THE NOW AND FUTURE OF AIR TRANSPORT MARKET: THE COMPARISON OF SELECTED TURKISH CITIES BASED ON TIME SERIES FORECASTING MODEL

GÜNÜMÜZDE VE GELECEKTE HAVA YOLU ULAŞIM PAZARI: TÜRKİYE'DE SEÇİLMİŞ ŞEHİRLERİN ZAMAN SERİSİ TAHMİNLEME MODELİYLE KARŞILAŞTIRILMASI

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Abstract

The air transport industry has experienced significant growth over the past few decades due to the rapid growth of international trade and increases in travel opportunities. Accurate forecasts of the air transportation, which has the right quality to improve competitiveness of Turkiye in economic, is crucial regarding the precautions that will be taken in the future. It is also an essential input for an investment planning. Air transportation provides some social and economic advantages that other transport modes could. In the field of air transportation forecasting, there are a number of empirical models, which can be classified as judgemental, causal and time series. Time series forecasting is an important area of forecasting in which past observations of the same variable are collected and analyzed to develop a model describing the underlying relationship. The model is then used to extrapolate the time series into the future. The present study, which is based on Turkiye's domestic and international aviation statistics of 2007-2014, argues that "time series" models are more compatible while estimating the air passenger and plane parameters for Turkiye and selected cities. Also, the purpose of this paper was to construct mathematical models to forecast the Turkish air transport market in long-term period. For this purpose, the study first presented the short review of the main classical forecasting methods and also gave a brief introduction into a mathematical modeling. For empirical study, a combination of three basic functions such as a trend function, a seasonal function, and an irregularity function is chosen. A genetic algorithm process was used to determine the coefficients of each function. The study tested a second degree polynomial as a trend function, a periodic function like sinusoidal, and an irregular function such as logistic distribution fits better. The projection about Turkish aircraft traffic with using mathematical modeling is uniq and the results also confirmed that the Turkish air transport market is an emerging market. According to the forecasting based on the constructed mathematical models, the study projects a 62.09 % increase in Turkish aircraft traffic and a 60.3 % increase in Turkish air passenger traffic between 2015-2019 years.

Key Words: Turkishair transport market, time series, forecasting.

Özet

Havacılık sektörü, uluslararası ticaretin ve seyahat imkanlarının artışından yararlanarak son dönemde önemli ölçüde gelişim kaydetmiştir. Ülkemiz havacılık sektörünün geleceğine ilişkin doğru tahminlerde bulunmak hem ülkemizin ticari faaliyetlerdeki rekabet gücünün artmasına hem de bu alanda yapılması planlanan yatırımlara önemli katkı sağlayacaktır. Havayolu ulaşımına ilişkin tahminlemede kullanılan deneysel modeller; "yargılayıcı", "nedensel" ve "zaman serileri" olarak sınıflandırılmaktadır. Bu sınıflandırma içinde yer alan zaman serileri; geçmişe ilişkin elde edilen deneyimleri dikkate almaktadır. Bu kapsamda zaman serileri; araştırmada yer alan değişkenler arasındaki ilişkiyi tespit etmekte ve ilişkinin matematik modellemesinin yapılmasına imkân sağlamaktadır. Bu yöntemle elde edilen matematik model konuya ilişkin gelecek öngörülerinin yapılabilmesine de imkan vermektedir. Çalışmada; Türkiye ve seçilmiş şehirlerin 2007-2014 dönemi ulusal ve uluslararası uçuş istatistikleri zaman serisi kapsamında modellenerek geleceğe ilişkin tahmin yapılmıştır. Bu amaçla; çalışmada, öncelikle tahminlemede kullanılan klasik yöntemler ve matematik modelleme hakkında bilgi verilmiştir. Uygulama kapsamında da uçak ve yolcu istatistikleri; "trend", "mevsimsellik" ve "düzensizlik" şeklinde üç alt fonksiyona ayrılarak bunların birleşiminden oluşan ikinci derece polinom fonksiyonu ile matematik modelleme yapılmıştır. Bu matematik modelin; eldeki geçmiş dönem verileri kullanılarak doğruluğu ve uygunluğu değerlendirilmiştir. Elde edilen sonuçlara ilişkin grafikler, modelin uyumlu olduğunu göstermiştir. Uyumluluğu doğrulanan matematik model kullanılarak 2015-2019 dönemine ilişkin Türk Hava ulaşımında uçak ve yolcu sayısının genel ve seçilmiş şehirlerdeki değişimi bulunmuştur. Özellikle model çerçevesinde, söz konusu dönemde "uçak trafiğinde % 62,09'luk" ve "yolcu sayısında % 60,3'lük" artış tahmini ülkemizin hava ulaştırmasında gelişen bir pazar olduğunu göstermiştir.

Anahtar Kelimeler: Türkiye hava ulaşım sektörü, zaman serileri, tahminleme.

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Introduction

The air transport industry has experienced significant growth over the past few decades due to the rapid growth of international trade and increases in travel opportunities. The gradual freeing of trade across the globe has added to this growth. Accurate forecast of demand for an airport is of crucial importance for its construction, investment and management (Xiao, 2014).

Air transportation provides some social and economic advantages that other transport modes could. In addition, air transportation enables the accessibility to distant destinations safely and swiftly. On account of the developments in electronical communication era, including especially the Internet, worldwide trading has increased. The need for a safe and secure delivery service has expedited air transportation of cargo. Goods, equipments and staff have achieved a dynamism of accessing every destination wolrdwide within 24 hours thanks to air transportation (Atik et al., 2013).

