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Gravitational force exerted by Brazilian tourist destinations on foreign air travelers

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ABSTRACT

This article analyses the context of international tourist flows by air and tourism in Brazil, by applying the principles of the gravity model. The study includes 13 Brazilian international airports that served 108 origin-destination pairs, which accounted for 80.14% of the total tourist flows by air in 2012. In the statistical analysis applied, the dependent variable *Ft* is the tourist flow between the country of origin and the Brazilian state of destination. To approximate an explanatory equation, we formulated a linear function that was able to support, in 31.7% of the cases, the dependence of the international tourist flows with the variables considered in the linear regression performed. The conclusion is that the assumptions considered in this study only partially explain the gravitational force exerted by Brazilian tourist destinations, so there is a need to refine the model by including other variables that can influence the flows by air of international tourists.

1. Introduction

Availability of transports is a key element for the development of tourist destinations (Heraty, 1989; Prideaux, 2000; Bieger and Wittmer, 2006; Dieken and Button, 2011; Lohmann et al., 2013), and is included in the broad universe of tourist mobilities (Allis, 2013), helping to determine the geographic flow of tourists (Page, 2008). Interdisciplinary and multidisciplinary studies that bring together transport engineering and other disciplines like economics and geography, among others, are important to advance knowledge about tourism.

Brazil is the largest country by area and population in South America and is politically divided at the local level into 5570 municipalities[1] (IBGE, 2014), located in 27 "federative units" (26 states plus the Distrito Federal, containing the capital, Brasília, treated as a state here). These are arranged in five geographic regions (South, Southeast, Midwest, Northeast and North). Of these municipalities, 3345 are part of the process of regionalisation of tourism (Brasil, 2013a). While a process of municipalisation of tourism occurred in the 1990s under the National Program for Municipalisation of Tourism (PNMT), the regionalisation process began in 2003 with the Program for Regionalisation of Tourism (PRT), tied to the National Tourism Plan 2003–2007 (Brasil, 2003). This plan has been successively updated for the period 2007–2010 (Brasil, 2007) and the current one, 2013–2016 (Brasil, 2013a). Brazil has long been a major tourist destination in the global context, and this position has increased in recent years, both due to the holding of mega-events (2014 World Cup and the upcoming 2016 Olympic Games) and efforts under these plans to enhance the attractiveness of tourist destinations. According to the official statistics of the Ministry of Tourism, in 2012 the country received 5,676,843 foreign tourists, of whom 77.23%, arrived by air (Brasil, 2013b). Therefore, air transport plays a crucial role for the competitiveness of this activity in the context of the strategy to regionalise tourism in the country. According to the *Anuário Estatístico de Turismo* ("Tourism Statistical Yearbook") for 2013 (Brasil, 2013b), in 2012 there were 13 airports that received international traffic flows, located in 12 states (Amazonas, Bahia, Ceará, Minas Gerais, Pará, Paraná, Pernambuco, Rio Grande do Norte, Rio Grande do Sul, Rio de Janeiro, Santa Catarina and São Paulo) and the Distrito Federal.

The process of regionalisation marked its tenth anniversary in

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[1] The municipality is the local administrative unit in Brazil. It is akin to a county, except with a single mayor and municipal council. Municipalities range from lightly populated rural ones with one or two small towns to heavily populated urban ones that are part of greater metropolitan regions. There are no unincorporated areas in Brazil.

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2013, so with more than a decade now concluded, it is worthwhile analysing the results. Therefore, the general objective of this study is to identify, based on the principles of the gravity model, the attractive force of Brazilian states that have international airports. The study is exploratory and quantitative in nature, through statistical analysis.

2. Literature review

The relationship between transport and tourism distribution has been analysed in several empirical ways, a portion of which focused on the regional dispersal of tourists. For instance, Koo et al. (2012), undertaking a dispersion analysis of international tourists in Australia, stressed the need to provide an interpretation of the different distribution of tourism on a given territory and pointed out the importance of measuring the tourists' dispersion. This paper, instead, enquiries the pertinence of the gravity model in explaining the international tourist flows in Brazil.

