

# THE LONG-RUN RELATIONSHIP BETWEEN ECONOMIC GROWTH AND PASSENGER AIR TRANSPORT IN FOUR SOUTH AMERICAN COUNTRIES

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## ABSTRACT

This paper analyzes the dynamic relationship between air transportation and economic growth in four South American countries: Argentina, Brazil, Chile and Uruguay. This work investigates these linkages without imposing a priori any parametric model to represent them.

A set of “free-model” tests (unit root test, cointegration and causality non-parametric tests) are applied to annual data of per capita GDP and number of air passengers for the period 1970-2015 to examine the existence of linear and nonlinear relationships between these variables. Real exchange rate is introduced in each country model in order take account for the price-effects. We test the existence of a cointegration relationship between these variables. In addition, an alternative causality test to identify the causality direction (unidirectional or bidirectional) between transportation activity and economic growth is introduced. This test allows us concluding for each country whether the development of transport sector improves economic growth, or if is the economic growth what gives impulse to air transport development, or, alternatively a bilateral influence takes place.

**Keywords:** *air transport and growth, nonlinear co-integration; non-parametric causality tests; MERCOSUR & Chile.*

**JEL codes:** C30; E43; L83

## 1. Introduction

Air transportation is a complex mixture of transport-related sectors and interest groups that operate regulate and interact with the aviation sector (Page, 2003). Likewise, this industry can play a role in economic development and in enhancing long-term economic growth (Chang and Chang, 2009) by generating employment, facilitating greater global travel, economic links and trade (ATAG, 2014). It provides greater opportunities for travel and tourism (53%

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of international tourist travel by air); it connects firms to larger potential sales markets (Smyth and Pierce, 2007) and contributing to capital goods that can be used in the production process (Van De Vijver et al., 2014). In summary, a sector that can help boosting a country's competitiveness. In particular, in peripheral areas, the development of air transportation could be considered as an important stimulus for promoting economic growth, reducing economic inequality (Yao and Yang, 2008). Air transport also has important multiplier effects, this means its overall contribution to global employment and GDP is much larger than its direct impact alone (ATAG, 2014).

On the other hand, it is assumed that as a region grows (in national and international economic activity), air transport demand increases (Goetz, 1992). Economic growth of a country can also lead on air transport expansion by developing airport infrastructures that give firms the opportunity to exchange goods over the world, fostering the growth of air cargo movements; therefore, enhancing business operations and productivity,

Within this frame, the analysis of these relationships, searching for the existence of causality between them, it has been of interest of few researchers (Green, 2007). The literature shows that these studies have emerged in the last years. Chang and Chang (2009) analyse the relationship between air cargo expansion (as a proxy of air transport) and economic growth in Taiwan under a Granger causal framework. Their results indicate that air cargo traffic and economic growths are co-integrated showing that in the short and in the long run there is a bi-directional causality. From a different geographic sphere, Fernandes and Rodrigues Pacheco (2010), and Marazzo et al. (2010) investigate the relationship between airport services (using passenger kilometer data as proxy of airport traffic) and economic growth (GDP as proxy) in Brazil. Both studies found a co-integration between the mentioned variables and the existence of a unidirectional equilibrium relationship.

From a regional perspective, Mikkala and Tervo (2012) analyse data from European regions finding bidirectional causality. Causality processes from regional growth to air traffic were more homogenous while the existence of causality from air traffic to regional growth was more evident in peripheral regions than in core regions. Likewise, Baker et al (2015) provide evidence that there is a short and long run causality between regional aviation and economic growth for the case of 88 regional Australian airports. Their results found a significant bidirectional relationship where passenger movements have an impact on regional economic growth and the economy directly impacts regional air transport.

On the other hand, Chi and Baek (2013) analyse both the short and long run relationships between economic growth and air transport (representing by air passenger and cargo movements) using the ARDL dynamic model (autoregressive distributed lag) for the case of US. Authors also examine how some external shocks have effects on airport business. Main

results indicate that in the long run, air passenger and cargo business tends to increase with economic growth. On the contrary, in the short run, air passengers movements are negatively affected by some external shocks (SARS epidemic and 9/11 event), however, these shocks have little effect on cargo demand.

