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“CLEANER PRODUCTION TOWARDS A SUSTAINABLE TRANSITION”

Green Issues in the Supply Chain Management Training

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Abstract

Green Supply Chain Management is an important issue for organizations that spend significant yearly investments on personnel training. Although these investments present positive effects, the manner to assess the effectiveness of training is unclear. A research that carries out multi-criteria training assessment for Green Supply Chain Management through the process and presentation of the model based on the Supply Chain Operations Reference Model is hereby depicted. Analytic Hierarchy Process was applied in the solution considering Plan, Source, Make and Deliver as criteria, and individual and organizational benefits are identified alternatives in a chemical industry. The modelling considered pairwise judgments for criteria and ratings or absolute measure for alternatives. The main result of the analysis revealed that training essentially contributes to the organization, resulting in the perception of 88% for organizational benefits, and 78% for individual benefits. This result was presented to managers of the company, and they validated it as consistent and applicable in practice.

Keywords: Analytic Hierarchy Process, Green Supply Chain Management, Supply Chain Management, Training

1. Introduction

Supply Chain Management (SCM) is a critical factor in the current scenario by global economic relations. Some important issues in the SCM are SC's performance, SC integration and SC sustainability. Components of Green Supply Chain Management (GSCM) contribute to SC's performance, for instance reducing the environmental impact.

The purpose of the present article is to provide a model for training assessment of GSCM. This model incorporates elements from SCM Theory and Multi-criteria Decision Making (MCDM). As a result, it allows measuring individual and organizational benefits from the training. Analytic Hierarchy Process (AHP) is an MCDM method to solve complex problems, priority settings, resource evaluation, assessment of costs and benefits, among others (Saaty, 2010a). In Operations Management, AHP applications were published from 1990 to 2009 in 291 peer reviewed journals articles (Subramanian and Ramanathan, 2012).

A literature review on GSCM was conducted identifying 300 articles published in the latest 15 years (Seuring, 2013). Only in 36 articles applied MCDM methods. The research method adopted in this article was Mathematical Modelling (Bertrand and Fransoo, 2002; Salgado et al., 2012).

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Section 2 introduces GSCM concepts, Supply Chain Operations Reference (SCOR) Model (Supply Chain Council, 2010), and a SCM training program (APICS, 2011). The AHP is described in Section 3. In Section 4 AHP is applied for the training assessment of GSCM. The article ends with Conclusions and the references.

2. Theory background

The SCM term was created by consultants in the 1980's, and expatiated with other researchers' works (Mahmood et al., 2003). Many SCM concepts are found in literature that remain valid and convergent: the activities and processes coordination within organizations; information, product and service flow from customer to supplier; the transformation of activities and goods flow; the integration of core processes from end user through suppliers (Cooper et al., 1997; Ballou et al., 2000; Lambert and Cooper, 2000).

Up-to-date studies focus on the integration between the SC, the customer, the supplier and an internal integration. They also focus on the degree of cooperation between SC parties through intra- and inter-organizational processes based on information technology (Flynn et al., 2010; Thun, 2010). The SC design and integration depend on the management strategy adopted by the business based on the corporation's core competency, involving decision-making to outsource some supply chain 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 Green Issues as environmental sustainability practices' disposal of waste, and best use of resources (Zhu et al., 2012). Sustainability refers to "the efforts a company makes related to conducting the business in an environmentally sustainable manner, and it involves social responsibility" (Supply Chain Management Terms and Glossary, 2013). Another sustainable development concept is stated as "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs" (United Nations Economic Commission for Europe, 2005).

This sustainability statement should include a strategy for short, medium and long-term period in the organization, associated with significant impacts, as (Global Reporting Initiative, 2011):

- Materials – under use and recycled input.
- Energy – saved due to conservation, being efficient or renewable, and consumption reduction.
- Water – recycled and reused.
- Emission and waste – greenhouse gas emission reduction and waste reduction.
- Transport – environmental reduction impacts.

Presently, many companies have placed sustainability permanently on their management agenda, including the sustainability strategic development which is based on economic, environmental and social metrics. With waste elimination through the supply chain, companies have found ways to attain profit and see sustainability as a competitive advantage (Kumar et al., 2012; Haanaes et al., 2012; Presley et al., 2007). The adoption of environmental aspects in production management includes the use of environmental and cleaner technologies (Jabbour, 2010).

