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Analysis model to quantify potential factors in the growth of air cargo logistics in airports

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Abstract

This paper presents an analysis model that allows evaluating the growth opportunities of air cargo in an airport. For this, a model which identifies the elements that affect the capacity of an airport to attract cargo operations and air cargo airlines has been developed. The identification of the elements of the model has been performed through a sectoral review of air cargo, an analysis of the entire logistics chain including the physical flow, the documentary flow, and all the agents involved in it. The analysis of the logistics chain has been carried out from the operational, technological, socio-economic and environmental standpoint, considering all the factors that influence the competitiveness of the logistics chain. Specifically, the operational characteristics that an air cargo transport requires both at the airport infrastructure and the logistics operators level, the technologies for the handling of freight and its control (on land and on-board) have been examined. Other characteristics include the different types of products transported according to their characteristics, the associated supply chains considering locations and routes with their origins and destinations, and the existing markets with the main demands of each type of merchandise. The model has been developed by using the Analytic Hierarchy Process methodology with absolute measurements. This methodology considers the judgements of experts in terms of the weightings of the different factors and attributes that constitute the model. The Zaragoza airport has been used for the model assessment. Furthermore, minimum thresholds were established for the attributes. Thus, it is obtained a model that allows an analysis of the improvement capabilities of airports focused on air cargo activity.

Keywords: Air cargo logistics; competitive logistics chain; airports; AHP

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1. Introduction

Logistics can be defined as (Antún, 1994): "the set of activities that aim at the placement, at the lowest cost, of a quantity of product in the place and time where a demand exists". Therefore, logistics involves all operations that determine the movement of products: location of production units and warehouses, provisioning, management of physical flows in the manufacturing process, packaging, storage and handling of inventories, product management in cargo units and preparation of lots for clients, transport and design of the physical distribution of products (Unam, s.f.).

The main characteristics of airfreight are (Antún, 1994): fast transport service; transfer of high value and low volume products; generally, service terminal to terminal; service coverage limited to origins and destinations with higher flows; shorter transit times (delays in terminal can affect this advantage); flexibility and reliability of services; minimum losses and damages; less need for packaging; reduce inventory costs (given the speed of the aircraft, it can be used to implement Just in Time (JIT) supply strategies, thus reducing inventory spending and the risks of obsolescence) (Air Cargo Guide, 2013).

For all these characteristics, air transport is a relevant player in international trade allowing companies to have a faster response to the needs of their customers. This paper presents an analysis model that allows evaluating the growth opportunities of air cargo in an airport. For this, a model which identifies the elements that affect the attractiveness of an airport to attract cargo operations and air cargo airlines has been developed.

2. Air cargo supply chain

The air cargo supply chain is responsible for articulating the flows, both physical and documentary, of the air freight. One of the characteristics of the air freight is the impossibility of directly associate the goods as users. Therefore, the user of air freight transport is understood as anyone who requires transporting freight by air. For nomenclature purposes, the loader represents the user at the origin and the consignee at the destination (see Fig. 1).

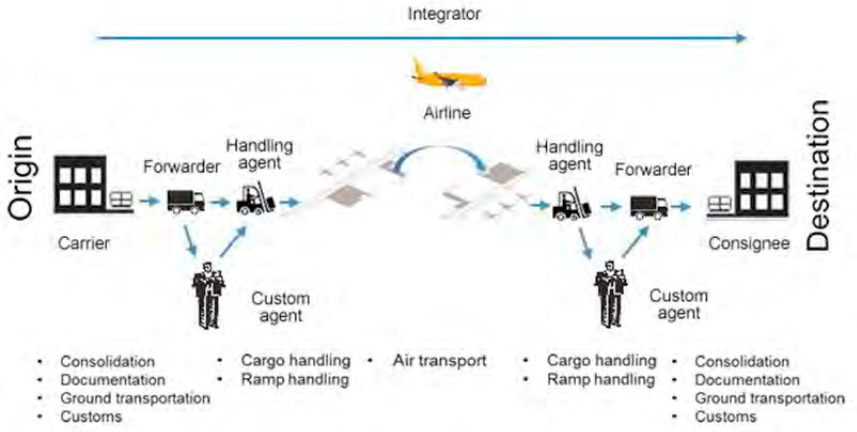

Fig. 1. Air cargo supply chain (Mendoça-Parentoni et al., 2016)

