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The airport choice of exporters for fruit from Brazil

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ABSTRACT

Decisions related to transportation should be optimized using criteria and indicators. Although the literature shows relevant criteria and indicators in competitiveness between airports, this study intends to contribute to the airport choice theory presenting perceptible indicators to air cargo service users. In this sense, this study aims to analyze the airport choice factors for the export of perishables from Brazil. Based on criteria found within the literature, a sensitivity analysis was performed under simulation for airport choice. Specifically, using the Analytic Hierarchy Process (AHP) method, indicators related to time and cost criteria were compared based on interviews performed with Brazilian mango exporters. It was simulated the choice between of Brazil's main airports used for fruit export in recent years on the basis of the selection criterion pointed out by these exporters. The results show that the prioritization or choice based on time, commonly used as a reference, can result in loss of road freight, increasing costs for access to the airport by 23%. Hence, future studies can be conducted with the purpose of verifying the relation between cost and time in the decisions for choosing specific cargo airports for exporting nonperishable products.

1. Introduction

The decision about which airport to use is presented as a topic of interest in air cargo transportation research (Kupfer et al., 2011, 2016) and according to Ohashi et al. (2005), this choice results from competition between airports. The literature presents several variables for measuring the performance and competitiveness of airports (Sarkis, 2000; Gillen and Lall, 2001; Pels et al., 2001; Fernandes and Pacheco, 2002; Martín-Cejas, 2002; Pels et al., 2003; Oum and Yu, 2004; Yoshida, 2004; Barros, 2008; Assaf, 2009; Chung and Han, 2013; Chung et al., 2015), such as the number of international air cargo transit lanes and gates, cargo terminal areas and aircraft flights, and cargo destination traffic. However, a lack of studies addressing indicators perceptible to users was noticed. This paper contributes to research on the relationship between air cargo exporters and airport choice in relation to perishable goods.

Decisions involving product transportation encompasses two criteria, time and cost (Murakami and Matsuse, 2014). Studies show time (Zhang and Zhang, 2002; Adenigbo, 2016) and access cost (Hess and Polak, 2005; Jung and Yoo, 2016) as relevant for choosing an airport. Although the cost of access to the airport is a relevant criterion in the choice for an airport (Hess and Polak, 2005), it is noted that users of air transportation services are willing to incur additional costs if this results in less time (Loo, 2008; Jung and Yoo, 2016).

Thus, the purpose of this study is to analyze the process of airport choice for the export of perishable products, specifically the export of Brazilian mango by air, identifying the criteria followed by exporters as well as the relationships the exporters hold with airports. In this sense, a survey with producers and exporters of mangoes from the São Francisco Valley, the region responsible for 85% of mangoes exported by Brazil, was performed. Through Multiple-Criteria Decision-Making (MCDM) analysis and using the Analytic Hierarchy Process (AHP) method, exporters evaluated time and cost indicators related to airport performance and access to terminals and pointed out their relevance in the choice for a cargo airport for the export of mangoes. A simulation of the choice process was performed using the International Airport Governor André Franco Montoro/Guarulhos (GRU) in São Paulo, International Airport Luís Eduardo Magalhães/Salvador (SSA) in Bahia, and International Airport Gilberto Freyre/Guararapes (REC) in Pernambuco.

Section 2 provides the conceptual framework considered by air cargo agents for airport choice focusing on the criteria of time and cost. Section 3 demonstrates the method used in this research and the characterization of the object of study. Section 4 presents the decision

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weights from the analyzed variables. Section 5 show simulate the choice of airport from the evaluated criteria. And section 6 presents the final considerations of the research.

2. Conceptual framework

Air cargo transportation is an area that has attracted the attention of academics. Though, as shown in Merkert et al. (2017), publications on airfreight are quite limited because traditional literature has focused on passenger transport. However there are several study gaps, such as the choice of airports.

The airport choice is commonly approached in literature on passenger transport (Zhang and Zhang, 2002; Pels et al., 2003; Hess and Polak, 2005; Loo, 2008; Hess, 2010; Postorino and Praticò, 2012; Jung and Yoo, 2016). Although the focus of this study is on the movement of cargo, it is possible to identify decision criteria presented in studies with passengers that fit the airport choice process for cargo transportation. The study by Hess and Polak (2005) analyzed the criteria that influence the choice of passengers in region of San Francisco and identifies the consistent relationship between airport choice, airfare, access time and flight frequency. Loo (2008) also identifies this relationship, but in a multi-airport region of China. With a focus to examine the relative advantages and disadvantages between factors, the author used Multinomial Logit (MNL) from stated preference data and found that there is a statistically significant relationship between airport choice and airfare, access time to the airport, and frequency of flights. The author also demonstrate that passengers are able to pay more if this results in a reduction of the time spend in the airport.

In the same sense, Jung and Yoo (2016) demonstrate in their study the factors involved in the choice of passengers from Seoul, South Korea, regarding the three largest airports. Through the MNL and Nested Logit (NL) models, the authors present the behavior regarding choice of airport and airline simultaneously. Corroborating with the study of Loo (2008), Jung and Yoo (2016) also identify that passengers would be willing to pay more to reduce the time of access to the airport.

Pels et al. (2003) analyzed the airport choice regarding three airports in the San Francisco Bay Area, California, with reference to the relevance of the variable “access.” The authors divided survey participants into two groups, “business travelers” and “leisure travelers,” and identified through NL that there is a difference concerning the sensitivity for each group in relation to the evaluated criteria, especially when referring to time. For the authors, the time of access to the airport is of great relevance in the competition between airports of one specific region.

