Air Transportation and Economic Growth in Egypt using ARDL Approach

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Abstract

Development of air transportation sector is of crucial importance for stimulation of "economic growth". Most of international freight in Egypt relies on maritime transportation, which requires further study of air transportation in the Egyptian economy. The paper analyzes short-run and long-run dynamics among studied variables on annual basis from 1970 till 2019 to investigate the relationship between "economic growth" and air transportation. The paper derived economic hypotheses using logical deduction, then empirical testing through econometric methods deploying ARDL "Autoregressive Distributed Lag" technique based on specification and model examination, estimating three models; first model main hypothesis that air transportation accelerates "economic growth" estimation found positive statistical significance of infrastructure and air passengers on "economic growth", and insignificance of air freight, second model main hypothesis "economic growth" accelerates air passenger which found to be statistically positive significant, third model main hypothesis that "economic growth" accelerates air freight which found to be insignificant. The study recommends further investment in air transportation to enhance economic growth.

Keywords: Egypt, ARDL, economic growth, Air Transport, air passenger, Air freight.

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دراسة العلاقة بين النقل الجوي والنمو الاقتصادي بجمهورية مصر العربية

مستخلص

تبحث الدراسة من خلال بناء وتقدير ثلاثة نماذج قياسية في العلاقتين قصيرة وطويلة الاجل بين النمو الاقتصادي والنقل الجوي بشقيه (الركاب والبضائع) في مصر باستخدام بيانات سنوية للفترة من 1970 الى 2019 بتطبيق نموذج الانحدار الذاتي للإبطاء الموزع ثم دمج نموذج تصحيح الخطأ لتحديد التعديل قصيرالاجل والعلاقة طويلة الاجل بين المتغيرات محل الدراسة. تناول النموذج الأول تقدير تأثير النقل الجوي على النمو الاقتصادي، واشارت نتائجه الى التأثير المعنوي الإيجابي للبنية التحتية وعدد الشركات المسجلة والنقل الجوي للركاب على النمو الاقتصادي، بينما لم يظهر النقل الجوي للبضائع اي دلالة معنوية، وجاء النموذج الثاني لتقدير تأثير النمو الاقتصادي على النقل الجوي للركاب، واكدت نتائجه على وجود علاقة معنوية ايجابية متبادلة بين النقل الجوي للركاب والنمو الاقتصادي، في حين لم يظهر تقدير النموذج الثالث للعلاقة بين النقل الجوي للبضائع والنمو الاقتصادي اي نتائج معنوية في الاجلين الطويل والقصير؛ نتيجة عدم الاعتماد على الشحن الجوي في نقل البضائع في مصر والاعتماد على النقل البحري بنسبة تزيد عن 99٪ من اجمالي الشحن الدولي. بينما وجد تأثير معنوي للصادرات على النقل الجوي للبضائع عند التوسع في تحليل المؤثرات ذات الدلالة لنقل البضائع واخيرا توصي الدراسة بزيادة توجيه الموارد الاستثمارية لتحسين البنية التحتية للنقل الجوي ورفع كفاءتها وجودتها وزيادة الاهتمام بقطاع الشحن الجوي للاستفادة اقتصاديا منه. بالإضافة الى العمل على توازن سياسات واستراتيجيات النقل بين جهود الحكومة في تحسين النقل والشحن الجوي وفتح بوابات اتصال دولية أكثر كفاءة مما يعمل على حفز النمو الاقتصادي.

الكلمات الدالة: مصر، النقل الجوي للبضائع، النقل الجوي للركاب، البنية التحتية، النمو الاقتصادي، الانحدار الذاتي لفترات الإبطاء الموزع.

Introduction

The development of transportation is of great importance for acceleration of "economic growth" in opening access to higher international trade and domestic production. Air transportation in Egypt makes an important economic contribution as mentioned by IATA “International Air Transport Association” the air transportation industry-supported US $ 3 billion in 2019, of almost 1.1% of Egypt's GDP, and 602000 jobs.

Air transportation developed in 20th Century due to technological advancement since the Second World War. According to ATAG "Air Transport Action Group” 2020 report 87.7 million jobs on the international level was supported by air transport and 4.1% of global GDP, while supported 3.4 million jobs of almost 4.5% of all Middle east employment and $213 billion in GDP almost 7.6% of all GDP in Middle East countries, and supported 7.7 million jobs of almost 2.2% of African countries employment and $63 billion almost 2.7% of African countries GDP.

Problem of study that in Egypt international freight relies mainly on maritime transportation, which requires studying of air transportation in the Egyptian economy, as one of the major governmental goals is the enhancement of transportation sector focusing on freight transportation to increase international trade, that shows the importance of studying the dynamic relationship of air passenger, air freight and "economic growth" in Egypt, which stress on current paper importance.

There are numerous literatures studying the importance of transportation for enhancing "economic growth", however, transportation and "economic growth" could have a bi-directional relationship as higher levels of GDP and income level can stimulate transportation development. The main

objective of the current paper is studying the bi-directional relationship between "economic growth" and air transportation in Egypt from 1970 till 2019.

The paper uses deductive approach deriving economic hypotheses using logical deduction, then empirically testing them through econometric methods deploying ARDL technique using three models; first model main hypothesis that air transportation accelerates "economic growth", second model main hypothesis that "economic growth" has positive impact on air passenger, third model hypothesis is the direct significant impact of "economic growth" on air freight.

The remaining of paper planned as follows second section is covering theoretical and literature background; then continues with a brief discussion of air transportation in Egypt at third section. The fourth section covers data description and explanation of methodology, followed by results of empirical analysis at fifth section, then ending with conclusion and recommendations.

Theoretical Background

Transport infrastructure improvement in the short run will lead to a reduction of time and costs, raising the reliability of transport services which in turn will encourage specialization and international trade which stimulate economic growth. In long-run, further improvement of transportation will cause market expansion and openness to the outside world which increase export and import. Growth of exports will raise production levels and profits while imports raise competitiveness at the local market which enhances efficiency (Amairia and Amaria, 2017).