In turn, the findings in Chi (2014) support a strong relationship between economic growth and demand for international air travel. Long-run results demonstrate foreign GDP as the major determinant of demand for inbound travel to the US and US GDP is a crucial factor affecting demand for outbound travel from the US; on the other hand, in the short-run, economic growth tends to be a primary factor influencing international travel flows to and from the US

Hu et al., (2015) examine 29 provinces in China from 2006-2012. Main conclusions show evidence of a long-run equilibrium relationship between economic growth and domestic air passenger traffic. They also found a long-run bidirectional Granger causal relationship between the two variables.

In a recent work, Rodríguez-Brindis et al (2015) analyze the effects in the long-run between air transport demand (using air passenger as proxy) and economic growth (GDP) in Chile for the period 1986-2014, finding that the causality relationship is positive and bidirectional from GDP to air passengers and vice versa.

It is the aim of this study to introduce an alternative methodology in order to analyze the dynamic relationship between air transportation and economic growth in four South American countries: Argentina, Brazil, Chile and Uruguay. In particular, a set of “free-model” tests) are applied to annual data of per capita GDP and number of air passengers for the period 1970-2015 to examine the existence of linear and nonlinear relationships between these variables. The methodology proposed allow us concluding for each country to what extent air transport enhances economic growth, vice versa, or whether they boost each other.

## **1. Methodological framework**

The present paper follows the procedure described in Breitung (2001), Holmes and Hutton (1990) and Ye Lim et al (2011) for testing and estimating the relationship between air transport activity and growth. The procedure suggested is: (i) apply non parametric unit root test (ii) testing the existence of cointegration by using nonparametric tests (iii) testing linearity and finally (vi) performing the rank-causality test. In what follows a quick reference of these tests are presented.

### Nonparametric Unit Root Test

Breitung (2002) constructs a statistic test that does not require the specification of the short run dynamic; such approach is called “model free” or “nonparametric” because the asymptotic properties of the test do not depend on the short run dynamics or the nuisance parameters. Then, the test is robust against a possible misspecification. Following Davison (2002), Breitung employs a definition of integration that is not restricted to a specific time series model.

A time series  $y_t$  is integrated of order one (I(1)) if, as  $T \rightarrow \infty$ ,

$$T^{-1/2} y_{[aT]} \xrightarrow{T \rightarrow \infty} \sigma W(a) \quad (1)$$

where the symbol  $\xrightarrow{T \rightarrow \infty}$  means weak convergence with respect to the associated probability measure,  $\sigma > 0$  is a constant,  $[ \cdot ]$  represents the integer part, and  $W(a)$  is a Brownian motion defined on  $C[0,1]$ .

Breitung (2002) proposes the variance ratio statistic to test the null hypothesis that  $y_t$  is I(1) against the alternative hypothesis  $y_t$  is I(0). Critical values are available in Breitung (2002).

The  $Q_T$  is the variance ratio of the partial sums and the original series, and variance ratio statistic is defined as:

$$\widehat{Q}_T = \frac{T^{-1} \sum_{t=1}^T \widehat{U}_t^2}{\sum_{t=1}^T \widehat{u}_t^2} \quad (2)$$

where  $\widehat{U}_t = \widehat{u}_1 + \dots + \widehat{u}_t$  and  $\widehat{u}_t = y_t - \widehat{\delta}' z_t$  are the ordinary least square (OLS) residuals from the regression of the data  $y_t$  on (i)  $z_t = 0$ , let  $\widehat{u} = y_t$ , with no deterministic term, (ii)  $z_t = 1$ , with an intercept, or (iii)  $z_t = (1, t)'$ , with an intercept and linear trend, respectively. The variance ratio statistic is a left tailed test, where the hypothesis of a unit root process is rejected if the test statistic value is smaller than the respective critical value.

