USING ANALYTIC HIERARCHY PROCESS FOR ANALYSIS AND CHOICE OF BRAZILIAN CARGO AIRLINES

Miguelangelo Geimba de Lima*, Clarissa Côrtes Pires, Claudio Luis Piratelli, Mischel Carmen Neyra Belderrain, **Anderson Ribeiro Correia,**

Instituto Tecnológico de Aeronáutica – ITA
Praça Marechal Eduardo Gomes 50, Vila das Acácias
São José dos Campos, SP, Brasil
mgeimba@gmail.com, clarissa@ita.com.br, clpiratelli@gmail.com, carmen@ita.br, correia@ita.br

Keywords: Air cargo transport, logistics, competitive performance, AHP.

Summary: *Air cargo transport is an important driver in industrial development, integrating cargo transport and logistics, facilitating intermodality and fostering imports and exports, resulting in a significant increase in airline revenue. In addition, competition in the sector requires that these companies use strategic management tools, such as decision-making and efficiency analysis methods, in order to remain competitive and operational on the market. Due to the sector's great importance, this survey presents a methodology for the evaluation of relevant criteria for the hiring as well as for the choice of domestic air cargo companies, using the Hierarchical Analysis (AHP) method. It is further believed that the results of this work will be directly useful to airport administrators, cargo terminals, cargo agents, highway transport companies, airlines and also to the National Civil Aviation Agency (ANAC) in putting forward efficiency–boosting suggestions by way of process improvements and audits, personnel training, infrastructure planning, and demand management.*

1. Introduction

The demand for air cargo transport observed in Brazil has experienced high growth rates. From 1994 to 2003 domestic and international air cargo traffic in Brazil increased by 35.9 % (DAC, 2003). In 2001 cargo handling (storage and terminal handling) accounted for 28.8% of total revenue for INFRAERO, the company that runs the 66 largest airports in Brazil.

According to the cargo transport registry, in 2000 this mode was responsible for just 0.33% of the cargo transported in Brazil, in ton-km (GEIPOT, 2005). However, considering the value of the cargo transported by air for overseas trade, its contribution becomes relevant. Air transport in 2000 accounted for a 28.9% share of total imports to the country, and 8.8% of total exports (Keedi, 2001). Moreover, air transport has been taking on an important role in organizing production as a result of its speed, flexibility, reliability, and security, with great potential for being used in new logistics strategies adopted by companies, mainly in the transport of high added-value goods.

Despite the importance of the cargo sector in Brazil, many authors consider in of little relevance to the country (Burmann, 2000; DAC, 2004) and have concentrated mainly on the study of passenger operations. Nevertheless, in many air companies revenue from cargo operations is higher than revenue from passenger operations.

In addition, most studies assessing air companies portray mainly the use of tools such as Data Envelopment Analysis (DEA), like Soares de Mello et al (2002) and Angulo Meza et al. (2002) who used DEA to set out the benchmarks for Brazilian air companies. In studies where selection criteria and human judgment perform a major role we find Arslan & Jotin Khirsty (2004), who have developed a behavioral model to explain route choice, where decision-makers' perceptions were modeled as fuzzy numbers. Tsaur et al. (2002) used the fuzzy technique to assess the quality of airline services in Taiwan. Service quality involves various attributes, many of which, such as security and comfort, are intangible and hard to measure.

This study, guided by these concerns, aims to make a contribution through its results for stakeholders in the Brazilian air cargo sector through presentation of a methodology to assess relevant criteria for the hiring as well as choice of air cargo companies using the Hierarchical Analysis (HA) method. Considering as criteria cost, speed, reliability and flexibility of logistics services, other secondary aspects of performance were also specified, based on the studies done by Lima, et al. (2006).

In section 2 there is a review of the literature on competitive performance assessment and AHP methodology. Section 3 describes the methodology used for the study of Brazilian air cargo company cases, which is presented in section 4. Final considerations are in the last section.3

2. Background review

2.1. Assessment of logistical and competitive performance

According to Christopher (1997), the challenges faced by logistics are tied into the explosion of client services, time comprehension, globalization of the industry, and organizational integration. Added to this are the challenge of understanding and the application of the concept of logistics in companies. The competency of each organization determines how these challenges are handled to serve the client, in the right time, in the right quantity, with the appropriate quality and costs for products and services.

