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DEVELOPMENT OF A REGRESSION MODEL TO FORECAST AIR TRAVEL DEMAND AT BAGHDAD INTERNATIONAL AIRPORT

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Abstract: The civil aviation demand forecast is a carefully formed perspective for airport system activities. Its main use is to predict possible needs for the planning and financial management processes for air carriers and civil aviation authorities. It is vital to conduct frequent analyses and projections of demand in order to meet their customers' expectations by balancing supply and demand and staying abreast of the ever-changing aviation industry. The purpose of this paper is to establish a mathematical relationship between the socioeconomic explanatory factors such as (population, Gross Domestic Product (GDP), consumption expenditure, rate of exchange, industry, imports, and exports) and activities (passenger movements and aircraft operations) at Baghdad International Airport in order to develop an econometric model. The required data had been collected for the past ten years. Eight models were developed depending on one or more of the explanatory variables using SPSS software, and they were then subjected to cross-comparison to see which model was more robust. According to the findings of the statistics, the gross domestic product, population size, and consumption expenditure are the most appropriate explanatory variables that have a significant impact on these activities, where it had a high R^2 and F-statistics value equal to 90% and 73.442, respectively, for the model of air passengers and GDP and 90% and 48.737 for the model of flight operations and GDP.

Keywords: *Iraqi hub airport; socio-economic variables; SPSS software; statistical analysis*

1. Introduction

In view of Iraq's political and economic conditions, the development of air transport is still in progress, and this is a difficult stage until it's overcome. External and internal factors have long influenced the aviation industry, most notably due to country conditions or the seasonal and cyclical nature of demand, which can vary greatly by day, week, and season [1];[2].

Air transportation is one of the world's most important investment sectors. It is billed as the speediest, most comfortable, and safest mode of transport for both citizens and commodities. As a result, air travel has several characteristics that set it apart from other modes. As well as one that greatly contributes to global economic progress, political stability, and an increase in social values. The estimation of air travel demand is an important factor in air carrier and new line planning, as well as potential markets, strategic plans, and the financial sector [3]. Schmalz et al. (2017) [4] studied variables impacting demand, including population, Gross Domestic Product (GDP), income, labor market, commerce, schedule, and airfares. Population growth or GDP increases demand, and airfare adjustments impact the elasticity of demand. Single events, such as exogenous crises caused by epidemics or political events, can influence passenger

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behavior patterns in some cases. The airlines' challenge is to plan and implement a schedule with a large variety of destinations and fewer flights.

The cyclical nature of air travel demand occurs in an obvious way in the main hub airport. The calculation of such types of demand is a very challenging task, particularly at airports, due to the variety of causes that are frequently difficult to quantify or estimate. As a result, it is assumed that using regression statistical analysis to establish the relationship between demand and independent variables is the best way to estimate demand.

The air travel demand study is a critical component of the airport's operational capacity planning. As a result, analyzing air travel demand allows operators to optimize their financial and human resources, as well as forecast future recruitment and training needs. Furthermore, it assists air carriers in objectively evaluating current and future requirements by destination and route [5].

There are numerous measurements and techniques used in the field of aviation system forecasting. Tascón and Olariaga (2020) [6] classified the most used prediction approaches into two groups;

- Time-series methods such as the adapted Markov model, Smoothing techniques, and Seasonal adjustment method.
- Economic methods include the Causality test, Gravitational models and, Regression analysis.

It is worth noting that aviation industry management necessitates decision-making at all stages based on what is likely to happen in the future of air travel because current business activities must be based on yesterday's strategy and tomorrow's expectations [7].

Typically, a model is created to represent historical events and is used to forecast potential demand for air travel. It examines current and historical market and industry trends in order to make a case for the future by analyzing and determining the correlation between the dependent and independent variables. In this method, many secondary variables can be used by analyzing their direct or indirect impact on the main variable. Historical socioeconomic and aviation data will be components of the forecasting method [8].

No matter how sophisticated the techniques employed or how precise the numbers are, it is essential to note that "the forecasts are unpredictable and controversial since numerous variables, such as humans and their civilizations, are continually changing." In the aviation sector, forecast timeframes are typically short-term, medium-term, and long-term [9].

Forecasting techniques are classified into three types: qualitative, quantitative, and decision-analysis. Quantitative techniques are primarily used to forecast future numerical data by utilizing previous patterns. Quantitative forecasting approaches require the availability of historical data. In the absence of the relevant data, these strategies are useless. In this situation, qualitative methods that rely on the expertise, judgment, and experience of experts or specialists may be used. The third is created by fusing the first two [10].

