AIR TRAFFIC DELAYS AND AIRLINE OPERATING COST IN KENYA:
THE CASE OF KENYA AIRWAYS

BY

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MAY 2012
DECLARATION

This paper is my original work and has not been presented for degree in any other university.

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DATE

27/05/2012

This Research Paper has been submitted for examination with our approval as university supervisors.

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DATE

28/05/2012
DEDICATION

This paper is dedicated to my lovely mother, Margret Njeri for bringing me up and for paying for my education even after the departure of our late father, Peter Mwangi. Her role in shaping my future shall never escape my memory.

I further dedicate this piece to my dear family: wife Naomi and the children; Victor, Paul and Grace for their patience and understanding when I could not be with them because I had to attend classes or finish some course assignment.

Let this work serve as an inspiration to my children to work hard in their search for academic excellence.
ACKNOWLEDGEMENT

I would like to thank God the Almighty for bringing me this far, for giving me knowledge, resources for my study and for providing me with good protection.

My sincere gratitude goes to all those who in one way or other assisted or supported me at any time during my entire school life. I am particularly indebted to my supervisors Dr. Moses Muriithi and Dr. Mary Mbithi for their helpful guidance and enthusiastic support without which it would not have been possible to complete this paper.

I also wish to thank all staff of the School of Economics for providing me with the assistance I needed during my university study. Special thanks go to all the teaching staff of the School of Economics, University of Nairobi, who faithfully and generously dispensed their knowledge and experience to me from my undergraduate classes through to this Master's course. Your guidance, tolerance, encouragement and willingness to assist enabled me to carry on and get this far.

Finally and most sincerely, I would like to express my appreciation to my former workmates, James Ngugi and John Nyariki for always standing in for me at work whenever I was required to attend classes.

Thank you all and may God bless you.
The linkage between flight delays and airline costs has become a major issue in discussions of the effectiveness of the air transportation system as many airports in the world become increasingly congested as they attempt to cope with rising passenger numbers. However, studies of this link increasingly focus on developed countries and this phenomenon has therefore not been documented for Kenya. Although the operating cost of Kenya's major airline, Kenya Airways, has increased tremendously in the recent years, little information currently exists on airline costs and how policy can effectively influence airline operating costs in Kenya. It is against this background that this study is being conducted. The study presents an empirical analysis of the determinants of airline operating costs in Kenya using Kenya Airways operating statistics. The main objective of the study however, was to investigate the effect of the poor performance of the air transportation system in Kenya (proxied here as air traffic delays) on airline operating costs and based on the findings draw policy recommendations to mitigate airline costs. Least Squares method is used to examine the effect of air traffic delays and the traditional volume and capacity variables on airline operating cost. Half yearly time series data for the period from 1995 (when Kenya Airways commenced its privatization process) to the first half of 2011 is used to estimate a long-run cointegrating equation and run an ECM regression. Results reveal that air traffic delays and output volumes are important airline cost drivers in Kenya. The result therefore supports the view suggested by earlier studies that poor performance of the air transportation system is associated with increase in airline operating costs. The study recommends investments to modernize and expand the aviation and airport infrastructures in Kenya so that they can accommodate air traffic growth without large increases in delay. Results for cargo lifted indicate that configuring passenger aircraft to accommodate more cargo in lieu of passengers increases operating costs. The study further establishes that there are economies of scale in the use of large aircraft and in serving a wide and dense route network.
### LIST OF ABBREVIATIONS AND ACRONYMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACFTS</td>
<td>Number of aircrafts in service.</td>
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<td>ATC</td>
<td>Air Traffic Control.</td>
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<tr>
<td>ANM</td>
<td>Available Seat Miles. Available seats multiplied by distance flown in miles.</td>
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<td>ATFM</td>
<td>Air Traffic Flow Management.</td>
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<tr>
<td>ATM</td>
<td>Air Traffic Management.</td>
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<tr>
<td>BUFFER</td>
<td>Extra time added by the airline to the schedule, providing more leeway for flights to arrive on time despite encountering congestion or other delays.</td>
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<tr>
<td>CARGO</td>
<td>Tons of Cargo carried.</td>
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<td>DELAYS</td>
<td>Air Traffic Delays in Minutes.</td>
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<td>DEST</td>
<td>Number of destinations.</td>
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<tr>
<td>DOC</td>
<td>Direct Operating Cost.</td>
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<tr>
<td>FIR</td>
<td>Flight Information Region.</td>
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<tr>
<td>IATA</td>
<td>International Air Transport Associations.</td>
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<tr>
<td>ICAO</td>
<td>International Civil Aviation Organisation.</td>
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<tr>
<td>KAA</td>
<td>Kenya Airports Authority.</td>
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<tr>
<td>KCAA</td>
<td>Kenya Civil Aviation Authority.</td>
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<tr>
<td>KM</td>
<td>Kilometres.</td>
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<td>KQ</td>
<td>Kenya Airways.</td>
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<tr>
<td>OC</td>
<td>Airline Operating costs.</td>
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<tr>
<td>PAX</td>
<td>Number of passengers carried.</td>
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<tr>
<td>PLF</td>
<td>Passenger Load Factor – percentage of RPK over ASK.</td>
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<tr>
<td>RPK</td>
<td>Revenue Passenger Kilometre - number of passengers carried multiplied distance flown.</td>
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<tr>
<td>SEATS</td>
<td>Available aircrafts seats per time period.</td>
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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

1.1.1 Why Air Traffic Delays

Air transport plays a key role in the development of a country. According to a survey conducted by the Air Transport Action Group (ATAG) in 2005, the Global Aviation Industry directly contributes US $275 billion to the global economy, facilitates total economic activity of US $2.960 billion and supports 29 million jobs globally. Air transport has also become a critical factor for sustainable economic development of developing countries. In the Kenyan economy, air transport supports 25 per cent of the GDP and provides about 40 per cent of foreign exchange earnings (Iches, 2005).

It is true that Kenya, with the tourist industry and horticulture industry as main foreign exchange earners, specifically depends on good flight connections. Therefore, efficient delivery of services at all airports is not just for the good of these sectors but of the entire economy.

Air traffic delays are the most common source of customer complaints by airline passengers. Not only is it a painful inconvenience for the actors but delays also have financial and economic consequences on airlines, on their clients and on the community.

The airline bears additional costs on fleets as well as flying and ground personnel, since delays prevent them from operating in optimum conditions. Additionally, although according to Warsaw Convention, passengers have no rights in compensation for flight delays; airlines may compensate them for their experienced discomfort and prejudices. According to their
type of operation, airline might also experience specific costs such as those linked to hub operations (Silke, 2000).

Delay related costs for users are mostly airline passenger’s opportunity cost, measured by their value of time. While delay-related costs for the community, involve environmental costs as well as costs incurred by other actors involved in the air transport business such as hotels, travel agents, tour operators, airports etc (Silke, 2000).

Flight delays are classified according to delay causes: Passenger and baggage, Cargo and mail, aircraft and ramp handling, technical and aircraft equipment, damage to aircraft, flight operations and crewing, weather, airport and governmental authorities, and Air Traffic Flow Management (ATFM – ATC) restrictions (US Government, 2000).

Most of the flight delays prior to departure are attributed to obtaining air traffic control (ATC) clearances or being given a later slot time to take off due to many planes queuing on a particular route. Air traffic control is concerned with the safe and expeditious movement of aircraft through airspace. Vital to safe operation of airspace are the air traffic controllers who assisted by technology and international rules and regulations, ensure that all aircraft under their jurisdiction maintain safe operation. The other function of ATC is moving planes around on the ground at airports (taxiing), which also involves safety and efficient use of capacity, but in a different way from when planes are en-route in the air (ICAO, 2002).

The standard measure of ATC performance with respect to capacity utilization is the amount of delay that can be attributed to the system (Steuer, 2010). Among all components of airport capacity, runways are usually the main constraint, because they are the key element
determining the number of take-offs and landings per hour. Other relevant elements of airport capacity are terminal, apron, gate and air traffic control (ATC) capacities. Delays associated with airport and airport capacities (the air transport system) are referred to as air traffic delays (Betancor et al., 2003).

1.1.2 Air Transport in Kenya

Two categories of infrastructure operators are involved in air transport in Kenya: the Air Traffic Management (ATM) and airport operators. ATM services (ATC services) in the Kenyan airspace, designated as the Nairobi Flight Information Region (FIR) by the International Civil Aviation Organization (ICAO), are provided by the Kenya Civil Aviation Authority, KCAA. Kenya has achieved complete radar coverage for its airspace. It uses six radar antennas that are integrated permitting air traffic controllers to see air traffic even beyond the national borders. Jomo Kenyatta International Airport, JKIA, the East Africa’s gateway and Regional hub is equipped with radio navigation aids for en-route navigation plus both visual and instrument approach and landing aids, and has one runway (Government of Kenya, 2000).

Kenya Airports Authority (KAA) is established as a statutory body in charge of investments, operation and management for the country’s major airports. The existing facilities at Nairobi Jomo Kenyatta international airport were commissioned in 1978. Facilities at the airport include, one 4,117 meters runway, 200,000 square meters of apron with 11 international and 9 domestic stands, passenger terminal with 58,000 square meters floor area, a cargo apron with four wide bodied-stands and two cargo terminals, a car park for 1,200 vehicles. The concerns expressed by the airport users according to the East Africa Air Transport Survey 2005 pertain to near-saturation of the terminal facility during peak hours (KAA, 2006).
Kenya has two major air carriers, Kenya Airways and the Kenyan franchise of British Airways as well as a large number of small air taxi and charter carriers operating with aircraft of small capacity. Kenya Airways, the National flag carrier was founded in 1977 after the collapse of East African Community and subsequent unviability of East African Airways that was then in existence. Since then the company has grown and has also been privatized with the Dutch airline KLM taking the greatest shareholding after 1996 when the privatization process was completed. With thirty two aircraft today, Kenya Airways is the fastest growing airline in Africa and is the only African airline in the prestigious Sky Team alliance (the 2nd largest alliance in the world). Its routing is from its main hub in Nairobi, JKIA, to several hub cities in Africa, Europe, and East Asia routes (Kenya Airways, 2011). Kenya Airways provides reliable flights for travel and tourism to and from Kenya and its air freight capacity supports Kenyan agriculture through the export of Kenyan agricultural products to the international market (Iches, 2005).

