Malaysian Aviation Commission
Suruhanjaya Penerbangan Malaysia
MAVCOM

TECHNICAL PAPER

DEFINING AND MEASURING AIR CONNECTIVITY

MAY 2018

This Technical Paper is a companion to the WAYPOINT May 2018 report and discusses the Malaysian Aviation Commission's study on Malaysia's air connectivity.

EXECUTIVE SUMMARY

Air connectivity is an indicator for the performance of airline networks and airports. It provides a link between civil aviation and tourism and trade. Globally, an estimated 54% of tourists travel by air. With regards to trade, higher air connectivity reduces the costs of air transport, thus enabling a location to be more strongly connected to the global value chains.

Air connectivity can be divided into three main categories: direct connectivity, indirect connectivity, and hub connectivity. Both the direct and indirect connectivity are based on the point-to-point passengers while the hub connectivity is based on the transiting passengers.

We measured Malaysia's point-to-point connectivity using an adjusted form of the International Air Transport Association (IATA) Air Connectivity Indicator methodology – both at the country and airport levels. Meanwhile, the hub connectivity was estimated using the OAG Aviation Worldwide Limited (OAG) and the Hub Connectivity Indicator (HCI) methodologies.

Based on the 2017 findings, at the country level, Malaysia ranked fourth in the Association of Southeast Asian Nations (ASEAN) after Thailand, Singapore, and Indonesia for its point-to-point connectivity. At the airport level, Kuala Lumpur International Airport (KUL) was ranked third after Singapore Changi Airport (SIN) and Suvarnabhumi Airport (BKK).

In terms of hub connectivity, KUL had the largest volume of hub traffic in 2017. Nonetheless, 49% of KUL's hub traffic were domestic passengers connecting at KUL from other domestic airports such as Penang International Airport (PEN), Langkawi International Airport (LGK), and Kota Kinabalu International Airport (BKI). When we segregated the hub traffic based on international and domestic passengers, KUL's international hub traffic size was the second largest in ASEAN after SIN.

When we studied the movement of connecting passengers in 2017, we observed that KUL's three largest international-to-international passenger flows had moved from intercontinental travel in 2010 (Great Britain to Australia, India to Australia, and Indonesia to Amsterdam) to intra-Asia and domestic travel. This change was mainly driven by the low-cost carriers (LCCs).

We also estimated the HCI for KUL, which measures the number of viable connections that an incoming passenger can connect to at a hub airport. Based on this measure, KUL's HCI score was 95,485 in 2017, which means that passengers can connect to an average of 24.4 connections per incoming flight. In comparison, passengers at SIN and BKK could connect to 61.0 and 65.7 connections per incoming flight, respectively.

There are many factors that drive connectivity. Based on our analysis, among the key determinants that influence connectivity are the population size, the number of airlines flying into a country, as well as, the airline alliances operating within the country. A market with a large population will have higher demand for flights and this will attract more airlines to fly into the area. Consequently, this will increase the available seats offered by the airport and increase its connectivity. Our regression analysis also shows the SkyTeam Airline Alliance (SkyTeam) having the highest influence on connectivity due to it having three out of the ten largest airlines (in terms of revenue passenger-kilometres flown) as its members.

ABBREVIATIONS

Abbreviations	
Act 771	Malaysian Aviation Commission Act 2015
ACI	Airports Council International
ALI	Air Liberalisation Index
ASA	Air Service Agreements
ASEAN	Association of Southeast Asian Nations
FAA	The Federal Aviation Administration of the United States
FSC	Full Service Carrier
HCI	Hub Connectivity Indicator
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
LCC	Low-Cost Carrier
MACT	Maximum Connecting Time
MAVCOM	Malaysian Aviation Commission
MCT	Minimum Connecting Time
OAG	Official Aviation Guide of The Airways
O&D	Origin and Destination
QCI	Quality of Connectivity Index
QVC	Quantity of Viable Connections
WTO	World Trade Organization
US	United States of America

ABBREVIATIONS FOR AIRLINES

Abbreviations	
AK	AirAsia Berhad
D7	AirAsia X Berhad
FD	Thai AirAsia Co., Ltd.
MH	Malaysia Airlines Berhad
MI	SilkAir (Singapore) Pte. Ltd.
OD	Malindo Airways Sdn. Berhad
QZ	PT Indonesia AirAsia
SQ	Singapore Airlines Ltd.
TR	Scoot Tigerair Pte. Ltd.

SELECTED AIRPORT CODES

No.	Code	Airport
Domestic Airports		
1	BKI	Kota Kinabalu International Airport
2	JHB	Senai International Airport
3	KUL	Kuala Lumpur International Airport
4	LGK	Langkawi International Airport
5	PEN	Penang International Airport
6	SZB	Skypark Terminal Sultan Abdul Aziz Shah Airport (Subang)
International Airports		
7	AKL	Auckland Airport, New Zealand
8	AMS	Amsterdam Airport Schiphol, Netherlands
9	ATL	Hartfield-Jackson Atlanta International Airport, United States
10	BDO	Husein Sastranegara International Airport, Indonesia
11	BKK	Suvarnabhumi Airport, Thailand
12	BNE	Brisbane Airport, Australia
13	BWN	Brunei International Airport, Brunei
14	CDG	Paris Charles de Gaulle Airport, France
15	CGK	Soekarno-Hatta International Airport, Indonesia
16	CNX	Chiang Mai International Airport, Thailand
17	DMK	Don Mueang International Airport, Thailand
18	DOH	Hamad International Airport, Qatar
19	DPS	Ngurah Rai International Airport, Indonesia
20	DXB	Dubai International Airport, United Arab Emirates
21	HKT	Phuket International Airport, Thailand
22	JED	King Abdulaziz International Airport, Saudi Arabia
23	KBV	Krabi International Airport, Thailand
24	KNO	Kualanamu International Airport, Indonesia
25	LHR	London Heathrow Airport, United Kingdom
26	MLE	Velana International Airport, Maldives
27	MNL	Ninoy Aquino International Airport, Philippines
28	NRT	Narita International Airport, Japan
29	PEK	Beijing Capital International Airport, China
30	PNH	Phnom Penh International Airport, Cambodia
31	REP	Siem Reap International Airport, Cambodia
32	RGN	Yangon International Airport, Myanmar
33	SGN	Tân Sơn Nhất International Airport, Vietnam
34	SIN	Singapore Changi Airport, Singapore
35	SUB	Juanda International Airport, Indonesia
36	VTE	Wattay International Airport, Laos

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INTRODUCTION

One of MAVCOM's functions as stated in the sub-paragraph 17(1)*(a)*(i) of the Malaysian Aviation Commission Act 2015 [Act 771] is "to improve connectivity, both globally and locally, so as to promote economic ties, integration and growth, and trade, investment and tourism".

Air connectivity provides an important linkage between the civil aviation industry and tourism and trade. For tourism, the IATA (2017) estimated that 54% of international tourists fly globally. With regards to trade, 35% of world trade (in terms of value) is shipped by air. Higher air connectivity reduces the costs of air transport and therefore enables a location to be more strongly connected to the global value chains. Various studies and rankings of competitiveness also indicate that well-connected cities rank highly in the hierarchy of global cities as air connectivity is a key factor in the location decisions of multilateral organisations and multinational corporations.

To improve Malaysia's connectivity, it is important to first identify Malaysia's competitive position in terms of air connectivity. This is followed by benchmarking against Malaysia's neighbours' connectivity positions within the same geographical market.

What does air connectivity mean and how does one measure it? There is no single definition of air transport "connectivity". The IATA defines a country's air transport connectivity as the scope of access between an individual airport or country and the global air transport network. Meanwhile, the ICAO defines it as an indicator of a network's concentration and its ability to move passengers from their origins to their destinations seamlessly[1].

Air connectivity relates to the degree in which the desired destinations are serviced from convenient airports, along with the nature of associated routes. The nature of the routes considers factors such as direct/indirect routes, number of destinations served by the airport, frequency of service, travelling costs, and total travelling time[2].

This paper measures the international connectivity of Malaysia and other ASEAN Member States. The paper covers the following areas:

- Explanation on the different categories of connectivity
- Methodologies to measure air connectivity
- Key findings based on the methodologies used
- Factors influencing connectivity

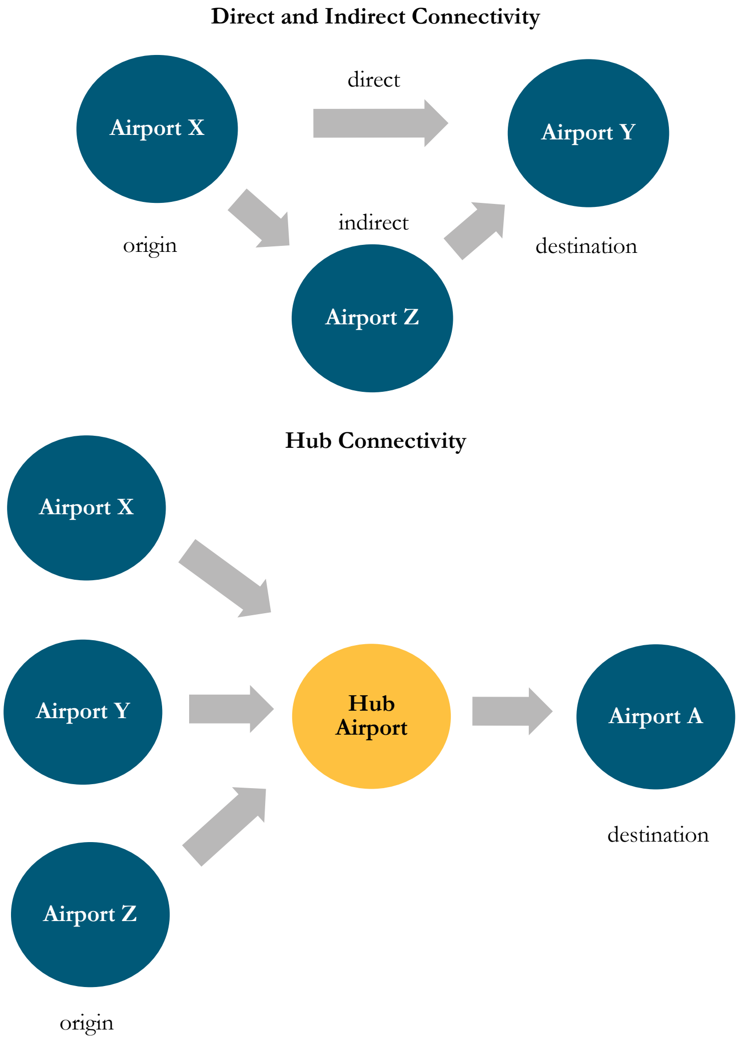
[1] Enhancement of Air Transport Connectivity and Facilitation. (2013). WORLDWIDE AIR TRANSPORT CONFERENCE (ATCONF). ATConf/6-WP/20, p. 4. International Civil Aviation Organisation.
[2] Oxford Economics; York Aviation. (2013). The Economic Value of International Connectivity. London.