Beamon (1999) suggests that a good assessment of the performance of the logistical chain must be based on three dimensions: resources, exits or outputs, and flexibility.

Slack et al (1997), Ballou (2004), and Corrêa, Gianesi & Caon (2001), define the aspects of main competitive performance to define secondary aspects from the perspective of the clients (Figure 1). This view of monitoring of competitive performance aspects from the client perspective shaped the definition of the decision criteria in this research. The quality criterion will not be considered in this study as it only describes product specifications.
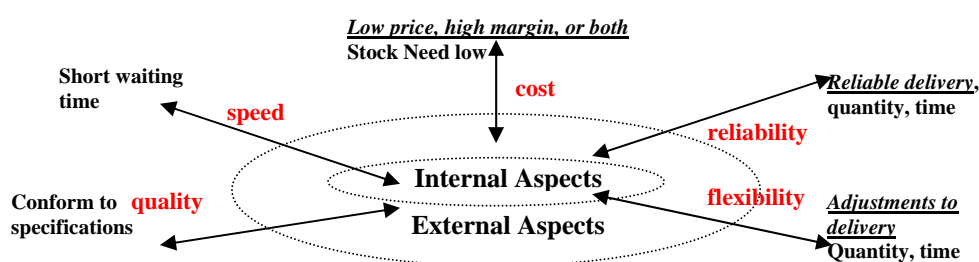

Figure 1: External aspects of performance
Source: Adapted from Slack *et al* (1997)

2.2. Multicriteria Decision Support (MCD) Processes

According to Gomes (2004), mathematical expectation was basically used to solve complex decision-making problems in random conditions up to the first half of the 20th century, involving one principal objective to be achieved. Nevertheless, the decision risk associated with the use of this technique is relatively high as a result of not having access to perfect information on the stochastic events, which often make this analysis procedure inadequate in reality. Hence, in the 1970s methods arose Multicriteria Decision Analysis (MDA) in order to aid decision-makers in solving problems in which various objectives are at stake.

2.3. Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process is an approach to the decision-making process that involves rational and intuitive judgments by decision-makers to select the best alternative from a range of options based on known and/or desirable criteria or attributes.

Saaty (2001) defines the AHP as a theory of measurement that attributes scales and weights to pairwise comparisons amongst attributes and/or alternatives in a hierarchical structure. In general terms, it is a non-linear decision-making problem model where it is possible to work with decisions involving tangible, psychological, physical and intangible aspects. To apply the AHP it is important to well modelling the hierarchical structure of a problem in the form of a network and for it to be possible to make pairwise comparisons that relate to each part of this structure. The simplest way found by Saaty (2001) to structure a decision problem was to think of a generic hierarchical tree made up of various levels, as illustrated in figure 2. In it, the main objective of the decision is represented by the highest hierarchical level, or top. The second level of the structure is made up of the criteria or attributes according to which the alternatives will be evaluated. Finally, the decision alternatives are found in the third level.

The purpose of the hierarchical structure is to provide an overview of the decision problem through the organization of the complex relations between the objectives, criteria, attributes and alternatives. In a second stage, the structure makes it possible to judge the importance of the elements in one level and thus to consider them in relation to the immediately superior elements.
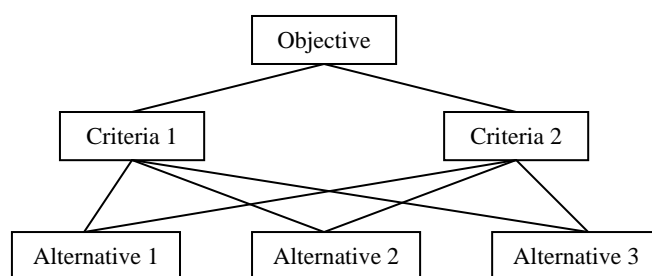

Figure 2: AHP Hierarchical decision structure
Source: Saaty (2001)

The advantages of the AHP making dialogue possible between the interjectors in the process and enabling the incorporation of uncertainty, according to the various points of view of the people involved, brought about the use of this process in this study.

3. Methodology

The methodology involves stages that aid in the defining of the criteria, in the creation of the hierarchical decision structure, and in the assessment of the respective criteria and alternatives associated with the hiring of the companies analyzed. The main clients of the Brazilian air cargo companies were used as assessors and decision-makers.