Endogenous Growth Model shows possible infrastructure impact on economic growth. Romer (1986), then Lucas (1988),

later Barro (1990), endogenize infrastructure in "aggregate production function".

Economic literature state long run relationship among output and public capital as proxy of infrastructure. Arrow & Kurz (1970), show based on "endogenous growth model" that stock of public capital causes output per capita to rise, along permanent growth effects. Aschauer (1989) stated that "infrastructure investment has strong positive impact on economic growth". Economic models studied growth effect of "public capital" through studying services offered by capital assets. Fernald (1999), assumed for industry *i*, the production depends, on labor "Li" in addition to capital "Ki", as well as, on transport services "*Ti*", depend on the services provided by government capital stock "*G"* (as roads), and vehicles stock "*Vi"*. Output depends as well on "Hicks-neutral level of technology *Ui*", which yield: "Qi = Ui F i (Ki, Li, Ti (Vi, G))". The model shows transport infrastructure impact on output.

Egger and Falkinger (2003) stated that Infrastructure improvement reduces fixed costs, which attract firms, and factors of production, then raise levels of production. Literature of "Krugman, 1991, Holtz-Eakin and Lovely 1996, Venables, 1996, Fujita *et al.* 1999", considered transportation cost as main factor in choosing location and size of business activity, as well as, trade pattern, which affect market size and lead to economies of scale.

As discussed by "Krugman 1991; Bougheas *et al*. 1999" transport cost modeled as "iceberg costs". A specific quantity of shipped production "melts" away during transportation process and with longer transport distance; the more the fraction will melt which raise transport costs. This shows the importance of

transport infrastructure as well-developed transport modes minimizes transport cost and raises production.

As stated by Kim (1998) studying Korean economy found positive impact of “transport investment on economic growth", as it facilitates higher economic activities including production, consumption and distribution activities, through using reliable transportation tools. One of the main modes of international transportation demanded by consumers and producers in long distance travelling is air transportation (Ananda *et al.*, 2020).

The impact of “transportation infrastructure on economic growth" have been studied in economic literature include "Esfahani and Ramirez 2003; Phang, 2003; Pradhan and Bagchi 2013; Short and Kopp 2005; Wang, 2002". Causality, can exist also in opposite direction between “infrastructure and economic growth" (Egert *et al*., 2009) which require studying this relationship in both directions.

Guan *et al*. (2011) stated that transport system is a main driver of economic activity. Miguel (2013) stated the importance of transport infrastructure, as airports, with "economic growth" studying Paris region, for the period starting 1993 till 2008.

Badalyan *et al*. (2014) studied causality direction among "economic growth, transportation infrastructure, and infrastructure investment" in Armenia, Turkey, Georgia and found positive significant impact of “gross capital formation, goods transported by railway, and road transportation” on "economic growth" in short-run showed also bi-directional causality between "infrastructure investment and economic growth".

Rodaiha & Bouzaid Amairia (2017) studied Tunisia relationship between "transport infrastructure and economic

growth", employing ARDL technique, found long-run relationship between studied variables from 1980 till 2013.

Recently empirical literature has studied "air transportation and its impact on economic growth" as studies of "Ba-Fail *et al.* 2000, Jin *et al*. 2004; Yao 2005; Karlaftis 2008; Chang & Chang 2009; Fu *et al.* 2010; Marazzo & Fernandes 2010; Yao & Yang 2012; Suryani *et al.* 2012; Chi & Baek 2013; Allroggen and Malina 2014; Profillidis & Botzoris 2015; Kalayci and Koksal 2015; Baltaci *et al.* 2015; Baker *et al.* 2015; Kalayci and Yazici 2016; Brida *et al.* 2016a,b; Hakim & Merkert 2016; Coppio *et al.* 2017; Kiracı & Battal 2018", which stressed on the importance of "air transportation and infrastructure on economic growth".

Ba-Fail *et al.* (2000) studied air travel determinants of "Kingdom of Saudi Arabia" and found positive correlation between "income growth and air travel". Jin *et al*. (2004) used longitudinal analysis approach of Chinese air transportation from 1980 till 1998; found civil aviation has positive effect on "economic growth". Yao (2005) studying USA from 1979 to 2004, found mutual causality between GDP and air cargo. Karlaftis (2008) investigated factors of demand of air passenger service at Greece; found positive significant effect of income on air passenger traffic. Chang & Chang (2009) found bilateral relationship between "economic growth and air cargo" in Taiwan from 1974 till 2006.

Marazzo & Fernandes (2010) studied relationship between "aviation demand and economic growth" in Brazil, employing “vector autoregressive (VAR)” using Passenger kilometer as proxy, the study found long-run stability between studied variables. Yao & Yang (2012), using panel approach studied relationship between "air transportation and economic growth"

at China 1995 till 2006, and found positive correlation among variables. Suryani *et al.* (2012), found GDP size has strong impact on air cargo at Taiwan.

Chi & Baek (2013) studying USA air transportation sector found that aggregate passengers and freight capacity increase with economic growth. Using ARDL model the study revealed long-term positive significance of GDP on aggregate passengers and freight capacity.

Allroggen and Malina (2014) using panel data approach found significance of air transportation of Germany's economic development. Profillidis & Botzoris (2015) investigated correlation between GDP and civil aviation; found that "economic growth" affects "civil aviation". Baker *et al.* (2015), using short–run dynamics along long-run analyses found considerable impact of domestic air transportation on GDP in Australia during the period from 1985/86 to 2010/2011 which reveal the impact of "air transportation on economic growth". Baltaci *et al.* (2015), using panel data covering twenty-six sub regions in Turkey from 2004 till 2011 studying the impact of airports traffic frequency on the macroeconomic variables, found positive relationship between airports volume and traffic capacity on Turkey's economic development.

