Air Cargo Competitiveness and Economic Performance of Asia-Pacific Countries

Supara Kapasuwan[1] and Dolchai La-ornual[2*]

[1,2*]Mahidol University International College, Mahidol University, Thailand

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Abstract

This study explores the relationship between dimensions of air cargo competitiveness in terms of airport physical infrastructure, connectivity and liberalization policy and the economic performances of Asia-Pacific countries. Runway length, terminal area size, aircraft movements, number of airlines in operation, connectivity, air transport liberalization, and air cargo volume of thirteen major airports in the region between 2010 - 2017 were analyzed with respect to GDP, GDP per capita, and GDP growth. Results from panel data analysis (with random effects) indicate that aircraft movements and the number of airlines are significant factors that positively impact the competitiveness in air cargo. In addition, the higher the level of openness to air transport, as represented by the number of agreements in air transport liberalization, the higher the tendency for each country's airport to accommodate more inflow and outflow of air cargo volume. Lastly, there is also evidence of a positive relationship between air cargo volume and GDP. As the Asia-Pacific is one the busiest trading regions in the world, the results provide some insights and recommendations for policy makers.

Keywords: 1) air cargo transportation 2) Asia-Pacific 3) competitiveness 4) economic growth

[1] Assistant Professor, Business Administration Division; E-mail: supara.kap@mahidol.ac.th

[2*] Assistant Professor, Business Administration Division; E-mail: dolchai.lar@mahidol.ac.th (Corresponding Author)

Introduction

Countries in East Asia and the Pacific region contributed one-third of the global economic growth and experienced a growth rate of approximately seven percent on average in 2021; however, the region's economies have encountered a slowdown due to weakening external demand combined with global trade policy uncertainty (World Bank, 2022, pp. 1-9). As of 2022, the COVID-19 pandemic is affecting the East Asia and Pacific economies profoundly but the region still has an important role in driving global economy since many countries are well integrated into global value chains (World Bank, 2022, pp. 1-9). Although it is inevitable to face a sharp economic contraction in 2022, in general several East Asia and Pacific countries have done well in terms of the containment of the pandemic and it is expected that a sustained recovery may be achieved later on. Several countries have issued proposals and statements to emphasize that they promote the markets to be open and the supply chain to be connected for global recovery.

The achievement of the ten member countries of the Association of Southeast Asian Nations (ASEAN) to establish regional economic integration of the ASEAN Economic Community (AEC) and more trade cooperation and agreements among Asian countries have led to increasing opportunities and competition for companies, industries and nations in the international production networks and movement of goods and services across different markets. Logistics management has been one of the significant factors that influence economic growth and competitiveness of nations around the world (Arvis, et al., 2014, pp. 1-3; Ekici, Kabak and Ülengin, 2019, p. 197). In recent years, as a part of the logistics system, air cargo management has played an important role in the economic growth of nations. Air cargo accounted for approximately 35 percent of global trade by value and transported goods worth more than $6 trillion (International Air Transport Association, 2022). In 2021, the air cargo volumes increased by 18.7% year-on-year and the Asia Pacific region still accounted for the highest proportion (32.4%) of the world's total cargo tonne- kilometres (CTKs) (International Air Transport Association, 2021, pp. 1-4).

Major airports around the world have been ranked by Airport Councils International in terms of cargo volume and growth, which partially account for the economic performance of countries where the airports are located (Chang and Chang, 2009, pp. 264-265). Air cargo will remain the preferred solution for transporting time-sensitive perishables and higher value goods such as computing equipment, machinery and electrical equipment, consumer electronics and pharmaceuticals, and the value per ton of total traded goods across the world is forecasted to rise (Boeing, 2020, p. 62). In addition, in the past few decades there has been an outstanding growth of e-commerce, especially in the Asia-Pacific region. Air cargo management has played an important role in the flow of goods and services and consequently has become one of the key factors that may impact countries' economic performance. As a result, there has been a higher competition between national airports, especially when the governments have goals to establish their nation as a major hub and logistical center (Loos, et al., 2016, p. 25).

Previous studies on air cargo examined the performance or competitiveness of airports based on several types of measures. For instance, Park (2003, pp. 353-360) analysed the competitive status of major airports in the East Asia region based on five factors, including service, demand, managerial, facility and spatial qualities. Oum, Yu and Fu (2003, pp. 285-297) compared airport productivity performance and investigated the relationships between productivity measures and airport characteristics and management strategies for 50 major airports in Asia Pacific, Europe and North America by computing gross total factor productivity (TF). Burghouwt, et al. (2009, pp. 387-388) studied three types of network connectivity of airports, including direct connectivity, indirect connectivity and hub connectivity of airports in East and South-East Asia. Yuan, Low and Tang (2010, pp. 215-225) used an air cargo supply chain operations reference (ACSCOR) model to examine the integrated impact of airport operating strategies and industrial forces on airport performances, and evaluated the economic benefits of the air cargo service business. Ha, Yoshida and Zhang (2010, pp. 9-20) and Huynh, Kim and Ha (2020, pp. 1-9) evaluated the level and change of efficiency (productivity) of several airports in East Asia and Southeast Asia by applying data envelopment analysis (DEA) to the panel data, investigating the relationship between the outputs the airports produced and the inputs they used in a given period of time. Homsombat, Lei and Fu (2011, pp. 573-591) benchmarked the key performance measures of the hub airports in Southeast Asia in terms of network connectivity, traffic growth, hub airline developments, and cargo logistics. Chao and Yu (2013, p. 320) compared major Asia-Pacific airports in terms of airline transport capacity, airport facilities and operations, and economic development, and Wong, Chung and Hsu (2016, p. 91-98) examined the competitiveness of airports in the dimensions of international trade, flight frequency, route distribution, national and foreign carrier distributions and centrality.