Because of the importance of the topic, many researchers have been interested in analyzing and predicting factors impacting air demand: Firstly, Zehawi et al. (2016) [11] stated that the most critical variables in projecting passenger volume at two of the busiest American airports, Atlanta International Airport and John F. Kennedy International Airport, are per capita Income and population, both on a national and regional basis. Suryani et al. (2010) [12] used a system

dynamics approach to research runway extension, passenger terminal capacity, and estimates of air passenger demand. They discovered that the following factors significantly influence the aviation system: population size, GDP, ticket prices, the level of service provided at airports, and the frequency of daily flights. In addition, Rodriguez et al. (2020) [9] used dynamic linear models to forecast aviation traffic in Colombia. They obtained reliable predictions with high accuracy in medium term at least. In Saudi Arabia, Abed et al. (2001) [13] used statistical analysis SPSS/software to analyze and predict the international air travel industry via econometric models; they reached the conclusion that population volume, and total expenditures, are the best variables to represent modeling. Abate (2016) [14] investigated the economic implications of the air transport liberalization in Africa, focused on the supply parameters: ticket price and quality of service, tested by departure frequency, in comparison to routes governed by limiting air transport contracts: the result is an increase in departure frequency on paths that have undergone some form of liberalization, also has a significant impact on service quality. However, there is no evidence that it has a fare-lowering effect. In addition, Secilmis and Koc (2016) [3] studied the relationship between air transport demand volume and economic variables influencing it in Turkey and the European Union: According to the findings, there are two effects on air demand: national capita income and the industrial production index have a positive influence, while airfares, inflation, and the exchange rate have an inverse influence. Furthermore, Schmalz et al. (2017) [4] investigated the variables influencing European aviation demand in terms of both quantitative and qualitative data; the regression analysis revealed that the key variables of air demand are the country's GDP, education level, and geographical location. Solvoll et al. (2020) [15] performed a case study at a Norwegian airport to anticipate air traffic volume using two forecasting methodologies and compared the results; The lowest expectations of air travel led to the project's having a negative net present value, and conversely, in the case with the largest expectations, it is positive. Guo et al. (2016) [16] created a machine learning-based model for forecasting real-time quantile transfer passengers at Heathrow Airport. They found seven main variables affecting travelers' connecting times and divide them into 16 parts. Adding correlations between people coming on the same aircraft improves arrival predictions at customs and security. This approach outperforms many standards in both point and cumulative probability predictions. For more, using Ordinary Least Square (OLS) regression, Olaniyi and Adedotun (2018) [7] analyzed long-term prediction for international air travel demand in Nigeria. The results indicate that demand is increasing. Similarly, Danesi et al. (2017) [17] studied long-term and short-term passenger demand forecasting approaches at Bologna Airport. They detected both the basic averaging and the more sophisticated local regression methods work well, also by using bootstrapping for past data, the peak hour demand shown constant. Chudy-Laskowska (2017) [18] created a prediction of air passenger transport at one of Poland's airports.

The result showed that there are numerous factors that influence aviation movement: population, GDP, foreign currency volume and value, and levels of consumption. Finally, Albayrak et al. (2020) [19] looked at the variables affecting Turkey's air passenger traffic and observed that GDP per capita, population, tourists, accessibility to alternative airports,

emigration, and prototype cities all contribute to increased civil aviation volume.

2. Aim and objectives

The primary aim of this paper is to develop a mathematical model to predict the potential future demand at Baghdad International Airport. The following are the main points of this aim:

1- Collecting air traffic data in terms of aircraft operations and passenger movement and pertinent local socioeconomic data for the last 10 years.
2- Identifying and analyzing the factors that have a major impact on air demand.
3- Developing a regression model that is provided by utilizing SPSS software.

3. Study Area and Methodology

Baghdad International Airport has several codes, including (BGW) for the International Air Transport Association (IATA) and (ORBI) for the International Civil Aviation Organization (ICAO). It is the local hub and one of the six airports in the country that serve both civil and military sectors, located west of the capital. The airport's market area includes Baghdad and the surrounding governorates (Diyala, Salah al-Din, and Anbar), which have a great impact on this airport.

Although the goal of this research is to discover the association between explanatory factors (population, GDP, consumption expenditure, rate of exchange, industry, and imports and exports) and civil aviation activities (passenger movements and aircraft operations) at Baghdad International Airport and then created a mathematical model for the potential demand, it may also serve as administrative guidance for the Civil Aviation Authority at Baghdad International Airport to evaluate the proper size of the airport system, such as requirements for air sides (runways, taxiways) or for land sides (gates, terminals, aprons, etc.). Air carriers can also benefit from demand forecasting models, which allow them to estimate their offers In terms of manpower requirements, capacity use, training policy, financial resources, and others, to cope with these projected demand volumes [20].

