Muhammed Bilge Kağan Albayrak[a*], İsmail Çağrı Özcan[b],
Raif Can[c], Frédéric Dobruszkes[d]

The Determinants of Air Passenger Traffic at Turkish Airports

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[a] Ministry of Transport and Infrastructure, Ankara, Turkey
[b] Department of Aviation Management, Yıldırım Beyazıt University, Ankara, Turkey
[c] Ministry of Trade, Ankara, Turkey
[d] Institute for Environmental Management and Land-use Planning (IGEAT), Université libre de Bruxelles (ULB), Brussels, Belgium
* Corresponding author

Abstract

Investigating the determinants of air passenger traffic has become commonplace. In contrast with most previous publications, this paper investigates these determinants in an emerging country, Turkey, at the provincial level between 2004 and 2014. We find that GDP/capita, population, distance to alternative airports, tourism, leading cities, and international migrations all support more air traffic. Furthermore, market concentration is associated with less traffic, and the presence of academics with more traffic. Mapping models' residuals suggest catchment areas, surface transport options, domestic migrations and (geo)politics could also matter. Accordingly, it appears the determinants of Turkey's air passenger traffic do not differ from those of developed economies. The results also suggest new airports should be built based on the aforementioned factors.

Keywords

Air travel demand, forecasting, airport traffic, aviation deregulation, Turkey.

1. Introduction

Trying to determine what drives air passenger traffic is not a new area of study. However, previous efforts have been mostly restricted to developed economies, including the United States, European Union, United Kingdom, and Australia (Wang and Song, 2010). Emerging economies have received less attention, though some authors have considered countries such as Brazil (Marazzo et al., 2010; Fernandes and Pacheco, 2010), China (Wang et al., 2019) or the so-called Middle Income Countries (Valdes, 2015). Recently, the growth in air traffic has taken place mostly in emerging countries (including oil-rich countries seeking to diversify their economies) while traffic has more or less stagnated in traditional leading markets (Boeing, 2019).

In this regard, Turkey is a typical fast-growing air market and by various metrics, Turkish Airlines has become a leading airline. Turkey has implemented both economic development policies and regulatory changes with the explicit goal of boosting its aviation market. In 2003, the Turkish government canceled two specific taxes, a transaction tax and a special education tax, which had been levied on airfares, effective January 1, 2004, hoping to stimulate the air transport industry, which had been significantly hurt by the economic crisis of 2001. The Minister of Transportation claimed that removing these taxes would reduce the price of a ticket worth 100 million Turkish Liras by 20% (Milliyet, 2003). The elimination of these taxes also removed an indirect barrier that had been keeping other airlines from entering the domestic air transport market. FLY Airlines was the first private airline to enter the domestic air market, with flights between Istanbul and Trabzon beginning in October 2003. This shift also meant the end Turkish Airline's de-facto monopoly, which had been in place for years.

Increased competition and reduced fares led to a huge expansion of the Turkish air transport market. Between 2003 and 2017, the total fleet capacity of the Turkish air carriers increased from 27,599 to 97,500 seats, the number of airports more than doubled from 26 to 55, the net revenue of the air transport market ballooned from 3.06 billion Turkish Liras (TRY) to 91.63 billion TRY, the number of airlines serving scheduled domestic routes has increased from 1 to 6, and the number of air passengers increased from 34.4 million to 193.3 million (SHGM, 2018). In addition, in terms of country-pairs, as of 2017, Turkey is the fourth most connected country, with direct regular flights to no fewer than 107 other countries, only below France (118), the UK (108), and the US (108), but more than Germany (104) and the United Arab Emirates (103).[1] In addition, Turkish Airlines now leads all other carriers worldwide, in terms of the number of countries flown to. To respond to such rapid growth, Turkish State Airports has launched new Build-Operate-Transfer airport projects that have almost doubled the passenger capacity across the country.

Such a dramatic growth deserves an in-depth examination of the determinants of the Turkish air transport market. Our work intends to widen the spatial range of markets studied by scholars and to help our field better understand what affects air traffic in emerging markets. We aim to analyze the determinants of the total (domestic and international) air passenger traffic in the provinces of Turkey, which is positioning itself as the primary air gateway between Europe and Asia. The rest of the paper is organized as follows: Section 2 provides a literature review; Section 3 explains our methodology and data; Section 4 reports and discusses our empirical findings; our conclusion offers policy implications and recommends future research topics.

2. Literature Review

The literature abounds with studies of the factors that determine air transport traffic. Wang and Song (2010) identified 115 articles published between 1950 and 2008 on air travel demand. A smaller subset of these studies focused on factors that contributed to air cargo traffic (Hwang and Shiao, 2011; Lakew and Tok, 2015; Gong et al., 2017; Alexander and Merkert, 2017).

However, the largest body of research focused on air passenger traffic. Within this group, some researchers have attempted to model air travel flows to and from a country or a group of countries using aggregate figures. For example, Cline et al. (1998) presented the air transport demand of the Kyrgyz Republic, based on a cross section of countries that represented future economic development scenarios that might be experienced by the Kyrgyz Republic. They showed that GDP per capita had a strong and statistically significant impact on air passenger

[1] Our computations based on OAG.

traffic per capita. In their study of Saudi Arabia's international air traffic, Abed et al. (2001) used a stepwise regression model and determined that total expenditure and population had the most significant impact. Chang (2012) found, using a nonparametric regression tree approach, that a shared language is a strong determinant of air passenger traffic between APEC (Asia-Pacific Economic Cooperation) countries apart from more commonly used variables such as GDP per capita, population, distance, and unemployment rates. Chi (2014) analyzed bilateral air passenger flows to and from the US with a multi-step autoregressive distributed lag approach and found that economic growth was the leading source of air demand. Zhang (2015) used a dynamic panel data model, finding that national income, trade volume, distance, common language, immigration, and air transport policy were all significant factors in shaping air traffic to Australia. Valdes (2015), using both dynamic and static panel data models, analyzed the Middle Income Countries, and found that income had the largest impact on air travel demand. Notably, the impact of migration on airline markets has actually received little attention. Boonekamp et al. (2018), using a comprehensive gravity model and a two-stage least-square technique, and Choo (2018), employing fixed and random effect models, both found that the impact of migration significantly increases air traffic. Dobruszkes et al. (2019) note that visits to friends and relatives (VFR) are usually the second most important reason people fly, only below holiday travel.