SECTION 1: DEFINING AND MEASURING CONNECTIVITY

Connectivity can be divided into three categories (see Figure 1):

- **Direct connectivity** refers to the direct connections offered by the origin airports (airport X) to the destination airports (airport Y) without stops
- **Indirect connectivity** refers to the indirect connections offered by the origin airports (airport X) to the destination airports (airport Y) via one or more intermediate airports (including hub airports)
- **Hub connectivity** refers to connections offered through hub airports between origin and destination airports

Figure 1: The Different Types of Connectivity



Source: MAVCOM, ACI

Both direct and indirect connectivity are based on point-to-point passengers while the hub connectivity is based on transiting passengers.

In general, a passenger would value a direct connection more than an indirect connection as the former has lower total travelling time. However, indirect connections are necessary in the absence of direct connections – for instance, if the distance between the destination and origin is too far for a direct flight, or, if there is not enough demand for a direct flight such that the airlines would need to combine passengers from various flights at a hub airport before flying them to their respective destinations.

Point-to-Point Connectivity

There are many ways to measure connectivity. Simpler methodologies measure the competitive positions of airports and levels of air accessibility using the number of passengers and aircraft movements. More complex models, such as the network quality models, take into consideration the minimum and maximum connecting times, route factors, and the total travelling time.

Table 1 shows some of the methodologies available to measure connectivity. Examples of simple measures of connectivity are the top ten lists which rank airports or airlines by the number of destinations served, flight frequencies, or seat capacity. Although these measures are easier to understand and compute, they do not provide insight on how changes in operations—such as improving the timetable coordination or cancelling flights to certain destinations—can impact the network development. More detailed models are explained further in other sections of this paper.

Table 1: Examples of Methodologies to Measure Connectivity

Methodology	Purpose	Details
Top 10 lists	Measures the competitive positions of airlines, airports, and level or air accessibility	Compares the total passenger boarding, the number of aircraft movements, or the total destinations served
Netscan Airport Connectivity Index	Measures the competitive positions of airports within Europe based on their functions as hubs and in terms of the flights offered	Identifies all direct and indirect (one-stop) connections available on an airport-pair. Each connection is weighted based on the total travel time
IATA Connectivity Indicator	Measures the quality of a country's air transport network by its "connectivity" from the point of view of its businesses	Combines information on the number of destinations served, frequency of service, number of seats per flight, and size of airport destination
World Bank Air Connectivity Index	Relates connectivity to cargo, and not passenger flows. Measures connectivity in terms of the repellent and attractive potential a country exerts on the rest of the network	Based on a gravity model network. Captures interactions among network nodes, even if there is no direct flight connection between them
World Economic Forum Available Airline Seat Kilometre/Week	Sub-indicator of the Global Competitive Index and forms part of the measure of the quality of infrastructure of a country	Uses scheduled available airline seat kilometres per week originating in a country as a measure

Source: MAVCOM, various

We chose the IATA Connectivity Indicator methodology to measure Malaysia's position in terms of international air connectivity as it considers the economic importance of destinations. Most methodologies measuring connectivity do not consider this factor. For example, a flight to a holiday destination is considered equally important as a flight to the capital of a large country, which can be invaluable for fostering trade and investment (Lieshout & Boonekamp, 2017). The IATA Connectivity Indicator methodology can also be scaled to measure connectivity at both airport and country levels.

IATA Connectivity Indicator

The IATA Connectivity Indicator measures the number of available seats to a destination in the first week of July each year. It then weights the number of available seats by the size of the destination airports (in terms of the number of annual passengers). This provides a proxy estimate for both the range and economic importance of the destination (Pearce, 2007). A larger airport is also deemed better for connectivity as it would have access to a larger number of onward connections, which is especially important for business passengers.

The formula for calculating the IATA connectivity indicator is as follows:

$$\frac{\sum(\mathit{frequency}_i \times \mathit{seats\ per\ flight}_i \times \mathit{airport\ weightage}_i)}{\mathit{scalar\ factor\ of\ 10{,}000}}$$

where *i* represents every other airport that the airport in question is connected to.

The airport weightage for an airport is calculated as follows:

$$\frac{\mathit{total\ passengers\ handled\ by\ the\ airport}}{\mathit{total\ passengers\ handled\ by\ the\ largest\ airport}}$$

For example, ATL, which handles the largest number of passengers in the world, is given a weightage of 1.00. BKK, which handles 51% of the number of passengers handled by ATL, is given a weightage of 0.51. Therefore, if an airport has 1,000 seats to ATL, it will receive a score of 1,000, but if it also has 1,000 seats to BKK it is given an additional score of 510. Overall, a higher figure for the connectivity indicator denotes a greater degree of access to the global air transport network.

MAVCOM Air Connectivity Indicator

We have adjusted the formula in the IATA Connectivity Indicator to measure the international connectivity of Malaysia.

The first adjustment done was to measure the number of available seats in the busiest month of the year instead of the first week of July. The IATA Connectivity Indicator uses the first week of July to reflect the full spectrum of connectivity, usually associated with the summer schedules. Although this is an appropriate representation of the travel patterns in Europe, it does not reflect travel patterns in ASEAN, as people are more inclined to travel during religious holidays, which may occur all year round. Also, the peak travelling month may vary by country. Therefore, it is more appropriate to identify the month with the highest seat capacity for each country. For example, for Brunei, the month with the highest seat capacity in 2010 was October, while in 2016 it was December. In comparison, the busiest month for Indonesia in 2010 was July, while in 2016 it was June.

The second adjustment made was for the airport weightage calculation. Instead of using the largest airport in the world as a weight measure, we used the airport with the largest number of international passengers. This was done to avoid the biasness towards large domestic airports like ATL and PEK. To identify the largest international airport, we segregated the domestic and international passengers handled by all airports and chose the airport with the highest number of international passengers.

We defined international passengers as passengers whose journeys include at least one of their consecutive departures, transfers or arrival airports to be located in different countries. Based on this measurement, LHR was the largest international airport from 2010 to 2013, while DXB was the largest international airport from 2014 to 2017.

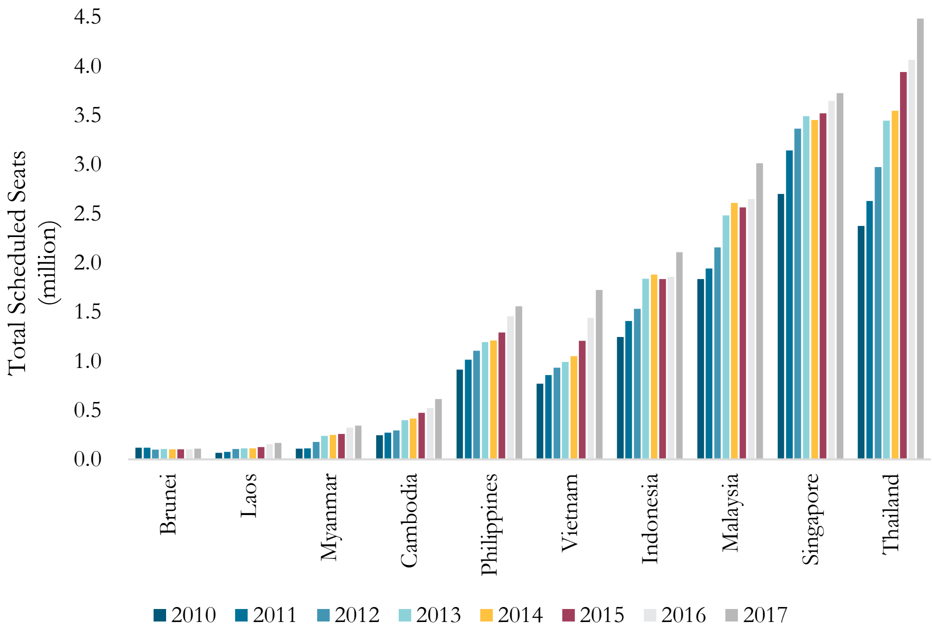
For all airlines' schedules and seats, our source of data was the IATA SRS Schedule Analyser and the study covers the period between 2010 and 2017.

We calculated the connectivity indicator scores at two different levels: country and airport levels. At the country level, we want to compare Malaysia's connectivity relative to the other ASEAN countries. At the airport level, we want to investigate KUL's score compared to the busiest airport in each ASEAN country such as BKK, CGK, and MNL.

Country Level Key Findings

We first calculated the connectivity indicator scores for Malaysia and its ASEAN neighbours at the country level. Country level connectivity can be defined as the total international connectivity of all the airports within the country. **In terms of the total scheduled seats offered by each country, Malaysia ranked third in ASEAN throughout 2010 to 2017.** In 2017, Thailand had 4.5 million seats to 180 international destinations while Singapore had 3.7 million seats to 161 destinations. In the same period, Malaysia had 3.0 million seats to 124 destinations (see Figure 2).

