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Using AHP and ANP to Evaluate the Relation between Reverse Logistics and Corporate Performance in Brazilian Industry

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Abstract

Reverse Logistics (RL) activities are practiced by most Brazilian industries. However, a relevant problem is to identify how different RL programs can affect corporate performance indicators. Analytic Hierarchy Process (AHP) is one of the analytical tools which can be used to handle a multi-criteria decision-making problem and the Analytic Network Process (ANP) is a similar technique, but it can capture the interdependencies between the criteria under consideration. Both approaches were adopted here to study the influence of RL practices in corporate performance. Preliminary results indicated that both methods can be used, being AHP the most efficient, because it requires a smaller number of judgments, and ANP the most reliable, because it considers element dependencies, which is more compatible to the reality of the Brazilian industries.

Keywords: Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Reverse Logistics.

Introduction

Today the sustainability theme has acquired great importance in business and academic fields, as well as in society in general. This concept is basically being introduced in companies by environmental regulations. Clean production, reduction,

re-using, recycling, and some other strategies are used in order to satisfy the needs without compromising the future.

Reverse Logistics (RL) is defined as the area of business logistics responsible for planning, operating and controlling raw materials reverse flows, in-process inventory, finished products, with the information from the consumption point to the origin point, in order to recapture value or adjust destination (Rogers and Tibben-Lembke, 1999). It can generate several benefits (including productivity gains) that react on the economic, social, and environmental spheres.

Improving customer service, reduction of operation costs, brand prestige increase and corporate image have been identified as potential benefits of RL programs (Daugherty, Autry and Ellinger, 2001) that can be an alternative source of income, contributing to business sustainability (Braga Junior, Costa and Merlo, 2006). RL in the recycling channel allows reaching economic and corporate image aims, reducing wastes and residues (Souza, Vasconcelos and Pereira, 2006; Cruz and Ballista, 2006). RL practice positively and strongly affect the performance indicators, which are closely linked to concept of corporate sustainability, but it is still hard to evaluate this impact quantitatively (Hernández, Marins and Castro, 2007).

Although current researches show greater level of awareness and clarity for RL procedures and policies in the companies (Leite, 2009), reverse flow is still not well thought out as a competitive advantage in many cases. Therefore, evaluating impacts of RL programs on competitiveness or corporate performance and its importance in the enterprise strategic thinking should have been priorital objectives to lead researches in that thematic.

Taking into account the previously mentioned statements, this work analyzes sustainable practices identified in Brazilian companies, which can be included into groups of different RL programs – economic, image, corporate citizenship, legal, and customer service drivers in order to evaluate the influence in corporate performance by using Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP).

Interviews with specialists were conducted in order to collect and validate data in the research preliminary phase. This qualitative and exploratory approach was fundamental to familiarize with the problem, and afterwards a quantitative approach allowed obtaining decision criteria and sub criteria, as well as giving them relevance or importance, establishing dependency relations in the model here proposed.

This research started with a referential general review regarding to diverse concepts that lead to an understanding of how RL influences corporate performance indicators, grouped into Balanced Scorecard (BSC) perspectives. Later, the research methodology is described, defining the model to be used. Finally, the results of AHP and ANP applications are presented, demonstrating advantages and disadvantages of each of them.

Theoretical Aspects

Corporate Performance and RL

The company sustainability and perpetuity in the long term have become aims with the same level of profit necessary in the short term, so, besides the pursuit of gain, it is necessary to honor a great variety of social, environmental, and governmental interests to ensure profitability for a long time.

RL is inserted in this context of multiple satisfactions, ever since a lot of productivity gains are obtained by RL practices. There are also several strategic drivers that support its implementation: economical factors, legislations, corporate citizenship, environmental aspects (Rogers and Tibben-Lembke, 1999); economical aspects, marketing, and legality (Fleischman *et al.*, 2000); economical aspects, corporate citizenship, image, customer service, and legality (Leite, 2006).