In addition to this literature that relies on aggregate figures, several studies have focused on smaller spatial units such as states, metropolitan areas, and small communities, instead of on countries as a whole. In their three-stage least-square regression model study that focused on the determinants of air passenger traffic among the states within the United States, Bhadra and Wells (2005) showed that both airfare and each state's gross product were significant determinants. Goff (2005) examined the determinants of the air service to small markets in the US, specifically cities. His regression study suggested that geo-economic factors like market size, proximity to both a hub airport and any airport offering passenger service, and the distance to a resort or major military installation were statistically significant in determining the availability and level of air passenger service. Liu et al. (2006) tested the factors contributing to the formation of major air passenger markets in the US, specifically across metropolitan areas. Their logistic regression analyses suggested that population, distance to the nearest major market, percentage of the workforce (in both tourism and professional, scientific and technical services), and management activities were statistically significant in determining the contours of a major air passenger market. Using a dataset containing major US domestic routes from 1995 to 2004, Hsiao and Hansen (2011) found, using a three-level nested logit model, that factors such as fare, flight frequency, flight time, direct flights, income, on-time performance, and market distance were all strong drivers of air passenger demand. Dobruszkes et al. (2011), using linear multiple regression models, addressed what influenced the volume of air traffic for major European metropolitan areas. Their results suggested that higher GDP, larger tourism activity (captured by the number of hotel beds and stars in the Michelin Guide), and longer distances to the nearest main air markets led to higher air traffic. Regarding the determinants of air travel in Turkey, we detected two papers. In the former one, Sivrikaya and Tunc (2013) used a semi-logarithmic regression model to analyze domestic city-pairs. They showed that population, bedding capacity, distance between the city-pairs, number of operating airlines, the number of months flown, and the larger availability of round trip flights were positively associated with air passenger demand, while higher airfares, travel time, and the lack of direct flights tended to decrease demand. In the latter study, Kiraci (2018) followed an aggregate approach where he examined the structural changes in the Turkish air transport traffic. His findings pointed out an observable structural change in 2002, which he tried to explain with the domestic economic crisis and September 11 attacks, both of which have taken place in 2001.

Lastly, a small vein of literature has emerged focused on estimating air passenger traffic for individual airports. After examining three cases from Norway, Strand (1999) concluded that, rather than employing generalized models, situation-specific behavioral functions (and, in particular, airport-specific forecasts) should take place-specific characteristics into account. To analyze the international air passenger demand of the tourist airport of Rhodes from 1977 to 1997, Profillidis (2000) used the exchange rate of Greek currency compared to that of passengers' origin countries in a fuzzy linear regression model. After testing the determinants of air passenger traffic and the expansion of passenger terminals for Taiwan Taoyuan International Airport, Suryani et al. (2010), using their system dynamics model approach, found that factors such as GDP, population, number of daily flights, level of airfare, and dwell time affect air passenger demand. Beria and Laurino (2016) analyzed the possible causes of daily fluctuations of air passenger traffic in Milan's Malpensa Airport using OLS models, and found that design and fashion shows in Milan could attract an additional 20% of passenger traffic over the baseline. (See Table A1 in the Appendix for a review of the methods and variables used in the relevant studies.)

In conclusion, previous authors have identified a wide range of factors, in three groups: market size (population, GDP, number of tourists, etc.), market attributes (e.g., GDP/capita), and geographical factors (such as the distance of the nearest hub). However, these factors have mostly been examined for developed countries and some developing or emerging economies, including China and Brazil. By contrast, we will investigate the case of Turkey in the remaining parts of this paper.

3. Methodology and Data

In this study, we analyze the determinants of air passenger traffic at the province level (NUTS-3) in Turkey. The review of the literature indicates a wide range of factors that determine air transport demand, including population, income level, the composition of the economic activities in the region served by the airport, accessibility of the airport, airfares, frequency of the flights, the proximity of the airport to the major destinations, competition among airlines, the activity of neighboring airports, and other transport modes. In order to investigate the role of these factors on air passenger demand in Turkey, we applied a panel data estimation methodology with the following regression specification:

$$Y = \alpha + \beta X + \acute{\varepsilon} \quad (1)$$

where Y is the measure of air passenger traffic, X is a vector of the explanatory variables, and $\acute{\varepsilon}$ is the error term.

Panel data models have several advantages over cross-sectional or time-series data. First, panel data models can more precisely estimate parameters as they have more degrees of freedom with higher variability in the sample. Second, panel data allows for inferences from more complex relations. For example, these models can help overcome omitted variable bias. Third, computation and statistical inferences become more simplified when using panel data (Hsiao, 2007).

We use the annual air passenger traffic in each Turkish province for Y. For five Turkish provinces (İstanbul, Muğla, Antalya, Balıkesir, and Çanakkale) with multiple airports, we added the annual total passenger traffic of the airports to get a single aggregate value.

The first two explanatory variables in X are the most commonly used parameters in the literature. The first, population, is the population of the province served by the airport. The second, GDP per capita, reflects the income level of each province. Regarding these linkages, the findings of many researchers (Cline et al., 1998; Battersby and Oczkowski, 2001; Bhadra and Wells, 2005; Bhadra and Kee, 2008; Suryani, Chou, and Chen, 2010; Dobruszkes, Lennert, and Van Hamme, 2011; Dobruszkes and Van Hamme, 2011; Chang, 2012; Chi and Baek, 2012; Chi, 2014; Zhang, 2015; Valdes, 2015; Kopsch, 2012) have shown that higher income (in different forms such as GDP, GDP per capita, GDP growth, disposable income, and gross state product) was associated with higher air passenger traffic. In our study, we expect that both of these two variables should have a positive effect on air passenger demand.