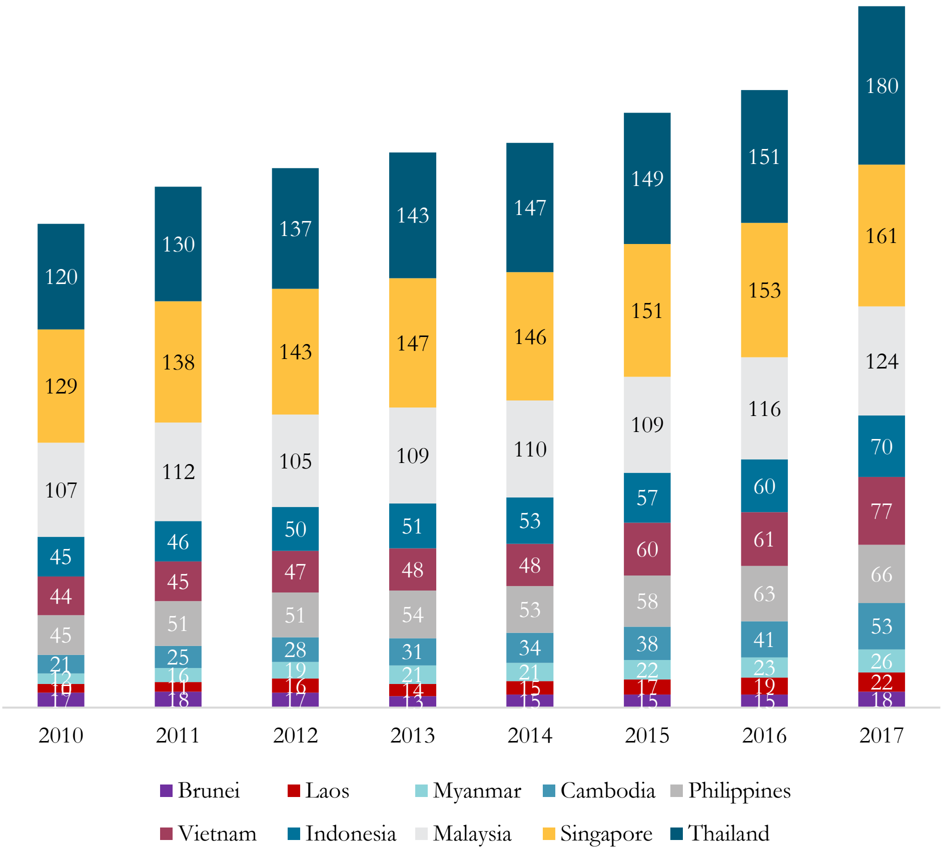
Figure 2: Total Scheduled Seats by Country, 2010 – 2017



Source: MAVCOM Analysis, AirportIS

Although some methodologies segregate direct and indirect connectivity, we have grouped both the direct and indirect connectivity together, as we believe that being able to connect to a high weightage destination is more important than whether the connectivity is direct or indirect. This method also avoids penalising countries due to their geographical positions as certain destinations can only be connected via indirect flights due to the flying distance that cannot be reached by a single flight. Therefore, in both Figures 2 and 3, the total seats available and the number of destinations served are the totals for both the direct and indirect flights. Figure 3 shows that in terms of the total destinations served by all airports in the country, Malaysia still ranked third in ASEAN.

Figure 3: Number of International Destinations Served by ASEAN Member States, 2017



Source: MAVCOM Analysis, AirportIS

Using the MAVCOM Air Connectivity Indicator methodology, we then computed the connectivity scores for all the ASEAN Member States in 2017 (see Table 2). **Based on the connectivity scores, Malaysia's connectivity was ranked fourth after Thailand, Singapore, and Indonesia.** Thailand's connectivity score was higher than Singapore's as it offered more scheduled seats. However, despite having more scheduled seats to more destinations than Indonesia, Malaysia's connectivity score was still lower.

Table 2: Connectivity Scores of ASEAN Member States, 2017

Country	Rank	Connectivity	Total Seats	Total Weightage	Total Destinations
Thailand	1	153.0	4,485,298	2,151%	180
Singapore	2	107.8	3,726,127	2,183%	161
Indonesia	3	99.4	2,107,948	1,458%	70
Malaysia	**4**	**88.8**	**3,012,387**	**1,663%**	**124**
Philippines	5	77.6	1,558,928	1,522%	66
Vietnam	6	74.4	1,723,282	1,540%	77
Cambodia	7	21.4	613,774	873%	53
Myanmar	8	14.7	341,792	758%	26
Laos	9	5.5	168,047	408%	22
Brunei	10	5.3	109,392	739%	18

Source: MAVCOM Analysis, AirportIS

There were two main reasons why Indonesia's connectivity score was higher than Malaysia's. Firstly, the connectivity indicator score is a product of the total seats and airport weightage. Airports like SIN and DXB have very high weightages—73% and 100%, respectively—as they serve high volume of international passengers. Therefore, although the total scheduled seats from Indonesia was lower than from Malaysia, Indonesia's connectivity score was higher as it had more seats to high weightage-airports like SIN and DXB.

Secondly, KUL had a weightage of 57% while CGK's was only 20%. Indonesia had 452,677 seats to KUL, while Malaysia had only 172,632 seats to CGK. Therefore, due to the higher number of seats and higher weightage of KUL, Indonesia benefited more from being connected to KUL than Malaysia to CGK (see Table 3).

Table 3: Connectivity Difference Between Indonesia and Malaysia, 2017

Airport	Weight	Indonesia		Malaysia		Connectivity Difference
		Seats (thousand)	Connectivity	Seats (thousand)	Connectivity	
KUL	**57%**	**452.7**	**25.8**			**25.8**
SIN	73%	463.2	33.6	362.4	26	7.3
AMS	76%	32.6	2.5	14.6	1	1.4
DXB	100%	57.6	5.8	42.7	4	1.5
DOH	41%	53.7	2.2	34.8	1	0.8

Source: MAVCOM Analysis, AirportIS

Airport Level Key Findings

Using the same MAVCOM Air Connectivity Indicator formula, we then measured the connectivity of the busiest airports in each ASEAN Member State. The connectivity of a country consists of the total international connectivity of all airports within the country.

Therefore, even though a country has a high overall connectivity score, the connectivity score at the airport level could be low. This is most obvious with countries with a geographically dispersed population or countries with many airports such as Indonesia.

Based on the 2017 connectivity scores, even though at the country level Malaysia ranked fourth, at the airport level KUL ranked third in ASEAN after SIN and BKK. CGK only ranked fifth after MNL, which ranked fourth (see Table 4). One of the reasons for this is that some countries, like Malaysia, have connectivity that are concentrated at their main airports like KUL, while Indonesia's connectivity is more spread out across two airports, namely CGK and DPS. Table 5 demonstrates how the connectivity of a country is contributed by its top five airports, as well as, its total number of airports.

Table 4: Connectivity Scores of the Busiest Airports in ASEAN Member States, 2017

Airport	Rank	Connectivity	Total Seats	Total Weightage	Total Destinations
SIN	1	107.8	3,726,127	2,183%	161
BKK	2	102.4	2,894,980	2,018%	154
KUL	**3**	**68.8**	**2,562,716**	**1,642%**	**122**
MNL	4	57.4	1,206,084	1,490%	56
CGK	5	50.1	969,287	1,378%	45
SGN	6	35.7	807,981	1,359%	50
PNH	7	13.5	318,755	782%	29
RGN	8	13.4	300,471	757%	25
BWN	9	5.3	109,392	739%	18
VTE	10	3.9	117,788	405%	19

Source: MAVCOM Analysis, AirportIS

Table 5: Connectivity Scores of the Top Five Airports in Malaysia, Indonesia, and Thailand, 2017

Malaysia		Indonesia		Thailand	
Airport	Connectivity Score	Airport	Connectivity Score	Airport	Connectivity Score
KUL	**68.77**	CGK	50.08	BKK	102.42
PEN	**8.09**	DPS	30.32	DMK	18.87
BKI	**6.43**	KNO	5.60	HKT	19.50
JHB	**0.40**	SUB	6.52	CNX	5.08
SZB	**1.13**	BDO	2.16	KBV	3.17
Total Airports	42		**113**		**34**

Source: MAVCOM Analysis, AirportIS

SECTION 2: HUB CONNECTIVITY

In the US, the word "hub" has been traditionally used to define any large airport. The FAA defines a large hub airport as any US airport that generates 1% or more of its national passenger enplanements (FAA, 2016). The term "enplaned passenger" is loosely defined as a passenger boarding a plane at an airport. Based on the 2016 data, the US had about 822.9 million enplanements. By this definition, any airport with more than 8.23 million passenger enplanements would be considered a hub airport.

There are many methodologies available to measure hub connectivity. In general, it can be measured from two perspectives:

- **Demand side:** Measures connectivity based on the volume of connecting passengers that the airport handles or actual passenger bookings

- **Supply side:** Measures connectivity based on the number of viable connections at each airport using the airlines' schedules. It is also an indicator of the efficiency of the airport's hub scheduling

In Table 6, we have listed the measures that have been investigated in detail and considered in our study. Although these measures are frequently used or cited in the recent air transport research, the methodologies listed in Table 6 are not exhaustive. Variations to these models are available: for example, Malighetti et al. (2008) and NieBe and Grimme (2015) use the shortest path-length models to measure hub connectivity. In the shortest path-length models, the connections between the origin and the destination points via transit airports are counted as qualified if they are the paths which offer the fewest number of connections.

Paleari, Redondi & Malighetti (2010) used quickest path-length models which are similar to the shortest path-length models, but instead of using the fewest number of stops, the former qualifies paths that offer the fastest travel time between two airports. A time-dependent minimum path approach is employed to calculate the minimum travel time between pairs of airports in a network, inclusive of flight times and waiting times at hub airports.

Disadvantages exist for both models. In both models, one would have to first identify the markets in which the hub airport offers the shortest connections – hence, they do not consider all the possible connections offered by the hub airport. Another disadvantage of the shortest and quickest path models is that they do not consider frequencies that are provided on these connections, therefore they do not provide insights to the relative importance of the different routes and markets.

Table 6: Hub Connectivity Methodologies

Model	Reference	Methodology	Details
OAG	OAG	Measures the size of the hub based on total passenger traffic that transit at the airport	Uses total passenger bookings that fly through the airport via segment data
Netscan	ACI and SEO Amsterdam Economics	Measures the number of indirect connections through the hub and weighs their quality in terms of transfer and detour time	Uses the perceived travel time, actual flight time, and transfer time of flights at a hub and the distance between the origin and the destination airports
Doganis and Dennis (1989)	Doganis and Dennis (1989)	Measures the number of connections that can be attained between groups of arriving and departing flights in a hub that fulfils a specific MCT and MACT	Does not consider routing factor
Weighted number of connections	Burghouwt & De Wit (2005)		Considers routing factor but does not specify threshold
Weighted Connectivity Ratio	Danesi (2006)		Considers routing factor and specifies a threshold of 1.5
Hub Connectivity Indicator	Li et al. (2012)		Combines both time factor and route factor to yield a QCI

Source: MAVCOM, various

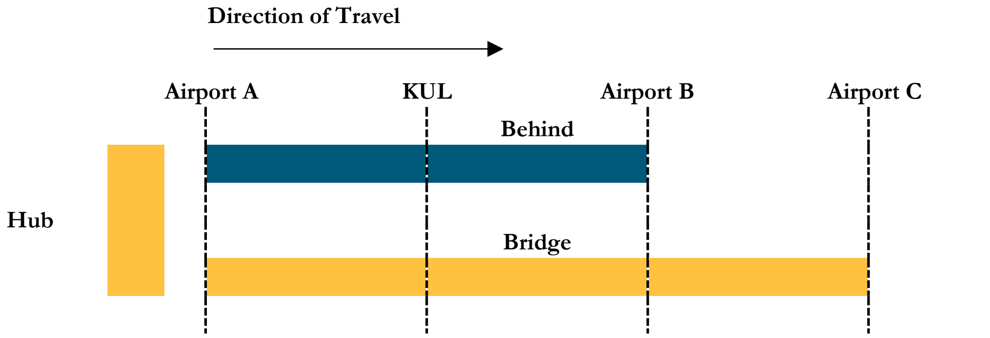
For this report, we will be measuring hub connectivity from the demand side using the OAG methodology. Furthermore, our study will use the HCI model to measure hub connectivity from the supply side. In measuring connectivity from the demand side, the OAG methodology provides the most intuitive understanding of hub connectivity, while the HCI model was chosen for reasons that will be described further in the Hub Connectivity Indicator section.

