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Estimation of Sudanese Airlines Domestic Services Cost Function

Maysoon A. Sultan[*1], Mohammed H. Mudawi[2] and Afra H. Abdellatif[3]
[1. *] *Department of Statistics, Faculty of Science, Sudan University for 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 for Sciences and Technology, Khartoum, Sudan.*

Abstract: *This paper attempt to estimate the function of total cost of Sudanese airlines domestic services. 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 the annual cost function of five Sudanese airlines companies for the period from 2004 to 2013, for a total of 50 balanced short Panel Data observations. The researcher study was to find out how the total cost (TC) behaves in relation to the domestic output, in revenue passenger (PAX), cargo/ freight (FRT), fuel cost (FC) and load factor (LF). The result shall lead us to estimate an airline cost function, by using Panel Regression Models to analyze the data obtained for this research. The researchers study the four possibilities Panel Regression Models: Pooled Ordinary Least Square (OLS) model, Fixed Effects Least Squares Dummy Variable (LSDV) model, Fixed Effects within-group (WG) model, and the Random Effects model (REM). These results shall be evaluated to determine the best suitable model for estimate an airline cost function. The models were represented as follows:*

$$\boldsymbol{TC_{it} = \beta_0 + \beta_1 PAX_{it} + \beta_2 FRT_{it} + \beta_3 LF_{it} + \beta_4 FC_{it} + u_{it}}$$

$$\boldsymbol{i = 1, 2, \dots, 5 \quad , \quad t = 1, 2, \dots, 10}$$

The F-statistic of Wald test equal 13.26867 with probability value equal to 0.0000, which is a highly statistically significant value at 5% level. So we can reject the null hypothesis; that is to say, all the dummy variables are equal to zero, that are represented in Pooled OLS model, and accept the alternative hypothesis which says that the Fixed Effect Least Squares Dummy variable (LSDV) is appropriate. The Chi-square statistic value for 4 degrees of freedom of Hausman test equals 53.074696 with probability value equal 0.0000, which is a highly statistically significant value at 5% level. So we can reject the null hypothesis; that is to say that the Random Effects model (REM) is appropriate, and accept the alternative hypothesis which says that the Fixed Effects within group (WG) is appropriate. According of Hausman test and Wald test, the researcher concluded that the Fixed effects model is appropriate and acceptable to the predictive purpose of forecasting the total cost.
Keywords: *Panel Data, Passenger, Freight, Fuel Price, Load Factor.*

I. Introduction

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 vocational 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.[(1), (2)]

Due to the lack of paved safe roads and to insufficient modern transport vehicles to avail a continuous flow of need, is now entirely dependent on air transport for everything. Since most of this volume of cargo consists of consumables, then this demand shall continue to persist as long as the safety situation remains unchanged. The air cargo movement include: Livestock, Meat, Fruit and Vegetables, Relief goods and generals goods.

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.

Direct Operating Cost (DOC) and price are the two major elements of aircraft cost. While price is a one-time cost for aircraft acquisition, DOC is a recurring cost over the lifetime of an airplane. However, in practice, both elements appear together as part of aircraft operating cost, DOC and investment, as the value of an airplane is depreciated over a large fraction of its lifetime. [(3), (4)]

The input cost categories listed below are subsets of traditional broad economic categories and are based on the operating expense categories of the Uniform System of Accounts used by the carriers to file financial data with Civil Aeronautics Board and Department of Transportation. The dependent variables are physical measures of the inputs when these are available and deflated cost measures otherwise: [(3), (4)]

1. Fuel, gallons of jet fuel and oils.
2. Flying operations labor, hours of labor of flight crews, including pilots, copilots, navigators, and flight engineers.
3. Passenger service labor, hour of labor of flight attendants.
4. Aircraft traffic servicing labor, hours of labor of ground personnel servicing aircraft and handling passengers at gates, baggage, and cargo.
5. Promotions and sales labor, hours of labor of reservations and sales agents primarily, but also of personnel involved in advertising and publicity.
6. Maintenance labor, hours of labor involved in maintenance of flight equipment and ground property and equipment.
7. Maintenance materials and overhead, total cost of maintenance of property and equipment, deflated by Producer Price Index for fabricated metals.
8. General overheads, total expenses corresponding to supplies, general and administrative personnel, utilities, insurance, and communications.
9. Ground property and equipment, flows of service from ground property and equipment, calculated with the method developed by Christensen and Jorgenson (1969) and including landing fees deflated by the Air Transport Association cost index for landing fees and rental expenses for ground property and equipment deflated by Producer Price Index for fixed nonresidential structures.
10. Flight equipment, flows of service from flight equipment (airframes, aircraft engines, avionics, etc.), calculated by imputing fair market rental values deflated by Producer Price Index for fixed-wing aircraft to owned and leased aircraft by aircraft categories.