Another possible determinant of air passenger traffic is the amount of passenger leakage to neighboring airports. Previously, scholars have identified passenger leakage from smaller to larger airports, which offer higher accessibility and/or lower airfares.[2] One might expect passenger leakage to increase with the proximity to the surrounding airports, as it becomes more economical and faster to use these alternative airports. With respect to this linkage, Jorge-Calderón (1997) has shown that PROX1, equal to one when only one airport was located within a 200 km radius of a major hub airport, had a statistically significant and negative impact on air traffic. Philips et al. (2005) documented the passenger leakage from small community airports to larger ones, revealing that the distance to hub airports affects the leakage rate. Fu and Kim (2016) depicted a relationship between airfare and passenger volume for local and substitute airport pairs, such that lower airfares at the substitute airport had a greater impact on airport choices made by travelers. Further, it was suggested that if an airport attracted increasingly smaller numbers of passengers with fewer air services, airport leakage might be difficult to reverse. To take passenger leakage into account, we use the distance by road, in kilometers, to the nearest operating airport and anticipated that air passenger traffic in a specific airport should increase with the increasing remoteness of the closest alternative airport.

Since the proximity to the major air transport markets should directly influence the air traffic figures of a province, we created a proximity index to capture this impact. On the one hand, Istanbul is the economic center of Turkey and has the largest population of Turkey's provinces. On the other hand, Ankara is the capital and home to many central government agencies, which attract significant traffic in the highly bureaucratic Republic of Turkey. In addition, its population is only second to Istanbul. With respect to the proximity to major markets, Liu et al. (2006) and Dobruszkes et al. (2011) have suggested that air traffic increased with increasing distance to main air markets. We expect that provinces will tend to have larger air passenger traffic when they are further from these two major centers. Our proximity index equals the sum of the distances from each province to Istanbul and Ankara in kilometers.

[2] Note that especially in Europe and the United States, the leakage of air passengers also occurs from large airports to smaller, regional airports that are served by specific low-cost airlines. In these cases, a decrease in surface accessibility is balanced by lower-priced tickets. However, this option does not exist currently in Turkey.

Since hub airports tend to experience much more traffic than needed given their actual local/regional potential, we used a dummy variable for provinces with hub airports in order to include the effect of hub airports. Jorge-Calderón (1997) employed two similar dummy variables, HUB1 and HUB2, for hub airports: HUB1 for the case where only one airport of the market pair is a hub; HUB2 for the case when both airports are hubs. He found that both variables had statistically significant coefficients, but that the magnitude was larger for HUB2. Bhadra and Hechtman (2004) reported that passengers preferred airports with broader transferability. In Turkey, the airports in İstanbul and Ankara have served as hub airports for more than two decades. To account for the effect of these hub airports, we use dummy variables, Ankara Dummy and İstanbul Dummy, which are set to one for Ankara and İstanbul provinces. We predict that the coefficient of these dummy variables will be positive.

Airfare should impact air travel with lower fares leading to more traffic. Conversely, larger markets should allow more competition and thus lower fares, all other things being equal, making the relationship between fares and air traffic is complex. However, relying on airfares raises issues of availability and representativeness. Several authors have explicitly excluded airfares from their analyses as they were unavailable (Lim, 2004, Chang, 2012) or due to data acquisition costs (Fleming and Ghobrial, 1994). In contrast, some scholars could afford airfares at the city-pair level, extracted from the MIDT datasets (e.g., Boonekamp et al., 2018). Fares can be more reasonably tracked by scholars when they work on a limited set of city-pairs, so even some fare classes can be considered. For instance, Battersky and Oczkowski (2001) considered three average fares (discount, economy, and business) for the four routes they covered. To compensate, some authors have approximated fares through proxies such as great-circle distances flown, jet fuel costs, and the consumer price index. But these proxies raise additional issues. For instance, planes do not fly the shortest route available and can take significant detours, so the shortest-route distance is not a reliable proxy of costs or of fares (Dobruszkes, 2019).

However, even more fundamentally, relying on average fares or their proxies introduces significant methodological limitations. First, as regulations are removed and competition grows, airfares diversify. Especially, the gap between so-called flag airlines and low-cost airlines has become significant, the average fare is misleading and does not reflect how fare-sensitive passengers can be. In addition, yield management has made fares more diverse and changeable over time. Furthermore, cheaper flights through indirect routes also complicate our reliance on fares and help explain why relying on economy fares only slightly improves some models (e.g., Kaemmerle, 1991). Finally, we argue that considering fares would make more sense for those who work with city-pairs as opposed to departure cities. When origins are concerned (as in our work), we believe there is no rationale for averaging fares related to a large set of routes. The result would have no robust meaning since it could mix a very cheap route from A to B with an expensive one from A to C. All in all, airfares are thus not included in our models.

Nevertheless, we acknowledge that competition at airports may affect air traffic demand. In a low-competition airport where there are a limited number of air carriers operating, air carriers can charge higher airfares and provide smaller air service in terms of frequency, number of destinations, and both age and size of the aircraft in use. On the other hand, at an airport with more competition, air carriers may tend to provide more frequent flights to a higher number of destinations with a newer and larger fleet, improving their market share. These positive factors, in turn, may tend to increase in air passenger demand. To determine the degree of competition, we calculated the market dominance index for each airport, which corresponds to the market share of the leading airline at that airport. This competition level is among the least frequently used determinants of air traffic in comparable studies. Sivrikaya and Tunç (2013) is the only study that adopts a competition variable, which they measured using the number of airlines in each route. We anticipate that lower market dominance should attract higher air passenger traffic; accordingly our market dominance index variable should have a negative coefficient.