The analytical approach is to be implemented by carrying out of two stages:

Stage 1- The historical data is explored to identify any correlation between the (independent and dependent) variables influencing air travel demand, for the last ten years (2010-2019). Data obtained should contain:

A. The size of the local population.
B. GDP stands for gross domestic product.
C. Final consumption expenditure.
D. The rate of exchange between the local currency and the US dollar.
E. Industry (including construction), value-added per worker.
F. Imports of goods and services.

Stage 2- Creation of a mathematical model to simulate and describe the size of potential demand by utilizing the SPSS software. The stepwise regression analysis has been selected as the analytical method to assess the most efficient explanation of variables to demand management. According to the statistically acceptable limits of the correlation coefficient, F-statistics, and measure of collinearity, as illustrated in the following models, this method either adds or removes an independent variable. As a result, it leaves the variables statistically significant and the data has a normal distribution with no collinearity between the explanatory variables. One of the most important advantages of this method is being able to control a wide range of potential independent factors and fine-tune a model to select the best ones.

4. Data Collection and Modeling

The gathering of historical civil aviation data was not an easy task; because it was private and varied from one governmental agency or department to another. The data from different sources for estimating the model has been collected for a ten-year period (2010–2019), except GDP, which has been collected for the period (2008–2017) to maintain a two-year lag behind aviation data. The sources are as follows:

1- Iraq Civil Aviation Authority / Planning department, as shown in Tables (1 & 2).
2- The social and economic characteristics from the Iraqi Ministry of Planning and the website of the World Bank's (World Development Indicators).

Aviation activities including aircraft movement and air passenger traffic are considered as criterion factors and the above social and economic factors as predictor factors. A "Stepwise" approach in the SPSS software is used to compute these equations. It is an iterative way of generating a multi-linear regression step by step, to select explanatory variables that are selected for inclusion in the final model, while unimportant parameters are neglected.

In this regard, it is important to note that the strength of the relationship between the socioeconomic characteristics and air traffic, but external conditions may occur that change the forecast trend of demand, as happened in 2014 (the factor of terrorism/war against ISIS) and 2019 (political conditions that the country witnessed).

The data used in this article, which relates to the aviation industry, is very large data and includes arrivals and departures for the last ten years. This information was compiled daily, monthly, and annually to make it easier to analyze, extrapolate and extract results.

Table 1. Data of Baghdad International Airport passenger movements

Year	Arriving passengers	Departing passengers
2010	504785	517595
2011	502876	514022
2012	664005	655981
2013	632994	655167
2014	913547	992292
2015	989594	1151164
2016	884854	902393
2017	1751372	1756538
2018	1978299	2038803
2019	1907517	1889896

Source: Iraq Civil Aviation Authority

Table 2. Data of aircraft operations at Baghdad International Airport

Year	Landing flights	Departure flights
2010	5940	5987
2011	5718	5751
2012	6953	6978
2013	6960	7044
2014	8759	8890
2015	10193	10337
2016	8389	8469
2017	15591	15751
2018	19458	19480
2019	18615	18650

Source: Iraq Civil Aviation Authority

It is worth mentioning that the main reason for choosing the above factors for a model is that the aviation system-based factors such as fares are almost constant, therefore they are not useful in developing any model.

The relationship between variables was investigated using a multi-linear regression model stepwise method in which they were the

local population, GDP, final consumption expenditure, local exchange rate (to dollars), industry (including construction) value-added per worker, and imports of goods and services are the explanatory variables in the work. As a result, flights operation and passenger movements were considered to be criterion variables.

By studying the correlation matrices in Tables 3 and 4, it is obvious how close the results are due to the positive relationship between air passengers and flight operations. Any increment in socio-economic characteristics, which are the controlling factors, causes a rise in air demand, and as a result, aviation authorities maximize their flights to accommodate the situation.

