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An AHP approach to airport choice by freight forwarder

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ABSTRACT

Choice of airport is a crucial issue from freight forwarder point of view. Freight forwarder takes into account all airports within an acceptable radius, considering supply of airlines. The supply includes total costs, structure of price and quality of connections affecting on transport time of shipment. The goal of this paper is to propose a multi-criteria decision making approach which will help freight forwarders to choose an airport based on selected criteria. The Analytic Hierarchy Process (AHP) is used to structure and rate criteria. The approach is illustrated by example based on real data for Serbian, Croatian and Slovenian market. The results in this paper point out that airports and airlines must develop the capacity and flexibility to accommodate changing trends and volumes of cargo in order to attract more demand. The sensitivity analysis reveals what should be improved by airports and airlines in order to attract more customers, which will further lead to more operationally efficient and sustainable cargo services in the region.

1. Introduction

Air cargo transport contributes to global economic development and supports millions of jobs [1]. In addition to the jobs, air cargo transport impacts on the flows of trade, industry partnerships and other investments resulting from users of cargo airlines services and the city pair connections that make these flows possible. Moreover, transport of goods by air, as a mode, fills the need for time-sensitive deliveries over larger distances, especially where the alternative modes, such as road, rail or maritime transport on international or transcontinental routes, are considerably slower. However, air transport can involve higher costs than other modes, which further impacts on lower demand for this type of service. As such, one of the most important issues for operators involved in air cargo transport is to sustain and increase their available market share. In this regard, the development of strategies to achieve a sustainable industry is key to guarantee the future of air cargo.

The movement of air cargo from origin to destination using several modes of transport represents intermodal or multimodal transport chain with the air segment as a central leg. Efficiency and sustainability of multimodal transport and logistics can be achieved by using multimodal transport that combines optimally the various modes of transport, exploiting each one's advantages and minimizing the disadvantages [2].

Air cargo transport is very complex business. It involves different players, very sophisticated processes, a combination of weight and volume, varied priority services, integration and consolidation strategies, and offers many different (possible) routes. Main stakeholders involved in air cargo transport are the so-called combination carriers, all-cargo carriers (scheduled or *ad hoc* charter), integrators, contract freighter operators, freight forwarders and consolidators, [3].

Freight forwarders are the link between the airline and the final customer who is the consignor/consignee. They provide services which include consolidation of deliveries from multiple shippers, choice of airport, space reservation on flights of cargo operators or passenger-cargo combination carriers, transport shipment arrangements, to/from freight forwarder' warehouse, to (from) departure (arrival) airport and to final destination as point of delivering shipment.

Freight forwarders are often located landside of an airport or they have warehouses that are located airside or on the border between landside and airside. Generally, from the origin, which is the supplier, to the destination, which is the customer, the process of air cargo transport covers several segments (Fig. 1): (1) transport from pick-up cargo point (supplier) to warehouse (consolidation of shipments), (2) transport from warehouse to the airport A, (3) flight (or several flights) from airport A to airport B, and (4) transport from airport B to the warehouse and further to the final point.

Freight forwarder (same as in first part of chain or another) arranges pick-up of shipment from arrival airport (airport B) and organizes transport to its warehouse or another location, and finally delivers it

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directly to customer (consignee). Accordingly, freight forwarder may offer a service related to the pick-up cargo from supplier, preparation, storage, carriage and final delivery of goods, including all necessary documentation, custom processing and insurance.

The forwarder acts between the shipper and the airport and airlines. The freight forwarder or truck operator provides the ground transport services before and after air transport. The airport through handling agent and airline receives, stores, transfers, tracks, loads and unloads cargo, and assigns and manages capacity. Along with the increase in the supply chain management and e-business practices, freight forwarders must handle tight schedules with frequent unplanned changes, non-fixed origins and destinations, along with special requests from shippers and consignees [4].

From the perspective of truck operators and airlines (cargo or combination carrier), freight forwarders are customers and represent demand side of the business while from the shippers' point of view, forwarders are part of supply side, offering transport services in competition with other operators (freight forwarders and integrators), [5].

In this paper the focus is on the freight forwarding activity where the main transport mode is air transport. The objective of the paper is to research how freight forwarders choose airport and create supply chain at the air cargo market from shipper to customer, and how to propose different options (offers) to consignor. Operators (freight forwarders, airports and airlines) that perform best in this area, can be considered to have sustainable business models mostly in terms of efficiency, reliability and economics. With the aim to understand the factors influencing the freight forwarder's choice of airport, and to understand the potential for growth of air transport in Southeast Europe, the case study of an actual location decision by a freight forwarder is adopted. The case study covers three air cargo markets, in Serbia, Croatia and Slovenia.

2. Literature review

Deregulation of the aviation industry enabled new opportunities for airports, airlines and other operators involved in air cargo industry. As a result, airports are free to adopt more sustainable business philosophy, while airlines are independent to allocate their resources and set transport prices. In such an environment, shippers have increased reliance on freight forwarders, who also have faced new freedoms and opportunities in the form of more capacity, modern equipment and communication technology, and even an opportunity to establish their own cargo services in the market. The roles and responsibilities of a freight forwarder can be quite manifold and crucial to international trade, [6]. In order to improve profitability, freight forwarders try to organize their operational transportation planning systematically, considering all options in each phase of the transport process.