OAG Hub Connectivity

Based on the OAG methodology, there are two types of hub traffic. Assuming that KUL is the airport of interest, hub traffic can be illustrated as in Figure 4. Route examples of behind and bridge traffic are as follows:

- **Behind:** AMS-KUL-DPS
- **Bridge:** SYD-KUL-DOH-BEY

Figure 4: Two Types of Hub Traffic



Source: OAG

The total connecting traffic data was sourced from AirportIS and only covers flights that connect within the following time limits:

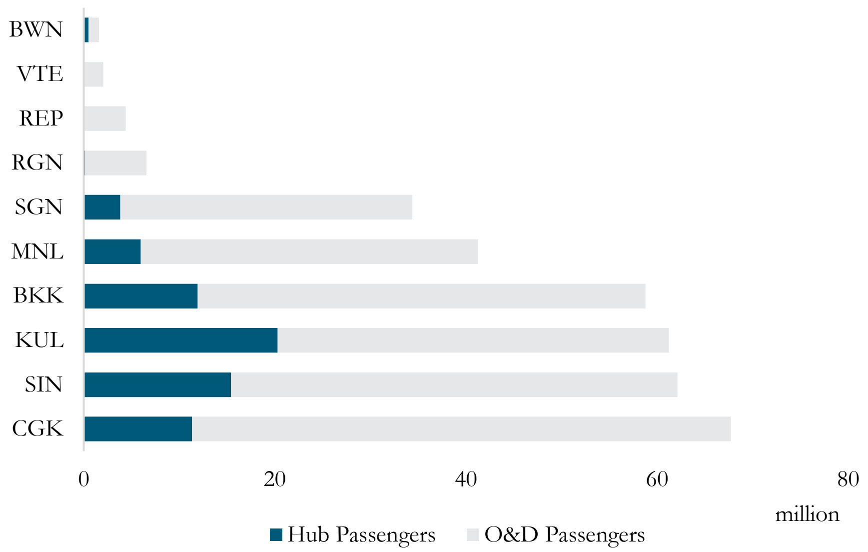
- 8 hours for intra-continental
- 18 hours for inter-continental

This means that if a passenger's outbound flight from KUL is 24 hours after his/her inbound flight, it will not be counted as part of the total connecting traffic.

OAG Key Findings

Figure 5 illustrates the breakdown of passengers at the busiest airports of each ASEAN Member State by point-to-point (O&D) and connecting (hub) passengers. In 2017, even though CGK had the highest number of passengers (domestic and international), **KUL had the largest volume of hub traffic. However, when the hub traffic was segregated further between international and domestic connecting passengers, KUL came second after SIN.**

Figure 5: Breakdown of O&D and Hub Passengers by Country, 2017

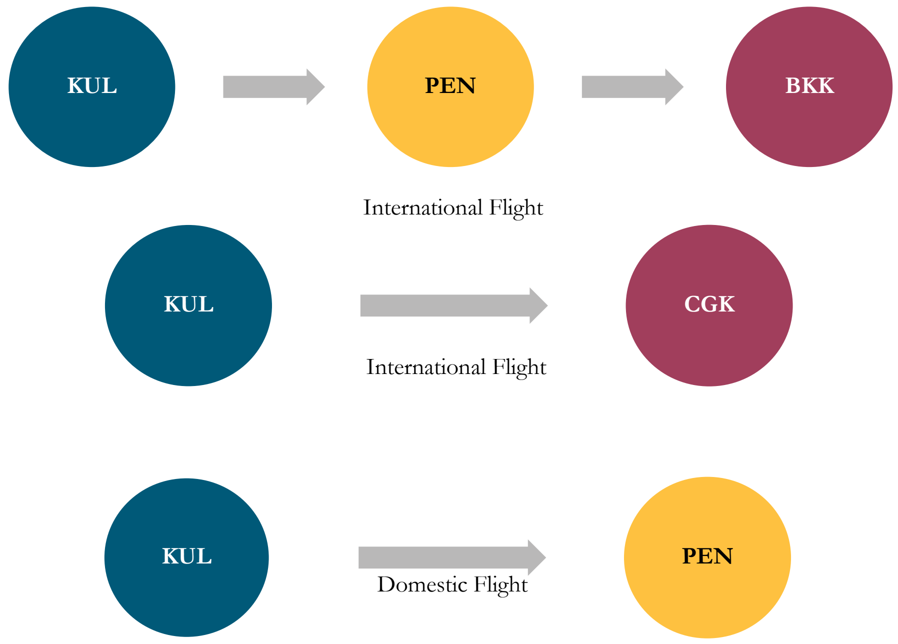


Source: MAVCOM Analysis, AirportIS

For this section of the report, we have defined domestic traffic as any passenger that transits at KUL and originates or ends their journey at another Malaysian airport. This is slightly different than the definition used in measuring the MAVCOM Air Connectivity Indicator score, where any passenger that flies from a domestic airport but arrives at an international airport is considered international traffic. This differentiation for the hub traffic was done to avoid penalising countries without domestic markets. For example, Singapore has only one airport and does not have domestic traffic. The differentiation also allows for a more like-for-like comparison between the airports.

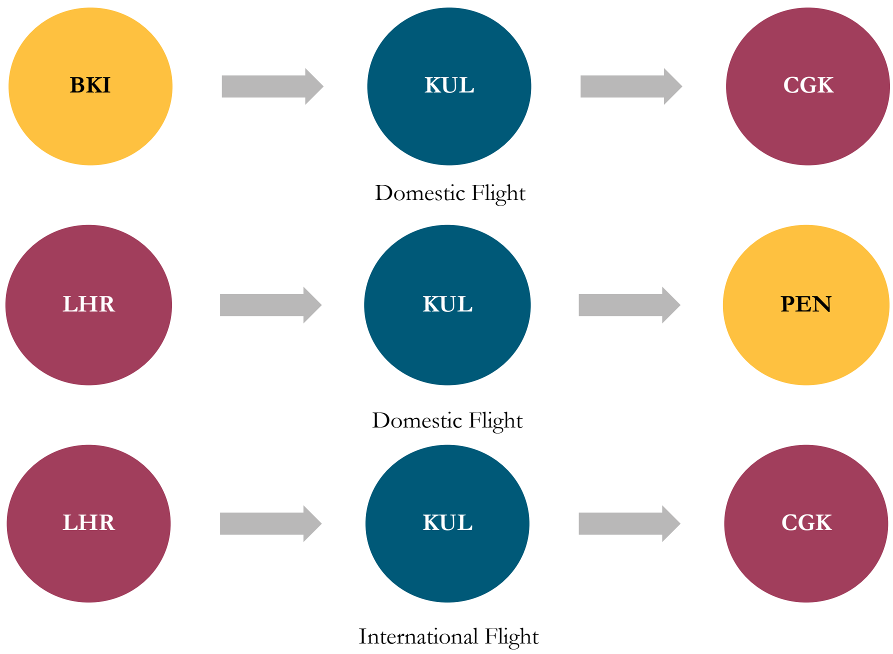
Figure 6 shows examples of international and domestic routes used in measuring point-to-point connectivity, while Figure 7 shows examples of international and domestic routes used in measuring hub connectivity.

Figure 6: Route Definition for Point-to-Point Connectivity



Source: MAVCOM Analysis

Figure 7: Route Definition for Hub Connectivity



Source: MAVCOM Analysis

When we segregated the hub traffic based on international and domestic passengers for 2017, **KUL's hub position came second after SIN, as 49% of KUL's hub traffic constituted domestic passengers travelling from the other domestic airports** such as PEN, LGK, and BKI (see Table 7). CGK, which had the highest number of total passengers, however ranked fourth based on the size of hub traffic and seventh based on international hub traffic, as 98% of the traffic that transits at CGK were domestic passengers.

Table 7: Hub Traffic Breakdown by International and Domestic Passengers, 2017

Airport	Rank	Number of Hub Passengers (thousand)		Number of O&D Passengers (thousand)	Total
		International	Domestic		
SIN	1	15,396	-	46,742	62,138
KUL	**2**	**10,435**	**9,867**	**40,976**	**61,278**
BKK	3	6,337	5,591	46,874	58,802
SGN	4	748	3,082	30,547	34,377
MNL	5	686	5,287	35,328	41,301
BWN	6	501	-	1,074	1,575
CGK	7	84	11,248	56,396	67,727
VTE	8	9	47	2,009	2,065
RGN	9	8	141	6,427	6,576
REP	10	5	25	4,380	4,410

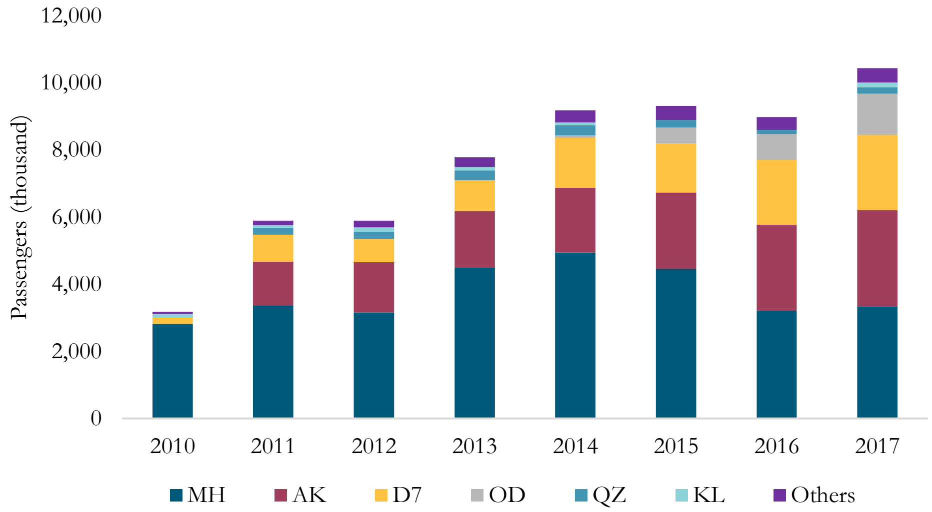
Source: MAVCOM Analysis, AirportIS

KUL's international hub traffic was further analysed by breaking down the passenger numbers based on the dominant operating airlines. Hub traffic consists of two segments of a journey, with one stopover at the hub airport. The two segments can be either operated by the same airline or by two different airlines. The dominant operating airline is the airline that operates the longest segment of the journey.

