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Forecasting Methods for Domestic Air Passenger Demand in Nigeria

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ABSTRACT

Two years single moving average and simple exponential smoothing with smoothing constant of 0.9 were applied to forecast the 2018 demand for domestic air passenger in Nigeria. Also, the two methods of forecasting were evaluated and compared with Mean Squared Deviations (MSD) to determine which method gives the lowest deviation as it will produce best forecast for the year 2018 domestic air passenger demand in Nigeria. The study relied on data of domestic air passenger demand between the periods of the year 2010 to the year 2017. It was revealed that the MSD of two yearly single moving average gave the best year 2018 forecast as it has a lower MSD when compared to the MSD of simple exponential smoothing with the smoothing constant of 0.9. This study is useful in the planning process of an airport, airline, and other stakeholders involved in Nigeria's air transportation. It will help to prevent problems of having excess air transport demand over air transport supply or having excess air transport supply over demand.

1. Introduction

1.1. Background of the Study

Mobility is a very important aspect of human existence as it is highly connected to transportation. The significance attached to transportation cannot be far-fetched from or beyond: economic purpose, social integration, and spatial interaction, as this makes transport business worthwhile for investors and business owners. It has been affirmed that no transport organization can operate profitably and productively unless there is a demand for its services and the estimation of expected future demands is a key element in planning transport operations including air transport. Air transport service (product) is a derived demand that is rarely demanded to satisfy its own purpose [1]. It was stated that the derived nature of the air transport is attributed to the unique characteristics of air transport: The air transport demand is a product that cannot be stored or kept; the product is usually personalized (consumers feel differently about the product), which is referred to as heterogeneity of product; there is no replacement for bad product; it is difficult to test the product before usage; delivery of air transport cannot be guaranteed because of unpredictable factors; and the product can be produced only in batches and not in individual units [2, 3, 4].

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Air transport demand is the quantity of air transport service that consumers (mostly air passengers) are willing to buy at an agreed price. Economists categorized demand as effective demand and ineffective demand. Effective demand in air transport is defined as the quantity of air transport service that consumer (mostly passengers) are willing and able to buy at a given price. While ineffective demand is the willingness to buy but it is not backed up by ability to pay. The focus for this study was effective demands, hence the number of passengers that demanded for domestic air travel between the periods of the year 2010 to the year 2017.

Typically, all levels of management that are involved in the air transport business requires decision making. Decisions are made about what is likely to happen in air transport in the future as it is said that business actions taken today must be based on yesterday's plan and tomorrow's expectations which is referred to as expectations, predictions, projections; all referred to as forecasting. It has been said by various authors that forecasting is an attempt to predict the future by using qualitative and/or quantitative means. It is an integral part of all human activity which might involve advanced statistical techniques [5]. Virtually, every form of decision making and planning activity in business involves forecasting such as airline planning, airport planning, inventory control, investment cash flows, demand forecasts, corporate planning, budgeting, and others. Forecasting is not planning, it is an indispensable part of planning and a management tool for deciding now what the company must do to realize its objectives. The purpose of forecasting can be attached to the duration of forecast. Short-term forecasts normally span a period of one month to one year and cover such day-to-day operations; medium-term forecasts generally span a period of one to five years and involve such things as route-planning decisions, and long-term forecast spans a period of 5 to 10 years and might involve planning decisions for airport and airline infrastructures.

Air travel demand is one of the major inputs for fleet planning, route development and preparation of the annual operating plan. Analyzing and forecasting air travel demand helps reduce the airlines' and airports' risk by objectively evaluating the demand side of the air transport business. Accurate forecasting is essential for airport and airline managers to plan effectively and efficiently as inaccurate forecasting may lead to bad decisions and ineffectiveness in overall operations of management. As over-forecasting increases the labor/technical cost, administrative cost, having excess air transport supply over air transport demand, and other associated costs, so also does under-forecasting result in the problem of having excess air transport demand over air transport supply. Inadequate supply of air transport service lead to increased stress for air passengers who are the direct customer, and finally the under-forecasting will lower employee morale and ridicule and challenge the competency of airport and airline managers [7].