Research Problem:

Preface:

1. Covers all States of Sudan.
2. Domestic civil airlines movements in Sudan carrying passengers and 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 river ways transportation services due to crucial, devastating political reasons, since May Military Coup Revolution in 1969.[(5)]
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. [(6)]
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.[(7), (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.
3. 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):
- 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 airline 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 analyzes the annually cost of the five airlines firms for the period from 2004 to 2013, for a total of 50 balanced short Panel Data observations.
- 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 researcher study the four possibilities Panel Data regression models: Pooled Ordinary Least Square (OLS) model, Fixed Effects Least Squares Dummy Variable (LSDV) model, Fixed Effects within-group model, and the Random Effects model (REM). These results shall be evaluated to determine the best suitable model for estimate an airline cost function.
- Panel Data Regression models shall be applied by using the Eview Statistical Package to estimate an airline cost function.

1. Pooled OLS Model:

The researcher pools all 50 observations and estimates a grand regression, neglecting the cross-section and time series nature of our data.
Consider the following model:

$$\boldsymbol{TC_{it} = \beta_1 + \beta_2 PAX_{it} + \beta_3 FRT_{it} + \beta_4 LF_{it} + \beta_5 FC_{it} + u_{it}} \qquad \textbf{(1)}$$

$$\boldsymbol{i = 1, 2, \ldots, 5 \quad , \quad t = 1, 2, \ldots 10}$$

Where; i is *i*th subject and t is the time period for the variables defined.

Assumptions: [10],[11]
1. The regression coefficients are the same for all the airlines. That is there is no distinction between the airlines.
2. The explanatory variables are nonstochastic.
3. The error term is $u_{it} \sim iid(0, \sigma_u^2)$, that is; it is independently and identically distributed with zero mean and constant variance.

2. The Fixed effect Least-Squares Dummy Variable (LSDV) Model:

The least-square dummy variable (LSDV) model allows for heterogeneity among subjects by allowing each entity to have its own intercept value [(10),(12)]. Consider the following model:

$$\boldsymbol{TC_{it} = \beta_{1i} + \beta_2 PAX_{it} + \beta_3 FRT_{it} + \beta_4 LF_{it} + \beta_5 FC_{it} + u_{it}} \qquad \textbf{(2)}$$

$$\boldsymbol{i = 1, 2, \dots, 5 \quad , \quad t = 1, 2, \dots 10}$$

Where; i is *i*th subject and t is the time period for the variables defined.

Note that; the subscript *i* on the intercept term to suggest that the intercepts of the five airlines may be different; due to special features of each airline. This model is known as Fixed Effects (regression) Model (FEM). The term "fixed effect" is due to the fact that, although the intercept may differ across the five airlines, each entity's intercept does not vary over time (time invariant). [(10),(12)]

Assumption:

Assumes that the slope coefficients of regressors do not vary across individuals or over the time.The researcher will use the Differential Intercept Dummy Technique, to determine how actually the intercept (fixed effect) vary among airlines. This is defining as follow:

$$\boldsymbol{TC_{it} = \alpha_1 + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \alpha_4 D_{4i} + \alpha_5 D_{5i} + \beta_2 PAX_{it} + \beta_3 FRT_{it} + \beta_4 LF_{it} + \beta_5 FC_{it} + u_{it}} \qquad \textbf{(3)}$$

Where:

$\boldsymbol{D_{2i}} = 1\ for\ airline\ 2, 0\ otherwise$;

$\boldsymbol{D_{3i}} = 1\ for\ airline\ 3, 0\ otherwise$; and so on.

The researcher has introduced only four dummy variables to avoid falling into the dummy variable trap.