We also include the effect of tourism activities on air passenger traffic. The link between tourism and air travel is quite straightforward as air transport and tourism are interconnected sectors that mutually stimulate one other (Bieger and Wittmer, 2006). Regarding this relationship, Liu et al. (2006) employed the percentage of the workforce in tourism and Dobruszkes (2011) used the number of beds and number of Michelin stars earned by places. To capture this effect, we use the number of hotel beds in each province. We anticipate that more hotel beds should be positively associated with larger air passenger traffic.

As noted in the previous section, international migration impacts airline markets but is rarely considered. We assume that the share of visits for friends and relatives will have a significant impact on both domestic and international travel. The stronger the ethnic ties, the higher demand for air travel. Boonekamp et al. (2018) show that ethnic links between airport pairs increase passenger demand. Thus, ethnicity has a positive and significant effect on passenger demand between airport pairs. Choo (2018) documented a positive relationship between immigration and air travel demand in Canada. In particular, a 10% increase in the number of foreign-born Canadian residents led to an increase of around 3% in inbound travel demand. Therefore, the number of foreign residents can capture some of the travel demand associated with visits from friends and relatives. As the number of foreign residents increases in a particular city, one can expect an increase in total air passenger traffic. In the case of Turkey, air traffic can be affected by Turkish citizens living abroad and by the number of foreign residents living in Turkey. Since statistics are not available at the province level for the former group, we will only incorporate the latter group into our analyses. We expect that the variable for the number of foreign residents, which corresponds to the number of non-Turkish citizens living in each Turkish province, should have a positive coefficient.

Another possible determinant of air passenger traffic is the number of university academics in each province. We argue that this variable incorporates two different impacts. First, it captures the sizes of the universities at which travelers are working. Universities attract a significant number of academics, students, and their families which should accordingly increase air passenger traffic. Secondly, the number of university academics can capture the level of high-tech activities in their respective provinces. The literature suggests that there is a positive correlation between air traffic and high-tech jobs and R&D activities. On the one hand, high-tech professionals take into consideration the availability of scheduled air traffic when considering the (re)location of their activities (Albalate and Fageda, 2015). On the other hand, according to Liu, Debbage, and Blackburn (2006), the nature of such activities stimulates air traffic growth. Since detailed employment statistics were not available for the study period of our research, we used the number of academics to capture this effect, considering the strong correlation and cooperation between universities and both R&D and high-tech activities. We would anticipate that the increase in the number of university academics should generate additional air passenger traffic.

Table 1: Definitions and data sources of the variables used in our analyses

Variable	**Data Definition**	**Mean (2014)**	**Standard Deviation (2014)**	**Range**	**Source**
Total Air Passenger Traffic	Natural logarithm of the total number of passengers at the airport (2004-2014)	3525962.42	12377853.81	8405-80189812	General Directorate of State Airports Authority (SAA)
GDP per Capita	Natural logarithm of the gross domestic product per capita in USD of each province (2004-2014)	9217.64	3770.65	3881-19958	TURKSTAT
Population	Natural logarithm of the population of each province (2004-2014)	1351016	2178430	192056-14377018	TURKSTAT
Ankara Dummy	Indicator representing the hub characteristic of Ankara, with a value 1 for Ankara airport, 0 for others (2004-2014)	0.0212766	0.145865	0-1	Our calculations
İstanbul Dummy	Indicator representing the hub characteristic of İstanbul, with a value 1 for İstanbul airports, 0 for others (2004-2014)	0.0212766	0.145865	0-1	Our calculations
Hub Dummy	Indicator representing the hub characteristic of İstanbul and Ankara, with a value 1 for, 0 for others (2004-2014)	0.425532	0.2019819	0-1	Our calculations
Market Dominance Index	Natural logarithm of the passenger market share of the leading carrier of each airport (2004-2014)	69.47	24.58	12-100	Our calculations
Distance to the Closest Airport	Natural logarithm of the distance in km to the nearest airport market (2004-2014)	134.82	45.25	78-234	General Directorate of Highways (GDH)
Number of Beds	Natural logarithm of the number of provincial bed capacity of each province (2004-2014)	15887.19	58678.66	134-386023	Ministry of Culture and Tourism (MoCT)
Number of Foreign Residents	Natural logarithm of the number of foreign residents of each province (2007-2014)	9353.30	23776.36	155-155536	TURKSTAT
Academician Ratio	Natural logarithm of the ratio of the total number of academic personnel to the population of each province (2004-2014)	0.0018241	0.0010347	0.0005092-0.0051053	Council of Higher Education (CHE)
Total Distance to Ankara and İstanbul	Natural logarithm of the total distance (in km) to İstanbul and Ankara, economic and official capitals of Turkey (2004-2014)	1503.87	717.46	453-2858	General Directorate of Highways (GDH)

TURKSTAT: Turkish Statistical Institute
SAA: General Directorate of State Airports Authority
GDH: General Directorate of Highways
MoCT: Ministry of Culture and Tourism
CHE: Council of Higher Education

Table 1. Definitions and data sources of the variables used in our analyses.

We have applied a logarithmic transformation to both dependent and independent variables except for the dummy variables. This transformation helps to linearize the relationships between the dependent variables and potential determinant factors. It also helps in the interpretation of the results as estimates become elasticities.

During the period we examined, Turkey had 52 airports serving scheduled flights in 47 provinces. We used NUTS-3 level data for airport catchment areas (provinces) and relevant indicators. All airports were linked to a province and passenger traffic was aggregated to a single value for provinces with two airports. In total, 47 different passenger catchment areas are defined, taking into account yearly regular air service availability.

We gathered air traffic statistics for each airport from the annual statistical yearbooks of the General Directorate of State Airports Authority. The per capita income, population, and number of foreign resident statistics come from the Turkish Statistical Institute database. The Council of Higher Education provided the distribution of academics in each province and we employed the General Directorate of Highways database to calculate both the proximity index and distance to the nearest airports. Lastly, the Ministry of Culture and Tourism provided the number of tourist beds in each province. Table 1 presents the definitions, summary statistics, and data sources of all variables used in our analyses.

