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THE TEMPORAL CONFIGURATION OF BANDARANAIKE INTERNATIONAL AIRPORT AS AN AVIATION HUB OF THE FUTURE

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Abstract

The temporal configuration of Bandaranaike International Airport (BIA), Sri Lanka is reviewed through this paper with the view of assessing the current performance of the airport which envisions its development into an aviation hub in South Asian region. Connectivity is evaluated by assessing the coordination of the published time-table of flights at the airport for the first week of July 2012. Two major concepts utilised in the study are: (1) Wave-System-Structure: which examined the arrival and departure flight patterns at BIA to identify whether there is a coordinated wave system created by banks of arrival and departure flights and (2) Hub Connectivity Indicator: which measured the quality of the connections created by the Wave-System-Structure as equivalent to a direct flight. The airport has a Wave-System-Structure mainly driven by the operations of the home carrier. On absolute terms quality of the temporal connectivity of the flight schedule at BIA is judged as low based on the fact that only 38% of the total viable connections made are equal to the quality of a direct connection. To assess the relative performance of the airport, it should be judged against the performance of nearby hub airports in the South Asian region.

Keywords: *Hub Airports, Connectivity, Temporal Configuration, Wave-System-Structure, Hub Connectivity Indicator*

JEL Codes: R4,L930, L980, L52, O250, O530

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INTRODUCTION

Sri Lanka envisions developing herself into a strategically important economic centre in the South Asian Region by taking advantage, among other things, of the country's strategic geographic location. Transforming the country into an "Aviation Hub" represents one important element of this development vision spelt out in the "Mahinda Chinthana" policy document [1] and in subsequent strategic action plans of the Government of Sri Lanka (Ten Year Development Plan, Ministry of Finance and Planning, 2011).

An aviation hub is a special node in a network, which facilitates connectivity for flights arriving within a short period of time from several origins, allowing time for connections, and departing to several destinations for airlines, passenger and cargo, (O'Kelly, 1998; Jayalath and Bandara, 2000). Advantages of such hub and spoke (HS) systems are multifaceted. For passengers, this offers a wide choice of destinations together with more transfer options by facilitating indirect connections[2] among nodes established via the central node, when no or only a very few direct connections[3] exist between nodes. Hub airports are also preferred by airlines due to the benefits of cost economies. Airlines can exploit economies of scale of flying larger aircraft with sufficiently high load factors enabled through "connectivity" driven passenger demand at the hub airport. HS network structure also provides economies of scope for an airline by enabling it to offer more services to different locations by establishing itself at the centre. Hence, the cost of production is less than that of different airlines operating similar services. This happens with more spokes being connected to the hub which allows for creating multiple connections without additional effort. Increased traffic at the hub, eventually increases the traffic between two Origin-Destination nodes (OD) allowing average unit cost of production to decline which is termed as economics of traffic density (Button, 2002; Kahn, 1993). In addition, a hub airport confers benefits on the community of the geographical area it serves. It stimulates the agglomeration of local industries around the catchment area of the airport, and further more new business ventures; since the airport opens up local industries: as buyers and sellers to international markets (Button, 2002; Yu Jian et al, 2011). Thus, developing BIA as a hub in the South Asian region is deemed to be an important part of the post-war economic development plans of Sri Lanka. It would support the national economy by linking the country to more destinations which will open up opportunities for the local economy to integrate with international markets.

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[1] Mahinda Chinthana Idiri Dekma – Election manifesto of the United People's Freedom Alliance at the Presidential Election – 2010.

[2] A connection made between an origin and a destination via a third stopover/transfer point.

[3] A connection made between an origin and destination without any stopovers /transfers.

Qualifying criteria to become a good air transport hub include having a unique geographical location that has spatial qualities of centrality (central point for locations) and intermediary (in between locations) (Fleming and Hayuth, 1994) with respect to the other connecting destinations; having an established hub carrier or two; adopting cost effective pricing solutions for passengers flying via the airport (Jayalath and Bandara, 2001); having a strong and stable Origin-Destination market; possessing necessary infrastructure facilities at the airport including access modes to the airport and ensuring operational efficiency of the airport (Yu Jian et al., 2011). Among these however ‘connectivity’ offered by an airport is the key factor for it to qualify as a hub in the global network.