Nevertheless, there is still a lack of research which combines the factors of airport physical assets, utilization, connectivity and air transport liberalization in relation with national economic performance in the context of the Asia Pacific region. In this study, the researchers aim to fill a research gap by integrating several measures of air cargo competitiveness as comprising of not only physical infrastructure and its utilization, but also the capabilities in terms of connectivity and the contextual factor of air transport liberalization in Asia-Pacific countries. This is because airport connectivity and air transport liberalization may enhance capacity utilization and subsequently the competitive position as a global hub (Abate and Christidis, 2020, p. 1; Cheung, Wong and Zhang, 2020, pp. 10-17). The relationship between these factors and air cargo volume are empirically investigated and the linkage between air cargo volume and economic performance is also assessed.

The objective of this study is to find answers to two research questions, including 1) what are the factors that contribute to countries' air cargo competitiveness? and 2) what is the relationship between these air cargo competitiveness factors and countries' economic performance? This study will also offer some insights and recommendations for policy makers of countries in the Asia-Pacific region about how to improve air cargo competitiveness, which in turn may influence national economic performance. Typically, the policy makers of some countries may give more consideration on hard 'tangible' infrastructure aspects, e.g. number of runways and terminals while policy makers of other countries may focus on the soft 'intangible' infrastructure aspects, e.g. customs management and business climate of air cargo competitiveness. Based on the findings of this research, policy makers may be able to identify an appropriate balance of planning and investment in developing their countries' air cargo competitiveness as a means to foster more trade and to obtain higher levels of economic development.

Literature Review

Trade within the Asia-Pacific region is increasingly shifting from trade in products to trade in tasks, as various firms become more closely integrated into global value chains (World Bank, 2022 pp. 1-9). During the past two decades, a decline in trade barriers and decreasing trade costs have driven a greater level of participation in global value chains of production. The emergence of the globally integrated, just-in-time (JIT) production and distribution network in which firms organize and spread interconnected functions and operations in producing and distributing goods and services has led to a higher level of demand for international air cargo services to supply the right goods or materials or parts to the right places at the right times while also saving as much cost as possible (Zhang, 2003, pp. 124-125; Leinbach and Bowen, 2004, pp. 299-307; Arvis and Shepherd, 2011, pp. 2-5; Grosso and Shepherd, 2011, pp. 203-205). Firms need to reduce inventories and cut down the time it takes to move products to the market, especially for those which have shorter product life cycles such as semiconductors, computers, pharmaceuticals, and designer clothes (Zhang, 2003, p. 124; Leinbach and Bowen, 2004, pp. 307-315; Yuan, Low and Tang, 2010, p. 215; Ekici, Kabak and Ülengin, 2019, pp. 197-200).

According to Arvis and Shepherd (2011, pp. 2-5), air transport is particularly important for production and trade of high-value lightweight goods within international production networks; therefore, developing countries seeking to deepen the level of involvement in this type of trade may focus on improving their air cargo capacity and connectivity. Essentially, countries which have a higher number of connections to the global air transport network can increase productivity and economic growth by providing better access to markets, enhancing links within and between businesses, and attracting foreign resources and capital investments (Yuan, Low and Tang, 2010, pp. 223-224; Homsombat, Lei and Fu, 2011, pp. 579-582; Wong, Chung and Hsu, 2016, pp.

96-98). As a consequence, governments of various countries recognize the importance of building their major airports to be efficient and competitive. In general, countries attempt to develop their major airports as a cargo hub to facilitate 1) air transportation of goods or materials from the point of supply to the point of demand with transshipment taking place at the hub (therefore little storage is needed) and 2) warehousing for inventories of goods, materials or parts that will be transported to the markets when the need arises (Zhang, 2003, pp. 124-125).

The air cargo markets in the Asia-Pacific region are expected to lead all other international markets in in terms of the average annual growth rate between 2020 and 2039 (Boeing, 2020, pp. 61-63). The governments of Asia-Pacific countries have shown strong support in developing their major airports as part of their economic strategies (Burnson, 2014, p. 64) such as Japan's Tokyo Narita International Airport, Korea's Incheon International Airport, Singapore's Changi International Airport, China's Shanghai Pudong International Airport, Hong Kong's Chek Lap Kok International Airport, Taiwan's Taoyuan International Airport, Malaysia's Kuala Lumpur International Airport, and Thailand's Bangkok Suvarnabhumi International Airport (Homsombat, Lei and Fu, 2011, pp. 574-590; Chao and Yu, 2013, pp. 322-324; Wong, Chung and Hsu, 2016, p. 92). These airports were ranked in the top 30 airports in 2013-2017 in terms of air cargo volume (loaded and unloaded freight and mail in metric tonnes) (Airports Council International, 2019). The details of cargo volume for the period of 2013-2017 for these airports are summarized in Table No. 1.