SCOR is an important model for managing processes in the supply chain. Developed by the Supply Chain Council, an independent and non-profitable administration body, which is open to all companies and organizations. The Model describes the business activities in order to meet the customer demands, improving the performance of the supply chain to support the SCM strategy. The following are considered as the core processes of companies: Plan, Source, Make, Deliver and Return. SCOR boundaries were defined from the supplier to customer (Medini and Bourey, 2012).

The scope of the five distinct processes of SCOR Model is (Supply Chain Council, 2010):

- 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 stocked, make-to-order, and engineer-to-order Product.
- Return – return of raw materials and receipt of returns of finished goods.

SCM elements contribute to value chains. Due to its importance, training in SCM has been growing as one of the most relevant bases to become Certified in Production and Inventory Management (CPIM) of APICS, whereas the goal of APICS is to build and validate the knowledge management supply chain and the operations management, providing certification programs for the community, members and customers. Certification as a strategic advantage is quite necessary in the present globalized world (Lummus, 2007).

The goal of the training program is to prepare employees to obtain CPIM. It contributes to the field of terminology, concepts and strategies related to SCM, demand management, master and materials planning, capacity management, sales and operations planning, production environments and process, purchasing, physical distribution, performance measures, supplier relationships, lean and JIT, quality systems and continuous improvement (APICS, 2011).

APICS suggests that SCM training could be evaluated using two sets of benefits as (APICS, 2011): Individual benefits and Organizational benefits. Individual benefits include:

- Increase your functional knowledge of production and inventory management
- Improve efficiency of your organization's supply chain
- Streamline operations through accurate forecasting
- Predict outcomes more accurately
- Maximize return on investment on systems and technologies
- Increase profitability by optimizing your organization's inventory investment
- Enhance your credibility among peers, employers, and customers
- Understand the various functions within a company (such as purchasing, planning, finance, engineering) that are linked by the ERP system

Expected organizational benefits from SCM training are:

- Proven knowledge and organizational skills to strategically streamline operations
- Tools to effectively manage global supply chain activities where suppliers, plants, distributors and customers are located around the world
- Ability to interact with existing resources and your ERP system to increase the efficiency of the workplace
- Skills to create consistency and foster collaboration through best practices, common terminology, and corporate-wide communication
- Knowledge to apply principles ERP software is based upon, including lessons covering various functions within a company (for example, purchasing, planning, finance, engineering)

3. Analytic hierarchy process

Training in SCM can be assessed using qualitative criteria to various SCM processes. The AHP method application uses hierarchy models (Saaty, 2010a). The AHP application often is taken in two phases of the decision process: the problem structuring and the elicitation of priorities through pairwise comparisons (Ishizaka and Nemery, 2013).

The characteristics of the AHP are the adoption of the well-known fundamental scale proposed by Saaty (2010b) to consult experts about the problem's alternatives and criteria, generating a pairwise comparison matrix **A**, in the sequence, using Linear Algebra concepts, as the eigenvector (**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 (Saaty, 1977), as presented in (1):

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

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

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

As pointed by Saaty (2010a), if μ is lower than 0.10 the Matrix A is consistent. Otherwise, a review on the comparisons may be necessary. In AHP applications, comparisons are based on the fundamental scale of absolute numbers, a linear scale from 1 to 9 (Saaty, 2010b).

4. Multi-criteria training assessment for green supply chain management

The research presented in this article was conducted in a major chemical plant located in the State of Sao Paulo State, Brazil. This plant belongs to a multinational group that acts in 170 countries, with direct production in 40 countries. The studied plant has around 1,000 employees, and it is part of the top 10 companies in the chemical and petrochemical sectors. With a portfolio of 8,000 products, the company has offered important contributions to product segments for agriculture, chemicals, performance products, plastics, oil and gas.

The company has been an active member of the United Nations Global Compact since 2000's, which is a "strategic policy initiative for businesses that are committed to aligning their operations and strategies with ten universally accepted principles in the areas of human rights, labor, environment and anti-corruption" (United Nation Global Compact, 2013).

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 was implemented one year ago to prepare and obtain CPIM with 5 modules and 32 hours each. More than 100 employees have participated in the training program. The company uses a reaction training assessment based on the participant's expectations, as location, training organization, workload, content, knowledge applied in day-to-day routine, and clarity to expose the contents by the instructor. There is no structured model to assess the effectiveness of training, which can provide the individual and organizational benefits along the employees' day-to-day routine.

