Feature Article

ESTIMATING THE ECONOMIC IMPACT OF AIR CONNECTIVITY USING NETWORK ANALYSIS

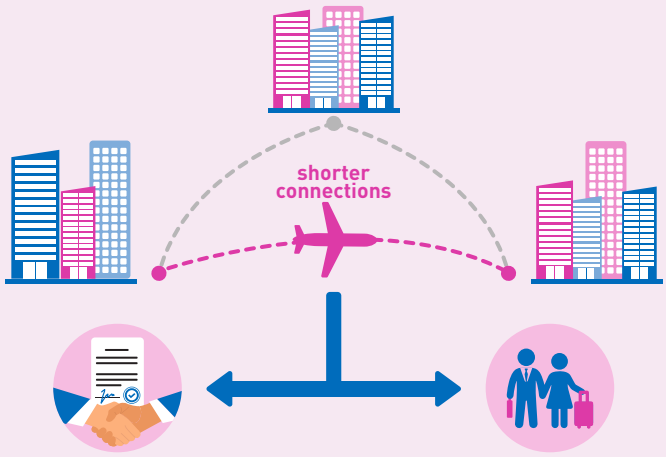
OVERVIEW

As a small and open island economy, Singapore relies on its strong aviation sector and international air connectivity to facilitate the movement of people and goods, support trade and the flow of essential supplies, and create good jobs for Singaporeans. Our air connectivity brings the world to Singapore and also allows Singaporeans to venture beyond our shores. Overall, Singapore's strategic location and connectivity reinforce Changi's position as a key air hub linking the region with the wider global economy.

FINDINGS

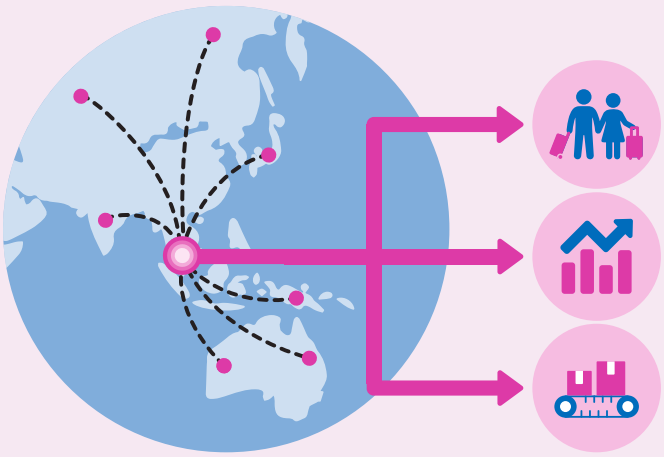
Finding 1:

Shorter and more convenient flight connections between cities are associated with higher foreign direct investment (FDI), direct investment abroad (DIA) and air passenger flows. These relationships are stronger for cities that are geographically closer together, possibly because such cities are more likely to have established regional production networks, trade and investment relationships, and travel links.



Finding 2:

Cities that lie along more efficient routes between other cities tend to have higher GDP. This may reflect the benefits of serving as an air hub, as facilitating a larger share of passenger and cargo flows results in greater economic activity to support these flows. The larger volume of flows may also generate agglomeration effects and economies of scale, such as enabling airlines to sustain more frequent flights due to transfer demand.



POLICY TAKEAWAY

Air connectivity generates significant economic benefits by improving access to overseas markets and strengthening a city's position as an air hub. The findings highlight the importance of considering network effects when assessing new air links, as the economic value of a connection extends beyond direct traffic flows and improves connectivity across the wider network. Our simulations suggest that strengthening links with less well-connected and growing regions yield significant economic gains.

EXECUTIVE SUMMARY

- Singapore's air connectivity is a strategic economic asset that undergirds its role as a global hub. With Changi Airport targeting 200 city links by the mid-2030s, this study seeks to understand how enhanced air connectivity could lead to economic gains and also provide a broad assessment of the cities and regions that Singapore could establish new links with to deliver the greatest economic gains to Singapore.

- To conduct the study, we combine flight schedules, city-level GDP and foreign investment data for over 2,000 cities from 2014 to 2024. We then apply network analysis on the dataset to estimate the economic impact of improving air connectivity.

- We find that shorter travel times arising from more direct flight routes are associated with stronger economic flows (i.e., foreign direct investment (FDI), direct investment abroad (DIA) and air passenger arrivals). Specifically, a 1-unit reduction in GDP-weighted flight distance experienced by a city is associated with higher FDI inflows of US$192 to US$490 and DIA outflows of US$100 to US$1,250 over five years, as well as an increase in 0.003 to 0.008 air passengers per annum, for the city, depending on the geodesic distance between the city and the source city.

- We also find that cities that are better connected within the global air transport network (i.e. with higher betweenness centrality) tend to achieve stronger GDP, reflecting gains from facilitating air passenger transfers and improved efficiency arising from network and scale economies. Specifically, an analysis on the global aviation network found that a 1 percentage-point increase in betweenness centrality of a city is associated with a 0.22 per cent increase in its GDP, while a smaller but statistically significant increase in GDP of 0.084 per cent is estimated for cities with GDP levels similar to Singapore's.