Postorino (2010) states that the location of the airport, as well as the distance between other terminals, are factors that influence competition between airports. The study of Postorino and Praticò (2012) uses MCDM to identify the classification of airports in a multi-airport region in northeastern Italy, considering criteria such as location, installations, financial revenue, efficiency, and operational effectiveness. According to the results, the choice criteria does not have any influence on the best-performing airport, however, it has greater influence on the other airports due to the dominant role of the main airport.

Although these studies assessed the airport choice criteria based on evaluation by passengers, it is assumable that these variables can be used to evaluate the choice of an airport in the context of cargo transportation. However, Kupfer et al. (2016) indicate that it is necessary to study passenger and freight transport separately as both have distinct rules. The study conducted by these authors approached the airport choice of airlines for regular operations with freighters in Europe. Based on data regarding the preference of 26 airlines, the authors used the Multinomial Logit (MNL) method and recognized that the presence of freight forwarders as well as nighttime operation of an airport are attractive factors. The results of this study are similar and reinforces the results of Gardiner et al. (2005) which also noted the presence of freight forwarders as a factor that influences the airport choice in cargo operations.

Table 1
Summary of reviewed literature.
Source: Author supplied.

Authors	Methods	Criteria
Pels et al. (2003)	Nested Logit (NL)	Access time to the terminal
Gardiner et al. (2005)	Arthritis Impact Measurement Scales (AIMS)	Presence of freight forwarders Location of the airport Opening hours Air rates
Hess and Polak (2005)	Mixed Multinomial Logit Model (MMNL)	Access cost to the terminal Access time to the terminal Air rates Frequency of flight
Ohashi et al. (2005)	Multinomial Logit (MNL)	Cost Air rates Location of the airport
Loo (2008)	Stated Preference (SP) Multinomial Logit (MNL)	Air rates Access time to the terminal Frequency of flight Airlines quantity acting
Hess (2010)	Stated Preference (SP)	Airport size Extent of service Location of the airport
Postorino and Praticò (2012)	Multi-Criteria Decision-Making (MCDM)	Air rates Airport efficiency level Service quality Parking Frequency of flight
Chung and Han (2013)	Conjoint Analysis	Air rates Frequency of flight Flight connectivity
Adenigbo (2016)	Factor Analysis (FA) Multiple Linear Regression (MLR)	Airport capacity Airport charges Customs efficiency
Jung and Yoo (2016)	Multinomial Logit (MNL) Nested Logit (NL)	Air rates Flight time Frequency of flight Access time to the terminal Access cost to the terminal
Kupfer et al. (2016)	Stated Preference (SP) Multinomial Logit (MNL)	Presence of freight forwarders Opening hours

According to the studies of Chung and Han (2013), most of the research on factors involved in airport choice analyzes the same types of attributes, such as airfare, frequency, and flight connectivity. For Boonekamp and Burghouwt (2017), the connectivity is a determinant in the choice of the airport. However, Zhang and Zhang (2002) affirm that customs operations in airports represents a relevant factor that influences the airport choice. Ohashi et al. (2005) argue that the choice emerges as result of competition in cargo transportation. The authors believe that this aspect makes freight forwarders prefer to perform their operations at an airport even when the airport's location is not in their favor. However, Gardiner et al. (2005) point out that location is a factor that increases the attractiveness of cargo terminals. Table 1 synthesizes the identified studies related to airport choice and presents the methods and criteria used by the authors.

According to Table 1, Adenigbo (2016) analyzes the factors that influence the choice of freight forwarders to operate at Abuja Airport in Nigeria. Through the combination of Factor Analysis (FA) and Multiple Linear Regression (MLR), the author identified that airport capacity, rates, and customs efficiency are the most significant factors in choosing a specific airport for cargo handling.

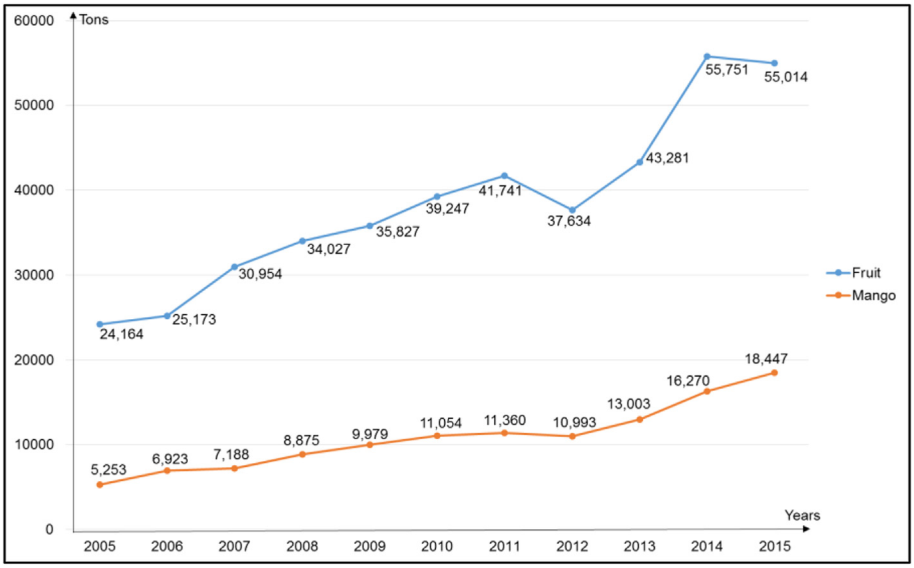

Fig. 1. Use of air transport in mango exports.
Source: MDIC (2016).

