IOSR Journal of Mathematics (IOSR-JM)
e-ISSN: 2278-5728, p-ISSN: 2319-765X. Volume 12, Issue 3 Ver. IV (May. - Jun. 2016), PP 74-85
www.iosrjournals.org

Past, Present & Future of Airlines Domestic Services in Sudan

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Abstract: *This paper reflects the present, past & future of Sudan domestic airline services. It is an attempt to identify the extent of aviation development in Sudan, particularly domestic flight services; by estimating the function of total cost. The data were obtained from the Planning Directorate of Sudan Civil Aviation Authority, Air Transport Directorate, Sudan Airways Directorate of Central Planning and some other currently active Sudanese airlines. The data were statistically analyzed determine the annual cost function of six Sudan airlines companies for the period from 2004 to 2013. The researcher study was to find 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 the Classical Normal Linear Regression Model (CNLRM), to evaluate the model for forecasting, by satisfying the main features of a good regression model. The model was represented as follows:*

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

The researcher concluded that the (CNLRM) is acceptable to the predictive purpose of forecasting the total cost of each airline, with a high statistically significant value of R-squared (99%), and statistically significant value of F-statistic probability between (0.000-0.00027) at level 5%. Additionally, the residual was normally distributed, not auto correlation (not serial correlation) and homoscedastic. This results means that the estimated regression models make sense; with strong power for prediction and forecast.

Keywords: *Classical Linear Regression Model, Cost Function, Fuel Price, Load Factor*.

I. Introduction

The endeavors to operate many types of aeroplanes in Sudan, offering a complete range of modern services, were 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.

Sudan is located in Northeastern Africa. It is bordered by Egypt to the north, the Red Sea to the northeast, Eritrea and Ethiopia to the east, South Sudan to the south, the Central African Republic to the southwest, Chad to the west and Libya to the northwest. It is the third largest country in Africa. (It had been the largest until South Sudan became an independent state on 9 July 2011).Geographic coordinates are 15°00′N 30°00′E. After separation from the South three years ago, Sudan's total remaining area amounted to some 1,861,484 square km [(1)].

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.

Being one of the largest African countries in area , Sudan has always been in need for air transport, both for domestic and international links . Aviation industry in Sudan has received close attention and encouragement by successive governments, and the Civil Aviation Authority has always been a technical, legislative and administratively, a priority institution. This institutional prominence has born fruition in establishing and managing a range of more than 40 airports and airstrips in towns and cities across the country and in areas which , otherwise , are very difficult to access over land. The country has from the outset managed to plan and develop its aviation industry by associating and acquiring the membership and signing agreements for all matters, technical or legal, for the promotion, control, and coordination of aviation locally, regionally and internationally. At present, the nation locates seven international airports in the north, south, east and west of the country, with Khartoum Airport as the main country hub. It is possible

to read within such a locational configuration the strategic nature of an aviation system for Sudan, the region and beyond. Technically, aviation in Sudan has shown constant development and eagerness to adopt and employ the latest technologies for communication, control, and safety operations in the skies and on the land[(2), (3)].

In mid-1991, scheduled domestic air services were provided by Sudan Airways, a government-owned enterprise operated by Sudan Airways Company. The company began its operations in 1947 as a government department. It has been operating commercially since the late 1960s, holding in effect a monopoly on domestic services. In 1991 Sudan Airways had scheduled flights from Khartoum to twenty other domestic airports, although it did not always adhere to its schedules. It also provided international services to several European countries, including Britain, Germany, Greece, and Italy. Regional flights were scheduled to North Africa and the Middle East as well as to Chad, Ethiopia, Kenya, Nigeria, and Uganda. Sudan Airways fleet in 1991 consisted of thirteen aircraft, including five Boeing 707s used in international flights, two Boeing 737s and two Boeing 727s employed in domestic and regional services, and four Fokker F-27s used for domestic flights [(4), (5)].

Sixteen international airlines provided regular flights to Khartoum. The number of domestic and international passengers increased from about 478,000 in 1982 to about 485,000 in 1984. Air freight increased from 6 million tons per kilometer in 1982 to 7.7 million tons per kilometer in 1984. As compared with the previous year, in 1989 passenger traffic on Sudan Airways fell by 32% to 363,181 people, reducing the load factor to 34.9%. By contrast, freight volume increased by 63.7% to 12,317 tons. At the end of 1979, Sudan Airways had entered into a pooling agreement with Britain's Trade Wind Airways to furnish charter cargo services between that country and Khartoum under a subsidiary company, Sudan Air Cargo. A new cargo terminal was built at Khartoum Airport [(2), (5), (6)].