Connectivity looks at two key aspects of the network associated with an airport: Spatial Connectivity, that is to say how well the airport is connected with other airports through the flights offered, and Temporal Configuration which relates to how well the scheduled arrival and departure flights from-and-to the different destinations are coordinated to optimise the number of viable connections available to passengers to choose from. In an era where ‘time’ is assigned increasing economic value by society, passengers look for ways and means of arriving at their destinations in the shortest possible time with the greatest possible convenience and value for money. In this respect choosing an indirect connection facilitated via a hub is based upon the generalised cost of the flights of indirect connections against available direct connections between two airports. Apart from the monetary value associated with the ticket price passengers, tend to compare costs in terms of flying time and connecting time between the options available to them. Passengers will neither prefer longer waiting times because of it being unproductive time; nor will they like very short connection times due to the risk of missing the connection when transferring from one flight to another. Hence, hub operators need to optimise the schedules to offer acceptable waiting times to arrival passengers to connect with their onwards journey (Veldhuis, 1997). Therefore, the operational efficiency of a given aviation HS System needs to be evaluated in terms of the quantity (number of viable indirect connections) and quality (travel times against the available direct connections) of scheduled flights.

The airport should take immediate steps to try and meet the above criteria in order to achieve its long term plan of converting itself into a hub airport. The objective of this paper is to appraise the temporal coordination of the schedules at BIA in terms of the quantity and quality of connections offered with a view to assessing the degree of its qualification to be admitted as an Aviation Hub. Thus, the paper looks at ways to measure this feature in terms of the hub-wave-system at BIA and by developing an index, namely a Hub Connectivity Indicator (HCI), to measure the quality of the indirect connections facilitated via BIA against the direct connections available between those origins and destinations. These indicators can be used as comparative measures to assess BIA's performance as a hub against other regional airports, if such calculations are carried out to include those airports as well.

LITERATURE REVIEW

Temporal configuration suggests that the connections offered via a hub should offer a well-coordinated set of arrival and departure flights for passengers. Since flying via a hub often replaces direct connections, attractiveness of such a network to an alternative will depend on the frequencies offered, coordination of flights and other through services, travel times and waiting times, ticket prices and many other features (Veldhuis, 1997; Jayalath and Bandara, 2001; Burghouwt and Veldhuis, 2006; Burghouwt and Wit, 2005). These will be the choice factors for passengers to select an indirect flight against a direct flight (Doganis and Dennis, 1989; Veldhuis, 1997; Burghouwt and Veldhuis, 2006; Burghouwt and Wit, 2005; Danesi, 2007;Li et al., 2012). Temporal coordination, which is the focus of this study; is measured using both quantity and quality of connections offered by airlines operating at the hub (Veldhuis, 1997; Burghouwt and Wit, 2005; Li, et al., 2012).

A temporally coordinated schedule will affect the operation of a wave-system-structure at the hub. In an 'ideal wave', the arrival wave would be followed by a transfer period and a corresponding departure wave of flights (Danesi, 2006). Hence, a wave-system-structure will have a number of continuous flight waves throughout the day. The time interval between the same points of two consecutive waves (e.g. start of arrivals of first wave to the start of arrivals of the second wave) would indicate the hub-repeat-cycle of a particular wave system structure. Opposed to the sophisticated methods used to assess hub wave systems (Bootsma, 1997 as cited in Danesi (2006) and Burghouwt and Wit, (2005)), this provides a simple measure to evaluate the organisation of a wave-system-structure at a hub airport (Danesi, 2006). Danesi (2006), in evaluating the performance of few European hubs, used the method of counting arrival and departure flights within each hour and plotting the counts against time intervals to pictorially describe the hub waves.