Brida *et al.* (2016a) discussed long-term links between GDP and air transportation in Mexico, and found two-sided causality between the variables. Also, Granger causality shows positive effect of "telecommunication infrastructure", and "gross capital formation" on GDP. Brida *et al.* (2016b) investigated relationship between "GDP" and "air transportation" employing "co-integration" approach and "Granger causality" test from 1970 till 2012, found co-integrated relationship among variables.

Kalayci & Yanginlar (2016) used "air transportation, export volume and economic growth" to study effect of “air transportation, on economic growth" 1974 till 2014, employing "Multiple Linear Regression MLR", and "Johansen co-integration test" in Indonesia and Malaysia. Found a long run co-integration between "economic growth, air transportation, and FDI".

Coppio *et al*. (2017) stated that in Brazil statistically significant impact of "GDP on air transportation” (Egilmez, 2020). Hakim & Merkert (2016), using panel data analysis from 1973 to 2014 investigating causality between "air transportation and GDP in South Asia", found statistically significant long-run impact of "economic growth on civil aviation" in passenger and freight activities. Kiracı & Battal (2018), studying variables affecting air freight in Turkey from 1983 to 2015 found that GDP has statistically significant impact on air freight.

Cahyadin & Sarmidi (2019) employing ARDL model for the period starting 1980 till 2016 found long-run co-integration between "export volume, labor force, external debt, and economic growth". Bozan (2019) studying Far East and Turkey from 2008 to 2018 investigated demand determinants of air cargo found that GDP per capita has influence on air cargo. Alıcı and Akar (2020) studied 13 high air cargo countries from 1980 to 2018 found that GDP affects air freight positively.

A lot of empirical literature investigating relationship among exports and air freight as, Kupfer *et al*. (2011), studying Europe and Asia from 1983 to 2007, using pooled regression found strong positive relation between exports and air cargo. Zhang and Graham (2018) studying 8 emerging countries employing panel data analysis from 1992 till 2014 found that GDP and exports are driving force of air freight. According to Piecyk and

McKinnon (2010), mentioned that demand of freight is influenced by economic expansion as increased demand on goods and services and increased production will raise the demands on air freight (Kiboi, 2017).

Previous empirical literature studied the relationship between economic growth and air transportation which showed the importance of studying this phenomenon in Egypt as there is gap in literature studying relationship between "air transportation and economic growth" in Egypt which needs further study. Most literature studying air transportation in Egypt concentrate on air transportation rule in tourism, international trade and liberalization of air transportation as Omar and Sekkat (2012) examined the relationship between liberalization and Egyptian airline performance. Fajjar and Zidan (2016) studied development and challenges of transportation in Egypt and Nigeria, found that increasing foreign trade between African countries increased the demand for more developed effective transportation. That shows the importance of further study of the phenomena in Egypt.

Air Transportation in Egypt

Transport Infrastructure development is essential for Egypt's "economic growth", for enhancing connectivity, that allows global integration. It enables access to new jobs, higher wages, skills development, and diversified products and services. While Egypt is experiencing economic transformation, there is an essential need for effective transport system as connectivity is crucial.

According to "Ministry of Investment and International Cooperation", Egypt invested lately almost $61.4 billion for improvement of infrastructure for better connection of governorates; and to enhance accessibility, as well as, mobility

of goods. Although Egypt recently has improved trade and transport infrastructure quality, but the bottleneck in the integration between different transportation modes especially in international freight (EBRD, 2017).

Connectivity improvement has been acknowledged in “Vision 2030” of Egypt at plans of transport and infrastructure, with the objective of increasing transport sector capacity for boosting Egypt's share of international transport volumes.

Recently, Egypt has improved its performance according to “quality of trade and infrastructure” indicator calculated by "World Bank’s Logistic Performance Index" LPI, Egypt's raised from 2.22 in 2010 to 2.82 in 2018, ranking from 106th in 2010 (out of 155) to 58th in 2018 (out of 160), also, moving up four places (from 56th to 52nd) according to "infrastructure pillar of Global Competitiveness Index 2019" (WEF, 2019). Although this improvement in sectors as maritime transportation, it has to improve international transport in other areas as air transport, as inefficient transportation raises trade cost and time which hinders distribution of resources and economic activity (EBRD, 2017). Based on "world bank data" air freight in Egypt was 483.4 million ton/km, in 2019 increased from 15.3 in 1970 with annual average growth rate of 9.29%, while air passengers' number in Egypt increased by average growth rate of 7.59% from 542,500 in 1970 to 13 million in 2019.

Quality of air transport infrastructure went up by 17 ranks from 2007 till 2017 with annual average growth rate of 0.62%, its latest rank is 42 out of 137 countries for 2017. Air transport rank (Global competitiveness Index GCI) by WEF went down by 4 ranks from 2017 to 2019. Its latest rank is 44 out of 141 countries for 2019. Airport connectivity and efficiency of air transport services score experienced annual average

growth rate -1.66%, -0.31% respectively from 2017 to 2019 (WEF, 2020).

Current bottleneck of transport infrastructure is mainly lack of integration between different transport modes (World Bank, 2015). Road infrastructure of good quality it's improved and almost 95% of Egypt roads are paved. The integration and development of international transportation modes in freight sector needs further attention as exceeding 99% of international freight depend on maritime transportation only (OECD, 2020) which requires further study to shows the importance of air transportation on economic growth. Air transportation is an important engine of "economic growth and development", stimulating direct and indirect jobs as well as, supporting local businesses, and stimulates foreign investment and raises international trade.

Estimation Technique - Model Specification

Empirical investigation used annual time series starting 1970 till 2019 from "World Bank World Development Indicators" variables used are:

Growth: “annual growth rate of real gross domestic product RGDP” proxy for "economic growth". GCF: "Gross capital formation constant 2010 US$" as proxy of infrastructure investment. AIRC: "registered air carrier departures worldwide" registered air carriers it will be used as proxy of air transport infrastructure. It considers an indicator of “air transport infrastructure” as airports as well as, air traffic control systems.