Sudan Airways' operations have generally shown losses, and in the early 1980s the corporation was reportedly receiving an annual government subsidy of about 500,000 Sudanese ponds. In 1987 the government proposed to privatize Sudan Airways, precipitating a heated controversy that ultimately led to a joint venture between the government and private interests. Like the railroads and river transport operators, however, Sudan Airways suffered from a shortage of skilled personnel, overstaffing, and lacked hard currency and credit for spare parts and proper maintenance.[(1)]

In the early 1980s, the country's civilian airports, with the exception of Khartoum International Airport and the airport at Juba, sometimes closed during rainy periods because of runway conditions. After the 1986 drought, which caused major problems at regional airports, the government launched a programme to improve runways, to be funded locally. Aeronautical communications and navigational aids were minimal and at some airports relatively primitive. Only Khartoum International Airport was equipped with modern operational facilities, but by the early 1990s, Khartoum and seven other airports had paved runways. In the mid-1970s, IDA and the Saudi Development Fund agreed to make funds available for construction of new airports at Port Sudan and Wau, reconstruction and improvement of the airport at Malakal, and substantial upgrading of Juba Airport; these four airports accounted for almost half of the domestic traffic. Because the civil war resumed, improvements were made only at Port Sudan. Juba airport runways were rebuilt by a loan from the European Development Fund, but the control tower and navigational equipment remained incomplete [(1)].

At present, the aviation scene is passing through an important transitional period, the main feature of which are upgrading, renovation and new constructions Khartoum New International Airport is an important project for future development[(2)].

Being the largest country in Africa, it becomes vitally important to link the different areas of the country with each other. Currently , there are several international airports in the country , in addition to a considerable number of landing strips. Also the following main projects have been processed:[(2), (7)]

1. A rehabilitation process to Khartoum International Airport and some of the other regional airports (El Obayed, Nyala, El Fashir, Dongola, Port Sudan, etc.) had been accomplished .
2. Technical and economic feasibility studies for the establishment of regional airports and landing strips , compatible with the international standards had been prepared. Moreover, the updating of the technical and economic feasibility studies for Khartoum New International Airport is now ready, and the execution of the project is now in progress.
3. Systems of communication, navigation and metrology have been modernized to secure air safety travels.
4. Several bilateral and multilateral agreements were conducted with some countries such as Nigeria and South Africa with respect to crossing the Sudanese airspace, and with some airlines with respect to having joint venture with Sudan Airways company.
5. Modern maintenance units have been established to meet the requirements of the new aircraft types .
6. Modern ground equipment for air handling modern aircraft types are introduced.
7. Training centres for Civil Aviation and Sudan Airways are also established, and a competent management of Technical Information System is also introduced.

8. Many chances have been granted to private sector companies to operate domestic and international flight services of transport, cargo and air handling.

Internationally, major changes in the Civil Aviation Regulations have been introduced to cope with globalization. Air transport is now in the process of liberalization , and fare pricings liberalization has been adopted in some regions in the world . Some airlines joints with others improve cost effectiveness and financial efficiency , while other public and national carriers preferred privatization.

In this regard, to come up with the optional decision, Sudan Government had already commenced studying this issue thoroughly and deeply , with the assistance of local and foreign expatriates. They evaluated the tangible and intangible assets of Sudan Airways Company, earmarked the productive units, restructured the company organization, and set up a plan for commercialization. Thereby, efforts to create a business plan conducive to potential investors have been exerted.[7]

Research Problem:

Preface:

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

Reasons for Research Problems:

1. The vital strategic importance of civil aviation services and rolls in Sudan; as being the largest country in Africa.
2. Few, poor, unsafe, unpaved, narrow roads all over the country, complete destruction and stoppage of railways and riverways transportation services due to crucial, devastating political reasons, since May Military Coup Revolution in 1969.
3. There is deterioration in Sudan airlines domestic services in terms of specific factors, e.g. quality and quantity. Seventy four Sudanese airlines Companies were registered by Sudan Civil Aviation Authority (CAA), before 2000 twenty five airlines were active in domestic flights. Due to war in the south and west and political unrest in the country only twelve airlines remained actively operating domestic flights from 2000 up to this year. [7]
4. There is a gradual rise in the total operating costs of main airlines firms in Sudan. The critical situation in Sudan led to operational cost increase due to fuel rise, maintenance cost, spare parts price rise, aircraft price, etc..; that led to bankruptcy of most of the airlines.[6], [8], [9]
5. There were specific factors contributing to the reduced efficiency of Sudan airlines**.**

Being a large strategic country, in the heart of Africa, Sudan definitely requires many reliable, capable modern domestic and international airline carriers to meet its development in various fields of investment and discoveries, such as transportation of passengers & cargo/freight, oil exploration, mining, industry, agriculture, etc.

Because of that, the researcher is interested in finding out how the total cost behaves in relation to the output in revenue, passenger, cargo, fuel price and load factor. The result shall lead to estimate an airline cost function.