The gravity model applied to tourism is empirical and is derived from the Law of Gravity developed by Newton in the seventeenth century. This law states that the force of attraction between two bodies is positively related to their masses and negatively related to the square of the distance between them. In the nineteenth century this law began to be applied to social phenomena (Saray and Karagöz, 2010) and is here considered relevant to study the relation between air transport and tourism in Brazil.

Archer (1976, cited in Lorde et al., 2015) was among the first authors to assume a critical position regarding the analysis of tourist demand through the traditional focus on economic theory, remarking that the influence of social, political and technological variables, which interact with strictly economic considerations, must be considered. This need for a broader perspective is confirmed in a recent study applying gravity models to investigate international flows of agritourists in Italy (Santeramo and Morelli, 2015). According to Morley et al. (2014), although the terminology "gravity models" have been largely overlooked by the international trade literature on tourist demand in recent decades, it has reappeared "within the literature fuelled by the good empirical results of such models".

After consulting the main international periodicals, we found 52 articles involving use of gravity models related to tourism. However, a careful reading of these works revealed that only some of them were focused on application of a gravity model. We also noted that the purposes for using gravity models to study tourism are varied. Table 1 summarizes these empirical works analysed, indicating the geographic-territorial focus, the correlation between the dependent variable of tourist flows/arrivals and the independent variable distance, and some remarks about transport and tourism.

Based on the review of the literature, it was evident that: (1) in examining the geographic distribution of tourist flows using gravity models, questions related to transport are typically tangential, even if not declaredly so; and (2) specifically regarding use of gravity models to analyse the interface of transport and tourism, some articles date from almost two decades ago (such as Taplin and Qiu in 1997 about car trips in Australia). Overall, studies focused on this relationship are scarce.

The article by Khadaroo and Seetanah (2008) served as an important source of inspiration for this study. The authors applied a gravity model to assess the relevance of transport infrastructure on the ability to attract tourist flows to destinations. The results indicated that along with tourist infrastructure, transport availability plays a significant role in generation of tourist flows. Therefore, here we address the following question: What is the influence of international tourist flows by air on the regionalisation of tourism in Brazil? On this matter, we also considered the article of Santos (2004), who after a theoretical analysis applied a gravity model of tourism to analyse the empirical relationship between transports and tourist flows in Brazil. That work was very useful as theoretical-methodological support for this study.

3. Data and method

Starting from notions of economic theories involving gravity models, in our basic model the flows (of products) between two points are directly proportional to the population of each centre and inversely proportional to the distance between them, as expressed in Equation (1):

$$Tij = \frac{k\,P_i P_j}{d_{ij}^{a}} \tag{1}$$

Where: k is a parametric constant; a denotes the transaction elasticity (varies according to the good or services considered); P indicates the population of each centre (i,j), which can be replaced by economic variables like GDP, per capita GDP, average income, employment or cost measures, among others; and d is the distance between the two points (ij). As defined in the first section, our overall objective is to investigate the applicability of the principles of gravity models to the context of international tourist flows by air to Brazilian states.

Therefore, the specific reference equation considered here is:

$$Ft_{(o,d)} = \frac{k\,C_o S_d}{D_{od}^{a}}. \tag{2}$$

Where: Ft represents the tourist flow from origin o to destination d; k is the parametric constant to be defined; C_o represents the socioeconomic variable(s) of the country of origin, S_d represents the socioeconomic variable(s) of the state of destination; D_{od} is the distance between the country of origin and the Brazilian destination state, and a is the transaction elasticity (parametric).