Studies on airport competition for air cargo are scarce. However, the cargo market became more relevant in the industry as traditional passenger airlines looked for additional sources of revenue and focused more on cargo. This has become especially important in the COVID-19 era which was proved to be a devastating year for global aviation, but many airlines found their way-out in transporting cargo in their passenger aircraft. According to IATA [7], industry-wide available cargo tonne-kilometers (ACTKs) felt down 23.3% year-on-year in 2020. However, cargo load factors, yields, and revenues rose to record-high levels, providing support to airlines and some long-haul passenger services affected by a collapse in passenger revenues [7].

Generally, airports closer to shippers and with lower total costs and shorter delivery times are strong candidates for freight forwarders' choice. Therefore, the most important factors when choosing an airport are geographical location, costs, and delivery times [8]. Moreover, the airport selection is the core to strategic route optimization for freight forwarders, because it could considerably affect on-time delivery, operational efficiency, and service quality in cargo handling and customs clearance [9–11]. Kupfer et al. [12], developed a model for selecting departure-destination airports for all-cargo aircraft operations in Europe. In their study the airport selection process was examined under 22-item criteria grouped in six categories (night time restrictions, airport experience with cargo, presence of forwarders, presence of passenger airlines, airport charges (including handling), and origin-destination demand).

Regarding the most important attributes for selecting cargo carriers in Taiwan, it is revealed that they are reliable and on-time services, possibility for express shipments and a good reputation of the carrier. On the other hand, the highest-rated attributes related to route choice, in the case of forwarders in Taiwan, are following: fewer intermediate stops, efficient handling, and customs clearance service at the destination airport [10].

Competitive factors among airports which offer air cargo service also

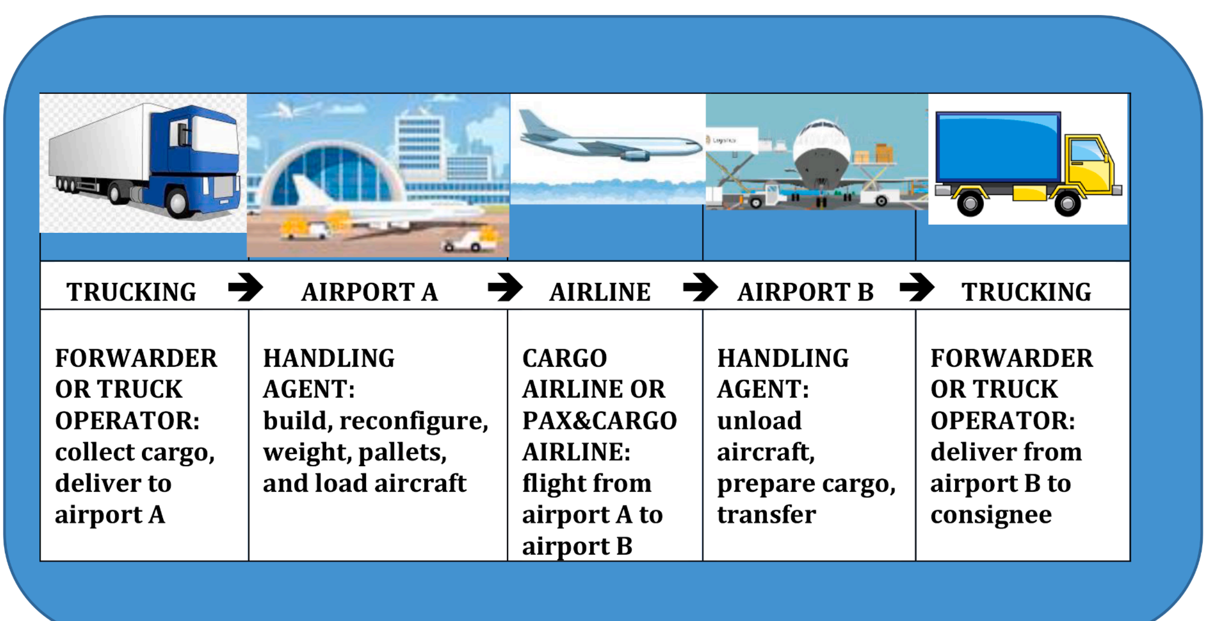

Fig. 1. The air cargo chain.

include infrastructure, customs, intermodal transport, and international aviation policy [13]. The choice of the air cargo transshipment location is more sensitive to the connecting time at an airport than airport charges e.g., landing fees and line-haul price [14]. Transshipment airport selection becomes increasingly important from the perspectives of shippers and freight forwarders, and, thus, selection must align with cost control strategy and sustain service reliability across cooperative service providers [15]. However, location does not establish the comparative advantage of a site. For freight, customs efficiency was also identified as being important by Zhang and Zhang [16], since customs administration should provide reliable, timely customs clearance, or immediate release based on pre-clearance, creating a competitive advantage. Reliability of the terminal operations time is very important in forwarders choice of airport, to define a more precise route planning [17].