Here the researcher treating airline 1 (Sudan Airways) as the base, or reference. As a result, the intercept α_1 is the intercept value of airline 1 and the other α coefficients represent by how much the intercept values of the other airlines differ from the intercept value of the first airline. Thus, α_2 tells by how much the intercept value of the second airline differs from α_1. The sum $(\alpha_1 + \alpha_2)$ gives the actual value of the intercept for airline 2. The intercept values of the other airlines will be computed similarly. [(10),(12)]

3. The Fixed Effect Within-Group (WG) Estimator:

One way to estimate a pooled regression is to eliminate the fixed effect, β_{1i} , by expressing the values of the dependent and explanatory variables for each airline as deviations from their respective mean values. Thus, for airline1 we will obtain the sample mean values of TC, PAX, FRT, LF and FC, ($\overline{TC}, \overline{PAX}, \overline{FRT}, \overline{LF}, \overline{FC}$, respectively) and subtract them from individual values of these variables. The resulting values are called "de-meaned" or mean corrected values [(10),(11)]. So the researcher does this for each airline and then pools all 50 mean-corrected values and run an OLS regression. Letting tc_{it} , pax_{it} , frt_{it} , lf_{it} and fc_{it} represent the mean-corrected values and run the following regression:

$$\boldsymbol{tc_{it} = \beta_2 pax_{it} + \beta_3 frt_{it} + \beta_4 lf_{it} + \beta_5 fc_{it} + u_{it}} \qquad \textbf{(4)}$$

$$\boldsymbol{i = 1, 2, \dots, 5 \quad , \quad t = 1, 2, \dots 10}$$

Note that equation (4) does not have an intercept term, because of differencing.

We obtain the intercept value of the *i*th airline by subtracting from the mean value of the dependent variable the mean values of the explanatory variables for the airline times the estimated slope coefficients from the WG estimators. Note that the estimated slope coefficients remain the same for all airlines and the estimated intercept of each airline represents the subject-specific characteristics of each airline, but not able to identify these characteristics individually. [(10),(11)]

$$\boldsymbol{\hat{\alpha}_i = \overline{TC_i} - \hat{\beta}_2 \overline{PAX_i} - \hat{\beta}_3 \overline{FRT_i} - \hat{\beta}_4 \overline{LF_i} - \hat{\beta}_5 \overline{FC_i}}$$

Where bars over the variables denote the sample mean values of the variables for the ith airline.

4. The Random Effects **Model (REM):**

It is known also as Error Components Model (ECM), is so named because the composite error term consists of two or more error components [(10),(13)]. The basic idea is starting in the following model:

$$\boldsymbol{TC_{it} = \beta_{1i} + \beta_2 PAX_{it} + \beta_3 FRT_{it} + \beta_4 LF_{it} + \beta_5 FC_{it} + u_{it}} \qquad \textbf{(5)}$$

Instead of treating $\boldsymbol{\beta_{1i}}$ as fixed, we assume that it is a random variable with a mean value of $\boldsymbol{\beta_1}$. The intercept value for an individual company can be express as follow:

$$\boldsymbol{\beta_{1i} = \beta_1 + \varepsilon_i}$$

Where ε_i is a random error term with mean value of zero and variance of σ_ε^2. The individual differences in the intercept values of each company are reflected in the error term ε_i. The equation obtains as follow:

$$\boldsymbol{TC_{it} = \beta_1 + \beta_2 PAX_{it} + \beta_3 FRT_{it} + \beta_4 LF_{it} + \beta_5 FC_{it} + w_{it}} \qquad \textbf{(6)}$$

Where, $\boldsymbol{w_{it} = \varepsilon_i + u_{it}}$

The composite error term w_{it} consists of two components:

$\boldsymbol{\varepsilon_i}$: Which is the cross-section or individual-specific error component.
$\boldsymbol{u_{it}}$: Which is the combined time series and cross-section error component and is sometimes called idiosyncratic term, because it varies over cross-section as well as time.
The assumptions made by the ECM are that: [(10),(13)]

$$\boldsymbol{\varepsilon_i \sim N(0, \sigma_\varepsilon^2)}$$
$$\boldsymbol{u_{it} \sim N(0, \sigma_u^2)}$$
$$\boldsymbol{E(\varepsilon_i u_{it}) = 0 \ , \ E(\varepsilon_i \varepsilon_j) = 0 \quad (i \neq j)}$$
$$\boldsymbol{E(u_{it} u_{is}) = E(u_{jt} u_{js}) = E(u_{it} u_{js}) = 0 \quad (i \neq j\,; t \neq s)}$$

That is, the individual error components are not correlated with each other and are not autocorrelated across both cross-section and time series units. Note that w_{it} is not correlated with any of the explanatory variables included in the model. Since ε_i is a component of w_{it} , it is possible that the latter is correlated with the explanatory variables. If that is indeed the case, the ECM will result in inconsistent estimation of the regression coefficients. So that we use Hausman test, which tell us in a given application if w_{it} is correlated with the explanatory variables, that is whether ECM is the appropriate model.[(10),(13)]