3. Methods

To achieve the proposed objectives of this study, it was limited the scope to export of Brazilian mango by air cargo transport. According to data from the Ministry of Industry, Foreign Trade and Services (MDIC) for the year 2015, fruit is the second most exported Brazilian product by air and the total exports of fruits, of which 33.5% are mangoes, is shown in Fig. 1 (MDIC, 2016).

In 2015, 18,000 tons of mango were exported by air. The São Francisco Valley contributed directly to the export of mango, with the region exporting 85% of all mangoes exported by Brazil. In this year, 4.87% of all mangoes exported by airplanes went to Europe, while 6.39% went to Africa, 6.31% to North America, and 2.43% to Asia, as shown in Fig. 2 (MDIC, 2016).

The main countries that received Brazilian mangoes by air in 2015 were Portugal with 45.81%, France with 13.15%, and the United Kingdom with 12.93%.

The state that uses air transportation for its exports most is Bahia, which was responsible for 58.72% of all exports of mango by air, followed by São Paulo with 32.15% and Pernambuco with 7.25% in 2015. Together, these three states were responsible for 98.12% of all exports of Brazilian mangoes by air for 2015.

Although Bahia is the state that exports the most amount of mangoes by air, the airport used most for exports is located in São Paulo. As

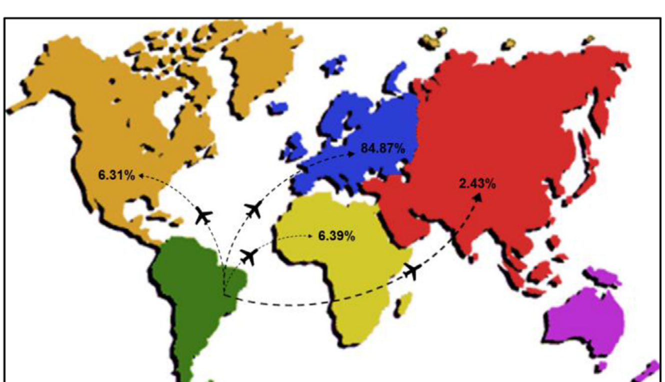

Fig. 2. International destinations of Brazilian mangoes by airplane.
Source: MDIC (2016).

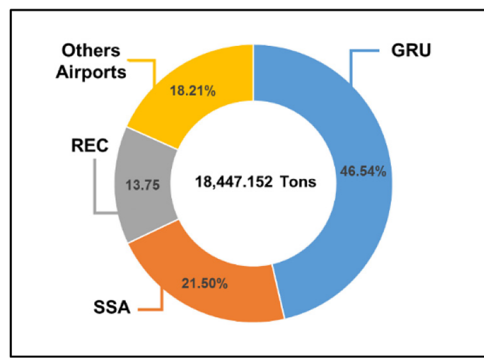

Fig. 3. Airport use for the export of mangoes.

shown in Fig. 3, GRU is the airport that is most often used for the export of mangoes.

Source: MDIC (2016).

It means, by Fig. 3, that 46.54% of all Brazilian mangoes are exported by air passed through GRU. SSA exported 21.50% of all mangoes, followed by REC which handled 13.75% of all mangos exported by air.

The next step is to define the methods used in this study. In the literature on airport choice, a predominant use of MCDM methods, mainly through logistic regressions, could be noted. However, a method used in transportation decisions is AHP, which has been used in decisions related to urban transport (Nosal and Solecka, 2014; Boujelbene and Derbel, 2015) and in the selection of third-party logistics (3PL) providers (Gürcan et al., 2016).

As the purpose of this research is not only to identify benchmarking indicators, but also to identify the decision weight that the user of air cargo transport assigns to the criteria, we decided to use AHP proposed by Saaty (1990) due to its adequateness when evaluating a transportation decision process from the user's perception. AHP is an analysis method of the decision-making process divided into hierarchical levels, facilitating its evaluation. A group of decision makers makes a comparison of each element with the aid of a verbal scale that is associated with a numerical scale (Saaty, 1990).

Usage of AHP for studies related to air transportation was identified in Rocha et al. (2016). The authors use this method for analyzing the operational performance of Brazilian airports. Furthermore, it was also

Table 2
Selection criteria of airports for cargo transportation.
Source: Author supplied.

Criteria	Acronyms	Indicators	Authors
COST	ARAT	Airport rates	Hess and Polak (2005); Loo (2008); Postorino and Praticò (2012); Chung and Han (2013); Adenigbo (2016); Jung and Yoo (2016).
	ACAT	Access cost to airport terminal	Hess and Polak (2005); Jung and Yoo (2016).
	AFRC	Air freight cost	Zhang and Zhang (2002); Chung and Han (2013).
TIME	COPT	Customs operation time	Adenigbo (2016).
	DIST	Distance between airport and product origin	Pels et al. (2003); Gardiner et al. (2005); Hess and Polak (2005); Loo (2008); Postorino (2010); Jung and Yoo (2016).
	AVFL	Availability of flights	Hess and Polak (2005); Loo (2008); Postorino and Praticò (2012); Chung and Han (2013); Jung and Yoo (2016).

possible to identify the use of AHP to evaluate the quality of service of air cargo carriers (Pandey, 2016), the safety risk of dangerous goods in air transport (Hsu et al., 2016), the competitiveness of airlines express air freight (Park et al., 2009), the competitiveness of airlines (Delbari et al., 2016), and the operational efficiency of airports (Lai et al., 2015). For Kubler et al. (2016), AHP is a method of MCDM that is applied often in studies, mainly due to its simplicity and flexibility. Through this method, one can perform evaluation, selection, and even identify the prioritization of the criteria used by decision makers, as is the case of Caetano and Amaral (2011) that used the AHP to define market, product, technologies and partners prioritization.