Proximity to port was also identified as major determinant of freight transport in highly urbanized cities [18,19]. The logistics ecosystem, including air cargo, urges greater collaboration in order to provide the most efficient and economically viable transport while also reducing the impact on the environment. Additionally, it is emphasized that the factors considered by air freight companies when choosing airports include opening hours, total costs, reputation in cargo transport, demands for local O/D cargo, influence of freight forwarders, transport from airports, customs clearance times, and financial incentives offered [20]. As stated in [21] the opening hours of an airport have a significant impact on airline flight scheduling and timely delivery of transshipment cargo. Shorter cargo clearance times may also reduce cargo transport times and stock costs.

Another significant finding mentioned above was that freighter operators placed so much importance on the reputation and experience of the airport for handling freighter flights [20]. Results of research conducted in [22] show that “if the freight-forwarding companies know the terminals and transit cities on the routes between origins and destinations, they will not risk trying new routes”, even though those routes may result in lower costs and shorter transport time.

3. Airport choice by freight forwarder

Freight forwarders usually make decisions about airport in the following way. First, based on geographical location, they consider airports that can be reached by truck within acceptable time.[1] For express cargo, it is important that airport is open and provides operations 24/7 [23].

Additionally, they take into account airport capabilities for processing and handle cargo. The availability of modern well-designed and cost-effective cargo facilities, as well as the ability to handle unusual cargo, are the key advantages in airport attractiveness for freight forwarder [24]. An airport operator is, also, responsible for the provision and security of the airport infrastructure [25]. Ground handlers are responsible for dealing with operational aspects, based on the instructions of freight forwarders and airlines. Ground handlers’ activities encopasses handling, preparing, and tagging cargo and mail, loading/unloading, transit, and storage of cargo and mail.

Second, they compare the total cost and transport time for each airport and appropriate routes from consignor to consignee and analyze trade-off between cost and quality of service (needed time to transport good). Airports often might produce the most delays in supply chain [5]. Thus, it is important to have data for each airport related to timetable, delays, customs clearance times as well as airports opening hours.

After choosing the airport and the route, negotiations with the airline will begin. One of the issues is how much capacity to book, or how to manage contracted space. Namely, freight forwarder can have contracted space for specific flight for specific day in one week. For other flights and other days, it is necessary to book space. Decision about flight is based on required time to deliver shipment as well as on special requirements related to goods. For example, perishable or dangerous goods must be handled with particular care and under strict procedure. Commonly, freight forwarders are most interested in delivering freight to the destination on time, efficiently, safely, and cost-effectively, thus they choose those airlines that offer lower prices as well as reliable and efficient services than with choosing transport routes [10].

Further, airlines can charge by volumetric mass, which is dimensional weight, or by actual weight. Cargo rates are negotiated between airlines and freight forwarders and usually quoted per kg or per ULD. The level of cargo rate is depending on specific product or service as well as on freight forwarder importance and its contribution to airline demand. Generally, rates are not published. The actual rate paid a freight forwarder to an airline may differ from the tariff, and are bilaterally agreed and remain confidential.

Additionally, there is a surcharge as an extra fee, charge, or tax that is added on to the cost of a good or service. Surcharges could include airport handling fee, airport screening fee, airport transfer fee, dangerous goods fee, fuel surcharges, handling fee, letter of credit fee, security surcharge and terminal handling fee [26].

One of the main questions is, what are the deciding factors influencing the freight forwarder choice of airport. In the next section, airport and airlines’ supply will be analyzed in order to illustrate input (factors) affecting airport choice for shipment.

4. Case study: freight forwarder’s choice of airport

In this section the case study is discussed, focusing on the characteristics of the supply in terms of transport cost and airline timetable. The primary data sources for this case are derived from the real pricelists of the considered airports and airlines [27]. In order to illustrate the choice of airport of freight forwarder, the examples of Serbian, Croatian and Slovenian markets are considered. The example covers following: (1) service door to airport will be offered by freight forwarder, (2) the origin point is Belgrade (Serbia), (3) the final destination is Dubai, and (4) three potential departure airports (Belgrade – BEG, Zagreb – ZAG, Ljubljana – LJU) and one arrival airport (Dubai International Airport – DXB) are taken into analysis.

The selection of the most appropriate route is based on two criteria: total transport costs and the quality of connection (with respect to airline schedules). In the case study, the airports are ranked first based on total transport costs which include cost of transport to the airport by truck, cost of ground handling and cost of transport by air. Then, for each of the considered airport the quality of the connection is determined based on available airline schedules and the most appropriate route is chosen.

Cost of transport by truck (from consignor to airport), cost of ground handling and airline air cargo rate, as factors that affect the airport choice of freight forwarder, will be analyzed, for different masses of goods (45 kg, 100 kg, 500 kg, 1000 kg, 3000 kg). Tables 1–3 display information regarding these costs. Table 1 contains the road transport

Table 1
Transport cost and unit cost from origin to airport, by truck.