The air cargo supply chain is developed from the moment the shipper or dispatcher send the goods to be transported to an importer or consignee. The shipper can perform the transport operation by own means or by hiring a freight forwarder. This second option is the most common given the specialization and training required by all the procedures that the merchandise must follow until destination. Once a service contract is signed with the land carrier, a freight forwarder or integrator, the goods are transported to the airport facilities, consolidating them for export (pallet construction or container filling).

Next, the freight forwarder or integrator and the customs agent prepare the necessary documents to export the merchandise. This documentation is delivered to the customs administration where certain controls are carried out

depending on the merchandise to be exported. Once these administrative procedures are completed, the ground handling agent is responsible for the handling of the merchandise in the cargo terminal, and the ramp handling agent is responsible for transporting the merchandise from the cargo terminal to the aircraft and its loading.

Thus, the transport service begins with the delivery of the merchandise to the airline. The contracted airline carries out the transport of the merchandise to its destination where the merchandise is unloaded and transported to the cargo terminal by the ramp handling agent. Then, the ground handling agent verifies that the merchandise received corresponds to what must be received (by way of an Air Waybill) and carries out its deconsolidation. Subsequently, the customs agent receives the documentation of the freight and, depending on the characteristics and origin, request for additional information or physical inspection. Once the requirements for the lifting of the merchandise have been met, it can be delivered by the ground handling agent to the importer or a land transport company to be sent directly to the importer at the final destination.

3. Development of a model for the analysis of the growing options in air cargo logistics

3.1. The Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a multicriteria method used in decision making based on the utility function. AHP structures the decision problem in different levels: goal, criteria, sub-criteria, attributes and alternatives. Conventional AHP provides the priorities of the elements being compared in an absolute scale. Four steps are considered (Saaty, 1996): (i) modelling of the problem (hierarchy construction); (ii) valuation or elicitation of judgments; prioritisation or local and global priorities derivation; and (iv) synthesis or derivation of total or final priorities. The prioritization of the elements is commonly carried out by using the eigenvector method (EGV) and the row geometric mean method. One of the main characteristics of this methodology is the measurement of the inconsistency of the actors when eliciting the judgments of the pairwise comparison matrices. Thus, the consistency ratio (CR) of the pairwise comparison matrices must be less than 0.1.

More and more, AHP is being used in the resolution of complex multi-actors problems because it can integrate the small with the large, the individual with the collective, the objective with the subjective and it incorporates the multi- actors visions into the model during the solution of the problem (Altuzarra et al., 2010).

3.2. Elements of the model

The identification of the elements of the model is based on the research performed by Gardiner and Ison (2008), Kupfer et al. (2011) and the expertise of a group of three experts in air cargo logistics (airport manager, air cargo company consultant, academics). The model consists of 1 goal (G), 4 criteria (C), 14 subcriteria (SC) and 22 attributes (Q). A representation is shown in Fig. 2.

C1. Economic factors:

SC1. Airport charges. Airport charges, in particular landing fees, are a charge that cargo planes have to pay each time they land at an airport. Airport charges vary greatly from one airport to another depending on congestion. Airports with a higher flow of passengers impose higher rates, while smaller airports with less traffic offer, or even eliminate, more attractive rates with the aim of attracting airport activity.

SC2. Handling costs. The handling of the merchandise is divided in two parts: ground handling and ramp handling. Ground handling consists of the handling and preparation of the goods in the cargo terminal. In turn, the ramp handling consists of the transport of the merchandise, by using pallets or containers from the cargo terminal to the hold of the aircraft and vice versa. Ground handling is liberalized; however, ramp handling is regulated by law. The number of handling agents in an airport is determined by the load circulating.

SC3. Indirect costs. Related to the standard of living of the region or country in which the airport is located. For instance, the cost of accommodation for airplane personnel (pilots, flight attendant), cost of services that the airline has to contract at the airport and surrounding areas, and so on.