According to Iches (2005) Kenya Airways represents 63% of aircraft movements, 55% of available seat capacity and 70% of international traffic at Nairobi’s Jomo Kenyatta International Airport. Because Kenya Airways strategy is based on its Nairobi hub, airport and airspace capacities are essential to its growth. This study will explore the determinants of Kenya Airways operating cost to investigate how air traffic delays generated by the ATM and airport systems affect airline operating costs in Kenya.

1.2 Statement of the Problem

Available literature (Dal, 1978, Ssamula et al., 2002; Cook et al., 2002 and Swan et al., 2006) argue that airline operating costs increase with the airline’s utilized output: expressed in terms of Revenue Passenger Kilometers (computed as the product of the number of
passengers carried and the route length during the specified time and freight and Mail lifted
during the specified time multiplied by distance (ton mile), the other factors identified by
literature as driving airline operating cost include the Available Seat Kilometers (the
available seats multiplied by the total distance flown by the aircraft), the number of points
served, the size of the aircraft operated, the number of aircraft in service and flight time.

Glockner (2007) observes that aircraft delays occur when demand for airport or airspace
facilities exceed available capacity. Analysis of Kenya Airways operating statistics shows
that its aircraft fleet had grown from eight aircraft in 1998 to thirty two aircraft in 2011
(Kenya Airways, 2011). In contrast, the airport and ATM facilities such as runways,
taxiways, ramps, and gates at Kenya’s major airports including Jomo Kenyatta International
Airport remained constant over the period. A further look at Kenya Airways operating
statistics reveal that the airline operating costs rose tremendously over the same period. For
instance, the airline’s direct operating costs rose from Ksh 5.512 billions in 1995 to Ksh
53.419 billion in 2011, making operating costs the largest cost component of the company’s
total cost.

Doganis (2001) argue that fixed costs are substantially higher for established airlines and
variable costs rise as low-cost carriers steal their market share. Although Kenya Airways
commands a good presence in the African region, competitors have launched flights on its
major routes. For example, Virgin Atlantic on the Nairobi-London route with other
destinations across the globe, Qatar Airways on various Middle East destinations, while
Emirates Airlines has been competitive in Africa and the rest of the world. The entry of low
cost flight carriers on the domestic and regional fronts has also reduced inland market share
for Kenya Airways. Rwandair, Fly540, Air Uganda, jetlink and precision Air have enhanced
their presence in the region on the back of new routes’ expansion and increased frequency on existing destinations. The motivating factor being to gain from the growing demand from the regional integration and tap into the growing travel in the regional cities of Entebbe, Juba, Kigali and Dar es Salaam (Sterling Investment Bank, 2011).

In the domestic market, the cutthroat price war on the Nairobi-Mombasa route has intensified. The price war has seen Kenya Airways reduce its fare by 50 per cent within six months (between October 2010 and April 2011) in an effort to gain market share from domestic budget airlines. The last KQ price cut of 22 per cent coming a week after rival carrier Fly540 reduced its fares on the route by 32 per cent and the budget carriers including Jetlink and Air Kenya reckon that they could not recover their running expenses at Kenya Airways rates (Sterling Investment Bank, 2011).

The linkage between air traffic delays and airline operating costs has been a major issue in discussions of the performance of airport and ATM systems in developed countries and recently in developing countries. However, no documented study was found for Kenya. Consequently, no information currently exists on the effect of flight delays on airline operating costs and how policy can effectively influence air carrier costs in Kenya. This study intends to address this research gap.

The study attempts to answer the following questions:

1. What has been the trend of airline operating costs in Kenya?
2. What is the effect of air traffic delays on airline operating costs in Kenya?
3. Do traditional factors of volume and output capacity such as the number of passengers carried, tons of cargo lifted, number of aircraft operated and number of routes operated affect airline operating costs in Kenya?

4. What measures should the air transport authorities and airlines in Kenya put in place to mitigate airline-operating costs?

1.3 Objectives of the Study

The aim of this study is to investigate the effect of air traffic delays on airline operating costs in Kenya, with the following specific objectives:

1. To analyze the trend of airline operating costs in Kenya.

2. To determine the effect of air traffic delays on airline operating cost in Kenya.

3. To analyze the effect of traditional factors of volume and output capacity such as the number of passengers carried, tons of cargo lifted, number of aircraft operated and number of routes operated on airline operating costs in Kenya.

4. On the basis of these three objectives, to draw policy recommendations for mitigating airline operating costs in Kenya.

1.4 Significance of the Study

Airlines have substantial level of fixed and operating cost in order to establish and maintain air services. These include labour, fuel, airplanes, engines, spares, IT services and networks, airport equipment, airport handling services, sales distribution, catering, training and insurance to name a few (Doganis 2001). According to Chew (1997), all airline businesses, regardless of their category, focus on increasing their margin of profitability, either by raising revenue, lowering costs, or both. With today’s computer reservation systems, airlines operate in a very competitive environment where airfares are instantly compared and matched (Chew,
As a result, airlines vigorously compete on the basis of costs and are extremely sensitive to any cost inequalities in the environment (Chew, 1997).

Increased competition on Kenya Airways key routes coupled with the entry of low-cost flight carriers in the domestic market and the ensuing price wars on the Nairobi-Mombasa route is likely to have some negative effects on the KQ's earnings and on the airline industry in Kenya. This necessitates an urgent study to help understand how policy can affect airline operating costs and safeguard the industry from suffering adverse effects. It is against this background that this study is being conducted to explore the relationship between air traffic delays and airline operating costs in Kenya. It is believed the study will go along way in informing air transport policy in Kenya, help reduce airline operating costs and enable the Kenyan airline industry to operate more efficiently and compete effectively in the domestic, regional and global markets.

CHAPTER TWO

2.0 LITERATURE REVIEW

This chapter reviews the theoretical and empirical studies carried out to determine the determinants of transportation cost with particular emphasis on airline operating costs. The first section focuses on the theoretical background while the second section presents the empirical literature. Section three provides an overview of the literature review.

2.1. Theoretical Literature

In formal economics a cost is defined as "benefit foregone". Cost therefore refers to tradeoff that individuals and society must make between use of resources. This can involve money.
time and other resources, or the loss of any potential benefit. For example, time spent travelling is a cost in terms of the opportunity cost to use that time in other activities. This same concept applies to tradeoffs between transport investments and other possible expenditures, between roads and other land uses and between transportation activities and environmental protection (Sinnott et al., 1998).

Costs related to ATM action can be evaluated by dividing them into fixed and variable components. Whether a cost is constant (fixed) or variable depends on the time horizon. In the short-term most costs are fixed, while all costs are considered variable in the long term. In the short run airlines are focused on flight operations and costs incurred in flight. Only a few costs are variable, and therefore only a limited number of cost categories can change in the short run. In the medium term an airline has more time to modify schedules, assess routes, and mitigate persistent disruptions to their networks. In the long-term an airline has the flexibility to respond to ATM system performance changes by changing its fleet mix or moving a hub (Sinnott et al., 1998).

The cost function of a firm is defined as the lowest cost at which it can produce a given set of outputs $Y$, given the prices it pays for inputs $P$. Equivalently it represents the optimal set of inputs $X$ given the outputs and prices. Thus we have

$$\text{COST} = P_t + \lambda(Y_t, P_t) = \xi_t(Y_t, P_t).$$

Where the subscript $t$, denotes a particular firm (airline) and $t$, identifies the time period.

The cost function like the production function is a way of depicting the technology available to the firm, i.e. its ability to transform inputs into outputs (Varian, 2003).
Profit for the airline company, \( \pi \) is defined as the difference between total revenue and total cost i.e. passenger (D) times fare (P) minus airline costs (C). \( \pi \) represents the airline market.

\[
\pi = \sum D^f P^f - \sum C^p
\]

Profit maximizing scheme can then be obtained through differentiating the above equation with respect to D, P and C (Varian, 2003).

The product of a transport firm is a vector of flows of persons and goods, moved during a number of periods and among many origins and destinations in space (Jara-Diaz, 1982). In the airline industry, output capacity is typically measured in terms of available seat miles (ASM) and available ton-miles (ATM). In air transportation services, output capacity increases with both the number of seats made available and distance travelled (Banker D., et al. 1993). Actual outputs (output volumes) on the other hand are measured in terms of revenue passengers and ton-miles, or the number of passengers and tons of cargo. Inputs in the air transport industry are the cost components represented by flight crew, fuel, ownership, maintenance, landing, En-route ATC, ownership and insurance (Ahmadbeigi et al., 2008).

Current practice of estimating the cost impact of imperfect operational performance on airlines can be classified into two approaches. The first, often called the cost factor approach, is based upon assigning unit cost to different categories of delay based on estimates of resources consumed when a given category of delay occurs. The total cost of delay, \( C \) is equal to the sum of delay cost in each category:

\[
C = \sum P \times X
\]

Where, \( P \) denotes the unit cost per minute for delay in the \( i \)th category, and \( X \) represents the corresponding total delay in minutes. Equation above represents the general formula of the
cost factor approach which admits many possibilities for classifying delay. One is based upon the phase of flight in which delay is taken. (Gate, taxi, and airborne delays are the primary (Hansen et al., 2001).

Determining cost factors rests on the assumption that delay causes additional consumption of largely the same inputs as the airline’s normal line production process. Judgement must be made about what cost components (e.g., fuel, labour, capital, airport charges) need to be included for a specific type of delay, and what are the unit cost per delay minute for each cost component (Cook et al., 2004).

The second avenue, termed the aggregate cost approach, is built upon firm or industry level relationship between total operating cost and delay. One simple version of this approach assumes that airline operating cost are proportional to the aircraft operating time, and estimates delay cost as a fraction of total aircraft operating time that results from delay multiplied by the total airline operating cost. This avoids the difficulty (if done carefully) task of determining cost factors, and only requires straightforward calculation of the total operating cost (Hansen, 2001).

