., Borchardt, M., Silva, R.I., Viegas, C.V., 2015. A SCOR-based model for supply chain performance measurement: application in the footwear industry. Int. J. Prod. Res. 53 (16), 4917–4926.
Seuring, S., 2013. A review of modeling approaches for sustainable supply chain management. Decis. Support Syst. 54 (4), 1513–1520.
Sipahi, S., Timor, M., 2010. The analytic hierarchy process and analytic network process: an overview of applications. Manag. Decis. 48, 775–808.
Shang, K.C., Lu, C.S., Li, S., 2010. A taxonomy of green supply chain management capability among electronics-related manufacturing firms in Taiwan. J. Environ. Manag. 91 (5), 1218–1226.
Shub, A.N., Stonebraker, W., 2009. The human impact on supply chains: evaluating the importance of “soft” areas on integration and performance. Supply Chain Manag. Int. J. 14 (1), 31–40.
Subramanian, N., Ramanathan, R., 2012. A review of applications of analytic hierarchy process in operations management. Int. J. Prod. Econ. 138, 215–241.
Testa, F., Iraldo, F., 2010. Shadows and lights of GSCM (Green Supply Chain Management): determinants and effects of these practices based on a multi-national study. J. Clean. Prod. 18 (10), 953–962.
Thun, J.H., 2010. Angles of integration: an empirical analysis of the alignment of internet-based information technology and global supply chain integration. J. Supply Chain Manag. 46 (2), 30–44.
Tramarico, C.L., Marins, F.A.S., Urbina, L.M.S., Salomon, V.A.P., 2015. Benefits assessment of training on supply chain management. Int. J. Anal. Hierarchy Process 7 (2), 240–255.
Treem, J.W., 2013. Technology use as a status cue: the influences of mundane and novel technologies on knowledge assessments in organizations. J. Commun. 63, 1032–1053.
Van Zyl, C., 2003. Supply chain knowledge management adoption increases overall efficiency and competitiveness. S. A. J. Inf. Manag. 5 (4).
Zhu, Q., Sarkis, J., Lai, K.H., 2012. Examining the effects of green supply chain management practices and their mediations on performance improvements. Int. J. Prod. Res. 50 (5), 1377–1394.
Zhu, Q., Sarkis, J., Lai, K.H., 2007. Green supply chain management: pressures, practices and performance within the Chinese automobile industry. J. Clean. Prod. 15 (11), 1041–1052.
Zhu, Q., Sarkis, J., 2004. Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. J. Oper. Manag. 22 (3), 265–289.