4. Results

Table 2 shows the correlation matrix of the variables between 2004 and 2014. Total passenger traffic is positively correlated with the GDP per capita, distance to nearest air market, number of beds, population, academician ratio, total distance to Ankara and İstanbul, and number of foreign residents. Total passenger traffic is correlated negatively with the market dominance index. A higher value of the market dominance index implies less competition in the respective airport.

Table 3 presents the results of the six-panel data specifications. Models 1, 3, and 5 are the random effect (RE) estimations, whereas Models 2, 4, and 6 are their corresponding fixed effect (FE) specifications[3]. We ran six different models to test the robustness of these parameters under different specifications. In each model, we kept GDP per capita and population, as, in the literature, they are widely accepted primary parameters determining air demand, and we tried alternative specifications by dropping certain variables. Our calculated Hausman statistics suggest that we should choose RE models, which we will use when we discuss our findings. We used robust regressions to handle issues of heteroscedasticity. The variables, which we adopted from the existing literature, have the expected signs. The variance inflation factors (VIF) of each explanatory variable for the three models under OLS estimation is less than 5, supporting our hypothesis that there would be no harmful multi-collinearity.

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[3]In order to check whether reverse causality (endogeneity) is significant in our estimations, we added lag of explanatory variables per capita income, market dominance index, and number of provincial bed capacity that can be also influenced from the number of air passenger. We observed that the sign and significance of the coefficients do not change and the changes in coefficients are not considerable. FE models account for unchanged characteristics of the measure of unit, airport in our case, while the RE models do not.

	Total Air Passenger Traffic[1]	GDP per Capita[1]	Market Share[1]	Distance to the Closest Airport	Number of Beds[1]	Population[1]	Academician Ratio[1]	Total Distance to Ankara and İstanbul[1]	Number of Foreign Residents
Total Air Passenger Traffic[1]	1								
GDP per Capita[1]	0.2682	1							
Market Dominance Index[1]	-0.6691	-0.2864	1						
Distance to the Closest Airport	0.1323	0.1033	-0.0275	1					
Number of Beds[1]	0.6438	0.6266	-0.6346	0.1153	1				
Population[1]	0.6275	0.4328	-0.3543	0.0786	0.6757	1			
Academician Ratio[1]	0.1995	0.4558	-0.1868	0.2692	0.1712	0.1231	1		
Total Distance to Ankara and İstanbul[1]	0.0542	-0.7943	-0.0524	-0.1056	-0.4103	-0.3887	-0.3375	1	
Number Foreign Residents[1]	0.5137	0.6904	-0.4346	0.0410	0.7459	0.6971	0.2749	-0.5181	1

[1] LN Transformation

Table 2. Correlation Matrix.

Variables	Model (1) RE	Model (2) FE	Model (3) RE	Model (4) FE	Model (5) RE	Model (6) FE
GDP per Capita[1]	1.30***	1.13***	1.87***	1.93***	1.73***	1.87***
	(0.270)	(0.364)	(0.326)	(0.414)	(0.297)	(0.385)
Population[1]	0.92***	2.61	0.97***	0.62	0.76**	0.46
	(0.222)	(1.669)	(0.299)	(1.084)	(0.245)	(1.066)
Distance to the Closest Airport[1]	0.53**	0.13	0.33*	0.22		
	(0.255)	(0.331)	(0.185)	(0.219)		
Total Distance to Ankara and İstanbul[1]	2.39***	(omitted)	2.89***	(omitted)	3.06***	(omitted)
	(0.317)		(0.410)		(0.358)	
Ankara Dummy	3.20***	(omitted)				
	(0.577)					
İstanbul Dummy	3.84***	(omitted)	2.95***	(omitted)		
	(0.707)		(0.884)			
Hub Dummy					3.66***	(omitted)
					0.562	
Market Dominance Index[1]	-1.28***	-0.85**	-0.90***	-0.817***	-0.99***	
	(0.320)	(0.405)	(0.247)	(0.262)	(0.249)	
Number of Beds[1]			0.28*	0.32	0.29**	0.33
			(0.159)	(0.235)	(0.149)	(0.237)
Number of Foreign Residents[1]	0.12**	0.117**				
	(0.046)	(0.054)				
Academician Ratio[1]			0.26**	0.24**	0.25**	0.242**
			(0.103)	(0.123)	(0.095)	(0.126)
Constant	-27.32***	-31.28	-36.68***	-11.84	-31,99***	-7.97
	5.75	22.54	7.35	13.45	6.36	13.00
Number of Observations	285	285	348	348	348	348
R-squared (within)	0.27	0.29	0.47	0.47	0.47	0.47
R-squared (between)	0.83	0.49	0.76	0.26	0.80	0.32
R-squared (overall)	0.79	0.49	0.74	0.34	0.78	0.39
Number of provinces	47	47	47	47	47	47

Robust standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01
[1] Natural logarithm transformation.

Table 3. Determinants of Air Passenger Demand in Turkey.

The variable we used to measure the prosperity of the provinces had a positive and significant relationship with total passenger traffic, after controlling other relevant variables. Specifically, a 1-% increase in per capita income was likely to increase the air passenger traffic in the range of 1.30-1.87%, and these coefficients are statistically significant at the 1% level. Similarly, the population has positive and significant coefficients. Our findings suggest that a 1-% increase in population was associated with a 0.76-0.97% increase in air passenger traffic. These findings are consistent with our theoretical expectations and what many other studies have documented previously.

Our results imply that spatial characteristics of the airports had a significant effect on air passenger traffic. Our analyses reveal that the distance to the nearest air market and distance to major attraction zones are positively associated with the number of air passengers in the province. More concretely, a 1-% increase in the distance to the nearest airport increases the air passenger traffic by 0.33-0.53% on average. We should note that these coefficients are statistically significant at the 10% and 5% levels, respectively. Similarly, a 1-% increase in the total distance to Ankara and İstanbul (namely, the economic, financial, and administrative centers of Turkey), was expected to create a 2.39-3.06% increase (all significant at the 1% level) in total air passengers, on average.