According to Burghouwt, et al. (2009, pp. 385-397) and Ha, Yoshida and Zhang (2010, pp. 9-13), strategic trade policies, the liberalization of international air service agreements and the formation of global airline alliances have led to intense competition among these major airports, which aim to become key traffic hubs for international air transportation in Asia. Planners of the Hong Kong International Airport (HKIA) expected its capacity to hit the limit by 2017-2019 (McCurry, 2014, p. 4). In response, the government invested in midfield development and plans a third runway to be complete by the end of 2023. Korea's Incheon International Airport has been successful in becoming an airfreight transport hub or logistics hub in Northeast Asia and pursued strategies to improve its competitiveness in terms of connectivity (Lee and Yang, 2003, p. 113; Wong, Chung and Hsu, 2016, pp. 91-98). The airport claimed to be the fastest among the 169 WCO (World Customs Organization) member countries in customs clearance (Incheon International Airport Corporation, 2014). Singapore Changi Airport provided incentives for its air cargo partners by giving a 5 percent landing fee rebate to all scheduled freighter flights and cargo tenants leasing Changi Airport Group cargo facilities at the Changi Airfreight Centre based on cargo tonnage handled up to 20 percent of their rentals (Air Cargo World, 2014, p. 14). Bangkok Suvarnabhumi International Airport also expected to increase the volume of air cargo and revenue generated by transshipment (National Economic and

Social Advisory Council Thailand, 2012, pp. 2-3). Malaysia's Kuala Lumpur International Airport strengthened its cost leadership by lowering landing charges (Homsombat, Lei and Fu, 2011, pp. 582-583).

Air Cargo Competitiveness

The main theoretical perspective adopted in this study to conceptualize air cargo competitiveness is the resource-based theory of competitive advantage (Barney, 1991, pp. 99-103; Grant, 1991, pp. 114-135). The crucial resources include both assets (tangible and intangible) and capabilities (Barney, 1991, pp. 103-107; Peteraf, 1993, pp. 179-187). It is expected that specific resources, which can be developed, extended and improved over time, enable the airports to formulate and implement strategies that improve their efficiency and effectiveness, resulting in successful performance (Barney, 1991, pp. 112-114; Grant, 1991, pp. 114-135). Various studies have investigated air cargo competitiveness of airports in the Asia-Pacific region (e.g. Oum, Yu and Fu, 2003, pp. 285-297; Park, 2003, pp. 353-360; Ha, Yoshida and Zhang, 2010, pp. 9-23; Homsombat, Lei and Fu, 2011, pp. 573-591; Chao and Yu, 2013, pp. 318-326; Wong, Chung and Hsu, 2016, pp. 91-98; Huynh, Kim and Ha, 2020, pp. 1-9). Generally, air cargo competitiveness has been analysed based on efficiency or productivity performance of the airports. There are several factors pertaining to air cargo competitiveness such as physical infrastructure or facilities, airline transport capacity and connectivity, airport operations and managerial capabilities, and international aviation policy towards air liberalization. In this study, the research objective was to assess the relationship between several factors related to air cargo competitiveness and the economic performance of the countries in the Asia-Pacific region. Therefore, the unit of analysis was country and only the top airports of these countries in terms of air cargo volume were used to represent the efficiency and productivity of air cargo at the national level.

Airport Physical Infrastructure and Utilization

Based on the results of Portugal-Perez and Wilson (2010, p. 27), who examined the relationship between country physical infrastructure and trade of 101 countries over the time period of 2004-2007, improving the quality of infrastructure led to an increase in export performance. Investment in transportation infrastructure has increased Asia-Pacific countries' ability to accommodate air cargo growth. Previous studies indicated that physical infrastructure is an important driver of air cargo competitiveness. The physical capital input measures which contribute to airport efficiency include runway length, number of runways and total terminal area size (Ha, Yoshida and Zhang, 2010, p. 15; Huynh, Kim and Ha, 2020, p. 4). These measures indicate the capacity of airports to provide air cargo services, leading to a higher air cargo volume. In addition, following Yuan, Low and Tang (2010, p. 220) and Chao and Yu (2013, pp. 320-321), the researchers investigated the utilization of the airports in the dimension of airline transport capacity, including the number of aircraft movements and number of airlines operating at the airports. It is hypothesized that

H1: There is a positive relationship between (a) runway length, (b) terminal area size, (c) aircraft movements, (d) airlines operating at the airports, and air cargo volume.

Airport Connectivity

One of the important factors that influence the competitiveness of airports is airport connectivity because it is positively related to airport performance (Wong, Chung and Hsu, 2016, pp. 96-98; Cheung, Wong and Zhang, 2020, p. 1). Connectivity reflects the ease of reaching the rest of the network starting from an airport or the opportunity for interconnections that a specific airport offers (usually assessed in terms of degree and betweenness centrality). Airports which have a higher level of connectivity tend to provide a competitive hub service (Wong, Chung and Hsu, 2016, pp. 96-98; Song and Yeo, 2017, pp. 120-124; Cheung, Wong and Zhang, 2020, p. 17). According to OAG Aviation Worldwide Limited (2018), six major airports in the Asia-Pacific region were ranked among the top 15 most connected airports, including Singapore's Changi International Airport (SIN), Indonesia's Jakarta Soekarno-Hatta International Airport (CGK), Malaysia's Kuala Lumpur International Airport (KUL), Hong Kong's Chek Lap Kok International Airport (HKG), Thailand's Bangkok Suvarnabhumi International Airport (BKK), and Korea's Incheon International Airport (ICN). The airports with high airport connectivity are likely to have high capacity volume. Based on the review of previous studies, the following hypothesis is proposed:

H2: There is a positive relationship between airport connectivity and air cargo volume.