Aviation sector provides an invaluable contribution to the development of the countries in the aspect of employing youth, increasing export of goods and service. In this context, a research conducted for IATA (International Air Transport Association) has revealed that aviation sector has provided an employment opportunity for 6.7 million people in 22 European countries and 200 billion USD of income. According to another research conducted in the USA, planning a flight to London from an American city will have a contribution of 268 million USD to the US local economy for the first year. It is also revealed that Chicago Airport has provided a job opportunity for 420 - 510 thousand people and a passenger flying to international destinations has contributed five times more (2310 USD) than a passenger flying domestically (Sarılgan, 2007). Besides, according to some research carried out in Europe, an increase of 1000 passengers for an airport provides a job opportunity for about 4 people (Sarılgan, 2007).

Considering the geographical position of Turkiye and the developments in air transportation in the future, it is estimated that important opportunities will be obtained. However, it is obvious that much effort needs to be made regarding the recent trading criteria. According to the analysis of the "Turkish Civil Aviation Assembly Sector Report 2012 published by the Union of Chambers and Commodity of Exchanges of Turkiye, it is stated that 150 thousand people were supplied with a job and Turkish Civil Aviation Sector made a profit of 15 billion USD in 2012 (Turkish Civil Aviation Assembly Sector Report 2012, 2013). Besides, according to IATA Press Release, aviation sector contributed 2,2 trillion USD to the economy worldwide and provided jobs for 5,5 million people directly. In addition, civil aviation sector provided jobs for 57 million people in total (IATA Pres Release, 9 Ocak 2013).

Accurate forecasts of the air transportation is crucial regarding the precautions that will be taken in the future. The present study, which is based on domestic and international aviation statistics of 2007-2014, argues for the comparison of selected Turkish cities for future of air transport market (2015-2019) based on time series forecasting model. It involves a comparison of the development that was made in the air transportation in the four largest cities of Turkey, namely, Istanbul, Ankara, Antalya and İzmir as well as in Turkiye overall for a period covering the years 2007–2014. In addition, thanks to the time series forecasting model to be proposed here, some projections and predictions regarding the period of 2015–2019 will be put forth. The results obtained here will ultimately be able to give a certain guidance to the planners and the policy makers.

Statistical Models for Forecasting

In general, there are two groups of methods for air transport demand forecasting, one is qualitative and the other is quantitative. *Qualitative methods,* e.g.,market surveys, Delphi method and expert meetings, etc. analyze the characteristics of the air transport market to determine empirically how the usage of an airport varies across different sectors of the population. *Quantitative methods,*usually establishmathematical forecastingmodels based on historical statistical data. Since the latter are more objective and precise, they have drawn more and more attentions. According to the difference of quantitative forecasting methods, they can be divided into three categories; time series, causal analysis and combination forecasting (Xiao, 2014).

Time series forecasting is an important area of forecasting in which past observations of the same variable are collected and analyzed to develop a model describing the underlying relationship. The model is then used to extrapolate the time series into the future. This modeling approach is particularly useful when little knowledge is available on the underlying data generating process or when there is no satisfactory explanatory model that relates the prediction variable to other explanatory variables (Zhang, 2003).

Time series methods, establishing a mathematical model only by historical data, include Second-Degree Polynomial (Profillidis, 2000), ARIMA/SARIMA (Box & Jenkins, 1976), (Samagaio & Wolters, 2010), (Tsui et al., 2014), Logit Model (Dupuis et al., 2012), Gravity Model (Grosche et al., 2007), Exponential Smoothing (Samagaio & Wolters, 2010), Gray Theory (Hsu and Wen, 2000), (Yin, 2013), which is multidisciplinary and generic theory that deals with systems characterized by poor information and/or for which information is lacking, Fuzzy System Method (Mardani et al.,2015), Holt-Winters, etc. Alekseev and Seixas (2009) developed a hybrid approach based on decomposition and back-propagation neural network (BPNN) for air transport passenger analysis. Time series methods assume that all the factors that determined the development of demand in the past, will continue to operate in the sameway in the future (Petrovic, Xie and Burnham, 2006). Although there are a number of studies which claim better forecasting performance than the other comparative methods, however, there is no method performing best across all scenarios. The optimal choice depends on both the time series characteristics like volatility or existence of long-term trends and the forecasting horizon (Schlüter and Deuschle, 2010).

Mathematical modeling

Time series including aircraft and passenger can be decomposed of three sub functions such as trend, seasonal, and irregularity component. A trend component shows a long term movement in a time series. It is the underlying direction showing an upward or downward tendency of a time series. A seasonal component describes any regular fluctuations. It is the component of variation in a time series which is dependent on the time of year. The last component named irregular or noise component is that left over when the other components of the series have been accounted for. It includes random fluctuations in a time series.

A functional for air transportation time series can be defined as the sum of a trend (f_t), a seasonal (f_s), and an irregularity (f_{ir}) functions like the following (Majani, 1987):

$$f(t) = f_t(t) + f_s(t) + f_{ir} \quad (1)$$

It is possible to use different trend functions in a functional. Exponential, polynomial, power, or even rational functions may be selected as a trend function. Among the possible trend functions, we preferred to use second-degree polynomial function (Pehlivanoğlu and Atik, 2015). Because; Polynomial function shows an increasing character. Therefore, its forecasting nature shows the existence of development in the future of industry. Based on the preferred function descriptions, a trend function such as a second degree polynomial, a periodic function like sinusoidal, and an irregular function such as logistic distribution as follows:

$$\hat{f}_i(t) = f_{i,t} + f_s + f_{ir} \quad (2)$$

where

$$f_t = \beta_1 t^2 + \beta_2 t + \beta_3 \quad (3)$$

$$f_s = \beta_4 \sin\left[\frac{2\pi}{\beta_5} t + \beta_6\right] \quad (4)$$

$$f_{ir} = \beta_7 rand(\text{'Logistic'}, \mu, s) \quad (5)$$

In this functional: β_1 is the coefficient of leading term, β_2 is another coefficient of the second term, and β_3 is the constant term. Similar to previous description, β_4 is amplitude, β_5 is a period, β_6 is a phase shift, and β_7 is a scale factor of irregularity. μ is the mean and s is a parameter related to standard deviation;

$$s = \frac{\sqrt{3}}{\pi}\sigma \quad (6)$$

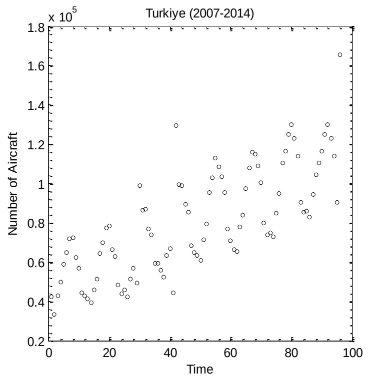
The β_i coefficients in each combination can be determined via a proper optimization process such as genetic algorithm. The objective function is usually a least-squares function given by

$$\sum_{i=1}^{n} (\hat{f}_i - f_i)^2 \quad (7)$$

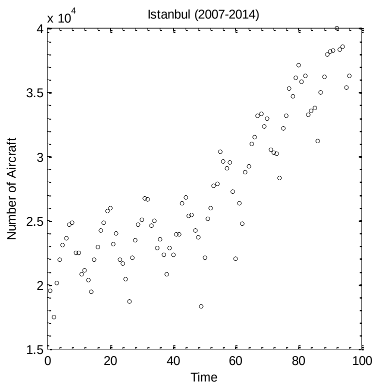
Where f_i is i^{th} value of a time series and $\hat{f}_i$ is i^{th} value of the computed response obtained from the forecasting model.

Model Constructions

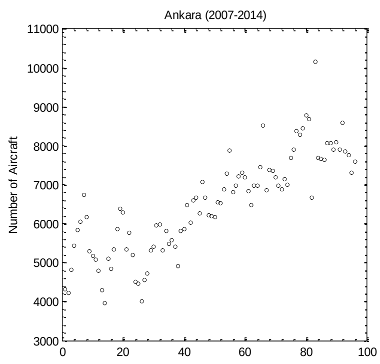
Two different quantities such as the number of aircraft take-off and landed and the number of passengersin domestic and international flights are taken into consideration for the future expectations. The data obtained from the official website of the General Directorate of State Airports Authority of Turkiye database(http://www.dhmi.gov.tr)is used inour experimentsand it is the total values of Turkish airports.The time series includes the monthly total numbers between January 2007 and December 2014 which means 96 observations. The following figure1 and figure 2 show the current data for each quantity.



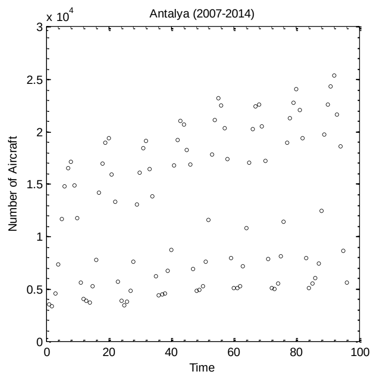
(a) Real data and general trend for Turkiye.



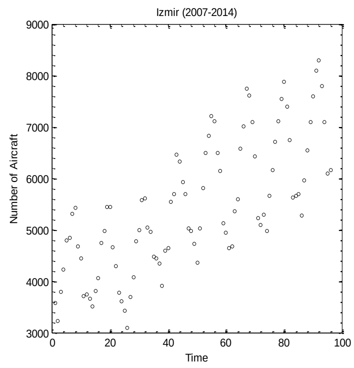
(b) Real data and general trend for Istanbul.



(c) Real data and general trend for Ankara.