The difference between FEM and ECM. In FEM each cross-sectional unit has its own (fixed) intercept value, in all *N* such values for *N* cross-sectional units. In ECM, on the other hand, the intercept represents the mean value of all the (cross-sectional) intercepts and the error component ε_i represents the (random) deviation of individual intercept from this mean value. [(10),(13)] So that the researcher needs to determine which model is appropriate ECM or FEM. Here, the researcher applied Hausman test to test the following hypothesis: Null hypothesis: random effects model (ECM) is appropriate. Alternative hypothesis: fixed effects within group (FEM) is appropriate. To determine which model is appropriate Pooled OLS Regression model or fixed effect least square dummy variable (LSDV) model. The researcher applied Wald test to test the following hypothesis:
Null hypothesis: all dummy variables are equal to zero, that mean pooled regression model is appropriate. Alternative hypothesis: fixed effect least square dummy variable (LSDV) is appropriate.

III. Results & Discussion

1. Pooled OLS Model:

Here the researcher simply pools all 50 observations and estimated a grand regression, neglecting the cross-section and time series nature of data. Consider the following model:

$$\boldsymbol{TC_{it} = \beta_0 + \beta_1 PAX_{it} + \beta_2 FRT_{it} + \beta_3 LF_{it} + \beta_4 FC_{it} + u_{it}} \quad \textbf{(7)}$$
$$\boldsymbol{i = 1, 2, \dots, 5 \quad , \quad t = 1, 2, \dots, 10}$$

Where *i* is ith subject and t is the time period for the variables.

$$\boldsymbol{TC_{it} = 3320956 + 0.864041 \mathrm{PAX_{it}} + 0.228435 \mathrm{FRT_{it}} - 3530482 \mathrm{LF_{it}} + 1.161783 FC_{it}} \quad \textbf{(8)}$$

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

Variable	Coefficient	Prob.
C	3320956	0.0000
PAX	0.864041	0.0000
FRT	0.228435	0.0743
LF	-3530482	0.0000
FC	1.161783	0.0000

As shown in the table (1); 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 (2): Tests Results of Goodness of Fit of the Estimated Pooled OLS Regression Model:

R-squared	0.941944
Prob(F-statistic)	0.000000
Durbin-Watson stat Prob.	1.023638

The R-squared value of about 0.941944 is statistically significant value (more than 60%), means that about 94% 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 (0.941944) is less than Durbin-Waston statistic (1.023638), which means this model is not spurious, and suggesting that there is no autocorrelation or partial correlation in the data.

The probability of F-statistic (182.5269) 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.

In spite of all good results, there is major problem of this model, that it does not distinguish between various airlines nor does it tell us whether the response of total cost to the explanatory variables over time is the same for all the airlines.

2. The Fixed Effects Least Squares Dummy Variable (LSDV):

Here the researcher pools all 50 observations, but allow each cross-section unit (airline) to have its own (intercept) dummy variable. Consider the following model:

$$\boldsymbol{TC_{it} = \alpha_1 + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \alpha_4 D_{4i} + \alpha_5 D_{5i} + \beta_2 PAX_{it} + \beta_3 FRT_{it} + \beta_4 LF_{it} + \beta_5 FC_{it} + u_{it}} \quad \textbf{(9)}$$

Where:

$\boldsymbol{D_{2i}} = 1$, for airline 2, 0 otherwise.

$\boldsymbol{D_{3i}} = 1$, for airline 3, 0 otherwise.

And so on..

The researcher is treating airline 1 (Sudan airways) as the base (reference) category, so the α_1 is the intercept value of Sudan airwaYs and other α coefficients represent the differ from the intercept value of the first airline Sudan airways. The airlines arrangement in the model as follow:

Airline1= Sudan airways (the reference).
Airline 2= Marsland Aviation.
Airline 3= Sun air.
Airline 4= Nova air.
Airline 5= Badr airlines.

$$\boldsymbol{TC_{it} = 1482810 + 1151300 D_{2i} - 600230 D_{3i} + 151433.4 D_{4i} + 3109517 D_{5i} + 0.946771 PAX_{it} - 0.00083 FRT_{it} - 1617728 LF_{it} + 1.154968 FC_{it} + u_{it}} \quad \textbf{(10)}$$