Although the benefits of RL programs are recognized, the reality of the Brazilian companies shows neither the usual possibility of verifying all their advantages nor how they would be directly linked to performance indicators, because, according to BSC (Kaplan and Norton, 1997), they are a combination of financial and non-financial indicators.

BSC was designed initially as a solution to measure performance, but, subsequently, it was proved as a strategic management tool to formulate or implement strategies (Kaplan and Norton, 1997).

This work employs four BSC perspectives to show how RL programs can affect corporate performance indicators. Table 1 summarizes the four perspectives and the indicators that, in the authors' opinion, can be affected by RL practices.

Table 1 - Corporate performance indicators related to RL.

Perspectives	Corporate performance indicators
Financial	Traditional economic-financial indicators Shareholder value Access to capital
Customer	Customer attraction and retention Brand value and reputation
Internal processes	Operational efficiency License to operate Innovation
Learning and Growth	Intellectual and human capital

Financial Perspective

Although logistics activities are consumers of financial resources, value recapture of returned materials can be an attractive activity for many companies (Rogers and Tibben-Lembke, 1999). Recycling provides earnings that stimulate new

initiatives to development and improvement of RL practices. According to Leite (2006), economic recovery is the basic reason to corporate use of these practices in Brazil.

Besides providing profit, there is an enterprise to generate value for its owners and shareholders. Nowadays, this value also becomes an investment indicator. Financial institutions use social and environmental checklists to measure credit risk. In Brazil, the Managerial Sustainability Index (ISE) is often used to evaluate investments (Silva and Quelhas, 2006).

RL programs basically with economic drivers are linked directly or indirectly to the economic results of the companies. Therefore, they influence most corporate performance indicators (Hernández, Marins and Castro, 2007). However, the environmental protection is vital for the survival of the companies, so image and corporate citizenship programs are also pointed as important drivers.

Customer Perspective

According to Valente (2002) *apud* Chaves and Alcântara (2006), "customer satisfaction is not simply reduced to acquisition of products and services, but a continuous evaluation before and after sale". Thus, RL can generate competitive advantage through an increase in the service level offered to customers by marketing relationship after-sale.

Studies conducted by Rogers and Tibben-Lembke (1999) in American companies in the second half of the 90's showed that the principal strategic reason for those companies operate reverse channels were the increase of the productivity, which enabled a differentiation of the offered services.

Similar studies carried out in Brazil in 2004 and 2005 demonstrated that economic targets had been gaining bigger importance in the RL programs, but customer retention, by adoption of liberal policies to the return of non-consumed products and offered services, keeps on an important strategic objective to achieve competitiveness in many companies (Leite, 2006). Consumers' requirements are a fundamental reason for several companies to operate reverse channels (Sinnecker, 2007), thus it is possible to say that RL has a strong impact on customer attraction and retention (Hernández, Marins and Castro, 2007).

RL allows companies to express actions that are not directly linked to their products, but strengthening their significance by making positive associations to them. Leite (2005) states that creation of corporate image, at the consumer's perception, has a subjective character. This perception is formed from the company/consumer relationship developed during all the negotiation stages, including the relationship with society and the environment. An adequate management of reverse channels can improve corporate image from the treatment of remnants, contributing to the social welfare with donations and environmental conservation with material recycling (Tibben-Lembke, 2000), influencing positively and strongly in the company reputation and corporate social responsibility.

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In Brazil, many industries have been stood out by relations fixed to communities where they are located. They promote social actions to education and programs of environment protection, involving common citizens (Epelbaum, 2004; Amato Neto, 2008).

Internal Processes Perspective

Kaplan and Norton (2000) comment that all internal processes are important and must be well carried out, but some of them cause a bigger impact on value proposition to customers. Managers must make a clear identification of these processes, in each particular case, to achieve success in the implementation of BSC (Campos, 2001).

Achieving Operational Excellence is a target of every company, so productivity indicators and costs are identified with a satisfactory performance of the processes. RL practices give economic gains when the manufacturing uses components and materials recovered by recycling (Leite, 2005).