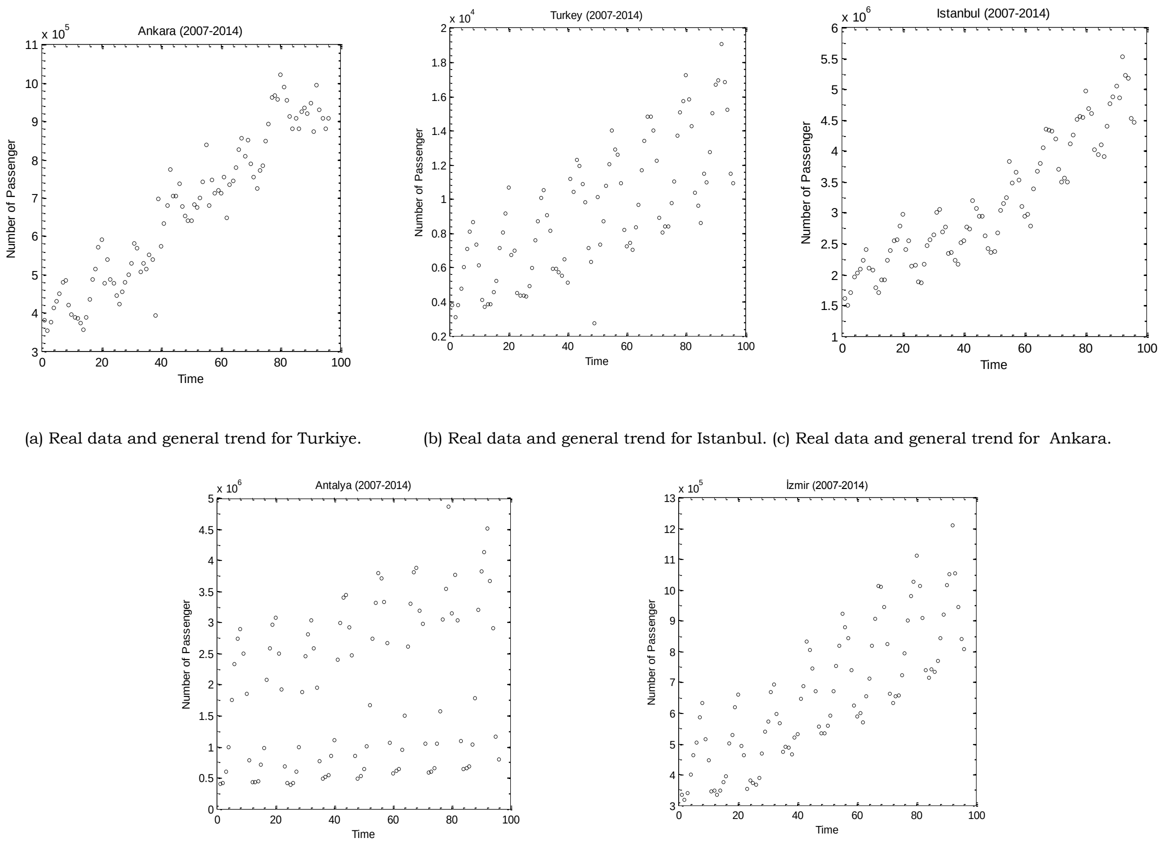


(d) Real data and general trend for Antalya.



(e) Real data and general trend for Izmir.

Fig. 1 The number of aircraft take-off and landed.



(a) Real data and general trend for Turkiye. (b) Real data and general trend for Istanbul. (c) Real data and general trend for Ankara.

(d) Realdata and general trend for Antalya. (e) Real data and general trend for Izmir.

Fig. 2 The number of airline passengers.

Forecasting Model for Aircraft Quantity

The forecasting model such as $\hat{f}_I(t)$ is constructed to make estimates for the future of **aircraft quantities in Turkiye, Istanbul, Ankara, Antalya and Izmir**. At the end of the optimization process, the functional is constructed by the following expression:

The functional for **"Turkiye"**is constructed by the following expression:

$$\hat{f}_I(t) = 2.308t^2 + 488.687t + 49{,}730.935 + 20{,}004.742 \sin\left[\frac{2\pi}{12.037}t + 35.464\right] - 2{,}320.257 rand\,(\text{Logistic}',0,\sqrt{3}/\pi) \quad (8)$$

The functional for **"Istanbul"** is constructed by the following expression:

$$\hat{f}_I(t) = 2.365t^2 - 50.432t + 2{,}2531.5 + 2{,}751.361 \sin\left[\frac{2\pi}{11.945}t + 85.607\right] + 245{,}565 rand\,(\text{Logistic}',0,\sqrt{3}/\pi) \quad (9)$$

The functional for **"Ankara"** is constructed by the following expression:

$$\hat{f}_I(t) = -0.244t^2 + 64.171t + 4{,}137.949 + 534.605 \sin\left[\frac{2\pi}{12.013}t + 98.368\right] + 94.526 rand\,(\text{Logistic}',0,\sqrt{3}/\pi) \quad (10)$$

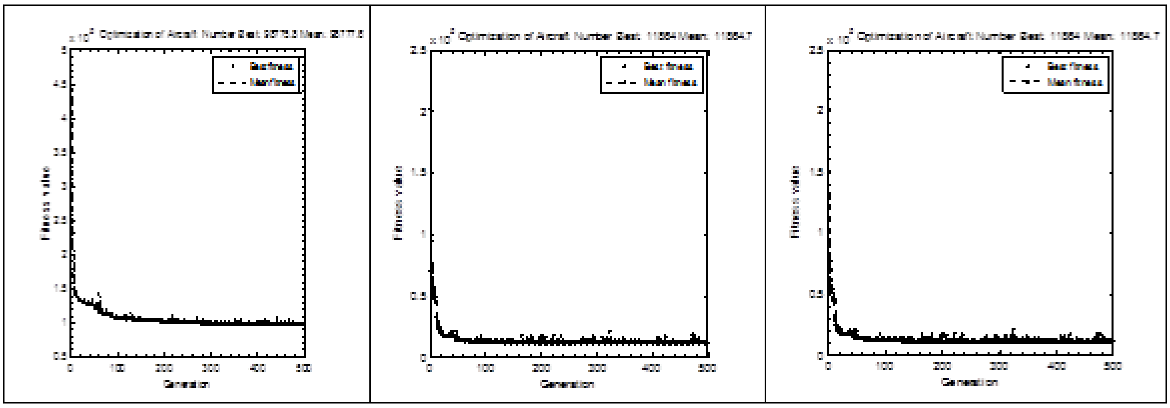
The functional for **"Antalya"** is constructed by the following expression:

$$\hat{f}_I(t) = -0.087t^2 + 70.03t + 9{,}348.88 + 9{,}066.68\sin\left[\frac{2\pi}{11.968}t + 22.794\right] + 163.433 rand\,(\text{Logistic}, 0, \sqrt{3}/\pi) \quad (11)$$

