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Liberalisation and the regional air network configuration from Nigeria to other West African Countries

Abstract: This paper examines the liberalisation and the regional air network configuration from Nigeria to other West African regions. It aims to study the impacts of liberalisation on the regional spatial structure of air networks from Nigeria to West Africa in the pre and post-liberalisation. The pre-liberalisation covers between 1988–2000, and the post-liberalisation ranges from 2001 to 2018. The methodology involves using the graph theory to calculate the route and the network topology in the pre and post-liberalisation and compare the resulting index. This hypothesis was tested using the alpha index. The alpha index analysis compares the level of connection in a pre-and post-liberalisation network via graphical depictions of each period's route and network structure and the resulting alpha index. The pre-liberalisation alpha index for the route and network was 0.297, while the post-liberalisation alpha index was 0.334. The alpha index ranged from 0 to 1 and was the perfect network for the post-liberalisation period. In post-liberalisation, the alpha index of the route and network are higher than in pre-liberalisation. Hence, the connection is better in post-liberalisation.

Keywords: air network; configuration; liberalisation; Nigeria; regional; West Africa

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Introduction

The liberalisation of the air transport industry has significantly influenced the aviation industry's operational and institutional structure globally (Niewiadomski, 2017). This effect of the policy has created a unique airline strategy that has impacted the network and operating system (Zou, Chen, 2017). The emerging network structure is a game-changer for the airline to enhance the bottom-line and route expansion (Wensveen, 2016). The cascading influence of the liberalisation policy on the airline and route

structure is noteworthy (Dai, Derudder, Liu, 2018). The regime has created a robust competitive environment among airline operators with a clear-cut impact scale from local to global aviation markets (Wang, Heinonen, 2015). This change has brought about alliances, mergers, and acquisitions to gain a competitive edge. However, in the end, the resultant spatial structure of the air network and the route are involved.

In 1978, the United States of America led the way in deregulating the domestic air transport market (Budd, 2017). The structural reforms of the US local market and the Canada-US open skies agreement significantly relaxed the spatial disconnection and strengthened aviation partnership and interaction between the two countries (Gillen, Morrison, 2017). The major US airlines have initiated a hub-and-spoke network as a spatial and commercial strategy. This innovation contrasts with the Civil Aeronautics Board (CAB) regulation era, where inter-urban routes were often 805 km or more in length.

Goetz (2017) studies the spatial effects of deregulation on US aviation and reveals that major operators provide 100–200 departures each day from some principal hubs. The enhanced interaction between the hub and spoke cities is evident. In Europe, the process of liberalisation was accomplished bit by bit in three phases and took ten years (Fox, Martín-Domingo, 2020). The resultant process led to a unified structure of air networks promoting accessibility among member states and removing all spatial barriers. In another vein, liberalisation of on-air networks is studied among Asian countries (Fu et al., 2015). The success of air liberalisation policies in the United States and Europe pushes African countries to devise a new strategy. This policy, known as the Yamoussoukro Declaration, was developed to circumvent bilateral air service agreements (BASA), which put several limitations on African carriers (Bwire, 2018; Ndivo, 2020). The essence is to strengthen route and the air network structure among the West African member states. The Africa civil aviation liberalisation draft is based on the fifth freedom of air transport. The year 2001 is the commencement date for the African civil aviation policy. In Nigeria, earlier studies on air transport, air transport deregulation and liberalisation have focused mainly on the domestic (Daramola, Jaja, 2011; Oluwakoya, 2011; Yusuf, Irwan, Normizan, 2017). However, how far has the strategy affected West Africa's air network structure and configuration, primarily from Nigeria's cities of Lagos and Abuja to the rest of West Africa, since its inception? Also, what is the level of route and network connectivity to West African nations from Nigeria? And lastly, what are the nature and characteristics of the relationships among the cities in West Africa. In the light of the preceding research questions, this study intends to examine the resultant outcome of liberalisation and the regional air network development in Nigeria to West Africa.