Table 3 also reports that hub airports in Istanbul and Ankara have significantly higher air passenger traffic, when compared to other airports, holding other variables constant. Our findings suggest that the number of air passengers was positively associated with the degree of competitiveness. More specifically, holding other explanatory variables constant, the number of air passengers should decrease by a 0.90-1.28% on average if the market share of leading airline in that province increases by 1%. Airports experiencing tougher competition among airlines should end up with lower fares, higher flight frequencies, and with flights to more destinations. This can, in turn, explain the inverse relation between the degree of dominance of the market-leading airline and air passenger traffic.

Supporting our expectations, the findings presented in Table 3 reveal that a higher number of both hotel beds and foreign residents tended to increase air passenger traffic. Holding other variables constant, we can anticipate a 0.28-0.29% increase in traffic if the number of beds increases by 1%. Likewise, a 1-% increase should be associated with a 0.12% increase in the number of foreign residents in that province.

University academics working with each province are also a possible determinant of air passenger demand. Models 3 and 5 show that a 1-% increase in the ratio of academics in the total population of the province increased the number of air passengers by 0.25-0.26%, on average.

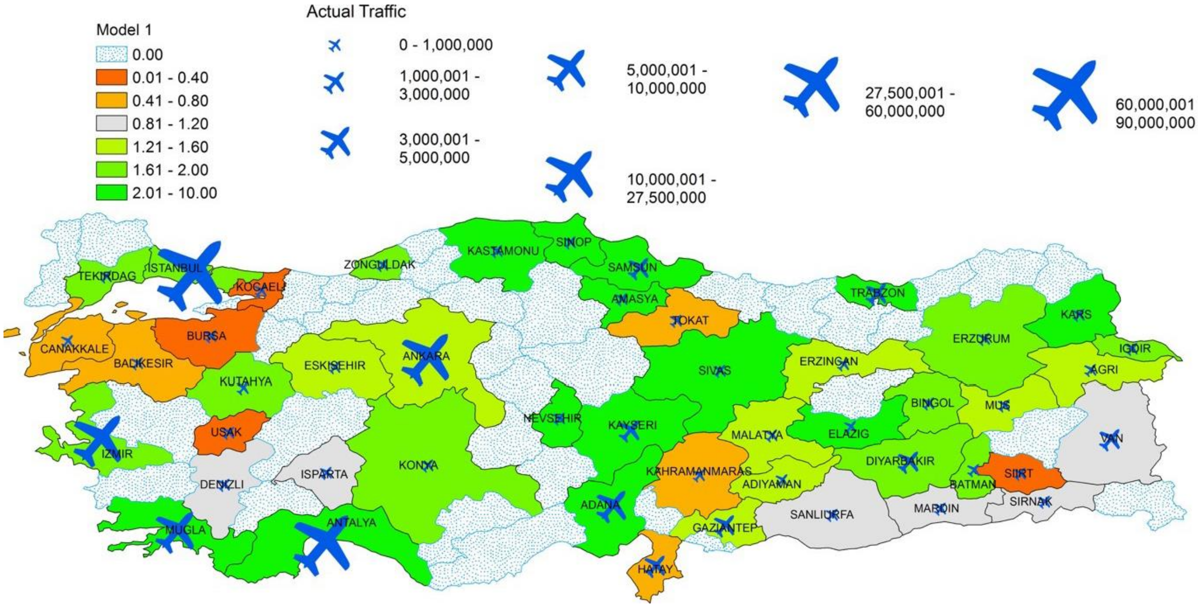

Figure 1. Model 1 observed vs expected traffic.

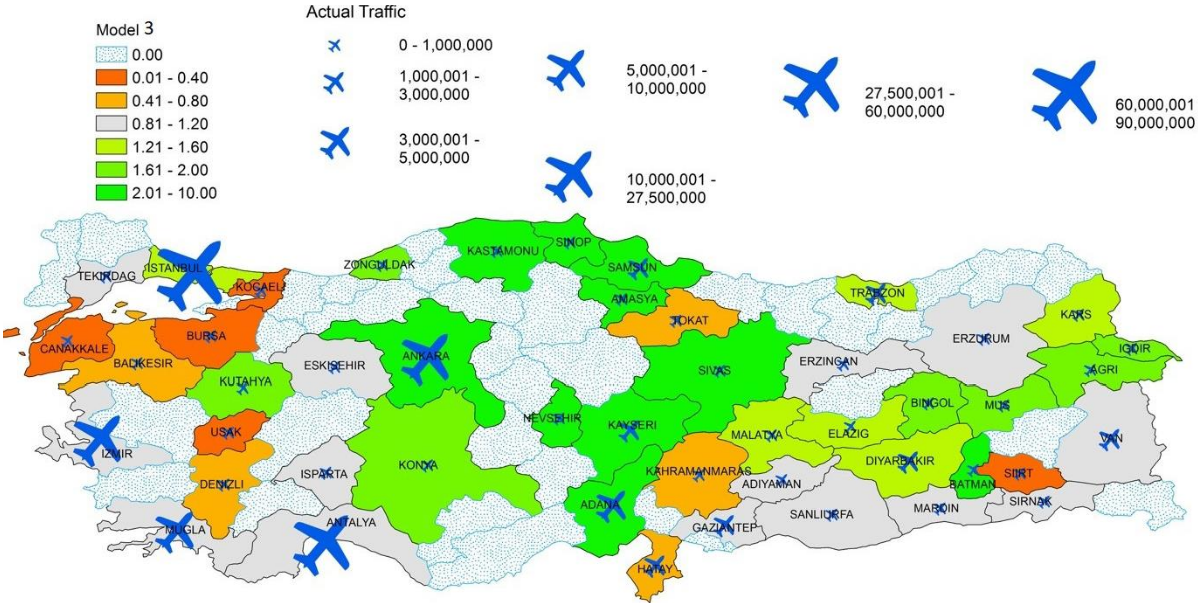

Figure 2. Model 3 observed vs expected traffic.