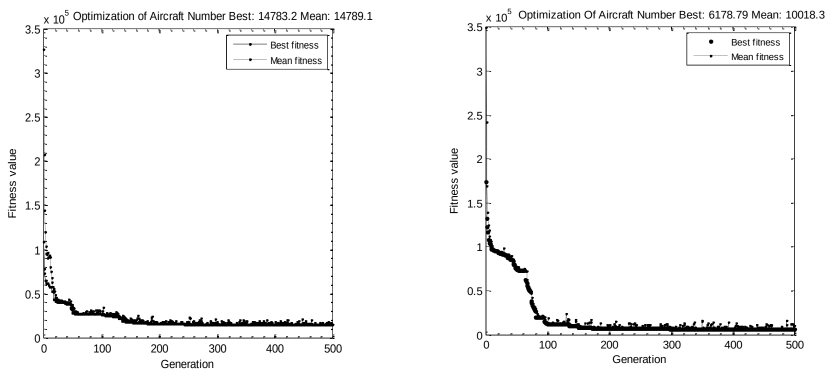
The functional for **"Izmir"** is constructed by the following expression:

$$\hat{f}_I(t) = 0.852t^2 - 54.95t + 5{,}470.929 + 1{,}132.802\sin\left[\frac{2\pi}{11.849}t + 16.253\right] - 84.006 rand\,(\text{Logistic}, 0, \sqrt{3}/\pi) \quad (12)$$

The period of a seasonal function is about 12 as expected. The genetic optimization process results including the best fitness values versus generations are depicted in Fig. 3.



(a) Optimization process for Turkiye. (b) Optimization process for Istanbul. (c) Optimization process for Ankara



(d) Optimization process for Antalya. (e) Optimization process for Izmir.

Fig. 3 TheOptimization process for Turkiye and selected cities.

4.2 Forecasting Model for Passenger Quantity

Similar to the previous analysis, the forecasting model such as $\hat{f}_I(t)$ is constructed to make estimates for the future of **passenger quantities in Turkiye, Istanbul, Ankara, Antalya and Izmir**. At the end of the optimization process, the functional is constructed by the following expression:

The functional for **"Turkiye"** is constructed by using the following expression:

$$\hat{f}_I(t) = 0.666t^2 + 33.791t + 5{,}618.512 + 3{,}333.593 \sin\left[\frac{2\pi}{11.987}t + 22.859\right] + 49.119 rand\left('Logistic',0,\sqrt{3}/\pi\right) \quad (13)$$

The functional for "Istanbul" is constructed by using the following expression:

$$\hat{f}_I(t) = 326.056t^2 + 324.609t + 2{,}161{,}956.303 + 449{,}689.427 \sin\left[\frac{2\pi}{11.894}t + 3.812\right] + 572.451 rand\left('Logistic',0,\sqrt{3}/\pi\right) \quad (14)$$

The functional for "Ankara" is constructed by using the following expression:

$$\hat{f}_I(t) = 9.217t^2 + 5{,}745.96t + 358{,}799.895 + 51{,}848.665 \sin\left[\frac{2\pi}{11.645}t + 15.89\right] + 1{,}197.895 rand\left('Logistic',0,\sqrt{3}/\pi\right) \quad (15)$$

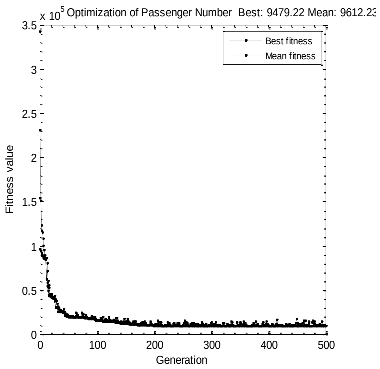
The functional for "Antalya" is constructed by using the following expression:

$$\hat{f}_I(t) = 40.579t^2 + 6{,}169.597t + 1{,}499{,}351.651 + 1{,}602{,}822.427 \sin\left[\frac{2\pi}{11.901}t - 128.201\right] + 385.002\, rand\left('Logistic',0,\sqrt{3}/\pi\right) \quad (16)$$

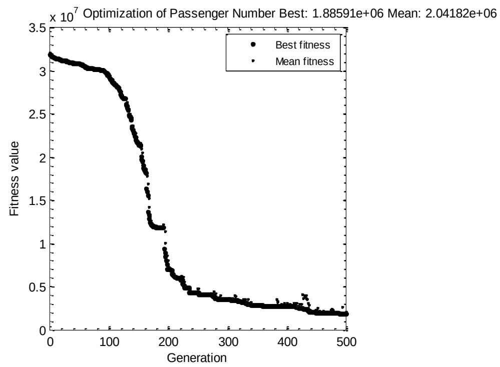
The functional for "Izmir" is constructed by using the following expression:

$$\hat{f}_I(t) = -12.672t^2 + 7459.939t + 335{,}351.694 + 163{,}191.655 \sin\left[\frac{2\pi}{12.119}t + 86.00\right] + 6{,}516.718 rand\left('Logistic',0,\sqrt{3}/\pi\right) \quad (17)$$