The methodological procedures involved building a database containing 108 origin country-destination state pairs. These pairs account for 80.14% of the total flow of tourists arriving by air. We collected the data from the Internet and successively tabulated them in a spreadsheet, considering the following variables and the respective sources:

- Tourist flow[2] (dependent variable) according to country of origin and state of destination, obtained from the *Anuário Estatístico de Turismo* from the Ministry of Tourism (Brasil, 2013b)
- Gross domestic product (GDP) per capita of countries of origin (World Bank, 2013a)
- Gross domestic product (GDP) per capita of Brazilian destination states (IBGE, 2012a)
- Population of countries of origin (World Bank, 2013b)
- Population of destination states (IBGE, 2012b)
- Distance between country of origin and state of destination (ANAC – SINTAC SACI, 2012; Airport Distance, 2014)

The population data of the country of origin were based on the

[2] According to the Statistical Yearbook of Tourism the "Tourist arrivals to Brazil-2011-2012" report gathers "data on the Flow of arrivals of Tourists to Brazil disaggregate by country of residence, months and access routes (air, sea, land or fluvial)." With respect to the different tourism segments, the purposes for considered travels are "leisure" and "business, events and conventions"(Brasil, 2013b).

Table 1
Empirical studies/applications of gravity models to tourist destinations and observations concerning the transport sector.

Authors (by year of publication)	Period	Geo	Focus	Method	Tourism Origin	Destination	Dependent variable	OD distance correlation/range (space, travel time or cost)	Remarks on transport and tourism
Taplin and Qiu (1997, Table 2)	1994	Australia	Regional	Gravity and route choice models	Internal origin-destination zones and External zones	Internal origin-destination zones and External zones	Number of trips	−2.181/−3.216	Propensity to make round trips to remote sites, by car
Gabe et al. (2006, Table 2)	2002	USA	Coastal Destination (by Cruise)	Gravity Model	Domestic (USA)	Bar Harbor, Maine	Intention of returning to destination	−0.054	Distance represents barriers to movement between origin and return destination
Falocci et al. (2007, Table 1)	1998–2002	Italy	Regions	Gravity Model	Regions	Regions	Bilateral tourist flows (between) Bilateral tourist Flows (within)	−0.176** −0.185	No explicit remark -Flows inversely proportional to geographic/economic distance
Pareja et al. (2007, Table 2)	2001–2003	World	Countries	Gravity Model	G-7 Countries	Countries	Tourism flows	−0.592/−0.862*	Distance between origins as proxy for transport cost. Rich countries trade more because of better transp. infrastructures
Zhong et al. (2007, Table 1, Eq. (1))	2002, 2004	China	Villages	Cluster Analysis Gravity Model	Domestic (China)	Huangcheng Village (Shanxi Province of China)	Temporal dist., Tour. flows, other Tourism flows	−1.916	Transport as attractiveness of a tourist site/Transp. network attracts more visitors
Khadaroo and Seetanah (2008, Table 2)	1990–2000	World	Countries	Gravity Model	Countries	Countries	Bilateral International tourism flows	−0.220	Role of transport infrastructure in tourism attractiveness of destinations
Keum (2010, Table 2)	1990–2002	World	South Korea	Gravity Model Linder hypothesis	Countries + South Korea	South Korea + Countries	Bilateral tourism flows	−1.05	Gravity Model vs. H-O model. Gravity Model overcomes the problematic assumptions such as no transport costs
Saray, Karagöz (2010, Tables 4,5)	1992–2007	Turkey	Country	Gravity Model	Countries (Primarily Europe)	Turkey	Number of tourists	0.0204/0.0784	Geographical distance reflects transport costs
Yang et al. (2010, Table 4)	2000–2005	China	World heritage sites	Gravity Model	Inbound	China's World Heritage Sites	Tourist arrivals	−1.417	Transport cost represented by distance as key determinant of tourist arrivals
Fourie and Santana-Gallego (2011, Table 1)	1995–2006	World	Countries	Gravity Model	Countries	Countries	Bilateral tourism flows	−1.482	Transport infrastructure as legacy of mega-events
De la Mata and Llano-Verduras (2012, Table 5)	2001–2007	Spain	Regions	Gravity Model	Regions	Regions	Bilateral trade flows of the tourist sector (between & within)	−1.114/−2499*	The survey records information on the origin and destination of trips include transport mode used
Huang et al. (2012, Tables 2 and 3)	1998–2009	Macau	City	Gravity Model	World	Macau	Tourist arrivals	−1.517/−1.529*	Distance reflects transport costs
Balli et al. (2013, Table 2)	1995–2010	Turkey	Country	Gravity Model	Middle East, Eastern Europe, North Africa	Turkey	Tourism flows	−0.87/−0.94	