A properly estimated cost model allows airlines to achieve more accurate forecast cost:

- As a function of changes in average fares.
- As given recent or planned changes to frequency of service.
- To account for changes in the market or economic conditions.

The research objectives are list below:

1. Evaluation of Sudanese Civil Airlines domestic Services in Sudan in regards to Passenger / Cargo Movements.
2. Estimation of a Sudanese airline cost function to identify the extent of aviation development in Sudan.

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):

- Based on our assumptions of what affects air travel cost.
- Can be linear models or non-linear models.
- Model specification reflects expectations of cost behavior.

Theoretical Frame:

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. Addition of that 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 annually cost of the six airlines firms for the period from 2004 to 2013.
- We are 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:

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

And satisfied the main features of a good regression model [(10), (11), (12), (13)], 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.

- CNLRM shall be applied by using the Eview Statistical Package to estimate an airline cost function.

III. Results & Discussion

1. Sudan Airways:

1.1. Evaluation of the Model:

The estimated of total cost by using (CNLRM) is represented as follow:

$$TC_t = 4848827 - 0.608596\text{PAX}_t + 0.008605\text{FRT}_t - 5131981\text{LF}_t + 1.098333FC_t \quad (1)$$

Table (1): Significant of the Total Cost (TC) Regression Model (1):

Variable	Coefficient	Prob.
C	4848827	0.0648
PAX	-0.608596	0.9465
FRT	0.008605	0.9642
LF	-5131981	0.0788
FC	1.098333	0.0001

As shown in the table (1); there is 25% of the explanatory variables represented only on fuel cost (FC); are statistically significant at level 5%; to influence the dependent variable; total cost (TC). According of that, the researcher suspects there is a problem of multicollinearity in the model and expected there is high correlation between any two explanatory variables, which will determined by using the following table:

Table (2): Correlation Matrix of Explanatory Variables:

Explanatory Variables	PAX	FRT	FC	LF
PAX	1	0.237142	-0.593871	0.787198
FRT	0.237142	1	-0.476148	0.251174
FC	-0.593871	-0.476148	1	-0.780397
LF	0.787198	0.251174	-0.780397	1

According this problem, he Chi square P-value of Breusch-Godfrey serial correlation LM test equal 0.0358 is statistically significant at 5% level, so we can reject the null hypothesis; that residual is serial correlation.

As shown in the table (2); there is a higher correlation between the load factor (LF) and passenger (PAX) rather than correlation between the load factor (LF) and freight (FRT), which they are results as not statistical significant in the model (1). So the researcher have to drop one of the two variables (LF and PAX), that registered high correlation (79%).

By dropping PAX; which has higher P-value (0.9465)**;** the estimated of total cost regression model is transferred as follow:

$$TC_t = 4861494 + 0.007127\text{FRT}_t - 5238669\text{LF}_t + 1.09743FC_t \quad (2)$$

Table (3): Significant of The Total Cost (TC) Regression Model (2):

Variable	Coefficient	Prob.
C	4861494	0.0407
FRT	0.007127	0.967
LF	-5238669	0.0178
FC	1.09743	00000

As shown in the table (3); there is 67% of the explanatory variables: load factor (LF) and fuel cost (FC); are statistically significant at level 5%; to influence the dependent variable; total cost (TC).

Table (4): Tests Results of Goodness of Fit of the Estimated Regression Model (2):

R-squared	0.990847
Prob (F-statistic)	0.000002
Durbin-Watson Stat Prob.	2.332225
Jarque-Bera-Normmality Prob.	0.613088
Breusch-Godfrey Serial Correlation Chi-square Prob.	0.2347
Breusch-Pagan-Godfrey Heteroskedasticity Chi-square Prob.	0.6117

The R-squared value of about 0.990847 is statistically significant value (more than 60%), means that about 99% of variation in total cost is explain by freight, load factor and fuel cost; that means the goodness of fit of the regression line is very high. Also the R-squared (0.99) is less than Durbin-Waston statistic (2.332225), which means this model is not spurious.

The probability of F-statistic equal 0.000002 is statistically significant at level 5%, means that the explanatory variables: freight, load factor and fuel cost are jointly significant to influence the total cost.

The P-value of Jarque-Bera normality test equal 0.613088 is not statistically significant value at 5% level, so we can not reject the null hypothesis; that residual is normally distributed.

The Chi square P-value of Breusch-Godfrey serial correlation LM test equal 0.2347 is not statistically significant at 5% level, so we can not reject the null hypothesis; that residual is not serial correlation.

The Chi square P-value of Breusch-Pagan-Godfrey heteroskedasticity test equal 0.6117 is not statistically significant value at 5% level, so we can not reject the null hypothesis; that residual is not heteroskedasticity.