The aim of this study is to examine the different forecasting methods for domestic air passenger demand in Nigeria. The objectives of this study are to forecast the domestic air passenger demand in the year 2018 using two year single moving average; to forecast the domestic air passenger demand in the year 2018 using simple exponential smoothing with smoothing constant of 0.9, and to determine the most appropriate forecasting method by comparing two yearly single moving average with exponential smoothing of smoothing constant 0.9. This study is limited to domestic air passenger demand in Nigeria. The data is also limited to eight years from the period of the year 2010 to 2017.

2. Literature

In the applications of forecasting methods, time series forecasting techniques such as naïve model, moving average, double moving average, simple exponential smoothing, and semi average method have

been applied to forecasting. This section of the study reviews the various literatures related to the topic under consideration in order to uncover the critical facts and findings which have already been established, and identify gaps.

In a study conducted by Sahu and Kumar [10] on the evaluation of forecasting methods and their application for sales forecasting of the sterilized flavoured milk in Chhattisgarh. They applied weekly data spreading over October 2011 to October 2012 on the sales of sterilized flavoured milk in liter. The forecasting method analyzed included naïve model, moving average, double moving average, simple exponential smoothing, and semi average method. The accuracy of the forecasting method was measured using Mean Forecast Error (MFE), Mean Absolute Deviation (MAD), Mean Square Error (MSE), and Root Mean Squared Error (RMSE) [8]. Their study was limited to the application for sales forecasting of sterilized flavoured milk in Chhattisgarh and has nothing to do with air transport demand.

Cacatto et al. [9] introduced the forecasting practices that have been used by food industries in Brazil and detect how these companies have used forecasting methods, i.e. the main factors that influenced their choice. The data was analyzed by multivariate statistics techniques using the SPSS software. The result shows that the companies do not use sophisticated forecasting methods; the historical analysis model is the mostly used [9]. The factors that influence the choice of the models are the type of product and the time spent during the forecasting, and the main difficulties is the availability of the appropriate software. Also, Ryu and Sanchez [11] evaluated the forecasting method for institutional food service facility. They identified the most appropriate forecasting method of forecasting the demand for meal in an institutional food service facility. The analyzed forecasting method included the naïve model 1, 2 and 3, moving average method, double moving method, exponential smoothing method, double exponential method, Holt's method, Winter method, linear regression, and multiple regression method. The accuracy of forecasting methods was measured using mean absolute deviation, mean squared error, mean percentage error, mean absolute percentage error method, root mean squared error, and Theil's U- statistic. The result of their study showed that multiple regressions was the most accurate forecasting method; but the naïve method 2 was selected as the most appropriate forecasting method because of its simplicity and high level of accuracy [10].

In the field of aviation, the study carried out by Poore [8] aimed at testing the hypothesis that forecasts the future demand for air transportation offered by airplane manufacturers [6], and the aviation regulators are reasonable and representative of the trends implicit in actual experience. The tests compared forecasts provided by Boeing, McDonnell Douglas, Airbus Industry, and the International Civil Aviation Organization with actual results of a baseline model of the demand for Revenue Passenger Kilometers (RPKs). The model is a combination of two equations describing RPKs demanded by the high- and the low-income groups, respectively. Variations in RPKs demanded by the high-income group are related to changes in income per capita. Variations in RPKs demanded by the low-income segment are related to changes in population size. The model conforms to the assumptions and conditions for appropriate use of regression analysis [11]. The study did not include time series forecasting and it was not carried out in Nigeria. Abed et al. established time series model for the domestic and international air travel demand for Saudi Arabia. The authors use passenger numbers as a dependent variable and non-oil gross domestic product, consumer price index, imports of goods and services, population size, total expenditures, and the total consumption expenditure as explanatory variables. In the mentioned studies, author used four different model specifications in order to see forecasting performance of each model. As a result, they found out that the model with population size and total expenditure is the best model to explain passenger demand for both domestic and international

air transportation [12]. Their study did not include time series forecasting technique and it was not carried out in Nigeria.