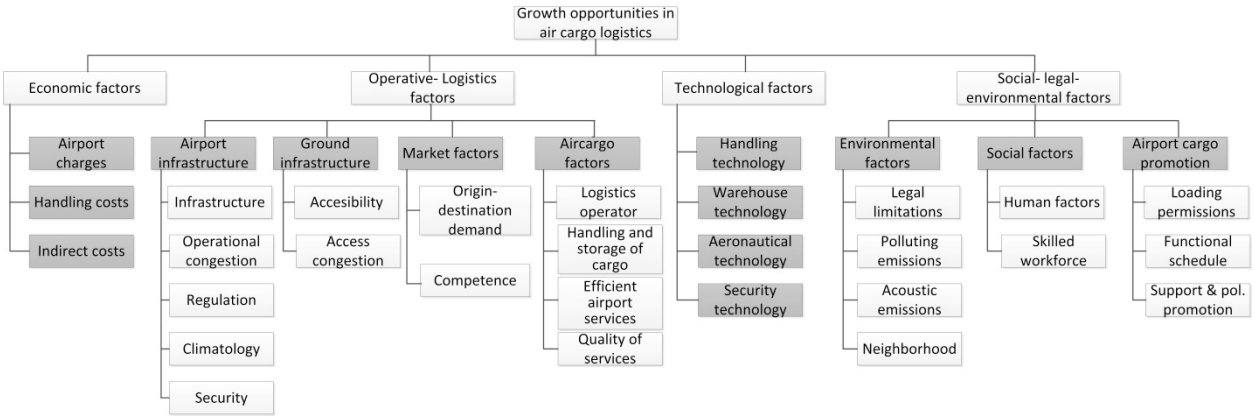

Fig. 2. Elements of the model

C2. Operative-Logistics factors:

SC4. Airport infrastructure:

- Q1. Infrastructure: length of the runways, load they can support, capacity of cargo planes on the airport platform, among others.
- Q2. Operational congestion: a certain level of congestion can be accepted by mixed cargo companies (pure freighters and passenger aircraft), especially at large airports, as they compensate with the advantages of collaborating with passenger flights. However, companies only using freighters can discard the operation of a large airport based on congestion. Sometimes, transporting merchandise by road from a more remote airport may take less time than flying to a larger airport closer to the final customer.
- Q3. Regulation of cargo operations at the airport: in case of restrictions on cargo operations, it will be less likely to attract air cargo activities to the airport.
- Q4. Climatology: degree of incidence of certain meteorological contingencies that hinder or prevent the take-off and landing at an airport, e.g. strong winds, heavy rains, heavy snow, and fog.
- Q5. Security: protection of the loading areas and merchandise from theft and intrusions by using security personnel, cameras, alarms, etc.

SC5. Ground infrastructure:

- Q6. Accessibility to the airport by road: easiness of access to the airport: is the road wide? Does it quickly connect freeways or highways? Are there several accesses? It is easy to maneuver with large logistics trucks?
- Q7. Congestion of road accesses: level of congestion, important for the merchandise to arrive on time to its destination.

SC6. Market factors:

- Q8. Origin-destination demand: amortize the high cost of air transport by balancing the load to be transported from the origin to the destination and vice versa. It is not always an easy balance given that the demand for products (origin) does not always coincide with the destination offer. For this reason, triangular routes (three loading and unloading points) or more points are often used to increase as much as possible the cargo transported in each trip.
- Q9. Presence of competitors at the airport: it is both considered an advantage and an inconvenience. This presence eliminates the competitive advantage that the airline could have for operating in a certain airport. On the other hand, this presence implies the availability of a greater number of flights to different destinations which, at a given moment, the airline can take advantage of to send goods to a certain place.