Brueckner et al. (2006) defines the cost of each flight exclusive of noise-abatement cost, as \( \phi + \alpha \) where \( \alpha \) equal seats per flight. Each flight thus entails a fixed cost \( \phi \) as well as a variable cost \( \alpha \) per seat. While this specification may not be completely realistic, it captures that an airline’s cost increases with the number of seats and cost per seat given by \( \phi + \alpha \) falls as aircraft size increases. Multiplying by flight frequency yields a total cost expression, \( f(\phi + \alpha) \).
2.2. Empirical Literature

Determinants of transportation costs have received much attention from researchers and economists. The most studied determinant of transport cost is geography, particularly distance. The greater the distance between the markets, the higher the expected transport costs (Combes and Miren, 2004).

In addition to distance however, many elements influence transport costs. As shown by Swan et al. (2006), Dal. (1978), Bruckner et al. (2009), Hansen and Zou (2008), Cook et al. (2002), Samula et al. (2004), and Sarndal et al. (1975) transportation costs depend on many complex details of geography, infrastructure, capacity, volume, and the state of competition in the transport industry.

Banker and Johnston (1993) studied cost drivers in the U.S. Airline using a panel of quarterly data from traffic and financial statistics submitted by carriers to estimate a multivariate system of cost functions with multiple cost drivers for the airline industry. Their findings demonstrate that output capacity and volume, operations-based drivers (aircraft size and average stage length) and product diversity (flight density) are important cost drivers in a major service industry. This supports earlier research on cost driver's analysis by Miller and Vollman (1985) and Cooper and Kaplan (1987) which suggests that output volumes and transactions deriving from a firm's product line drive costs.

Swan et al. (2006) evaluates a cost function for commercial passenger aircraft operating costs and find that airline operating costs are proportional to distance and seat capacity. These
results are supported by findings of Bruckner et al. (2009) who argue that airline operating costs are linearly related to seat capacity.

Dal (1978) estimated factors affecting commercial aircraft operating costs and found that operating costs increase with the duration of delay. Cook et al. (2002) estimated the block-hour direct operating costs for specific aircraft variants. Their findings revealed that direct operating costs vary according to length of delay, always higher for longer delays. Combes and Miren estimated system-wide excess costs for both short and long-term costs. They found that excess operating costs come from increased operating time due to operational delay. These results are supported by findings of Hansen and Zou (2008) study whose coefficient for delay suggest that, at the sample mean one minute increase in delay would cause 0.7 per cent increase in variable cost.

Williams (2008) argue that direct airline operating costs are proportional to the number of aircraft in service. Samdal et al. (1995) studied US local carriers cost functions and found operating costs to depend essentially on two network variables: the number of cities served and the number of aircraft miles flown by aircraft types. Aircraft operating costs increase with the number of routes served and the average stage length. In their study, Hansen and Zou (2008) find that an increase in network size of 1 per cent leads to an increase in variable cost of about 0.6 per cent at the sample size.

Aircraft operating costs are also driven by the aircraft utilized output and the size of the aircraft. Samoura et al. (2004) estimated costs of running specific aircraft types. They find that smaller aircraft have much less operating costs than larger aircraft. These results support Cook et al. (2002) study which estimated block-hour direct operating costs based on real
operational data from airlines and found operating costs to vary with the number of occupied aircraft seats (output): higher for larger aircraft and with higher load factors.

Doganis (2001) evaluated the cost dynamics of the airline industry to explain why established airlines have a hard time competing against, low-cost carriers. They find that fixed costs are substantially higher for established airlines and variable costs rise as low carriers steal their market share.

Micco and Serebrisky (2004) investigated the determinants of air transport costs and find that distance, airport infrastructure, government effectiveness and regulatory quality are important determinants of air transport costs. In their sample, an improvement in airport infrastructure from the 25th to the 75th percentile reduces air transport costs by 15 per cent. The results are supported by Combes and Miren (2004) study whose results reveal that ATM improvement can save short-term excess costs of fuel and crew and provide aircraft fleet savings in the long run.

Other studies refer to alternative transport modes. For instance, Clark et al. (2002) investigate the determinants of maritime transport costs. Their results indicate that geographical factors, transport insurance, transport conditions, trade imbalances, economics of scale, containerised transport, number of marine lines, port efficiency and anti-competition legal and practical restrictions affect transport costs. More specifically, they found that distance increase maritime transport costs, with estimated elasticity of 0.21.

Martinez et al. (2007) analyse door-to-door transport costs determinants of Spanish exports to Poland and Turkey. Their results show that the main determinant for short sea-shipping
transport costs are quality of service and the transportation conditions, whereas the main determinants of road transport costs are transport conditions, distance and transit time.

Zarzoso et al. (2008) investigated the determinants of maritime and overland transport costs. Their results from the cost estimation show that higher distance and poor infrastructure lead to notable increase in transport cost.

2.3. Overview of Literature

Empirical studies have identified several factors that influence transportation costs generally. Several studies have also analysed variables that affect costs in air transport (Dal, 1978; Banker and Johnston, 2001; Mecca and Serebrisky, 2004 and Williams, 2008) This study, like earlier similar studies of flight delays assumes airline operating costs to be linearly related to flight duration (and therefore to delay). However, unlike previous studies that evaluated the influence of the output, airline capacity or input variables on airline operating costs in isolation, this study will combine these variables together in a regression model to estimate the impact of each of these variables on airline operating costs.

The study will contribute to literature by exploring the factors that influence air carrier operating costs in Kenya. Specifically, the study will analyse how air traffic delays, output-volume and output-capacity affect airline operating costs in Kenya. Output-volume is expressed in terms of the number of passengers carried and tons of cargo lifted, while airline output capacity is expressed in terms of available seat kilometers (ASK), number of aircraft in the fleet and number of points served.
CHAPTER THREE

3.0 METHODOLOGY

This chapter presents the description of the analytical framework, empirical model, definitions and measurement of the variables, data types, sources and methods of analysis.

3.1. Theoretical Foundation

This study is conceived within the economic theory of the firm (Knight, 1921; Coase, 1937; Williamson, 1971; Alchian and Demsetz, 1972 and Arrow, 1987). According to the theory, firms maximize profit by minimizing the cost of producing any desired level of output $y$, and by choosing the most profitable level of output.

Varian (2003) defines the cost minimizing function as:

$$\min_{x_1, x_2} w_1 x_1 + w_2 x_2,$$

such that $f(x_1, x_2) = y$.

Where $w_1$ and $w_2$ are the prices of the two factors of production and $x_1$, $x_2$ are the amounts used of the two factors. $y$ is a given level of output and $f(y)$ is the production function.

The minimum cost necessary to achieve the desired level of output will depend on $w_1$, $w_2$ and $y$, so that we can write the cost function as $\epsilon(n_1, n_2, y)$

A given technology employed by a firm can have increasing, decreasing or constant returns to scale as $f(x_1, x_2)$ is greater, less than, or equal to $f(x_1, x_2)$ for all $t = 1$.

Decreasing returns to scale is a short-term phenomenon, with some factor being held fixed (Varian, 2003).
3.2. Model Specification

This is an exploratory study intended at determining and explaining the factors that drive airline costs in Kenya. Half yearly time-series data from 1995 to the year 2011 is used in the analysis to investigate how air traffic delays in Kenya affect airline operating costs.

Kenya Airways operating costs data is used in an OLS regression as the dependent variable while data on air traffic delays, available seat kilometers (ASK), number of passengers carried, tons of cargo lifted, number of points served and number of aircraft in service is used as explanatory variables.

The choice of OLS regression model is based on the assumption of a linear relationship between the dependent and the independent variables. OLS regression will allow us to estimate the independent effects of each of the explanatory variables on Kenya Airways operating cost while controlling the influence of the others.

According to Banker and Johnston (2001), airline costs are primarily associated with capacity and number of passengers served. Econometric cost functions estimated using aggregated output have been used mainly to analyze industry structure. The usual approach is based upon an estimated cost function \( C(Y, N) \). Where, \( Y \) is a vector of aggregate product descriptions and \( N \) is a variable representing the network (Jara-Diaz, 1982).

The model used in this study is of the form:

\[
OC = f(\text{Number of Pax}, \text{Cargo tonnage}, \text{No. of aircraft}, \text{ASK}, \text{Network size}, \text{Flight delay})
\]

Where,
\( O C \) is the Kenya Airways direct operating cost (the dependent variable) measured in millions of Kenya Shillings.

The specific regression to be used is as presented below:

\[
OC = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \ldots + \alpha_n X_n + \alpha_{n+1} X_1 + \alpha_{n+2} X_2 + \ldots + \alpha_{2n} X_n + \epsilon,
\]

Where:

- \( X_i \) is the measure of the independent variable (Number of passengers carried in millions, cargo lifted in tonnes, Number of aircraft in service, Available Seat Kilometers in millions, number of points served, and air traffic delay in minutes) per half year.
- \( \alpha_0 \) is the fixed cost component of the operating cost.
- \( \alpha_i \) is the coefficient of the specific independent variable to be estimated.
- and \( \epsilon \) is the stochastic error term.

It is expected that if the numbers of passengers and cargo tons increase operating costs will increase because costs increase with output (Cook et al., 2002). If the number of aircraft, number of points served and ASK increases, operating cost are also expected to increase because of the increased scale of operation (Williams, 2008; Saradal et al., 1975 and Hansen and Zou, 2008). Operating costs are also expected to increase with flight delays because delays lead to consumption of additional resources (Dal, 1978 and Cook et al. 2002).

### 3.3. Data Types and Sources

This study uses secondary data for its analysis. The data is used to establish the trends of Kenya Airways operating costs and of air traffic delays experienced by its flights. The data is also used to carry out econometric regressions to determine the nature and strength of the
relationship between the explanatory variables including air traffic delays and airline operating costs.

Half-yearly time series data on air traffic delays to Kenya Airways flights, Number of passengers carried, tonnage of cargo lifted, Number of aircraft in service, Available Seat Kilometers, number of points served, and of Kenya Airways operating costs for the period from 1995 to the year 2011 was sourced from Kenya Airways Flight Operations and Accounts records. Most of these data is also available online on the KQ’s website and at the International Air Transport Association’s IATA's library in Nairobi. Data on actual departure and arrival times of flights was sourced from Kenya Civil Aviation Authority’s (KCAA) Air Navigation Services statistics records.