More advanced measures of temporal connectivity looks beyond a simple wave-system-structure by evaluating quantity and quality of schedule coordination[4]. 'Quantity' of connections is the number of connection options a passenger is given by coordinating

[4] (a) Connectivity ratio (Doganis and Dennis, 1989)
(b) NETSCAN model (Veldhuis, 1997; Veldhuis and Burghouwt, 2006)
(c) Weighted Indirect connection index (WI) (Burghouwt and Wit, 2005)
(d) Weighted connectivity ratio (Danesi, 2006)
(e) Hub Connectivity Indicator (HCI)(Li et al., 2012)

the arrival bank of flights to be followed by a time period which allows passengers to make convenient transfers to the departing bank of flights. This convenient time period is called a 'Viable Connection Threshold' (VCT) (Li et al., 2012). A VCT is associated with the concepts of Minimum Connecting Time (MCT); the lower boundary and Maximum Acceptable Connecting time (MACT); the upper boundary. As first introduced by Doganis and Dennis (1989) in evaluating the European context, the standard thresholds lie between, MCT= 45 minutes and MACT= 90 minutes in order to minimise disutility related to waiting times experienced by passengers in making connections at airports. This threshold has been varied in other studies based on author assumptions and the standards used at respective airports. Burghouwt and Wit (2005) uses 40-90 minutes in assessing the European context. Improving on previous methods Dennis (2006) uses three different thresholds for combinations of continental and intercontinental flights, again for European airports. Li et al., (2012) uses the assumption that MACT is three times the MCT (45 minutes) in their Hub Connectivity Indicator developed to evaluate All Nippon Airways (ANA) hubbing practices at Tokyo Haneda and Narita International Airports. Hence a viable connection is the connection between any two arrival and a departing flights falling within the defined VCT. At a hub airport, the sum of all such connections within the VCT is identified as the Quantity of Viable Connections (QVC) (Li et al., 2012). Therefore, a larger QVC signals more connecting opportunities.

The second parameter, 'Quality' of the connections falling within the VCT is related to the economic concepts of disutility associated with travel time. As explained previously, Veldhuis (1997) and Veldhuis and Burghouwt (2006) in their NETSCAN model, argue that passengers' choice among alternative routes would depend on attractiveness of the available alternatives. They explain that this attractiveness is often expressed in '*utility functions'* related to frequencies, travel time against direct connections, ticket prices, comfort and loyalty to airlines. While the latter two dimensions are hard to measure, the former three should have accurate figures which can be used for evaluation of quality of the viable connections. The higher the frequencies, the more viable connections it would create. However, fare variations are often hidden in advanced revenue management systems. They suggest that total travel time is a near proxy to both travel times and associated fares. This is anchored on the market based notion that direct flights are usually more expensive than indirect flights. Danesi (2006) and the later developments by Li et al. (2012) use the same assumptions in assessing quality of QVC.

In measuring the quality of a connection, to accommodate the disutility associated with travel time of an indirect connection, the concept of 'Perceived-Travel-Time' (PTT) (Veldhuis, 1997; Burghouwt, 2005; Veldhuis and Burghouwt, 2006; Danesi, 2006; Li et al., 2012) is used. PTT is the time a passenger would perceive an indirect flight may take. This includes the travel time (TT) and the transfer times (TrT). In general passengers perceive TrT as more inconvenient than flying time. This is associated with the psychological stress related to risks of missing connections and losing baggage during transfers and the extra hassle of moving between aircrafts and terminals and waiting in a third airport (Veldhuis, 1997). Therefore passengers tend to perceive this time as longer than the actual TrT. This is accounted for by introducing penalties (Veldhuis, 1997; Burghouwt and Wit, 2005; Veldhuis and Burghouwt, 2006; Li et al., 2012) for the TrTs by multiplying it by a penalty factor (PF)[5]. Comparison is made between the Nonstop-Flight-Time (NFT) which is the estimated direct flight time between two connecting points (incoming flight's origin and outgoing flight's destination) and the PTT of the indirect flight facilitated via the hub airport. PTT includes actual flying time of two connecting segments plus the TrT after applying a penalty factor (Veldhuis, 1997; Burghouwt and Wit, 2005; Veldhuis and Burghouwt, 2006; Li et al., 2012).