Conceptual framework and literature review

Accessibility and regional spatial structure

The degree to which a location may be reached or accessed by other areas is referred to as accessibility. As a result, the limit and structure of transportation infrastructure are critical determinants of accessibility (Kelobonye et al., 2019; Rodrigue, Comtois, Slack, 2006). Locations are relational to one another. Also, it is essential to note that locations do not possess a constant attribute as transportation provision and infrastructure, to

a considerable extent, determine the levels of accessibility and interactions between locations.

Different locations differ in terms of relative uniqueness and distance due to their distinguishing characteristics. And the development of any location in space is a cumulative outcome involving transport infrastructure, levels of economic activities and the environment. Hence, effective transport infrastructure enhances accessibility and remains one of the major factors shaping the spatial structure. The connectivity within a specified spatial structure is a function of reliable and effective transport networks (Reggiani, Nijkamp, Lanzi, 2015). This transportation network provides an effective link between defined locations. One of the core areas of transport geography is to ensure an adequate flow between locations. Hence, transnational regional spatial linkage structure and interaction rely strongly on efficient air transportation terminals, which helps regional integraton. Thus, improvements in transport infrastructure and transport provision improve accessibility (Papatheodorou, Arvanitis, 2009).

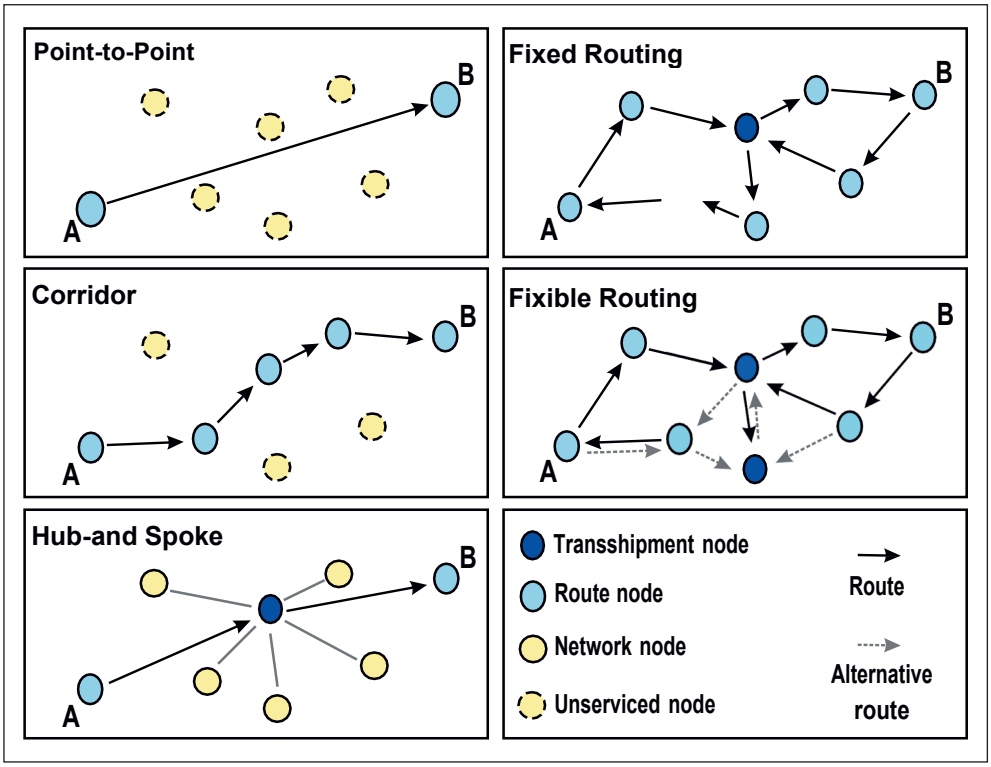
This essence for regional air services from Nigeria to other West African countries is the accessibility enabled by flight services and standard air terminals that can handle regional, transnational air services within the sub-region from Nigeria to other West African countries. One of the significant challenges facing the regional air services provision has been the scarcity of adequate flight linkages and connections. Therefore the level of flight frequency and activities from Nigeria to some countries in West Africa remained low. Also, the passenger movement from Nigeria to some West African countries has suffered because of the limited available flight services. Thus, this concept of accessibility and spatial structure offered the contextual basis for understanding the conceptual framework on accessibility and regional spatial structure development.