3.1. Study stages

The study was carried out in three distinct stages, as shown in chart 1.

Activities	Objectives
➤Interviews with specialists in the sector	➤ To learn more about the sector. ➤ To define the variables to be studied (relevant criteria and performance aspects)
➤ Assembly of decision instrument	➤T o define the main decision-making aspects ➤To develop the decision instrument
➤ Interview the main cargo agents together	➤ To apply the instrument and draw up the report

Chart 1: Study stages
Source: The authors

3.2. Analysis model of the agents in the Brazilian air transport

To determine the performance criteria for the agents in Brazilian air cargo transport the model in figure 3 was used.

According to the model in question, the main agents in defining the performance analysis criteria for the air companies are the air cargo agents, because they are the main direct clients. In this study three managers were selected from these companies based on the study done by Lima et al (2006).
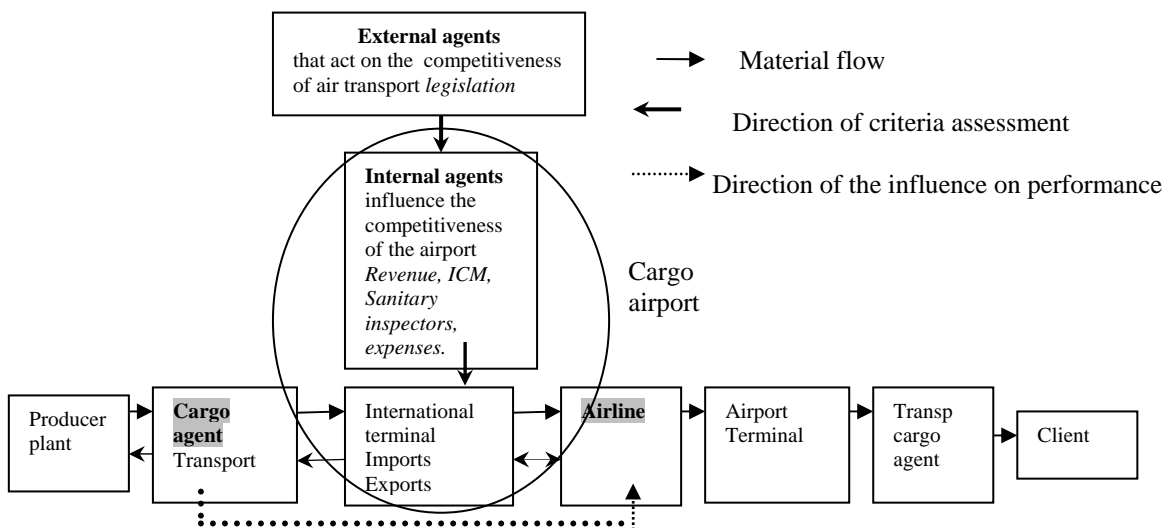

Figure 3: Agents in the Brazilian air system
Source: Adapted from Lima *et al*.2006

3.2.1 Airlines in the sample

The eight leading Brazilian cargo airlines were selected in this study, namely: Tam Linhas Aéreas, Gol Linhas Aéreas, Variglog, Skymaster Airlines, Beta – Brasilian Express Transporte Aéreos, TCB-Transportes Charter do Brasil, ABSA-Aerolinhas Brasileiras, Oceanair Linhas Aéreas.

4. Consolidation of the Scenario and Decision Analysis

A large number of different factors must be considered in the decision-making process when assessing which cargo agent can be hired. To this end, in determining the criteria, drawing up the hierarchical structure (figure 4) and comparing the alternatives amongst the criteria, sub-criteria and choice of the best airlines the results presented in the work done by Lima et al (2006) were used, as well as the interviews with the three company clients whose knowledge of the segment in question is significant.

The results of the analysis of criteria and sub-criteria for performance and choice of the best Brazilian cargo airlines in the opinion of the cargo agents are shown in graphs 1, 2, 3, 4, 5 and 6 and chart 4. These are representative in two situations: one further reaching, and another a little more delineated, with the creation of sub-criteria for each main criterion proposed.