3.4. Time Series Properties

Application of simple OLS using time series data is likely to produce inconsistent and spurious regression results. However, modern time series modelling techniques provide a better way of addressing these problems. Stationarity and cointegration analysis can be used to avoid spurious regressions while at the same time providing a means of explicitly distinguishing between long-run and short run relationships through the error correction formulation. If long-run relationships exist and are permanent, then it makes sense to analyse how short-run behaviour responds to long-run relationships. This technique is best suited for time series data analysis and is adopted in this study. The various tests applied on the data used in this study are explained in this subsection.
3.4.1 Correlation Analysis

One of the assumptions of Classical Linear regression Modeling (OLS) is that there should be no exact linear relationship among any of the independent variables in the model. That is, independent variables should not be highly linearly correlated, the econometric problem of multicollinearity, and therefore making it difficult to identify separate effects of each independent variable or making it impossible to compute respective coefficients. This problem would be detected in the event of getting the following three consequences jointly: inconsistent results (such as a wrong sign), a large R-squared and a small t-ratio. Multicollinearity can also be detected by getting a correlation matrix whereby, any correlation coefficient greater than R-squared would imply existence of multicollinearity. However, only severe cases of multicollinearity require solving.

There are three ways of dealing with the problem of multicollinearity: either adding more data, removing variables that are less theoretically relevant from the pairs that are correlated or using proxy variables.

This section outlines econometric techniques applied on the time series data to avoid getting spurious regressions. The tests considered are stationarity (order of integration) test, cointegration, and Granger causality tests.

3.4.2 Stationarity Analysis (Unit Root Test)

Standard inference procedures do not apply to regressions that contain an integrated dependent variable or integrated regressors. It is therefore important to check whether a series is stationary or not before using it in a regression. A series is said to be stationary if its properties (mean and the variance) are not affected by a change of time. Working with non-
stationary variables in their levels can lead to spurious or meaningless results. The formal method to test the stationarity of a series is the unit root test.

There are two widely used unit root tests; the Dickey-Fuller (DF) and augmented Dickey-Fuller (ADF) tests and the Phillips-Peron (PP) tests. We shall use augmented Dickey-Fuller (ADF) tests in this study.

ADF tests considers an autoregressive, AR (1) process.

\[ y_t = \mu + \rho y_{t-1} + \varepsilon_t. \]

Where \( \mu \) and \( \rho \) are parameters and \( \varepsilon \) is assumed to be white noise. \( y \) is stationary series if \( |\rho| < 1 \). If \( \rho = 1 \), \( y \) is a non-stationary series (a random walk with a drift); if the process is started at some point, the variance of \( y \) increases steadily with time and goes to infinity. If the absolute value of \( \rho \) is greater than one, the series is explosive. Therefore, the hypothesis of a stationary series can be evaluated by testing whether the absolute value of \( \rho \) is strictly less than one. ADF test take the unit root as the null hypothesis:

\[ H_0 : \rho = 1. \]

Which is tested against the one-sided alternative.

\[ H_1 : \rho < 1. \]

The test is carried out by estimating an equation with \( y_{t-1} \) subtracted from both sides of the equation.

\[ \Delta y_t = \mu + \rho y_{t-1} + \varepsilon_t. \]

Where \( \tau = \rho - 1 \) and the null and alternative hypotheses are:

\[ H_{\text{II}} : \tau = 0, \quad H_{\text{I}} : \tau < 0. \]

(Unit Root) (Stationarity)
In many cases, stationarity can be achieved by simple differencing or some other transformation (Greene, 2002). A difference stationary series is said to be integrated and is denoted as \( I(d) \) where \( d \) is the order of integration. The order of integration is the number of unit roots contained in the series, or the number of differencing operations it takes to make the series stationary.

### 3.4.3. Cointegration Analysis

The finding that many macro time series may contain a unit root has spurred the development of the theory of non-stationary series analysis. Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary series may be stationary. That is, if two series are both \( I(1) \), then there may be a \( \beta \) such that \( z_t = y_t - \beta x_t \) is \( I(0) \).

Intuitively, if the two series are both \( I(1) \), then this partial difference between them might be stable around a fixed mean. The implication would be that the series are drifting together at roughly the same rate. If such a stationarity, or \( I(0) \) linear combination exists, the non-stationary (with unit root), time series are said to be cointegrated. In such a case, we can distinguish between a long run relationship between \( y \) and \( x \), that is, the manner in which the two variables drift upward together, and the short run dynamics, that is, the relationship between deviations of \( y_t \) from its long run trend and deviations of \( x_t \) from its long run trend. If this is the case then differencing of the data would be counterproductive, since it would obscure the long run relationship between \( y \) and \( x \). Cointegration and a related technique, error correction are concerned with methods of estimation that preserve the information about both forms of covariation.
Two broad approaches for testing for cointegration have been developed. The Engle and Granger (1987) method is based on assessing whether equation estimates of the equilibrium errors appear to be stationary. The second approach due to Johansen (1988, 1991) and Stock and Watson (1988), is based on Vector Autoregressive (VAR) approach.

Engle-Granger test is based on the residual of the estimated equilibrium relationship for unit root.

That is, if we had

$$ Y_{t(1)} = \alpha_0 + \alpha_1 X_{t(1)} + \epsilon $$

$$ \epsilon_t = [Y - \alpha_0 - \alpha_1 X] $$

Then X and Y are cointegrated.

This means therefore that, in the Engle-Granger framework at a second step after the cointegration test, we can use residuals from the regression to estimate an OLS regression. In the case of cointegration, since there is a linear combination between the two variables, running a regression at levels would not give us spurious results.

$$ Y_t = \alpha_0 + \alpha_1 X_t + \mu_t $$

Where $\alpha_0$, $\alpha_1$ are long run effects and are not spurious but we loose out the short run effect.

We will then need to difference and run a regression to get the short run effect, which would be unbiased and consistent.
3.4.4 Error Correction Mechanism

The other option when cointegration is present is the formulation of the Error Correction Mechanism (ECM), generally written as:

$$\Delta y_t = \beta_1 \Delta x_t + \beta_2 \Delta y_{t-1} + \epsilon \left[ y_{t-1} - \alpha_0 - \alpha_1 x_{t-1} - \alpha_2 x_{t-2} \right] + \mu.$$ 

Where, $\beta_1 \Delta x_t + \beta_2 \Delta y_{t-1}$ is the short-run effect, $\epsilon$ is the degree of Adjustment and $\left[ y_{t-1} - \alpha_0 - \alpha_1 x_{t-1} - \alpha_2 x_{t-2} \right] + \mu$ is the long-run effect.

The dynamic interaction between the variables will be quantified using an error correction model: the ECM model allows for the quantification of the short-run and long-run interaction of the variables in the study. By running an ECM we get both the short run and the long run effects and the degree of adjustment; which gives us the proportion of the errors that are corrected in the first period.

3.4.4 Granger Causality Test

Granger (1988) pointed out that if a pair of series is cointegrated then there must be Granger causation in at least one direction. The Granger approach to the question of whether $x$ causes $y$ is to see how much of the current $y$ can be explained by past values of $y$ and then to see whether lagged values of $x$ can improve the explanation. $y$ is said to be Granger-caused by $x$ if $x$ helps in the prediction of $y$, or equivalently if the coefficients on the lagged $x$'s are statistically significant. Two way causation is frequently the case: that is $x$ Granger causes $y$ and $y$ Granger causes $x$.

The statement that "$X$ Granger causes $Y$" does not however imply that $Y$ is the effect of the result of $X$. Granger causality measures precedence and information content but does not by itself indicate causality in the more common use of the term.
In our analysis, we shall use Eviews Statistical Software which runs a bivariate regression of the form:

\[ y_t = \alpha_y + \alpha_1 y_{t-1} + \ldots + \alpha_k x_{t-k} + \beta_1 y_{t-1} + \ldots + \beta_l y_{t-l} \]

\[ x_t = \alpha_x + \alpha_1 x_{t-1} + \ldots + \alpha_k x_{t-k} + \beta_1 y_{t-1} + \ldots + \beta_l y_{t-l} \]

for all possible pairs of \((x, y)\) series in the group. The reported F-statistic is the Wald statistics for the joint hypothesis.

\[ \beta_1 = \ldots = \beta_l = 0 \quad \text{for each equation.} \]

The null hypothesis is therefore that \(x\) does not Granger-cause \(y\) in the first equation and the \(y\) does not Granger-cause \(x\) in the second regression.

### 3.5 Limitations of the Study

The most important limitation of this study is that it only looks at the impact of air traffic delays on airline operating costs using the experience of a single airline: Kenya Airways. Moreover, the airline's financial data is only available up to the year 1995 when the airline started its privatization process and although air traffic delays are recorded on a daily basis; financial records are only released half yearly. This limited the size of our sample and we note the need to caution against making inferences from our results.

Secondly, the study could not give robust results on the impact of flight delays on airline operating costs because it considers only the tactical delay as observed from Kenya Airways published schedules. These published schedules prevent us from capturing delay that might
be incorporated into the schedule (the buffer) as an "On-Time" performance strategy of the airline.

Finally, airport congestion and air traffic delays may also depend on the day of the week or time of the day. This is not provided for in our study although it may be an important factor in determining the pattern of flight delays in Kenya. Despite its limitations however, the study provides a starting point for determining the factors influencing air transport costs and the impact of flight delays to the airline industry in Kenya. Thus, replication of the study and an extension of the study to include specific aircraft types, days and times of the day could be done. The study therefore provides motivation for future research that could include several airline companies.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

In this chapter, empirical results are given which includes correlation analysis, descriptive statistics, unit roots tests, cointegration tests, Granger causality and long-run and short-run modeling (ECM). Discussion of the regression results is provided at the end of the section.