									Bilateral trade volumes to capture the comparative advantage of transp. costs
Fourie and Santana-Gallego (2013a, Table 3)	1995–2008	World	Countries – Ethnic reunion and cultural affinity	Gravity Model	Ancestor Country	Countries	Tourism flows	−1.54	Immigration boost the demand for travel related services
Fourie and Santana-Gallego (2013b, Table 3)	1995–2008	Africa	Countries	Static Gravity Model Dynamic Gravity model	Countries	Countries	Tourist arrivals (African-inbound and Within-African tourism)	−1.490** −0.495	Distance as a proxy of transport costs. Poor transp. infrastr. partly explains why trade is low
Marrocu and Paci (2013, Tables 5,6)	2009	Italy	Provinces	Gravity Model Spatial Autoregr. Models	Provinces	Provinces	Bilateral domestic tourism flows	−0.79/−0.78* −0.77**	Geographical distance as driving force of domestic tourist flows
Patuelli et al. (2013, Table 3)	1998–2009	Italia	World Heritage Sites	Gravity Model	Regions	Regions	Tourism flows	−1.0165	Transport infrastructure of the destination and public transport efficiency as supply-side variables
Rosselló, Santana-Gallego (2014, Table 1)	1995–2010	World	Countries	Gravity Model	Countries	Countries	Bilateral international tourism flows	−1.585	Cost of traveling is considered through the distance, among other variables
Zhang and Findlay (2014, Tables 5, 6)	2009	Asia-Pacific	Countries	Gravity Model	Domestic and Inbound	Asian countries	Tourism flows	−1.349/- 1.239*	Air transport as a facilitator of tourism development
Priego et al (2015, Table 2)	2005–2007	Spain	Provinces	Gravity Model	Provinces	Provinces	Domestic trips	−0.900/−0.886	Transport modal as one of most significant aspects in characterizing trips

*Range of values between different models.
**Values obtained by the different methods used.