### Rank test for cointegration

Breitung (2001) introduces a nonparametric test procedure based on ranks to test the hypothesis of a cointegration relationship (linear or not) and to identify whether this link is nonlinear. The idea of that residual based cointegration test (the rank test) is that the sequences of the ranked series tend to diverge if there is no cointegration between the variables. Breitung rank test checks whether the ranked series move together over time towards a linear or nonlinear long-term cointegrating equilibrium. The procedure starts checking the cointegration by using the rank test. If cointegration is accepted, the technique follows with examining linearity in the cointegration relationship, by using a scoring test.

Let  $f(x_t) \sim I(1)$  and  $g(y_t) \sim I(1)$  nonlinear increasing functions of  $x_t$  and  $y_t$ , and  $\mu_t \sim I(0)$ . Let suppose that a nonlinear cointegration relationship between  $x_t$  and  $y_t$  is given by

$$\mu_t = g(y_t) - f(x_t) \quad (3)$$

The rank statistic is constructed by replacing  $f(x_t)$  and  $g(y_t)$  by the ranked series

$$R_T[f(x_t)] = R_T(x_t) \quad (4)$$

and

$$R_T[g(y_t)] = R_T(y_t) \quad (5)$$

Given that the sequence of ranks is invariant under monotonic transformations of the variables, if  $x_t$  or  $y_t$  are random walk process then  $R_T[f(x_t)]$  and  $R_T[g(y_t)]$  behaves like the ranked random walks as  $R_T(x_t)$  and  $R_T(y_t)$ . The rank test procedure is based on two “distance measures” between the sequences of  $R_T(x_t)$  and  $R_T(y_t)$ .

The cointegration test is based on the difference between the sequences on the ranks can be detected by the bivariate statistics  $K_T^*$ : and  $\xi_T^*$ :

$$K_T^* = T^{-1} \max_t |d_t| / \hat{\sigma}_{\Delta d} \quad (6)$$

$$\xi_T^* = T^{-3} \sum_{t=1}^T d_t^2 / \hat{\sigma}_{\Delta d}^2, \quad (7)$$

where

$$d_t = R_T(y_t) - R_T(x_t), \quad (8)$$

for  $R_T(y_t) = \text{Rank} [\text{of } y_t \text{ among } y_1, \dots, y_T]$  and  $R_T(x_t) = \text{Rank} [\text{of } x_t \text{ among } x_1, \dots, x_T]$ .

The  $\max_t |d_t|$  is the maximum value of  $|d_t|$  over  $t=1, 2, \dots, T$  and

$$\hat{\sigma}_{\Delta d}^2 = T^{-2} \sum_{t=2}^T (d_t - d_{t-1})^2 \quad (9)$$

adjust for possible correlation between the series of interest.

#### Rank test for neglected nonlinearity

If cointegration exists in the first step, then we proceed to examine the linearity of the cointegration relationship.

For a convenient representation of the alternative and null hypothesis Breitung (2002) follows Granger (1995) and represents the nonlinear relationship as:

$$y_t = \gamma_0 + \gamma_1 x_t + f^*(x_t) + u_t, \quad (10)$$

where  $\gamma_0 + \gamma_1 x_t$  is the linear part of the relationship. Only when  $f^*(x_t) = 0$  there is a linear relationship between the variables. In this test the multiple of the rank transformation is used instead of  $f^*(x_t)$ .

If it is assumed that  $x_t$  is exogenous and  $u_t$  is a white noise with  $u_t \sim N(0, \sigma^2)$  a *score test* is obtained as the  $T \cdot R^2$  statistic of the MCO:

$$u_t \sim c_0 + c_1 x_t + c_2 R_t(x_t) + e_t. \quad (11)$$

Breitung (2001) generalizes the score test for the ECM representation and apply it to contrast the null hypothesis of linear cointegration against the alternative hypothesis of nonlinear cointegration.

