Determination of the Main Causes of Insufficient Sudanese Airlines Domestic Services by Using Regression Analysis of Cost Function

Maysoon A. Sultan[*1], Mohammed H. Mudawi[2] and Afraa H. Abdellatif[3]

[1, *] *Department of Statistics, Faculty of Science, Sudan University of Sciences and Technology, Khartoum, Sudan.*
[2.] *Department of Statistics, Faculty of Science, Juba University, Juba, South Sudan.*
[3.] *Department of Statistics, Faculty of Science, Sudan University of Sciences and Technology, Khartoum, Sudan.*
Corresponding Author: Maysoon A. Sultan

Abstract:
This paper aimed to evaluate Sudanese Civil Airlines domestic services for passenger & cargo, statistically estimate their cost function and determine the factors affecting their efficiency. The study endeavours to upgrade civil aviation activities to meet the future requirements for Sudan development. The data were obtained from Sudan Civil Aviation Authority and some currently active Sudanese airlines. They were statistically analyzed to determine the annual cost function of six Sudanese airlines from 2004 to 2013. The researcher was to find out how the total cost (TC) behaves in relation to the domestic output, in revenue passenger (PAX) and freight (FRT), fuel cost (FC) and load factor (LF). The data were analyzed by using the Eviews statistical package to estimate an airline cost function by using the Classical Normal Linear Regression Model (CNLRM), to evaluate the model for forecasting, by satisfying the main features of a good regression model that was represented as follows:

$$TC_t = \beta_0 + \beta_1 PAX_t + \beta_2 FRT_t + \beta_3 LF_t + \beta_4 FC_t + u_t$$
$$t = 1, 2, \ldots, 10$$

The researcher concluded that, the (CNLRM) is acceptable to the predictive purpose and forecasting the function of the total cost of each airline, with a high statistically significant value of R-squared (99%), and statistically significant values of F-statistic probability between (0.000-0.00027) at level 5%. Additionally, the residuals were Normally distributed; P-values of Jarque-Bera Normality Test between (0.510203-0.87321) are not statistically significant values at 5% level, and not autocorrelation; most of R-squared P-values of Breusch-Godfrey Serial Correlation; LM Test between (0.1463-0.8706) are not statistically significant values at 5% level, but are homoscedastic; R-squared P-values of Breusch-Pagan-Godfrey Heteroscedasticity Test between (0.2755-0.9278); are not statistically significant values at 5% level. The Theil Ineqauality coefficients values between (0.000505-0.034086) are close to zero and zero Bias Proportions for all airlines in sample research. These results mean that the estimated regression models make sense; with strong power for prediction and forecast. The results indicate to a negative attitudes and malpractices that have still been the most adverse reasons that caused serious, sorrowful drawbacks in Sudan Aviation field activities and services. Unfortunately, such negative matters shall not lead to any future development in aviation services, if not fully attended to, with utmost care, awareness and knowhow.
KEYWORDS: *CNLRM, Passenger, Freight, Fuel Price, Load Factor.*

I.   Introduction:

The endeavors to operate many types of aeroplanes in Sudan, offering a complete range of modern services, was reached by the Sudanese Authorities, a considerable time ago; but this dream could not be materialized. Sudan, the heart of Africa and the largest country in Africa, uniting widely separated regions and populations of diverse characters for whom, through history, has been the sole focal point of mutual contact and trade. On account of its geographical and economic characteristics, Sudan has a pronounced vocation to become the main air transport centre of the whole Continent, as well as regional and international air traffic. The government orientations in the national strategic planning, investment encouragement, production & export of Sudanese petroleum resources, tourism development, peace and political stability, all combine to generate very high demands for air traffic in the near future. Most of this will be focused, having good reliable airlines, to offer good facilities of the highest international standards.

Research Problem:

Preface:

1. Covers all States of Sudan.
2. Domestic civil airlines movements in Sudan carrying passengers and or cargo during 2004- 2013.

The research objectives are list below:

1. Evaluation of Sudanese Civil Airlines domestic Services in Sudan in regards to Passenger and Cargo Movements.
2. Statistical estimation of a Sudanese airline cost function to identify the extent of aviation development in Sudan.
3. Determination of the main causes of the inefficiency of Sudanese civil airlines services compared to the large area of the country.
4. Endeavours to upgrade & promote civil aviation activities in Sudan to meet the future requirements for Sudan developing economy.