According to above results, the researcher conclude that the residual is normally distributed, not auto correlated and homoscedastic, so this result means that the estimated regression model (2) make sense, and acceptable to predictive purposes and forecasting.

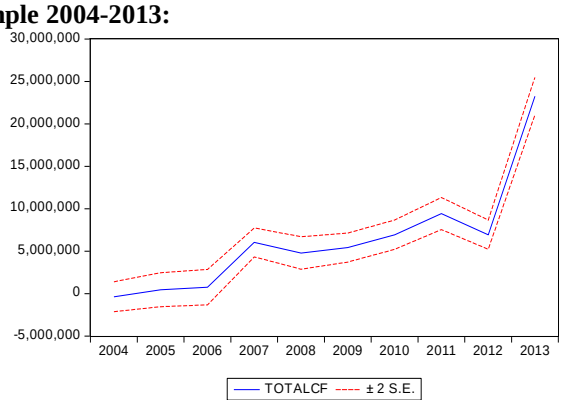
1.2. Forecasting:

Table (5): Result of Forecasting Sample 2004-2013 of Sudan Airways:

Root Mean Squared Error	615993.2
Theil Inequality Coefficient	0.034086
Bais Proportion	0.00000

As shown in table (5), root mean squared error is equal 615993.2 while Theil Ineqauality coefficient equal 0.034086 which is close to zero that means; the predictive power of this model is very strong. Bias proportion is equal zero that means, there is no gap between actual total cost and predictive total cost and they are moving closely.

Graph (1): Forecasting Sample 2004-2013:



As shown in graph (1); the total cost value has been forecasted is passing throw 50% confidence interval, so the forecasting of total cost is significant and the ability of forecasting model is satisfactory.

2. Marsland Aviation:

2.1. Evaluation of the Model:

The estimated of total cost (CNLRM) is represented as follow:

$$TC_t = 3141858 - 3.678765\text{PAX}_t - 3.989002\text{FRT}_t - 209550.1\text{LF}_t + 1.048604FC_t \quad (3)$$

Table (6): Significant of the Total Cost (TC) Regression Model (3):

Variable	Coefficient	Prob.
C	3141858	0.2104
PAX	-3.678765	0.4985
FRT	-3.989002	0.0059
LF	-209550.1	0.9398
FC	1.048604	0.0000

As shown in the table (6); there is 50% of the explanatory variables: freight (FRT) and load factor (LF); are statistically significant at level 5%; to influence the dependent variable; total cost (TC).

Table (7): Tests Results of Goodness of Fit of the Estimated Regression Model (3):

R-squared	0.990896
Prob(F-statistic)	0.000027
Durbin-Watson stat Prob.	1.625457
Jarque-Bera-Normmality Prob.	0.659185
Breusch-Godfrey Serial Correlation Chi-square Prob.	0.1463
Breusch-Pagan-Godfrey Heteroskedasticity Chi-square Prob.	0.864

The R-squared value of about 0.99 is statistically significant value (more than 60%), means that about 99% of variation in total cost is explain by passenger, freight, load factor and fuel cost; that means the goodness of fit of the regression line is very high. Also the R-squared (0.99) is less than Durbin-Waston statistic (0.864), which means this model is not spurious.

The probability of F-statistic equal 0.000027 is statistically significant at level 5%, means that the independent variables: passenger, freight, load factor and fuel cost are jointly significant to influence the total cost.

The P-value of Jarque-Bera normality test equal 0.659185 is not statistically significant value at 5% level, so we can not reject the null hypothesis; that residual is normally distributed.

The Chi square P-value of Breusch-Godfrey serial correlation LM test equal 0.1463 is not statistically significant at 5% level, so we can not reject the null hypothesis; that residual is not serial correlation.

The Chi square P-value of Breusch-Pagan-Godfrey heteroskedasticity test equal 0.864 is not statistically significant value at 5% level, so we can not reject the null hypothesis; that residual is not heteroskedasticity.

According to above results, the researcher conclude that the residual is normally distributed, not auto correlated and homoscedastic, so this result means that the estimated regression model (3) make sense and acceptable to predictive purposes and forecasting.