Table 3. Correlation matrix for total passenger movements

	Y_1	X_1	X_2	X_3	X_4	X_5	X_6
Y_1	1	0.82	0.95	0.95	0.71	0.82	0.74
X_1		1	0.90	0.88	0.74	0.67	0.48
X_2			1	0.99	0.73	0.88	0.74
X_3				1	0.73	0.83	0.71
X_4					1	0.55	0.43
X_5						1	0. 6
X_6							1

Table 4. Correlation matrix for total flight operations

	Y_2	X_1	X_2	X_3	X_4	X_5	X_6
Y_2	1	0.79	0.92	0.93	0.74	0.79	0.75
X_1		1	0.90	0.88	0.74	0.67	0.48
X_2			1	0.99	0.72	0.88	0.74
X_3				1	0.73	0.83	0.7
X_4					1	0.55	0.43
X_5						1	0.92
X_6							1

where:

Y_1: No. of total passengers.
Y_2: No. of total flights.
X_1: Final consumption expenditure in Iraqi dinar.
X_2: Local population size.
X_3: GDP in dollars.
X_4: Imports of goods and services in Iraqi dinar.
X_5: Industry (including construction) in Iraqi dinar.
X_6: Official exchange rate in Iraqi dinar.

There are several models that are calculated through regression equations, utilizing various variables that appear most pertinent to demand. Table 5, which represents the statistical outputs.

Table 5. Regression results

Model	R	R Square	F-statistics	VIF
1	0.950	0.902	73.442	1
2	0.909	0.826	16.572	1.294
3	0.946	0.895	67.985	1
4	0.817	0.667	16.004	1
5	0.927	0.859	48.737	1
6	0.895	0.801	13.141	1.294
7	0.921	0.847	44.457	1
8	0.792	0.628	13.493	1

The stepwise method produced eight models and is described as follows:

- Cases 1 and 5(X_3, X_1, X_6): the program chose one of the three independent variables, and (X_3) appears to be the most appropriate choice and the best model identification.
- Cases 2 and 6(X_1, X_6): the program chooses all of the variables.

- Cases 3 and 7(X_2, X_4): the program chose (X_2).
- Cases 4 and 8(X_2, X_5): the program chose (X_5).

Through the above statistical values in Table 5, there is a significant relationship between the variables in cases 1 and 5, which have the best fit. The regression line contains the majority of the observations for all models. This suggests a substantial correlation between the independent variable of passenger volume and flights. Moreover, R-squared values are normally between 0 and 1, with values closer to 1 indicating more accurate data, and the p-value significance is set at 0.05 or 5%. The null hypothesis is rejected if the p-value is less than 5%; this means there is a statistically significant difference between Y and X and the variables are accepted, and vice versa. If it is greater than 5%, the null hypothesis is accepted. Finally, the multi-collinearity test was conducted, and the result indicated that the variance inflation factor (VIF) was less than 3, suggesting that this problem did not exist. Besides that, multi-collinearity can arise as economic factors begin to move concurrently over time [21];[22];[23].

5. Results and Discussion

The statistical analysis results for the previously mentioned predictor factors reveal the following regression equations:

$$-51.264 + 2.544\,X_3 = Y_1 \quad (1)$$

$$-274.394 + 1.184\,X_1 + 35.382\,X_6 = Y_1 \quad (2)$$

$$-75.226 + 5.167\,X_2 = Y_1 \quad (3)$$

$$-35.59 + 4.553\,X_5 = Y_1 \quad (4)$$

$$-46.191 + 2.17\,X_3 = Y_2 \quad (5)$$

$$-252.875 + 0.966\,X_1 + 32.698\,X_6 = Y_2 \quad (6)$$

$$-66.413 + 4.394\,X_2 = Y_2 \quad (7)$$

$$-32.577 + 3.861\,X_5 = Y_2 \quad (8)$$

According to the estimated results of the models, the best were model 1 for passenger movements and model 5 for operating flights. These models obtained the greatest statistical determinants for R^2 (0.902 and 0.859), F-statistics (73.442 and 48.737), and VIF (1 for both models), indicating that the aviation movement in Iraq is totally dependent on socioeconomic factors. As demonstrated in the accompanying figures (1 to 4), during the study period, which lasted for the previous ten years, the variable GDP had a considerable impact on air travel demand, with the degree of convergence between actual and predicted statistics being highly statistically significant and varying depending on this component. Furthermore, these figures show the prediction in the short term of the volume of aviation activities in the next six years (2020–2025).

Furthermore, the social components indicated by population size have a significant impact on the aviation sector. As explained previously, various factors influence air traffic within a state. Leaving aside other resources such as airport basic structure or regulatory restrictions, the main emphasis was on population size, GDP, consumption expenditure, exchange rate, and industry. Therefore, the independent variables have significant coefficients and positive effects on air travel demand. That means when the (X1, X2, X3, X4, X5) are raised the demand average rises.