II. Materials & Methods:

Cost models are mathematical representation of the relationship between the total cost and explanatory variables (the output, in revenue passenger and cargo, fuel price and load factor), model specification reflects expectations of cost behavior, by using the Classical Normal Linear Regression Model (CNLRM), to evaluate the model for forecasting, by satisfying the main features of a good regression model.

Analysis of the data obtained from the Planning Directorate of Sudan Civil Aviation Authority, Air Transport Directorate and Sudan Airways Directorate of Central Planning and some other currently active Sudanese airlines, namely Sudan Airways, Marsland Airlines, Badr Airline, Nova Airlines, Sun Air Airlines and Mid Air Airlines shall be conducted. These data consist of the total number of passengers and freight/cargo carried domestically in Sudan, and also the data consist of the total number and types of aircraft in each Sudanese Airlines through the years from 2004 to 2013. For each airline these data shall be tabulated for each year separately, in addition to the data of Fuel price obtained from Nile Bakri Aviation Co.Ltd., and price of currency from Bank of Sudan; which were used in calculation of airlines total cost.

Specifications and Estimation of the Models:

- The data analyze the annual cost of the six Sudanese Airlines companies for the period from 2004 to 2013.
- The researcher is interested in finding out how the total cost (TC) behaves in relation to the domestic output, in revenue passenger (PAX) and cargo/ freight (FRT), fuel cost (FC) and load factor (LF). The result shall lead us to estimate an airline cost function, by using Classical Normal Linear Regression Model (CNLRM), and evaluate the model for forecasting. The model represented as follow:

$$TC_t = \beta_0 + \beta_1 PAX_t + \beta_2 FRT_t + \beta_3 LF_t + \beta_4 FC_t + u_t \quad , \quad t = 1, \dots, 10 \ (1)$$

And satisfied the main features of a good regression model [1], [2], [3], [4], represented by:

Feature (1): Regression line must be fitted to data strongly. Value of R-square should be more than 60%, because the higher R-square value; better the model or model fitted.

Feature (2): Most of explanatory variables (at least 50%) should individually significant to explain dependent variable. Here t-test was performed.

Feature (3): Explanatory variables should be jointly significant to explain dependent variables. Here F-test should be performed.

Feature (4): Residuals of the model have no serial correlation, no heteroscedasticity and are normally distributed.

- By using the Simple Exponential Smoothing (smoothing parameter equals 0.7), the researcher forecasted the data of the explanatory variables, and then used the results to forecast the total cost of each airline from 2014 to 2018, by using CNLRM.
- CNLRM shall be applied by using the Eview Statistical Package to estimate an airline cost function.

III. Results & Discussion:

Table (1): Significant Value of the Total Cost (TC) Regression Model (CNLRM) for the Sudanese Airlines: [5], [6], [7], [8]

An Airline	Variable	C	PAX	FRT	LF	FC
Sudan Airways	Coefficient	4861494	-----	0.007127	-5238669	1.09743
	Prob.	0.0407	-----	0.967	0.0178	00000
Marsland Aviation	Coefficient	3141858	3.678765	-3.989002	209550.1	1.048604
	Prob.	0.2104	0.4985	0.0059	0.9398	0.0000

Sun Air	Coefficient	93500.7	3.375324	0.446059	-107630.7	0.99644
	Prob.	0.025	0.0014	0.1774	0.1007	0.0000
Nova Air	Coefficient	352633.7	0.988587	-0.073409	-409289.9	6.793882
	Prob.	0.0005	0.0000	0.7052	0.0111	0.0109
Mid Airlines	Coefficient	229609.5	5.772532	-----	-242048.6	0.997609
	Prob.	0.0000	0.0000	-----	0.0000	0.0000
Badr Airlines	Coefficient	5667100	53.89931	-0.063447	-8774699	-8774699
	Prob.	0.0000	0.0226	0.6302	0.002	0.0000

Source: Prepared by the researcher.