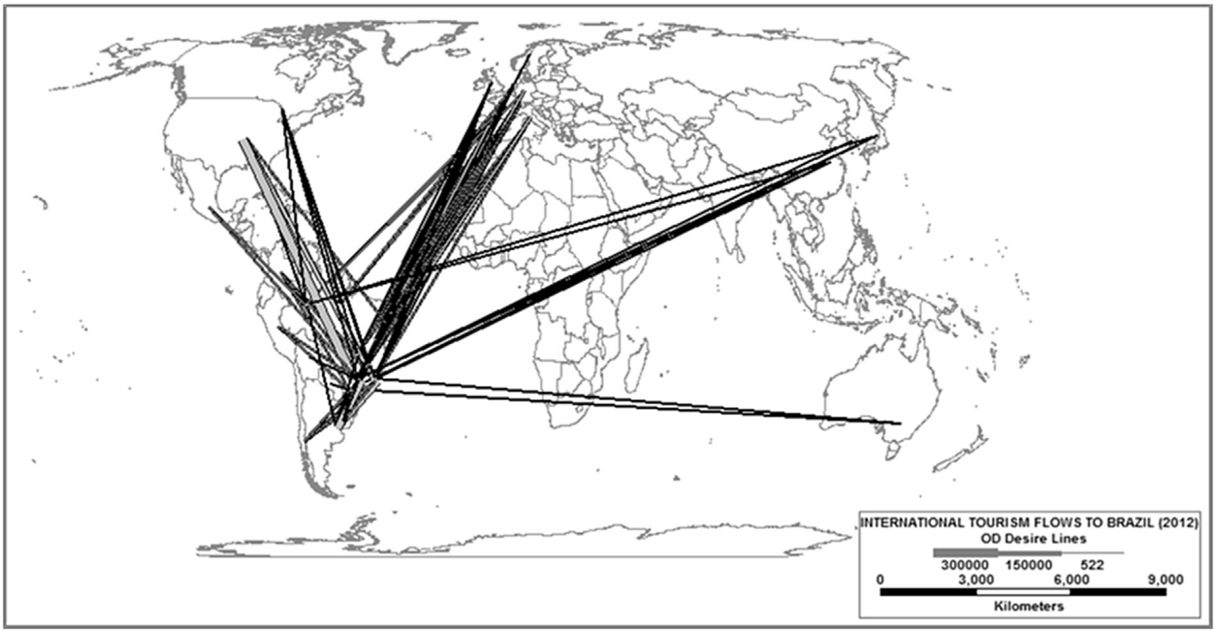

Fig. 1. Desire lines of international tourist flows by air in Brazil (reference year 2012).
Source: Prepared by the authors, based on the Anuário Estatístico de Turismo (Brasil, 2013b).

Table 2
Model summary.[b]

Model	R	R square	Adjusted R square	Std. error of the estimate	Change statistics				
					R square change	F change	df1	df2	Sig. F change
1	0.580[a]	0.336	0.317	44,853.684	0.336	17.544	3	104	0.000

[a] Predictors: (Constant), $Dist_{od}$, Pop_{Ed}, $rGDP_{o/d}$.
[b] Dependent Variable: Ft_{od}.

de facto population, a count that includes all residents, regardless of their legal status or citizenship, except for refugees, who are generally counted in the population of their home country. The numbers are mid-year estimates. For distances, if there were no direct flights in 2012 between the country of origin and the destination state, we calculated the minimum travel distance of multiple flights with final connection to the Brazilian state in question.

We then calculated the ratios between GDP, per capita GDP and population of each origin country-destination state pair to obtain other parameterized variables. For each origin-destination pair, we analysed the correlations using Pearson's coefficient, rho (ρ), to ascertain the existence of a significant tendency in the interaction between them, according to Equation (2).

The second phase of the analysis involved application of multiple linear regression to the variables that presented significant correlations with the dependent variable tourist flow (Ft) and independent variable O-D distance ($Dist_{od}$), the denominator in the equation to be tested. To conclude the statistical analysis, we used analysis of variance (ANOVA) and identification of unstandardized coefficients B_i.

4. Results and discussion

The desire lines between the main countries of origin of tourist flows to Brazil by air based on this study (accounting for 80.14% of the total) are shown in Fig. 1. These lines allow identifying and statistically analysing the traffic zones.

In the basic model (Equation (1)), the flows (of products) between two points are generally directly proportional to the population of each centre and indirectly proportional to the distance between them. However, since our purpose here is to analyse the gravitational force exerted by the different Brazilian states/destinations on air travelers from the countries of origin, we focus on unidirectional flows between origin countries and the Brazilian destination states considered (those having airports serving international traffic). The reason is that in applying origin-destination models in studies of tourism, a single-direction gravitational effect is implicit, in contrast to consideration of bidirectional commercial flows between two points. The first phase of the data analysis indicated the correlations between the variables, with the dependent variable being the sum of passengers (Ft) per destination (Brazilian state), considering the main origins (countries). As said, these countries accounted for 80.14% of the total flow of tourists arriving in Brazil by air in the reference year.

The second phase involved analysis with inclusion of the variables that in the initial analysis had high values of Pearson's rho (ρ). The variables that were significantly correlated (α) with total tourist flow (Ft) were: (1) O/D per capita GDP ratio ($rGDPpc_{o/d}$), with inverse correlation, $\rho = -0.222$, $\alpha = 0.05$, linear regression coefficient of determination $R^2 = 0.049$; (2) destination state population (Pop_{Ed}), direct correlation, $\rho = 0.552$, $\alpha = 0.01$, $R^2 = 0.305$; and (3) O*D population product ($pPop_{od}$), direct correlation, $\rho = 0.186$, $\alpha = 0.05$, $R^2 = 0.008$.