Transport networks and spatial interaction model

The spatial structure of the modern transportation network infers the spatial distribution structure (Olariaga, Zea, 2018). These networks fill in as spatial linkage towards bigger distribution centres and frequently serve significant trans-national catchments. It is essential to note that air transport routes and networks fit into transport network models. Four transport network model procedures were identified in the literature (Rodrigue, Comtois, Slack, 2006; Woxenius, 2002). These are shown in Figure 1 and as follows:

1. Point to point: This is essential when specialised and customised one-time orders must be completed, which frequently results in less-than-full-load and unfulfilled return difficulties.
2. Corridor: This connects high-density agglomerations with passenger and freight services regularly. Local/regional distribution stations, which serve as sub-hubs in this distribution system, can load and unload traffic along the corridor (Rodrigue, Comtois, Slack, 2006).
3. (Hub-and-spoke network: This was visible in air freight passenger distribution and high throughput distribution sites. Typically, a notable circulation centre located near the hub will have preferential access to a terminal.
4. Routing network uses spherical configurations where passengers can be transited from one route to another at a particular hub.

Figure 1. Transport network strategies



Source: Rodrigue, Comtois, Slack (2006)

The research assesses if regional air routes and networks align with the above spatial air patterns or have a distinctive spatial pattern across the network.

According to several spatial interaction models, flows are a component of the properties of the locations of origin, the attributes of the locations of destination, and the friction of distance between the respective origins and destinations (Rodrigue, Comtois, Slack, 2006). The following is a general version of the spatial interaction model:

$$Tij = f (Vi, Wj, Sij)$$

Tij = interface amid location i (origin) and location j (destination). The elements of estimations are fluctuated and can include people, tonnes of freight, traffic volume etc. It also refers to a time, such as exchanges by the hour and day.
Vi = features of the origin location i. Socioeconomic variables are frequently employed to express these traits.
Wj = attributes of the destination's location j.

Sij denotes the features of the distance between both the origin and destination locations. Distance, transportation expenses, and journey time are variables used to characterise these properties.

Three basic sorts of interaction models may be developed using this broad approach:

(i) The gravity model calculates all potential location pairings' exchanges. The degree of interaction between two places is calculated by multiplying their qualities and dividing by their distance.

$$Tij=VI*Wj/S2ij$$

(ii) Potential Model predicts transactions between one place and all others. The degree of interaction between one site and all others is calculated by adding the attributes of each other location and dividing them by their amount of separation.

$$Ti=\sum jWj/S2ij$$

(iii) Retail model estimates the market area border between two places competing for the same market. This approach emphasizes boundaries rather than exchanges.

$$Bij=Sij/1+Wj/Vi$$

It is important to note that regional aviation markets are expressed in an origin and destination pair. The volume of air traffic in any O-D pair largely depends on the location attributes of the origin and destination pair. In the West Africa regional aviation market, air transport liberalisation policy is assumed to have engendered increased passenger traffic between origin and destination pair in a regional aviation market. This study intends to examine the city pair route and network structure from Nigeria to West African nations.

