Demand for air cargo and demand for virtual commerce goods in Brazil

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ABSTRACT

Some studies have reported that current demand for air cargo transport has largely derived from the demand for goods in B2C-type electronic commerce. Marketing experts consider that consumer income bracket, cost of goods, freight costs and other less tangible factors influence consumer decisions to purchase online. This study makes an econometric investigation as to whether determinants of e-commerce demand in Brazil can explain the behavior of the demand for air cargo transport services. The study sample period is 2000 to 2016. Unit root and co-integration tests were conducted prior to the regression analysis of the results obtained for the air transport services demand as well as tests for correlation among explanatory variables for the air cargo demand. The reported results make it possible to conclude that the determinants of e-commerce demand do explain the demand for air cargo transport services. It is important to underscore that studies designed to determine the dimensions of cargo aircraft fleets and airport cargo terminals installed at airports or in their vicinities must always take into account the demand for goods offered by B2C-type e-commerce in their analyses.

Keywords: E-commerce. Air cargo. Econometric study. Brazil.

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1. INTRODUCTION

Air cargo transport began in 1910 in the United States. In the following year, some American and European territories inaugurated the first air postal services and during the Second World War, they intensified considerably. The main cargoes were foodstuffs, water, tobacco, military uniforms, medicines and war material (KIBOI; KATUSE; MOSOTI, 2017).

After the Second World War, air transport mainly handled products with high specific value and small volume such as medicines, high-tech equipment, perishable goods – fruits, flowers, seafood – and others that required fast transportation and therefore could not be shipped for long distances by sea, road or rail.

Depending on the volume and weight of whatever is to be transported, regular passenger aircraft companies or companies working exclusively with cargoes transport air cargo. In the last decade transport researchers have emphasized that contemporary demand for air cargo transport services can be at least partly explained by the demand for goods in the field of e-commerce (KIBOI; KATUSE; MOSOTI, 2017; KISO; DELJANIN, 2009; KUPFER *et al.*, 2017).

E-commerce has expanded everywhere since 1995 when the Internet began to provide user-friendly interfaces. The launching of apps facilitating online shopping using computers stimulated another boom and the appearance of cell phone and smartphone apps created the current surge in activity.

It is now apparent that air cargo has lost its initial specific characteristic of being limited to goods or materials with high specific value because 50% of all the products purchased via internet are in the categories of clothing, toys and electronic appliances. Currently uncostly, lightweight products dominate international electronic commerce. Around 81% of the items weigh less than 2 kg, 45% less than 500 g and 36% cost less than 80 Brazilian reals (IATA, 2017).

Again, according to IATA (2017), every day more than 19 billion dollars-worth of goods are transported by air and that corresponds to one third of the total cargo transported worldwide. In Pacific Asia virtual commerce, perishable and pharmaceutical products have accounted for much of the freight transport in recent years (ICAO, 2018). E-commerce has

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brought new challenges as well as opportunities to the air cargo industry as a matter of fact
(LEUNG *et al*, 2000).

Experts in the business-to-customer (B2C) type of e-commerce consider that the
factors influencing customers' purchasing decisions regarding goods being retailed online
include the price of the goods, the delivery costs and some other aspects that are difficult to
measure, such as: convenience, security and speed (KOTLER *et al.*, 2010). The literature
reports that the purchase of goods irrespective of whether it is made in the traditional manner
or via e-commerce also depends on *per capita* income which, in turn, depends on the state of
the economy (KOTLER *et al.*, 2010).

Churchill and Peter (2000) establish theoretical criteria for the support of decision-
making regarding the transport modality for the delivery of purchased goods (Table 1). An
analysis of their criteria suggests that air transport best addresses the needs of those who set
priority on speed of delivery of the products they purchase.

Table 1 - Criteria for selecting cargo transport modality

Means of transport	Cost	Speed	Cargo Flexibility
Road	High	Fast	Moderate
Rail	Moderate	Moderate	High
Air	Very high	Very fast	Low
Sea	Very low	Very slow	Very high

Source: Table 15.3 from the book by Churchill and Peter (2000).