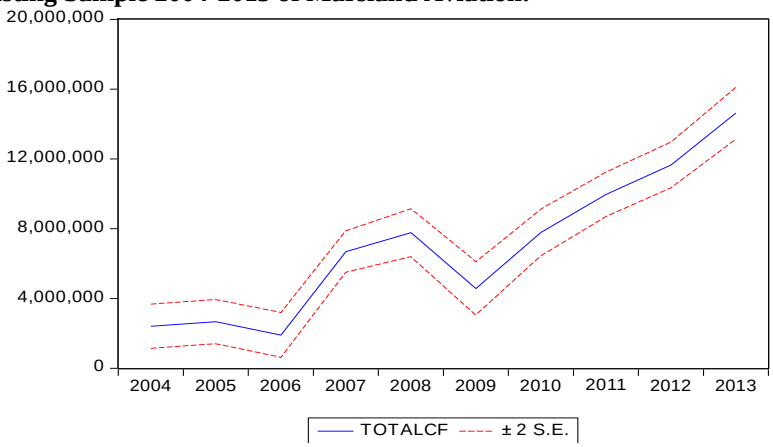
2.2. Forecasting:

Table (8): Result of Forecasting Sample 2004-2013 of Marsland Aviation:

Root Mean Squared Error	385280.7
Theil Inequality Coefficient	0.023852
Bais Proportion	0.00000

As shown in table (8), root mean squared error is equal 385280.7 while Theil Ineqauality coefficient equal 0.023852 which is close to zero that means; the predictive power of this model is very strong. Bias proportion is equal zero that means, there is no gap between actual total cost and predictive total cost and they are moving closely.

Graph (2): Forecasting Sample 2004-2013 of Marsland Aviation:



As shown in graph (2); the total cost value has been forecasted is passing throw 50% confidence interval, so the forecasting of total cost is significant and the ability of forecasting model is satisfactory.

3. Sun Air:

3.1. Evaluation of the model:

The estimated of total cost (CNLRM) is represented as follow:

$$\boldsymbol{TC_t = 93500.7 + 3.375324PAX_t - 0.446059FRT_t - 107630.7LF_t + 0.99644FC_t} \quad \textbf{(4)}$$

Table (9): Significant of the Total Cost (TC) Regression Model (4):

Variable	Coefficient	Prob.
C	93500.7	0.025
PAX	3.375324	0.0014
FRT	-0.446059	0.1774
LF	-107630.7	0.1007
FC	0.99644	0.0000

As shown in the table (9); there is 50% of the explanatory variables: passenger (PAX) and fuel cost (CF); are statistically significant at level 5%; to influence the dependent variable; total cost (TC).

Table (10): Tests Results of Goodness of Fit of the Estimated Regression Model (4):

R-squared	0.999844
Prob(F-statistic)	0.000000
Durbin-Watson stat Prob.	1.88048
Jarque-Bera-Normmality Prob.	0.611736
Breusch-Godfrey Serial Correlation Chi-square Prob.	0.8706
Breusch-Pagan-Godfrey Heteroskedasticity Chi-square Prob.	0.9278

The R-squared value of about 0.999844 is statistically significant value (more than 60%), means that about 99.98% of variation in total cost is explain by passenger, freight, load factor and fuel cost; that means the goodness of fit of the regression line is very high. Also the R-squared (0.999844) is less than Durbin-Waston statistic (1.88048), which means this model is not spurious.

The probability of F-statistic equal 0.000000 is statistically significant at level 5%, means that the independent variables: passenger, freight, load factor and fuel cost are jointly significant to influence the total cost. The P-value of Jarque-Bera normality test equal 0.611736 is not statistically significant value at 5% level, so we can not reject the null hypothesis; that residual is normally distributed.

The Chi square P-value of Breusch-Godfrey serial correlation LM test equal 0.8706 is not statistically significant at 5% level, so we can not reject the null hypothesis; that residual is not serial correlation.

The Chi square P-value of Breusch-Pagan-Godfrey heteroskedasticity test equal 0.9278 is not statistically significant value at 5% level, so we can not reject the null hypothesis; that residual is not heteroskedasticity. According to above results, the researcher conclude that the residual is normally distributed, not auto correlated and homoscedastic, so this result means that the estimated regression model (4) make sense and acceptable to predictive purposes and forecasting.

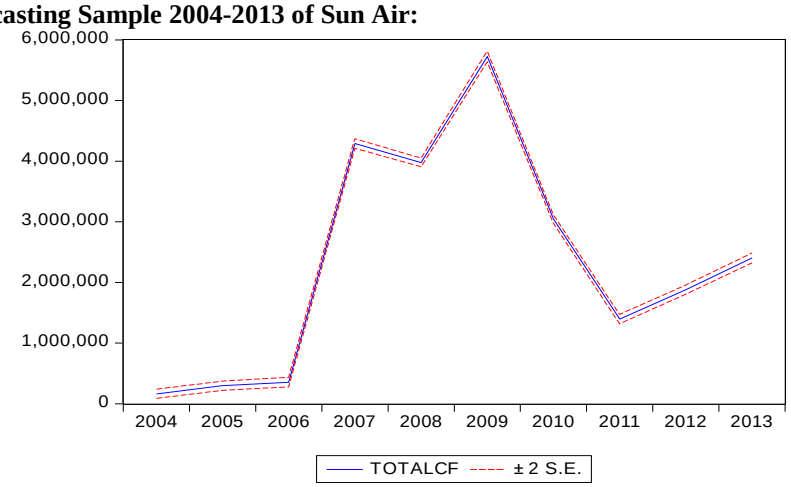
3.2. Forecasting:

Table (11): Result of Forecasting Sample 2004-2013 of Sun Air:

Root Mean Squared Error	22469.18
Theil Inequality Coefficient	0.003792
Bais Proportion	0.00000

As shown in table (11), the mean squared error is equal 22469.18 while Theil Ineqauality coefficient equal 0.003792 which is close to zero that means; the predictive power of this model is very strong. Bias proportion is equal zero that means, there is no gap between actual total cost and predictive total cost and they are moving closely.