In addition to the above analysis of Time Factor (TF), Burghouwt and Wit (2005), Danesi (2006) and Li et al. (2012) have introduced a Routing Factor (RF) as an indicator of how efficient the hub is, in terms of routing passengers between two points. A De-Routing Factor Index (DRF) is arrived at by dividing the indirect distance by direct distance of two connecting flight segments (Danesi, 2006, Li, et al., 2012), which gives a ratio between one to positive infinity. An index equal to one indicates that the transferring hub is geographically located between the two points. The bigger the DRF, the less efficient the transfer option is. However, given that routing of flights are of less concern to passengers compared to a time or schedule factor, a less stringent approach is adopted by assigning dummy values for the RF based on the value ranges of the DRF (Danesi, 2006;Li et al., 2012).

Li et al. (2012) derive the Quality of Connectivity Index (QCI) for the QVC by using the product of the TF and RF that is measured in percentage terms and ranges from zero to positive 100%. Positive 100% is the direct flight's service quality, and acts as a benchmark, which decreases to zero with increasing transfer time and if there is additional backtracking involved in the routing. Connections with a QCI equal to zero are considered as non-viable connections and are excluded in the determination of QVC and overall hub performance. The Hub Connectivity Indicator (HCI) combines both quantity and quality dimensions.

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[5] (a) Factor of 3 (Veldhuis, 1997;Veldhuis and Burghouwt, 2006) :TrT x 3

(b) Factor of 2.4 (Burghouwt and Wit, 2005) :TrT x 2.4

(c) Factor of θ which takes into account the availability of an alternative direct connection and also multi-hub transfers in the case ANN at Tokyo Haneda and Narita Airports (Li et al : 2012, pp 13)

$$HCI = \sum (QVC_i \times QCI_i)$$

One unit of HCI is equal to one direct connection (Li et al., 2012). For example, 100 units of the HCI mean that the number of qualifying connections at the hub is equal to 100 direct flight services (Li et al., 2012).

The studies and indexes on measuring temporal coordination of schedules at airports have been mostly carried out in the European region (Veldhuis, 1997; Burghouwt and Wit, 2005; Veldhuis and Burghouwt, 2006; Danesi, 2006). The only study in the Asian context by Li et al. (2012) also looks at a single airline's hubbing practices. It does not provide an indication on the hub operation of an entire airport.

Evaluation of temporal coordination of South Asian airports, which are more relevant in the context of the proposed study, are not found in the body of extant literature on the subject.

METHODOLOGY

In order to appraise the BIA's status as an Aviation Hub, temporal connectivity was used as an indicator among the other necessary features already explained. The methods adopted were twofold. First, arriving and departing flight patterns at BIA were examined to assess whether there was a coordinated set of arrival and corresponding departure waves (a wave-system-structure), which is a primary qualifier for a hub airport. Second, a Hub Connectivity Indicator (HCI) was derived to measure the 'connectivity' offered by BIA through the operation of the above identified wave-system-structure.

The data set consisted of the published flight schedule of BIA for the month of July 2012. This contained the information on origins, destinations, OD flight times and elapsed time, weekly frequency, operating carrier, type of aircraft, and number of seats. Further the information on the coordinated flights by ways of interlining and code-share agreements between different operating carriers were gathered from the Civil Aviation Authority of Sri Lanka (CAASL), Srilankan Airlines (ALK/UL) Amadeus schedules database and individual airlines. Alternative flights and their respective details were gathered from Amadeus schedules database. Distances between origins and destinations were gathered from flight time and distance calculator by Rockwell Collins Ascend Flight Information Solutions.

The flight count was plotted against time in a bar chart using the flight schedule data applicable for the selected month in order to identify the arrival and departure waves. Observations were made to gather how many hub waves were there and time interval after which the cycle was repeated in the same manner and throughout seven days of the week, following the method used by Danesi (2006).

The HCI was developed following methods similar to that of Li et al., (2012), but with slight variations to accommodate the context of BIA. The differences were that the index was calculated for the hub operations of all the carriers operating at the airport with the marketing feasibility of making connections (intra-connections of Srilankan Airlines flights and connections made possible through marketing agreements of interlining and code sharing in the case of connections between different carriers). Secondly, the index only looked at a single hub operation.