Rovere (2001) *apud* Amaral (2003) mentions that the inclusion of the technological dimension on the concept of sustainability, evaluating efforts that companies make to create new technologies that are able to develop cleaner and more economical processes. The technological innovations, which bring better use of resources available for recycling, are extremely important to structure reverse channels. According to Leite's rating (2000), technology is necessary to ensure essential conditions in establishing post-consumption reserve flows and the legislation can be a factor of modification for RL organization, because it can develop new technologies. Brazilian business reality indicates there are few programs with legal drivers. Therefore, legislation compliance does not appear as an important factor in the corporate scenario (Leite, 2006). But an establishment of minimum levels for recovering is part of European companies' everyday, under the legal punishment of the operation license loss, and this may be a decisive factor for creativity and innovation increase (Hammond and Beulles, 2007).

The concept of product life cycle for logistics comes from conception to final destination, no matter which: discarding, repair or reusing (Trigueiro, 2002). Most companies invest strongly in material reduction, including the application of biodegradable products, showing that there is, since the conception, preoccupation with destination after lifetime, and it is part of the RL concept.

Learning and Growth Perspective

Learning and functional growth of the enterprise mean its capacity of maintaining human resources at a high level of motivation, satisfaction, and productivity. Kaplan and Norton (2000) cite that, in a study made with different companies, value accounting of tangible assets was no greater than 15% of the market value, the last one was imputed to intangible assets related to knowledge, intellectual, and human capital. According to Herrero (2005), human capital can be understood as

intellectual (knowledge, information, industrial property, experience) that can be used to generate wealth.

Therefore, human capital is an important factor for the companies' survival and renewal in all activity levels. RL policies require skilled and trained human resources, and strategic investment (Hernández, Marins and Castro, 2007).

It is important to mention that the effect of the RL programs on performance indicators can vary according to several factors, such as the type of business sector, value chain, position of the reverse channel, etc. Then, in-depth studies for each kind of business must be developed.

Thus, it shall be needed to develop in-depth studies involving managers and specialists that enable to evaluate, as much qualitative as quantitative approaches, the influence of those practices in corporate success.

This relation can be conceived as a problem with multiple criteria, where several factors must be noted and treated. So, this research seeks after determining the RL practices influence in corporate performance by using Multiple Criteria Decision Making (MCDM) methods.

The different MCDM methods use basically the same tool, the decision matrix. They also follow the same three major steps: establishment of criteria and alternatives, assigning of weights and a summary of results. The big difference between one method and another is how these steps are executed. Thus, applications of different MCDM methods, in the same decision problem may yield different results; therefore, the choice of which method to be used must be defined in terms of specific objectives based on quality and efficiency criteria.

Among several methods, AHP and ANP, both developed by Saaty (1980; 1996), were chosen. The principal reasons for this choice are:

a) AHP is the MCDM method more referred in the literature in last 20 years (Vaidya and Kumar, 2004; Ho, 2008);

b) AHP has innumerable applications related to management methods, like BSC (Marinho and Selig, 2008), and other decision-making methods, mainly ANP (Hou and Su, 2007; Shyur and Shih, 2006; Ustun and Dermitas, 2008).

Both AHP and ANP (Saaty, 2008), considering the latter as an extension of the former, are Multiple Criteria Decision Making (MCDM) methods that use a decision matrix as the basic tool.

Taliscali and Ercan (2006) *apud* Nascimento, Silva and Belderrain (2008) show as fundamental advantages of AHP/ANP, in comparison with other MCDM methods, the "user-friendly", and the application of qualitative and quantitative factors together in the evaluation.

The basic difference between them is that ANP has a network structure that allows the analysis of dependence among elements of the model, which make it more powerful in uncertain situations and let the problem analyzed closer to reality (Nascimento, Silva and Belderrain, 2008).

Research Methodology

In order to achieve the main goal of this paper, it is necessary to decide which MCDM methodologies can be used and which one adapted better to the characteristics of the study objectives based on the existence of a dependency rule between criterion and alternatives. Therefore, the main question is: can the AHP and the ANP methodologies be used to measure the influence that the RL practices exert over performance benchmarking indicators?