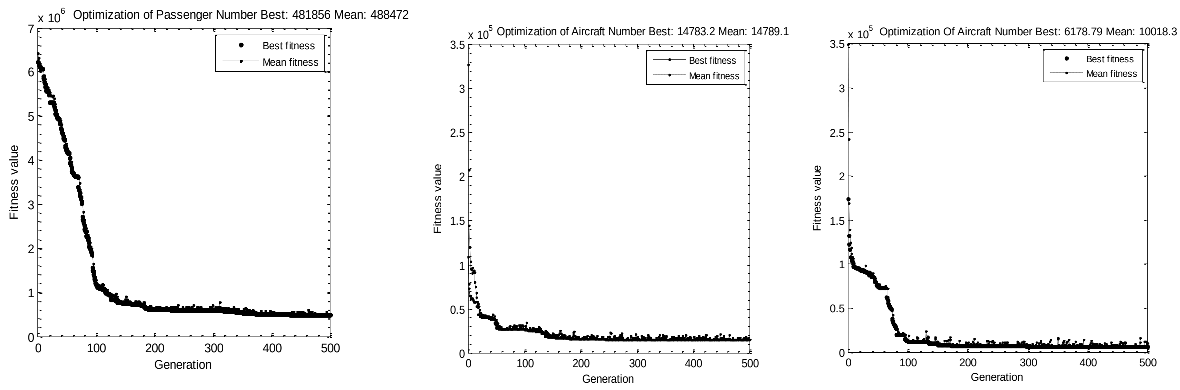
The period of a seasonal function is about 12 as expected. The genetic optimization process results including the best fitness values versus generations are depicted in Fig. 4.



(a) Optimization process for Turkiye.



(b) Optimization process for Istanbul.



(c) Optimization process for Ankara. (d) Optimization process for Antalya. (e) Optimization process for Izmir.

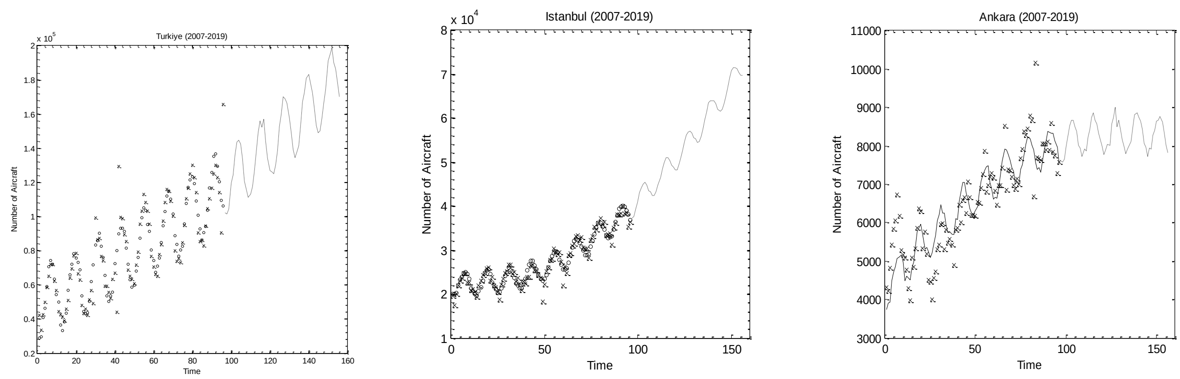
Fig. 4 The Optimization process for Turkiye and selected cities.

Similar to the previous conclusion, the figures and best fitness values show that the polynomial fits. The number of passengers carried by Turkish airline industry is in rising trend. The future does not show a stagnation process.

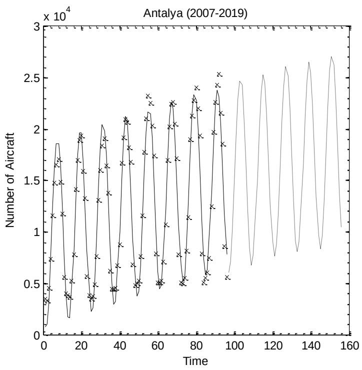
The Future of Turkish Air Transport Market: 2015-2019

The Forecast for The Number of Aircraft

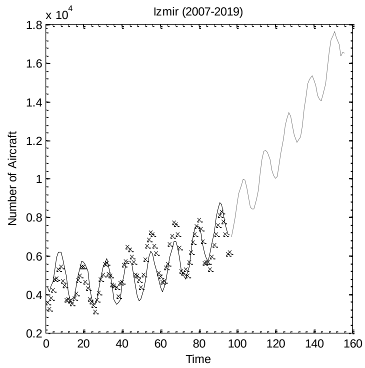
Optimization results shows that a forecasting model based on a second degree polynomial, a periodic function, and an irregular function fits better and can be taken into consideration for future expectations. It is possible to use Eq. (8,9,10,11,12) to make **the forecast for the number of aircraft** in Turkiye and selected cities. Similarly, Eq. (13,14,15,16,17) can be utilized to make **the forecast for the number of passengers.**For that purpose, we need to establish a time horizon. A five-year term including 2015-2019 years and 60 months in total is selected as the long-term time horizon.



(a) Real data and the future expectations for the thenumber of aircraft in Turkey. (b)Real data and the future expectations for the number of aircraft in Istanbul. (c)Real data and the future expectations for the number of aircraft in Ankara.



(d)Real data and thefuture expectations for the number of aircraft in Antalya.



(e)Real data and the future expectations for the number of aircraft in Izmir.

Fig. 5 The future expectations for the number of aircraft in Turkeyand selected cities.

The estimated numbers of aircraft amount versus months forecasted by Eq. (8,9,10,11,12) are shown in Fig. 5. Additionally; the minimum, the maximum, an average, and the total number of aircraft in each year are tabulated in Table I,II,III,IV and V. On Fig. 5, the real data belong to the past and the forecasted data are depicted together.

According to the forecasting model of **Turkiye**, it is expected to increase % 9.06 in the number of aircraft take-off and landed in each year. At the end of five-year term, the number of aircraft is going to be around 2,106,900. This increase means %41.47 development in total.