Adeniran and Ben [4] carried out a study on econometric model of domestic air travel in Nigeria vis-à-vis some selected economic variables. Their study revealed that the predictors (economic variables) cannot give true estimate of the domestic air travel forecast due to the fact that the model estimate was not validated. The invalidation was as a result of the following- no statistical significant between the variables and problem of multi-collinearity presence; although the regression value signifies that the model can give a true forecast [4]. Their study does not include time series forecasting technique.

In summary of the previous studies, it was discovered that the majority of the studies carried out the adopted use of causative method of quantitative forecasting for air travel demand; the studies were not carried out in Nigeria, and the one carried out in Nigeria was limited to domestic air passenger travel. Hence, the major identified gaps are location gap, time gap, variable gap, and method of data analysis gap. This study therefore adopts two yearly single moving average and simple exponential smoothing with smoothing constant of 0.9 which are time series analysis to forecast domestic air passenger travel in Nigeria. The methods are preferred to those adopted in earlier researches, because the trend of data is medium and the method is simple.

Growth pole and growth centre theory

In the 1950s, French economist proposed a growth pole theory with the joint efforts of the French economist JR Boudeville [13]. The concept of the growth pole is extended to the significance of the geospatial city, town or other geographic units such as the first propulsion unit, and underdeveloped areas. The basic content of the growth pole theory are:

- The development of one or several of the leading industrial sectors with economic and technological links with other economic production will be driven by the corresponding development of other sectors. That means the development will be often affected by other sectors compared with its own development.
- The results of the above development for the region are productions greater than their own needs.
- The growth pole extends to all directions in the surrounding area. The “polarization”, which is gathering process, is an increase of its very strong economic and technological strength and favourable conditions.

Diffusion tends to be the dominant process of the growth pole theory. On one hand, the proliferation of material, energy output and spaces develop itself, so it grows pole scale, increasing strength; On the other hand, the formation of the new growth pole will promote the progress of diffusion. The implication of this theory is that growth pole attracts population and investments which enhances the demand for air transportation.

Forecasting

Forecasting can be defined as attempt to predict the future by using qualitative or quantitative means. It is an integral part of all human activity, but from the business point of view, the increasing attention is being given to formal forecasting systems which are continually being refined [5]. Every form of decision making and planning activities in business without exemption to air transport business adopts forecasting. There are two techniques involved in forecasting: Qualitative techniques which involve the use of causal method such as correlation and regression analysis, and time series analysis such as single

exponential smoothing and single moving average; quantitative techniques which are solely judgmental method such as expert opinion, poll, and sales force opinion [7].

Emphasis of this study is on quantitative techniques; it has varying levels of statistical complexity which are based on analyzing past data of the item to be forecast. A very good example that will be captured in this study is international air passenger traffic (movement). However, the sophisticated technique are used; there is the underlying assumption that the past patterns will provide some guidance to the future [5]. The main assumption behind the use of quantitative technique of forecasting is that the longer period is covered by the data; more likely the data will be representative of the future. Nevertheless, long a period is covered by past data; any extrapolations or forecasts produced from that data by whatever technique should be treated with caution. For the purpose of quantitative forecast, the use of time series cannot be overemphasized.

2.2. Time Series Analysis

Time-series or trend analysis is a sophisticated statistical method of forecasting analysis; it is the oldest and the most widely used method of forecasting air transportation demand in many cases. It is a sequence of values expressed at regular recurring periods of time simply, and it is possible from these time-series studies to detect regular movements that are likely recur and thus can be used as a means of predicting future events. Forecasting by time-series or trend extension actually consists of interpreting the historical sequence and applying the interpretation to the immediate future. It assumes that the past rate of growth or change will continue [5, 7].

3. Methodology

There are uncertainties in demand of product and services, which can be reduced through forecasting methods. The forecasting models used in the analysis are single moving average method and simple exponential smoothing method. The most appropriate forecasting method was determined on the basis of accuracy using Mean Squared Deviation (MSD).