Correlation (1) indicates an inverse tendency of the propensity of international tourists to visit destinations where the average socioeconomic profiles are markedly lower than the origin country.

Table 3
Coefficients.[a]

Model 1	Unstandardized coefficients		Standardized coefficients	t	Sig.	Correlations			Collinearity statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
(Constant)	11,028.068	10,690.745		1.032	0.305					
$rGDPpc_{o/d}$	−636.228	1619.133	−0.034	−0.393	0.695	−0.222	−0.039	−0.031	0.863	1.159
Pop_{Ed}	0.002	0.000	0.568	6.680	0.000	0.552	0.548	0.534	0.882	1.134
$Dist_{od}$	−2.188	1.092	−0.168	−2.004	0.048	−0.096	−0.193	−0.160	0.908	1.101

[a] Dependent Variable: Ft_{od}.

Table 4
Cases most strongly represented by Model 1, in rising order of absolute value of standardized residuals.

Pair	Origin (country)	Destination (Brazilian state)	Flows observed	Flows provided by model 1	Residuals	Standardized residuals
1	Spain	Rio de Janeiro	30,300	30,449	−149	−0.0033
2	Australia	Rio de Janeiro	15,843	15,442	401	0.0089
3	Italy	São Paulo	88,691	88,134	557	0.0124
4	Switzerland	Ceará	5400	5971	−571	−0.0127
5	Argentina	Bahia	35,064	36,372	−1308	−0.0292
6	Germany	Pernambuco	9829	11,245	−1416	−0.0316
7	Australia	Paraná	1730	181	1549	0.0345
8	Spain	Rio Grande do Norte	3440	1855	1585	0.0354
9	Italy	Bahia	21,296	23,003	−1707	−0.0381
10	France	Pará	4393	2532	1861	0.0415
11	France	Amazonas	526,000	−1462	1988	0.0443
12	Portugal	Rio Grande do Norte	6350	4249	2101	0.0468
13	Canada	Amazonas	902,000	3121	−2219	−0.0495
14	Netherlands	Pará	732,000	−1718	2450	0.0546
15	Canada	Distrito Federal	1583	−979	2562	0.0571
16	Netherlands	Ceará	5963	8564	−2601	−0.0580
17	France	Ceará	8461	11,165	−2704	−0.0603
18	France	Rio Grande do Norte	2377	−954	3331	0.0743
19	Portugal	Ceará	13,111	16,705	−3594	−0.0801
20	China	Rio de Janeiro	14,777	11,134	3643	0.0812
21	Switzerland	Pernambuco	3263	7182	−3919	−0.0874
22	Spain	São Paulo	94,660	90,733	3927	0.0876
23	Chile	São Paulo	107,796	103,828	3968	0.0885
24	Chile	Santa Catarina	24,902	20,588	4314	0.0962
25	U.S.A.	Amazonas	12,105	7438	4667	0.1040
26	United Kingdom	Distrito Federal	1171	−3589	4760	0.1061
27	German	Ceará	5148	9947	−4799	−0.1070
28	France	Distrito Federal	2180	−2643	4823	0.1075
29	Italy	Pernambuco	7705	12,817	−5112	−0.1140
30	Argentina	Rio Grande do Norte	1798	8397	−6599	−0.1471
31	Portugal	Pernambuco	10,691	17,420	−6729	−0.1500
32	Colombia	Distrito Federal	2269	9082	−6813	−0.1519
33	German	Bahia	14,351	21,789	−7438	−0.1658
34	U.S.A.	Pernambuco	4931	12,538	−7607	−0.1696
35	Argentina	Distrito Federal	3727	11,847	−8120	−0.1810

To validate this result, Choi (2002), revisiting the hypothesis of Linder (1961), conducted a study covering 63 countries and concluded that countries with smaller differences between per capita GDP tend to develop stronger commercial relations. The results of the study by Lorde et al. (2015) on the attractiveness of Caribbean tourist destination point in the same direction: they concluded that tourist flows have an inverse relation with differences between the purchasing power and income in the origin and destination region, i.e., the closer the per capita GDP of the origin and destination are, the greater the tourist flow will tend to be. Correlation (2) indicates greater ability to attract tourists by states with larger populations, which appears to be in line with the Gravity Model formulation with respect to the numerator of Equation (2). Finally, correlation (3), like correlation (2), but with lesser significance ($\alpha = 0.05$), confirms that the product between the origin and destination populations (again, numerator of Equation (2)) is directly proportional to the tourist flows.