As an example, for a journey from CGK to JED via KUL, operated by airline A for the CGK-KUL leg and airline B for the KUL-JED leg, the dominant operating carrier would be airline B as it flew the longer segment from KUL to JED. Figure 8 and Table 8 illustrate KUL's hub traffic by the dominant operating airline.

In 2010, the FSCs were the main drivers of hub traffic with MH carrying 89% of the traffic. However, this trend gradually changed throughout the years. **As of 2017, the LCCs carried more than half of KUL's international hub traffic.** AK, D7, and QZ in total carried 51% of KUL's hub traffic.

Figure 8: KUL's International Hub Traffic by Dominant Operating Airline



Source: MAVCOM Analysis, AirportIS

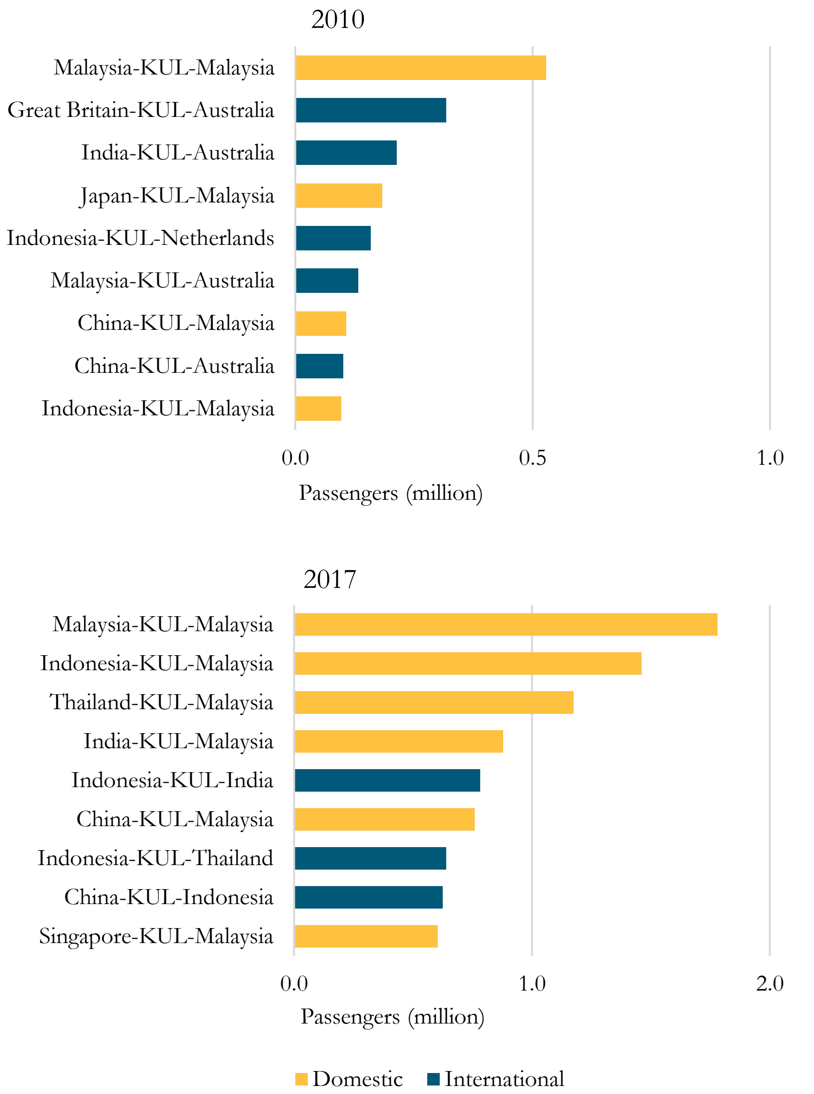
Table 8: KUL's International Hub Traffic by Dominant Operating Airline

Passenger (%)	2010	2011	2012	2013	2014	2015	2016	2017
MH	89	57	54	58	54	48	36	32
AK	-	22	25	22	21	25	29	28
D7	6	14	12	12	16	16	22	21
OD	-	-	-	-	1	5	9	12
QZ	1	4	4	4	3	3	1	2
KL	2	1	2	1	1	-	-	1
Others	2	2	3	4	4	4	4	4

Source: MAVCOM Analysis, AirportIS

Figure 9 displays how the three largest international-to-international passenger flows via KUL have moved from the intercontinental travel in 2010 (Great Britain to Australia, India to Australia, and Indonesia to Amsterdam) to intra-Asia and domestic travel in 2017. **In 2017, the movement of domestic passengers connecting between two domestic airports via KUL was the largest movement of hub traffic in Malaysia**. However, in terms of international-to-international passenger flows, the top three largest movements were from Indonesia to India, Indonesia to Thailand, and China to Indonesia. The main drivers of intra-Asia and domestic traffic in 2017 were the LCCs.

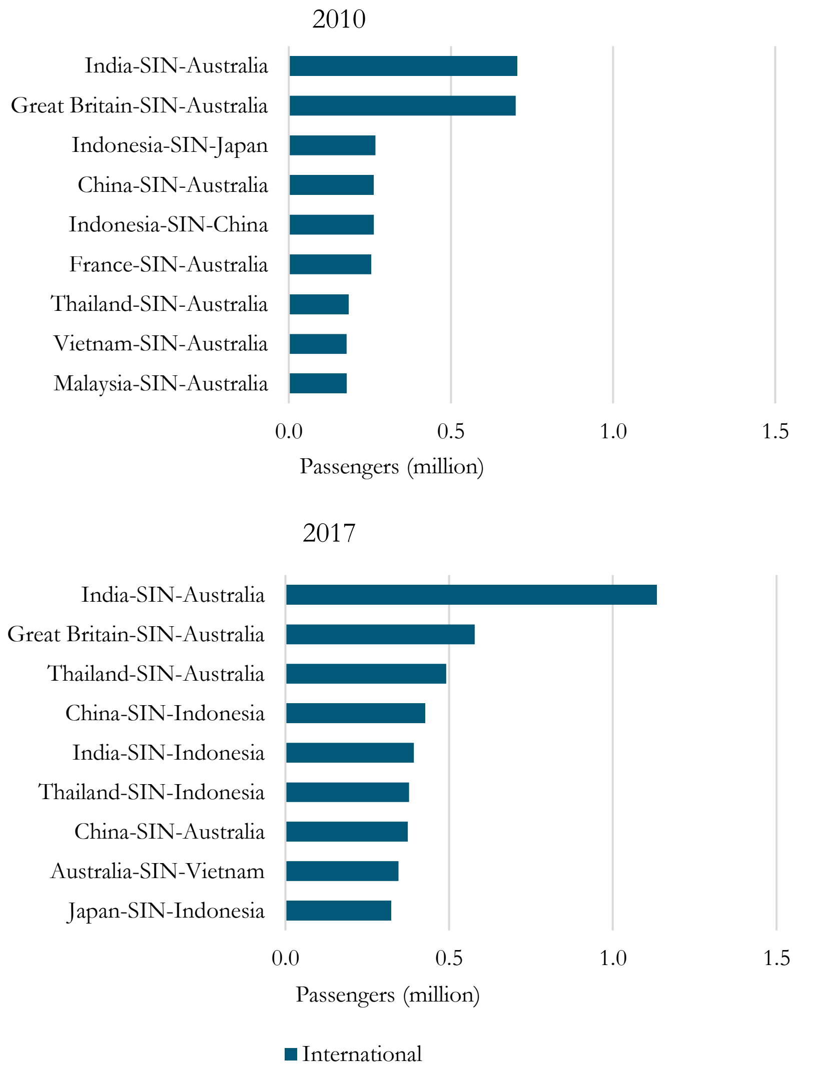
Figure 9: KUL's Hub Traffic Movement



Source: MAVCOM Analysis, AirportIS

This contrasted with the hub traffic flow via SIN as shown in Figure 10. For SIN, the international hub traffic breakdown by country-pair did not change much throughout the years. In both 2010 and 2017, the top two largest international-to-international passenger flows were India-Australia and Great Britain-Australia. However, there seem to be an increase in movement from Asian countries like China, India, and Thailand via SIN to Indonesia. SQ was the main carrier for hub traffic in SIN.

Figure 10: SIN's Hub Traffic Movement



Source: MAVCOM Analysis, AirportIS

Hub Connectivity Indicator

This section discusses a measure of hub connectivity from the supply side by looking at the number of viable connections that an incoming passenger can connect to at a hub airport.

A viable connection is an outgoing flight that fulfils a specific MCT and MACT requirement. The MCT is the shortest time required to transfer passengers and baggage from an arriving to a departing flight. It is normally set by the airport depending on how efficient its operations are in transferring passengers.

On the other hand, the MACT is very subjective as it measures the maximum time passengers would tolerate waiting at a hub during a stopover. This can differ from one passenger to another depending on the total length of the journey and can be influenced by the airport amenities, as well as, lower fares which "compensate" for longer transfer times[3].

However, the attractiveness of a connection does not solely depend on fulfilling a given MCT and MACT. Passengers would also consider the quality of the connections. The quality or attractiveness of the transfer options depends on several factors.

The first factor is the availability of a direct service. An indirect route via a hub would be more attractive if there were no direct flights between the origin and destination. The second factor is the number of hubs involved during the transfer process. Flights involving more than one stopover would lead to an increase in transfer time and in the uncertainty and risk associated with transfers such as the risk of missing the connecting flight. The third factor is that routes that involve backtracking would increase the total travel time and thus be deemed as less attractive. An example of backtracking is a flight that travels from KUL to AKL but transits in NRT.