Following the standards used by many of the previous studies (Doganis and Dennis, 1989; Veldhuis, 1997, Danesi, 2006; Veldhuis and Burghouwt, 2006; Li et al., 2012), which was also the standard used by the home carrier ALK; 45 minutes was used as the MCT for BIA as well. In previous studies also, different upper limits had been used based on the respective airports under consideration. It is evident that higher the MACT, higher would the number of viable connections. But this should not be over extended, since it would increase the disutility experienced by passengers and the index would not represent the true quality of the connections.

Taking into consideration the specific operational and landside infrastructure limitations at BIA, the MACT was set at 180 minutes (four times the MCT). BIA runway had certain operational limitations (due to capacity limitations of terminal and apron facilities) which only allowed it to handle 22 aircrafts within a given hour, though the ideal operations should handle 45 movements per hour (CAASL, 2013).

On the other hand this was also justified by the findings of Ranatunga (2013) on the causes of departure flight delays at BIA which reported that 26% of departure delays happen due to bottlenecks in airport related operations and ramp handling. Home carrier ALK also considers 180 minutes or less as an acceptable level. As presented in the results, close observation of flight waves showed that the gap between the first arrival and last departure flight of a flight wave was on average 4.75 hours which was an approximation to the intervals allowed. Thus, 45 – 180 was considered as an acceptable VCT for BIA under the circumstances.

By taking into account the sum of all the connections within the above identified viable connection threshold of 45 – 180 minutes, the QVC for BIA was established. Only the intra ALK flights and other flights between different airlines having a marketing agreement as explained earlier were accounted for in calculating the QVC. The connections established between low cost carriers and full service carriers were also eliminated as low cost carriers do not have such marketing agreements.

QCI of the viable connections were established following Li et al. (2012). Deviation from the Li et al (2012) method was the introduction of the penalty factor. The Penalty Factor for transfer time was applied as 1 if there were no alternative direct connections available and 2 if there was an alternative direct connection available, which would reduce the attractiveness of the transfer option.

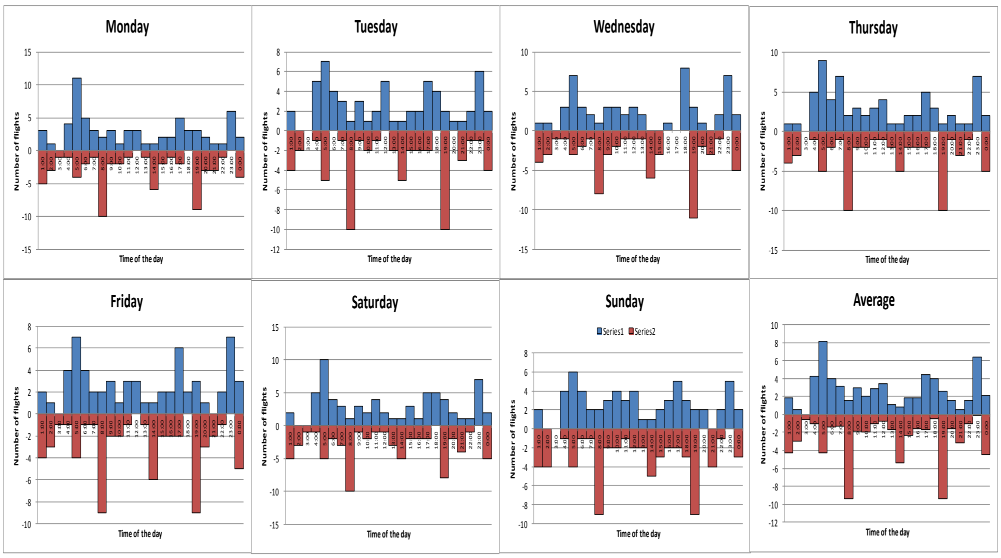
A summary of the analytical process is outlined below.