According to Kupfer *et al.* (2017), e-commerce has leveraged air cargo transport.
Regional air cargo companies have been created, cargo aircraft purchased and consequently
the installation of goods distribution centers in airports' areas of influence has proliferated all
over the world. In 2016, the International Air Transport Association (IATA) created an
internet-based platform to eliminate the need to present printed documents when embarking
air cargo; IATA (2017) considers the move will stimulate point-to-point air cargo transport
even further.

Against that background, the design of the present study sought to investigate whether
the determinants of goods demands in the B2C type e-commerce explain the performance of
demands for air cargo transport services. It is a different approach than that of the traditional,
primary demand model for air cargo transport services employed by researchers like Basak,
West and Narang (2013), Kasarda and Green (2005) and Kiboi, Katuse and Mosoti (2017).
The relevant explanatory variables in these empirical studies are: *per capita* GNP, GNP

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growth rate, interest rate and the price of aviation kerosene. The first two variables are expected to have a positive impact on air cargo demand and the last two, a negative one.

The empirical study investigated the respective Brazilian scenario. The sample period from 2000 to 2016 is admittedly a relatively short one. That restriction was due to the poor availability of data concerning air cargo transport services demand and, even more so, due to the fact that the consolidation of e-commerce in Brazil has only taken place in the course of the last two decades. The data concerning the annual amounts of cargo transported by air in tons was obtained from various editions of the statistical yearbook published by the Brazilian Civil Aviation Board (*Agência Nacional de Aviação Civil* - ANAC). Annual data on *per capita* income and freight values were obtained from the IPEADATA database. The monetary values used in the model correspond to those for the year 2016.

The layout of the paper is as follows. Section 2 presents an overview of e-commerce and of the air cargo transport services involved in that kind of transaction. Section 3 presents the theoretical model of air cargo demand to support the analysis and comments on the sources of the data for the variables involved in the model. Section 4 discusses the results obtained with the estimations of this model and lastly, section 5 sets out the research conclusions.

Before proceeding, it is important to point out that studies for dimensioning cargo aircraft fleets, terminals and air cargo warehouses in airports and their vicinities must necessarily take the demand for goods that exists in the B2C-type e-commerce into account in their analyses.

Studies of this type may be useful for a wide variety of transport and logistics operations and may be useful to assist in the establishment of economic-financial feasibility studies of airport concessions. Between 2012 and 2019, Brazil granted twenty-two airports from the busiest to the least busy (PEREIRA; ROCHA, 2019).

2. THEORETICAL FOUNDATION

2.1 E-commerce

The retail trade is an important channel for commercializing goods. There are two types of retail trade: the traditional, on-premises type – consisting of actual physical shops – and the off-premises or distance-selling modality typified by virtual shops.

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Distance retailing has been in existence for a long time. Formerly, customers would have a printed catalogue in hand and purchase the goods they selected from retailers in other cities or even in other countries. The retail shops offering off-premises sales usually made use of the postal services for the delivery of purchased goods.

Since 1993, as Torezani (2008) and Zwass (1996) have pointed out, the popularization of user-friendly internet and applicative has led to an intensification of distance retail selling. A historic milestone in that process was the emergence of *Amazon.com*, in 1995 in the United States.

Nuernberg (2010) reports that, at first, companies were the main users of electronic commerce which they used to make transactions by sending documents such as orders and invoices to other companies electronically.

From the year 2000 on e-commerce began to become consolidated. Various North American and European companies began to offer products and services in the worldwide computer network, effectively establishing what is known as e-commerce today (NUERNBERG, 2010). França and Siqueira (2003) point out that the applicative devised for use with cell phones have led to a new global wave of expansion of off-premises retailing.

While the international on-line sales market rapidly intensified and progressed, the Brazilian market took a long time to adhere to the new sales modality and the process was slow and gradual in the early years, possibly because of the late advent of lower computer prices and broad band internet availability in Brazil (TOREZANI, 2008).

Some of the bigger Brazilian companies that had previously only operated with chain stores also began to sell their products and services via the Internet. Outstanding among them were *Lojas Americanas, Gol* (airline), *Casas Bahia* and *Ponto Frio*. From then on the Brazilian e-commerce sector has returned highly expressive figures. In the period 2001 to 2016 its annual revenues grew at the rate of 34.1% a year according to data from Ebit (entity that guarantees security in electronic purchases).