International Aviation Policy Towards Air Transport Liberalization

Liberalization of international aviation is necessary to establish hub/transshipment position in air cargo services (Zhang, 2003, pp. 136-137; Kasarda and Green, 2005, pp. 459-462; Fu, Oum and Zhang, 2010, p. 24). A few previous studies (e.g. Grosso and Shepherd, 2011, p. 207) used the World Trade Organization's Air Liberalization Index (ALI) as a measure of how liberal a country's air transport policy environment is. In establishing the air liberalization index, the World Trade Organization did take into account significant factors for market access such as designation, withholding, tariffs, capacity, traffic rights, absence of exchange of statistics and allowance of cooperative arrangements (World Trade Organization, 2006). The ALI ranges between 0 and 50, where 0 is associated with the most restrictive agreement and 50 denotes the most liberal agreement (Piermartini and Rousova, 2008, p. 7). Moving towards more liberal policy regimes can improve air transport connectivity and consequently increase trade volume (Fu, Oum and Zhang, 2010, p. 24; Arvis and Shepherd, 2013, pp. 1-4). Air liberalization (as measured by the number of air service agreements) positively influences air freight, trade per capita, GDP per capita and net foreign direct investment per capita (Kasarda and Green, 2005, pp. 459-462); bilateral trade in manufactured goods, time sensitive products, and parts and components (Grosso and Shepherd, 2011, p. 209); and reduction in fares, increasing demand and higher levels of capacity utilization (Abate and Christidis, 2020, p. 1). As such, it is hypothesized that

H3: There is a positive relationship between air transport liberalization and air cargo volume.

Air Cargo Competitiveness and Economic Performance

Air cargo competitiveness can influence countries' economic performance because the air cargo industry can provide better access to markets, enhance links within and between businesses increase employment, tax revenue and service production (Chang and Chang, 2009, pp. 264-265; Yuan, Low and Tang, 2010, pp. 221-224; Homsombat, Lei and Fu, 2011, pp. 573-590). According to Yuan, Low and Tang (2010, pp. 218-219), the competitiveness of air cargo service, the efficiency of an airport, the logistics industry development and the economic progress of countries are closely related. Nations with good air cargo connectivity are expected to have competitive trade and production advantage over those without such capability (Kasarda and Green, 2005, pp. 459-462; Arvis and Shepherd, 2013, pp. 1-4). Although air cargo and trade may be highly interdependent (with reciprocal causal relationship), air cargo tends to lead to trade and gross domestic product (GDP) and GDP growth (Kasarda and Green, 2005, pp. 459-462; Chang and Chang, 2009, pp. 264-265; Chen, Xuan and Qiu, 2021, p. 48).

H4: There is a positive relationship between air cargo volume and countries' economic performance including (a) GDP, (b) GDP per capita, (c) GDP growth.

All the hypotheses in this study are indicated in the conceptual framework in Picture No. 1.

Methods

Data Collection

Selection of Airports for this Study

To measure air cargo competitiveness at a national level, this study included only the airport with the highest air cargo volume of each country (or special administration region) to represent air cargo efficiency and productivity, based on a similar approached implemented by Chao and Yu (2013, pp. 322-324). The sample in this study includes the following airports:

1. China's Shanghai Pudong International Airport (PVG)
2. Japan's Tokyo Narita International Airport (NRT)
3. South Korea's Incheon International Airport (ICN)
4. Taiwan's Taoyuan International Airport (TPE)
5. Singapore's Changi International Airport (SIN)
6. Hong Kong's Chek Lap Kok International Airport (HKG)
7. Australia's Sydney Kingsford Smith International Airport (SYD)
8. Thailand's Bangkok Suvarnabhumi International Airport (BKK)
9. Malaysia's Kuala Lumpur International Airport (KUL)
10. Indonesia's Jakarta Soekarno-Hatta International Airport (CGK)
11. Philippines's Ninoy Aquino International Airport (MNL)
12. New Zealand's Auckland International Airport (AKL)
13. India's Indira Gandhi International

Airport (DEL).

Secondary data was used in this study. Owing to data availability, panel data covering the years 2010 – 2017 for all thirteen airports was obtained from various sources. The data of runway length (in meters), terminal area size (in square meters), aircraft movements, number of airlines operating at the airports and volume of air cargo (in metric tonnes) were collected from the annual reports available on the official websites of the airports and airport authorities of the countries in the study. As for the economic measures, nominal values of gross domestic product (GDP) (in billion US dollars), GDP per capita (in billion US dollars) and GDP growth (in percentages) were taken from the World Bank official website, the Observatory of Economic Complexity (OEC) online tool developed by Simoes and Hidalgo (2011), and the official website of the Ministry of Finance of the Republic of China. The number of aircraft movements and the volume of air cargo were obtained from the Airports Council International website. The connectivity index was obtained from OAG Megahubs International Index 2017. Lastly, the data of air transport liberalization was obtained from the World Trade Organization (WTO) Air Services Agreement Projector (https://www.wto.org/asap/index.html).

Model Specification

To test the hypotheses, we analyzed the obtained data using the following models. First, we tested the relationship between the independent variables (runway length, terminal area size, aircraft movements, number of airlines, connectivity, and air transport liberalization) and the dependent variable which is air cargo volume. Then, we tested the relationship between the air cargo volume and the economic performance measures including GDP, GDP per capita, GDP growth.