To compute the score statistic, the following two multiple regressions are run consecutively:

$$y_t = \alpha_0 + \sum_{i=1}^p \alpha_{1i} y_{t-i} + \alpha_2 x_t + \sum_{i=-p}^p \alpha_{3i} \Delta x_{t-i} + u_t \quad (12)$$

$$\tilde{u}_t = \beta_0 + \sum_{i=1}^p \beta_{1i} y_{t-i} + \beta_2 x_t + \sum_{i=-p}^p \beta_{3i} \Delta x_{t-i} + \theta_1 R_T(x_t) + \tilde{v}_t, \quad (13)$$

where  $\beta_0 + \sum_{i=1}^p \beta_{1i} y_{t-i} + \beta_2 x_t + \sum_{i=-p}^p \beta_{3i} \Delta x_{t-i}$  is the linear part of the relationship and it involves the ranked series  $R_T(x_{jt})$ .

Under the null hypothesis, it is assumed that the coefficients for the ranked series are equal to zero,  $\theta_1 = 0$ . The appropriate value of  $p$  is selected based on Akaike Information Criterion, such that serial correlation  $\tilde{u}_t$  and possible endogeneity are adjusted based on Stock and Watson (1993). The *score statistic*  $T \cdot R^2$ , is distributed asymptotically as a  $\chi^2$  distribution, where  $T$  is the number of observations and  $R^2$  is the coefficient of determination of the second equation. The null hypothesis may be rejected in favor of nonlinear relationship if the score statistic value exceeds the  $\chi^2$  critical values with one degree of freedom<sup>5</sup>.

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<sup>5</sup>We consider 2 degree of freedom because the score test is applied using 2 variables.

### Causality Rank Test

To examine the casual linkage, conventional Granger causality test uses Vector Autoregression (VAR) or Vector Error Correction Model (VECM). However, results from the conventional parametric tests are limited by the augmenting hypothesis of the specific functional forms of the variables and the assumptions of homoscedasticity and normality of the error terms. As pointed by Ye Lim et al (2011), violation of these conditions can cause spurious causality conclusions. If one of these conditions is violated, Holmes and Hutton (1990) multiple rank F-test is more robust than the standard Granger causality test. Moreover, if the conditions of Granger estimations are satisfied, the multiple rank F-test results are alike the Granger results.

Holmes and Hutton (1990) analyzed the small sample properties of the multiple rank F-test, showing that with non-normal error distributions the test has significant power advantages both in small and in large sample. This is also true for weak and strong relationships between the variables.

The Holmes and Hutton (1990) multiple rank F-test is based on rank ordering of each variable. In this test, the causal relationship between  $y_t$  and  $x_t$  involves a test of a subset of  $q$  coefficients in the Autoregressive Distributed Lag (ARDL) model. The multiple rank F-test in ARDL (p,q) model can be written in the following framework:

$$R(y_t) = a_0 + \sum_{i=1}^p a_{1i}R(y_{t-i}) + \sum_{i=1}^q a_{2i}R(x_{t-i}) + e_t \quad (14)$$

$$R(x_t) = b_0 + \sum_{i=1}^p b_{1i}R(x_{t-i}) + \sum_{i=1}^q b_{2i}R(y_{t-i}) + \varepsilon_t \quad (15)$$