The appearance of cargo transport companies equipped with powerful Information and Communication Technology helped to pave the way for Brazilian e-commerce's growth over the said period (SCHNEIDER; TEZZA, 2016). The postal services lost their exclusive role in the transportation and delivery of products to customers.

Another factor that contributed to stimulating e-commerce everywhere was the development of banking applicative connected directly to the "accounts receivable" of the

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electronic commerce companies. E-commerce stimulated the offer of banking products and, in doing so, contributed indirectly to generating employment and income. Such applicatives allow the e-commerce consumers to accompany the financial trajectory of their purchases practically instantaneously.

E-commerce has also developed mechanisms to enable the return of goods whenever the consumer rejects them for any reason. Customers can accompany the trajectory of the returned goods in the same way as they accompany the status of goods being delivered to them. Johnson *et al.* (2007) consider that those mechanisms are strategic ways of coopting consumers.

A considerable portion of the goods sold via e-commerce is transported by passenger aircraft or aircraft specifically dedicated to cargo transport. E-commerce has a positive impact on areas adjacent to airports by stimulating the installation of goods distribution centers, for example.

2.2 E-commerce advantages and disadvantages

One of the main reasons for e-commerce's success is the convenience it offers its customers insofar as they can make their purchases at anytime and anywhere, provided they have Internet access, so they do not have to waste time to acquire whatever they want to buy. Other attractive aspects are the security of online transactions and the possibility of purchasing from retailers in distant locations.

Guerreiro (2006) identifies other e-commerce advantages such as: (a) facilitating the product display; (b) establishing more agile seller-buyer relations, given that the stores are open for business at all hours and can be accessed from anywhere; (c) greater visibility for information to support decision making insofar as customers can make a rapid analysis of other retailers' offers; and (d) facilitating market analysis because of databases created based on consumers searches and purchases – the information helps retailers to design new strategies for their businesses.

Among the limitations or disadvantages are the impossibility of identifying the product in person, the non-immediate delivery of goods and the dependence on the existence of a reliable, efficient, distribution chain.

Guerreiro (2006) has identified other disadvantages associated to this kind of trading, especially security failures in the data made available for the transactions, which can lead to

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loss of confidentiality of information exchanged between suppliers and purchasers and, quite often, actually facilitate frauds. The same author warns about the fragility of client-company trust given the fact that the transaction takes place at a distance.

Nevertheless, despite all the uncertainties involved in this kind of retailing, e-commerce represents a veritable commercial revolution and together with the currently available technological innovations, it has made it possible for companies to obtain greater flexibility and efficiency in their operations by bringing suppliers and consumers closer together.

2.3 Demand for air cargo

The ability of consumer goods to meet human needs is known as utility. From its maximization it is possible to determine the demand function of individuals for goods and services given a budget constraint.

The demand function is an important tool in identifying what consumers would like to buy, depending on the price of the product, the prices of similar and complementary products, the levels of their incomes, and other factors.

Price is the fundamental piece of information that helps consumers allocate their resources to achieve the best uses (BAYE, 2008; PINDYCK; RUBINFELD, 2005). The price of freight is an important element to guide decisions for the purchase of virtual commerce products (IATA, 2018).

Chi and Baek (2012), Jiang *et al* (2003) and Wadud (2014) point out that income is also a key variable in determining the demand for passenger and cargo air transport services. For Kasarda and Green (2005) and Wang *et al* (1981) there is an established statistical relationship between transported air cargo and per capita income.

The classic demand function can be written like this:

$$D = f(Y,P) + \varepsilon \qquad (1)$$

Where *D* is demand, *Y* is income, *P* is the price of product or service and ε is a term that captures the effects on demand from other variables not included in the function argument.