4.1 Correlation Analysis

One of the assumptions of Classical Linear regression Modeling (OLS) is that there is no exact linear relationship among any of the independent variables in the model. That is the matrix $[X'X]$ should be full rank, or alternatively that the expected value of the independent variables should be equal to zero. $E(X'X) = 0$. Highly linearly correlated independent variables cause multicollinearity making it difficult to identify separate effects of each
independent variable on the response variable and sometimes making it impossible to compute respective coefficients. Multicollinearity can be detected by getting a correlation matrix whereby any correlation coefficient greater than R-squared would cause multicollinearity. However, only severe cases of multicollinearity require solving.

There are three ways of dealing with the problem of multicollinearity: adding more data, removing variables that are less theoretically relevant from the pairs that are correlated or using instrument (proxy) variables.

Table 4.1 (a) Correlation Matrix

<table>
<thead>
<tr>
<th></th>
<th>OC</th>
<th>DELAYS</th>
<th>PAX</th>
<th>CARGO</th>
<th>ASK</th>
<th>ACFTS</th>
<th>DEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>OC</td>
<td>1.0000</td>
<td>0.7921</td>
<td>0.9722</td>
<td>0.9651</td>
<td>0.9789</td>
<td>0.9742</td>
<td>0.9623</td>
</tr>
<tr>
<td>DELAYS</td>
<td>0.7921</td>
<td>1.0000</td>
<td>0.3962</td>
<td>0.3582</td>
<td>0.9927</td>
<td>0.9662</td>
<td>0.9773</td>
</tr>
<tr>
<td>PAX</td>
<td>0.9722</td>
<td>0.3962</td>
<td>1.0000</td>
<td>0.3582</td>
<td>0.9927</td>
<td>0.9662</td>
<td>0.9773</td>
</tr>
<tr>
<td>CARGO</td>
<td>0.9651</td>
<td>0.3582</td>
<td>0.3582</td>
<td>1.0000</td>
<td>0.9590</td>
<td>0.9389</td>
<td>0.9178</td>
</tr>
<tr>
<td>ASK</td>
<td>0.9789</td>
<td>0.9927</td>
<td>0.9927</td>
<td>0.9590</td>
<td>1.0000</td>
<td>0.9679</td>
<td>0.9457</td>
</tr>
<tr>
<td>ACFTS</td>
<td>0.9742</td>
<td>0.9662</td>
<td>0.9662</td>
<td>0.9389</td>
<td>0.9679</td>
<td>1.0000</td>
<td>0.9483</td>
</tr>
<tr>
<td>DEST</td>
<td>0.9623</td>
<td>0.9730</td>
<td>0.9470</td>
<td>0.9178</td>
<td>0.9457</td>
<td>0.9483</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

Source: Author, 2012

High correlation is detected between capacity variables (ASK, ACFTS and number of DEST) with most variables, we therefore substitute these three variables with some suitable instrument (proxy) variables which are related to operating costs but are uncorrelated with the other explanatory variables. We use the number of aircraft seats availed in the period (SEATS) and the number of kilometres flown (KMs) which according to literature (Banker et al., 1993) are also good representative of output capacity to replace the above variables (ASK, ACFTS and DEST).
We first run a correlation matrix to find out whether the selected variables meet the requirements of good instrument variables.

Table 4.1 (h) Correlation Matrix - New Model

<table>
<thead>
<tr>
<th></th>
<th>DELAYS</th>
<th>PAN</th>
<th>CARGO</th>
<th>KM</th>
<th>SEATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DELAYS</td>
<td>1.0000</td>
<td>0.3962</td>
<td>0.2989</td>
<td>-0.2168</td>
<td>0.2809</td>
</tr>
<tr>
<td>PAN</td>
<td>0.3962</td>
<td>1.0000</td>
<td>0.3582</td>
<td>-0.3615</td>
<td>0.2744</td>
</tr>
<tr>
<td>CARGO</td>
<td>0.2989</td>
<td>0.3582</td>
<td>1.0000</td>
<td>-0.4437</td>
<td>0.3657</td>
</tr>
<tr>
<td>KM</td>
<td>-0.2168</td>
<td>-0.3615</td>
<td>-0.4437</td>
<td>1.0000</td>
<td>-0.3056</td>
</tr>
<tr>
<td>SEATS</td>
<td>0.2809</td>
<td>0.2744</td>
<td>0.3657</td>
<td>-0.3056</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

Source: Author, 2012

As can be seen from the Correlation Matrix table 4.1 (h) above the two proxy variables selected (SEATS and KM) are not highly correlated with the other independent variables and there is therefore no risk of multicollinearity. The study will therefore adopt the two variables, number of aircraft seats availed (SEATS) and the total distance flown in kilometers (KM) as independent variables representing airline output capacity in the new model.

The new model:

\[ OC = \{D|\text{Delays, Pax, Cargo, Seats, Kilometres(KM)}\} \]

Where,

\( OC \) is the airline operating costs in millions of Kenya shillings.

\( \text{Delays} \) is the amount of air traffic delay in minutes.

\( \text{Pax} \) is the number of airline passengers carried.

\( \text{Cargo} \) is the amount of cargo lifted by the airline in tonnes.

\( \text{Seats} \) is the amount of seats availed for passengers and
KM is the total distance flown by all aircrafts of the airline in kilometres.

4.2 Descriptive statistics

Descriptive analysis enables us to describe and compare variables numerically. The mean, median and mode are the common measures of central tendency. While the range (maximum - minimum), and the standard deviation are the basic measures of dispersion.

The relationship among arithmetic mean and median depends on the distribution of the data. In a symmetric data set the mean and the median are equal. In a data set skewed to the right or positively skewed the median is less than the mean. In a data set skewed to the left or negatively skewed, the mean is less than the median. Skewness therefore measures the degree of departure of a distribution from symmetry. The Coefficient of Skewness (SK) generally between -3 and +3, and according to Karl Pearson (1857-1936) can be measured as:

\[ SK = \frac{1}{SD} (AM - Median) \]

Where,

AM is the Arithmetic Mean and SD is the Standard Deviation.

A coefficient of skewness of zero indicates that the distribution is symmetrical. A symmetrical curve is one which the right half of the curve is the mirror image of the left half of the curve. The closer the coefficient of skewness to positive (+ve) 3 the more positively skewed the distribution. On the other hand, the closer the coefficient of skewness to negative (-ve) 3, the more negatively skewed the distribution.

Kurtosis measures the degree of peakedness. In terms of Kurtosis a frequency curve can be described as being platykurtic that is flat with the number of observed values distributed
relatively evenly across the classes. Mesokurtic that is neither flat nor peaked, with respect to
the general appearance of the curve or leptokurtic implying that it is peaked with a large
number of observed values concentrated within a narrow range of possible values of the
variable being measured.

Table 4.2 Descriptive Statistics

<table>
<thead>
<tr>
<th>OC= f{Delays, Pax, Cargo, Seats, Kilometres(KM)}</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OC</strong></td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
</tr>
<tr>
<td><strong>Median</strong></td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
</tr>
<tr>
<td><strong>Std. Dev.</strong></td>
</tr>
<tr>
<td><strong>Skewness</strong></td>
</tr>
<tr>
<td><strong>Kurtosis</strong></td>
</tr>
<tr>
<td><strong>Observations</strong></td>
</tr>
</tbody>
</table>

As can be seen from the table 4.2 above, all the series are positively skewed and near
symmetrical with the median slightly less than the mean. The Coefficient of Skewness for
almost all the series except for Delays is close to zero further confirming the near
symmetrical and normal nature of the distributions.

30
4.3 Time Series Properties

4.3.1 Stationarity analysis - Unit Root Tests

To evaluate the effect of shock and to avoid spurious regression associated with non-stationary variables, it is critical to ensure that the model is in a stable equilibrium. We therefore test the time series properties of variables used in the model using Augmented Dickey–Fuller (ADF) test. The results are given in the Table 4.3 below.

Table 4.3.1 (a) Results for unit root test at levels

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF Test Stat.</th>
<th>1% Critical Value</th>
<th>5% Critical Value</th>
<th>STATIONARITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>OC</td>
<td>0.908625</td>
<td>3.6576</td>
<td>2.9591</td>
<td>NON STATIONARY</td>
</tr>
<tr>
<td>DELAYS</td>
<td>0.331075</td>
<td>3.6576</td>
<td>2.9591</td>
<td>NON STATIONARY</td>
</tr>
<tr>
<td>PAX</td>
<td>1.164975</td>
<td>3.6576</td>
<td>2.9591</td>
<td>NON STATIONARY</td>
</tr>
<tr>
<td>CARGO</td>
<td>-0.005504</td>
<td>3.6576</td>
<td>2.9591</td>
<td>NON STATIONARY</td>
</tr>
<tr>
<td>SEATS</td>
<td>1.574683</td>
<td>3.6576</td>
<td>2.9591</td>
<td>NON STATIONARY</td>
</tr>
<tr>
<td>KM</td>
<td>-2.249452</td>
<td>3.6576</td>
<td>2.9591</td>
<td>NON STATIONARY</td>
</tr>
</tbody>
</table>

Results of the ADF unit root test shown above shows that all the variables are not stationary at levels. We therefore difference them once and test for the order of integration.

Table 4.3.1 (b) Results for unit root test after differencing once

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF Test Stat.</th>
<th>1% Critical Value</th>
<th>5% Critical Value</th>
<th>STATIONARITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>OC</td>
<td>-3.584197</td>
<td>3.6661</td>
<td>2.9627</td>
<td>1(1) at 5%*</td>
</tr>
<tr>
<td>DELAYS</td>
<td>-4.128777</td>
<td>3.6661</td>
<td>2.9627</td>
<td>1(1)</td>
</tr>
<tr>
<td>PAX</td>
<td>-5.974541</td>
<td>3.6661</td>
<td>2.9627</td>
<td>1(1)</td>
</tr>
<tr>
<td>CARGO</td>
<td>-4.612977</td>
<td>3.6661</td>
<td>2.9627</td>
<td>1(1)</td>
</tr>
<tr>
<td>SEATS</td>
<td>-4.612977</td>
<td>3.6661</td>
<td>2.9627</td>
<td>1(1)</td>
</tr>
<tr>
<td>KM</td>
<td>-4.215898</td>
<td>3.6661</td>
<td>2.9627</td>
<td>1(1)</td>
</tr>
</tbody>
</table>

Note: 1(d) refer to the order of integration.
The tests show that all the variables are non-stationary at 5% level. However, the variables become stationary in first differences and are integrated of order one (1). The next step is to examine whether the integrated variables are cointegrated.