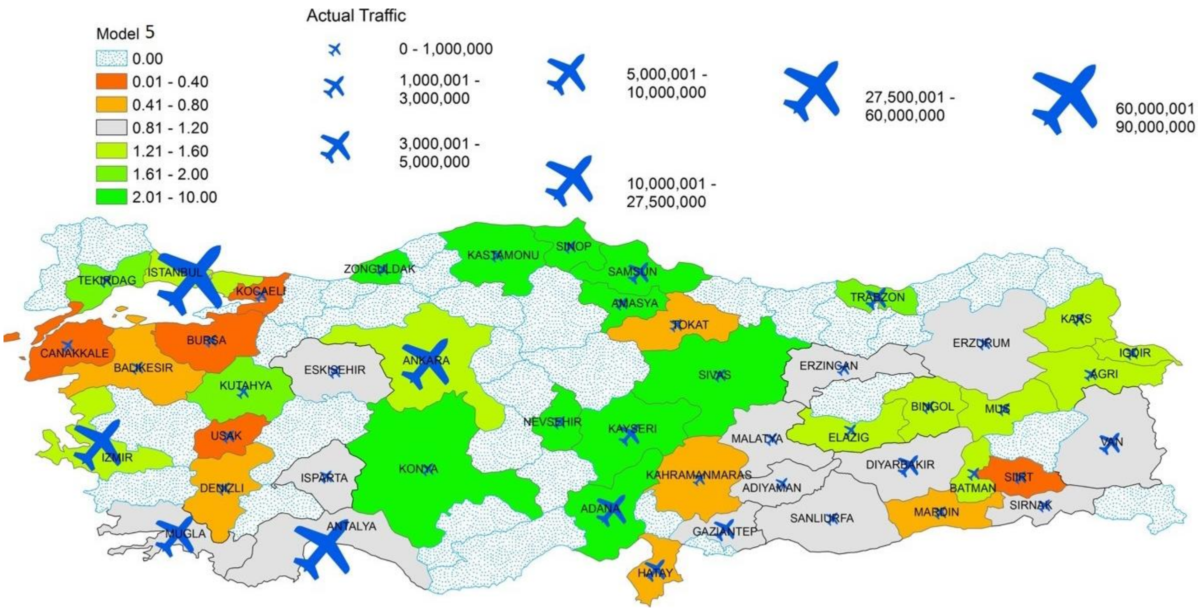

Figure 3. Model 5 observed vs expected traffic.

Further, we investigated the geography of the models' residuals. This is a technique familiar to geographers, which helps to think beyond the models. A specific spatial pattern could suggest extra factors. Since residuals depends on the value of dependent variables, we compared the expected air passenger traffic with the observed one. Figures 1, 2, and 3, which were produced following Models 1, 3 and 5, respectively, show the ratio between the observed and expected air passenger traffic. Empty labels show cities with no airports. Grey labels show that the differences between forecasted and observed traffic figures were negligible. Green labels denote cities with over-demand zones (observed/expected is greater than 1) and orange and red labels indicate those with under-demand zones (observed/expected is lower than 1). Darker colors indicate extreme outcomes for both over- and under-demand zones.

The differences between predicted and actual traffic could be explained by additional factors not captured within our models. When we look at the figures of the three models, we observe that some airports in high-density metropolitan areas have over-demand. One typical example of such a province is İstanbul. There might be two explanations for this traffic beyond predicted levels for İstanbul. First, the actual catchment area of İstanbul extends beyond its provincial borders. We argue that there is a good deal of air passenger leakage to Istanbul from neighboring provinces like Bursa, Kocaeli, and Tekirdağ, which are among the top industrial centers of Turkey. This leakage also explains the underperformance of air traffic in Bursa and Kocaeli, when compared with their forecasted levels. The second explanation is valid not only for İstanbul, but also for Ankara, for which we should take into account the hub and spoke strategies developed by airlines. Most of Turkey's legacy carriers set up hub and spoke networks, allowing them gather and distribute passenger traffic to and from major airports. Distributing traffic through hubs provided carriers with a wider number of destinations in exchange for increased travel times and detours for passengers. Hub airports in İstanbul and Ankara, therefore, attracted more passengers and are labelled as over-demand zones. Figures 1, 2, and 3 reveal that the dummy variables we adopted to capture hub characteristics in our estimations do not fully represent the potential of the two hub provinces.

In addition to the special case of Istanbul and surrounding airports, Trabzon, Samsun, Sinop, Kastamonu, Amasya, and Zonguldak, all in the Black Sea area, have excess traffic compared with our model's estimations. This area is a mountainous region with poor inter-inland connections, due to highland topography. Both east-west and south-north corridors have capacity constraints in terms of road and rail connections and thus passenger traffic might have shifted towards air travel. With respect to over-demand in Sinop, Kastamonu, and Sivas provinces, domestic immigration can be a factor. These three provinces contain cities with the most immigration to İstanbul. According to 2014 population statistics, residents of Istanbul from Sivas, Kastamonu, and Sinop ranked first, second, and tenth within the total population of İstanbul, respectively. In other words, over-predicted travel demand might be due to family ties of non-İstanbul origin residents of İstanbul. Finally, we should note that air travel demand may shift from provinces without an airport to neighboring provinces with an airport. More clearly, this passenger leakage can lead to an over-demand in the provinces having no airport neighbors.

Finally, we should underline that certain cities fulfill specific economic, military, and social functions that are not reflected by our explanatory variables. These cities' particular characteristics produce greater air traffic than what we predict. On the other hand, some other features might have negatively affected air passenger traffic. For instance, due to regional tensions in the south-eastern region, Siirt and Şırnak might not have been fulfilled their air traffic potential and have under-performing passenger movements. Similarly, Gaziantep might have outperformed with the start of the Syrian civil war, due to unexpected refugee influx and related national and international charity movements.