In the calculations of the multiple regression, we only considered the first two correlations, since correlation (3) is linked to (2) by an expression of the population variable, but was less significant than the latter. For the variable Distance ($Dist_{od}$), although the correlation was negative (ρ −0.096), it was not significant in the inverse correlation with Ft. However, this inverse correlation is according to Equation (2), where tourism flows decrease with the distance; hence, this variable will be included in the linear regression.

Table 2 reports the results of the model. Of particular note is the adjusted coefficient of determination $R^2 = 0.317$, hence only explaining 31.7% of the variance of the observed values of the response variable (Ft). However, the combination of the three variables (Sig. F Change = 0.000) significantly predicts the value of the dependent variable (Ft_{od}).

On the other hand, the statistical significance of the three variables (see Table 2) points to a greater single statistical contribution of the explanatory variable Destination State Population (Sig. = 0.000). In turn, the contribution of the explanatory variable

$Dist_{od}$ is significant at $\alpha = 0.05$ (Sig. = 0.048), while the contribution of $rGDPpc_{o/d}$ is not statistically significant (Sig. = 0.695).

The standardized coefficient of regression ($\beta_2 = 0.568$) confirms the direct correlation between the explanatory variable Pop_{Ed} and the response variable (*Ft*). Likewise, the pairwise inverse correlation between the explanatory variables $rGDPpc_{o/d}$ ($\beta_1 = -0.034$) and $Dist_{od}$ ($\beta_3 = -1.168$) with *Ft* is confirmed.

The semipartial correlation (Part) indicates that more than 50% of the total variance (R^2) in the result is explained by the explanatory variable POP_{Ed} (0.534), followed by the explanatory variable $Dist_{od} = 0.160$ (negative), where the participation of the explanatory variable $rGDPp.c._{o/d}$ is 0.031 (negative), revealing itself nearly uninfluential in determining the response variable.

According to Table 3, the model to estimate the dependent variable denoting tourist flows between origin country and destination state (Ft) is the following:

$$Ft_{od} = \beta_0 + \beta_1\,(rGDPpc_{o/d}) + \beta_2\,(Pop_{Ed}) + \beta_3\,(Dist_{od}) + \varepsilon \tag{3}$$

Where β_0 is the parametric constant and ε is the random error. Considering the standardized Beta coefficients found, the model can be expresses as:

$$Ft_{PoEd} = 11{,}028.068 - .034\ rGDPpc_{o/d} + 0.568\ Pop_{Ed} - 0.168\ Dist_{od} + \varepsilon \tag{4}$$

The statistical analysis of the variance inflation factors (VIF) of the three variables indicated low collinearity, so can be excluded the probability that the computations related to these variables are affected when considering them individually. This result was confirmed by the collinearity diagnosis, according to the distribution of the proportions of explained variance.

Although the ANOVA linear regression applied to the three explanatory variables confirmed their influence (Sig. = 0.000) on the variance of the response variable Ft_{od}, the portion of the response explained (31.7%) by the independent variables considered was not satisfactory, mainly with respect to $Dist_{od}$, the denominator of Equation (2). Besides this, the coefficient β_0 was very high (11,028.068), greater than a substantial portion of the P_o-E_d flows observed.

Based on analysis of the standardized residuals (= Ft_{od} observed − Ft_{od} predicted) for the model, it was possible to identify the individual cases (O-D pairs) for which the model demonstrated greater reliability. The result of this analysis is presented in Table 4, where we selected the 35 cases with the lowest standardized residuals. However, it can be seen that six values in the column "Flows Predicted by Model 1" are negative. This indicates the need for calibration of the model, by including other qualitative binary predictor variables (dummies).