Graph (3): Forecasting Sample 2004-2013 of Sun Air:



As shown in graph (3); the total cost value has been forecasted is passing throw 50% confidence interval; which is very small intervals, so the forecasting of total cost is significant and the ability of forecasting model is very strong.

4. Nova Air:

4.1. Evaluation of the model:

According to the data in table (4.4), the estimated of total cost (CNLRM) is represented as follow:

$$\boldsymbol{TC_t = 352633.7 + 0.988587PAX_t - 0.073409FRT_t - 409289.9LF_t + 6.793882FC_t} \quad \textbf{(5)}$$

Table (12): Significant of the Total cost (TC) Regression Model (5):

Variable	Coefficient	Prob.
C	352633.7	0.0005
PAX	0.988587	0.0000
FRT	-0.073409	0.7052
LF	-409289.9	0.0111
FC	6.793882	0.0109

As shown in the table (12); there is 75% of the explanatory variables: passenger (PAX), load factor (LF) and fuel cost (CF); are statistically significant at level 5%; to influence the dependent variable; total cost (TC).

Table (13): Tests results of goodness of fit of the estimated regression model (5):

R-squared	0.99996
Prob(F-statistic)	0.000000
Durbin-Watson stat Prob.	1.53558
Jarque-Bera-Normmality Prob.	0.87321
Breusch-Godfrey Serial Correlation Chi-square Prob.	0.4533
Breusch-Pagan-Godfrey Heteroskedasticity Chi-square Prob.	0.3192

The R-squared value of about 0.999962 is statistically significant value (more than 60%), means that about 99.996% of variation in total cost is explain by passenger, freight, load factor and fuel cost; that means the

goodness of fit of the regression line is very high. Also the R-squared (0.99996) is less than Durbin-Waston statistic (1.53558), which means this model is not spurious.

The probability of F-statistic equal 0.000000 is statistically significant at level 5%, means that the independent variables: passenger, freight, load factor and fuel cost are jointly significant to influence the total cost.

The P-value of Jarque-Bera normality test equal 0.87321 is not statistically significant value at 5% level, so we can not reject the null hypothesis; that residual is normally distributed.

The Chi square P-value of Breusch-Godfrey serial correlation LM test equal 0.4533 is not statistically significant at 5% level, so we can not reject the null hypothesis; that residual is not serial correlation.

The Chi square P-value of Breusch-Pagan-Godfrey heteroskedasticity test equal 0.3192 is not statistically significant value at 5% level, so we can not reject the null hypothesis; that residual is not heteroskedasticity.

According to above results, the researcher conclude that the residual is normally distributed, not auto correlated and homoscedastic, so this result means that the estimated regression model (5) make sense and acceptable to predictive purposes and forecasting.

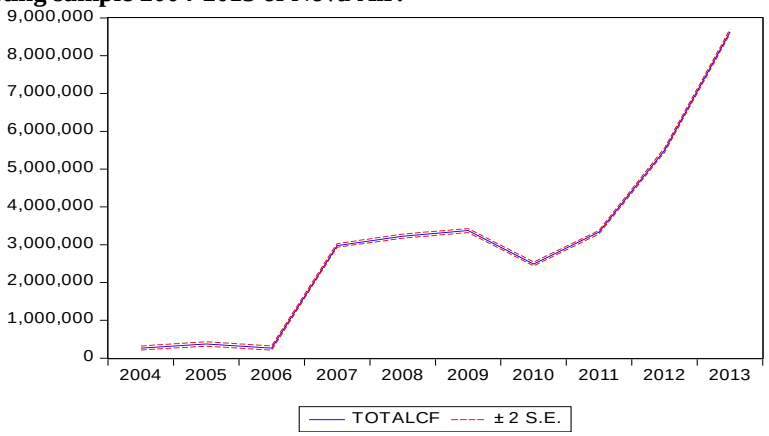
4.2. Forecasting:

Table (14): Result of Forecasting Sample 2004-2013 of Nova Air:

Root Mean Squared Error	15604.13
Theil Inequality Coefficient	0.001995
Bais Proportion	0.00000

As shown in table (14), root mean squared error is equal 15604.13 while Theil Ineqauality coefficient equal 0.001995 which is close to zero that means; the predictive power of this model is very strong. Bias proportion is equal zero that means, there is no gap between actual total cost and predictive total cost and they are moving closely.