Literature review

Deregulation and changes in hubbing and nodal accessibility

The concept of deregulation has continued to be one of the most considerable potential determining the air transportation subsector and the resulting air traffic patterns. It tends to provide a framework to advance the economic competence of air traffic operations, induce innovations in the air traffic market and restrict overbearing government dominance in the running and provision of air transport services. Deregulation was to a great extent embraced as an approach for minimising government participation in economic affairs. The political functionaries frequently respect regulators with expanding contempt; they are perceived either as hostages of the industry they are regulating or as redundant bureaucrats inhibiting the progression of business (Abeyratne, 2016; Lenaerts, Malina, Allroggen, 2020; Wong et al., 2019; Derudder, Witlox, 2016; Roucolle, Seregina, Urdanoz, 2020). Deregulation was chiefly set on the principle of a theory that the market for a loose airline industry would be pretty accurate, a seamlessly competitive one with a large number of carriers (because of zero sunk costs) and no significant economies of scale or entrance obstacles (Kahn, 1977). The notion of contestable

markets strengthened the dominant view by hypothesizing that even intimidation of new enterprises would prevent large corporations from exercising monopoly power (Debbage, Alkaabi, 2016; Knieps, 2014)

The literature is replete with geographical assessments of the impact of liberalisation on air networks (Grancay, Szikorova, 2014; Hindley, 2019; Huber, 2016; O'Connor, Fuellhart, 2012). These studies suggest a relationship between the adoption of deregulation policy and changes in air traffic patterns. The emergent spatial pattern observed resembles airline services' concentration between core airports within urban and regional hierarchies. The outcomes of these studies seem more of a universal generalisation of the relationship to the neglect of specific locale factors which might alter the supposed spatial effects. However, geographical location peculiarities and their attributes have primarily influenced inter-city linkages and patterns of flow within regional hierarchies of air traffic movement (Chen, Xu, Xu, 2015).

Airline deregulation and impact on nodal accessibility have attracted the interest of researchers. The amount to which residents in one city may travel to other cities via robust airline services is referred to as nodal accessibility (Lenaerts, Malina, Allroggen, 2020). Following deregulation, there are some variances in nodal accessibility of air transportation (Olariaga, Zea, 2018). They examined data from the pre-and post-deregulation origin and destination surveys of airline passenger travel in 84 locations across the United States. Multiple regression analyses are used to validate the effects of deregulation on nodal accessibility. The distribution of nodal accessibility variations between 1970 and 1980 shows a distinct southwest-northwest pattern. During the post-deregulation period, the trend was stabilised. The analysis found that increased hubbing activities after deregulation have not increased the geographical concentration of nodal accessibility.

Furthermore, in Europe, the impacts of European Union deregulation on airline hub operations in Europe were investigated. Air transport deregulation in Europe makes hubbing an increasing strategy for European airlines (Burghouwt, De Leon, De Wit, 2015). The EU's air transport liberalisation process, its consequences, and future considerations (Dennis, 1994). Paris and Brussels have been identified as the optimum geographical locations for a unique European centre. The two notable airlines delivering the most successful hubbing operations seemed to be KLM in Amsterdam and Lufthansa in Frankfurt. British Airways at London Heathrow and Air France at Paris Charles de Gaulle (CDG) have less connectivity despite their enormous networks. Although individual regional hubs can increase capacity, Amsterdam and Paris's airports have the best expansion.

Moreover, other theoretical and empirical research in the literature relates to airline network configuration. Many of these studies on airline network setup underscore the spatial extent of airline networks. The hub and spoke networks are generally seen as spatially robust networks. The hub and spoke network often reflect a structure, where routes are deliberately concentrated on a few key nodes (Burghouwt, de Wit, 2015; Lieshout et al., 2016). These studies mainly focused on the spatial and temporal concentration of flights. However, these studies did not consider such factors as interacting city population, city's political status, and available infrastructure, among other factors responsible for concentrating flight between hub cities.

METHODOLOGY

This study uses graphical analysis to calculate the connectivity level of the route and network structure. Maps and charts depict the changing regional route network in West Africa from Nigeria during the pre-liberalisation and post-liberalisation eras. The study covered time period between 1988 to 2018. The period was divided into the pre-liberalisation era (1988–2000) and post-liberalisation (2001 to 2018). The graphical analysis of the route and network chart was done using graph theory. The graph theory is a connectedness metric that compares the number of cycles in a graph to the maximum number of cycles. The greater the alpha index, the more linked a network is. Several zeros represent a tree or basic network, but a value of 1 indicates a wholly connected network. It also involves a map chart comparing the number of network structures in pre-and post-liberal eras. The alpha index from the identified route and spatial structure is calculated to unravel the connectivity level in Nigeria's route and network structure to West African cities.