AIRF: "Air transport freight million-ton km", it is the volume of freight carried on air flights, measured in metric tons times kilometers traveled. AIRP: "Air transport passengers carried million passenger- km" per year. Exports: Exports of goods and services "constant 2015 US$"

Estimation Technique: ARDL Approach

The study employs "Autoregressive Distributed Lag ARDL" technique to estimate long-run co-integration and short-run dynamics among studied variables. ARDL technique chosen due to its advantage as its applied independently even if each individual series is stationary or integrated at different levels (Persan et al, 2001:290).

The study will estimate three regression models to examine relationship between "economic growth and air transportation" in both directions. All variables have been transformed to natural logarithms.

First Model: The following equation will be used to investigate the direct impact of air transportation and infrastructure on economic growth.

$$LnGROWTH_t = \beta_0 + \beta_1 LnGCF_t + \beta_2 AIRC_t + \beta_3 LnAIRP_t + \beta_4 LnAIRF_t + \mu_t \quad \dots (1)$$

β_1, β_2, β_3, β_4 are parameters that will be estimated, and t represent annual time period; μ_t is the "white noise error". Equation (2) is conditional "ARDL-ECM" implemented to test the boundary approach.

$$LnGROWTH_t = a_0 + \sum_{i=1}^{p} \beta_{1i} LnGROWTH\,t\text{-}i + \sum_{i=1}^{p} \beta_{2i} \Delta LnGCF\,t\text{-}i + \sum_{i=1}^{p} \beta_{3i} \Delta LnAIRC\,t\text{-}i + \sum_{i=1}^{p} \beta_{4i} \Delta LnAIRP\,t\text{-}i + \sum_{i=1}^{p} \beta_{5i} \Delta LnAIRF\,t\text{-}i + \pi_1 \Delta LnGROWTH\,t_{t-1} - \pi_2 \Delta LnGCF\,t_{t-1} - \pi_3 \Delta LnAIRC_{t-1} + \pi_4 \Delta LnAIRP_{t-1} + \pi_5 LnAIRF_{t-1} + \varepsilon t \quad \dots . (2)$$

P is "optimal lag length", Δ refers to deploying first difference of variables I (1), and summation signs terms represent error corrections dynamics "short run multipliers of the model" β_1, β_2, β_3, β_4, β_5. The equation second part terms with (π s) represents the model "long run multipliers", and a_0 is “drift component”, and ε_t is "white noise error".

Second Model: equation (3) will be estimated to investigate the direct effect of infrastructure and "economic growth" on air passengers.

$$LnAIRP_t = \beta o + \beta_1 Ln\ GCF_t + \beta_2 LnAIRC_t + \beta_3 \text{LnGROWTH}t + \mu_t \quad \ldots(3)$$

"β_1, β_2, β_3" are parameters that will be estimated, and t is annual time periods, μ_t is the "white noise error".

Equation (4) is conditional "ARDL-ECM" implemented to test the boundary approach:

$$LnAIRP_t = a_0 + \sum_{i=1}^{p} \beta_{1i}\ \text{LnAIRP}_{t\text{-}i} + \sum_{i=1}^{p} \beta_{2i} \Delta LnGCF_{t\text{-}i} + \sum_{i=1}^{p} \beta_{3i}\ \Delta LnAIRC_{t\text{-}i} + \sum_{i=1}^{p} \beta_{4i}\ LnGROWTH_{t\text{-}i} + \pi_1\ LnAIRP_{t\text{-}1} + \pi_2\ LnGCF_{t\text{-}1} + \pi_3 Ln\ AIRC_{t\text{-}1} + \pi_4 \text{LnGROWTH}_{t\text{-}1} + \varepsilon_t \quad \ldots\ (4)$$

β_1, β_2, β_3, β_4 are short run multipliers. π_1 , π_2, π_3, π_4 are "long run multipliers" and a_0 is the "drift component", and ε_t is "white noise error".

Third Model: equation (5) will be estimated to investigate the direct effect of infrastructure and "economic growth" on air Freight using exports as control variable.

$$LnAIRF_t = \beta_0 + \beta_1\ \text{LnGROWTH}_t + \beta_2 Ln\ GCF_t + \beta_3 LnAIRC_t + B_4 Lnexport_t + \mu_t \quad \ldots\ (5)$$

"β_1, β_2, β_3, β_4" are parameters that will be estimated, and t is annual time periods, μ_t is the "white noise error".

Equation (6) is conditional "ARDL-ECM" implemented to test the boundary approach:

$$LnAIRF_t = a_0 + \sum_{i=1}^{p} \beta_{1i} \Delta \text{LnAIRF}_{t-i} + \sum_{i=1}^{p} \beta_{2i}\ \text{LnGROWTH}_{t-i} + \sum_{i=1}^{p} \beta_{3i}\ \Delta LnGCF_{t\text{-}i} + \sum_{i=1}^{p} \beta_{4i}\ \Delta LnAIRC_{t\text{-}i} + \sum_{i=1}^{p} \beta_{5i}\ \Delta LnEXPORT_{t\text{-}i} + \pi_1\ Ln\ AIRF_{t\text{-}1} + \pi_2 \text{LnGROWTH}_{t\text{-}1} + \pi_3\ LnGCF_{t\text{-}1} + \pi_4 Ln\ AIRC_{t\text{-}1} + \pi_5 Ln\ export_{t\text{-}1} + \varepsilon_t \quad \ldots\ldots(6)$$

"β_1, β_2, β_3, β_4, β_5" are short run multipliers while "π_1, π_2, π_3, π_4, π_5" are "long run multipliers", a_0 is "drift component", ε_t is "white noise error".

First step; test long-run co-integration relationship among studied variables employing "ARDL bound test", using F-statistic for testing joint statistical significance of lagged levels variables coefficients. Second step; in case of existence of long-run co-integration the conditional ARDL long-run model can be estimated. Third step; estimate short-run dynamics by constructing a lagged "error correction model ECM" of ARDL model, associated with long-run coefficients.