HCI	=	$\sum (QVC_i x QCI_i)$
QVC	=	Count of viable connections within 45-180 minutes VCT
QCI	=	TF x RF
TF	=	NST/PTT
PTT	=	TT+ (TrT x PF)
PF	=	1 if No and 2 if Yes on the availability of a direct connection
RF	=	Based on values of DRF
		RF = 1, if DRF$\leq$ 1.2
		RF = 0.5 if 1.2< DRF $\leq$ 1.5
		RF = 0 if 1.5< DRF

RESULTS

The results obtained are graphically depicted in Figure 1.

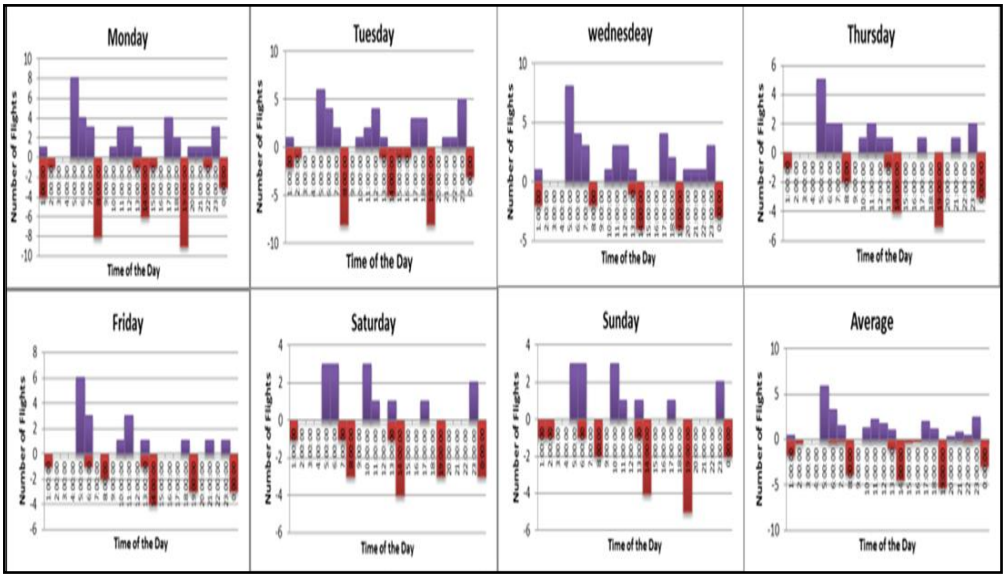
Figure 1: Weekly Hub Wave System at BIA: Number of Flight Arrivals & Departures per Hour



Though the arrival and departure flight patterns at the BIA do not reveal a structure of an ideal wave system, there appear to be four (4) waves from 0400–0900hrs, 1000-1400hrs and 1500–2100hrs and 2200-0200hrs in general, with an average hub repeat cycle of 4 hours and 45 minutes, on each day of the week.

This wave system structure is particularly influenced by the operations of the home/national carrier, ALK; with four flight waves aligned to the above mentioned time periods (Figure 2).

Figure 2: Weekly Hub Wave System of ALK/UL at BIA – Number of Flight Arrivals and Departures per Hour



As per Figure 2, the operations seem to peak during early mornings and late nights with the contribution of other foreign airlines operating to BIA. During mid-day, however, only the ALK flights appear to provide a significant contribution to create a wave. The full operational capacity of BIA runway is only utilised during 0500-0600, 0800-0900and 1900-2000hrs.

Table 1details the results of the Quantity of Viable Connections (QVC), Quality of Connectivity Index (QCI) and Hub Connectivity Indicator (HCI) calculations for BIA. There are 894 arrivals and departures handled by BIA per week. These arrivals and departures create 1961 QVCs within the VCT identified for BIA as 45-180 minutes. It gives a HCI of 749.38 that is equal to approximately 750 direct connections in terms of quality and quantity. This is only 38% from the total connections made (HCI/QVC). Within this QVC, ALK as the home base carrier accounts for 94% of the viable connections which is equal to a HCI of 709.12 equivalent direct connections. Therefore, as evident from the comparison drawn in Table 1, the majority of connections at BIA are offered by the national carrier ALK.