SC7. Aircargo factors:

- Q10. Presence of logistics operator at the airport: it is related to the market volume of the air cargo at the airport, and the opportunities to establish air cargo operations there.
- Q11. Presence of facilities for handling and storage of cargo: facilities such as warehouses are of utmost importance to airlines. In addition, the airport must have enough ramps, parking spaces, capacity in the terminal, tracks and special facilities for certain products (refrigerated warehouses, high security, radioactive containment stores, cargo weighing, automated storage, etc.).
- Q12. Efficient airport services: it includes documentation requirements, customs clearance time, availability of a veterinarian 24 hours a day (for transportation of food and animals), etc. In case the airport can ensure short transit times, the need for warehouses is reduced.
- Q13. Quality of the services provided by the airport: it is associated with customs services and the handling of merchandise. Cargo airlines assess aspects such as a minimum loss rate, and damage to goods handled at the airport, especially given the high value of the merchandise transported. The quality of an airport also depends on its experience in the transport of goods, how it is advertised and its reputation.

C3. Technological factors:

SC8. Handling technology. This factor includes all the technology related to the ramps used for the loading and unloading of the aircraft, freight elevators, transfers, high loaders, dollies, etc.

SC9. Warehouse technology. It refers to the weighing technology of the load, pallet control/ tracking in the warehouse, pallet counter, and automated storage.

SC10. Aeronautical technology. To attract cargo operations, it is essential for the airport to have the latest load weighing technology for its balance on the plane, the use of electronic waybill or Air Waybill, etc.

SC11. Security technology. The airport must have the necessary security technology, i.e, scanners to ensure that no drugs or explosives are being transported, to carry out detection of dogs, action protocols, etc. In addition, all these technologies must be regularly reviewed, receive the appropriate maintenance and replaced by the latest market technologies when required.

C4. Social-legal-environmental factors:

SC12. Environmental factors:

- Q14. Legal limitations: referred to the restriction or disablement of the operation of a cargo aircraft at a specific airport.
- Q15. Polluting emissions: related to the restrictions on polluting emissions produced by a cargo aircraft (normally older) introduced by certain airports that, due to their geographical location, should reduce air pollution in their area. Furthermore, the rates applied to these aircrafts can reduce the attractiveness of an airport for air cargo operations.
- Q16. Acoustic emissions: this restriction especially affects companies only using pure freighters, usually related to older aircrafts that produce higher levels of noise. The new acoustic rates being implemented in European airports are causing these airlines to incur extra costs.
- Q17. Neighborhood: related to the fact that the area of influence of the airport has a special status that restricts air cargo operations (populated areas, nature reserves, etc.).

SC13. Social factors:

- Q18. Human factor: the activity carried out by the director of the airport to attract cargo operations. An active director trying to find new operations, airlines and destinations for the airport will be a factor of success in the promotion.

- Q19. Qualified workforce: the presence of skilled labor in the region in which the airport is located is important since it greatly reduces the cost of training. A cargo airport needs personnel trained in the handling of machinery such as mechanical bulls, transfers, high loaders and so on.

SC14. Airport cargo promotion:

- Q20. Loading permissions: this factor contemplates the fact that a country imposes an air cargo restriction in the form of permits for an airline to transport a certain cargo on a given route.
- Q21. Functional schedule of the airport: the schedule of operation at an airport is limited by night in case the airport closes. Airports opened 24 hours will be more likely to attract air cargo.
- Q22. Support and political promotion of air cargo: the veto of certain airports for air cargo due to congestion because of passenger transport, the increase of government fees to companies, among others, are a key factor. These measures are political decisions that will vary depending on the use of the airport (pure cargo, passengers, or mixed).

3.3. Assessment of the model

The assessment of the model has been carried out by the group of three experts in air cargo logistics which participated in the definition of the model. The global priorities of the hierarchy elements were obtained and consistencies were acceptable (CR<0.1). Values are shown in Table 1.

Table 1. Priority vector (w) of the model elements

	SC1	SC2	SC3	Q1	Q2	Q3	Q4	Q5	Q6	Q7
w	0.0905	0.0972	0.0490	0.0584	0.0497	0.0274	0.0308	0.0208	0.0353	0.0312
	Q8	Q9	Q10	Q11	Q12	Q13	SC8	SC9	SC10	SC11
w	0.0955	0.0260	0.0260	0.0235	0.0265	0.0190	0.0475	0.0475	0.0375	0.0375
	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	
w	0.0177	0.0067	0.0067	0.0082	0.0188	0.0154	0.0195	0.0170	0.0135	