Table I Future data for the number of aircraft in **Turkiye**

Year	Min.	Max.	Average	Total
2015	101,410	144,720	124,110	1,489,300
2016	111,310	157,080	135,470	1,625,700
2017	125,170	170,150	148,670	1,784,000
2018	134,510	183,230	161,460	1,937,500
2019	148,950	198,890	175,580	2,106,900

According to the forecasting model of **Istanbul,** it is expected to increase % 12,83 in the number of aircraft take-off and landed in each year. At the end of five-year term, the number of aircraft is going to be around 821,500. This increase means % 62.09 development in total.

Table II Future data for the number of aircraft in **Istanbul**

Year	Min.	Max.	Average	Total
2015	37,167	45,336	42,235	506,820
2016	42,374	51,048	47,816	573,790
2017	48,222	57,028	54,034	648,410
2018	54,745	63,933	60,922	731,060
2019	62,059	71,462	68,458	821,500

According to the forecasting model of **Ankara,** it is expected to increase % 0.34 in the number of aircraft take-off and landed in each year. At the end of five-year term, the number of aircraft is going to be around 99,114. This increase means % 1.37 development in total.

Table III Future data for the number of aircraft in **Ankara**

Year	Min.	Max.	Average	Total
2015	7,574.7	8,676.7	8,147.5	97,770
2016	7,733	8,863.5	8,290.2	99,482
2017	7,767.1	9,006	8,316.2	99,795
2018	7,788.8	8,866.7	8,317.2	99,806
2019	7,724.8	8,769.2	8,259.5	99,114

According to the forecasting model of **Antalya,** it is expected to increase % 3.49 in the number of aircraft take-off and landed in each year. At the end of five-year term, the number of aircraft is going to be around 214,780. This increase means % 14.72 development in total.

Table IV Future data for the number of aircraft in **Antalya**

Year	Min.	Max.	Average	Total
2015	6,004.4	24,646	15,601	187,210
2016	6,789.8	2,524.5	1,614.8	193,770
2017	7,646.8	26,091	16,833	201,990
2018	8,045.4	26,494	17,297	207,570
2019	8,380.4	27,086	17,898	214,780

According to the forecasting model of **Izmir,** it is expected to increase % 17.06 in the number of aircraft take-off and landed in each year. At the end of five-year term, the number of aircraft is going to be around 197,790. This increase means %87.80 development in total.

Table V Future data for the number of aircraft in **Izmir**

Year	Min.	Max.	Average	Total
2015	6,985.2	9,954.6	8,776.7	105,320
2016	8431.3	11,491	10,338	124,060
2017	10,104	13,416	12,148	145,780
2018	12,171	15,363	14,229	170,740
2019	14,367	17,671	16,482	197,790

When we take a look at the table VI, which compares the projections concerning Turkiye and the four most developed cities in the aviation, we can see that there is a match between the growth rate of Turkiye at large and the growth rates of Istanbul and Izmir for the period of 2015-2019. On the other hand, the growth rates of Ankara and Antalya are quite low when compared with Turkiye at large as well as with the other cities.

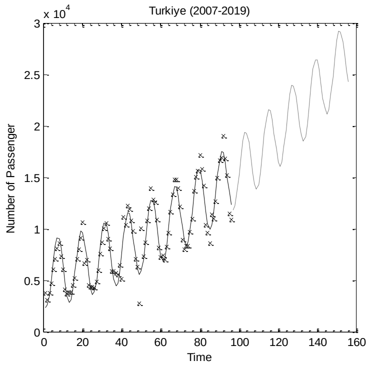
Table VI Comparison (%)

Year	Turkiye	Istanbul	Ankara	Antalya	Izmir
2015*	10.79	15.31	3.54	5.24	28.83
2016	9.16	13.21	1.75	3.50	17.79
2017	9.74	13.0	0.31	4.24	17.50
2018	8.60	12.74	0.01	2.76	17.12
2019	8.74	12.37	-0.07	3.47	15.84
2015-2019 Average*	9.40	13.32	1.11	3.84	19.41

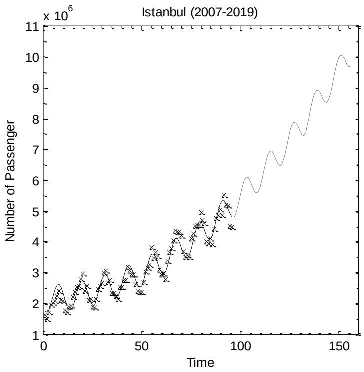
*(By using real data of 2014)

The Forecast for The Number of Passenger

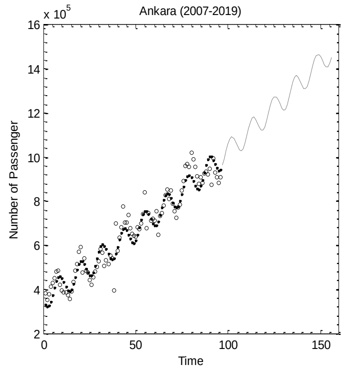
The estimated numbers of passengers carried by airlines versus months forecasted by Eq. (13,14,15,16,17) are shown in Fig. 6. In addition to this figure, the minimum number of passengers, the maximum number of passengers, an average number of passengers, and the total number of passengers in each year are tabulated in Table VII,VIII, IX,X and XI.



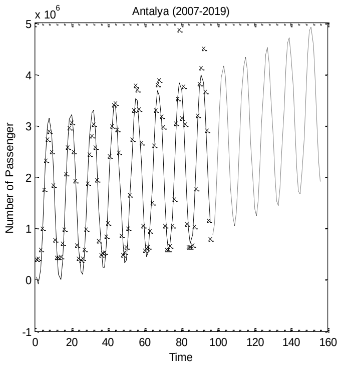
(a)Real data and the future expectations for the number of passenger in Turkiye.