4.1. Results of pairwise decision comparison criteria

Firstly the most important variable to be considered by the air cargo agents is regarding cost (0.409, graph 1). In practice the decision criteria for airlines related to cost are at the top of the structure, as the reduction of costs related to the tariffs charged per kilo transported and overall ground operation costs generate higher margins for the cargo agents. The criterion related to speed is the second most important aspect (0.295), as it represents sub-criteria that require improvements in land transport to produce faster and lower cost operations.
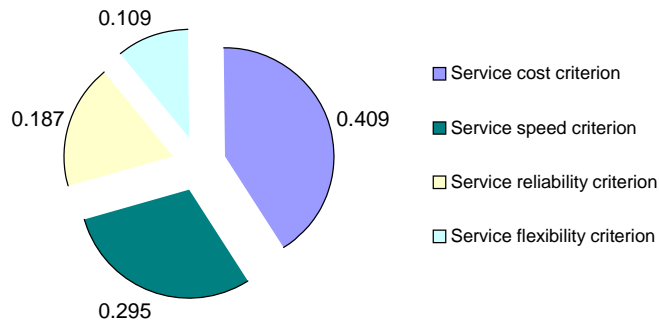
Graph 1: Pairwise comparison of decision criteria for air cargo companies
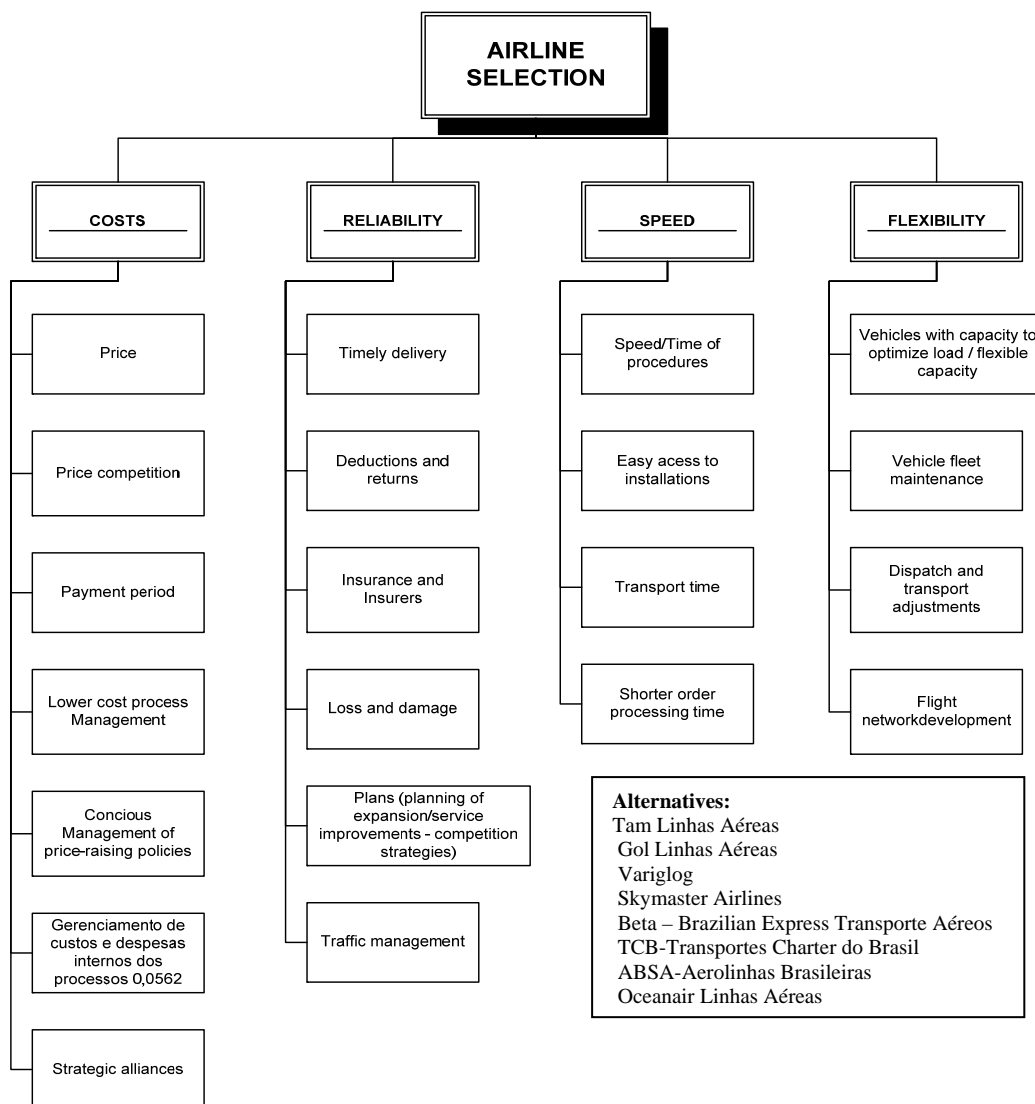**Source**: Authors