The first step of the method is to identify indicators related to the airport that can be used as choice criteria, and for this, a literature review was performed (Tranfield et al., 2003). After this, indicators related to the internal operation of the airport were selected, as well as external factors that can be used as airport choice criteria. Table 2 shows the selection criteria of airports for cargo transportation.

After defining of the indicators involved in the airport selection process, a peer evaluation of the indicators is performed, identifying the relevance between them. In order to carry out this evaluation, it was selected the Brazilian exporters of mango located in the region of the São Francisco Valley, which is responsible for 85% of the total Brazilian mango exports. Questionnaires were sent to the 38 producers and exporters located in the region and a total of 16 questionnaires were answered. Although apparently the sample with the sixteen observations could be considered small, it is noted that this quantity is sufficient to support the theories constructed from multiple cases analyzed. Classical authors from managerial literature, such as Yin (1994), in his case study protocol, already considers the validity of the use of only one case, combined with the theoretical framework, in the proposition of new theories. Also Eisenhardt (1989), Eisenhardt and Graebner (2007), when discussing the construction of theories from until six multiple cases, point out that representative cases on a given topic, as analyzed in this study, have already become relevant to the basis of discussions about the state of the practice combined with the state of the art in the theme. In this sense, it is reaffirmed the solidity in the use of the cases analyzed here.

From the closed questions as shown in Table 3, a comparison of dominance between the indicators is performed, in scales from 1 to 9, where 1 is when the two indicators contribute equally to the decision and 9 is when one element has absolute importance over the other in the decision weight.

After that, based on the AHP methodology (Saaty, 1990), a calculation of the vector of priority, consistency of the matrix and definition of the total weight of the indicators is performed. With the decision weights defined, it was performed a simulation of choice between airports from a linear regression.

4. Results

The indicators that were evaluated in regard to the airport choice are presented in a hierarchical structure of decision problems in Fig. 4.

According to Fig. 4, the cost criterion was divided into three indicators: airport rates (ARAT) that correspond to storage and handling costs, access cost to airport (ACAT) that is composed of freight by road from the point of origin to the airport, and air freight cost (AFRC) that is calculated between the airport of departure and the destination airport.

The time criterion was divided into three indicators: customs operation time (COPT) that represents the time spent with inspection and conference of the cargo by Federal Revenue and surveillance agencies, distance between airport and product origin (DIST), and availability of flights (AVFL) that correspond to the frequency and connectivity of flights from the airport.

After the definition of the selection criteria, the exporters of mango were evaluated based on the relevance of the time and cost criteria, which is shown in Table 4.

In order to finalize the evaluation and relevance of the criteria, the next step is to define the priority vector for each criterion. First, normalization is established based on the sum of all components of the column, right after each component is divided by its sum. Second, the priority vector is calculated by means of each indicator. Table 5 presents the respective priority vectors of the criteria.

It is not possible to calculate index consistency of the matrix because the Random Index (RI) for two variables is 0.00.

Based on the evaluation of exporters, it was possible to observe that the time criterion was more relevant (0.74) in relation to the cost criterion (0.26) in the process of airport choice for exporting fruit. The relevance of the time criterion regarding airport choice is also indicated in the studies of Loo (2008), Jung and Yoo (2016), as well as in the study of Alexander and Merkert (2017) that show that the cost is not as significant as the distance, directly related to the time, in the transportation decision. Although cost is a relevant criterion in making a choice (Hess and Polak, 2005), neither decision maker has indicated cost as the most relevant criterion. Yuen et al. (2017) shows that to dispatch Hong Kong air cargo has a higher cost of Shenzhen, but the authors note that the cargo volume at Shenzhen airport is only 15% of the volume of Hong Kong airport.

The next step was to perform evaluation between the indicators. The cost criterion was subdivided into three indicators: ARAT, ACAT, and AFRC. The evaluation of these indicators is presented in Table 6.

After the evaluation between indicators, the normalization of data was performed as well as the calculation of the priority vectors, which is presented in Table 7.

In the comparison between the indicators related to cost, AFRC was the indicator that carried the most decision weight. In identifying the priority vectors of each indicator, it is necessary to perform a Consistency Ratio (CR) calculation to verify the validity of the data. This calculation is initiated by the identification of the eigenvalues that are obtained through multiplication of priority vectors with assigned values for indicators. To find the eigenvalues of each indicator, it is necessary to add up the values for each line as shown in Table 8.

The CR must be less than 0.10 ($CR < 0.10$) for the comparison

Table 3
Sample question used in the survey.
Source: Author supplied.