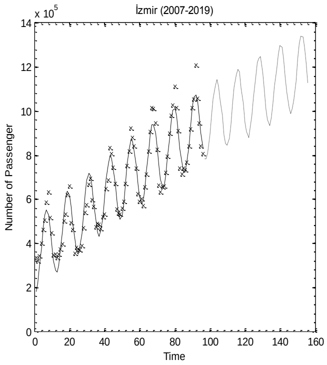
(b)Real data and the future expectations for the number of passenger in Istanbul.



(c)Real data and the future expectations For the number of passenger in Ankara.



(d)Real data and the future expectations for the number of passenger in Antalya.



(e)Real data and the future expectations for the number Of passenger in Izmir.

Fig. 6 The future expectations for the number of passenger in Turkey and selected cities.

According to the forecasting model of **Turkiye,** it is expected to increase % 12.52 in the number of passengers in each year. At the end of five-year term, the number of passengers is going to be above 309.49 million. This increase means % 60.3 development in total.

Table VII Future data for the number of passengers in **Turkiye (x 1000)**

Year	Min.	Max.	Average	Total
2015	11,871	19,442	16,088	193,060
2016	13,937	21,595	18,235	218,820
2017	16,124	23,971	20,573	246,880
2018	18,543	26,485	23,078	276,940
2019	21,164	29,275	25,791	309,490

According to the forecasting model of **Istanbul,** it is expected to increase % 14.30 in the number of passengers in each year. At the end of five-year term, the number of passengers is going to be above 115.16 million. This increase means % 70.73 development in total.

Table VIII Future data for the number of passengers in **Istanbul (x 1000)**

Year	Min.	Max.	Average	Total
2015	4,812.3	6,101.9	5,620.7	67,449
2016	5,624.7	6,956.2	6,473.7	77,684
2017	6,534.5	7,900.8	7,420.5	89,046
2018	7,536.3	8,939.8	8,461.1	101,530
2019	8,635.4	10,071	9,596.3	115,160

According to the forecasting model of **Ankara,** it is expected to increase % 8.22 in the number of passengers in each year. At the end of five-year term, the number of passengers is going to be above 17.17 million. This increase means % 37.23 development in total.

Table IX Future data for the number of passengers in **Ankara (x 1000)**

Year	Min.	Max.	Average	Total
2015	962.25	1,091.9	1,043	12,517
2016	1,061.9	1,180.5	1,136.3	13,636
2017	1,164.7	1,272.4	1,232.7	14,792
2018	1,270.9	1,368.9	1,331.2	15,975
2019	1,380.3	1,464.5	1,431.4	17,177

According to the forecasting model of **Antalya,** it is expected to increase % 6.972 in the number of passengers in each year. At the end of five-year term, the number of passengers is going to be above 40.0 million. This increase means % 30.96 development in total.

Table X Future data for the number of passengers in **Antalya (x 1000)**

Year	Min.	Max.	Average	Total
2015	876.67	4,167.6	2,545.6	30,547
2016	1,051.6	4,345.7	2,725.1	32,701
2017	1,242.8	4,530.4	2,916.3	34,996
2018	1,449.6	4,722.4	3,119.4	37,433
2019	1,672.8	4,921.5	3,334	40,007

According to the forecasting model of **Izmir,** it is expected to increase % 4.90 in the number of passengers in each year. At the end of five-year term, the number of passengers is going to be above 14.04 million. This increase means % 21.12 development in total.

Table XI Future data for the number of passengers in **Izmir (x 1000)**

Year	Min.	Max.	Average	Total
2015	781.28	1,144.3	966.4	11,597
2016	843.74	1,188.4	1,022.3	12,268
2017	878.24	1,248.2	1,074.8	12,898
2018	933.49	1,298.7	1,125.3	13,503

2019	988.82	1,338.7	1,170.5	14,047

When we take a look at the table XII, which compares the projections about the number of passangers concerning Turkiye and the four most developed cities in the aviation, we can see that there is a match between the growth rate of Turkiye at large and the growth rate of Istanbul for the period of 2015-2019. On the other hand, the growth rates of Ankara, Antalya and Izmir are quite low when compared with Turkiye at large as well as with Istanbul.

Table XII Comparison (%)

Year	Turkiye	Istanbul	Ankara	Antalya	Izmir
2015*	16.32	18.42	13.66	7.78	6.03
2016	13.34	15.17	8.94	7.05	5.78
2017	12.82	14.62	8.47	7.02	5.13
2018	12.17	14.02	7.99	6.96	4.69
2019	11.75	13.42	7.52	6.87	4.03
2015-2019 Average*	13.28	15.13	9.31	7.13	5.13

*(By using real data of 2014)

Conclusions

The purpose of this paper was to construct mathematical models to forecast the Turkish air transport market in long-term period. For this purpose we first presented the short review of the main classical forecasting methods and also gave a brief introduction into a mathematical modeling. For our empirical study, we chose a combination of three basic functions such as a trend function, a seasonal function, and an irregularity function. A genetic algorithm process was used to determine the coefficients of each function. We tested a second degree polynomial as a trend function, a periodic function like sinusoidal, and an irregular function such as logistic distribution fits better. The results also confirmed that the Turkish air transport market is an emerging market. According to the forecasting based on the constructed mathematical models, we project a 62.09 % increase in Turkish aircraft traffic and a 60.3 % increase in Turkish air passenger traffic between 2015-2019 years.

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