Departure airport	Mass of goods				
	45 kg	100 kg	500 kg	1000 kg	3000 kg
	Transport cost from origin to airport, by truck, in EUR				
BEG	30	30	70	70	120
ZAG	250	250	350	350	420
LJU	280	280	400	400	510
	Transport unit cost from origin to airport, by truck, in EUR/kg				
BEG	0.66	0.3	0.14	0.07	0.04
ZAG	5.55	2.5	0.7	0.35	0.14
LJU	6.2	2.8	0.8	0.4	0.17

[1] For example, for the given market, one freight forwarder considers only airports that can be reached by truck within 12 h.

Table 2
Ground handling cost at the airport, in EUR/kg.

Departure airport	Mass of goods				
	45 kg	100 kg	500 kg	1000 kg	3000 kg
BEG	0.06	0.06	0.06	0.1	0.1
ZAG	0.15	0.15	0.15	0.15	0.15
LJU	0.1	0.1	0.1	0.1	0.1

Table 3
Airline rates – transport cost by plane, in EUR/kg.

Departure airport	Mass of goods				
	45 kg	100 kg	500 kg	1000 kg	3000 kg
BEG	2.37	2.21	2.05	1.9	1.77
ZAG	2.22	2.12	1.75	1.35	1.25
LJU	2.35	2.22	1.92	1.88	1.05

cost for different masses of goods, from origin to the selected airports. In this example, we consider the transport of general cargo which does not require a special type of handling equipment or service. The truck operator, generally takes into account the cargo mass, dimensions and the number of pallet spaces required. Based on those data, it was determined that goods up to 100 kg can be packed in a vehicle with a capacity of two pallet places. In that case, it would cost 30 euros to be transported to Belgrade Airport, 250 euros to Zagreb Airport, and 280 euros to Ljubljana Airport. For goods over 100 kg and less than 1000 kg it can be transported by a vehicle with four pallet places (van), and goods between 1000 kg and 3000 kg can be transported by a vehicle with 10 pallet places (avia truck). In order for these costs to be comparable, it is necessary to convert them into unit costs per kilogram and this is, also, given in Table 1. It is evident that costs decrease with increasing mass, but it is also observed that the difference in unit costs decreases with increasing mass.

Ground handling cost represents the cost of unloading the goods from the truck, the cost of placing the goods in the customs warehouse at a certain position and the cost of X-ray control of the goods (Table 2). This cost is usually charged by airports as a unit cost per kilogram of actual mass and it can be observed that Belgrade Airport is the cheapest among these airports.

Table 3 shows the unit cost of air transport service from the departure airport to the destination airport. The airline rates in Table 3 refers to the summer flight schedule in 2018. Although, the airline rates decrease with the mass of goods transported, the airline from Belgrade airport charges the highest prices in all cases, while from Zagreb airport is the cheapest. Generally, airlines determine rate based on simple calculation. To calculate the volumetric mass, first the volume should be determined: length multiply by width multiply by height (all values in centimeters). Then this number should be divided by 6000.00 for air freight (for other mode of transport this value is different), [26]. The final shipping costs are calculated based on the highest value of the actual and volumetric mass: this is the “chargeable mass”.

Regarding this case study, there are two assumptions:

- aircraft capacity issue is not considered (i.e., available capacity is sufficient),
- the chargeable mass is actual mass (kg).

To determine which route is the most cost-effective, a freight forwarder needs to sum up the following: (a) the cost of transport to the departure airport; (b) the cost of ground handling, and (c) the cost of air transport from the departure airport to the destination airport. Table 4 summarizes the costs of door-to-airport services. Based on this total cost Belgrade airport is the first choice for goods up to 500 kg, Zagreb airport is the first choice for goods of 1000 kg and Ljubljana airport is the most

Table 4
Total transport cost from door to arrival airport, in EUR/kg.

Departure airport	Mass of goods				
	45 kg	100 kg	500 kg	1000 kg	3000 kg
BEG	3.09	2.57	2.25	2.07	1.91
ZAG	7.92	4.77	2.6	1.85	1.54
LJU	8.65	5.12	2.82	2.38	1.32

suitable for goods of 3000 kg. Note that total transport costs vary from airport to airport depending on the mass of goods. Moreover, the difference among unit costs of transport from origin to the departure airports (Table 1) decreases with increasing mass.

In case that the clients are not only interested in the total transport costs, but also take into account the transit time and the quality of the connection at the given airports, then it is necessary to analyze the flight schedule of the airlines. The available flights and departure timings for the selected departure airports and destination airport are given in Table 5. The data used is collected from Flight radar between July 30 and August 8, 2020.

The *NetScanCargo* model is than used to quantify the performance of air transport networks, i.e., to measure the quality of a network's indirect connections [28]. More particular, the *NetScan* model quantifies the quality of an indirect connection and scales it to the quality of a theoretical direct connection [29]. The original *NetScan* model was introduced by Veldhuis [30], and after that used by many others [29,31]. Main parameters are given in Table 6.

In order to achieve $T_{max} \approx 48$ h, time sensitive parameter (α) and correction parameter for short flights (τ) are chosen to be $\alpha = 15$ and $\tau = 0.5$. It should be noted that a higher value of α indicates a lower time-sensitivity. Regarding parameter τ, it is included to allow for a little more time flexibility for short flights. These parameters are determined based on the freight forwarders' historic data.