Question	Choice Options	Assigned values
Regarding the factors: Cost and Time, which factor is more important and what its relevance to the other factor when deciding which airport to use in the exports of mangoes.	( ) Cost has an absolute relevance to Time	9
	( ) Cost has a very great relevance to Time.	7
	( ) Cost has great relevance to Time.	5
	( ) Cost has little relevance to Time.	3
	( ) Cost and Time have the same relevance.	1
	( ) Time has a small relevance to Cost.	1/3
	( ) Time has great relevance to Cost.	1/5
	( ) Time has a very great relevance to Cost.	1/7
	( ) Time has an absolute relevance to Cost.	1/9

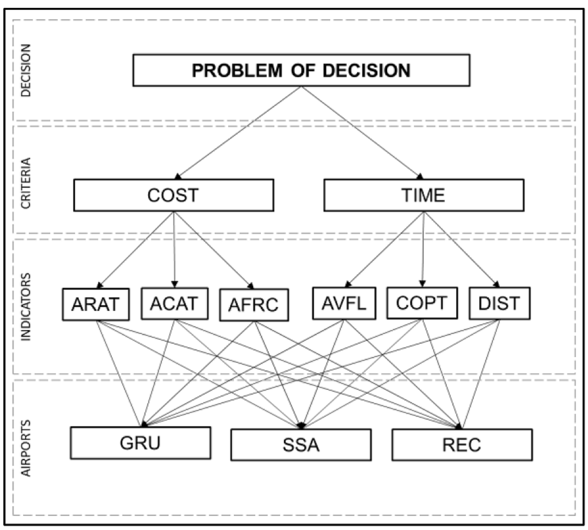

Fig. 4. Decision matrix of choice of the airport.
Source: Author supplied.

Table 4
Matrix of comparison between cost and time.
Source: Author supplied.

	TIME	COST
TIME	1.00	2.78
COST	0.36	1.00
Total:	1.36	3.78

Table 5
Vector priority of cost and time criteria.
Source: Author supplied.

	TIME	COST	Priority Vector
TIME	0.74	0.74	0.74
COST	0.26	0.26	0.26
Total:	1.00	1.00	1.00

matrix to be accepted. First, the maximum eigenvalue (λmax) is found by dividing the sum of the eigenvalue of all indicators with the number of indicators. After this, the Consistency Index (CI) is calculated through the following equation: $\frac{\lambda max - 1}{n - 1}$. Then, the established CI is divided with the Random Index (RI) of the number of variables involved in the matrix. According to Saaty (1990), the RI for three

Table 6
Matrix of comparison between cost indicators.
Source: Author supplied.

	ARAT	ACAT	AFRC
ARAT	1.00	1.67	0.30
ACAT	0.60	1.00	0.47
AFRC	3.32	2.14	1.00
Total:	4.92	4.81	1.77

Table 7
Priority vector of cost indicators.
Source: Author supplied.

	ARAT	ACAT	AFRC	Priority Vector
ARAT	0.20	0.35	0.17	0.24
ACAT	0.12	0.21	0.26	0.20
AFRC	0.67	0.45	0.57	0.56
Total:	1.00	1.00	1.00	1.00

Table 8
Eigenvalue of cost indicators.
Source: Author supplied.

	ARAT	ACAT	AFRC	Eigenvalues
ARAT	1.00 x 0.24	1.67 x 0.24	0.30 x 0.24	3.08
ACAT	0.60 x 0.20	1.00 x 0.20	0.47 x 0.20	3.05
AFRC	3.32 x 0.56	2.14 x 0.56	1.00 x 0.56	3.17

variables is 0.58. Equations (1)–(4) demonstrate the consistency calculations.

$$\text{Maximum Eigenvalue } (\lambda_{\max}) = \frac{\sum Eigenvalue}{n} = \frac{9.30}{3} = 3.10 \quad (1)$$

$$\text{Consistency Index (CI)} = \frac{\lambda max - 1}{n - 1} = \frac{3.10 - 3}{3 - 1} = \frac{0.10}{2} = 0.05 \quad (2)$$

$$\text{Random Index (RI)} = 0.58 \quad (3)$$

$$\text{Consistency Ratio (CR)} = \frac{CI}{RI} = \frac{0.05}{0.58} = 0.0862 \quad (4)$$

The CR of the matrix resulted in 0.0862 which is below of what was indicated by Saaty (1990). Thus, with a result of < 0.10, the matrix and its priority vectors are considered to be accepted as consistent and regular. The processes performed with indicators related to the cost criterion were also performed with the indicators related to the time criterion. The time criterion was subdivided into three indicators:

Table 9
Matrix of comparison between time indicators.
Source: Author supplied.

	COPT	DIST	AVFL
COPT	1.00	3.16	1.02
DIST	0.32	1.00	0.80
AVFL	0.98	1.25	1.00
Total:	2.30	5.41	2.82

Table 10
Priority vector of time indicators.
Source: Author supplied.

	COPT	DIST	AVFL	Priority Vector
COPT	0.44	0.58	0.36	0.46
DIST	0.14	0.18	0.28	0.20
AVFL	0.43	0.23	0.35	0.34
Total:	1.00	1.00	1.00	1.00

COPT, DIST, and AVFL. The evaluation of these factors is presented in Table 9.

The next step is to normalize the data as well as to calculate the priority vectors, which is presented in Table 10.

In the comparison between time indicators, COPT carried the most decision weight (0.46), which aligns with other studies that indicate that the time of the customs operations is a relevant criterion of airport choice (Zhang and Zhang, 2002; Adenigbo, 2016).

To verify the consistency of the data, CR calculation was performed from the eigenvalues presented in Table 11. Equations (5)–(8) demonstrate the consistency calculation.

$$\text{Maximum Eigenvalue } (\lambda_{\max}) = \frac{\sum Eigenvalue}{n} = \frac{9.27}{3} = 3.09 \quad (5)$$

$$\text{Consistency Index (CI)} = \frac{\lambda max - 1}{n - 1} = \frac{3.09 - 3}{3 - 1} = \frac{0.09}{2} = 0.045 \quad (6)$$

$$\text{Random Index (RI)} = 0.58 \quad (7)$$

$$\text{Consistency Ratio (CR)} = \frac{CI}{RI} = \frac{0.045}{0.58} = 0.0789 \quad (8)$$

The CR of the matrix of time indicators resulted in 0.0789, which is also below of what was indicated by Saaty (1990). With this result, the matrix and its priority vectors are also accepted.