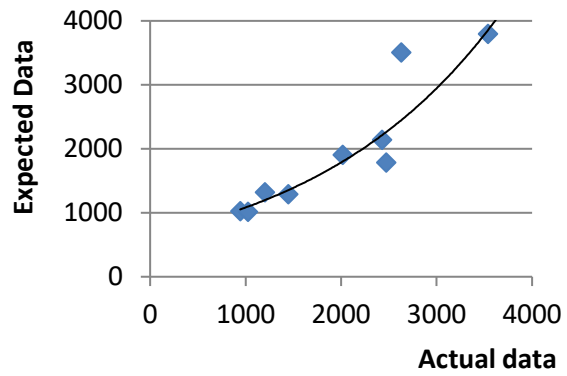

Figure 1. The relationship between actual and expected data for total passengers based on Model (1) in Thousands

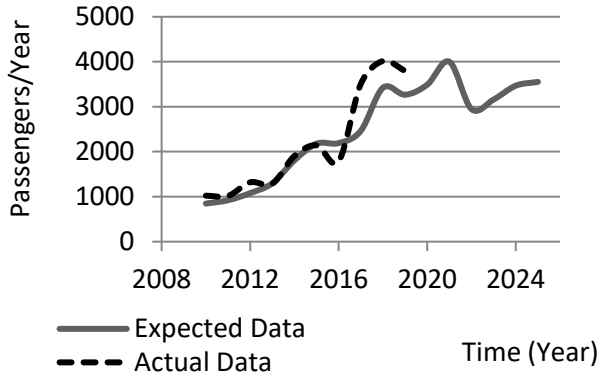

Figure 2. Actual and expected data for total passengers based on Model (1) in Thousands

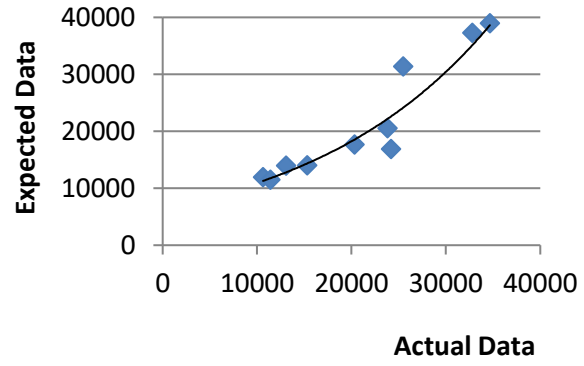

Figure 3. The relationship between actual and expected total flights based on Model (5)

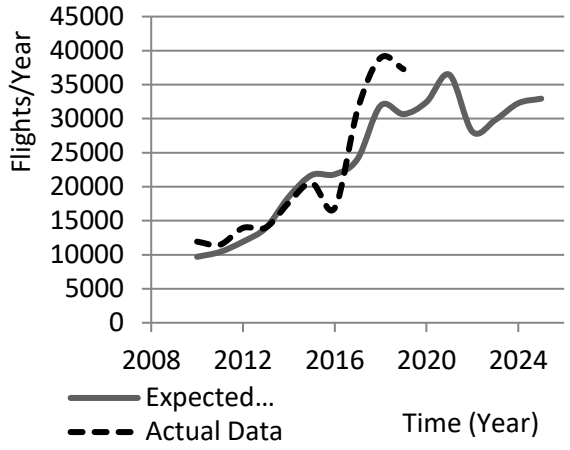

Figure 4. Actual and expected total flights data for Baghdad International Airport based on Model (5)

6. Conclusion

The essence of this paper is to analyse the levels of demand, which includes passenger movements and flight operations at Baghdad International Airport, using socioeconomic variables for the ten past years (2010–2019) to develop mathematical relationships that predict the level of future demand for the next six years (2020–2025).

The data was statistically analysed using the SPSS program's multi-linear regression approach to identify the numerous factors and determine the degree of the relationship between certain demand-influencing variables and the related aviation activities. Prior to selecting the optimal model that complies with the technique's limitations, a procedure that predicts all potential control variables has been utilized, followed by a Pearson correlation. The study results show demand was directly impacted by economic factors that had a delayed effect, such as the GDP, where it took 24 months for a change in demand to be noticeable. Also, the demand is influenced by population size, as a more significant demand base elevates the demand for mobility. Hence, a country's population must be

considered while measuring and forecasting the demand for air travel. Another variable that can be used as an explanation is the exchange rate between the local currency and the dollar, as the difference in currency exchange rates between countries significantly impacts the ability to attract flights.

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Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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