For testing H1, H2, and H3

$$\begin{aligned} AirCargoVolume_{it} = \alpha &+ \beta_1 RunwayLength_{it} + \beta_2 TerminalArea_{it} \\ &+ \beta_3 AircraftMovements_{it} + \beta_4 NumberOfAirlines_{it} \\ &+ \beta_5 AirportConnectivity_{it} + \beta_6 AirTransportLiberalization_{it} + \varepsilon_{it} \quad (1) \end{aligned}$$

where

AirCargoVolume = Volume of air cargo (in metric tonnes)

RunwayLength = Runway length (in meters)

TerminalArea = Terminal area size (in square meters)

AircraftMovements = Number of aircraft movements

NumberOfAirlines = Number of airlines operating at the airports

AirportConnectivity = Connectivity Index

AirTransportLiberalization = Air Transport Liberalization

For testing H4

$$GDP_{it} = \alpha + \beta AirCargoVolume_{it} \quad (2a)$$

$$GDP\_Per\_Capita_{it} = \alpha + \beta AirCargoVolume_{it} \quad (2b)$$

$$GDP\_Growth_{it} = \alpha + \beta AirCargoVolume_{it} \quad (2c)$$

where

GDP = Nominal gross domestic product (in billion US dollars)

$GDP\_Per\_Capita_{it}$ = Nomial GDP per capita (in billion US dollars)

GDP_Growth = GDP growth (in percentages)

Results

Unit Root Tests

Due to the small size of the data set, especially one with a short time span, such tests may not be necessary or reliable (Wooldridge, 2010, p. 175). In addition, some of the explanatory variables such as Number of Airlines, Airport Connectivity, and Air Transport Liberalization are time-invariant. These are by definition stationary. Nevertheless, we conducted Im–Pesaran–Shin's (2003, pp. 53-74) unit root tests and found that Aircraft Movements, Air Cargo Volume, and GDP have unit roots, which means that they are non-stationary. In contrast, we coinlearned that GDP per Capita and GDP Growth are stationary. Because it is theoretically impossible for a non-stationary variable, Air Cargo Volume, to cause stationary variables, GDP per Capita and GDP Growth, we will omit regressions of equations (2b) and (2c) from further analyses as they would be invalid.

Cointegration Tests

Cointegration is the phenomena that linear combinations of non-stationary variables become stationary. Again, because of the limited data set, it may not be necessary or reliable to conduct such a test (Greene, 2012, pp. 1010-1011). Nonetheless, we conducted the Pedroni (2004, pp. 597-625) test on Aircraft Movements and Air Cargo Volume and found that they are cointegrated ($p < .05$) with respect the modified variance ratio. Moreover, the same test also reveal that Air Car Volume and GDP are also cointegrated ($p < .01$) with respect to the modified variance ratio. Cointegration implies that the regressions between the variables are not spurious, which confirms the validity of our regression analyses in the next section.

Panel Model Selection

We analyze the panel data by running both the fixed-effects and random effects models for all independent airport variables with respect to air cargo volume. (The results are presented in Table No. 3). For the fixed-effects model, the time-invariant variables drop out from the regression equation. We then keep removing insignificant variables one by one according to the highest p-value until we arrive at the final and best fixed-effects model in Table No. 4 with only Aircraft Movements being significant with respect to Air Cargo Volume. The Chow-test result, ($F(12,90) = 671.33$, $p < .001$), implies that the fixed-effects are significant and that this model is preferred to the pooled OLS model.

We then run the random effects model starting with all independent variables, presenting the results in Table No. 3. As before, we remove insignificant ones one by one in order of decreasing p-value. In the end, the best random-effects model presented in Table No. 4 only has Aircraft Movements and Number of Airlines as significant explanatory variables for Air Cargo Volume. The Breusch-Pagan Lagrange Multiplier (LM) test, ($\chi^2(2) = 97.54$, $p < .001$), show that the random-effects model is better that the pooled OLS model.

We then conducted Hausman's (1978, pp. 1251-1271) test to compare the fixed-effects model versus the random-effects mode. Comparison between the two models with all independent variables in Table No. 3 results in $\chi^2(3) = 0.78$, $p = .853$, meaning that the random-effects model is preferrred to the fixed-effects model. Similar results presented in Table No. 4 also occur in the comparison between the best fixed-effects model and the best random-effects model. More specifically, $\chi^2(1) = 1.44$, p = .230, which indicates that the random-effects model is again preferred to the fixed-effects model.

In conclusion, the results from Chow, Breusch-Pagan (LM), and Hausman tests demonstrate that the best random-effects model is the most preferred model, followed by the best fixed-effects model, and then lastly the pooled OLS model. However, the best random-effects models also has autocorrelation problems according to Wooldridge's (2010) test, $F(1,12) = 15.779$, $p < 0.01$. (There were no issues of cross sectional dependence or heteroskedasticity for these models.) However, we can alleviate these problems by using robust standard error estimation or the feasible general least squares (FGLS). We conducted these two analyses and the results are two competingly good random-effects models, presented in Table No. 5. The first with Aircraft Movements, Number of Airlines being significant at 5% level and Runway Length being significant at 10% level uses the robust robust standard error. The second with only Aircraft Movements and Number of Airlines being significant at 5% level is applicable for both methods, robust standard error and (two step) FGLS. We also conducted similar panel data analysis for air cargo volume and GDP, presenting the results in Table No. 6 and Table No. 7.