Finally, the AHP allowed defining the global weight of the indicators related to the cost and time criteria, which helped identify the level of priority that exporters attribute to the criteria involved in the process of airport choice for exporting their products.

Table 12 presents the factors involved in airport selection as well as the global decision weight of each indicator.

It can be noted that the indicator that carried the most decision weight was customs operation time. According to the results, this indicator has a great impact on the decisions of exporters (0.34). The availability of flights carried the second largest weight in the decision (0.25), followed by the air freight cost (0.15), the distance between airport and product origin (0.15), and airport rates (0.06). Finally, the indicator that had the least impact was the access cost to airport (0.06).

Table 11
Eingenvalue of time indicators.
Source: Author supplied.

	COPT	DIST	AVFL	Eigenvalue
COPT	0.46	0.64	0.34	3.13
DIST	0.15	0.20	0.27	3.06
AVFL	0.45	0.25	0.34	3.09

Table 12
Global decision weight of indicators.
Source: Author supplied.

Indicators	Relative weight	Global weight	Position
ARAT	0.24	0.06	5°
ACAT	0.20	0.05	6°
AFRC	0.56	0.15	3°
COPT	0.46	0.34	1°
DIST	0.20	0.15	4°
AVFL	0.34	0.25	2°

A Pearson Correlation Test was performed to analyze the relationship between the criteria and decision indicators. It was found that there was a strong correlation (0.697) regarding the significance $p < 0.01$ between the evaluations performed by exporters on the relevance of the cost, customs operation time, and distance between airport and product origin. Thus, the greater the relevance that the exporter gives to the time criterion over the cost criterion, the greater is the weight assigned to customs operation time in relation to distance between exporter and airport. The efficiency of customs operations at the airport (weight = 0.34) is a strong decision factor for exporters even if this means having to transport the fruit over long distances (weight = 0.15), resulting in a higher cost of road transportation (weight = 0.05).

5. Simulation of airport choice and its impacts

Having defined the priority levels of the criteria and indicators, it is possible to identify the best alternative, taking into account the factors approached in this study. Thus, the process of airport choice was simulated based on the criteria assessed by exporters.

For this simulation, the main municipalities that export fruit by air were selected as the origin of mango and the European continent was selected as the fruits' destination. The selected airports are GRU in São Paulo, SSA in Bahia, and REC in Pernambuco.

Each airport shared information regarding the time necessary for customs operations, air rates, and average cost of air freight. For the average cost of road freight, which comprises the cost involved for gaining access to the airport, the Hortifruti Brazil worksheet, which is part of the Center for Advanced Studies in Applied Economics of Esalq/USP that conducts research on the costs of fruits, was used (CEPEA, 2016). In this hypothetical situation and for simulation purposes it was assumed that all airports have flights available for the final customer.

Based on these parameters, the best choice for each municipality was calculated. The results are presented in Table 13, which also shows the distance between municipalities and airports and the total time for these operations. Hereby, the total time is comprised of the time spent between municipality and airport and the time spent on the airport's customs operations.

The airport choice is defined by the highest value found in the calculation of choice through the weights assigned by exporters. In regard to the criteria "distance" and "time," the lower the value the better the alternative. Thus, the values highlighted in Table 13 correspond to the shortest distance between airport and exporter, the fastest option, and the value of the best alternative determined based on the calculation of weight of the criteria.

GRU was identified as the best option for all cities, but when analyzing the values of distance and total time spent, only the city of Livramento de Nossa Senhora/BA noted that it is advantageous to use this airport. Even though the distance between this municipality and GRU is greater than the distance to SSA and REC, the total time spent is lower in the case of GRU. According to Jung and Yoo (2016) as well as Loo (2008), air transport users are willing to pay more money if this ends up in a reduction of time.

Table 13
Comparison between distance, time, and best alternative.
Source: Author supplied.

LOCAL	DISTANCE (Km)			TOTAL TIME (h)			ALTERNATIVE		
	GRU	SSA	REC	GRU	SSA	REC	GRU	SSA	REC
Livramento de Nossa Senhora/BA	1492	**598**	1270	**21.8**	25.9	27.3	**0.43**	0.30	0.28
Juazeiro/BA	2171	**500**	717	30.0	24.7	**19.2**	**0.41**	0.29	0.30
Petrolina/PE	2176	**505**	712	31.0	24.9	**15.9**	**0.41**	0.29	0.30
Casa Nova/BA	2239	**568**	774	32.0	28.8	**19.7**	**0.41**	0.29	0.30
Belém de São Francisco/PE	2387	625	**481**	33.0	26.1	**16.2**	**0.41**	0.27	0.33
Mamanguape/PB	2851	941	**167**	39.0	30.3	**12.5**	**0.39**	0.22	**0.39**
Salvador/BA	2025	**23.9**	795	27.0	**18.5**	20.8	**0.39**	0.38	0.23

Table 14
Correlation between criteria and choices.
Source: Author supplied.