Figure 4: Hierarchical decision structure in air cargo company analysis
Source: Adapted from Lima *et al*, (2006).

The interrelations showing certain variables associated with the generation of additional costs through loss and damage, deductions and returns, amongst others, are represented in fourth and penultimate place by the reliability criterion (0.187 as in graph 1). Flexibility is a decision criterion that is represented in this study as being the evolution of the flight network, vehicles with flexible capacities, and other factors. This aspect is in fifth and last place in degree of importance (0.109), to the surprise of the authors.

4.2. Results of pairwise comparison of decision sub-criteria

The definition of the sub-criteria denotes the importance of these aspects in explaining specific situations experienced by the cargo agents and professional representatives, leading to greater knowledge of the market in question.

4.2.1. Pairwise comparison of the sub-criteria regarding service costs

As previously seen, the cost criterion was considered the most important factor in the cargo agents decision process in choosing Brazilian airlines in their daily operations. This happened because the sub-criteria represented the most important factors in boosting margins through various operating cost reductions. A detailed explanation creating decision sub-criteria was then proffered.

According to the interviewees, the price sub-criterion for services was considered the most important in the main hierarchy regarding costs (with 0.293 according to graph 2). It should be remembered that the airlines charge tariffs using cargo volume or weight, which sharply alters the formation of their prices, as the differentiation in the size of the airplanes makes certain companies better able to offer their services than others.

Price competition is the second most important sub-criterion (with 0.236 according to graph 2), due to the lack of infrastructure needed for the more efficient running of the processes, leading to better quality and consequently lower costs.

In practice price competition generated by the airlines to gain larger market share is directly dependent on the business model they have created and the external factors provided by the transport infrastructure throughout the country.

Payment periods and strategic alliances are two factors of a certain importance for the segment in question (with 0.162 and 0.108 respectively). This was heavily criticized by the professional surveyed as they claimed the companies do not treat them as true "partners," but rather they just offer the option of transport packages to the locations they operate, not generating the information needed for better operational planning.

Other factors, such as lower cost process management, conscious policy management to increase prices, and internal process cost and spending management, were considered less important to the cargo agents' decision hierarchy (with 0.089, 0.056 and 0.056 respectively), as they represent the lack of knowledge regarding the processes adopted by the companies by these professionals.
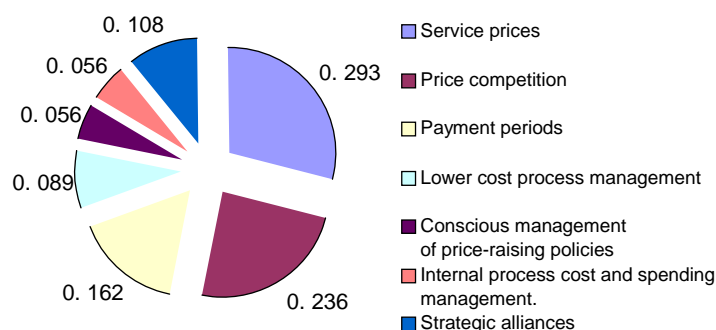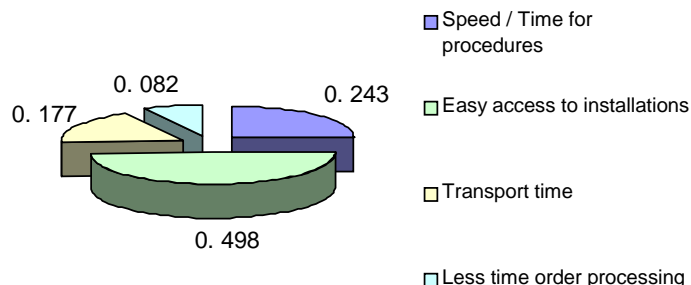