Table (3): Significant of the Total Cost (TC) Fixed Effects Least Squares Dummy Variable (LSDV) Model:

Variable	Coefficient	Prob.
C	1482810	0.0332
PAX	0.946771	0.0000
FRT	-0.00083	0.9938
LF	-1617728	0.015
FC	1.154968	0.0000
D_2	1151300	0.015
D_3	-600230	0.2145
D_4	151433.4	0.7973
D_5	3109517	0.0000

As shown in the table (3); 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). As these regression show, the mean of total cost in Sudan airways is about 1482810 dollar, that of total cost in Marsland aviation is higher about 1151300 dollar than the mean total cost of Sudan airways as benchmark category, with actual mean about 2634110 dollar. By contrast, the total cost of Sun air is lower about 600230 dollars, for an actual mean total cost 882580 dollar. But, the total cost of Nova air is higher about 151433.4 dollars, for an actual mean total cost 1634243.4 dollar. Also, the total cost of Badr airlines is higher about 3109517 dollars, for an actual mean total cost 4592327 dollar.

Table (4): Tests Results of Goodness of Fit of the Estimated Fixed Effects Least Squares Dummy Variable (LSDV) Model:

R-squared	0.974698
Prob(F-statistic)	0.000000
Durbin-Watson stat Prob.	2.209698

The R-squared value of about 0.974698 is statistically significant value (more than 60%), means that about 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 (0.974698) is less than Durbin-Waston statistic (2.209698), which means this model is not spurious, and suggesting that there is no autocorrelation or partial correlation in the data.

The probability of F-statistic (197.4250) equal 0.0000 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.

According to above result it seems Fixed Effect Least Squared Dummy Variable model (LSDV) is better than Pooled OLS model; so to check this result, the researcher uses Wald Test, that depend on F-test approach (Restricted least squares).

The F-statistic of Wald test equal 13.26867 with probability value equal 0.0000, it is highly statistically significant value at 5% level, so we can reject the null hypothesis; that say all the dummy variables are equal to zero, which represent in Pooled OLS model, and accept the alternative hypothesis which says that the Fixed Effect Least Squares Dummy variable (LSDV) is appropriate.

3. The Fixed Effect Within-Group (WG) Estimator:

The researcher does this model for each airline and then pools all 50 mean-corrected values and run an OLS regression. Letting tc_{it} , pax_{it} , frt_{it} , lf_{it} and fc_{it} represent the mean-corrected values and run the following regression:

$$\boldsymbol{tc_{it} = \beta_2 pax_{it} + \beta_3 frt_{it} + \beta_4 lf_{it} + \beta_5 fc_{it} + u_{it}} \quad \textbf{(11)}$$

Where,

$$\boldsymbol{i = 1, 2, \dots, 5 \qquad t = 1, 2, \dots 10}$$

Table (5): Significant of the Total Cost (TC) Fixed Effect Within-Group (WG) Model:

Variable	Coefficient	Prob.
C	2245214	0.0001
PAX	0.946771	0.0000
FRT	-0.00083	0.9938
LF	-1617728	0.015
FC	1.154968	0.0000

As shown in table (5), we observe that the slope coefficients of the TC, PAX, FRT, LF and FC are identical with slope coefficients of (LSDV) model, because mathematically the two models are identical.
The researcher obtains the estimates of the intercepts using the WG method by subtracting from the mean value of the dependent variable the mean values of the explanatory variables for the airline times the estimated slope coefficients from the WG estimators. By using the following equation:

$$\boldsymbol{\hat{\alpha}_i = \overline{TC_i} - (0.946771) * \overline{PAX_i} - (-0.00083) * \overline{FRT_i} - (-1617728) * \overline{LF_i} - (1.154968) * \overline{FC_i}} \quad \textbf{(12)}$$

Also can study the effect of airline on total cost to calculate the intercept values of five entities are given at the regression result, as shown in table below:

Table (6): The Cross-Section Random Effects Represent Effect of Airline on Total Cost in Dollar:

Firm	Airline	Effect
1.	Sudan airways	-762404
2.	Marsland Aviation	388895.5
3.	Sun air	-1362634
4.	Nova air	-610971
5.	Badr airlines	2347113