3.1. Study Area

Nigeria is located in the West Africa sub-region within the longitude 30E and 150E and latitude 40N and 140N of the equator. It is bounded in the north by Niger Republic, south by Atlantic Ocean, east by Cameroon and Chad and west by Benin Republic. It is the most populous country in Africa. With respect to NPC, 2006, Nigeria accounted for more than 140 million and by August 2011 it was estimated to be about 167 million [14]. It was also indicated in their study that Nigeria has about twenty functional domestic airports in Nigeria. There are airports located in Lagos, Abuja, Kano, and Port-Harcourt which always account highest percentage of domestic passenger patronage.

3.2. Research Design

This study evaluated different forecasting model using domestic air passengers demand data from Nigeria. Yearly data from 2010 to 2017 were collected and used to forecast the domestic air passenger demand. The forecast model used in the analysis included single moving average method (n =2) and simple exponential method (α=0.9). The most appropriate forecasting method was determined on the basis of accuracy using mean squared deviation.

3.3. Materials and Method of Data Collection

Data for this analysis are secondary data sourced from Federal Airport Authority of Nigeria (FAAN) (2018), Nigerian Bureau of Statistics (2018), and journals covering the periods of eight years spanning from the year 2010 to the year 2017.

3.4. Model Specification

3.4.1. Forecasting method using single moving average

The single moving average method of forecasting involves calculating the average of observations and employing the average as the predictor for the next period. The single moving average method is highly dependent on *n* which is the number of terms selected for constructing the average.

$$F_{t+1} = \frac{(Y_t + Y_{t-1} + Y_{t-2} + \ldots + Y_{t-n+1})}{n} \quad (1)$$

where $F_{t+1}$is the forecast value for the next period, Y_t is the actual value at period t, and n is the number of term in the single moving average based on the discretion of the researcher.

For single moving average, the second year moving average was calculated for each year and the forecast for the demand in the year 2018 was calculated.

3.4.2. Forecasting method using simple exponential smoothing

The simple exponential smoothing method is a technique that uses weighted single moving average of past data as the basis for a forecast. This method keeps a running average of demand and adjusts it for each period in proportion to the difference between the latest actual demand figure and the latest value of the average. The equation for the simple exponential smoothing method is

$$F_{t+1} = F_t + \alpha Y_t + (1 - \alpha) F_{t-1} \quad (2)$$

where $F_{t+1}$is the new smoothing value or the forecast value for the next period, α is the smoothing constant *(0 < α <1),* Y_t is the new observation or actual value of the series in period t, F_t is the old smoothed value or forecast for period t.

For the exponential smoothing, a smoothing constant of 0.9 was chosen because it is closer to 1; the forecast for the demand in the year 2018 was calculated. The accuracy of simple exponential smoothing is dependent on the optimal value of α which is the smoothing constant. When comparing the two forecasts, the Mean Squared Deviation (MSD) of the two forecasts will be calculated and compared, and then the MSD that has a lower value is selected as preferred.

3.3.3. Mean squared deviation

According to Jarrett (1991) the Mean Squared Deviation (MSD) is a generally accepted technique for evaluating exponential smoothing and other methods. The equation is:

$$MSD = \sum_{t=1}^{n} \frac{(Y_t - F_t)^2}{n} \quad (3)$$

where Y_t is the actual value in time period t, F_t is the forecast value in time period t, and n is the number of periods

4. Results and Discussions

Two years single moving average and simple exponential smoothing with smoothing constant of 0.9 were applied to forecast the 2018 demand for domestic air passenger in Nigeria; the two methods of forecasting were evaluated and compared with Mean Squared Deviations (MSD) to determine which method gives lowest deviation as it will produce best forecast for the year 2018 domestic air passenger demand in Nigeria.

The results of this study will be in-line with the established objectives. The Table 1 below shows the demand for Nigeria domestic air passengers in the past eight years.