		DIST GRU	DIST SSA	DIST REC	TEM GRU	TEM SSA	TEMP REC	AHP GRU	AHP SSA	AHP REC
AHP	Correlation	−0.513	0.375	0.581	−0.404	0.424	0.488	1	−0.282	0.016
GRU	Significance	0.239	0.407	0.171	0.368	0.344	0.267		0.540	0.973
AHP	Correlation	−0.584	**−0.986**	0.557	−0.654	**−0.907**	0.526	−0.282	1	**−0.958**
SSA	Significance	0.169	**0.000**	0.194	0.111	**0.005**	0.225	0.540		**0.001**
AHP	Correlation	**0.768**	**0.926**	−0.751	0.809	**0.836**	−0.694	0.016	**−0.958**	1
REC	Significance	**0.044**	**0.003**	0.052	0.027	**0.019**	0.084	0.973	**0.001**	

Table 15
Choice of airport from cost and time criteria.
Source: Author supplied.

Location of Exporters	DISTANCE (GRU)	TIME (0.74)			COST (0.26)		
		GRU	SSA	REC	GRU	SSA	REC
São Paulo/SP	26.1	63.11	5.63	5.26	25.64	0.12	0.25
Mogi das Cruzes/SP	44.6	63.42	5.41	5.17	25.47	0.11	0.41
São Jose dos Campos/SP	71.2	62.63	5.82	5.55	25.23	0.11	0.66
Valinhos/SP	104	61.24	6.46	6.31	24.91	0.11	0.98
Campinas/SP	110	61.20	6.48	6.33	24.87	0.11	1.02
Mogi-mirim/SP	178	59.58	7.38	7.04	24.25	0.11	1.64
Avaré/SP	284	57.14	8.53	8.34	23.51	0.10	2.39
Monte Alto/SP	375	54.70	9.80	9.50	22.63	0.11	3.26
Belo Horizonte/MG	585	48.68	1.91	12.40	20.06	0.12	5.82
Urania/SP	612	51.31	11.61	11.08	21.09	0.10	4.81
Santa Maria de Jetibá/SP	949	38.96	17.91	17.13	17.06	0.13	8.81
Linhares/SP	1056	36.29	19.19	18.52	15.95	0.14	9.90
Sooretama/SP	1104	35.20	19.77	19.04	15.62	0.14	10.24
Jaíba/MG	1185	34.60	20.12	19.28	15.05	0.14	10.81
Livramento de N.Sra./BA	1492	27.99	23.62	22.38	11.87	0.18	13.95
Salvador/BA	2025	19.69	28.73	25.58	6.62	2.52	16.86
Juazeiro/BA	2171	19.58	23.75	30.67	6.43	0.12	19.46
Petrolina/PE	2176	17.61	21.94	34.45	6.38	0.11	19.50
Casa Nova/BA	2239	19.83	22.02	32.15	6.65	0.11	19.24
Belém de São Francisco/PE	2387	17.17	21.75	35.08	4.35	0.06	21.59
Mamanguape/PB	2851	13.65	17.58	42.77	1.44	0.01	24.55

Concerning the municipalities of Juazeiro/BA, Petrolina/PE, and Casa Nova/BA, the calculation indicated that the best option is GRU, the closest airport is SSA, and the airport that is most efficient in regard to time is REC. For the municipality of Belém de São Francisco/PE the nearest and most efficient airport is REC, but the calculation showed that GRU is the best option. The best options for Mamanguape/PB were GRU and REC, even though REC is closer and more efficient.

A poor prioritization of airport selection criteria can be noted since apparently GRU is not the most viable option concerning cost and time. Exporters communicated that time is more relevant than cost in choosing an airport. Although the time spent in GRU on customs operations is well below that of other airports, the time spent on transportation from exporter to cargo terminal makes this choice unfeasible.

For Pels et al. (2003) and Postorino (2010), the distance from the airport can be decisive when deciding for one airport. The greater the distance between exporter and terminal, the greater the cost associated with moving the freight by road, which leads to higher costs in the export chain of mangoes.

In order to understand the relationship between variables external to an airport and the choice indicated through the prioritization of criteria, a Pearson Correlation Test was performed as shown in Table 14.

It is noticeable that choosing SSA had a strong negative correlation (−0.986) and significance ($p < 0.01$) concerning the distance between exporter and airport. Furthermore, it showed a strong negative correlation (−0.907) and significance ($p < 0.01$) regarding the time spent at the airport until releasement of the merchandise for shipment. The decision to export using SSA is related to the proximity and total time spent. The lower these two factors, the greater the probability of choosing this airport.

Choosing REC showed strong positive correlations and a high significance level ($p < 0.05$) in regard to the distance of exporters to GRU (0.0768) and SSA (0.926), as well as regarding the total time spent at GRU (0.809) and SSA (0.836). Thus, choosing REC depends on external factors related to competing airports.

The preference for GRU did not show correlations with the evaluated factors. It is believed that the level of operational efficiency of the cargo terminal, such as the time spent on customs operations (Zhang and Zhang, 2002; Adenigbo, 2016), may represent a relevant factor in airport choice, especially when assessing the performance of the cargo terminal.

Apparently, the airport choice based on the global weight of indicators evaluated by exporters does not optimize the process and a poor prioritization of the indicators can be noted. In this sense, an analysis of the relationship between cost and time criteria was performed in order to optimize the airport choice. For this purpose, a linear regression analysis was performed using the method of least squares.