In order to answer this question, a complete and broad approach is necessary, as it was necessary to find evidences of a given relationship, so that the influences could be measured and analyzed, and this can be assured whenever the qualitative and quantitative approaches are combined (Creswell and Clark, 2006).

Considering the above mentioned the mixed method with sequential exploratory strategy was chosen, dealing with qualitative data collected in the first stage in order of priority (Creswell, 2007). In this case, the quantitative data is supposed to help interpret and confirm the qualitative results.

The chosen sample included companies that represent nine branches of economics and that practice any kind of RL. The 33 people interviewed were logistics and purchasing experts and managers of the companies mentioned located in the Southern Fluminense area.

Detailed individual interviews were chosen as a means for collecting data, which involves the primary collection of data and also involves the analysis and interpretation of the obtained data. This interview differs by the type of question (open or closed) according to the applied qualitative or quantitative procedures.

In the first stage, qualitative data about the RL programs and its influence on the performance benchmarking were collected which is rather important in order to collect extensive information about the characteristics of RL in the investigated companies. According to Martins (2010), although there is not a previously arranged manner to analyze data in a qualitative approach, it is quite usual to use the content analysis criterion based on the detailed reading of each part of the text. This allows the identification of relationships among all elements and it is the chosen criterion in this research.

The obtained hierarchical matrices and the identification that attribute could produce different results led to the use of the Multiple Criteria Decision Making methodology (MCDM), specifically the AHP/ANP methodologies.

The hierarchical structure of Figure 1 shows this relationship succinctly, and in each perspective there are only included indicators shown in Table 1.
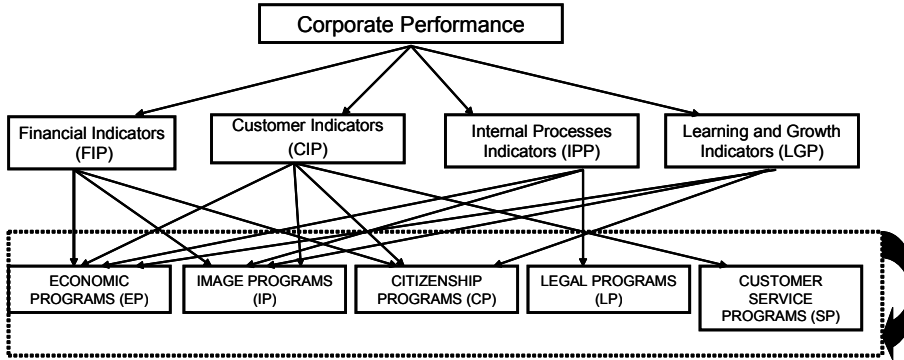

Figure 1 - Corporate performance and RL.

From the model shown in Figure 1 it passed on to the second phase of the research where, by quantitative approach, values of importance were attributed to criteria and alternatives.

It was possible to determine the influence that each RL program had in the performance benchmarking indicators, as well as which advantages and disadvantages each of these methodologies had in each case according to the final result of the application of the AHP and ANP methodologies.

Result Analysis

AHP Application

In the AHP applications, the data needed are judgments to compound matrix of comparisons between elements of the model (alternatives or criteria), two by two. The data generated by method application includes the decision matrix (compounded by performance values of alternatives for each criterion), the consistency ratio (CR) values of the judgments and the decision vector (compounded by global performance values of alternatives) (Salomon, 2004).

According to the model shown in Figure 1, RL programs identified in the Brazilian industry are: economic (EP), image (IP), citizenship (CP), customer service (SP), and legal (LP). Each of them included a set of alternatives or own activities. In this particular case, we are not interested in selecting alternatives. We intend to determine the importance that each RL program has on corporate performance, considering that indicators, in each BSC perspective, have the same importance (same weight = relevance?).