4.3.2 Cointegration Analysis

Modeling using variables in the first difference to achieve stationarity leads to loss of long-run information. The concept of cointegration implies that if there is a long-run relationship between two or more non-stationary variables, deviations from this long-run path are stationary. In other words, variables are said to be cointegrated if they are integrated of the same order and if a linear combination of these variables assumes a lower order of integration. There are two main methodologies for testing for cointegration. The Engle Granger test, which is based on the residuals of the estimated equilibrium relationship for unit root and Johansen's method that test the restrictions imposed by cointegration on the unrestricted Vector Autoregressions (VAR) involving the series.

Engle Granger method of testing for the existence of cointegrating relationship is twofold. First step, a test is done for the order of integration of the variables involved in the postulated long-run relationship. If they appear to have a unit root, then a model based on these variables (non-stationary) in static form is estimated by OLS to obtain the residuals. A second test is done for the order of integration of the residuals generated in step one.

If we had:

\[ Y_{1(t)} = \alpha_0 + \alpha_1 X_{1(t)} + \varepsilon \]

and get:

\[ \varepsilon_{1(t)} = [Y - \alpha_0 - \alpha_1 X] \]

then X and Y are cointegrated.
In the case of cointegration, since there is a linear combination between the variables, running a regression at levels would not give us spurious results.

\[ y_t = \alpha_0 + \alpha_1 x_t + \mu. \]

Where \( \alpha_0, \alpha_1 \) are long run effects and are not spurious but we lose out the short run effect.

We would then need to difference and run a regression to get the short run effect, which would be unbiased and consistent.

The other option when cointegration is present is to run an Error Correction Model (ECM), generally written as:

\[ \Delta y_t = \beta_1 \Delta x_{t-1} + \beta_2 \Delta x_2 + r \left[ y_{t-1} - \alpha_0 - \alpha_1 x_{t-1} - \alpha_2 x_{2,t-2} \right] + \mu. \]

Where, \( \beta_1 \Delta x_{t-1} + \beta_2 \Delta x_2 \) is the short-run effect, \( r \) is the degree of adjustment and \( \left[ y_{t-1} - \alpha_0 - \alpha_1 x_{t-1} - \alpha_2 x_{2,t-2} \right] + \mu \) is the long-run effect.

By running ECM we get both short run and long run effects and the degree of adjustment.

Both Johansen and Engle-Giranger methods are used in this analysis.

We first use Johansen’s multivariate procedure to check whether the variables are cointegrated in the long run. The results are given in table 4.3.2 (a) below.
### Table 4.3.2 (a): Johansen's Cointegration Test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Lag Interval</th>
<th>Lags</th>
<th>Regression</th>
<th>Test Statistic</th>
<th>Critical Value</th>
<th>Hypothesized Cointegration</th>
</tr>
</thead>
<tbody>
<tr>
<td>OC</td>
<td>1 to 1</td>
<td>1 to 1</td>
<td>Co-integration</td>
<td>3</td>
<td>Co-integration</td>
<td>1</td>
</tr>
<tr>
<td>DELAYS</td>
<td>Co-integration</td>
<td>2</td>
<td>Co-integration</td>
<td>2</td>
<td>Co-integration</td>
<td>2</td>
</tr>
<tr>
<td>PAX</td>
<td>Co-integration</td>
<td>3</td>
<td>Co-integration</td>
<td>3</td>
<td>Co-integration</td>
<td>3</td>
</tr>
<tr>
<td>CARGO</td>
<td>Co-integration</td>
<td>4</td>
<td>Co-integration</td>
<td>4</td>
<td>Co-integration</td>
<td>4</td>
</tr>
<tr>
<td>SEATS</td>
<td>Co-integration</td>
<td>5</td>
<td>Co-integration</td>
<td>5</td>
<td>Co-integration</td>
<td>5</td>
</tr>
<tr>
<td>KM</td>
<td>Co-integration</td>
<td>6</td>
<td>Co-integration</td>
<td>6</td>
<td>Co-integration</td>
<td>6</td>
</tr>
</tbody>
</table>

**Percent** denotes rejection of the hypothesis at 5% significance level.

**LR** test indicates 3 co-integrating equations at 5% significance level.

The test fails to reject cointegration and the Likelihood Ratio (LR) test indicates that there are three cointegrating equations at 5% significance level. For further verification, the Engle-Granger two-step procedure is carried out by testing the residuals from long-run equation for stationarity using the ADF test. This was done by first estimating the long-run equation using Ordinary Least Square Method (OLS) with variables that are integrated of order 1 at 1, in their levels (Engel and Granger 1987). The results are shown in Table 4.6 below.
Table 4.3.2(b) OLS regression results: Long-run relationships

<table>
<thead>
<tr>
<th>Dependent Variable: C</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DELAYS</td>
<td>0.221122</td>
<td>0.160706</td>
<td>1.375941</td>
<td>0.1801</td>
</tr>
<tr>
<td>PAX</td>
<td>0.00036</td>
<td>0.00319</td>
<td>0.112715</td>
<td>0.9111</td>
</tr>
<tr>
<td>CARGO</td>
<td>0.16838</td>
<td>0.097577</td>
<td>1.725604</td>
<td>0.0958</td>
</tr>
<tr>
<td>KM</td>
<td>0.001237</td>
<td>0.002264</td>
<td>0.546279</td>
<td>0.5894</td>
</tr>
<tr>
<td>SEATS</td>
<td>3.918855</td>
<td>1.133099</td>
<td>3.458528</td>
<td>0.0018</td>
</tr>
<tr>
<td>C</td>
<td>-3620.681</td>
<td>3135.549</td>
<td>-1.15472</td>
<td>0.2583</td>
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</table>

The table above depicts the results of the long run OLS Equation. The next step in accordance with Engle-Granger two-step procedure was to carry out a cointegration test based on the residuals obtained from the equation above by running an ADF unit root test. In this case stationarity of the residuals implies existence of cointegrating relationships among the variables in the long run equation.
The results of the unit root test on the residuals shows that the ADI test statistic, -3.039547, is less than the 5% critical value of -2.9591, implying that the resultant residual is stationary at the 5% level.

Further to the above analysis, we run a Granger-Causality test to further confirm the existence of cointegrating relationships among the variables.

### 4.3.3 Granger Causality Test

According to Granger (1988), if a pair of series is cointegrated, then there must be Granger causation in at least one direction. y is said to be Granger-caused by x if y helps in the prediction of y, or equivalently if the coefficients on the lagged y's are statistically significant.

In our analysis, we shall use Eviews Statistical Software which runs a bivariate regression of the form:

\[
\begin{align*}
    y_t &= \alpha_0 + \alpha_1 y_{t-1} + \ldots + \alpha_k y_{t-k} + \beta_1 x_{t-1} + \ldots + \beta_m x_{t-m} + \epsilon_t, \\
    x_t &= \alpha_0 + \alpha_1 y_{t-1} + \ldots + \alpha_k y_{t-k} + \beta_1 y_{t-1} + \ldots + \beta_l y_{t-l} + \beta_{l+1} x_{t-1} + \ldots + \beta_m x_{t-m} + \epsilon_t
\end{align*}
\]

for all possible pairs of \(\{x, y\}\) series in the group. The reported F-statistic are the Wald statistics for the joint hypothesis:

\[
\beta_1 = \ldots = \beta_m = 0 \quad \text{for each equation.}
\]

### Table 4.3.2 (c) Results for the ADF test on the residual

<table>
<thead>
<tr>
<th>ADF Test Statistic</th>
<th>1% Critical Value*</th>
<th>5% Critical Value</th>
<th>10% Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3.039547</td>
<td>-3.6576</td>
<td>-2.9591</td>
<td>-2.6181</td>
</tr>
</tbody>
</table>

*MacKinnon's critical values for rejection of hypothesis of a unit root
The null hypothesis is therefore that $x$ does not Granger-cause $v$ in the first equation and the $v$ does not Granger-cause $x$ in the second regression.

**Granger Causality test results**

Results for Granger Causality test (Appendix 5) show that there is at least a uni-directional causality running from all the independent variables to the dependent variable. This further confirms the existence of cointegrating relationship among the series. We therefore conclude that an Error Correction Model (ECM) is a better fit than one without.

4.4 **Error Correction Model**

We then move to the second step of estimating the ECM as postulated by Engel and Granger by using the residual from the long run equation. We are using stationary data since all the regressors are in their first difference form (11) which includes the residual of the long run equation. The error correction term (ECT) in the equation below is derived from the long-run equation above.

4.4.1 **The General Estimated Model**

Since we are introducing the residual from the long-run relationship as our Error Correction Term, we need to specify our general model to include it as shown below.

\[
\Delta OC = \beta_0 + \beta_1 \Delta DELAYS + \beta_2 \Delta PAX + \beta_3 \Delta CARGO + \beta_4 \Delta SEATS \\
+ \beta_5 \Delta KM + ECT + \varepsilon
\]

In the equation above, $ECT$ is the error correction term derived from the long run cointegrating relationship and its estimated coefficient measures the long-run relationship (speed of adjustment).
$\beta_0$ is the intercept and the remaining coefficients $\beta_1, \beta_2, \ldots$ measure the short run causal relationship.

$\epsilon$ is the white noise and $\Delta$ denotes that the variable is differenced once and represents a change in the variable over one period.

### 4.4.2 Regression results and the estimated equation

Using a general to specific estimation procedure, the preferred error correction model estimation results are given below.