Empirical Results and Discussions

Descriptive Statistics

As shown in table (1), among all studied variables the lowest standard deviation value is growth rate 0.49853 and worldwide air carriers 0.613299 which states the ranking of those variables in explaining variability in dependent variable. The highest standard deviation 1.071152 is air freight. The table shows that all variables are normally distributed.

Unit Root Test

Non-stationarity of time series would cause problems of biased results and spurious regression (Maddala, 2001). Two tests used for stationarity as results may differ (Nieh & Wang, 2005), the paper using "Augmented Dickey – Fuller (ADF) test" (Dikey and Fuller, 1979), "Philips and Perron" (PP, 1988) for testing integration order of studied variables by using "Akaike information criteria AIC" with maximum lag lengths of 1 as found by lag length criteria test. As shown from table (2) test results shows that "economic growth rate" series is stationary I (0) and the other variables are stationary at first difference I (1).

Then results for the test shows that the used series are integrated with I (0), and I (1), which support usage of ARDL model.

ARDL Bounds Test

Regression models were tested for optimal lag lengths which found to be 1 for three models, selection based on the "Akaike info criterion AIC", "Schwarz Information Criterion SIC", "Hannan-Quinn Information Criterion HQC" for determination of optimal lag length. According to Pesaran *et al.* (1999) and Narayan (2004) choosing maximum 2 lags order for annual observations. Then the models are estimated for examining long run co-integration among variables, using ARDL bound test.

Table (3) shows the existence of long run co-integration between variables of the three models since the estimated F-statistic of models 1, 2 and 3 are 5.066799, 6.284445, 4.978501 respectively which exceed the upper critical bound values of each model at 1% level of Significance (5.03), (5.61), and (4.68) respectively.

Models Estimation

First Model Estimation

R squared (coefficient of determination) shows almost 47 percent of total variations in "economic growth" explained by explanatory variables in fact in time series if R squared is close to 1, it is usually a bad sign of significant time patterns in errors. Also, if the dependent variable is a stationary series rather than levels as the case of this model as growth rate is I (0), and then R-squared of 25% is quite good. The model also supported by the diagnostics tests which found that the time series deployed are stable and normally distributed as well as free of serial correlation and Heteroscedasticity problems as shown in table (7).

All long run and short coefficients found to be statistically significant with signs consistent with expectation except coefficient of freight found to be insignificant which is expected in Egypt case as mentioned that international freight in Egypt depends mostly on maritime transport only. The results of short-run dynamic estimates associated with long-run relationship derived from the error correction model "ECM" shown in table (4). ECM model is well fitted as the coefficient of the lagged "error correction term" ECT -0.052 (0.000) is statistically significant at 1% level with negative sign as expected which means that disequilibrium from previous periods shock will bounce back to equilibrium.

At long run air Passengers and air carriers found to be positive and statistically significant at 1% confidence level. According to short run estimates the results matches the long run results as air passenger is statistically significant at 1% confidence level and air carriers statistically significant at 10% confidence level. This result suggests that air transport is an important factor in explaining economic growth in Egypt supporting findings of (Krugman, 1991, Bougheas *et al*. 1999; Chi and Baek, 2013; Marazzo and Fernandes, 2010; Baker *et a*l., 2015, Brida *et al.*, 2016 a; Jin *et al.*, 2004; Yao and Young, 2012; Kalayci and Yanginlar, 2016; Coppio *et al.*, 2017). At long run "Gross capital formation GCF" used as proxy of transport infrastructure found to be positive statistically significant at 5% confidence level, and at short run GCF also statistically significant at 5% confidence level, which suggests that transport infrastructure has positive impact on economic growth rate of Egypt supporting findings of (Arrow and Kurz, 1970 ; Aschauer, 1989; Kim, 1998, Miguel, 2013; 1998; Fernald, 1999; Egger and Falkinger, 2003; Badalyan *et al.*, 2014;

Rodaiha and Bopuzaid, 2017). Stock of public capital causes output per capita to rise, along permanent growth effects which positively raise economic growth, as **i**nfrastructure improvement reduces fixed costs, which attract firms, and factors of production, that, raise production levels.

Development of transport infrastructure reduce time and cost in short run, which increase international trade, stimulating economic growth, causing market expansion in long-run, rising market openness which increase export and import causing higher production levels and profits.

Second Model Estimation

R squared shows that 66 % of the total variations in Air passenger is explained by independent variables in the model. The model also supported by the diagnostics tests which found that the time series deployed are stable and normally distributed as well as free of serial correlation and Heteroscedasticity problems as shown in table (7).

The results of short run dynamic estimates associated with long-run relationship derived from the "error correction model ECM" shown in table (5). "ECM" model is well fitted as the coefficient of the lagged "error correction term ECT" -0.48 (0.000) is significant at 1% confidence level with negative sign as expected which means that disequilibrium from previous periods shock will converge to the long run within 2 years. All explanatory variables found to be statistically significant with signs consistent with expectation at short-run and long-run models. According to long-run, air carriers as proxy of air transport infrastructure found to be positive statistically significant at 1% confidence level. Gross capital formation GCF used as proxy of transport infrastructure found to be positive and statistically significant at 1% confidence level.

Economic growth rate is statistically significant at 5% confidence level. Short run results show that, air carriers and GCF both are statistically significant at 1% confidence level. and economic growth rate statistically significant at 5% confidence level.

The results found that economic growth rate has positive relationship with air passenger in short and long run in both directions that goes with findings of (Egert *et al*., 2009; Badalyan *et al*., 2014). Short run and long run analysis found positive significance of economic growth on air passenger that goes with findings of (Ba-Fail *et al*., 2000; Karlaftis, 2008; Marazzo *et al*. 2010; Chi and Baek, 2013). As shown from model estimation results and goes with literature "economic growth" of Egypt has significant impact on air passengers as higher growth rate means higher governmental income which facilitate more pubic capital directed towards development of infrastructure include airports and required equipment and systems as navigation systems (Brida *et al*., 2016a).