A few questions managers frequently ask regarding the training gains are: (i) "Does the training program deliver individual benefits based on GSCM?", and (ii) "Does the training program deliver organizational benefits based on GSCM?" The answers to both questions will contribute to develop the training assessment process whose main idea is to measure the impact on individual and organizational benefits. i.e., the model aims to reveal how important is the course to obtain individual benefits in relation to organizational benefits detailed in the three following steps:

Figure 1 presents the training assessment model. This proposal is based on SCOR Model's four top-level processes (Plan, Source, Make and Deliver). Twelve benefits were identified considering Green Issues in its components: "being on a long-term perspective", "best uses of resources", and "avoiding rework and waste management" for instance. These components are related to waste management, which is crucial to Green Supply Chain (Azzone and Noci, 1998; Digalwar et al., 2013).

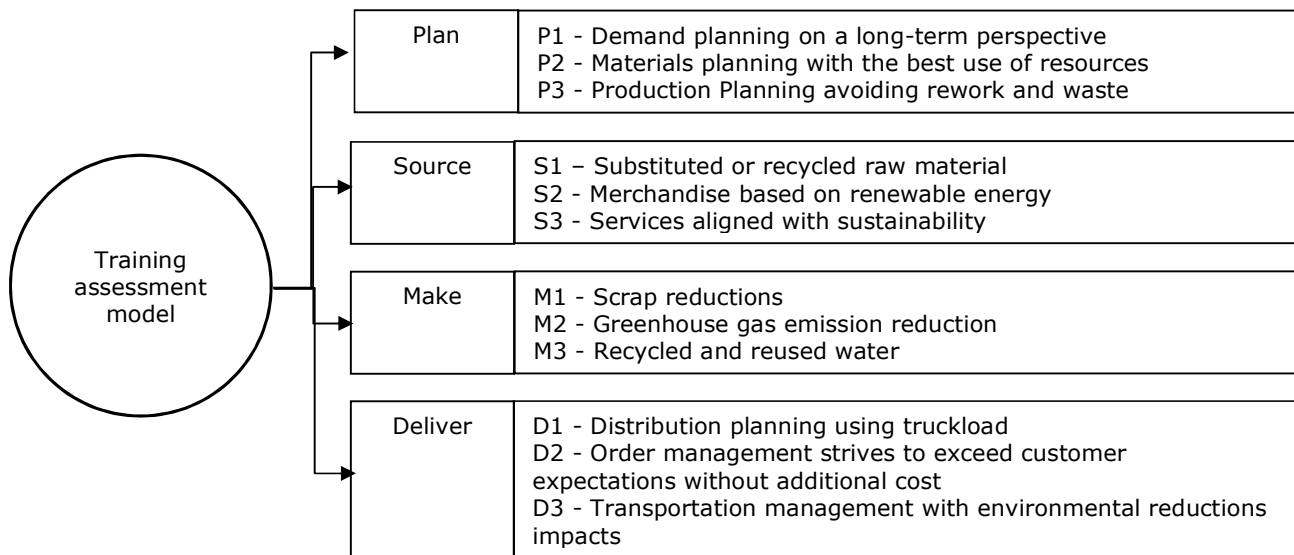


Fig. 1. Training assessment model.

Figure 2 presents the complete hierarchical structure. As it can be seen Individual and Organizational benefits by APICS (2011) are in the bottom level, as the alternatives. Criteria will be pairwise compared. Alternatives will be rated as illustrate in the following.

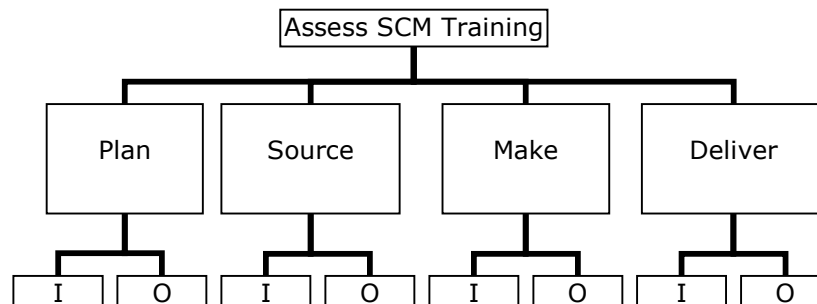


Fig. 2. Training assessment hierarchy.