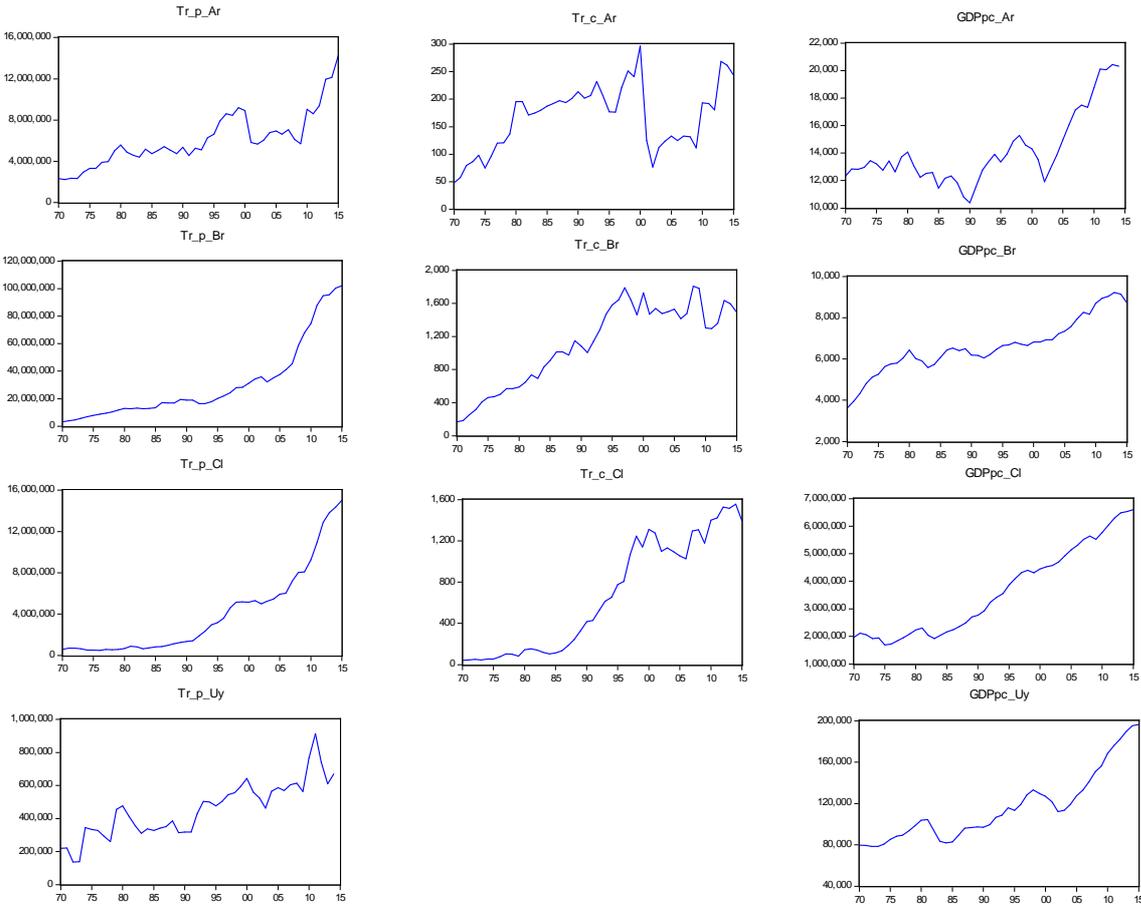
where  $R(\cdot)$  represents a rank order transformation and, each lagged values of the series in each model are treated as separate variables when calculating their ranks, for example,  $R(Y_t)$  and  $R(Y_{t-1})$ . The residuals,  $e_t$  and  $\varepsilon_t$  are assumed to be serially uncorrelated. The values of  $p$  and  $q$  may differ in each equation. When choosing  $p$  and  $q$ , two things have to be considered: the significance of the estimated coefficients and the serial correlation of resulting residuals. From the first equation, rejection of the null hypothesis ( $a_{2i} = 0$ ) implies causality from X to Y; whereas in the second one, rejection of the null hypothesis ( $a_{2i} = 0$ ) implies the reverse causality from Y to X. The null hypothesis is rejected if the F-test statistic is significant with respective  $q$ 's value and N-K ( $K=p+q+1$ ) degrees of freedom.

### **3. Data**

Data used in this study are time series of annual data, ranging from the first quarter of 1970 through 2015. To represent air transport, two different variables have been used: air

passengers and air cargo (except for Uruguay due to non-availability of cargo data). The other variables used in the model are per capita GDP and real exchange rate.

Source of these variables is World Bank for all the country. Real exchange rate indicators (with respect to US) were constructed on the base of domestic prices and exchange rates of each country (on the source of statistical institutions and central banks) and international inflation (US cpi, from US Bureau of Labor Statistics). For the empirical analysis variables in their logarithmic transformation are used. Figure 1 shows the set of main series (in logs) for each country.



**Figure 1 - Passenger transportation (tr\_p), Cargo transportation (tr\_c), GDP per capita (GDPpc)**

Source: Wold Bank data, BCB, BCRA. BCU, INE, BCChile, INE, INDEC. IBGE.