Table 1: Quantity of Viable Connections (QVC) and Hub Connectivity Indicator (HCI)

	All Airlines	Srilankan Airlines (ALK/UL) contribution
Total Arrivals and Departures	894	481
Quantity of Viable Connection (QVC): *Number of connections made by all airlines [within Viable Connection Threshold (VCT)]*	1961	1847
Quality of Connectivity Index (QCI): *Quality of the QVC*	304.5	300.3
Hub Connectivity Indicator (HCI): $HCI = \sum (QVC_i \times QCI_i)$	749.38	709.12

In order to further analyse the connectivity offered by the national carrier, the contribution of its code-share partners and interline partners towards the above estimated HCI were analysed, as shown in Tables 2 and 3 below. This indicates that 537 out of the total connections made by ALK, are attributable to the interline partners of Srilankan Airlines and 102 connections provided through its code-share partners.

Table 2: Contribution from Interline Partners

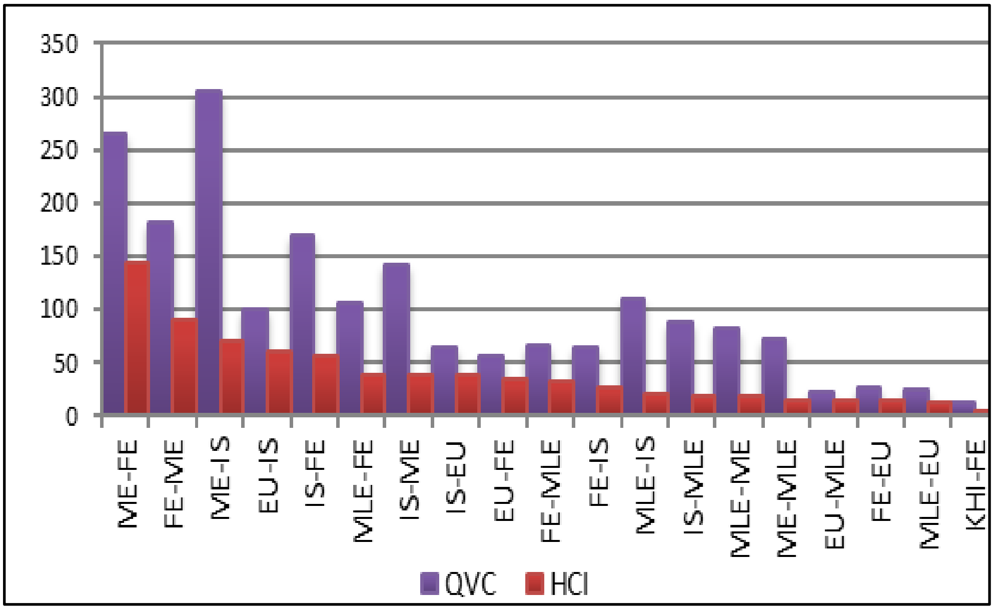
	Interline Partners
Quantity of Viable Connection (QVC) : *Number of connections made by all airlines [within Viable Connection Threshold (VCT)]*	1454
Quality of Connectivity Index(QCI): *Quality of the QVC*	226.8
Hub Connectivity Indicator (HCI): $HCI = \sum (QVC_i \times QCI_i)$	537.0

Table 3: Contribution from Code-share Partners

	Code-share Partners
Quantity of Viable Connection (QVC) : *Number of connections made by all airlines [within Viable Connection Threshold (VCT)]*	249
Quality of Connectivity Index (QCI): *Quality of the QVC*	38.5
Hub Connectivity Indicator (HCI): $HCI = \sum (QVC_i \times QCI_i)$	102.2

As illustrated in figure 3, the highest number of viable connections is made between the Middle East (ME) region and the Indian Sub-Continent (IS) region. But their quality is considerably low. Second highest is between the Middle East (ME) and Far East (FE) and vice versa. Examined closely, it can be perceived that the quality of the flight schedule to the Indian subcontinent and Male (MLE) is low, which in turn negatively impacts the HCI.