5. Conclusions

Despite the vast literature on the determinants of air passenger traffic in developed economies and very large emerging markets, developing countries have largely been ignored. We fill this gap by examining case of Turkey, a special case of the air traffic dramatic growth over the last fifteen years following market deregulation and intense expansion. We adopt a dataset covering 52 airports from 47 Turkish provinces from 2004 to 2014. In addition, we consider some potential factors—including the degree of competition at airports, the presence of foreigners, and the number of academics—that are usually disregarded. Our panel data estimations suggest that GDP per capita and population have a positive and statistically significant effect on air passenger demand. Our model findings are consistent with the theoretical expectations present in the literature and also confirm other authors' recent findings related to the under-explored factors. The model outputs showed positive and significant effect of tourism, foreigners, R&D capability and the number of academics on air passenger volumes. Regarding the competition, we document that higher competition is positively associated with air passenger demand.

Our analyses show that the determinants of air transport demand in an emerging economy are almost identical with those of the developed economies. Our findings also suggest crucial policy implications. The negative association between the air passenger traffic and the proximity to both İstanbul and Ankara indicates that the Turkish governments should re-consider airport projects in the vicinity of these metropolitan areas. The poor performance of airports at Kocaeli and Bursa (the fifth largest Turkish city) are striking examples of this proximity effect. High-speed rail connections might be a more reasonable solution to improve the accessibility of cities close to İstanbul and Ankara. Likewise, a similar negative effect of the proximity to neighboring airports on air passenger traffic should be taken into account. The policy of "an airport at every 100 kilometers" of the Turkish government implies building many new airports with only small distances between them (UDHB, 2011). We recommend that rather than using predetermined distances between the airports when making new investment decisions, the actual potential of the airports should be considered through other significant determinants like population, income level, and tourism activity.

Our analyses also reveal that the level of tourism activities, which we approximate by the number of hotel beds, and the number of foreign residents are statistically significant determinants of air passenger traffic. Since air travel goes hand in hand with tourism, the Turkish governments should give priority to tourism destinations, which also attract a significant number of foreigners for living, when planning the national airport infrastructure.

The positive effects of improved competition on air traffic are also noteworthy. To prevent the airlines having significant market power at the airport level, slot allocation mechanism can be used as a way of enhancing competition at the large airports. In the smaller airports with thin routes, increasing the attractiveness of the airport for the newcomer airlines through subsidized airport services and providing traffic guarantees (or travel banks) might work.

Appendix

Table A-1: Summary of Methods and Parameters

Author and Date	Method	Modelling Parameters
Cline et al. (1998)	Cross Section Regression Analysis	GDP Per Capita
Abed et al. (2001)	Stepwise Regression Analysis	Total non-oil GDP, consumer price index, import of goods and services, per capita income, population, total expenditures, total consumption expenditures
Chang (2012)	Nonparametric Regression Tree	Passenger flow, GDP, population, language, per capita income, consumer price index, unemployment rate, import/export value, distance
Chi (2014)	Multi-Step Autoregressive Distributed Lag Models	GDP, bilateral real exchange rate of the currency, consumer price index
Zhang (2015)	Dynamic Panel Data Regression Analysis	GDP, jet fuel price, distance, real exchange rate, consumer price index, real effective exchange rate, aviation policy dummy variable
Valdes (2015)	Dynamic and Static Panel Data Regression Analysis	Passenger flow, available seats, GDP per capita, net flows of foreign direct investment, consumer price index, real exchange rate, jet fuel prices, deregulation policy dummy variables, distance, membership policy dummy variables
Boonekamp (2018)	Gravity Model	Population, GDP per capita, employment in aviation dependents sectors, number of hotel nights, ethnicity, frequency, distance, direct airport connectivity, domestic routes dummy variable, share of low cost carriers passenger, public service dummy variable, air fare, passenger demand
Choo (2018)	Panel Data (Fixed and Random Effect) Analysis	Passenger flow, number of immigrants, distance, GDP, population, visa requirement dummy variable, membership policy dummy variable
Bhadra and Wells (2005)	Three Stage Least Square Regression Analysis	Employment, concentration of airport hubs, GSP, passenger flow, fare, region dummy variable,
Goff (2005)	Multivariate Regression Analysis	Market size, per capita income, distance to large hubs, distance to any hub, distance to any airport, resort/military dummy variable

Liu et al. (2006)	Logistic Regression Analysis	Population, percentage of workforce in tourism, percent of workforce in professional, scientific or technical services and management activities, distance to a nearest major market, days of sun
Hsiao and Hansen (2011)	Three Level Nested Logit Models	Fare, frequency, flight time, routing type, on-time performance, income, market distance, hub, seasonality, airport dummy variables,
Dobruszkes et al. (2011)	Linear Multiple Regression Analysis	Population, GDP, scores of administrative level, scores of number of headquarters of the 2000 largest global firms distance to nearest main air market, scores of number of touristic beds and Michelin guide stars, scores of ranking of the 500 top European universities and the 100 top research centers, percentage of employment in high-technology and knowledge-intensive sectors
Sivrikaya and Tunc (2013)	Semi Logarithmic Regression Analysis	Population, bedding capacity, distance, transit dummy variable, fare, number of airlines, travel match, schedule consistency, travel time
Profillidis (2000)	Fuzzy Linear Regression Analysis	Exchange rate
Suryani et al. (2010)	System Dynamics	Growth rate of demand, passenger demand, GDP, airfare, price elasticity, time elasticity, cost per hour, runway capacity, population
Beria and Laurino (2016)	OLS Estimations	Day of week, month of year, season, day of departures, peak day of departures, off-peak day of departures, day of arrivals, peak day of arrivals, off-peak day of arrivals, airstrikes, trade fair/event, congresses, sport events dummies

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