Table 4.4 The Error Correction Model Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>$t$-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDELYS</td>
<td>0.391917</td>
<td>0.075705</td>
<td>5.17692</td>
<td>0.00000</td>
</tr>
<tr>
<td>DPAX</td>
<td>0.001446</td>
<td>0.001289</td>
<td>1.121078</td>
<td>0.2729</td>
</tr>
<tr>
<td>DCARGO</td>
<td>0.232388</td>
<td>0.053591</td>
<td>4.336321</td>
<td>0.0002</td>
</tr>
<tr>
<td>DSEATS</td>
<td>-0.67555</td>
<td>0.761899</td>
<td>-0.886666</td>
<td>0.3837</td>
</tr>
<tr>
<td>DNM</td>
<td>-0.000425</td>
<td>0.001092</td>
<td>-0.389442</td>
<td>0.7002</td>
</tr>
<tr>
<td>ECT</td>
<td>0.648827</td>
<td>0.142635</td>
<td>4.548859</td>
<td>0.0001</td>
</tr>
<tr>
<td>C</td>
<td>429.9659</td>
<td>136.2235</td>
<td>3.156327</td>
<td>0.0041</td>
</tr>
</tbody>
</table>

R-squared: 0.754122  (Mean dependent var: 738.4375)
Adjusted R-squared: 0.695111  (S.D. dependent var: 1194.474)
S.E. of regression: 659.55  (Akaike info criterion: 16.01163)
Sum squared resid: 10875155  (Schwarz criterion: 16.33226)
Log likelihood: -249.1861  (F-statistic: 12.77938)
Durbin-Watson stat: 1.705401  (Prob (F-statistic): 0.000001)

Notes: D' at the start of the variable acronym indicates the first difference of the variable. ECT is the
error correction term obtained from the residual of the long-run cointegrating equation.

The ECM regression results above gives the following equation:

\[ \Delta c_t = 429.9659 + 0.391917 \Delta D E L A Y + 0.001446 \Delta D P A X + 0.232388 \Delta R G O - 0.67 \Delta S E A T S \\
- 0.000425 \Delta K M + 0.648827 \Delta E C T \]

4.5 Discussion of Results

We first analyze results of the long-run relationships from the OLS regression and then proceed to the error correction model. From the long-run cointegrating equation regression results table (table 4.3.2b), we see that the model has a very high goodness of fit (0.98) and all the coefficients are positive as expected. However, only the coefficient for number of aircraft seats (SEATS) is significant, implying that operating costs increase with capacity expansion in the form of using more or larger aircraft in the long run. The results support findings by Brueckner et al. (2009) who found airline operating costs to be linearly related to seat capacity.

Table 4.4 reports our preferred Error Correction Model (ECM) results. The ECM regression results show that most variables except for change in the number of aircraft seats availed (DSEATS) and change in kilometres flown (DKM) have the expected signs. The Durbin-Watson (DW) statistic is 1.7 confirming that we have no autocorrelation problem and our results are not spurious. The p-value for the F-statistic in our regression results 0.000001 is less than the 0.01 significant level and we therefore reject the null hypothesis that all slope coefficients are not significant.

The goodness of fit (R Squared) is 0.754, implying that changes in the regressors represent about 75 percent of the changes in the dependent variable (airline operating cost), which is a good fit for our
analysis. The individual coefficients reflect the sensitivity of airline operating cost to various regressors at the sample mean.

The coefficient for change in delays (DELAYS) is positive as expected and significant at 1 percent significant level. The coefficient is 0.39, indicating that a one percent increase in air traffic delays causes an increase of 0.39 percent in airline operating cost. The results support findings by Dal, (1978), Cook et al (2002) and Hansen (2008) that airline operating cost increase with the length of delay.

The coefficient for change in the number of passengers carried (DPAX) is positive as expected but not significant, implying that the increase in direct airline operating cost as result of an increase in the number of passengers is not significant. This perhaps because airlines usually have excess capacity and occupation of the extra seat in the aircraft by an additional passenger would not attract significant additional operating costs. This result supports the findings by Banker and Johnson (1993) that only a small fraction of cost (for personnel who handle passengers, reservations and sales) vary in direct proportion to the number of passengers handled.

The coefficient for the change in the amount of Cargo lifted (DCargo) is also positive and significant at 1 percent level. The coefficient is 0.23, implying that an increase of 1 percent in the amount of cargo lifted leads to an increase of 0.23 percent in airline operating cost. This perhaps because Kenya Airways main business is the carriage of passengers and therefore reconfiguring the aircraft to accommodate extra cargo results in inefficient use of aircraft space and additional operating costs. The results however seems to support the conventional wisdom in economic literature that output volumes drive operating costs.

Surprisingly perhaps, and unlike in the long-run equation, the coefficients for the airline output
capacity variables: change in the available aircraft seats (DSEATS) and change in kilometres flown (DKM) have negative signs, suggesting a trend towards increasing returns to the scale of production. The results support findings by both Bailey et al. (1985) and Kirby (1986) who have documented decreases in operating costs with increase in average aircraft size all else held constant. The results are also consistent with those of Caves et al. (1984) and Kirby (1986) who have both found decreases in total operating costs with increases in average stage length (distance flown).

The coefficient for the error correction term (ECT) is positive and significant with a relatively high speed of adjustment of about 0.65 - suggesting that about 65% of deviations from long-run equation are made up within one time period (half year).

The constant term \( c \) is 429.97, is positive as expected and significant at 1% level, implying that there are operating costs that do not change with the scale of operation.

CHAPTER V

5.0 SUMMARY, CONCLUSIONS AND POLICY RECOMMENDATIONS

This chapter gives the summary of the research, the main findings, the conclusions, and policy recommendations.

5.1. Summary

This study attempted to evaluate the determinants of airline operating costs in Kenya to investigate the impact of air traffic delays on airline costs in Kenya. The objectives of this study were to establish the trend of airline operating costs in Kenya and determine the effect of air traffic control delays and the traditional volume and output capacity variables on airline
operating costs in Kenya. The volume-based variables used in the study are the number of passengers carried and the amount of cargo lifted in tonnes, while the output capacity-based variables used in the estimation are the available aircraft seats and the total distance flown in kilometers. A long run cointegration regression was run to estimate the long-run relationships and an Error Correction Model was formulated to estimate the short-run dynamics.

Plotting time series data for Kenya Airways' operating costs and of air traffic delays for the period 1995 to 2011 reveal that Kenya operating cost and air traffic delays have been increasing over time (Figure in appendix I).

The long-run cointegrating regression reveals that all the variables are positively related to airline operating cost. However, only coefficients for the number of aircraft seats (SEATS) are significant, implying that increasing the number of aircraft seats by buying more and larger aircrafts will increase airline operating costs in the long-run.

Results of the ECM regression on air traffic delays are positive and significant implying that in the short run, air traffic delays increase with airline operating costs. The result confirms that flight delays generated by the air transport system in Kenya are associated with increase in airline operating cost.

Results for number of passengers were positive but not significant suggesting that the change in operating cost due to increase in the number of passengers is minimal and not significant. This is the case perhaps because flights are seldom full and the excess seating capacity can always be utilized without attracting extra operating costs.
Results on tons of cargo show that the amount of cargo lifted is positively related to airline operating costs. The results indicate that converting aircraft cabin configuration to accommodate more cargo and less passengers' increases operating costs.

Results on airline output capacity variables, available aircraft seats and total distance flown are negative and not significant pointing to the possibility of existence of increasing returns to scale of production. These results seem to support the argument by Brueckner et al. (2000) that cost per aircraft seat falls as aircraft size increases.

5.2 Conclusions

Our findings have empirically revealed that both air traffic delays and output volumes are important cost drivers in the airline industry in Kenya. The results for the output capacity variables suggest that there are economies associated with the use of larger aircraft and flying longer distances.

Results from estimating both the long-run cointegrating equation and the ECM model suggest that air traffic delay represent an important cost driver in airline operating cost. The results therefore supports the view, suggested by earlier studies that air traffic delays are associated with increased airline operating costs.

The two volume-based variables, number of passengers carried (DPAX) and the amount of cargo lifted (DCARGO) were found to be positively related to airline operating cost. However, only change in the amount of cargo lifted DCARGO was found to be significant with a very high t-statistic of 4.336. This is the case perhaps because Kenya Airways main
business is the carriage of passengers and there are always some extra seats remaining which can be occupied by additional passengers without attracting additional operating costs.

On the contrary, the results for change in the amount of cargo lifted while supporting the conventional economic theory that operating costs increase with output volumes also seem to suggest that carriage of additional cargo in a passenger aircraft in lieu of passengers leads to substantial increase in operating costs.

The results for the output capacity variables, number of aircraft seats (DSEATS) and the number of kilometres travelled (DKM) were negative in the ECM model. The results point to the possibility of existence of economies of scale in using aircraft of a larger size with more seats and serving a wider and denser route network.

5.3 Policy Recommendations

Our results for air traffic delays indicate that increase in delays causes increases in airline operating costs in Kenya. Since air traffic delays are a direct result of the inability of the aviation system to handle traffic demands that were placed upon it, improvement in the air transportation capacity is required. Substantial investments are required in order to modernize and expand the aviation infrastructure so that it can accommodate air traffic growth without large increases in delay. The government through the Kenya Civil Aviation Authority should consider investing in the so-called Next Generation Air Transportation System (NextGen) which deploys improved systems for communication, surveillance, navigation and air traffic management (CNS ATM), and require flight operators to invest in new on-board equipment.
Substantial improvements in the air transportation capacity also require airport infrastructure enhancement. The study recommends construction of another runway with its associated taxiways, and expansion of the terminal and the apron to improve airport traffic handling capacity and reduce delays at Nairobi's Jomo Kenyatta International airport. The business case for these investments should rest on the value of reducing air traffic delay and its associated costs. It is however important to note that some flight delays are unavoidable in the real world. Even in the presence of ample capacity, certain causes of delays such as aircraft mechanical problems, aircraft loading and passenger related issues are therefore likely to remain. In addition, it may not be economically viable to size the air transportation system to fully accommodate peak period traffic flows, and so there will always be some amount of queuing during those periods. Therefore, total elimination of flight delays is neither practical nor desirable.

The results for number of passengers indicate that picking additional passengers attracts very small costs that are not significant in our analysis. Established airlines like Kenya Airways should therefore use their price discrimination strategies to charge competitive fares on routes that are invaded by low-cost flight carriers in order to reclaim their market shares. This should enable them attract more passengers to fill the extra seats in their fleet and earn more revenue without incurring significant additional operating cost.