On the other hand, some cases showed high residual values, in which the three explanatory variables were unable to confirm the observed O-D flows between the pairs. Therefore, considering our focus on tourist flows by air to Brazil, it is necessary to investigate other variables (continuous and/or discrete) to include in the equation to improve the explanation of the tourist flows generated by each origin country to each Brazilian state.

The new map of regionalisation of tourism in Brazil (Brasil, 2013c) points to 303 tourist regions, distributed as follows: (a) North: 35 regions; (b) Northeast: 81 regions; (c) Midwest: 36 regions; (d) Southeast: 102 regions; and (e) South: 49 regions (Brasil, 2013c). Moreover, through the Ministerial Decree nr. 144 of 27 August 2015 (Brazil, 2015), the municipalities with touristic vocation belonging to these tourist regions, were categorised and divided into five groups, in decreasing order of performance, with the letters A, B, C, D, E, in order to determinate the economic performance of tourism sector in the municipalities included in the Map of Brazilian Tourism. The purpose of the categorization was to enable the improvement of decision-making and policy implementation, respecting the peculiarities of these municipalities.

It is observed that the totality of municipalities that hosts the airports of arrival of the tourist flows belong to the category "A" proposed by the Process of Regionalization of Tourism and are "municipalities with higher tourist flow and increased number of jobs and establishments in the hosting industry" (Brasil, 2015). It should be noted that the destination of the first three pairs included in Table 4, the most representative in model 1, lists Rio de Janeiro and São Paulo, which stand out in the Brazilian context, precisely for the characteristics outlined by the Process of Regionalization and this seems to relate with their gravitational force.

Furthermore, observing the column "Destination" in Table 4, it is possible to identify an over-representation of the Destinations located in the Northeast region, i.e.: Bahia, Ceará, Rio Grande do Norte, Pernambuco, which sum is almost 50% of the most representative cases, and the large majority of these flows departs from a European country. These observations suggest that some Destination, due to its own characteristic and tourism vocation, exert a gravitational force on specific Origins.

It is therefore evident that understanding the influence of international tourist flows by air in a Brazilian state provides an opportunity to relate this to the tourist regions. Furthermore, from the perspective of the planning policies, interpreting this relation would be useful in sizing the regional air transport offer (supply of seats and structures capacity) as highlighted by Koo and Lohmann (2013). These authors, in an exhaustive analysis carried in the Brazilian context, pointed out the volatility of aviation policies in Brazil and its impacts on the spatial evolution of regional air transport supply.

Finally, it is possible to state that the results shown and commented in this section, although not yet sufficient with respect to the explanatory power of the flows between origin countries and Brazilian destination states, demonstrate the explanatory potential of an equation inspired by the general gravity model, to support policy decisions.

5. Final remarks

The challenge of creating more gravitation/attractiveness to boost international tourism in Brazil, particularly by air, is a problem related to the overall competitiveness of the country as an international tourist destination. Therefore, investigation of the tourist products by regions, in accordance with the process of regionalising tourism in Brazil, is relevant to complement this study.

Another avenue for future research is closer examination of the profile of international demand, according to the product and the tourism supply of these regions, because the absence of correlation between tourist flows and the populations of the origin countries (large suppliers of tourists who visit Brazil) suggests that this variable needs to be reconsidered according to the socioeconomic reality and the distribution of wealth among the citizens of these countries. Therefore, it is necessary to examine other variables (continuous and/or discrete) that can be included in the equation to better explain the tourist flows generated by each origin country to each Brazilian state.

A well-calibrated equation can be used as an instrument to support policy decisions on the process of regionalising tourism in Brazil and to strengthen destinations (namely states) in specific markets (origin countries). In the ambit of transport planning linked to tourism, this can help target investments to expand/improve airport infrastructure and to promote tourism, to be shared through partnerships with transport companies (notably airlines) and governmental entities responsible for promoting tourist destinations.

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