Figure 3: Regional Distribution of QVC and HCI



CONCLUSION AND POLICY RECOMMENDATIONS

From a policy perspective, as explained at the beginning of the discussion, hubs also serve as windows and bridges to open up a country or a region, and lay the foundation for the local or regional economy to participate in international cooperation and competition. In this context, the optimisation of temporal connectivity at BIA gains significant importance in the policy directions aimed at developing Sri Lanka as an aviation hub in the South Asian Region.

The results of the research reveal that, even though it is not an ideal system, BIA has a certain wave-system structure which is driven by the operations of the home carrier ALK. In absolute terms quality of the temporal connectivity of the flight schedule at BIA can be judged as low based on the figure that the HCI only accounts for 38% of the QVC, which in other words mean that only 38% of the total viable connections made are equal to the quality of a direct connection. To assess the relative performance of BIA as a hub in the South Asian Region, it should be compared with indexes calculated for other nearby hub airports such as Dubai and Singapore which are giving strong competition in the North West (NW)-South East (SE) markets, which have been identified previously as a desirable route direction for BIA to operate as a hub (Jayalath and Bandara, 2000). It is also important to consider the three main hub operations in the Indian aviation market; Delhi, Mumbai and Chennai in comparison with BIA operations. A main drawback of this study is the lack of comparative measures to assess the relative postion. Only in absolute terms, BIA can be advised to look into ways of improving the HCI of the current flight schedule.

In looking at ways to imporve temporal connectivity, policy makers can pursue two options in relation to BIA. One is to optimise the utilisation of exisiting infrstructure by encouraging operators to introduce more flights and frequencies, which would improve the quantity of connections falling within the VCT. In doing this, certain limitations highlighted previously on the operations at BIA should be addressed. Therefore, it is important to improve the handling capacity and ground services to utilise the existing runway capacity in order to accommodate more aircrafts. However these would incur costs to airport operators. Simultaneously increased frequencies will also put an additional burden on the operating cost of airlines. If required load factors are not achieved these additional frequencies may not be economically viable for the airline. Hence proper cost benefit analysis should be carried out prior to introducing such services. Furthermore, the quality of the connections provided may be hindered by the negative records on punctuality at BIA by the handling agent (on average 75%) (Ranatunga, 2013). Hence,the lower margin of VCT of 45 minutes may not be practical in such a context due to the delays caused by the ground handlers.

ALK provides a major portion of the connections established. However, out of the total viable connections made by ALK, only 38% of flights are of accepted quality from a transfer passenger point of view in saving time. Also these connections fall closer to the upper boundary of the VCT. Apparently the quality of the connections offered via BIA have been hampered eventhough a higher quantity of connections are offered. Hence, the national carrier has enough room to improve the quality of their connections by careful schedule planning of their own arrival and departure flights. For example the arrival ALK flight from London Heathrow (LHR) from NW at 0155hrs on Monday in the first week of July 2012 at BIA, does not have any corresponding flights which falls within the VCT (upper limit 0455 hrs) directed towards SE, which may have created an ideal connection options. Instead all the departing flights which fall within the VCT were directed to the ME region.

Therefore, BIA should work along with the national airline and other airlines operating at the airport to deliver a much more coordinated service. Code sharing and interlining arrangements between the airlines serving at BIA have a pivotal role to play in improving quality, without which the connection may not be a saleable option for passengers. This would enable improving the productivity of the performance of ALK as a hub carrier, which in turn would strengthen BIA's hub positioin. It is also interesting to note that, though the BIA was recognised to have the potential to be a hub on the cross roads between NW-SE and NE–SW air routes (Jayalath and Bandara, 2000) that even after tweleve years, the potential of NE-SW routes have not been explored. Except for Male the rest of the connections are between the NW-SE and the IS regions(Figure 3).

In addition to overcoming the limitation of having no comparative indicators, future attempts to improve this evaluation should also look at the addition of Hambantota Mahinda Rajapaksha International Airport (MRIA) to the airport network in Sri Lanka as this would create a multi-airport scenario having further implications on BIA's operations. Future studies should be aimed at evaluating the scenario from a dual-hub perspective.

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