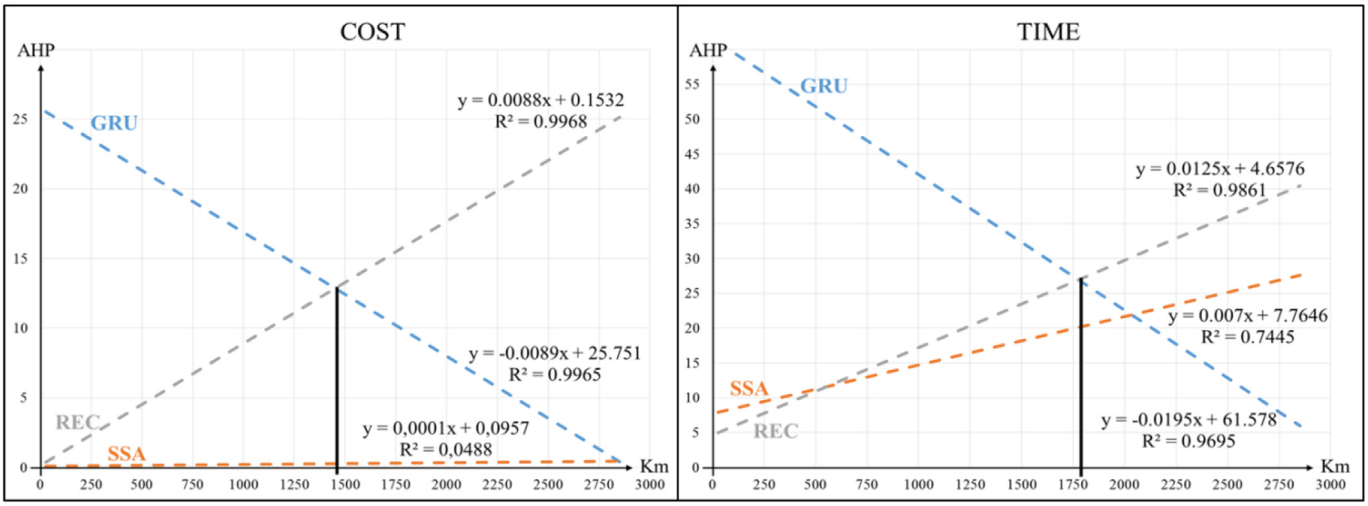

Fig. 5. Comparison between the criteria "cost" and "time of access to the airport".
Source: Author supplied.

As GRU was more efficient and, consequently, the best choice for the prioritization of time indicators, the distance between this terminal and the main exporters was defined as an independent variable since distance is directly related to time and cost. The dependent variables are access cost to airport and total time of access, including the time in transit and the time spent on customs operations.

The data was normalized on a scale from 0 to 1 and multiplied by the weight of the cost criterion (0.26) and time criterion (0.74), which is described in Table 15.

Table 15 shows that an increased distance between exporter and GRU results in a decreased likelihood of choosing this airport and consequently increases the values of other airports. Fig. 5 shows the best option in conjunction with the cost criterion and the time spent to ship the products from GRU, SSA, and REC airport.

Based on the linear regression calculation, the trend lines were generated with the corresponding equations. And, through equating, it was possible to obtain the critical points between cost and time.

The cost line for GRU ($y = -0.0089x + 25.751$) crosses the cost line for REC ($y = 0.0088x + 0.1532$) at the equality of $x = 1446.200$. That is, exporters who are in municipalities of up to 1446 km away from GRU should use this terminal for optimizing their costs. Once exporters are more than 1446 km away from GRU and, consequently closer to REC, the best option to optimize costs is to use REC.

However, upon analyzing the time criterion, it is noticeable that the GRU line ($y = -0.0195x + 61.578$) intersects with the REC line ($y = 0.0125x + 4.6576$) at the equality of $x = 1778.762$. Thus, exporters who are up to 1779 km away from GRU and want to optimize time should use this airport for exporting their products. Exporters using GRU will spend more time than when using the REC terminal.

In that sense, the time-optimizers would use GRU up to 1779 km, whereas cost-optimizers would use GRU at a shorter distance of 1446 km. The exporter located more than 1446 km away from GRU and prioritizes the time criterion can spend up to 23% more on freight by road. If an exporter is located more than 1779 km away from GRU, there is an infeasibility of both cost and time, unless the other airports do not have flights available. Thus, decision-makers should define airport selection criteria in order to avoid increased costs in the export chain of mangoes or to ensure that costs are offset by the value of the sale of the product on the international market.

6. Conclusion

Regarding the airport, it was identified that the time indicator of customs operations carries the major weight in choosing the cargo terminal. Furthermore, this indicator may be responsible for the choice of using an airport to export perishable products while disregarding external variables related to airport access, such as distance and freight cost. The results show that the greater the operational performance of the airport is, the greater is its scope, meaning that the distance between the locations of the exporter and transporter of air cargo becomes a factor of little relevance.

In relation to the decision makers, it was possible to identify that poor prioritization of airport selection criteria may result in loss of road freight, leading to increased costs of the export chain and directly affecting the competitiveness of the fruit in the external market. Moreover, it has been identified that if the exporter prioritizes time, this can result in an increase of up to 23% in the access cost to the airport.

It was noted that AHP is recommended to evaluate the decision involving questions of airport choice, however, this method is not recommended for evaluating many different criteria because the comparison matrix would be very extensive and respondents might not be willing to respond.

Although the respondents in this study present great representativeness in the mango export industry, the sampling was relatively small. For future studies, it is suggested to verify the priority of criteria with a larger sample. In addition, as well as the connectivity in the air freight industry is analyzed by Boonekamp and Burghouwt (2017), future studies could also consider the spatial distribution of these airports in the operational viability of air cargo transport. Other studies also can be conducted with the purpose of verifying the relation between cost and time in the decisions for choosing specific cargo airports for exporting nonperishable products.

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