Furthermore, it has been used the absolute measurement variant in which each attribute (lowest level of the hierarchy) is assessed in a scale of five levels (Very low-VL, Low-L, Regular-R, High-H, Very high-VH). From an operational point of view when assessing the model, instead of deriving (9x10) judgements, three sub-models were identified according to the importance different levels can have for one element of the lowest level. For this, three comparison matrices were derived with a total of (9x3) judgements, and the priority vectors obtained were assigned to the elements of the model (lowest level). Table 2 shows the priority vector for the elements with regards to the levels of the model. In addition, two types of criteria have been defined: positive criteria (in which "Very high" is the best score) and negative criteria (in which "Very low" is the best score). The experts established the minimum threshold (bold, see Table 2) for an airport to attract cargo operations. The attractiveness of an airport to attract cargo operations and air cargo airlines has been defined by means of the following function:

$$Attractiveness\ airport_i = \sum_{j=1}^{n} v_{ij} w_{ij} \tag{1}$$

where v_{ij} is the priority (ideal mode) of the level assigned when evaluating the airport i with respect to the attribute or subcriteria of the lowest level j (j=1, …, 29), and w_j is the global priority of the attribute or subcriteria of the lowest level j. Thus, the recommended score for an airport is identified (0.6559).

Table 2. Priorities of the elements of the model

	SC1	SC2	SC3	Q1	Q2	Q3	Q4	Q5	Q6	Q7
w_i	0.0905	0.0972	0.0490	0.0584	0.0497	0.0274	0.0308	0.0208	0.0353	0.0312
VH	0.0476	0.0476	0.1111	1	0.0476	0.1111	**1**	1	1	0.0476
H	0.1429	0.1429	0.3333	**0.5000**	0.1429	0.3333	0.5000	**0.6190**	**0.6190**	0.1429
R	0.3334	0.3334	0.5556	0.2500	0.3334	0.5556	0.2500	0.3334	0.3334	0.3334
L	**0.6190**	**0.6190**	**0.7778**	0.1500	**0.6190**	**0.7778**	0.1500	0.1429	0.1429	**0.6190**
VL	1	1	1	0.0500	1	1	0.0500	0.0476	0.0476	1
	Q8	Q9	Q10	Q11	Q12	Q13	SC8	SC9	SC10	SC11
w_i	0.0955	0.0260	0.0260	0.0235	0.0265	0.0190	0.0475	0.0475	0.0375	0.0375
VH	1	0.1111	1	1	1	1	1	1	1	1
H	**0.6190**	**0.3333**	**0.7778**	**0.6190**	0.6190	**0.6190**	**0.7778**	**0.7778**	**0.7778**	**0.7778**
R	0.3334	0.5556	0.5559	0.3334	**0.3334**	0.3334	0.5559	0.5559	0.5559	0.5559
L	0.1429	0.7778	0.3333	0.1429	0.1429	0.1429	0.3333	0.3333	0.3333	0.3333
VL	0.0476	1	0.1111	0.0476	0.0476	0.0476	0.1111	0.1111	0.1111	0.1111
	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	
w_i	0.0177	0.0067	0.0067	0.0082	0.0188	0.0154	0.0195	0.0170	0.0135	
VH	0.0476	0.0476	0.0476	0.0476	1	1	1	1	1	
H	0.1429	0.1429	0.1429	0.1429	**0.7778**	**0.7778**	**0.7778**	**0.6190**	**0.7778**	
R	**0.3334**	**0.3334**	0.3334	0.3334	0.5559	0.5559	0.5559	0.3334	0.5559	
L	0.6190	0.6190	**0.6190**	**0.6190**	0.3333	0.3333	0.3333	0.1429	0.3333	
VL	1	1	1	1	0.1111	0.1111	0.1111	0.0476	0.1111	

4. Case study

The developed model was applied to the Zaragoza airport (ZA). Table 3 shows the results obtained with regards to the minimum threshold (MT) established by the experts. The score obtained for the airport of Zaragoza is 0.5477.