The following tables show different judgment matrixes and the final result of the AHP application. Tables 2, 3, 4 and 5 present the judgments of relative

importance of each activity (alternative), in each RL program (criteria). The CR values are between 0.0000 and 0.0624. As they are lower than 0.1, the judgments can be considered as coherent with one another.

Table 2 - Judgment of RL programs under financial criterion.

Alternatives	EP	CP	IP	Decision vector
EP	1	7	3	0.65372
CP		1	1/5	0.07243
IP			1	0.27385

Table 3 - Judgment of RL programs under internal processes criterion.

Alternatives	EP	LP	IP	Decision vector
EP	1	6	4	0.69096
LP		1	1/3	0.09140
IP			1	0.21764

Table 4 - Judgment of RL programs under customer criterion.

Alternatives	SP	IP	CP	EP	Decision vector
SP	1	3	6	3	0.52740
IP		1	3	1	0.19791
CP			1	1/3	0.07553
EP				1	0.19916

Table 5 - Judgment of RL programs under learning and growth criterion.

Alternatives	EP	CP	IP	Decision vector
EP	1	4	2	0.57143
CP		1	1/2	0.14286
IP			1	0.28571

Table 6 shows the global performance of each program regarding the performance indicators contained in the BSC perspectives. Taking into consideration the objective of the study, a similar weight (0,25) was given to each perspective, ever since the goal was not to demonstrate which would be the most important for the performance of the companies.

Table 6 - Global performance for each RL program (Alternatives).

Alternatives	Global performance (priorities)
EP	0.52882
IP	0.24378
SP	0.13185
CP	0.07270
LP	0.02285

The analysis of these results demonstrates that RL programs with economic purpose have great influence in corporate performance and how they are gaining increasingly relevance.

Leite (2006) on a research carried out in 44 Brazilian companies of different sectors evidenced that 50% of the RL programs implemented had as a driver reaching economic goals.

On the other hand, the corporate image shown up in second place because there are few companies that utilize RL as marketing to improve image (Sinnecker, 2007) and the result of AHP application reinforce these affirmations.

However, there are other realities that this method is not able to treat and that other results, called marginal, may be confused with real goals or drivers of a program in particular (Leite, 2006). It was corroborated through interviews with managers and specialists of the logistic activities. They revealed that, despite being possible the identification of RL activities within each program according to basic objective that should be achieved, the final result is difficult to measure because many of these activities influence other programs.

We understand that this result is due to implicit consideration existent in hierarchical structures: the independence among elements of the same level. And this is assumed by the AHP. The continuation presents how influence analysis among criteria and subcriteria or alternatives can be included in the model by using ANP.

ANP Application

In order to apply the ANP, it's necessary to analyze the dependency relationships between the criterion and the alternatives. According to Figure 1, the arch-shaped arrow in the alternative group (RL practices) indicates that these do not influence themselves. The lack of this arrow in the criterion group means they were considered independent to our study.

The next step for implementation of ANP is the realization of the judgments, and it needs establishing dependency relations that can be represented by networks or reachability matrices (Saaty, 1980), being these binary.

We need two matrices: the global one (for dependency between clusters) and the local one (for dependency inside clusters) (Salomon, 2004). The Table 7 presents global reachability matrix. As the criteria were considered independents, the component, criteria x criteria", is 0, and the component "alternative x alternative" is 1 due to the relations of dependency. The other components relate to AHP application, taking into account criteria importance (component "criteria x alternative") and alternative performance according to each criterion (component "alternative x criteria").

Table 7 - Global reachability matrix.

Clusters	Alternative	Criteria
Alternative	1	1
Criteria	1	0

Even existing dependency relations among elements of the alternative cluster, these ones are not total and depend on the answers to questions like "Do

RL programs with image goal (IP) produce marginal results which can be confused with the result of an economic program (EP)?", and so for each program. A Table 8 presents local matrix for dependency inside clusters.

Table 8 - Local reachability matrix.