The HCI methodology was chosen as it considered all these factors and identified suitable thresholds. The HCI model combines the time factor and route factor to yield a measure of the quality of a connection. The HCI model only considers connections of interline and online carriers.

The HCI is calculated as follows:

$$HCI = \sum (QVC \times QCI)$$

where the QVC is the number of viable connections that fulfils the specific MCT and MACT and the QCI is the product of time factor (TF) and route factor (RF).

A QVC score of 1,000 means there are 1,000 possible flight connections at the airport that fulfil the MCT and MACT requirements. However, after adjusting for the quality of the connections using the TF and RF, the finalized HCI score could be 750.

[3] Li, W., Miyoshi, C., & Pagliari, R. (2012). Dual-hub network connectivity: An analysis of all Nippon Airways' use of Tokyo's Haneda and Narita airports. Journal of Air Transport Management, 10-16.

The TF is calculated by taking the ratio of the non-stop flight time to actual travel time – values closer to one indicate the higher quality of a direct flight. The low time factor value indicates that an indirect flight will take much longer than the corresponding direct flight. This makes the connecting flight a much less attractive option. The formula for TF is as follows:

$$TF = \frac{\textit{estimated non-stop flight time}}{\textit{actual travel time of indirect flight (including transfer time)}}$$

The RF is used to account for any backtracking problems. This is calculated by dividing the indirect distance of the flight over the theoretical direct distance:

$$RF = \frac{\textit{great circle distance of two connecting flights}}{\textit{great circle distance of origin and destination that avoids the intermediate stopover}}$$

A route factor of less than 1.2 is given a score of 1.0, 1.5 is scored 0.5 and anything more than 1.5 is scored 0.0. The lower the route factor, the less backtracking the indirect flight does and the closer the quality of the connecting flight is to a direct flight. Therefore, a flight with a route factor of 1.2 or less is considered nearly as good as a direct flight and given the maximum score of 1.0. As the route factor increases, the score of the connecting flight drops. Flights with a route factor of more than 1.5 are considered undesirable by a passenger and gets a score of 0.0.

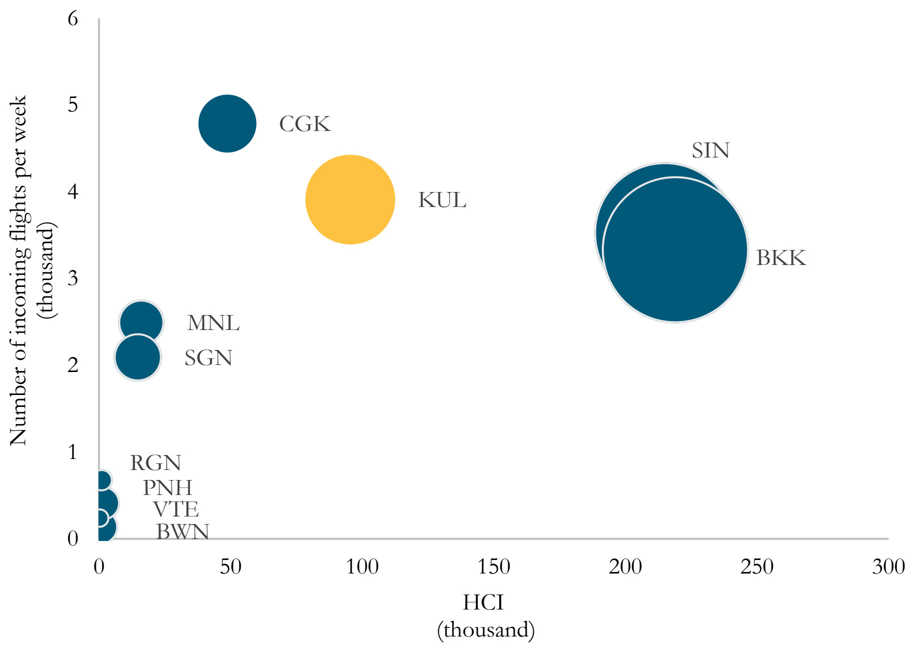
For this study, the HCI was measured based on the weekly flights of the busiest month of the year. Like the point-to-point connectivity, we have chosen the busiest month of the year to reflect the full spectrum of connectivity during the peak travelling period.

In generating the QVC, the MCT is as reported by the respective airport authorities, sourced from the OAG database. On the other hand, the MACT is subjective and is usually different for each connection type – international-to-international, international-to-domestic or domestic-to-domestic. However, we have set the MACT at a fixed period of 390 minutes (6 hours and 30 minutes) for all types of connections as it would cover 80% of the flight data.

HCI Key Findings

Using the HCI methodology, we calculated the scores for the busiest airports in each ASEAN Member State. In Figure 11, we plotted the total number of incoming flights (domestic and international) at each airport against its HCI scores. The larger the circle, the higher the number of available connections that an incoming passenger can access. **Based on the findings, even though KUL had more incoming flights per week as compared to SIN and BKK, KUL's HCI score was lower than SIN and BKK.**

Figure 11: HCI Scores for Busiest ASEAN Airports, 2017



Source: MAVCOM Analysis, OAG

The hub connectivity score is driven by several factors including the timetable coordination by the network carriers, the frequency of incoming flights, and the MCT at the airport[4]. In 2017, SQ, MI, and TR contributed more than 40% of the incoming flights into SIN. This could be due to the better hub scheduling in SIN as all three airlines are part of the same group and would have better visibility of each other's schedules. SIN's and BKK's higher HCI scores could also be due to their lower MCTs.

[4] Jantachalobon, N., & Vanichkobchinda, P. (2012). An analysis of airfreight transhipment connectivity at Suvarnabhumi International Airport. European Journal of Business Management, 141-148.

In 2017, CGK had the highest number of incoming flights per week at 4,786 flights compared to SIN, BKK, and KUL which had 3,525, 3,332, and 3,910 flight arrivals per week, respectively (see Table 9). However, when the HCI scores were calculated, CGK's score was 48,797, which translates into 10.2 possible connections per incoming flight. Out of this 10.2 connections, 6.4 were domestic connections (domestic outgoing flights) and 3.8 international connections (international outgoing flights) (see Table 10). In comparison to the other airports, **for each incoming flight into KUL, passengers could connect to 24.4 outgoing flights, while in SIN and BKK passengers could connect to 61.0 and 65.7 outgoing flights, respectively.**

Table 9: HCI Scores for Busiest ASEAN Airports, 2017

2017	MCT (min)	No. of Incoming Flights	HCI Domestic	HCI International	HCI Total
SIN	45	3,525	-	215,046	215,046
BKK	55	3,332	59,411	159,587	218,998
KUL	**60**	**3,910**	**24,195**	**71,291**	**95,485**
CGK	45	4,786	30,702	18,096	48,797
MNL	30	2,492	4,869	11,222	16,090
SGN	60	2,092	24	14,732	14,756
BWN	40	136	-	524	524
PNH	40	410	43	1,430	1,472
VTE	20	239	54	220	274
RGN	30	676	355	674	1,029

Source: MAVCOM Analysis, OAG

Table 10: Number of Connections per Flight, 2017

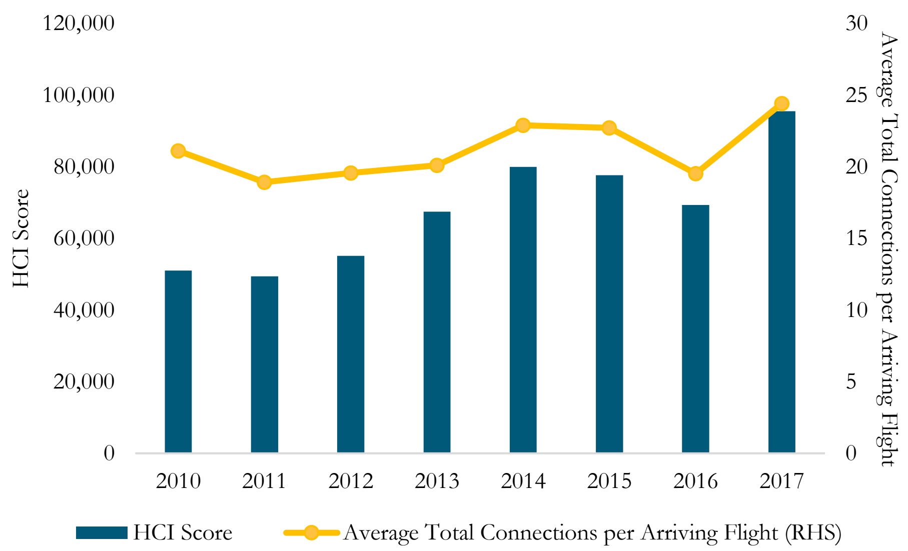
2017	Average Domestic Connections per Incoming Flights	Average International Connections per Incoming Flights	Total Average Connections per Incoming Flight
SIN	-	61.0	61.0
BKK	17.8	47.9	65.7
KUL	**6.2**	**18.2**	**24.4**
CGK	6.4	3.8	10.2
MNL	2.0	4.5	6.5
SGN	0.1	7.0	7.1
BWN	-	3.9	3.9
PNH	0.1	3.5	3.6
VTE	0.2	0.9	1.1
RGN	0.5	1.0	1.5

Source: MAVCOM Analysis, OAG

Between 2010 and 2017, KUL's HCI had improved to 95,485 in 2017 (2010: 51,021). However, between 2014 and 2016, KUL's hub efficiency declined as passengers could connect to fewer connections per incoming flight (see Figure 12).

In 2014, passengers could connect to an average of 22.9 connections per incoming flight but in 2016, this was reduced to 19.5 connections. This may be due to the reduction in the number of MH flights between 2015 and 2016. As MH is KUL's main network carrier, contributing 35% of incoming flights to KUL, a reduction in the number of MH flights would affect KUL's HCI score. MH reduced flights from 1,213 flights per week in 2015 to 1,010 flights per week in 2016. Among the destinations that MH stopped flying to in 2016 were BNE, CDG, KBV, and MLE. MH also reduced the frequency of flights to SIN from 66 per week to 56 and to MNL from 35 flights per week to 21.

Figure 12: KUL Hub Efficiency



Source: MAVCOM Analysis, OAG

In 2017, KUL's hub efficiency improved due to an increase in the number of incoming flights per week at KUL. Table 11 shows the number of incoming flights per week at KUL by airline between 2010 and 2017.