Patterns of air route and network from Nigeria to other West African countries

This section examines the airline route and network structure during the pre-and post-liberalisation eras and changes in the route and network from Nigeria to other West African countries. The changes in the volume and temporal pattern of passenger movement from Nigeria to other countries in the pre- and post-liberalisation eras are discussed.

Pre-liberalisation era

The regional air network structure from Nigeria has changed significantly from the pre-liberalisation to the post-liberalisation eras. This sub-section discusses the patterns and the characteristics of the route and the network structure in the pre-liberalisation era. Figure 2 shows that Nigeria's pre-liberalisation air network structure to other West African countries has a scheduled operation routed from a single dominant node in Lagos. All regional flights from other airports destined for other West African countries are routed through the Lagos international airport. Although, during this period, other major international airports such as Kano, Port Harcourt and Abuja, only handled non-scheduled flight operations from Nigeria to other West African countries. Other travellers from Nigerian cities such as Sokoto, Kaduna, Jos, Yola, and Maiduguri were routed straight to Lagos or other international airports in Lagos to other West African nations.

Nigeria's regional air network consisted of a linear point-to-point network structure from Lagos to other West African countries and internal hub structures linked to other major cities. Figure 2 shows Lagos as the only hub within the country during this era. The dominant airline on domestic airline services during this period was Nigeria Airways. Similarly, Nigeria's regional air route network to other West African countries was equally dominated by Nigerian Airways. Besides the nature of the route and network structure from Nigeria was a linear point-to-point along the West African coast from Lagos, Nigeria to Dakar, making intermittent stops along the west coast to carry and discharge passengers along this route.