Connectivity is a measure of accessibility and centrality of airports, regions and countries, while accessibility denotes the extent to which an airport provides connections to other world regions. It should be noted that this accessibility relates to airside accessibility and it should not be confused with landside accessibility (i.e., accessibility by road, rail or maritime transport) [32].

The amount of CNU on a certain route is determined by the system of equations given by [28]. Considering data related to airlines' offer from selected airport, it is observed that flights from Ljubljana are performed by inappropriate aircraft type; therefore, the value of CNU for Ljubljana – Dubai is equal to zero, and the airport in Ljubljana is excluded from further consideration. The values of CNU for Belgrade – Dubai is equal to 0.42, while for Zagreb – Dubai CNU is equal to 0.67 (Table 6).

Bearing in mind that described problem is multi-criteria decision making (MCDM) problem by its nature, and considering all above-mentioned, it is obvious that some of MCDM techniques can be applied. The advantage of Analytic Hierarchy Process (AHP) [33], which will be used in this example, is that the final ranking is obtained on the basis of

Table 5
Airline supply from Belgrade, Zagreb and Ljubljana to Dubai.

FLIGHT WITH ONE STOP	AIRLINE OFFERS: TIMETABLE, AIRCRAFT TYPE			
	FIRST LEG		SECOND LEG	
BEG-DBX	**BEG-IST** TK6575 A310F	31.07.2020. DEP. 17:30 ARR. 19:10	**IST-DBX** TK760 B777W	01.08.2020. DEP. 18:10 ARR. 23:43
ZAG-DBX	**ZAG-CDG** AF6767 B767F	31.07.2020. DEP. 21:40 ARR. 23:40	**CDG-DBX** AF662 A350	01.08.2020. DEP. 13:45 ARR. 22:35
LJU-DBX	**LJU-MOW** SU2611 A320	01.08.2020. DEP. —- ARR. —-	**MOW-DBX** SU521 B737	02.08.2020. DEP. —- ARR. —-

Table 6
Net Scan Cargo model.

Parameters	Description	BEG-DXB	ZAG-DXB
Frequency (f)	Weekly number of flights	1	1
$T_{nonstop}$	Theoretical non-stop flying time	5.33	5.66
T_{max}	Maximum acceptable transport time	47.64	49.29
T_{fly}	In-flight time	6.79	10.33
$T_{transfer}$	Transfer time	23	9.91
$T_{perceived}$	Perceived transport time is a linear function of the total in-flight time, transhipment time and a penalty for the inconvenience of a transhipment.	29.79	20.24
$P_{perceived}$ - $T_{nonstop}$	Difference between indirect and direct non-stop flight time	24.46	14.58
T_{max} - $T_{nonstop}$	Maximum allowed difference between indirect and direct non-stop flight time	42.31	43.63
q	Quality of the connection	0.42	0.67
CNU= q*f	Connectivity network unit	0.42	0.67

the pairwise relative evaluations of both the criteria and the options provided by the user. Also, the logic of AHP approach is rational and comprehensible, and the computation process is relatively easy. The AHP can be applied to this problem to provide systematical choice of an appropriate solution, as well as to confirm the process of freight forwarders decision making.

For considered MCDM problem, the AHP is used to support selection of the most suitable airport by freight forwarder. The three criteria (Total transport costs, CNU (connectivity) and Fleet) are chosen in the second level of hierarchy from freight forwarders experience, as aforementioned. The third level includes three airports selected to be candidates in the set of alternatives (Belgrade, Zagreb and Ljubljana). The criteria of Total transport costs and CNU are described by numerical, quantitative values, while the Fleet is quantitatively defined as appropriate, acceptable and unacceptable.

The fundamental scale showing the intensity of importance on an absolute scale in order to compare alternatives and criteria was introduced by [33]. The scale consists of verbal judgments of preference ranging from equal to extreme importance (equal, moderate, strong, very strong, extreme) with the corresponding numerical judgments (1, 3, 5, 7, 9), as well as intermediate values between the two judgements. The numerical judgements in the pairwise comparison matrix satisfy the reciprocal property, which means if activity i has one of the above nonzero numbers assigned to it when compared with the activity j, then j has the reciprocal value when compared with i ($a_{ji} = 1/a_{ij}$). Pairwise comparison matrices for the criteria and alternatives enable computing of local and global priorities as well as ranking of alternatives. Priorities from pairwise comparisons can be calculated in different ways using different methods (e.g., eigenvector method, geometric mean method or arithmetic average method), and the arithmetic average method will be used in this paper to determine ranking of airports.

The matrix of pairwise comparisons of the criteria with priority vector is shown in Table 7. In this example, the highest priority is given to Fleet (0.539) – if the fleet is not appropriate regarding available capacity, the transport cannot be offered from considered airport. Therefore, the Fleet is considered as an eliminating criterion.

Table 8 present the domination measure of one airport over another

Table 7
Pairwise comparison matrix for the first level.