Note that, in Sudan Airways; the researcher had to drop one of the two variables (LF and PAX), that registered high correlation (79%). So the researcher was dropped PAX; which has higher P-value (0.9465)**.**

Also, the estimated model of the total cost of Mid Airlines uses sample size eight years (2004-2011) instead of ten years, because their activity was stopped in since 2011. Also the researcher did not include the Freight (FRT) in the model, because Mid Airlines did not work in this field.

As shown in table(1); there was no statistical significant of freight (FRT) at level 5% to influence the total cost (TC) in two companies; Sun Air and Nova Air, because there were no activities in this field for eight years in Sun Air and four years in Nova Air. Although, there was a negative significant of freight (FRT) at level 5%, to influence the total cost (TC) in Marsland Aviation which stopped loading freight for about four years during the sample size research. Although there were no continuous freight activities performed by some of these airlines, the researcher observed that there were no statistical significant of freight to influence the total costs in Badr Airlines and Sudan Airways**.**

Table (2): Tests Results of Goodness of Fit of the Estimated CNLRM for the Sudanese Airlines: [5], [6], [7], [8]

Source: Prepared by the researcher.

As shown in the table (2), the Classical Normal Linear Regression Model (CNLRM) is acceptable to the predictive purpose of forecasting the function of total cost of each airline, with a high statistically significant value of R-squared (99%), and statistically significant values of F-statistic probability between (0.000 - 0.00027) at level 5%. Additionally, the residuals were Normally distributed; P-values of Jarque-Bera Normality Test between (0.510203 - 0.87321) are not statistically significant values at 5% level, and also the residuals were not autocorrelation (not serial correlation); most of R-squared P-values of Breusch-Godfrey Serial Correlation; LM Test between (0.1463 - 0.8706) are not statistically significant values at 5% level, also the residuals were

An Airline	R-Squared	Prob. (F-Statistic)	Durbin-Waston Stat.	Jarque-Bera-Normality Prob.	Breusch-Godfrey Serial Correlation Chi-Square Prob.	Breusch-Pagan-Godfrey Heterosceda-sticity Chi-Square Prob.
Sudan Airways	0.990847	0.000002	2.332225	0.613088	0.2347	0.6117
Marsland Aviation	0.990896	0.000027	1.625457	0.659185	0.1463	0.864
Sun Air	0.999844	0.0000	1.88048	0.611736	0.8706	0.9278
Nova Air	0.99996	0.0000	1.53558	0.87321	0.4533	0.3192
Mid Air	0.999996	0.0000	3.215065	0.636362	0.038	0.2755
Badr Airlines	0.995109	0.000006	1.976693	0.510203	0.4906	0.4406

homoscedastic; R-squared P-values of Breusch-Pagan-Godfrey Heteroscedasticity Test between (0.2755 - 0.9278); are not statistically significant values at 5% level.

Table (3): Result of Forecasting Sample 2004-2013 of Airlines:

An Airline	Root Mean Squared Error	Theil Inequality Coefficient	Bias Proportion
Sudan Airways	615993.2	0.034086	0.0000
Marsland Aviation	385280.7	0.023852	0.0000
Sun Air	22469.18	0.003792	0.0000
Nova Air	15604.13	0.001995	0.0000
Mid Air	1039.812	0.000505	0.0000
Badr Airlines	418794.4	0.017145	0.0000

Source: Prepared by the researcher.

As shown in the table (3), the Theil Ineqaulity coefficients values between (0.000505 - 0.034086) are close to zero and zero Bias Proportions for all airlines in sample research. These results mean that the estimated of CNLRM models make sense; with strong power for prediction and forecast.

To recapitulate, the following conclusions are detailed here below:

▪ The Classical Normal Linear Regression Model (CNLRM) is acceptable to the predictive purpose of forecasting the function of total cost of each airline, with a high statistically significant value of R-squared (99%), and statistically significant values of F-statistic probability between (0.000 - 0.00027) at level 5%. Additionally, the residuals were Normally distributed; P-values of Jarque-Bera Normality Test between (0.510203 - 0.87321) are not statistically significant values at 5% level, and also the residuals were not autocorrelation (not serial correlation); most of R-squared P-values of Breusch-Godfrey Serial Correlation; LM Test between (0.1463 - 0.8706) are not statistically significant values at 5% level, also the residuals were homoscedastic; R-squared P-values of Breusch-Pagan-Godfrey Heteroscedasticity Test between (0.2755 - 0.9278); are not statistically significant values at 5% level. The Theil Ineqauality coefficients values between (0.000505 - 0.034086) are close to zero and zero Bias Proportions for all airlines in sample research. These results mean that the estimated regression models make sense; with strong power for prediction and forecast.