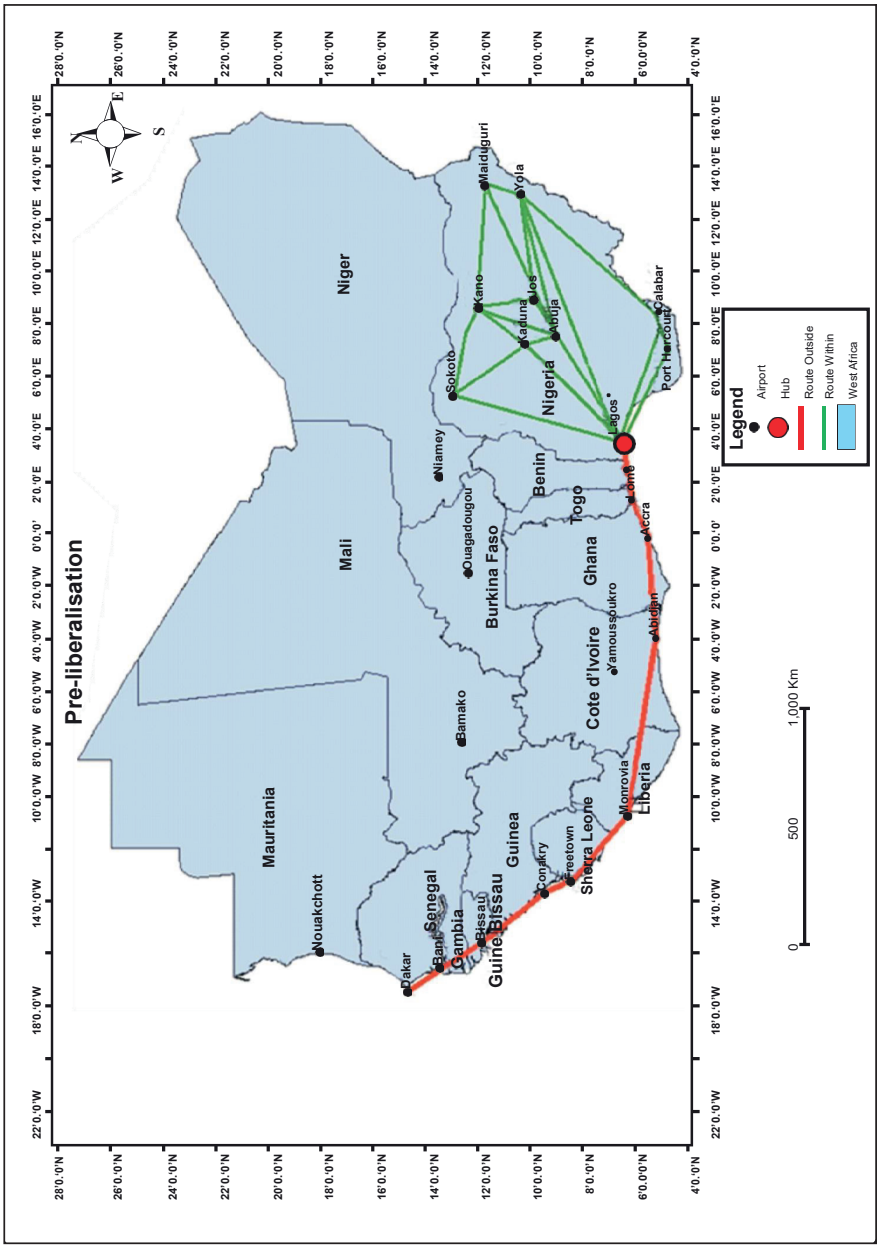


Figure 2. Pre-liberalisation regional air network structure from Nigeria, 1988–2000

Source: Author's analysis, 2019

Figure 2 depicts the nations and capitals that formed the sub-region during this period. In the pre-liberalisation era, the sub-region consisted of sixteen nations: Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra-Leone, Togo, and Mauritania (which, however, left ECOWAS in the year 2000).

Furthermore, there is a duality in the colonial attitude of the West African countries. The separation is mostly between the Anglophone and Francophone nations, with a third being the Portuguese colony. In view of the foregoing, the ECOWAS Commission has adopted English, French, and Portuguese as the working languages of the sub-citizens region's. However, socio-cultural membership may have little impact on regional socioeconomic connections and cooperation.

Post-liberalisation era

This section discusses the patterns and features of the route and network structure in the post-liberalisation period. The post-liberalisation regional air network structure of Nigeria has evolved dramatically from the pre-liberalisation era. When compared to Figure 2, these modifications are depicted in Figure 3. Nigeria's air network structure to West Africa was routed from two major nodes during the post-liberalisation era compared to a single node during the pre-liberalisation era. These nodes served as the hubs from where the flights to other West African countries are concentrated and dispatched. During this period, the two major hubs in the country are located in Lagos and Abuja.

However, Lagos is the dominant hub, as significant flight operation from Nigeria to other West African routes occurs at the Lagos hub. Another characteristic of this period is that additional hubs were created to extend the links from the major hubs within the country – Lagos and Abuja. The extension hubs situated outside of Nigeria are in Cotonou and Lome, respectively. For instance, the Lome hub was linked directly from Abuja to connect Niamey, Ouagadougou, Bamako, Dakar to Praia. Lagos linked the Cotonou directly. From Cotonou, it linked the following cities: Niamey, Ouagadougou, Bamako, and Dakar to Praia.

Figure 3 reveals the hubs created within the country and the extension to other cities outside Nigeria. Though during this period, other major airports were added to the existing airports. These are Benin City, Uyo, Asaba, Enugu and Makurdi. The post-liberalisation period has a denser route and network structure, with Abuja and Lagos serving as critical hubs connecting every other major airport and functioning as the gateway to Nigeria's regional air network structure.