Eleven areas of improvement for the airport of Zaragoza have been identified (as long as they fit within its capacity of action) with the aim of increasing its attractiveness as a cargo airport:

- SC1. Airport charges: it is recommended to decrease the airport charges to foster the activity at the airport.
- SC2. Handling costs: defined by the number of handling agents at the airport. The presence of these agents is regulated by the state depending on the amount of freight transported. Handling costs will decrease if the number of companies that provide this service at the airport increases; it automatically occurs with an increase in air cargo activities. Thus, Zaragoza Airport cannot directly influence handling costs.
- Q5. Security of freight in cargo areas, warehouses and the airport in general: it should be increased through the hiring of security personnel, the installation of more advanced security systems and the application of good practice codes for the workers who handle the freight.
- Q8. Origin-destination demand balance: industrial activities in the vicinity of Zaragoza airport should increase to have a greater demand/ supply of products. There is little possibility of action at the airport of Zaragoza in this regard.
- Q9. Competition of other cargo airlines at the airport: the number of cargo airlines operating at the airport of Zaragoza is very high. This may dissuade other airlines from operating here. However, it is not an area in which the airport should influence as it goes against its own interests.
- Q10. Presence of logistics operators at the airport: a greater presence of logistics operators would encourage the air cargo activity at the airport. The airport of Zaragoza can give facilities to these entities to settle. However, this will depend on the existing demand.
- SC8. Handling technology: to have enough handling technology and invest in the latest technology (ramps, load elevators, transfers ...) and perform checking and updates periodically.

- SC9. Warehouse technology: invest in the latest technology (heavy loading, pallet control, pallet counter, automation ...) and perform checking and updates on a regular basis.
- SC10. Aeronautical technology: invest in the latest technology (load balancing technologies in the warehouse, electronic delivery note ...) and carry out periodic checking and updates.
- SC11. Security technology: have enough and invest in the latest technology (scanners) and perform checking and updates periodically.
- Q16. Restrictions in terms of acoustic emissions: As far as possible, the airport of Zaragoza should work in reducing restrictions on acoustic emissions, thus, airlines with older (and therefore noisier) aircraft could operate here. It should be noted that, in the air cargo business, aircraft used are usually old (given the high cost of a new aircraft) and in many cases reconverted passenger aircraft.

Table 3. Assessment of the case study

	SC1	SC2	SC3	Q1	Q2	Q3	Q4	Q5	Q6	Q7
MT	0.6190	0.6190	0.7778	0.5000	0.6190	0.7778	1	0.6190	0.6190	0.6190
ZA	0.3334	0.3334	0.7778	1	0.6190	1	1	0.3334	0.6190	0.6190
	Q8	Q9	Q10	Q11	Q12	Q13	SC8	SC9	SC10	SC11
MT	0.6190	0.3333	0.7778	0.6190	0.3334	0.6190	0.7778	0.7778	0.7778	0.7778
ZA	0.1429	0.1111	0.5559	0.6190	1	0.6190	0.5559	0.3333	0.3333	0.5559
	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	
MT	0.3334	0.3334	0.6190	0.6190	0.7778	0.7778	0.7778	0.6190	0.7778	Score
ZA	0.3334	0.3334	0.3334	1	0.7778	0.7778	1	1	0.7778	0.5477

5. Conclusions

This paper presents the study of the growth opportunities of an airport as an airport specialized in cargo operations. A model has been created by using the AHP methodology. It has been identified the elements that, to a lesser or greater extent, have an impact on the potential of a cargo airport to attract air freight activity and therefore cargo airlines. The model has been applied to the airport of Zaragoza. The results show those possible areas for improvement in which the airport of Zaragoza should concentrate its efforts in order to increase its potential for attracting airlines and air cargo activities.

The model presented in this paper for the valuation of an airport specialized in cargo is completely valid for any similar airport. The opinion of the experts throughout the model construction process is crucial for the validity of the results obtained. Thus, other airports can be valued by carrying out comparisons of each other to know which one offers better opportunities for the growth of air cargo logistics. As a more relevant conclusion, it is observed that the factors related to airport charges (SC1) and handling costs (SC2) are the most influential, as well as the existence of a balance between the cargo demand between origins and destinations (Q8).

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