Graph (4): forecasting sample 2004-2013 of Nova Air:



As shown in graph (4); the total cost value has been forecasted is passing throw 50% confidence interval with minimum square error; which is very small intervals, so the forecasting of total cost is significant and the ability of forecasting model is very strong.

5. Mid Airlines:

5.1. Evaluation of the model:

The estimated of total cost (CNLRM) is represented as follow:

$$TC_t = 229609.5 + 5.772532\text{PAX}_t - 242048.6\text{LF}_t + 0.997609FC_t \qquad (6)$$

Table (15): Significant of the Total Cost (TC) Regression Model (6):

Variable	Coefficient	Prob.
C	229609.5	0.0000
PAX	5.772532	0.0000
LF	-242048.6	0.0000
FC	0.997609	0.0000

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

As shown in the table (15); there is 100% of the explanatory variables: passenger (PAX), load factor (LF) and fuel cost (CF); are statistically significant at level 5%; to influence the dependent variable; total cost (TC).

Table (16): Tests Results of Goodness of Fit of the Estimated Regression Model (6):

R-squared	0.999996
Prob(F-statistic)	0.000000
Durbin-Watson stat Prob.	3.215065
Jarque-Bera-Normmality Prob.	0.636362
Breusch-Godfrey Serial Correlation Chi-square Prob.	0.038
Breusch-Pagan-Godfrey Heteroskedasticity Chi-square Prob.	0.2755

The R-squared value of about 0.999996 is statistically significant value (more than 60%), means that about 99.9996% of variation in total cost is explain by passenger, freight, load factor and fuel cost; that means the goodness of fit of the regression line is very high. Also the R-squared (0.999996) is less than Durbin-Waston statistic (3.215065), which means this model is not spurious.

The probability of F-statistic equal 0.000000 is statistically significant at level 5%, means that the independent variables: passenger, freight, load factor and fuel cost are jointly significant to influence the total cost.

The P-value of Jarque-Bera normality test equal 0.636362 is not statistically significant value at 5% level, so we can not reject the null hypothesis; that residual is normally distributed.

The Chi square P-value of Breusch-Godfrey serial correlation LM test equal 0.038 is not statistically significant at 5% level, so we can not reject the null hypothesis; that residual is not serial correlation.

The Chi square P-value of Breusch-Pagan-Godfrey heteroskedasticity test equal 0.2755 is not statistically significant value at 5% level, so we can not reject the null hypothesis; that residual is not heteroskedasticity.

According to above results, the researcher conclude that the residual is normally distributed, not auto correlated and homoscedastic, so this result means that the estimated regression model (6) make sense and acceptable to predictive purposes and forecasting.

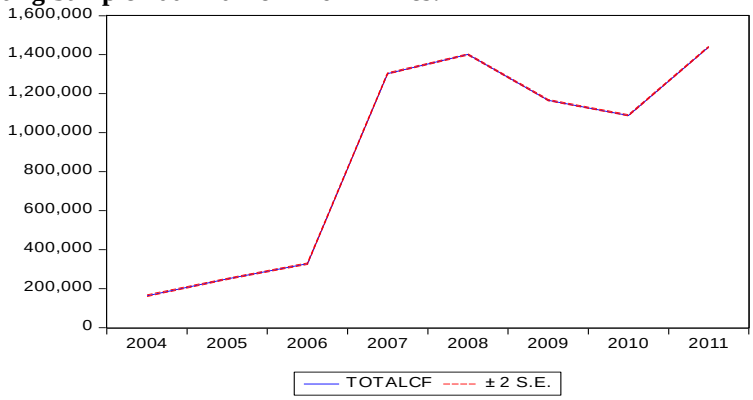
5.2. Forecasting:

Table (17): Result of Forecasting Sample 2004-2011of Mid Airlines:

Root Mean Squared Error	1039.812
Theil Inequality Coefficient	0.000505
Bais Proportion	0.00000

As shown in table (17), root mean squared error is equal 1039.812 while Theil Ineqauality coefficient equal 0.000505 which is close to zero that means; the predictive power of this model is very strong. Bias proportion is equal zero that means, there is no gap between actual total cost and predictive total cost and they are moving closely.

Graph (4): Forecasting Sample 2004-2011of Mid Airlines:



As shown in graph (4); the total cost value has been forecasted is applicable on 50% confidence interval, so the forecasting of total cost is significant and the ability of forecasting model is very strong.