The post-liberalisation regional air network topology is primarily a hub and spoke network structure spanning from Nigeria to West Africa. The hub structure increased from one to four from the pre- to post-liberalisation era. The hub structure is segmented into internal and external hub structures of linear points to point network structures along the west coast from Lagos to other West African countries. The internal hub structure links Lagos to other major cities within the country. Figure 3 reveals the changes in the countries and their capitals.

During this time period, this was the sub-region. In the post-liberalisation era, the total number of countries in the sub-region have now been reduced to fifteen. They are as follows: Cape Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia,

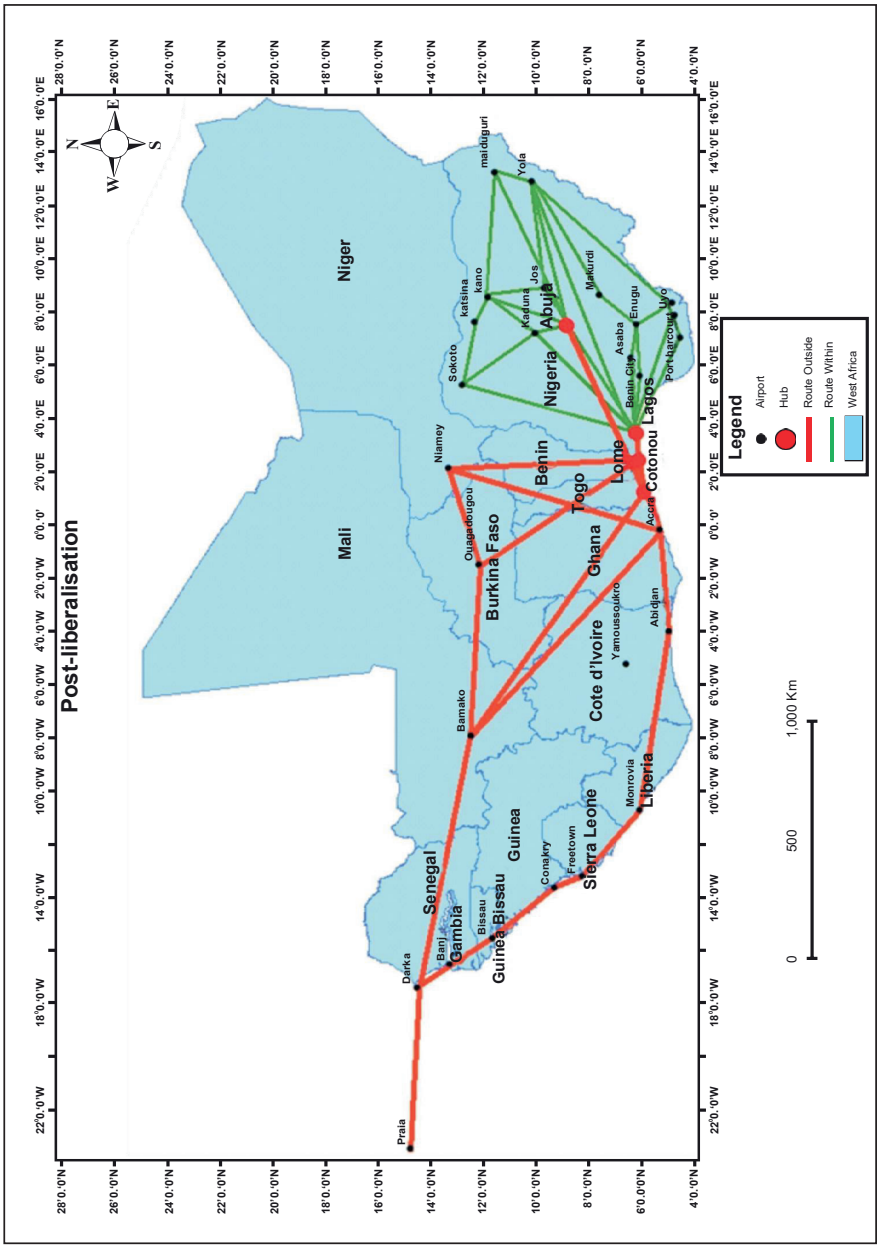


Figure 3. Post-liberalisation regional air network structure from Nigeria, 2001–2018

Source: Author's analysis, 2019

Mali, Niger, Nigeria, Senegal, Sierra Leone, Benin, Burkina Faso, and Togo. Mauritania withdrew from ECOWAS in the year 2000.