Graph 2: Pairwise comparison of the sub-criteria regarding service costs
Source: Authors

4.2.2. Pairwise comparison of the sub-criteria regarding service speed

The sub-criterion representing ease of access to installations was in first place in the survey (with 0.498 according to graph 3) as regards the speed of service provided.
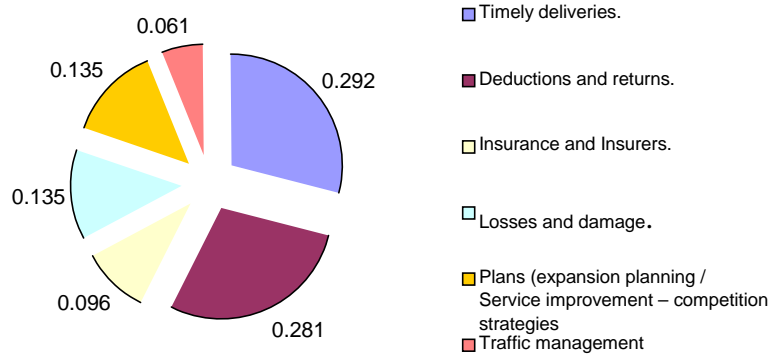

Graph 3: Pairwise comparison of the sub-criteria regarding the speed of services
Source: Authors

This happened because shorter times of the transport fleet and the professionals involved are very important for the cargo agents, enabling their infrastructure to generate more business opportunities and reducing situational costs while waiting.

In the same way, the time involved in procedures also generates improvements in the business, reducing avoidable expenses and generating greater use of the existing structure. For this reason this sub-criterion is in second place in the survey as regards the speed of services provided (0.243). Other aspects, such as shorter time in order processing and time involved in transport are less important sub-criteria for the survey in question (with 0.082 and 0.177, respectively), which highlight the situations directly linked to air transport processes, which place factors such as speed relatively high. The companies and professionals surveyed criticized issues regarding shorter order processing time regarding the process' relation with the moment it is done as the airlines only input the information on the shipments (knowledge that is passed onto the end client) when it is available for the palletizing process, increasing uncertainty and forcing cargo agents to make their fleet available, increasing costs.

4.2.3. Pairwise comparison of the sub-criteria regarding service reliability

Timely deliveries were considered the best aspect regarding the service reliability criterion (with 0.292 according to graph 4). There was then an explanation from interviewees as regards the timely execution of processes, as there are no further complaints about delays in airplane arrivals. Deductions and returns represent the second most important sub-criterion in the survey (0.281) because there is a tendency for airlines to accept the cargo without knowing what is being transported with a tendency for the product not to be accepted during handling and dispatch, meaning that   clients have to take on additional return expenses. Expansion plans and losses and damage are in third place in decision analysis (0.135). This happened in the midst of a discussion about improvements to the infrastructure without causing losses to factors related to service levels that result in high margins. Insurance and insurance companies are an aspect of performance of little importance (0.96) because there are no further discussions about compensation for accidents or aeronautical incidents. In last place in the survey is the issue of traffic management (0.061) because there is said to be no need for a release of capital to track cargo in airplanes with known routes.
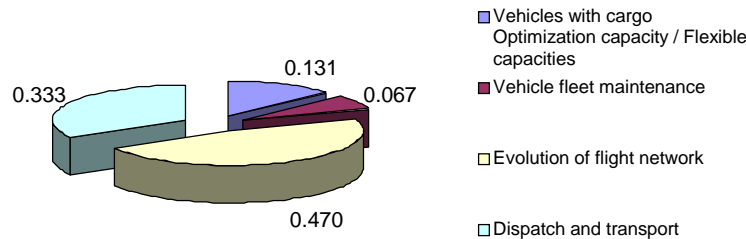
Graph 4: Pairwise comparison of service reliability
Source: Authors

4.2.4. Pairwise comparison of the sub-criteria regarding service flexibility

In the context of flexibility of services provided, one factor is considered of great importance due to the demand created by the dynamic segment of domestic and international cargo transport.