Cluster	EP	IP	CP	SP	LP	FIP	CUP	IPP	LGP
EP	1	1	0	1	1	1	1	1	1
IP	1	1	1	1	1	1	1	1	1
CP	0	0	1	0	0	1	1	0	1
SP	0	1	0	1	0	0	1	0	0
LP	0	0	0	0	1	0	0	1	0
FIP	1	1	1	1	1	0	0	0	0
CIP	1	1	1	1	1	0	0	0	0
IPP	1	1	1	1	1	0	0	0	0
LGP	1	1	1	1	1	0	0	0	0

As result of replacing vectors of dependence among alternatives (obtained from 5 new matrices with 11 judgments), and vectors of performance of the alternative and the vector of importance of the criteria (obtained from AHP), is formed the Supermatrix. For results synthesis, the Supermatrix must be weighted in order to become a column stochastic matrix. It is considered the same weight for each cluster because we know that there is dependence, but not how a criterion or an alternative influences more than others. The powers of the Weighted Supermatrix converge to a matrix which is also stochastic and with all columns equal.

This matrix is denominated Limit Matrix of which normalization results in the priorities of the alternatives (Table 9).

Table 9 - Alternatives priorities.

Alternatives	Global performance (priorities)
EP	0.55715
IP	0.24654
SP	0.12111
CP	0.05816
LP	0.01704

The use of ANP does not change the priority order of RL programs, being corroborated that programs with economic and image purposes have the greatest influence in corporate performance.

However, the importance of economic and image programs is greater than the one obtained with AHP application, and this result is realer due to the fact that the programs with other purposes cause marginal results that may be confused with goals of economic and image programs. Legal and citizenship programs had a lesser importance because they received little influence from others.

Conclusions

The analysis of relevant studies of several authors has shown that, although still without establishing a quantitative impact, the RL policies and practices strongly and positively affect corporate performance indicators that are closely linked to the corporate sustainability concept. Therefore, it would be necessary to find methods and tools that allow evaluating this influence.

Thus, answering the main question of this research, we are able to affirm that both methods – AHP and ANP – can be used to evaluate the influence that RL practices have on corporate performance indicators, but the result obtained with the application of each of them can vary in terms of efficiency and reliability. With this study, it was possible to establish priorities with both methods.

From the point of view of efficiency, the best method is the AHP because it requires a smaller number of judgments (4 matrices with 13 judgments), so the consumption of time and resources decreases.

The inclusion of dependence analysis among alternatives increases the time consumed for data collection (in this case, 5 new matrices with 11 judgments is necessary), but it can improve the quality of process and results, being more compatible to reality. According to Leite (2006), image, customer service, and citizenship programs provoke economic results that can be appreciated through ANP application.

Although there are advantages and disadvantages of each method, both require specific knowledge and familiarity with the processes of the company to correctly identify all activities and dependence relations.

Future researches should analyze specific companies of different business sectors or different type/position of the reverse channel, ever since these are relevant characteristics related to RL programs and corporate performance indicators.

With respect to AHP and ANP applications, we believe that the best way is the combined use of them, considering that the first one can assist in the development of a hierarchy that subsequently will be used by the second method.

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References

Amaral, S. P. (2003), Estabelecimento de Indicadores e Modelo de Relatório de Sustentabilidade Ambiental, Social e Econômica: Uma Proposta para a Indústria do Petróleo Brasileira. Tese (Doutorado). Universidade Federal do Rio de Janeiro. (in Portuguese)

Amato Neto, J. A. (2008), "Sustainability in the Brazilian automotive productive chain: a multiple case study", Available: http://www.administradores.com.br/noticias/Volkswagen. Access August, 2008.