6. Badr Airlines:

6.1. Evaluation of the model:

The estimated of total cost (CNLRM) is represented as follow:

$$TC_t = 5667100 + 53.89931\text{PAX}_t - 0.063447\text{FRT}_t - 8774699\text{LF}_t + 1.085344FC_t \quad (7)$$

Table (18): Significant of the Total cost (TC) regression Model (7):

Variable	Coefficient	Prob.
C	5667100	0.0000
PAX	53.89931	0.0226
FRT	-0.063447	0.6302
LF	-8774699	0.002
FC	1.085344	0.0000

As shown in the table (18); there is 75% of the explanatory variables: passengers (PAX), load factor (LF) and fuel cost (FC); are statistically significant at level 5%; to influence the dependent variable; total cost (TC).

Table (19): Tests Results of Goodness of Fit of the Estimated Regression Model (7):

R-squared	0.995109
Prob(F-statistic)	0.000006
Durbin-Watson stat Prob.	1.976693
Jarque-Bera-Normmality Prob.	0.510203
Breusch-Godfrey Serial Correlation Chi-square Prob.	0.4906
Breusch-Pagan-Godfrey Heteroskedasticity Chi-square Prob.	0.4406

The R-squared value of about 0.995109 is statistically significant value (more than 60%), means that about 99.5% of variation in total cost is explain by passenger, freight, load factor and fuel cost; that means the goodness of fit of the regression line is very high. Also the R-squared (0.995109) is less than Durbin-Waston statistic (1.976693), which means this model is not spurious.

The probability of F-statistic equal 0.000006 is statistically significant at level 5%, means that the independent variables: passenger, freight, load factor and fuel cost are jointly significant to influence the total cost.

The P-value of Jarque-Bera normality test equal 0.510203 is not statistically significant value at 5% level, so we can not reject the null hypothesis; that residual is normally distributed.

The R-squared P-value of Breusch-Godfrey serial correlation LM test equal 0.4906 is not statistically significant at 5% level, so we can not reject the null hypothesis; that residual is not serial correlation.

The R-squared P-value of Breusch-Pagan-Godfrey heteroskedasticity test equal 0.4406 is not statistically significant value at 5% level, so we can not reject the null hypothesis; that residual is not heteroskedasticity.

According to above results, the researcher conclude that the residual is normally distributed, not auto correlated and homoscedastic, so this result means that the estimated regression model (7) make sense and acceptable to predictive purposes and forecasting.

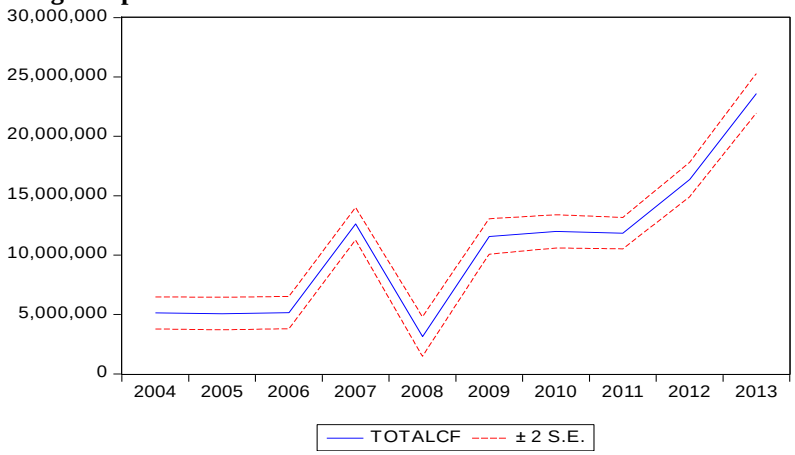
6.2. Forecasting:

Table (20): Result of Forecasting Sample 2004-2013 of Badr airlines:

Root Mean Squared Error	418794.4
Theil Inequality Coefficient	0.017145
Bais Proportion	0.00000

As shown in table (20), root mean squared error is equal 418794.4 while Theil Ineqauality coefficient equal 0.017145 which is close to zero that means; the predictive power of this model is very strong. Bias proportion is equal zero that means, there is no gap between actual total cost and predictive total cost and they are moving closely.

Graph (6): Forecasting Sample 2004-2013 of Badr airlines:



As shown in graph (6); the total cost value has been forecasted is passing throw 50% confidence interval, so the forecasting of total cost is significant and the ability of forecasting model is satisfactory.

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 total cost of each airline.
- 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 Lines 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.
- The Past situation records in the research showed a progressive increase in passenger/cargo demand, as there was stability in the status of the country and its economy and the number of airlines fleet.
- The Present situation records in the research showed drastic deterioration in aviation activities due to instability of the political situation of the country and the adverse economical development caused by regional wars and unrest in most of Sudan states that led to stoppage and bankruptcy of aviation companies.
- For Sudan Aviation Future we have to be optimistic. But the there is a gradual rise in the total operating costs of main airlines firms in Sudan.

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