Analyses

Prior to testing the hypotheses, we examine the correlation among all variables to assess whether there is an issue of multicollinearity. Based on the matrix in Table No. 2, the pairwise correlation coefficients among all exogeneous variables (runway length, total terminal area size, etc.) are lower than 0.9 in magnitude. This indicates that there is not a severe problem of multicollinearity (Hair, et al., 2010, p. 202). The positive correlation was strongest between the total terminal area size and the number of airlines ($r = 0.848$, $p < .01$). The negative correlation was strongest between aircraft movement and air transport liberalization ($r = -0.655$, $p < .01$). The pairwise correlation coefficients between all exogenous variables (with exception of air transport liberalization) and the endogenous variable, volume of air cargo, was positive. There is a significant positive correlation between the volume of air cargo and GDP ($r = 0.381$, $p < .01$). However, the correlation between the volume of air cargo is not significant with either GDP per capita and GDP growth.

According to the panel data analyses in the previous section, Table No. 5 presents the most reliable models for the relationship between air cargo volume and the independent airport variables. In particular, based on RE1-RSE (random-effects model using robust standard error), we found that the two measures for airport utilizations, number of aircraft movements and number of airlines, are most significantly related to the volume of air cargo ($p < .001$ with positive coefficients for both variables). For the number of airlines, the effect is the largest with a change of 40153.43 in metric tonnes of air cargo volume on average per one airline that operates at the airport (holding other independent variables constant). For the number of aircraft movements, which inherently has a larger value than the number of airlines, the effect is 2.654 metric tonnes of air cargo volume on average for each movement (holding other independent variables constant). Hence, these results support the hypotheses H1c and H1d.

Another variable, which is air transport liberalization, is also positively correlated with the volume of air cargo. More specifically, for a change in the value of the index, which is a measure of liberalization for each country's air transport policy, of 1 will result in an average change of 37408.28 metric tonnes of air cargo volume ($p < 0.05$), holding other independent variables constant. This result implies that hypothesis H3 also holds.

In contrast, the physical infrastructure, runway length and terminal area size, are not significantly related to the volume of air cargo at airports in the Asia-Pacific region. However, closer inspection of the RE1-RSE model results reveal that runway length is actually significant at 10% level, with a meter in length being associated with 36.100 metric tonnes of air cargo volume on average (holding other independent variables constant). Thus, these results marginally support H1a, but not H1b.

Lastly, with respect to air cargo volume, connectivity, which reflects the ease of transit and accessibility for or the opportunity for interconnections, is not significantly relevant. As a result, H2 is also rejected.

And as was stated in the previous section, the discovery of GDP per capita and GDP growth as stationary variables makes it theoretically impossible to construct a valid panel data model with the volume of cargo as the regressor. In addition, these two dependent variables are also not significantly correlated with air cargo volume. Thus, we have focused on the effort to analyze only GDP with respect to air cargo volume as presented in Table 6 and Table No. 7. The random-effects-FGLS (feasible general least squares) model in Table No. 7 turned out to be the most appropriate one from the specificity test with respect to the fixed-effects model and also due the issue of autocorrelation. The result shows that air cargo volume is indeed related to GDP ($p < 0.001$). More specifically, one metric tonne of air cargo corresponds to 0.00013 billion US dollars in GDP on average. Therefore, this proves that H4a is true.

Discussion and Conclusion

The results of this study indicates that in the Asia-Pacific region, air cargo competitiveness depends on utilization of airports more than their physical infrastructure. Total terminal area size do not significantly affect the volume of air cargo and the length of runways do so marginally. By looking at the data, it is noticeable that the busiest airports like Tokyo Narita International Airport (NRT), Taoyuan International Airport (TPE), Chek Lap Kok International Airport (HKG), and Suvarnabhumi Airport (BKK) had two runways but handled a lot more air cargo compared with Sydney Kingsford Smith International Airport (SYD) or Kuala Lumpur International Airport (KUL), both of which had three runways. In addition, Taoyuan

International Airport (TPE) and Suvarnabhumi Airport (BKK) which had smaller terminal areas than Kuala Lumpur International Airport (KUL) handled more air cargo volume. According to Huynh, Kim and Ha (2020, pp. 5-8), physical infrastructure itself does not necessarily impact air cargo competitiveness unless the airports can improve the level of efficiency in utilizing such physical infrastructure at the best of their capacity to generate more outputs such as aircraft movements and amount of cargo.

In terms of utilization, there are positive relationships between both aircraft movements and the number of airlines operating at the airports and air cargo volume. Consistent with previous research (e.g. Mayer, 2016, p. 62), the airports in Asia tend to become international primary hubs which accommodate numerous aircraft movements and major international network airlines serving numerous passengers, subsequently resulting in the high volume of cargo. Thus, these factors are related to air cargo competitiveness.