**4. Preliminary Results**

The empirical exercise aims to apply both integration and cointegration tests proposed by Breitung (2002 and 2001) to analyze the existence of non-linear relationship in the long run between real GDP and Number of passengers traveling by air and Cargo transportation for Argentina, Brazil, Chile and Uruguay.

In the first step, the order of integration of the levels and differenced series is analyzed by applying the non-parametric unit root test proposed by Breitung (2002) to the series. The variance ratio statistic is employed to test the null hypothesis that  $y_t$  is  $I(1)$  against the alternative  $y_t$  is  $I(0)$ . This is a left tailed test which indicates rejection for small values of the test statistic. The results indicate that all the variables (the levels and their logarithmic transformation) are integrated of order 1 (see Table 1).

**Table 1 - Results of nonparametric Unit Root Test**

<b>Argentina</b>			
<b>Variable</b>	<b>Test spec.</b>	<b><math>\hat{Q}_T</math> Statistic</b>	<b>Res.</b>
GDP_pc_ar	constant, trend	0.017**	I(1)
Tr_p_ar	constant, trend	0.0039**	I(1)
Tr_c_ar	constant, trend	0.010**	I(1)
Rer_ar	constant, trend	0.007**	I(1)
<b>Brazil</b>			
<b>Variable</b>	<b>Test spec.</b>	<b><math>\hat{Q}_T</math> Statistic</b>	<b>Res.</b>
GDP_pc_br	constant, trend	0.0099**	I(1)
Tr_p_br	constant, trend	0.019**	I(1)
Tr_c_br	constant, trend	0.016**	I(1)
Rer_br	constant, trend	0.0088**	I(1)
<b>Chile</b>			
<b>Variable</b>	<b>Test spec.</b>	<b><math>\hat{Q}_T</math> Statistic</b>	<b>Res.</b>
GDP_pc_cl	constant, trend	0.0182**	I(1)
Tr_p_cl	constant, trend	0.019**	I(1)
TR_c_cl	constant, trend	0.009**	I(1)
Rer_cl	constant, trend	0.012**	I(1)
<b>Uruguay</b>			
<b>Variable</b>	<b>Test spec.</b>	<b><math>\hat{Q}_T</math> Statistic</b>	<b>Res.</b>
GDP_pc_uy	constant, trend	0.014448 **	I(1)
Tr_p_uy	constant, trend	0.00264 ***	I(1)
Tr_c_uy	constant, trend	0.0044**	I(1)
Rer_uy	constant, trend	0.00724 **	I(1)

Note 1: \*, \*\* and \*\*\* denote significance at 10%, 5%, 1%.

Note 2: Breitung (2002) Critical value (10%) 0.00436, (5%) 0.00342, (1%) 0.00214

To investigate the existence of a cointegration relationship between air transport and economic growth, without assuming the hypothesis of linearity of the underlying model, we applied the methodology proposed in Breitung (2001). The author stated that when theory does not provide a precise specification of the functional form is desirable to have

nonparametric tools for estimation and inference and proposes a rank test for detect cointegration. Table 2 resumes the empirical results.

**Table 2 - Results of nonparametric cointegration test and linearity test**

	[GDPpc, tr_p, rer]		[GDPpc, tr_c, rer]	
	Test Statistics		Test Statistics	
	$\Xi_T^2[1]$	$T \cdot R^2$	$\Xi_T^2[1]$	$T \cdot R^2$
Argentina	0.0472	2.4541	0.0472	2.4541
Brazil	0.0211	2.9243	0.0217	2.9149
Chile	0.0140**	18.2342***	0.0336	4.4093
Uruguay	0.0151**	27.8148***	0.0319	9.0999
Significance Level	Critical values		Critical values	
10%	0.0197	4.6052	0.0197	4.6052
5%	0.0165	5.9915	0.0165	5.9915
1%	0.0119	9.2104	0.0119	9.2104

Notes: The hypothesis of no cointegration is rejected if the rank statistic,  $\Xi_T^2[1]$ , is below the respective critical value and the hypothesis of linearity is rejected if the score statistic,  $T \cdot R^2$ , exceeds the  $\chi^2$  critical values with two degree of freedom. \*, \*\* and \*\*\* denote significance at 10%, 5%, 1%.