Third Model Estimation

R squared shows that almost 51 % of the total variations in Air freight explained by explanatory variables in the model which consider moderate according to Chin (1998) and the model also supported by the diagnostics tests which found that the time series deployed are stable and normally distributed as well as free of serial correlation and Heteroscedasticity problems as shown in table (7). The results of short-run dynamic estimates associated with long-run relationship derived from the "error correction model ECM' shown in table (6). ECM model is well fitted as the coefficient of the lagged error correction term ECT -0.30 (0.000) is statistically significant at 1% level with negative sign as expected which means that disequilibrium

from previous periods shock will converge to the long-run within 3.3 years.

According to long-run estimation all explanatory variables found to be significant with signs consistent with expectation except "economic growth" which doesn't goes with literature but goes with Egypt case that international freight depend mostly on maritime transportation. Air carriers as proxy for air transport infrastructure found to be positive and statistically significant at 1% confidence level. Gross capital formation GCF used as proxy of transport infrastructure found to be positive and statistically significant at 10% confidence level, which suggests that transport infrastructure has positive impact on air freight of Egypt supporting findings of "Brida *et al.*, 2016 b; Chi and Baek, 2013; Copio *et al.*, 2017; Profillidis and Botzoris, 2015; Yao and Yang, 2012". Exports variable is statistically significant at 5% confidence level. According to short run estimates explanatory variables coefficients are statistically significant with sign consistent with expectations except economic growth rate, estimation found that air carriers, GCF and export are statistically significant at 1%, 5% and 10% confidence level respectively. Exports have positive significance on growth of air freight in Egypt on short and long run which goes with findings of (Kupfer *et al.*, 2011; Zhang and Graham, 2018). There is non-significance relationship between air freight and "economic growth" on both directions as international freight depends mainly on maritime transportation. As mentioned by literature air freight should be affected by "economic growth" as economic expansion mainly depend on increased demand on goods and services which raise also national production levels which lead to increased exports

that's raise the demand on air freight as mean of international transportation which goes with the current paper findings.

Diagnostics tests

Several diagnostics tests were performed to verify stability of models the results shown at table (7); serial correlation test probability of F-stat. value for the "Breusch-Godfrey test" shows that there is no serial correlation in the long run relationship among the three models. BPG test "Breusch-Pagan-Godfrey" carried to check whether the model suffers from a Heteroskedasticity problem. Probability of F-stat value for the BPG test implies that there is no Heteroskedasticity in the three models. ARCH test carried to check whether the model suffers from ARCH effect problem. Probability of F-stat value implies that the three models are free from ARCH effect. Normality test shows that the probability of data of the three models are normally distributed

Stability Test

To determine the goodness of fit of the ARDL model, the stability tests proposed Borensztein *et al*. (1998) and suggested by Pesaran *et al*. (1999) and pesaran *et al*. (2001) performed to examine stability of long-run coefficients. In addition, the "cumulative sum CUSUM" and the "cumulative sum of squares CUSUMQ" stability tests performed to assess the parameter constancy based on "AIC" based error correction models. Figure (1) confirm that the parameters are stable over the sample period as the plot of "CUSUM" and "CUSUMQ" statistics stay within the 5% level of significance for the three models.

Table (1): Descriptive statistics

	LNAIRFR	LNAIRP	LNAIRC	LNEXPORT	LNGCF	LNGROWTH
Mean	4.826139	15.07697	10.57070	23.35138	23.48354	1.541424
Median	5.194678	15.17518	10.57132	23.33368	23.44684	1.556991
Maximum	6.180873	16.37735	11.66010	25.22645	25.00230	2.586236
Minimum	2.631889	13.15270	9.457200	21.43700	21.19960	0.118143
Std. Dev.	1.071152	0.821018	0.613299	1.045055	0.950395	0.498536
Jarque-Bera	5.542569	1.809009	1.575955	1.466387	4.129487	2.842256
Probability	0.062582	0.404742	0.454764	0.480372	0.126851	0.241442
Obs.	49	49	49	49	49	49

Source: calculated by author depending on "World Bank data".
All variables expressed in natural logarithm

Table 2: Unit Root Test

variable	ADF		PP	
	Level	Differenced	Level	Differenced
Growth	-4.3945 (***0.0010)***	-10.5674 (***0.0000)***	-4.3209 (***0.0012)***	-14.2523 (0.0000)
GCF	-2.5940 (***0.1013)***	-5.1312 (0.0000)	-1.9873 (***0.2913)***	-5.2138 (0.0001)
AIRF	-1.3795 (***0.5845)***	-7.4452 (0.0000)	-1.7681 (***0.3915)***	-7.5105 (0.0000)
AIRP	-2.4018 (***0.1467)***	-10.3649 (0.0000)	-2.3482 (***0.1617)***	-9.7851 (0.0000)
AIRC	-0.4811 (***0.8857)***	-9.9013 (0.0000)	-0.8412 (***0.7980)***	-10.0318 (0.0000)
Export	-1.0849 (***0.7146)***	-5.6788 (0.0000)	-1.1174 (***0.7018)***	-5.4953 (0.0000)

Source: Author's estimate depending on "World Bank data"
All variables expressed in natural logarithm

Table 3: ARDL Bounds Test results

	F-stat.	Sig. level	lower limit	upper limit
First Model				
F-stat.	5.066799	10%	2.45	3.52
K	4	5%	2.86	4.01
		2.5%	3.25	4.49
		1%	3.74	5.03
Second Model				
F-stat.	6.284445	10%	2.72	3.77
K	3	5%	3.23	4.35
		2.5%	3.69	4.89
		1%	4.29	5.61
Third Model				
F-stat.	4.978501	10%	2.26	3.35
K	4	5%	2.62	3.79
		2.5%	2.96	4.18
		1%	3.41	4.68