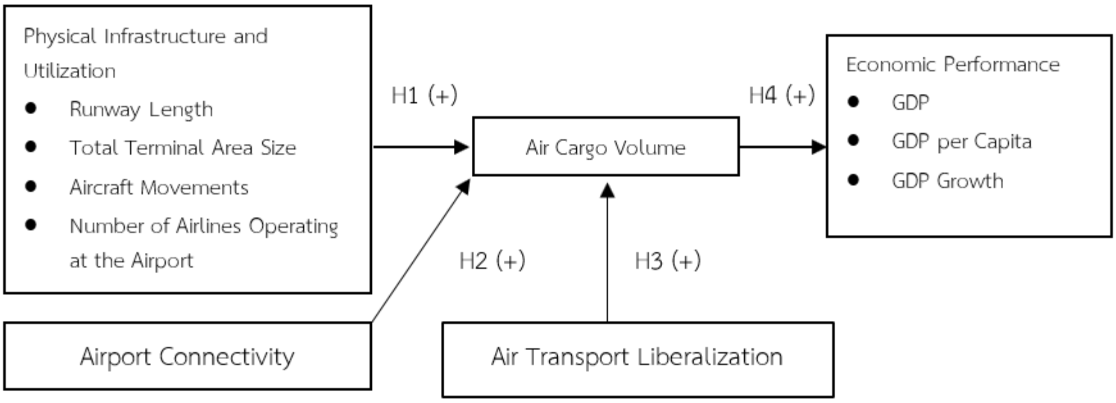
Our study also found that air transport liberalization is positively correlated with air cargo volume. This is consistent with other previous studies such as Kasarda and Green (2005, pp. 459-462), which found that the number of air service agreements are positively related to economic variables such as air freight. However, this may not be so evident when one casually observes the data. Countries with high degrees of liberalization such as New Zealand (AKL) achieve relatively low levels of air cargo volume, especially when compared to countries such China (PVG), which have low degrees of liberalization. However, when one controls for aircraft movements and the number of airlines, the impact of higher levels of liberalization will become positive. Such a situation arises in the comparison between South Korea (ICN) and Thailand (BKK). Both have approximately the same number of aircraft movements and number of airlines. However, the former which has higher air transport liberalization also have higher air cargo volume.

On the other hand, connectivity were found not to be significantly affecting air cargo volume. Considering the data in this study, this result is understandable since the airports which have high connectivity such as Malaysia's Kuala Lumpur International Airport (KUL) and Indonesia's Jakarta Soekarno-Hatta International Airport (CGK) do not have a high level of air cargo volume whereas China's Shanghai Pudong International Airport (PVG) and Japan's Tokyo Narita International Airport (NRT) have much larger amounts of air cargo although their connectivities are relatively lower.

Lastly, there is a strong evidence that the volume of air cargo is related to GDP, which is collaborated by many researchers, including Chang and Chang, 2009, pp. 264-265; Yuan, Low and Tang, 2010, pp. 219-224; Homsombat, Lei and Fu, 2011, pp. 575-579.

Based on the results in this paper, we can derive some specific insights and recommendations for policy makers in order to increase the volume of air cargo through a nation's airport, which will consequently raise its GDP. First, it may not be prudent for an airport to invest heavily in physical infrastructure. As the results have shown, factors such as runway length and total terminal area may not be the strongest determinants of air cargo volume. Second, airports should focus on improving the utilization of existing resources. Measures such as aircraft movements and the number of airlines operating at an airport have found to be highly correlated with air cargo volume. Thus, attracting additional airlines to operate at an airport in particular, will most likely cause a surge of cargo flow. Finally, countries should pursue bilateral and perhaps even multilateral air services agreements. Such actions of augmented liberalization will eventual lead to more air cargo volume and better economic performance.

Due to the scope of the focus on Asia Pacific and the nature of the data, only a small sample size can be obtained. Thus, the findings might not be generalized across the entire air cargo industry. Future research should collect more data across all countries' major airports and also investigate more factors related to capacity and operations that may influence air cargo performance, for example the number of linkages between source and destination cities, cargo clearance time, and airport charges and fees.



Picture No. 1 Conceptual Framework

Table No. 1 Cargo Volume of Major Airports in the Asia-Pacific Region during 2010-2017 (loaded and unloaded freight and mail in metric tonnes)

Airport	Cargo Volume (metric tonnes)							
	2010	2011	2012	2013	2014	2015	2016	2017
Hong Kong (HKG)	4,165,852	3,976,768	4,066,738	4,122,000	4,376,000	4,460,065	4,615,241	5,049,898
Shanghai (PVG)	3,228,081	3,085,268	2,938,157	2,928,527	3,143,188	3,275,231	3,440,280	3,824,280
Incheon (ICN)	2,684,499	2,539,221	2,456,724	2,464,385	2,557,681	2,595,678	2,714,341	2,921,691
Tokyo (NRT)	2,167,853	1,945,351	2,006,173	2,019,844	2,043,372	2,122,314	2,165,427	2,336,427
Taipei (TPE)	1,767,075	1,627,463	1,577,730	1,571,814	2,088,727	2,021,865	2,097,228	2,269,585
Singapore (SIN)	1,841,004	1,898,850	1,870,577	1,885,978	1,843,799	1,887,000	2,006,300	2,164,700
Bangkok (BKK)	1,310,146	1,321,853	1,345,490	1,236,223	1,234,176	1,230,563	1,351,878	1,439,913

Airport	Cargo Volume (metric tonnes)							
	2010	2011	2012	2013	2014	2015	2016	2017
New Delhi (DEL)	600,045	568,355	546,311	605,699	696,539	787,168	857,419	963,032
Kuala Lumpur (KUL)	674,902	669,849	673,107	680,983	753,899	726,230	642,558	710,186
Manila (MNL)	425,383	390,047	461,550	416,193	509,796	584,599	630,283	662,257
Jakarta (CGK)	510,442	572,610	629,706	645,298	626,046	614,822	597,807	657,008
Sydney (SYD)	391,060	408,593	418,242	413,569	411,084	443,374	477,277	511,383
Auckland (AKL)	167,973	168,833	171,834	170,772	175,562	178,035	178,065	178,243