Additionally and following Brida et al. (2015b), causality between both variables can be tested by applying the rank test proposed by Holmes and Hutton (1990). As explained before, this test is more robust than conventional parametric tests usually applied. Results are shown in Table 3.

**Table 3 - Causality test (H-H)**

H-H causality test	Argentina			Brazil			Chile			Uruguay		
	df	Pr.	NC	df	Pr.	NC	df	Pr.	NC	df	Pr.	NC
d(tr_p)-->d(GDPpc)	(4, 27)	0.707	A	(4, 28)	0.346	A	(4, 28)	0.313	A	(4, 28)	0.307	A
d(GDPpc)-->d(tr_p)	(4, 28)	0.998	A	(4, 28)	0.213	A	(4, 28)	0.029	R (5%)	(4, 27)	0.601	A
d(tr_c)-->d(GDPpc)	(4, 27)	0.037	R (5%)	(4, 28)	0.437	A	(4, 28)	0.149	A	--	--	--
d(GDPpc)-->d(tr_c)	(4, 28)	0.625	A	(4, 28)	0.887	A	(4, 28)	0.217	A	--	--	--
tr_p-->GDPpc	--	--	--	--	--	--	(4, 29)	0.062	R (10%)	(4, 29)	0.027	R (5%)
GDPpc-->tr_p	--	--	--	--	--	--	(4, 29)	0.000	R (1%)	(4, 28)	0.008	R (1%)

Notes: F-statistic,df (degree freedom), NC: H<sub>0</sub>: non causality.

The empirical results show that, when air transport is represented by air cargo, no long run relationship can be obtained for any of the countries. On the other hand, when the number of air passengers is used, in the case of Uruguay and Chile the cointegration relationship can be obtained, but the opposite is found for Argentina and Brazil.

The test of linearity shows that the non-linear relationship is non rejected for the Uruguay and Chile cases.

When short run is considered, the results show that, for the case of Argentina there is unidirectional causal relationship from air cargo to economic growth. In turn, for Chile and Uruguay, a bidirectional relationship is found when air passengers are used. Finally, for the case of Brazil, there is no any short run relationship

## **5. Conclusions**

The present article proposes a new approach to examine analyzes the dynamic relationship between air transportation and economic growth in four South American countries (Argentina, Brazil, Chile and Uruguay), by means of a non-linear methodology. We use annual series for the period 1970 to 2015, which allows us to perform a comparative analysis. Applying this new approach enable to contrast these new results with those obtained by the classic linear methodology. Previous papers (for instance, Sousa et al., 2015) show the possibility that the relationship between transport (by total CO<sub>2</sub> emissions) and growth is nonlinear.

Dissimilarities between the analyzed countries in terms of economic growth and development of air transport encouraged this new approach based on a nonlinear analysis. Following Ye-Lim et al. (2011) methodology, the hypothesis is tested by means nonparametric tests.

The non-parametric cointegration tests show that there is a cointegration relationship between economic growth and air transport only for Uruguay and Chile and when air transport is represented by the number of air passengers. However, linearity was rejected for both countries, which means that in these cases the relationship between air transport and growth may show some kind of asymmetry or non-linear behavior (e.g. since a certain point of development of air transport sector, the impact on the economy is significantly lower than in earliest stages). In addition, the non-parametric cointegration tests show that when air transport is represented by air cargo, no long run relationship can be obtained for any of the countries. Furthermore, the nonparametric causality tests, confirm biidirectional causality from air transport to growth for the cases of Uruguay and Chile.

Further analysis should be conducted to investigate the plausibility of nonlinearity in the dynamic relationship between air transportation and economic growth. One possible line for further research is to consider nonlinearities associated with the degree of development of each country as far as air transport is concerned. Such nonlinearities can be studied even within a time series approach, applying the methodological framework of threshold family models (TAR, STAR, LSTAR and ESTAR models).

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