Table 1. *Demand for Nigeria domestic air passengers in the past eight years [4, 15, 16].*

Years	2010	2011	2012	2013	2014	2015	2016	2017
Demand	10,753,725	11,303,215	9,770,453	9,159,612	11,447,601	10,222,441	10,971,608	7,646,600

4.1. Forecasting for Domestic Air Passenger Demand in the Year 2018 Using Two Years Single Moving Average

Eq. (1) in the model specification has to do with forecasting method using two years single moving average. In order to derive the forecasts, the variables in the equation will be substituted with values.

Table 2. *Forecast of domestic air demand using two yearly single moving average.*

Year	**Demand**	**Forecast (Two Yearly Moving Average)**
Yr 2010	10,753,725	
Yr 2011	11,303,215	
Yr 2012	9,770,453	$\frac{10,753,725 + 11,303,215}{2}$ = 11,028,470
Yr 2013	9,159,612	$\frac{11,303,215 + 9,770,453}{2}$ = 10,536,834
Yr 2014	11,447,601	$\frac{9,770,453 + 9,159,612}{2}$ = 9,465,033
Yr 2015	10,222,441	$\frac{9,159,612 + 11,447,601}{2}$ = 10,303,607
Yr 2016	10,971,608	$\frac{11,447,601 + 10,222,441}{2}$ = 10,835,021
Yr 2017	7,646,600	$\frac{10,222,441 + 10,971,608}{2}$ = 10,597,025
2018 Forecast		$\frac{10,971,608 + 7,646,600}{2}$ = 9,309,104

The forecast of demand in the year 2018 is the two years single moving average for the years before (i.e. 9,309,104**)**. In the forecast, there were approximations because forecast cannot produce a fractional demand.

4.2. Forecasting for Domestic Air Passenger Demand in the Year 2018 Using Simple Exponential Smoothing with Smoothing Constant of 0.9

Eq. (2) in the model specification has to do with forecasting method using simple exponential smoothing with smoothing constant of 0.9. In order to derive the forecasts, the variables in the equation will be substituted with values.

Table 3. *Forecast of domestic air demand using exponential smoothing of 0.9.*

Year	Demand	Forecast (Exponential Smoothing 0.9)
Yr 2010	10,753,725	
Yr 2011	11,303,215	10,753,725
Yr 2012	9,770,453	0.9 (11,303,215) + 0.1 (10,753,725) = 11,248,266
Yr 2013	9,159,612	0.9 (9,770,435) + 0.1 (11,248,266) = 9,918,234
Yr 2014	11,447,601	0.9 (9,159,612) + 0.1 (9,918,234) = 9,235,474
Yr 2015	10,222,441	0.9 (11,447,601) + 0.1 (9,235,474) = 10,123,744
Yr 2016	10,971,608	0.9 (10,222,441) + 0.1 (10,123,744) = 10,212,571
Yr 2017	7,646,600	0.9 (10,971,608) + 0.1 (10,212,571) = 10,895,704
2018 Forecast		0.9 (7,646,600) + 0.1 (10,895,704) = 7,971,510

The forecast of demand in the year 2018 is the average of the year 2017 (i.e. 7,971,510). In the forecast, there were approximations because forecast cannot produce a fractional demand.

4.3. Determining the Most Appropriate Forecasting Method

This is done by comparing two yearly single moving average with exponential smoothing of smoothing constant 0.9. Before comparison using mean squared deviation, Fig. 1 below is the line graph depicting the demand for domestic air passenger in Nigeria, the two yearly single moving average, and the simple exponential smoothing with smoothing constant of 0.9.