Source: Author's estimate depending on "World Bank data"

Table 4: Model 1 Estimated coefficients of ARDL (1,1,1,0,1) model

Estimated Long run coefficients				
Variable	Coef.	Std. Error	t-Stat.	Prob.
LNGCF(-1)	0.428019	0.186893	2.290178	0.0274
LNAIRC(-1)	0.762191	0.256345	2.973306	0.0050
LNAIRP	1.109157	0.367279	-3.019927	0.0044
LNAIRFR(-1)	0.042480	0.114362	0.371454	0.7123
Estimated Coefficients of Short run Dynamic "Error correction model"				
C	0.811321	0.205066	3.956397	0.0003
LNGROWTH(-1)	0.337012	0.130934	2.573906	0.0138
D(LNGCF(-1))	1.193116	0.528250	2.258622	0.0293
D(LNAIRC(-1))	0.758529	0.407310	1.862292	0.0697
D(LNAIRP)	1.462572	0.473963	3.085837	0.0036
D(LNAIRFR(-1))	0.051256	0.364370	0.140670	0.8888
ECT (-1)	-0.052101	0.009910	-5.257468	0.0000
R-squared	0.469499			

Source: Author's estimate depending on "World Bank data"

Table 5: Model 2 Estimated coefficients of ARDL (1,0,0,0) model

Estimated Long run coefficients				
Variable	Coef.	Std. Error	t-Stat.	Prob.
LNGCF	0.176584	0.052358	3.372639	0.0016
LNAIRC	0.339339	0.052977	6.405393	0.0000
LNGROWTH	0.043106	0.021268	2.026849	0.0492
Estimated Coefficients of Short run Dynamic Error correction model				
C	-0.049563	0.042982	-1.153126	0.2554
D(LNAIRP(-1))	-0.267760	0.107846	-2.482793	0.0171
D(LNGCF)	0.308950	0.113567	2.720425	0.0094
D(LNAIRC)	0.434815	0.089287	4.869879	0.0000
LNGROWTH	0.057284	0.028202	2.031181	0.0486
ECT (-1)	-0.483887	0.093164	-5.193951	0.0000
R-squared	0.661382			

Source: Author's estimate depending on "World Bank data"

Table 6: Model 3 Estimated coefficients of ARDL (1,0,0,0,0) model

Estimated Long run coefficients				
Variable	Coef.	Std. Error	t-Stat.	Prob.
LNGROWTH	-0.113003	0.174582	-0.647276	0.5212
LNGCF	0.640863	0.329827	1.943031	0.0591
LNAIRC	1.769913	0.542022	3.265390	0.0022
LNEXPORT	1.041009	0.464521	2.241036	0.0306
Estimated Coefficients of Short run Dynamic Error correction model				
C	0.928825	1.698409	0.546880	0.5875
D(LNAIRFR(-1))	0.301935	0.072098	-4.187860	0.0002
LNGROWTH	-0.034119	0.055400	-0.615878	0.5415
D(LNGCF)	0.506890	0.226856	2.234415	0.0311
D(LNAIRC)	0.534399	0.134765	3.965413	0.0003
D(LNEXPORT)	0.314317	0.156220	2.012012	0.0510
ECT (-1)	-0.301935	0.052085	-5.796972	0.0000
R squared	0.508779			

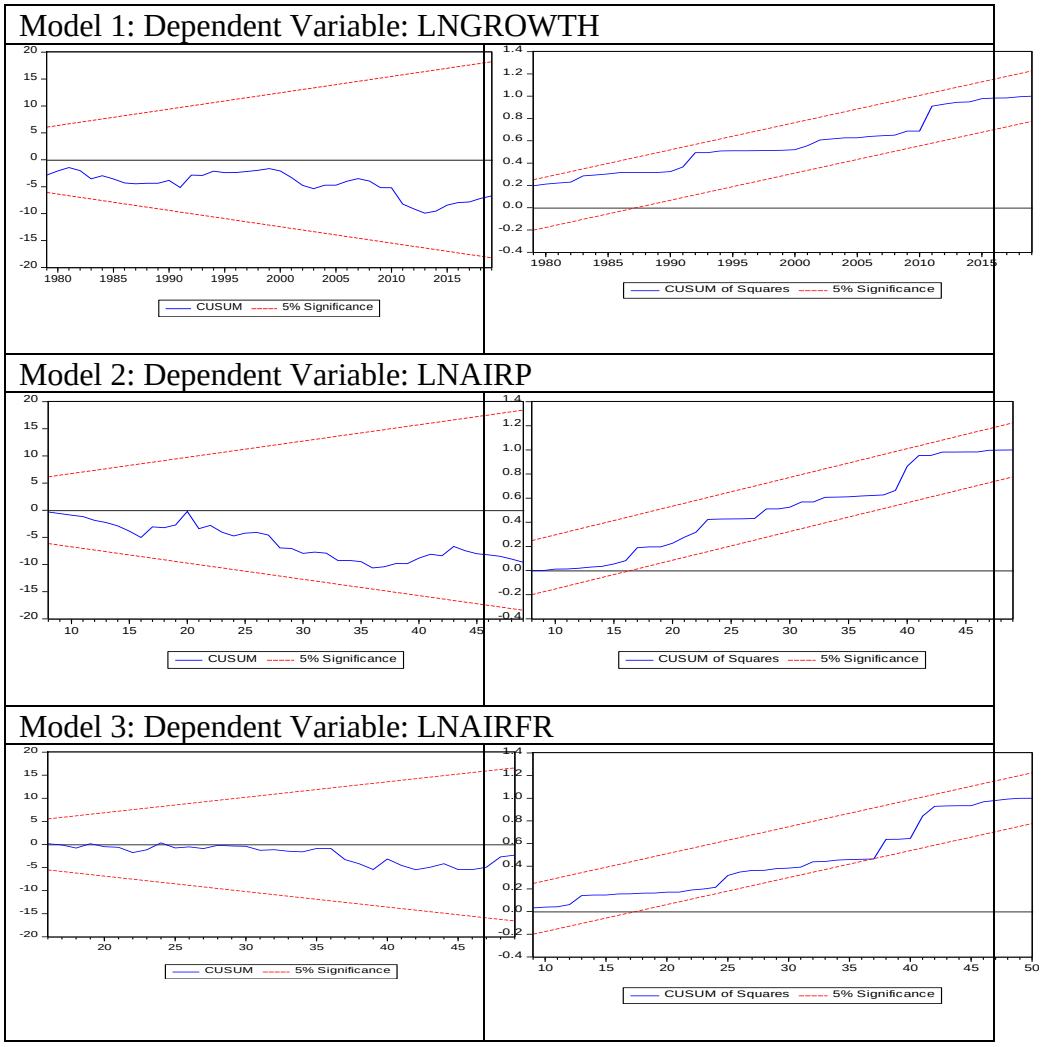
Source: Author's estimate depending on "World Bank data"