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3. MATERIAL AND METHODS

The premise is that the demand for air cargo transport derives from the on-line demand for retailed goods. Accordingly, Equation (2) gives the theoretical model for the derivative demand for air cargo transport. The demand can be expected to grow if there is an increase in consumers' incomes and to decrease whenever prices of e-commerce goods rise and whenever freight charges for the delivery of e-commerce goods rise.

$$ACD = f(Y, P, F) \tag{2}$$

Where *ACD* is the air cargo demand, *Y* is the per capita income, *P* is the average price of e-commerce good and *F* is the average amount (B2C) e-commerce charges its customers for goods delivery.

Expressed in econometric terms, in linear-log or double-log form, Equation (1) becomes:

$$lnACD = \beta_0 + \beta_1 lnY + \beta_2 lnP + \beta_3 lnF + \varepsilon \tag{3}$$

With *ln* denoting a natural logarithm. The β_j parameters are obtained using the method of least squares (MLS). Supposing that the error term ε satisfies the usual MLS premises and is therefore capable of capturing the influence of other non-included variables, then it can be expected that parameter β_1 will have a positive value and that β_2 and β_3 will be negative. Parameter β_1 measures income elasticity, parameter β_2 price elasticity and β_3 freight charge elasticity of the air cargo demand.

The research contemplated a sample period of the years 2000 to 2016. Annual data referring to air cargo transported expressed in tons was taken from various editions of the statistical year books of the Brazilian Civil Aviation Board (ANAC). The data for annual *per capita* income and freight values were obtained from the IPEADATA database and prices were taken to be those operated in 2016.

Considering that the air cargo demand equation does not contain any metric for price or freight, and considering that according to Kotler *et al.* (2010), the e-commerce customer's decision regarding the amount he will have to pay for the goods in question usually considers the sum of the price of the goods and the freight charges, then the equation to be estimated took the following form:

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$$lnACD = \beta_0 + \beta_1 lnY + \beta_2 lnPF + \varepsilon \qquad (4)$$

The variable *PF* denotes the sum of the price of the e-commerce goods plus the freight charge for delivery ($PF = P + F$). Parameter β_2 is expected to be negative. The research took the Wholesale Price Index (*índice de preços no atacado*- IPA) as a proxy for the variable *PF* in Equation (4). The IPA (2016 = 100) was also taken from the IPEADATA database and it measures the evolution of prices in commerce as a whole (MUNHOZ, 1989).

Briefly stated, the intention was to obtain estimates for the parameters in Equation (3) with the best possible fit for the available data. The study tests the following hypotheses:

a) $H0_1$: *per capita* income has no significant effect on air cargo demand.

b) $H0_2$: the price of e-commerce goods and the freight charge for delivery have no significant effect on air cargo demand.

4. RESULTS

Prior to the analysis of the results obtained from the regression of Equation (4), the variables *ACD*, *Y* and *PF* were submitted to the unit-root and co-integrations tests as presented in the sub-items below. On the one hand it was found that the three variables are not stationary thereby jeopardizing the regression. On the other hand, however, they are co-integrated, making possible to execute the air cargo demand equation, Equation (4).

4.1. Unit-root test

Modern econometric analysis requires that prior to carrying out the estimation of any model with temporal series data, researchers should submit the variables involved to the unit root test in order to ascertain that the regression is not a spurious one (GUJARATI, 2006; WOOLDRIDGE, 2010). Alves, Alvarenga and Rocha (2011) and Fernandes, Alves and Oliveira (2014) used the same procedure in their research work involving air passenger transport.

The Dickey-Fuller unit root test is usually applied using the following equation:

$$\Delta X = \alpha_0 + \alpha_1 X_{-1} + \mu \qquad (5)$$

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Where X represents one of the variables from Equation (3), Δ is the first difference operator and μ is the error term. If the least squares estimator for α_1 is zero, then the X series is said to have a unit root. The critical values for this test were tabulated by David A. Dickey, using the Monte Carlo method, and they are presented in the lower part of table 8.5.2 of the book by Fuller hence the name Dickey-Fuller test (HARVEY, 1990, p. 81).

The results set out in table 2 show that the variables ACD, Y and PF all have unit root. The critical value of the Dickey-Fuller for n equals 25 is -3.0, for a significance level of 5% (the critical value becomes more negative as n values go down).