Thus, developing the number of origins, destinations, and connections, as well as increasing the number of cities served by the service provider increases the chances of making clients more loyal. Hence the evolution of the flight network is the first sub-criterion on the decision tree (with 0.470 according to graph 5). So, as with the evolution of the flight network, the adjustments in dispatch and transport are also of great importance for the market in question (0.333), as they reduce the instability caused by uncertainty when it comes to dispatching.

Graph 5: Pairwise comparison of the sub-criteria regarding service flexibility
Source: Authors

4.3. Ranking of Brazilian airlines from the client standpoint

As its main proposal this model presented a ranking of the leading Brazilian airlines using the criteria selected and the total points given by the cargo agents.

Chart 2 shows the results from the nine companies in the sample, the three leading airlines being represented in red (highest score), yellow and green

The results from the model in the view of the authors are in line with reality. This is because TAM Linhas Aéreas is in first place in global assessment, showing a business model that constantly seeks greater competitiveness through air cargo operating cost reduction, and a constant increase in the quality of the processes generated, wit the necessary infrastructure for ground service in order to reduce the time taken in processes, and the flight network constantly being altered to cover every opportunity. It thus has its process focused on serving the needs of its clients.

The company only failed to reach first place in reliability, as in this regard GOL was unbeatable. This company scored very well in all criteria, coming second in costs and flexibility, and third in speed, failing only in the issue of quality.

Brasilian Airlines	Criteria				
	Cost	**speed**	**reliability**	**flexibility**	**total**
TAM linhas Aéreas	**0,068**	**0,047**	**0,032**	**0,022**	**0,169**
Gol Linhas aéreas	**0,064**	**0,040**	**0,040**	**0,017**	**0,162**
Variglog	0,052	**0,044**	0,018	0,014	**0,128**
Skymaster Airlines	**0,059**	0,033	**0,020**	0,011	0,123
BETA - Brasilian Express Transportes Aéreos	0,056	0,034	**0,020**	0,011	0,121
Tcb - Transportes Charter do Brasil	0,042	0,033	0,019	0,011	0,104
Absa -Aerolinhas Brasileiras	0,042	0,033	0,019	0,011	0,104
Oceanair Linhas Aéreas	0,027	0,031	0,019	0,011	0,088
Total	0,409	0,295	0,187	0,109	

Chart 2: Ranking of Brazilian airlines from the client standpoint
Source: Authors

The results of this survey also surprised the authors in this respect, as it had not been expected that a company such as GOL, which began cargo operations only a short while ago more because of an operational issue than an idea that good business opportunities existed (considering that the company's business model did not include cargo transport) could achieve such results. Operational infrastructure issues in airspace and airports mean that its airplanes have more time on the ground. Hence GOL could not achieve its pre-stipulated concept as a low fare company, and so invested in cargo to bring in revenue.

In third place was the company that everyone had expected to be in first place, as Variglog has the largest infrastructure in the sector. It appears amongst the first places only in issues related to quality and speed, which is not a surprise considering the company's investment in its operational structure. Currently, with the crisis being experienced by the Varig group, Variglog has reduced its flights on all routes, sharply reducing its domestic and international market share. However, there has not been an overall fall in its scores, hence it has remained at the top of the global assessment by domestic cargo agents.

Skymaster was fourth in the decision tree for interviewees, and third in the criteria related to costs, quality, and reliability of the service provided. This can be explained by analysis of its business model, considering that it does not carry passengers, so increasing air cargo transport to the destinations it serves, having the chance to reduce costs and improve processes because of its infrastructure to work exclusively in this segment.

In a practically identical situation to Skymaster is Beta, as it has exclusive infrastructure for cargo transport. The company scored similarly to Skymaster, also coming third for quality of service provided and the reliability of its processes.

According to specialists in the sector, the air cargo market cannot be studied without these two companies, as they are present in all the possible analysis of the segment.

Surprisingly, TCB and ABSA tied in all the decision criteria. This happened because they have not improved their structures to serve all the main demand centers, keeping their businesses centralized and creating operational obstacles to agents outside their areas of service.

In seventh and last place in the specialists' choice hierarchy is Oceanair, being amongst the three best companies only in quality of service provided. This is because the development of its infrastructure was not planned in step with the growth of its business through the acquisition of airplanes that made possible a higher volume of service.

In practice it can be explained that this company always had small airplanes, serving only cities near to large urban centers, so doing business in the regional passenger segment, not being involved in cargo. As its network grew through the acquisition of larger airplanes, Oceanair needed to create an appropriate infrastructure for the needs of the cargo market, which was not fully executed (according to the interviewees).