▪ The researcher used the Classical Normal Linear Regression Model (CNLRM) to estimate the total costs of five airlines, namely Sudan Airways, Marsland Aviation, Sun Air, Nova Air and Badr Airlines, for ten years duration from 2004 to 2013. The final results of the highest mean total costs per annum were 5, 667, 100 US dollars for Badr Airlines, followed by Sudan Airways; which registered (4,861,494 US dollars) per annum and Marsland Aviation which registered (3,141,858 US dollars) per annum. In the other hand, the lowest mean total costs were of Nova Air (352,633.7 US dollars) per annum and Sun Air (93,500.7 US dollars) per annum.

▪ For the estimated model of total cost of Mid Air the researcher used a sample size of eight years (2004 – 2011) duration instead of 10 years; because this Airline stopped its activities in 2011, when its mean total cost was only (229,609.5 US dollars) per annum.

▪ Also, the study concludes that, there was no statistical significant of freight (FRT) at level 5% to influence the total cost (TC) in two companies; Sun Air and Nova Air, because there were no activities in this field for eight years in Sun Air and four years in Nova Air. Although, there was a negative significant of freight (FRT) at level 5%, to influence the total cost (TC) in Marsland Aviation which stopped loading freight for about four years during the sample size research. Although there were no continuous freight activities performed by some of these airlines, the researcher observed that there were no statistical significant of freight to influence the total costs in Badr Airlines and Sudan Airways. These results were due to the market competitions during certain seasons in some important routes. Moreover, the undercut fare rates policies practiced by some airlines restricted offering some services during flights, such as free food, drinks, etc… Also, during some seasons the airline used to raise the fare rates to the maximum feasible, so as to compensate for these reductions or, almost, to approach a breakeven. Due to the very high market global competition, it becomes vitally and critically important for the airline to struggle for existence in the sky. So, in the results of Panel Regression Models, there was no statistical significant of freight (FRT) at level 5% to influence the total cost (TC).

▪ In the subject airlines, there were negative statistical significant of load factor (LF) at level 5%, to influence the total cost (TC). That means when the Load Factor increases, the total cost decreases. Such cases indicate that the airlines policy was not running after high profit gains during that season; but it was just trying to break even, by offering such low fare rates of undercuts for the sake of sky existence..! If such particular airline is not financially capable and strongly managed, it will not be able to commercially exist in aviation field.

▪ The researcher found a high correlation between the passengers and load factor in Sudan Airways cost analysis statistical data. Accordingly, he did not consider evaluation of passenger's data analysis by the (CNLRM), because the passengers coefficient was of a lower statistical significant value than, statistical significant value of load factor coefficient, which statistically should not be considered in this case. This unique case of a high correlation shows that, Sudan Airways total costing depends on the load factor without any considerations to the passengers, which indicates that overloading the aircraft could have often been practiced. As it seems to be illegal and violent, strict warnings and penalties should be circulated to all airlines concerned to strictly abide to safety and air law regulations to immediately cease overloading the aircraft.

IV. Recommendations:

During data collection and statistical analysis of this research the researcher had clearly noted the negative attitudes and malpractices that have still been the most adverse reasons that caused serious, sorrowful drawbacks in Sudan Aviation field activities and services. Unfortunately, such negative matters shall not lead to any future development in aviation services, if not fully attended to, with utmost care, awareness and knowhow. For such alarming situation, *the researcher recaps the following mandatory recommendations so as to see Sudan Flag hovering in the sky all over the globe:*

On the account of its vast area of strategic, geographical location, variable climate, diversified, agricultural, livestock, industrial resources of oil, gold and other precious mineral resources, Sudan is

considered to be a suitable environment for aviation industry. As it is divided into many states, Sudan need to be linked with both regional and international markets to obtain the maximum benefit of these resources.