Table 2 - Results obtained using Equation (4), for n=16

Variável	a_1
$X = \ln ACD$	-0.26
	(-1.63)
	[0.45]
$X = \ln PF$	-0.11
	(-1.46)
	[0.53]
$X = \ln Y$	-0.52
	(-2.23)
	[0.20]

Source: Student's t-test statistics in ordinary brackets, P-values in square brackets.

Given that the variables of the model proved to be not stationary then, in principle, Equation (3) could not be executed unless they were shown to be co-integrated after applying the Engle-Granger test.

4.2. Engle-Granger test for co-integration

The Engle and Granger (1987) co-integration test takes the residues from the estimation of Equation (4), $\hat{U}$, to estimate Equation (6) and test whether $\hat{\rho}$ is statistically significant.

$$\Delta \widehat{U} = \hat{\rho}\widehat{U}_{-1} \tag{6}$$

It should be noted that the $\widehat{U}$ series was obtained based on the estimation of the regression equation in Table 4. Wooldridge's textbook (2010: p. 597) presents the critical value for the parameter, $\hat{\rho}$. Whenever $\hat{\rho}$ is significant, then the variables (in this case ACD, Y and F) are considered to be co-integrated.

The Equation (5) regression produced the following results:

$$\Delta \widehat{U} = -0.89\ \widehat{U}_{-1} \tag{7}$$

$$(-3.29)$$

The value in brackets associated to Equation (7) is the calculated value for the *t* statistic. The critical value for $\widehat{\rho}$ at a significance level of 10% (-3.04) is less negative than that calculated for the *t* statistic, thereby removing the problem of a possibly spurious regression and justifying the execution of the air cargo demand equation (GUJARATI, 2006; STEWART, 1991; WOOLDRIDGE, 2010).

4.3.   Analysis of the estimated model results

Table 3 presents the results of the regression of Equation (4) using the least squares criterion with the lag-independent variables (best estimates). The estimated coefficients make sense from the economic point of view and are statistically significant to the level of 5% and confirm the results of previous work (CHI; BAEK, 2012; WADUD, 2014; WANG *et al*, 1981).

If the *PF* variable were to increase 1% with the effect of *per capita* income being kept constant, there would be a drop in the demand for air cargo services of 0.11%. It should be noted that, as the model is a log-linear model, the β_2 coefficient expresses the elasticity-price-freight charges of the demand and in this case it shows that the demand is inelastic in regard to the price of the goods being traded and also to the freight charges for goods delivery.

As for the regression coefficient R^2 it can be seen that the model of the demand for air cargo transport services is a very reasonable fit with the data. The $F_{(2,13)}$ statistic calculated with 2 degrees of freedom for the numerator and 13 for the denominator confirms the existence of a regression. The *P*-value for the $F_{(2,13)}$ statistic is less than 1%.

From the Durbin-Watson (DW) statistic it is possible to conclude that the model does not suffer from first order, serial correlation ($1.54 < DW < 2.42$, with $n = 16$ and $k = 2$; k represents the number of explanatory variables). Furthermore, the calculated value for the Durbin-Watson statistic (1.76) corroborates the verification of the co-integration test because in most cases a spurious regression presents high R^2 and low DW (GRANGER; NEWBOLD, 1974).

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In Table 4, η represents Ramsey's RESET statistic used to test the functional form of the estimated equation whose distribution is an $F_{(1,12)}$. At a level of significance of 5%, the critical value for $F_{(1,12)}$ is 4.75; in any event, the regression results are statistically satisfactory.

Table 3 - Regression results obtained with n=16
$$(lnACD = b_0 + b_1 lnY_{-1} + b_2 lnPF_{-1})$$

b_0	b_1	b_2	$F_{(2,13)}$	R^2	DW	η
14.91	0.94	-0.11	22.56	0.78	1.76	1.35
(14.57)	(5.58)	(-2.15)				
[0.000]	[0.000]	[0.050]	[0.000]			

Source: Student's *t*-test statistics in ordinary brackets, *P*-values in square brackets.

4.4. Variance analysis

The results for the calculations of the $F_{(2,13)}$ statistics can readily be obtained using the Variance Analysis table –ANOVA; Table 4 is the ANOVA table corresponding to the air cargo demand.