The intercept value is 2245214. By using the differential intercept values of the five entities are given in table (6). Firm number 1 (Sudan airways) has intercept value which is 762404 dollar lower than the common intercept value of 2245214; the actual value of the intercept Sudan airways is 1482810 dollar. On the other hand, the intercept of firm number 2 (Marsland aviation) is higher by 388895.5 dollar than the common intercept value; the actual intercept value for Marsland aviation is 2634110 dollar. The other intercepts values for the other airlines similarly and shown in the following table:

Table (7): The Intercept Values Represent an Actual Mean Total Cost of Sudanese Airlines in Dollar:

Airline	Intercept
Sudan airways	1482810
Marsland Aviation	2634110
Sun air	882580
Nova air	1634243
Badr airlines	4592327

4. The Random Effects Model (REM):

The researcher applied the following model:

$$TC_{it} = \beta_1 + \beta_2 PAX_{it} + \beta_3 FRT_{it} + \beta_4 LF_{it} + \beta_5 FC_{it} + w_{it} \quad \mathbf{(13)}$$

Where, $w_{it} = \varepsilon_i + u_{it}$

The composite error term w_{it} consists of two components:

ε_i : Which is the cross-section or individual-specific error component.

u_{it}: Which is the combined time series and cross-section error component and is sometimes called idiosyncratic term, because it varies over cross-section as well as time.

The estimated of total cost by random effects model is represented as follow:

$$TC_{it} = 3320956 + 0.864041 PAX_{it} + 0.228435 FRT_{it} - 3530482 LF_{it} + 1.161783 FC_{it} + w_{it} \quad \mathbf{(14)}$$

Table (8): Significant of the Total Cost (TC) Random Effects Model (REM):

Variable	Coefficient	Prob.
C	3320956	0.0000
PAX	0.864041	0.0000
FRT	0.228435	0.0113
LF	-3530482	0.0000
FC	1.161783	0.0000

As shown in the table (8); all the differential intercept coefficients are individually highly statistically significant: PAX, FRT, LF and FC; are statistically significant at level 5%; to influence the dependent variable; total cost (TC).

Table (9): Tests Results of Goodness of Fit of the Estimated Regression Model:

R-squared	0.995109
Prob(F-statistic)	0.000000
Durbin-Watson stat Prob.	1.023638

The R-squared value of about 0.995109 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 (0.995109) is less than Durbin-Waston statistic (1.023638), which means this model is not spurious, and suggesting that there is no autocorrelation or partial correlation in the data.

The probability of F-statistic (182.5269) equal 0.0000 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. If we compare the results of the random effect and pooled OLS regression; the researcher find there are no difference between the two; so there are some doubt on the results. According this result; it seems fixed effect within group (WG) is better than the random effects model (REM); so to check this result, the researcher uses Hausman Test, the test statistic developed by Hausman has an asymptotic χ^2 distribution.

The Chi-square statistic value for 4 degrees of freedom of Hausman test equal 53.074696 with probability value equal 0.0000, it is highly statistically significant value at 5% level, so we can reject the null hypothesis; that say the REM is appropriate , and accept the alternative hypothesis which says that the Fixed Effects within group (WG) is appropriate.

According of all results; the decision of Hausman test and Wald test that Fixed effects model is appropriate.

To recapitulate, the following conclusions are detailed here below:

- By comparing the results of the Panel Regression Models, Pooled OLS Model, Fined Effects Least Squares Dummy Variable (LSDV), Fixed Effect within–Group (WG) Estimator and Random Effects Model (REM), the researcher found that there was no difference between (REM) and Pooled (OLS) Model. In the other hand, (LSDV) and (WG) Models were identical. Finally, according to Hausman Test and Wald Test, the researcher decided that the Fixed Effects Model was appropriate to estimate the total costs of airlines domestic services.
- The researcher used the Fixed Effects Model of five Sudanese Airlines , namely Sudan Airways, Marsland Aviation, Sun Air, Nova Air and Badr Airlines, for ten years duration from 2004 to 2013. In (WG) Model the highest mean total cost of Badr Airlines was about (4,592,327 US Dollars) per annum, followed by Marsland Aviation whose mean total cost was about (2,634,110 US Dollars) per annum, and Nova Air whose mean total cost was about (1,634,243 US Dollars) per annum. In the other hand, the lowest mean total cost registered for Sudan Airways was about (1,482,810 US Dollars) per annum and for Sun Air it was (882,580 US Dollars) per annum.
- Generally, as there were no continuous freight activities performed by some of these airlines, so that the researcher observed there were no statistical significant of freight (FRT) to influence the total costs (TC) at level 5% in all Panel Regression Models. These variations 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.

- 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.

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