	Total transport costs	Connectivity	Fleet	Priority vector
Total transport costs	1	2	0.5	0.297
Connectivity	0.5	1	0.333	0.164
Fleet	2	3	1	0.539
CR=0.010				

with respect to given criteria for different mass of goods. The consistency ratio (CR), is checked for all pairwise comparison matrices, and it is found out that it is acceptable (it should be lower than 10%) in all cases, which confirms the validity of the solutions reached. Moreover, the results obtained, are in accordance with results reached by decision making of freight forwarders: Belgrade airport is the most suitable solution for the freight up to 500 kg, while Zagreb seems to be the most appropriate for shipments with mass between 500 kg and 3000 kg. Note that fleet operating from Ljubljana airport in the case of mass 500 kg is acceptable for transport, while in the case of 1000 kg and more Ljubljana offers unacceptable fleet (Table 8).

Regarding possible improvements of airport offers, sensitivity analysis is conducted. The results show that:

- Belgrade Airport would be the most appropriate solution goods over 500 kg, if it provides connectivity significantly better compared to Zagreb and Ljubljana, while importance of other criteria over each other is unchanged. Moreover, that would have aligned with the generally higher prices offered by the airlines serving this airport.
- Belgrade Airport could have leading position for goods over 500 kg if the prices offered are slightly lower than those offered from Zagreb and Ljubljana, while importance of other criteria over each other is unchanged.
- Ljubljana Airport could be the first choice if airlines serving this airport have the appropriate fleet (wide-body aircraft) for transport of goods between 1000 kg and 3000 kg, while importance of other criteria over each other is unchanged.
- Zagreb Airport could be the first choice if the total transport costs for goods between 100 kg and 500 kg, are the same as from Belgrade Airport, while importance of other criteria over each other is unchanged.

However, to make final choice of the airport, freight forwarder needs to take into account maximum transit time required by consignor. Depending on this time, and bearing in mind that departure times of flights are fixed, the freight forwarder would decide whether the requirements can be meet or not, and under what conditions. Moreover, if shipments need to be sent periodically, then airline's flight schedule can be limiting factor.

The methodology applied in this study will be useful for various stakeholders of the air cargo industry such as the freight forwarders, airlines and airport authority to derive and evaluate policies on cargo operations and management. For example, the findings indicate that from the perspective of freight forwarders airlines should develop operating strategies with respect to attractive discounted rates, offering more connectivity options which are on-time and reliable. In order to achieve sustainable management, a key aspect of competitiveness within the airports with cargo services is cost-efficiency in order to attract choice of operations from freight forwarders. However, the results also showed that the continuous improvement of service quality is an important issue for maintaining a competitive advantage and to handle air cargo across the region. The main challenge for all tree considering airports is that they are predominantly passenger-oriented airports and that they need more air cargo connections in order to attract more cargo business. This methodology could be helpful for taking investment decisions in development of these reginal airports based on their cargo growth potential. It will, also, mean investing in proper facilities to achieve efficient cargo handling and better growth in business.

5. Conclusion

This paper presents an analysis of airport choice by freight forwarder located in Serbia. In most circumstances, the attractiveness of an airport depends on the characteristics of the supply in terms of transport cost and airline flight schedule. For the sake of this paper, an airline flight

Table 8
Domination measure of one airport over another with respect to criteria and global priority weights for different mass of goods (45 kg, 100 kg, 500 kg, 1000 kg, 3000 kg).

Mass of goods	Airport	Total transport costs BEG	ZAG	LJU	Priority vector	CNU BEG	ZAG	LJU	Priority vector	Fleet BEG	ZAG	LJU	Priority vector	Global priority vector
45kg	**BEG**	1	6	7	0.755	1	0.5	0,333	0.164	1	1	1	0.333	**0.411**
	ZAG	0.167	1	2	0.153	2	1	0,5	0.257	1	1	1	0.333	0.274
	LJU	0.143	0.5	1	0.092	3	2	1	0.539	1	1	1	0.333	0.295
		CR=0.051				CR=0.010				CR=0				
Mass of goods	Airport	Total transport costs BEG	ZAG	LJU	Priority vector	CNU BEG	ZAG	LJU	Priority vector	Fleet BEG	ZAG	LJU	Priority vector	Global priority vector
100 kg	**BEG**	1	3	5	0.633	1	0.5	0,333	0.164	1	1	1	0.333	**0.395**
	ZAG	0.333	1	3	0.261	2	1	0,5	0.257	1	1	1	0.333	0.306
	LJU	0.2	0.333	1	0.106	3	2	1	0.539	1	1	1	0.333	0.299
		CR=0.048				CR=0.010				CR=0				
Mass of goods	Airport	Total transport costs BEG	ZAG	LJU	Priority vector	CNU BEG	ZAG	LJU	Priority vector	Fleet BEG	ZAG	LJU	Priority vector	Global priority vector
500 kg	**BEG**	1	2	3	0.539	1	0.5	0,333	0.164	1	1	3	0.429	**0.418**
	ZAG	0.5	1	2	0.297	2	1	0,5	0.257	1	1	3	0.429	0.368
	LJU	0.333	0.5	1	0.164	3	2	1	0.539	0.333	0.333	1	0.143	0.214
		CR=0.010				CR=0.010				CR=0				
Mass of goods	Airport	Total transport costs BEG	ZAG	LJU	Priority vector	CNU BEG	ZAG	LJU	Priority vector	Fleet BEG	ZAG	LJU	Priority vector	Global priority vector
1000 kg	BEG	1	0.5	2	0.297	1	0.5	0,333	0.164	1	1	9	0.474	0.370
	ZAG	2	1	3	0.539	2	1	0,5	0.257	1	1	9	0.474	**0.464**
	LJU	0.5	0.333	1	0.164	3	2	1	0.539	0.111	0.111	1	0.053	0.165
		CR=0.010				CR=0.010				CR=0				
Mass of goods	Airport	Total transport costs BEG	ZAG	LJU	Priority vector	CNU BEG	ZAG	LJU	Priority vector	Fleet BEG	ZAG	LJU	Priority vector	Global priority vector
3000 kg	BEG	1	0.5	0.333	0.164	1	0.5	0,333	0.164	1	1	9	0.474	0.331
	ZAG	2	1	0.5	0.297	2	1	0,5	0.257	1	1	9	0.474	**0.392**
	LJU	3	2	1	0.539	3	2	1	0.539	0.111	0.111	1	0.053	0.277
		CR=0.010				CR=0.010				CR=0				