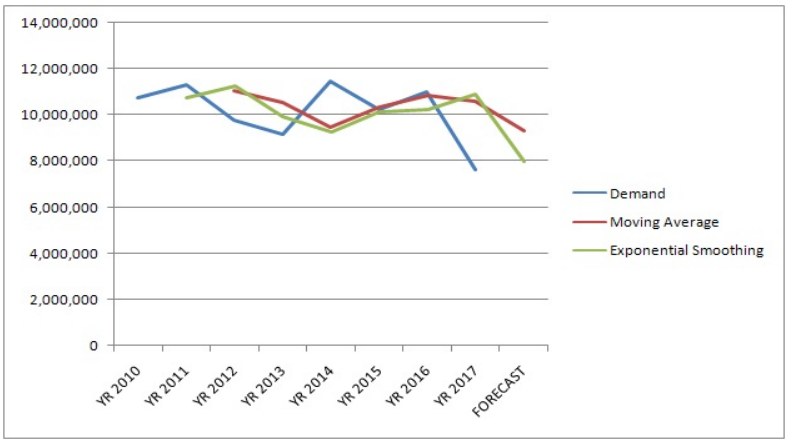

Fig. 1. *Line graph depicting the comparison of the demand and forecasts using two methods.*

From Fig. 1 above, it can be seen that the forecasts produced by the two yearly single moving average and the simple exponential smoothing with smoothing constant of 0.9 seems similar in trend and is quite confusing as they seems different from the original demand. Hence, to avoid this confusion, mean squared deviation was adopted for proper verification as to choose the most reliable forecasting method in this study.

Eq. (3) in the model specification has to do with Mean Squared Deviation (MSD) for comparing the two forecasting methods. In order to derive the forecasts, the variables in the equation will be substituted with values.

MSD for single moving average:

$$\frac{(11{,}028{,}470 - 9{,}770{,}453)^2 + (10{,}536{,}834 - 9{,}159{,}612)^2 + (9{,}465{,}033 - 11{,}447{,}601)^2 + (10{,}303{,}607 - 10{,}222{,}441)^2 + (10{,}835{,}021 - 10{,}971{,}608)^2 + (10{,}597{,}025 - 7{,}646{,}600)^2}{6} = 2.69*10^{12}$$

MSD for simple exponential smoothing:

$$\frac{(10{,}753{,}725 - 11{,}303{,}215)^2 + (11{,}248{,}266 - 9{,}770{,}453)^2 (9{,}918{,}234 - 9{,}159{,}612)^2 + (9{,}235{,}474 - 11{,}447{,}601)^2 + (10{,}123{,}744 - 10{,}222{,}441)^2 + (10{,}212{,}571 - 10{,}971{,}608)^2 + (10{,}895{,}704 - 7{,}646{,}600)^2}{7} = 2.73*10^{12}$$

From the comparison between the two MSDs, it can be seen that the MSD of single moving average appears to give the best year 2018's forecasts as it has a lower MSD than exponential smoothing. Hence, the forecast of 9,309,104 that has been produced by single moving average was preferred.

5. Conclusion and Recommendations

In conclusion, this study examined forecasting methods using single moving average (n=2) and simple exponential smoothing (α=0.9) to forecast domestic air passengers demand in Nigeria. Yearly data from 2010 to 2017 were collected and used to forecast the year 2018 domestic air passenger demand. The study revealed that the two years single moving average is closer to the original raw data than the exponential smoothing with smoothing constant of 0.9. Hence, it can be said that two years single moving average will give a better forecast for the demand in the year 2018 and subsequent years if adopt. The evaluation statement was best justified in the third objective where the mean square deviation was adopted to compare the two methods of forecast, so the year 2018 forecast of 9,309,104 that has been produced by two years moving average was preferred. The implication of this study is that the forecast of domestic air passenger demand in Nigeria at the year 2018 is likely to be 9,309,104.

It is important to note that the airport planner is not alone within the air transport system in needing forecasts. The airlines, the manufacturers, the sub-system suppliers, and the national transport planning authority all need forecasts of air transport activity. The technical feasibility and the strategic master planning of an airport can often be examined adequately in the imprecise light of maximum forecasts likely. However, the more detailed design of airport facilities and financial feasibility require a set of forecasts which estimate the demand to an acceptable level of accuracy at a given point in time [17]. Hence, the implication of this study is its usefulness in the planning process of domestic air transport business which concerns the airport, airline, and other stakeholders involved in Nigeria's air transportation. It will help to prevent problems of having excess domestic air transport demand over domestic air transport supply or having excess domestic air transport supply over demand.

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