The results for cargo tonnage imply carrying more cargo in lieu of passengers in an airline whose main business is the carriage of passengers imposes extra operating costs. Therefore, airlines whose main business is the carriage of passengers are discouraged from configuring passenger aircrafts to accommodate more cargo in order to avoid incurring additional operating costs.
Results on airline output capacity variables, available aircraft seats and kilometres flown suggest there are economies of scale and density in air transport business. These results support the case for use of large aircraft and serving a wide and dense route network. Airlines that enjoy good market shares on certain routes are therefore encouraged to use large aircraft with more seats to serve the routes because they have cost advantages. This clearly supports Kenya Airways recent purchase of nine “Dreamliners” (Boeing 787-8) aircrafts - the first of which is expected to make its maiden flight in 2013. Market research for new routes is also encouraged as operating costs per kilometre, according to our regression results, decrease with increase in distance flown.
6.0. REFERENCES


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42. Williams G., 2008. “Benchmarking of Key Airline Indicators” Cranfield University

## APPENDIX I: DATA USED FOR ANALYSIS

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<td>1400</td>
<td>1400</td>
<td></td>
</tr>
</tbody>
</table>

Source: Kenya Airways
## APPENDIX 2: KENYA AIRWAYS FLEET IN 1995

<table>
<thead>
<tr>
<th>AIRCRAFT TYPE</th>
<th>Number of Seats</th>
<th>Number of Aircrafts of Type</th>
<th>Total Available Aircraft Seats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airbus A310-300</td>
<td>179</td>
<td>3</td>
<td>537</td>
</tr>
<tr>
<td>Boeing 737-300</td>
<td>116</td>
<td>1</td>
<td>116</td>
</tr>
<tr>
<td>Boeing 737-200</td>
<td>105</td>
<td>1</td>
<td>105</td>
</tr>
<tr>
<td>Fokker 50</td>
<td>58</td>
<td>3</td>
<td>174</td>
</tr>
<tr>
<td><strong>GRAND TOTAL</strong></td>
<td><strong>8</strong></td>
<td><strong>8</strong></td>
<td><strong>932</strong></td>
</tr>
</tbody>
</table>

*Source: Kenya Airways.*

## KENYA AIRWAYS FLEET IN 2011

<table>
<thead>
<tr>
<th>AIRCRAFT TYPE</th>
<th>Number of Seats</th>
<th>Number of Aircrafts of Type</th>
<th>Total Available Aircraft Seats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boeing 777-200ER</td>
<td>322</td>
<td>4</td>
<td>1288</td>
</tr>
<tr>
<td>Boeing 767-300ER</td>
<td>216</td>
<td>6</td>
<td>1296</td>
</tr>
<tr>
<td>Boeing 737-800</td>
<td>145</td>
<td>5</td>
<td>725</td>
</tr>
<tr>
<td>Boeing 737-700</td>
<td>116</td>
<td>4</td>
<td>464</td>
</tr>
<tr>
<td>Boeing 737-300</td>
<td>116</td>
<td>6</td>
<td>696</td>
</tr>
<tr>
<td>Embraer 170</td>
<td>72</td>
<td>4</td>
<td>360</td>
</tr>
<tr>
<td>Embraer 190</td>
<td>96</td>
<td>2</td>
<td>192</td>
</tr>
<tr>
<td><strong>GRAND TOTAL</strong></td>
<td><strong>32</strong></td>
<td><strong>32</strong></td>
<td><strong>5821</strong></td>
</tr>
</tbody>
</table>

*Source: Kenya Airways.*
From the figure above we observe that Kenya Airways operating cost have been increasing with time since the year 1995.

Source: Kenya Airways

Source: Kenya Airways

The figure above shows that air traffic delays encountered by Kenya Airways have been increasing over time since the year 1995.
### APPENDIX 5: Granger Causality Test Results

**Pairwise Granger Causality Tests**

**Sample**: 1995:1 - 2011:1  
**Lags**: 2

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Obs</th>
<th>F-Statistic</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>DELAYS does not Granger Cause DOC</td>
<td>31</td>
<td>3.83192</td>
<td>0.05480</td>
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<tr>
<td>OC does not Granger Cause DELAYS</td>
<td>31</td>
<td>7.01913</td>
<td>0.00365</td>
</tr>
<tr>
<td>PAX does not Granger Cause DOC</td>
<td>31</td>
<td>11.3780</td>
<td>0.00028</td>
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<tr>
<td>OC does not Granger Cause PAX</td>
<td>31</td>
<td>6.23053</td>
<td>0.00810</td>
</tr>
<tr>
<td>CARGO does not Granger Cause DOC</td>
<td>31</td>
<td>3.85725</td>
<td>0.03412</td>
</tr>
<tr>
<td>OC does not Granger Cause CARGO</td>
<td>31</td>
<td>3.45946</td>
<td>0.08654</td>
</tr>
<tr>
<td>SEATS does not Granger Cause DOC</td>
<td>31</td>
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<tr>
<td>OC does not Granger Cause SEATS</td>
<td>31</td>
<td>1.17751</td>
<td>0.32394</td>
</tr>
<tr>
<td>KM does not Granger Cause DOC</td>
<td>31</td>
<td>9.40275</td>
<td>0.00085</td>
</tr>
<tr>
<td>OC does not Granger Cause KM</td>
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<td>0.17891</td>
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<tr>
<td>PAX does not Granger Cause DELAYS</td>
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<td>0.00547</td>
</tr>
<tr>
<td>DELAYS does not Granger Cause PAX</td>
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<td>0.90641</td>
<td>0.41636</td>
</tr>
<tr>
<td>CARGO does not Granger Cause DELAYS</td>
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<td>0.13426</td>
</tr>
<tr>
<td>DELAYS does not Granger Cause CARGO</td>
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<td>1.95082</td>
<td>0.16241</td>
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<tr>
<td>SEATS does not Granger Cause DELAYS</td>
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<td>DELAYS does not Granger Cause KM</td>
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<td>0.72924</td>
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<tr>
<td>CARGO does not Granger Cause PAX</td>
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<td>0.14439</td>
<td>0.86624</td>
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<td>PAX does not Granger Cause CARGO</td>
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<td>0.76208</td>
<td>0.47684</td>
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<td>KM does not Granger Cause PAX</td>
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<td>0.30841</td>
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<tr>
<td>PAX does not Granger Cause KM</td>
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<td>0.51594</td>
<td>0.60292</td>
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<tr>
<td>CARGO does not Granger Cause SEATS</td>
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<td>0.82241</td>
<td>0.45048</td>
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<tr>
<td>KM does not Granger Cause CARGO</td>
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<tr>
<td>CARGO does not Granger Cause KM</td>
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<td>0.01986</td>
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<tr>
<td>KM does not Granger Cause SEATS</td>
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<td>1.10761</td>
<td>0.34543</td>
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<tr>
<td>SEATS does not Granger Cause KM</td>
<td>31</td>
<td>9.40275</td>
<td>0.00085</td>
</tr>
</tbody>
</table>
**APPENDIX 6: Correlation Matrix table**

(OC=f(Delays, Pax, Cargo, ASK, Acfts, Dest))

<table>
<thead>
<tr>
<th></th>
<th>OC</th>
<th>Delays</th>
<th>Pax</th>
<th>Cargo</th>
<th>ASK</th>
<th>Acfts</th>
<th>Dest</th>
</tr>
</thead>
<tbody>
<tr>
<td>OC</td>
<td>1.00000</td>
<td>0.79210</td>
<td>0.97224</td>
<td>0.96513</td>
<td>0.97893</td>
<td>0.97415</td>
<td>0.96239</td>
</tr>
<tr>
<td>Delays</td>
<td>0.79210</td>
<td>1.00000</td>
<td>0.39621</td>
<td>0.35824</td>
<td>0.99274</td>
<td>0.96622</td>
<td>0.76421</td>
</tr>
<tr>
<td>Pax</td>
<td>0.97224</td>
<td>0.39621</td>
<td>1.00000</td>
<td>1.00000</td>
<td>0.95903</td>
<td>0.93889</td>
<td>0.96622</td>
</tr>
<tr>
<td>Cargo</td>
<td>0.96513</td>
<td>0.35824</td>
<td>1.00000</td>
<td>1.00000</td>
<td>1.00000</td>
<td>0.94574</td>
<td>0.94574</td>
</tr>
<tr>
<td>ASK</td>
<td>0.97893</td>
<td>0.99274</td>
<td>0.95903</td>
<td>1.00000</td>
<td>1.00000</td>
<td>0.96794</td>
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<tr>
<td>Acfts</td>
<td>0.97415</td>
<td>0.96622</td>
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<td>0.94574</td>
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<td>0.91839</td>
<td>0.94839</td>
</tr>
<tr>
<td>Dest</td>
<td>0.96239</td>
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<td>0.91788</td>
<td>0.94574</td>
<td>0.91839</td>
<td>1.00000</td>
<td>1.00000</td>
</tr>
</tbody>
</table>

Source: Author, 2012.

As can be seen from the two proxy variables selected (SEATS and KM) are related with the direct airline operations cost (the dependent variable) but not highly correlated with the other independent variables. The variables were therefore adopted as the independent variables representing airline capacity in the new model.

**APPENDIX 7: Correlation matrix of New Model after differencing**

<table>
<thead>
<tr>
<th></th>
<th>DOC</th>
<th>DDelays</th>
<th>DPax</th>
<th>DCargo</th>
<th>DKM</th>
<th>DSEATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOC</td>
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<td>0.43187</td>
<td>0.60943</td>
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<td>0.50786</td>
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<td>DDelays</td>
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<td>1.00000</td>
<td>0.27125</td>
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<td>0.23589</td>
<td>0.22010</td>
</tr>
<tr>
<td>DPax</td>
<td>0.60943</td>
<td>0.27125</td>
<td>1.00000</td>
<td>0.33222</td>
<td>0.29391</td>
<td>0.74213</td>
</tr>
<tr>
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<td>-0.07100</td>
<td>0.33222</td>
<td>1.00000</td>
<td>0.49958</td>
<td>0.35116</td>
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<tr>
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<td>0.74213</td>
<td>0.35116</td>
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