Sources: Airports Council International; Airports of Thailand Public Co., Ltd.; Airports Authority of India Traffic News and Statistics; Malaysia Airport Annual Reports; PT Angkasa Pura II (Perseo) Annual Reports; Civil Aviation Authority of the Philippines; Sydney Airport Annual Review and Financial Highlights; Sydney Airport Freight; International Airline Activity Australian Government, Department of Infrastructure and Transport, Bureau of Infrastructure, Transport and Regional Economics - Statistical Report, Aviation; Auckland Airport Annual Review; Ministry of Transport, New Zealand Freight and the Transport Industry: Freight volume

Table No. 2 Correlations among Independent and Dependent Variables

Variable	Runway Length	Terminal Area	Aircraft Movements	Number Of Airlines	Airport Connectivity	Air Transport Liberalization	Air Cargo Volume	GDP	GDP Per Capita	GDP Growth
Runway Length	1									
Terminal Area	.433**	1								
Aircraft Movements	.542**	.399**	1							
Number of Airlines	.350**	.848**	.326**	1						
Airport Connectivity	.330**	.473**	.585**	.339**	1					
Air Transport Liberalization	-.580**	-.413**	-.655**	-.450**	-.515**	1				
Air Cargo Volume	.271**	.660**	.336**	.855**	.248*	-.310**	1			
GDP	.425**	.380**	.283**	.365**	-.304**	-.243*	.381**	1		
GDP per Capita	-.298**	.214*	-.192	.124	-.079	.610**	.170	-.115	1	
GDP Growth	.342**	.081	.225*	.014	.129	-.486**	-.043	.176	-.494**	1

Notes: *p < 0.05, **p < 0.01

Table No. 3 Fixed-Effects and Random-Effects Model Estimations for Air Cargo Volume (with all Independent Airport Variables)

Variable	Fixed-Effects	Random-Effects
Runway Length	33.982	40.002
Terminal Area	-.3125	-.266
Aircraft Movements	2.827***	2.542***
Number of Airlines	-	42142.44***
Airport Connectivity	-	-2268.121
Air Transport Liberalization	-	21182
Constant	611276*	-2617057
R^2 overall	0.033	0.783
F / χ^2	426.23	289.67
Prob > F / χ^2	0.000	0.000
Hausman's Specification Test:	$\chi^2(3) = 0.78$, Prob > $\chi^2 = 0.853$	

Notes: *p < 0.05, **p < 0.01, ***p < 0.001.

Table No. 4 The Best Fixed-Effects and Random-Effects Models for Air Cargo Volume

Variable	Fixed-Effects	Random-Effects
Runway Length	-	-
Terminal Area	-	-
Aircraft Movements	2.861***	2.828***
Number of Airlines	-	36206.78***
Airport Connectivity	-	-
Air Transport Liberalization	-	-
Constant	717905.6***	-2054445**
R^2 overall	0.113	0.722
F / χ^2	671.33	324.26
Prob > F / χ^2	0.000	0.000
Hausman's Specification Test:	$\chi^2(1) = 1.44$, Prob > $\chi^2 = 0.230$	

Notes: *p < 0.05, **p < 0.01, ***p < 0.001.

Table No. 5 The Best Random-Effects Models for Air Cargo Volume using Robust Standard Error Estimation and Feasible General Least Squares (FGLS)

Variable	Random-Effects1-RSE	Random-Effects2-RSE	Random-Effects2-FGLS
Runway Length	36.100-	-	-

Variable	Random-Effects1-RSE	Random-Effects2-RSE	Random-Effects2-FGLS
Terminal Area	-	-	-
Aircraft Movements	2.654***	2.828***	1.662524***
Number of Airlines	40153.43***	36206.78***	36172.88***
Airport Connectivity	-	-	-
Air Transport			
Liberalization	37408.28*-	-	-
Constant	-3268965***	-2054445***	-1751016***
R^2 overall	0.756	0.722	-
χ^2	393.75	40.38	620.12
Prob > χ^2	0.000	0.000	0.000

Notes: *p < 0.05, **p < 0.01, ***p < 0.001.

Table No. 6 Fixed-Effects and Random-Effects Model Estimations for GDP

Variable	Fixed-Effects	Random-Effects
Air Cargo Volume	.00103**	.00098**
Constant	114.294	196.017
R^2 overall	0.146	0.146
F / χ^2	147.47	324.26
Prob > F / χ^2	0.000	0.000
Hausman's Specification Test:	$\chi^2(1) = 0.08$, Prob > $\chi^2 = 0.781$	

Notes: *p < 0.05, **p < 0.01, ***p < 0.001.

Table No. 7 Random-Effects Models for GDP using Robust Standard Error Estimation and Feasible General Least Squares (FGLS

Variable	Random-Effects-RSE	Random-Effects-FGLS
Air Cargo Volume	.00098-	.00013***-
Constant	196.016	854.5034***
R^2 overall	0.146	-
χ^2	1.44	13.53
Prob > χ^2	0.230	0.000

Notes: *p < 0.05, **p < 0.01, ***p < 0.001.

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