schedule is evaluated in terms of transit time and the quality of the connection at the given airports. The AHP is used to support freight forwarders choice of airport based on selected criteria.

Belgrade airport is generally cost-effective in term of transport costs, due to its proximity. However, the shipping rates offered by airlines tend to be high in comparison to the Zagreb and Ljubljana, which put them in first choice for higher masses (over 1000 kg). Moreover, for high-volume shipments, truck operators offer discounted shipping rates and in those cases Zagreb and Ljubljana can be cost-effective, too.

In terms of quality of the connections, there is a large difference between considered airports (Belgrade, Zagreb and Ljubljana) in their role as cargo airports. Ljubljana airport offers very limited number of cargo services, while the situation at Belgrade and Zagreb airports is much better which makes two of them very competitive.

The results of AHP sensitivity analysis point out that airports and airlines must develop the capacity and flexibility to accommodate changing trends and volumes of cargo in order to attract more demand. They should adapt their business models by offering innovative products (more services, 24 h operations, capacity guarantees, better connectivity, appropriate fleet, etc.) to freight forwarders and shippers that added value to the existing offer. This type of improved services should attract more cargo operators and lead to more operationally efficient and cost-effective cargo services in the region.

There are a number of areas for further research. A thorough survey of the freight forwarder airport choice should be conducted in order to develop a choice model based on real data. Moreover, it would be interesting to assess the preference of cargo routings for freight forwarders and which route characteristics determine their choice. Also, the role of road transport in air cargo networks in this part of the Europe should be studied, too.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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References