The hypothesis that states a significant variation in the spatial pattern of the route and network structure from Nigeria to West Africa countries was tested. This hypothesis was analysed using a graphical representation of the route and network structure in both periods and calculating the alpha index to compare the level of connectivity in the pre-and post-liberalisation network. The calculated alpha index for the route and network in the pre-liberalisation era was 0.297, and the alpha index for the post-liberalisation era was 0.334. The alpha index ranges between 0 and 1, with 1 being the perfect network. The route and network alpha index is higher in post-liberalisation when compared with pre-liberalisation. Hence the connectivity is better during the post-liberalisation.

DISCUSSION

This study focused on analysing the impact of liberalisation and the regional air network configuration from Nigeria to other West African countries. It seeks to underscore the liberalisation policy on the pre-and post-liberalisation eras' spatial air network structure.

Pre-liberalisation era

During pre-liberalisation, the nature of route structure shows a linear point to point internal and external link from Nigeria to other West African countries. Nigeria's dominant hub in Lagos offers only scheduled flights from Nigeria to other West African States. All regional flights from other airports destined for other West African countries are routed through the Lagos international airport. Although, during this period, other major international airports such as Kano, Port Harcourt and Abuja, only handled non-scheduled flight operations from Nigeria to other West African countries. Travellers from other cities in Nigeria travelling to other countries such as Sokoto, Kaduna, Jos, Yola and Maiduguri, were either routed directly to Lagos or routed through other international airports to Lagos to other West African countries.

Post-liberalisation era

Nigeria's post-liberalisation regional air network topology differs significantly from that of the pre-liberalisation era. Nigeria's air network structure to West Africa was routed from two major nodes during the post-liberalisation era compared to a single node during the pre-liberalisation era. These nodes operated as flight hubs, concentrating and dispatching flights to other West African countries. Lagos and Abuja are the country's two primary hubs during this period. This study confirms comparable findings in the United States, Europe, and other regions of the world.

CONCLUSION

This paper examines the policy of liberalisation and the regional air network from Nigeria to other West African countries. The Declaration of Yamoussoukro in 1988 was the

first effort at a united African aviation strategy (Abate, 2007). The 1999 Abuja Treaty served as a springboard for implementation, which is set to begin in 2001. Nigeria has dramatically benefited from the ECOWAS directive for its member states to adopt the African civil aviation policy. The findings from this study reveal that liberalisation policy has effectively influenced the air network structure configuration from Nigeria to other West African countries. The regional spatial air network has evolved from a point-to-point to a hub-and-spoke structure, with additional hubs located within and outside the nation. Liberalisation has transformed from a linear route structure to a web joint networks structure linking Nigeria's principal cities – Lagos and Abuja, to other West African States. The post-liberalisation regional air networks suggest improved aviation paraphernalia across the West African member state. Specifically, the Nigerian aviation infrastructure has dramatically improved since the liberalisation of the regional market.

The study establishes a noteworthy change in the spatial pattern of the route and network structure from Nigeria to West African countries from pre and post-liberalisation. This hypothesis was examined using a graphical representation of the route and network structure in both times and calculating the alpha index to compare the extent of the connection between pre-and post-liberalisation networks. The calculated alpha index for the route and network before liberalisation was 0.297, whereas the alpha index after liberalisation was 0.334. The alpha index ranges between 0 and 1, with 1 being the perfect network. When comparing post-liberalisation to pre-liberalisation, the alpha index of the route and network is higher. As a result, connectivity is better in the post-liberalisation period.

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