Following the expert experience, the pairwise judgments for the Plan, Source, Make and Deliver criteria were achieved, and the consistency can be considered as valid when the highest consistency index equals to 0.09. The Make criterion is the most significant priority result, 45%, followed by Plan with 21%, Deliver with 18%, and Source with 16%. Table 1 shows the judgments for each criteria and priorities.

Process	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%

Table. 1. Processes priorities.

After the achievement of all judgments, overall priorities were calculated, highlighting sub-criteria M1 - scrap reductions of 20%, followed by M2 - greenhouse gas emission reduction with 14%, and M3 - recycled and reused water, with 12% (listed in Table 2).

	Process	Overall Priority
Plan	P1 - Demand Planning on a long-term perspective	6%
	P2 - Materials Planning with the best use of resources	5%
	P3 - Production Planning avoiding rework and waste	10%
Source	S1 - Substitute or recycled raw material	5%
	S2 - Merchandise based on renewable energy	5%
	S3 - Services aligned with sustainability	6%
Make	M1 - Scrap reductions	20%
	M2 - Greenhouse gas emission reduction	14%
	M3 - Recycled and reused water	11%
Deliver	D1 - Distribution planning using truckload	6%
	D2 - Order management strives to exceed customer expectations without additional cost	5%
	D3 - Transportation management with environmental impact reduction	7%

Table. 2. Overall priorities of processes

There is also possibility of using ratings or absolute measure in AHP application, i.e. each alternative is compared with many other alternatives, while ratings compare each alternative with an ideal one (Saaty, 2006). Table 3 presents the intensity levels or degrees of quality set for training assessment alternatives.

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

Table. 3. Training rating scale

Figure 3 shows the qualitative performance attribution by the same expert based on rating for each sub-criterion on individual and organizational benefits.

Benefits	P1	P2	P3
Individual benefits	Very Good	Good	Excellent
Organizational benefits	Excellent	Good to Very Good	Very Good

Benefits	S1	S2	S3
Individual benefits	Good	Very Good	Good
Organizational benefits	Very Good	Very Good	Very Good

Benefits	M1	M2	M3
Individual benefits	Very Good	Very Good	Good to Very Good
Organizational benefits	Excellent	Excellent	Good to Very Good

Benefits	D1	D2	D3
Individual benefits	Very Good	Very Good	Very Good
Organizational benefits	Good to Very Good	Excellent	Excellent

Fig. 3. Qualitative performance

Table 4 presents the quantitative performance based on rating for each benefits on individual and organizational benefits.

Benefits	S1	S2	S3
Individual benefits	0.5	0.83	0.5
Organizational benefits	0.83	0.83	0.83

Benefits	M1	M2	M3
Individual benefits	0.83	0.83	0.67
Organizational benefits	1	1	0.67

Benefits	D1	D2	D3
Individual benefits	0.83	0.83	0.83
Organizational benefits	0.67	1	1

Table. 4. Quantitative performance

Aggregating the overall priority (Table 2) and the quantitative performance (Table 4), it was obtained 88% for organizational benefits, followed by 78% for individual benefits delivered by the training program based on GSCM.

These results were presented to the managers of the company under study. They validated it as consistent and applicable in practice. There was no formal method used for validation.

5. Conclusions

A model was proposed to assess the effectiveness of a training program based on what had been delivered by training. The SCOR Model top-level process and sustainability elements were considered in its development. The AHP was applied in the modelling, and pairwise judgments were considered as criteria for ratings the alternatives.

The Make Criterion was considered as the highest overall priority. The main result of the analysis reveals that SCM training contributes with individual and organizational benefits. Therefore, the managers of the company should not be worried because there is a proven return on the investment on SCM training, measured in terms of benefits which are based on SCOR and Green Issues.

In a real application, the importance of adopting a consistent assessment model through the incorporation of components and elements of sustainability is revealed. However, the model was applied in a company and therefore all employees of the company under study that attended the training program should be considered for this research to be carried on. Evaluation a long term based on tangible aspects of training efficacy, efficiency should be considered as next steps, and new approach based on Benefits, Opportunities, Costs and Risks is suggested as future research (Saaty and Ozdemir, 2003).

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