Table 4 - ANOVA for air cargo demand (regression model of Table 3)

Variance source	Sum of the Squares	Degrees of Freedom	Mean Square value	$F_{(2,13)}$	P-Value
Regression	0.189513	2	0.0947567	22.5597	0.000
Residue	0.054603	13	0.0042002		
Total	0.244117	15	0.0162745		

Source: The authors.

4.5. Multicollinearity

Most of the independent variables of a multiple regression model are, to some extent, related to one another. Thus the term multicollinearity refers to the correlation among the independent variables of a multiple regression. One condition that is crucial for the application of the least squares method is that the model's explanatory variables should not be *perfectly* correlated (KOUTSOYIANNIS, 1988).

Statistics experts have developed tests to determine whether multicollinearity is sufficiently high to cause a problem; A practical rule is that multicollinearity is only potentially problematical if the absolute value of the coefficient of correlation between any two independent variables is over 70% (SWEENEY; WILLIAMS; ANDERSON, 2013).

The coefficient of correlation between *x* and *z*, two independent or explanatory variables is given by:

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$$r_{xz} = (sinal\ de\ b_1)\sqrt{R_{xz}^2} \tag{8}$$

The correlation coefficient for the two independent variables in Equation (4) was calculated as being -25.94%. Therefore, it can be concluded that the air cargo demand model does not suffer from multicollinearity (x = *per capita* income and z = the wholesale price index).

The results for the Glauber and Ferrar Chi-square statistic (χ^2 = 1.01) underscore the conclusion that the model's variables are not linearly dependent. The formula for the Glauber-Farrar Chi-square statistic is (KOUTSOYIANNIS, 1988: p. 244):

$$X^2 = -\left[n - 1 - \frac{1}{6}(2k + 5)\right]\ln D \tag{9}$$

Where χ^2 is the Glauber and Farrar Chi-square statistic, n is the sample size, k is the number of explanatory variables for the model, ln is the natural logarithm and D is the determinant for the sample's correlation coefficients matrix.

If the calculation of the Glauber and Farrar χ^2 statistic is greater than the critical χ^2 value, then, given the level of significance adopted, the model's variables are linearly related.

The data for calculating Equation (9) are:

**Table 5 - **Data for calculating Equation (8)

n	k	D	GL	α	χ2 calculated	χ2 critical
17	2	-0.06966	1	5%	1.01	3.84

GL are the degrees of freedom. GL = 1/2 x $k(k-1)$. α = level of significance.
Source: The authors.

4.6.   Sample size

It is common knowledge that sample size has a direct and considerable impact on the statistical power of the regression. A rule of thumb is that there should be at least five observations for each independent variable. The desirable level, however, for a model to be suitable for prediction is from 15 to 20 observations for each independent variable (HAIR *et al.*, 2005).

The sample size in this study did meet the minimum requirements but, nevertheless, it was relatively small and that jeopardized the model's power of prediction. In any event, the results of the regression are statistically satisfactory.

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5. CONCLUSION

This article makes an empirical investigation as to whether e-commerce demand determinants in Brazil explain the behavior of air cargo transport services demand. The study sample period was the years 2000 to 2016. The most important variables for determining air cargo demand were: *per capita* income and the sum of the prices of goods and the freight charges to deliver them. The study submitted the model's variables to unit root and co-integration tests prior to conducting an analysis of the regression results obtained for the air cargo demand.

Certain provisos must be made when interpreting results based on a temporal series that is relatively short (2000 to 2016). Nevertheless, the results reported here make it possible to conclude that the determinants of the primary e-commerce demand do explain the (derived) demand for air cargo transport services; the two null hypotheses tested were rejected. It is worth remembering that the starting point for studies designed to determine the dimensions of air cargo fleets and airport cargo terminals, for example, must always be the demand, and it is equally essential in economic and financial viability projects (WOILER; MATHIAS, 2013). The results referred to in this paper may, in some way, contribute towards the formulation of future demand studies. Finally, the overall results of this paper should prove useful to a wide variety of transportation and logistics operations.

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