Air transport as a service is not a goal in itself; it is rather a service complementary to other services available to those travelling for business, shopping, tourism, holidays, education, medical treatments, etc...It has proved instrumental in keeping Sudan as a unified entity, and it can play a vital role in cases of emergencies and disasters; *so,*

- *It is highly recommended* to grant the national airlines companies privileges and facilities as encouraging incentives for, like comprehensive exemptions from input custom fees charges on aviation equipment, tools, machines, spare parts, transport facilities, operations and air ground handling equipment, vehicles, computers and communication appliances as required. Also tax free exemption for the first ten years from the date of operation.
- *It is also recommended* that SCAA mobilize its various administration potentials to provide the necessary infrastructure to airports, airstrips, communication facilities and air navigation aids, so as to link Sudan with the regional and international network airports.
- *It is also recommended* to urge SCAA to continue constructing new modern airports, and to rehabilitate activities for the existing airports and airstrips.

- *It is highly recommended* that the government should economically encourage the airlines by determining a fixed rate of foreign currency to purchase their operational needs, so as to stop violations or selfish greediness that leads them to corruption in black market fare rates charges, etc...Such an acceptable practice shall definitely have positive repercussions on the increase of air traffic, and, consequently refresh the national economy that attracts more investors.
- To guarantee trusted actual aircraft inputs and outputs statistical data on daily basis, it is *strongly recommended* that SCAA Traffic Directorate Data Bank shall always keep comprehensive current details of each aircraft. This shall help economists and researchers in aviation field to do further studies for evaluation and development in this unique field.
- Beside the financial capability, each airline investor should be aviation minded, educated in aviation business; NOT JUST, a greedy, money maker, or an ignorant money slave, running after wealth, and ignoring safety. So, *Education specialty is strongly recommended* and mandatory, for the sake of aircraft serviceability, airworthiness and safety.
- *Fleet type standardization is highly recommended* for Sudan to minimize the risk of facing aircraft grounding and technical delays and cancellations due to shortage of aircraft components or spares. Fleet standardization shall make it easier and faster for each airline to get whatever is needed from any sister company, on loan basis, or by direct purchase through a pool agreement with the neighbouring countries or national companies. It also facilitates availability of qualified trained technical staff and crew, etc.
- As long as standardization can be applicable to the operating airlines in Sudan, it becomes utterly urging to *highly recommend* establishing a unified aviation body in Sudan to standardize the salary structure, benefits, fleet type, staff, crew and premises insurance.

References:

[1]. Gujarati, D.N. and Porter, D.C. (2009). *Basic Econometrics*, Fifth Edition, Uni McGraw-Hill Companies.ted State Military Academy,West Point and University of Southern California.
[2]. Maddala, G.S. (1992). *Introduction to Econometrics*, Second Edition. University of Florida, Macmillan Publishing Company.
[3]. Greene, W.H. (1951). *Econometric Analysis*, Fifth Edition. New York University, Upper Saddle River, New Jersey.
[4]. Rawlings, J.O., Pantula, S.G. and Dickey D.A. (1932). *Applied Regression Analysis: A Research Tool*, Second Edition. North Carolina State University, Springer, USA.
[5]. Sultan, M.A., Mudawi, M.H. and Abdellatif, A.H. (2016). Statistical Estimation of Sudanese Airlines Cost Function and Determination of the Main Causes of Insufficient Airlines Domestic Services, Ph.D. Thesis, Graduate College, Sudan University of Sciences and Technology.
[6]. Sultan, M.A., Mudawi, M.H. and Abdellatif, A.H. (2016). Forecasting of Sudan Airways Domestic Services Total Cost. *IOSR Journal of Mathematics (IOSR-JM).13*(1), Ver. II, 56-60.
[7]. Sultan, M.A., Mudawi, M.H. and Abdellatif, A.H. (2016). Forecasting of Badr Airlines Domestic Services Total Cost. *IOSR Journal of Mathematics (IOSR-JM).13*(2), Ver. III, 25-28.
[8]. Sultan, M.A., Mudawi, M.H. and Abdellatif, A.H. (2016). Forecasting of Marsland Aviation Domestic Services Total Cost. *IOSR Journal of Mathematics (IOSR-JM).13*(2), Ver. III, 21-24.