Braga Junior, S. S.; Costa, P. R. and Merlo, E. M. (2006), "Um estudo comparativo das práticas de logística reversa no varejo de médio porte", In: Simpósio de Administração da Produção, Logística e Operações Internacionais, August 29-31, São Paulo, Brazil. (in Portuguese)

Campos, L. M. S. (2001), SGADA - Sistema de gestão e avaliação do desempenho ambiental: uma proposta de implementação. Tese (Doutorado) Universidade de Santa Catarina. Florianópolis. (in Portuguese)

Chaves, G. L. D. and Alcântara, R. L. (2006), "Logística reversa como atividade geradora de vantagem competitiva ao canal de distribuição de alimentos refrigerados", In: Simpósio de Engenharia de Produção, November 6-8, Brazil. (in Portuguese)

Creswell, J. W. (2007), Projeto de pesquisa: Métodos qualitativo, quantitativo e misto. 2.ed. Porto Alegre: Artmed. (in Portuguese)

Creswell, J. W. and Clark, V. L. (2006), Designing and conducting mixed method research. Londres: Sage.

Cruz, M. M. and Ballista, B. R. (2006), "Logística Reversa dos estabelecimentos de Saúde da Grande Vitória", In: Simpósio de Engenharia de Produção, November 6-8, Brazil. (in Portuguese)

Daugherty, P. J.; Autry, Ch. W. and Ellinger, A. E. (2001), "Reverse Logistics: The relationship between resource commitment and program performance", Journal of Business Logistics, Vol. 22, No. 1, pp. 107-123.

Epelbaum, M. (2004), A influência da gestão ambiental na competitividade e o sucesso empresarial. Dissertação (Mestrado). Escola Politécnica da Universidade de São Paulo. (in Portuguese)

Fleischman, M.; Krikke, H. R.; Dekker, R. and Flapper, S. D. P. (2000), "A characterization of logistics network for product recovery", Omega, Vol. 28, pp. 653-666.

Hammond, D. and Beullens, P. (2007), "Closed-loop supply chain network equilibrium under legislation", European Journal of Operational Research, Vol. 183, No. 2, pp.115-129.

Hernández, C. T., Marins, F. A. S. and Castro, R. C. (2007), "A logística reversa e a responsabilidade social corporativa: influência nos indicadores de desempenho empresarial", In: Simpósio de Engenharia da Produção, November 6-8, Brazil. (in Portuguese)

Herrero, E. F. (2005), Balanced Scorecard e a gestão estratégica: uma abordagem prática. Rio de Janeiro: Campus. (in Portuguese)

Ho, W. (2008), "Integrated analytic hierarchy process and its applications – A literature review", European Journal of Operational Research, Vol.186, No. 1, pp. 211–228.

Hou, J. and Su, D. (2007), "EJB-MVC oriented supplier selection system for mass customization", Journal of Manufacturing Technology Management, Vol. 18, No.1, pp. 54-71.

Kaplan, R. S. and Norton, D. P. (2000), Organização orientada para a estratégia. Rio de Janeiro: Campus. (in Portuguese)

Kaplan, R. S. and Norton, D. P. (1997), A Estratégia em Ação. Rio de Janeiro: Campus. (in Portuguese)

Leite, P. R. (2009), "Pesquisa mostra evolução da Logística Reversa no país", Revista Tecnologística, Ano XIV, No. 162, pp. 30-36. (in Portuguese)

Leite, P. R. (2006), "Direcionadores ("DRIVERS") estratégicos em programas de logística reversa no Brasil", In: Simpósio de Administração da Produção, Logística e Operações Internacionais, August 29-31, São Paulo, Brazil. (in Portuguese)

Leite, P. R. (2005), "Logística reversa e a competitividade empresarial", Revista Tecnologística, Ano XI, No. 117, pp. 32-40. (in Portuguese)

Leite, P. R. (2000), "Canais de distribuição reversos: Fatores de influência sobre as quantidades recicladas de materiais", In: Simpósio de Administração da Produção, Logística e Operações Internacionais, August 28-30, São Paulo, Brazil. (in Portuguese)

Marinho, S. V. and Selig, P. M. (2008), "Análise comparativa do BALANCED SCORECARD com alguns dos principais sistemas de medição de desempenho", In: Simpósio de Administração da Produção, Logística e Operações Internacionais, São Paulo, Brazil. (in Portuguese)