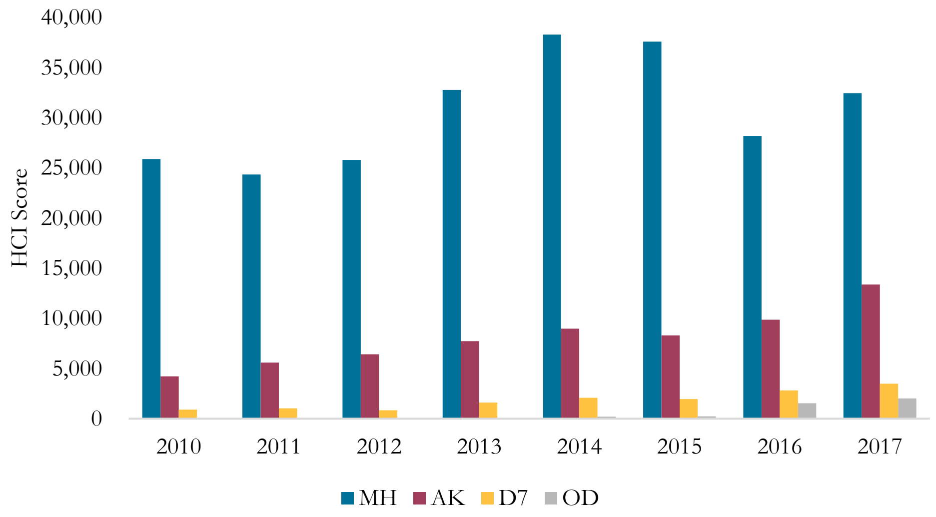
Table 11: Incoming Flights per Week by Airlines

Year	Total	MH	AK	D7	OD	Others
2010	2,416	900	899	83	-	534
2011	2,611	882	1,057	91	-	581
2012	2,815	945	1,089	80	-	701
2013	3,356	1,119	1,182	136	126	793
2014	3,491	1,210	1,272	164	142	703
2015	3,418	1,213	1,190	162	158	695
2016	3,554	1,010	1,241	184	406	713
2017	3,910	938	1,467	198	425	882

Source: MAVCOM Analysis, OAG

Figure 13 shows KUL's HCI score by airlines, namely MH, AK, D7, and OD, which include connections involving interlining arrangements and alliances. For example, for AK, the HCI score includes connections with the AK outgoing flights, as well as, connections with the other AirAsia Group airlines such as D7, QZ, and FD. The highest growth in HCI for MH was between 2012 and 2013 from 25,799 to 32,781 which was due to MH joining the oneworld alliance in February 2013. This increase was also contributed by an increase in the number of MH flights from 945 flights per week to 1,119 flights per week.

Figure 13: KUL's Connectivity by Airlines (Interlines and Alliances)



Source: MAVCOM Analysis, OAG

SECTION 3: FACTORS THAT INFLUENCE CONNECTIVITY

Literature Review

We analysed the various factors that could influence connectivity and built an econometric model to examine the relationship between the selected variables and connectivity. There has not been any research that approach connectivity in a similar manner, although there have been many studies on the drivers of connectivity, mostly in the literature relating to measuring connectivity or competitive positions of airports and airlines.

Burghouwt (2017) listed the **size and strength of the local O&D market, presence of an airline hub operation, airport and airspace capacity, airport visit costs, airport service levels, and market access as the determinants of air connectivity performance** of an airport or region. Market access in this context refers to the availability of traffic rights, the slot allocation regime, the regulatory and infrastructure restrictions on airports usage by airlines.

Arvis and Shepherd (2013) discovered a **strong positive relationship between air liberalisation as measured by the WTO's ALI** and connectivity as measured by the World Bank's Air Connectivity Index. Connectivity from the WTO's perspective is defined as a country's relative position in the network in terms of the total push and pull it exerts on air traffic, considering all the possible links with other countries regardless of whether there are any direct flight connections between them.

Redondi, Malighetti, and Paleari (2011) measured the competition between airport hubs by considering the minimum travel time required to connect a pair of airports within the world major markets. The sample studied composed of 232 airports, which accounted for 75.4% of the total seats offered by more than 3,000 airports worldwide. The major markets for indirect connections identified were between North America and Asia, North America and Europe, and Europe and Asia. Their analysis showed that **the most common driver of performance—in this case the average travel time—for any given hub and its main competitors was its geographical location.** They found that the European markets dominated the worldwide rankings due to their convenient geographical positions in relation to the main world markets. On the other hand, the Asian hubs were at a disadvantage compared to the European hubs for two reasons. Firstly, the Asian air transport market is more geographically dispersed and secondly, the domestic airline markets in Asia-Pacific were less integrated than in the case of North America and Europe. Even if the open sky agreements were considered (for example the ASEAN Single Aviation Market), there still exist significant entry barriers and asymmetric regulations.

Similarly, Lohmann, Albers, and Pavlovich (2009) identified **three critical factors for airlines operating from hubs. These factors include the geographical location in relation to the markets served, good airport facilities, and coordination of schedules.** They acknowledged that although both SIN and DXB are at an advantage due to them being centrally-located geographically, location alone is not enough for an airport to succeed. Both the Singapore and Dubai governments had developed clear strategies in which the importance and roles of the air transport system have been clearly articulated through government investment and governance. They also transformed hubs into destinations by complementary interactions of attractions, transportation, and accommodation sectors. Both countries also promote large scale retail developments to attract visitors.

Variables Selection

We ran two separate regression models to investigate the relationship between connectivity and the factors that affect it at the airport level and at the country level to account for the different dynamics of connectivity at both levels. For a variable to be included in a regression analysis, it must be both measurable and available across all countries or airports, across all years. Therefore:

- some variables that were included in the country level regression analysis may not be included in the airport level analysis and vice versa; and

- certain variables such as airport capacity were excluded from the regression analysis, not because they were not considered important factors that influence connectivity but due to the lack of official data.

The regression models incorporate different variables. For example, connectivity at the country level is influenced by the number of airports the country has, but connectivity at the airport level is only determined by the particular airport itself. Thus, it was not included at the country level analysis. On the other hand, within a country, some airports may have rail access from the nearest city while others might not. Since rail access is represented by a single dummy variable to indicate whether rail access is available or not, it was only included as a variable at the airport level analysis. The HCI scores could only be measured at the airport level, hence it was excluded from the country level analysis.

Table 12 displays the list of independent variables used in the regression model at country and airport level. In both cases the dependent variable was the MAVCOM Air Connectivity Indicator score.

Table 12: Variables for Country and Airport Level Regression

Independent Variable	Country Level	Airport Level
Number of Destinations	✓	✓
Flight Frequency	✓	✓
ALI	✓	✓
LCC (Total scheduled seats)	✓	✓
Oneworld (Total scheduled seats)	✓	✓
SkyTeam (Total scheduled seats)	✓	✓
Star Alliance (Total scheduled seats)	✓	✓
Others (Total scheduled seats)	✓	✓
Number of Airlines	✓	✓
Number of Airports	✓	×
Population	✓	✓
Hub Connectivity	×	✓
Rail Access	×	✓

Source: MAVCOM Analysis

The number of destinations and flight frequency variables were obtained from AirportIS and represented by the total number of destinations and total frequency of all flights available in the busiest month of the year. The busiest month of the year is the month with the largest number of scheduled seats and was chosen as it represents the full spectrum of connectivity usually associated with peak travelling periods. Connectivity increases as the range of destinations that can be reached from an airport increases. Similarly, routes with higher frequencies are perceived to have higher connectivity values especially if there are no direct links between the origin-destination pair. For example, an airport with three daily flights to a destination is considered more connected than another airport offering only one flight a day to the same destination.

The ALI as measured by WTO represents seven features of ASAs as relevant indicators of openness for scheduled air passenger services. Each feature is given a score according to its level of air liberalisation. The seven features identified are grant of rights, capacity clause, tariff approval, withholding, designation, statistics, and cooperative arrangements.

- The **grant of rights** refers to the rights to provide air services between two countries and scores are awarded to ASAs which allow fifth freedom, seventh freedom, and cabotage.

- The **capacity clause** identifies the regime to determine the capacity of an agreed service, where capacity refers to the volume of traffic, frequency of service and/or aircraft type. The three commonly used capacity clauses—sorted from the most restrictive regime to the most liberal—are predetermination, Bermuda I, and free determination. Predetermination requires that capacity is agreed prior to the service commencement, Bermuda I regime gives limited right to the airlines to set their capacities without prior governmental approvals, and free determination which is given the highest score leaves the capacity determination out of regulatory control.

- The **tariff approval** refers to the regime for pricing air services. The most restrictive regime is that of dual approval, whereby both Parties must approve the tariff before this can be applied. The most liberal regime, which is given the highest score is free pricing, where prices are not subject to approval by any party. The semi-liberal regimes are country of origin disapproval, where tariffs may be disapproved only by the country of origin; dual disapproval, where both countries must disapprove the tariffs to make them ineffective; and zone pricing, where Parties agree to approve prices falling within a specific range and meeting certain characteristics.

- The **withholding clause** defines the conditions required for the designated airline of the foreign country to operate in the home country. Restrictive conditions require substantial ownership and effective control, meaning that the designated airline is the "flag carrier" of the foreign country. More liberal regimes are community of interests and principal place of business regimes. Community of interest regime still requires a vested substantial ownership and effective control of the airline in one or more countries that are defined in the agreement, but principal place of business regime, which is awarded the highest score removes the substantial ownership requirement and is thus more liberal.

- **Designation** governs the right to designate one (single designation) or more than one (multiple designation) airlines to operate a service between two countries, with multiple designation receiving the higher score.

- **Statistics** refers to rules on exchange of statistics between countries or their airlines. If exchange of statistics is requested, it is an indicator that the Parties intend to monitor the performance of each other's airlines and is thus viewed as a restrictive feature of an agreement. Scores are allocated if the ASAs do not request for the exchange of statistics.

- **Cooperative arrangements** define the right for the designated airlines to enter into cooperative marketing agreements (such as code sharing and alliances). This right is considered a liberal feature and thus given scores because it provides a means to rationalise networks, much in the same way as the liberalisation of the ownership clause.

The **"LCCs, oneworld, SkyTeam, Star Alliance and others"** variables represent the breakdown of groups of airlines that fly into a country or airport by the total seats available in the busiest month of the year. These variables were included in the regression analysis to identify which group of airlines would influence connectivity the most. The theory is that the LCCs would normally fly into secondary or regional airports due to their lower aeronautical costs and thus would influence connectivity less as secondary airports have fewer onward connections. On the other hand, the FSCs tend to fly into larger airports or hub airports with better onward connection options available and thus influence connectivity more.