5. Final Considerations

Increased competition requires companies to be more competitive and to full knowledge of the environment they are in. This leads to a need for the development of decision making methods regarding the criteria linked to their operations, so allowing analysis of competitiveness and logistical systems.

The modeling developed has principally produced a ranking of the main Brazilian airlines using the sub-criteria selected by the cargo agents.

The results produced by the modeling were surprising not just for the authors but also for the specialists interviewed throughout the specificities presented by the study in question. This has represented a great advance in academic research as all the possible situations will now be analyzed to bring about improvements and the possibility of creating better scenarios for the air cargo transport segment.

It has also been shown that criteria such as those related to cost are still considered more important, with higher margins than for other possible situations. This has denoted a need to create improved business and operating conditions so that other opportunities can be created, thus fostering better management, making specialists and professionals on the market in question consider other aspects that influence all the processes.

This being the case, this study has demonstrated the importance of the study of all the criteria included here to bring about improvements in all the issues related to air cargo transport. Improvements can be made not just in situations related to the airlines, but to the air transport segment as a whole, considering airport infrastructure and all of its attributes.

6. References

Angulo Meza, L., Gomes, E.G. and Soares de Mello, J.C.C.B. (2002), Enfoque multiobjetivo para determinação de benchmarks de companhias aéreas brasileiras DEAineficientes. Anais do XVI ANPET, Natal, October, 27-34.

Arslan, T. and Jotin Khisty C. (2006), *A rational approach to handling fuzzy perceptions in route choice.* European Journal of Operational Research 168, 571–583.

Ballou, R, H.(2001), *Gerenciamento da cadeia de suprimento planejamento, organizaçao e logistica empresarial* 4 ed. Porto Alegre Bookman.

Beamon, B. M.(1999), *Measuring supply chain performance*. International Journal of Operations & Production Management, Bradford, v. 19, n. 3, p.275-292.

Burmann, P. (2000), Análise Prospectiva do Mercado de Carga Aérea no Brasil. Tese de Mestrado, COPPE/UFRJ, Rio de Janeiro.

Christopher M. (1997), *Logistica e Gerenciamento da Cadeia de Suprimentos, Estratégias para Redução de Custos e Melhoria dos Serviços.* São Paulo: Pioneira.

Corrêa, H.L. Gianesi, I.G.N.Caon (2001), *Planejamento, Programação e Controle da Produção MRP II/ERP*. São Paulo: Atlas, 452p.

DAC (2004), *Estudo de Carga Aérea Internacional no Brasil.* Departamento de Aviação Civil, Ministério da Aeronáutica.

DAC (2003), *Anuário do Transporte Aéreo*. Departamento de Aviação Civil, Ministério da Aeronáutica.

Lima, M. G., Nogueira , R. Q., Correia, A. R. and Felipe, D. (2006), *Aspectos de desempenho competitivo: um estudo exploratório com os atores do modal de carga aérea no Brasil* . In: IV Simpósio de Transporte Aéreo (Sitraer), Brasilia.

GEIPOT (2005), www.geipot.gov.br, *dados coletados na internet no dia 02 de maio de 2005*, às 16:42.

Gomes, L, Araya, M. and Carignano, C. (2004), *Tomada de decisão em cenários complexos: introdução aos método discretos de apoio multicriterio à decisão*. São Paulo: Pioneira.

Keedi, S. (2001), *Logística de Transporte Internacional: Veículo Prático de Competitividade*. Aduaneiras, São Paulo.

Slack, N., Chambers, S., Harland, C., Harrison, A. and Johnston, R. (1997), *Administração da produção*. São Paulo: Editora Atlas.

Saaty, T.L. (2001), *Models, methods, concepts & applications of the Analytic Hierarchy Process*, Kluwer Academic Publishers.

Soares de Mello et al (2002), Análise de Envoltória de Dados no estudo da eficiência e dos benchmarks para companhias aéreas brasileiras In: XVI ANPET - Congresso de Ensino e Pesquisa em Transportes.

Tsaur, S., Chang T. and Yen C. (2002), The evaluation of airline service quality by fuzzy MCDM. Tourism Management 23 107–115.