Martins, R. A. (2010), Abordagens Quantitativa e Qualitativa. In: Cauchick Miguel, P. A. (Org), Metodologia de Pesquisa em Engenharia de Produção e Operações. Rio de Janeiro: Elsevier. (In Portuguese)

Nascimento, L. S. N.; Silva, A. C. S. and Belderrain, M. C. N. (2008), "Revisão de literatura sobre a aplicação do método ANP ao problema de seleção de fornecedores", In: Simpósio Brasileiro de Pesquisa Operacional, João Pessoa, Brazil. (in Portuguese)

Rogers, D. S. and Tibben-Lembke, R. S. (1999), Going Backwards: Reverse Logistics trends and practices. Reno, University of Nevada.

Rovere, E. L. (2001), Palestra: Indicadores de Sustentabilidade para Empresas Workshop Gerencial sobre Desenvolvimento Sustentável. Rio de Janeiro. (in Portuguese)

Saaty T. L. (2008), "Relative Measurement and Its Generalization in Decision Making Why Pairwise Comparisons are Central in Mathematics for the Measurement of Intangible Factors The Analytic Hierarchy/Network Process", RACSAM, Vol.102, No. 2, pp. 251–318.

Saaty, T. L. (1996), Decision making with dependence and feedback: the analytic network process. Pittsburgh, PA: RWS Publications.

Saaty, T. L. (1980), The analytic hierarchy process. New York, NY: McGraw-Hill.

Salomon, V. A. P. (2004), Desempenho da modelagem do auxílio à decisão na análise do planejamento e controle da produção. Tese (Doutorado). Escola Politécnica da Universidade de São Paulo. (in Portuguese)

Shyur, H. J. and Shih, H. S. (2006), "A hybrid MCDM model for strategic vendor selection", Mathematical and Computer Modeling, Vol. 44, No. 7-8, pp. 749–761.

Silva, L. S. A. and Quelhas, O. L. G. (2006), "Sustentabilidade empresarial e o impacto no custo de capital próprio das empresas de capital aberto", Gestão & Produção, Vol. 13, No. 3, pp. 385-393. (in Portuguese)

Sinnecker, C. A. (2007), O. estudo sobre a importância da logística reversa em quatro grandes empresas da região metropolitana de Curitiba. Dissertação (Mestrado). Pontifícia Universidade Católica de Paraná. (in Portuguese)

Souza, M. T. S.; Vasconcelos, M. W. and Pereira, R. S. (2006), "A contribuição da Logística Reversa na adequação da Política Nacional de Resíduos Sólidos: Um Estudo de Caso no Setor de Embalagem", In: IV Simpósio de Gestão e Estratégia em Negócios, Rio de Janeiro. (in Portuguese)

Taliscali, A. K. and Ercan, S. (2006), "The Analytic Hierarchy & the Analytic Network Processes in multicriteria decision making: a comparative study", Journal of Aeronautics and space technologies, Vol. 2, No.4, pp. 55-65.

Tibben-Lembke, R. S. (2000), "Life after death – reverse logistics and the product life cycle", International Journal of Physical Distribution & Logistics Management, Vol. 32, No. 3, pp. 223-244.

Trigueiro, F. R. (2002), "Logística Reversa: A gestão do ciclo de vida do produto", Available: http://www.guiadelogistica.com.br. Access August, 2006. (in Portuguese)

Ustun, O. and Dermitas, E. A. (2008), "An integrated multi-objective decision-making process for multi-period lot-sizing with supplier selection", Omega, Vol.36, No. 4, pp. 509-521.

Vaidya, O. S. and Kumar, S. (2004), "Analytic hierarchy process: An overview of applications", European Journal of Operational Research, Vol. 169, No. 1, pp. 1–29.

Valente, T. R. G. (2002), "Marketing de Relacionamento e CRM: uma análise da gestão de clientes no setor financeiro", São Paulo. Available: http://www.ead.fea.usp.br/tcc/trabalhos/Artigo_Thais%20Valente.pdf. Access May, 2005. (in Portuguese)

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