[1] IATA, Value of air cargo, https://www.iata.org/en/programs/cargo/sustainability/benefits/; 2022 [Accessed 27 June 2022].
[2] European Commission, Logistics and multimodal transport, https://transport.ec.europa.eu/transport-themes/logistics-and-multimodal-transport_en; 2022 [Accessed 27 June 2022].
[3] R. Doganis, Flying Off Course: Airline Economics and Marketing, Routledge, London, 2010.
[4] W.H. Wong, L.C. Leung, Y.V. Hui, Airfreight forwarder shipment planning: a mixed 0-1 model and managerial issues in the integration and consolidation of shipments, Eur. J. Oper. Res. 193 (1) (2009) 86–97, https://doi.org/10.1016/j.ejor.2007.10.032.
[5] P.S. Morrell, T. Klein, Moving Boxes by Air: The Economics of International Cargo, 2nd ed, Routledge, 2019.
[6] L. Budd, S. Ison, The role of dedicated freighter aircraft in the provision of global airfreight services, J. Air Transp. Manag. 61 (2017) 34–40, https://doi.org/10.1016/j.jairtraman.2016.06.003.
[7] IATA, Airline industry statistics confirm 2020 was worst year on record. Available online: https://www.iata.org/en/pressroom/pr/2021-08-03-01/; 2021 [Accessed 27 June 2022].
[8] Y. Park, An analysis for the competitive strength of Asian major airport, J. Air Transp. Manag. 9 (6) (2003) 353–360, https://doi.org/10.1016/S0969-6997(03)00041-3.
[9] N.K. Tran, Studying port selection on liner routes: an approach from logistics perspective, Res. Trans. E 32 (1) (2011) 39–53, https://doi.org/10.1016/j.retrec.2011.06.005.
[10] H.C. Chu, Exploring preference heterogeneity of air freight forwarders in the choices of carriers and routes, J. Air Transp. Manag. 37 (2014) 45–52, https://doi.org/10.1016/j.jairtraman.2014.02.002.
[11] M.T. Nugroho, A. Whiteing, G. de Jong, Port and inland mode choice from the exporters' and forwarders' perspectives: case study – Java, Indonesia, Res. Trans. Bus Manag. 19 (2016) 73–82, https://doi.org/10.1016/j.rtbm.2016.03.010.
[12] F. Kupfer, R. Kessels, P. Goos, E. Van de Voorde, A. Verhetsel, The origin-destination airport choice for all-cargo aircraft operations in Europe, Transp. Res. E 87 (2016) 53–74, https://doi.org/10.1016/j.tre.2015.11.013.
[13] A. Zhang, Analysis of an international air-cargo hub: the case of Hong Kong, J. Air Transp. Manag. 9 (2) (2003) 123–138, https://doi.org/10.1016/S0969-6997(02)00066-2.
[14] H. Ohashi, T.S. Kim, T.H. Oum, C. Yu, Choice of air cargo transshipment airport: an application to air cargo traffic to/from Northeast Asia, J. Air Transp. Manag. 11 (3) (2005) 149–159, https://doi.org/10.1016/j.jairtraman.2004.08.004.
[15] G. Chen, W. Cheung, S.C. Chu, L. Xu, Transshipment hub selection from a shipper's and freight forwarder's perspective, Expert Syst. Appl. 83 (2017) 396–404, https://doi.org/10.1016/j.eswa.2017.04.044.
[16] A. Zhang, Y. Zhang, Issues on liberalisation of air cargo services in international aviation, J. Air Transp. Manag. 8 (2002) 275–287.
[17] M.J. Meixell, M. Norbis, A review of the transportation mode choice and carrier selection literature, Int. J. Logist. Manag. 19 (2) (2008) 183–211, https://doi.org/10.1108/09574090810895951.
[18] A. Pani, P.K. Sahu, A. Chandra, A.K. Sarkar, Assessing the extent of modifiable areal unit problem in modelling freight (trip) generation: relationship between zone design and model estimation results, J. Transp. Geogr. 80 (2019), e102524, https://doi.org/10.1016/j.jtrangeo.2019.102524.
[19] P.K. Sahu, A. Pani, Freight generation and geographical effects: modelling freight needs of establishments in developing economies and analyzing their geographical disparities, Transp 47 (2019) 2873–2902, https://doi.org/10.1007/s11116-019-09995-5.
[20] J. Gardiner, S. Ison, I. Humphreys, Factors influencing cargo airlines' choice of airport: an international survey, J. Air Transp. Manag. 11 (6) (2005) 393–399, https://doi.org/10.1016/j.jairtraman.2005.05.004.
[21] C.C. Chao, P.C. Yu, Quantitative evaluation model of air cargo competitiveness and comparative analysis of major Asia-Pacific airports, Transp. Policy 30 (2013) 318–326, https://doi.org/10.1016/j.tranpol.2013.10.001.
[22] D. Li, The Impact of Using Air Cargo in Multimodal Transportation systems, Master thesis, HEC Montreal, Canada, 2017.
[23] F. Kupfer, H. Meersman, E. Onghena, Van de Voorde E. The underlying drivers and future development of air cargo, J. Air Transp. Manag. 61 (2017) 6–14, https://doi.org/10.1016/j.jairtraman.2016.07.002.
[24] Y.C. Hu, P.C. Lee, Y.S. Chuang, Y.J. Chiu, Improving the sustainable competitiveness of service quality within air cargo terminals, Sustainability 10 (2018) e2319, https://doi.org/10.3390/su10072319.
[25] ICAO-WCO, Moving Air Cargo Globally: Air Cargo and Mail Secure Supply Chain and Facilitation Guidelines, 2nd ed. 2016.
[26] IATA, Air cargo tariffs and rules: what you need to know, https://www.iata.org/en/publications/newsletters/iata-knowledge-hub/air-cargo-tariffs-and-rules-what-you-need-to-know/; 2021 [Accessed 27 June 2022].
[27] S. Živojinović, Airline Supply in the Air Cargo Market in Serbia, Croatia and Slovenia, Graduate Thesis, University of Belgrade – Faculty of Transport and Traffic Engineering, 2020 in Serbian language.
[28] T. Boonekamp, G. Burghouwt, Measuring connectivity in the air freight industry, J. Air Transp. Manag. 61 (2017) 81–94, https://doi.org/10.1016/j.jairtraman.2016.05.003.
[29] G. Burghouwt, J. Veldhuis, The competitive position of hub airports in the Transatlantic market, J. Air Transp. 11 (1) (2006) 106–130.
[30] J. Veldhuis, The competitive position of airline networks, J. Air Transp. Manag. 3 (4) (1997) 181–188, 1997.
[31] P. Suau Sanchez, G. Burghouwt, Connectivity levels and the competitive position of Spanish airports and Iberia's network rationalization, J. Air Transp. Manag. 18 (1) (2012) 47–53.
[32] G. Burghouwt, R. Redondi, Connectivity in air transport networks: an assessment of models and applications, J. Transp. Econ. Policy 41 (1) (2013) 35–53. https://www.jstor.org/stable/24396351.
[33] T.L. Saaty, The Analytic Hierarchy Process, Planning, Priority Setting, Resource Allocation, McGraw-Hill, New York, 1980.