Table 7: Diagnostics Tests Results

Serial Correlation LM Test			
Model	Prob	Chi-Square	F-statistic
Model 1	0.8298	0.7995	0.187484
Model 2	0.1080	0.0841	2.354689
Model 3	0.1352	0.0840	2.345306
Heteroskedasticity Test			
Model 1	0.7533	0.7186	0.567905
Model 2	0.2541	0.2404	1.389437
Model 3	0.6108	0.5781	0.721932
Autoregressive Conditional Heteroscedasticity (ARCH) test			
Model 1	0.9790	0.9784	0.000699
Model 2	0.2761	0.2659	1.216439
Model 3	0.1487	0.1420	2.163779
Normality Test			
Model	Prob	Jarque-Bera	F-statistic
Model 1	0.2746	2.5848	0.000699
Model 2	0.5669	1.1350	1.216439
Model 3	0.5331	1.2578	2.163779

Source: Author's estimate depending on "World Bank data"

Figure 1: Plotting of CUSUM and CUSUMQ for stability test



Source: Author's estimate depending on "World Bank data"

Conclusion and Recommendations

The paper investigated short-run dynamics and long-run relationships among studied variables; "economic growth rate, air passengers, air freight, air carriers, gross capital formation and exports only in third model", the data used on annual basis from 1970 till 2019. ARDL "Autoregressive Distributed Lag" technique selected based on specification and model examination.

The paper has presented theoretical and empirical literature to theoretically analyze the studied phenomena. First; studying the relationship between "economic growth" and infrastructure investment based mainly on endogenous economic growth models then focusing on the relationship between transport infrastructure and "economic growth". Second section; covering literature review of the long-run and short-run relationships among air transportation and "economic growth" for both air passenger and air freight with a brief study of the impact of exports on air freight.

The paper studied used empirical analysis choosing ARDL approach as it was appropriate due to usage of time series of different degrees of integration of I (0) and I (1), also "ARDL" using "ECM" can integrate short-run adjustments with long-run equilibrium without loss of long-run information

The paper used three models; the first model investigates the significant effect of infrastructure and air transport on "economic growth", the second model investigates the significance of "economic growth" and infrastructure on air passengers and the third model investigates the significance of "economic growth" on air freight with further study of the impact of exports on air freight.

The first model found positive statistically significant impact of air passengers and air carriers taken as proxy of air transport infrastructure on "economic growth" which shows air transportation importance to economic growth in Egypt supporting findings of (Krugman, 1991, Bougheas *et al*. 1999; Chi and Baek, 2013; Marazzo and Fernandes, 2010; Baker *et al.*, 2015, Brida *el al*., 2016 a; Jin *et al.*, 2004; Yao and Young, 2012; Kalayci and Yanginlar, 2016; Coppio *et al.*, 2017). Gross capital formation GCF used as proxy of transport infrastructure found to be positive and statistically significant to economic growth of Egypt supporting findings of (Arrow and Kurz, 1970; Aschauer, 1989; Kim, 1998, Miguel, 2013; 1998; Fernald, 1999; Egger and Falkinger, 2003; Badalyan *et al.*, 2014; Rodaiha and Bouzaid, 2017), air freight found not statistically significant to "economic growth" which doesn't go with literature.

Second model; found positive statistically significance impact of "economic growth" on air passenger in both short-run and long-run estimation which shows that the relationship between air passenger and "economic growth" is bi-directional relationship which goes with literature of (Egert *et al*, 2009; Badalyan *et al*., 2014, Ba-Fail *et al*. 2000; Karlaftis, 2008; Marazzo *et al*. 2010; Chi and Baek, 2013).

Third model; studying the impact of "economic growth" on air freight using exports as control variable the results at long-run and short-run found insignificant impact of "economic growth" on air freight and statistically significant impact of exports on air freight supporting findings of "Brida *et al*., 2016a; Chi and Baek, 2013; Copio *et al*., 2017; Profillidis and Botzoris, 2015; Yao and Yang, 2012".

According to the empirical analysis there is statistically non-significance relationship between air freight and "economic growth" in both directions in Egypt which doesn't go with literature, the reason behind this finding was the shortage of using air transportation in international freight as more than 99 percentage of international freight in Egypt depends on maritime transportation. The study shows the economic importance of air passenger, air transportation infrastructure, and infrastructure investment on economic growth. Infrastructure investment and air transport infrastructure found to have positive statistical significance impact in the three estimated models which shows infrastructure economic importance to economic growth, air freight and air passenger. Therefor it's recommended to direct higher investment resources towards improvement of infrastructure with further focus on air transportation infrastructure to raise its efficiency and quality and further attention to air freight sector.

In addition, transport policies and strategies should balance government's efforts and infrastructure investments in improvement of air freight transportation to open more efficient international connectivity gateways to Egypt which could raise economic growth.

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