The **"number of airlines"** variable indicates the total number of airlines (foreign and domestic) that fly into the airport or country in the busiest month of the year. Initial investigations show that connectivity score of airports increases as the number of airlines that fly through it increases.

The **"population"** variable is represented by the population of the country in the year for the country level regression model. This is illustrative of the catchment area of all the airports in the country as any passenger in the country would have to use any of the airports to fly. However, at the airport level, determining the catchment area for a specific airport is more difficult and even if the area was identified, it is problematic to get the population breakdown by year and country. Therefore, as a proxy, the population variable for the airport level analysis is based on the urban agglomeration of the city where the airport is located. The term "urban agglomeration" refers to the population contained within the contiguous territory inhabited at urban levels of residential density (irrespective of whether that population lives within or outside the administrative boundaries of the city) (United Nations, 2004). It usually incorporates the population in a city or town plus that in the suburban areas lying outside of, but adjacent to the city boundaries.

The **"number of airports"** variable is only included in the country level analysis and not at airport level. As per the point-to-point connectivity findings, countries with larger number of airports like Indonesia (113 airports in 2017) had a higher connectivity score than countries with fewer airports like Malaysia (42 airports in 2017).

The **"hub connectivity"** and **"rail access"** variables are only considered at the airport level analysis. Hub connectivity is measured using the HCI methodology and can only be measured at airport level, while the rail access is represented by a dummy variable to indicate availability of rail access from the nearest city.

A panel regression approach was used for this purpose and the data collected was yearly data from 2010 to 2017 for all ten ASEAN Member States. Therefore, each variable would have 80 observations. Yearly data was used instead of the monthly data as some of the variables were only available on a yearly basis such as country population and for some variables such as the number of airlines and airports, they would not have had enough variations in the data if the data was taken on a monthly basis.

Country Level Findings

Table 13 illustrates the regression results for country level connectivity. Based on the findings, **the variable with the highest coefficient is the country's population at 0.866.** This indicates that for every 10.0 million increase in population, the connectivity score may increase by 0.866 points. This is consistent with previous air transport research findings that indicated the size and strength of the local market as important factors to attract airlines to fly into the country. As more airlines enter the market, the connectivity of the area grows.

Although the ALI is the only coefficient that is not significant out of all eleven variables, it can be observed that there is a positive relationship between a country's level of air liberalisation and connectivity. We believe that one of the reasons that the ALI's coefficient is not significant is data limitation where historical values for the ALI were only available for 2016.

Table 13: Country Level Connectivity Regression Results

Variable	Coefficient
Number of Destinations	**0.181***
Flight Frequency	**-0.534***
ALI	0.002
LCC	**0.480***
oneworld	**0.398***
SkyTeam	**0.463***
Star Alliance	**0.422***
Others	**0.283***
Number of Airports	**0.181***
Number of Airlines	**0.211***
Population	**0.866***
Constant	-3.879

Source: MAVCOM Analysis
** Statistically significant at the 5% level*

Airport Level Findings

Table 14 displays the regression results for the airport level connectivity. Unlike the country level analysis, **there is a negative correlation between the number of destinations served and airport-level air connectivity.** This could be due to capacity constraints at airports such as terminal capacity, slots, check-in counters, boarding gates, and runway capacity. Airports usually have specific design capacities and adding more flights to the same destination or flights to destinations with lower economic value may reduce the connectivity score of the airport.

Of all the 12 variables, the number of airlines has the biggest influence on airport connectivity. For every additional airline that flies into an airport, the airport connectivity score may increase by 0.186 points. As more airlines fly into an airport, the number of available scheduled seats may increase and subsequently the connectivity of the airport will also increase.

The regression results show that the coefficient for ALI, HCI, availability of rail transport, as well as, population are not statistically significant. This does not necessarily mean that these variables do not influence airport level connectivity. Rather, it could be due to data limitations, such as ALI which was only available for 2016, and certain variables such as the rail transport dummy variable which remained relatively constant throughout the years. The identification of the coefficients depends on there being sufficient variation over time, so the estimators may perform poorly when there is insufficient variation. As for the population data for airport, it was based on the urban agglomeration of the city where the airport is located. This data might not capture the correct catchment area, which could explain why the coefficient is not significant.

Table 14: Airport Level Connectivity Regression Results

Variable	Coefficient
Number of Destinations	**-0.381***
Flight Frequency	**-0.009***
ALI	0.001
LCC	**0.075***
oneworld	**0.095***
SkyTeam	**0.109***
Star Alliance	**0.070***
Others	**0.107***
HCI	0.000
Number of Airlines	**0.186***
Availability of Rail Connection	-9.883
Population	0.000
Constant	**2.443***

Source: MAVCOM Analysis
** Statistically significant at the 5% level*

Out of the three airlines alliances, **SkyTeam had the highest coefficient at 0.109 compared to the Star Alliance and the oneworld alliances at 0.070 and 0.095 respectively.** This signals that for every 1,000 additional scheduled seats on a SkyTeam alliance member, the airport's connectivity increases by 0.109 points. These findings are consistent with the country level connectivity regression results in which the SkyTeam's coefficient is 0.463, compared to the Star Alliance at 0.422 and the oneworld at 0.398.

We believe one of the reasons that the SkyTeam alliance had a higher influence on connectivity than the other alliances, was the fact that it had three out of the top ten biggest airlines in terms of revenue passenger-kilometres as its members in 2016. Table 15 lists the top ten biggest airlines in terms of revenue passenger-kilometres according to alliance in 2016.

Table 15: Top Ten Biggest Airlines, 2016 (Revenue Passenger-Kilometres)

SkyTeam	Oneworld	Star Alliance	Non-Alliance Members
Delta Air Lines	American Airlines	United Airlines	Emirates
China Southern Airlines	British Airways	Lufthansa	RyanAir
China Eastern Airlines			Southwest Airlines

Source: MAVCOM Analysis

CONCLUSION

The air connectivity measures are useful tools for the decision makers in answering questions on the position of Malaysia's civil aviation sector. The strength of air connectivity of a country can be measured in terms of point-to-point connectivity and hub connectivity.

Based on the findings of the study, at country level, Malaysia ranked third in ASEAN in terms of scheduled seats and international destinations, behind Thailand and Singapore. However, Malaysia's connectivity indicator scores placed Malaysia fourth after Thailand, Singapore, and Indonesia. At the airport level, KUL's connectivity score was ranked third in ASEAN, behind SIN and BKK.

In terms of hub connectivity, measured from the supply side or the number of viable connections that an incoming passenger can connect to at a hub airport, KUL is third behind SIN and BKK. However, based on the volume of transit passengers, KUL ranks highest in ASEAN with 51% of connecting traffic in KUL being passengers connecting from domestic airports like PEN or BKI.

There are various factors that influence the connectivity of a country or airport. Among the key variables include the size and strength of the market or destination, the number of airlines, as well as, the type of airlines that fly into an airport. These were the variables included in our analysis. Nonetheless, they are not exhaustive and other factors such as the geographical location of the airport could be an important factor in attracting traffic and influencing connectivity. However, research shows that location alone is not enough for an airport to succeed. Other factors such as good management and governance are equally crucial for an airport's success. We can take examples of airports like SIN and DXB whose governments had developed clear strategies to transform their hubs into destinations by implementing complementary interactions of attractions, transport and accommodation sectors.

APPENDIX

Figure A1: Stata Results Display for Country Level Regression

```
Cross-sectional time-series FGLS regression

Coefficients:  generalized least squares
Panels:        homoskedastic
Correlation:   no autocorrelation

Estimated covariances      =         1          Number of obs      =        98
Estimated autocorrelations =         0          Number of groups   =        14
Estimated coefficients     =        12          Time periods       =         7
                                                Wald chi2(11)      =   12682.63
Log likelihood             = -311.6674          Prob > chi2        =    0.0000
```

Connectivity	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Noofdestinations	.1810878	.0574262	3.15	0.002	.0685345	.2936411
FlightFrequency	-.5339753	.056584	-9.44	0.000	-.6448779	-.4230727
AirLiberalizationIndex	.0022988	.0022818	1.01	0.314	-.0021735	.0067711
LCC	.4806187	.0425692	11.29	0.000	.3971846	.5640528
oneworld	.3978335	.0373619	10.65	0.000	.3246054	.4710615
Skyteam	.4632743	.0575582	8.05	0.000	.3504623	.5760863
Star	.4218699	.0328058	12.86	0.000	.3575717	.4861681
Others	.2830491	.0225734	12.54	0.000	.238806	.3272922
NoofAirports	.1808165	.0315595	5.73	0.000	.118961	.242672
Noofairlines	.2113368	.0610729	3.46	0.001	.0916361	.3310375
Population	.8661236	.127653	6.78	0.000	.6159283	1.116319
_cons	-3.878641	2.21631	-1.75	0.080	-8.22253	.4652471

Figure A2: Stata Results Display for Airport Level Regression

```
Cross-sectional time-series FGLS regression

Coefficients:  generalized least squares
Panels:        homoskedastic
Correlation:   no autocorrelation

Estimated covariances      =         1          Number of obs      =        70
Estimated autocorrelations =         0          Number of groups   =        10
Estimated coefficients     =        13          Time periods       =         7
                                                Wald chi2(12)      =   20790.78
Log likelihood             = -146.5788          Prob > chi2        =    0.0000
```

Connectivity	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Noofdestinations	-.3808056	.0737111	-5.17	0.000	-.5252767	-.2363345
FlightFrequency	-.0088864	.0018494	-4.81	0.000	-.0125111	-.0052617
AirLiberatizationIndex	.0010512	.0008739	1.20	0.229	-.0006615	.002764
HubScheduling	5.59e-07	.0000211	0.03	0.979	-.0000408	.0000419
Noairlines	.1865701	.0478225	3.90	0.000	.0928398	.2803004
LCCseat	.0000749	.0000109	6.88	0.000	.0000536	.0000963
oneworldSeat	.0000945	7.86e-06	12.02	0.000	.0000791	.0001099
Skyteamseat	.0001093	9.97e-06	10.96	0.000	.0000897	.0001288
Starseat	.0000701	7.22e-06	9.70	0.000	.0000559	.0000842
Otherseat	.0001072	8.55e-06	12.54	0.000	.0000905	.000124
RailTransport	-9.883519	5.087858	-1.94	0.052	-19.85554	.0884996
UrbanAgglomerationPopulation	-.0000394	.0002788	-0.14	0.888	-.0005857	.000507
_cons	2.443571	1.180847	2.07	0.039	.1291535	4.757988

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