- Our simulations specific to Singapore suggest that the largest economic gains would come from stronger air links with developing and emerging regions, including Latin America, Africa and Central Asia.

- Our findings support continued investment in Singapore's air hub and access to future growth markets, while recognising that route development will also depend on aircraft availability and capability, airline strategies, and the availability of air traffic rights in air service agreements.

The views expressed in this paper are solely those of the authors and do not necessarily reflect those of the Ministry of Trade and Industry or the Government of Singapore.[1]

INTRODUCTION

As an open economy with a small domestic market, Singapore's economic growth depends heavily on its connections with the rest of the world. By enabling the efficient movement of people and goods between Singapore and overseas markets, our air connectivity supports trade, investment, tourism and other economic activities. Singapore's strong air connectivity to cities across various regions also enables it to serve as a key transfer hub that efficiently connects other city pairs through Singapore, thereby generating additional passenger and cargo flows for Singapore. Taken together, these benefits make air connectivity a key economic asset for Singapore.

Over the years, the Government and industry partners have taken steps to strengthen Singapore as an air hub and improve its connectivity. In 2025, Changi Airport (henceforth "Changi") served around 70.0 million passengers, an increase of 3.4 per cent from the 67.7 million in 2024. Almost 2.1 million tonnes of air cargo were handled by the airport in the same year, up 4.5 per cent from 2024. As at January 2026, Changi is connected to over 170 cities in 50 countries and territories worldwide.

1 *We would like to thank Ms Yong Yik Wei, Dr Andy Feng, Dr Tan Di Song, Dr Tan Yi Jin, and MOT and CAAS colleagues for their useful suggestions and comments. All remaining errors belong to the authors.*

Changi aims to grow its number of city links to more than 200 by the mid-2030s when Terminal 5 becomes operational.[2] Given Changi's role as a key enabler of the Singapore economy, important questions to address include the extent to which improved air connectivity will benefit the Singapore economy and where the new air links should be established in order to reap the largest economic gains for Singapore.

Broadly, industry and academic studies provide evidence that improved connectivity leads to economic gains for countries and cities. For example, studies by the International Air Transport Association (IATA) report that a 10 per cent increase in air connectivity led to a 0.07 per cent increase in labour productivity (Smyth and Pearce, 2007), and a 1.1 per cent increase in long-run GDP among EU countries (IATA, 2006). In the economic literature, Campante and Yanagizawa-Drott (2018) found that long-distance non-stop flights led to significant increases in business linkages and capital flows between cities. Overall, they estimated that a one standard deviation increase in air connectivity would lead to a 0.8 per cent growth in the cities' GDP on average.

In this study, we similarly seek to improve our understanding of how air connectivity generates economic benefits for cities by first developing centrality-based[3] measures of air connectivity that account for the broader structure of the global aviation network. Using a city-level panel dataset, we then use these measures to examine how improvements in air connectivity have contributed to economic outcomes such as foreign direct investment (FDI), direct investment abroad (DIA) and air passenger arrivals, and hence GDP of the cities. Finally, we outline how these findings may be used in simulations to identify cities and regions where new direct air links could generate significant economic benefits for Singapore.

CONNECTIVITY / CENTRALITY MEASURES AND DATA

Before describing the data, we first describe the conceptual framework used to understand how economic gains could accrue from enhanced air connectivity via the establishment of direct air links, and the relevance of centrality measures in quantifying the extent of such gains, using Singapore as an example.

In assessing the economic gains from direct air links, it is important to account for network effects, as a new connection does not just link two cities but will also have an impact on the global aviation network, which could lead to additional benefits for the cities. Taking into account network effects, there could be two main channels of impact when new air links are established: improved market access and enhanced air hub status. For example, when Singapore establishes a direct air link with a previously-unconnected city, it could:

- **Channel 1: Improve market access for Singapore**. This occurs as the new link shortens (i) the direct flight distance between Singapore and the newly-linked city, and also (ii) the effective flight distance to other cities that are not directly linked to Singapore but are now better connected to Singapore via this newly-linked city (i.e., indirect link). The overall improvement in Singapore's flight distance to the newly-connected city and other cities increases Singapore's attractiveness as a destination for business and tourism, which leads to increased FDI and tourist expenditure, respectively. It also improves Singapore's access to overseas markets, thus facilitating DIA.

- **Channel 2: Reinforce Singapore's role as an air transfer hub.** This occurs as the new link may lead to changes in the global aviation network such that other city pairs in the network may now benefit from a reduction in their total flight distance and travel time by routing through Singapore as a new stopover option. The resulting increase in passenger transfers and cargo transshipments through Singapore will benefit the Singapore economy, including the services and logistics sectors. Additionally, increased demand for flights through Changi allows Singapore to enjoy economies of scale, such as increased flight frequencies and lower input costs.

2 *Source: The Business Times (https://www.businesstimes.com.sg/singapore/changi-airport-banks-apac-aviation-boom-strong-partnerships-growth)*
3 *Centrality is a concept from network analysis that describes the importance of a node within a network based on its connections with other nodes. Central nodes generally have larger contributions to the overall connectivity of the network, hence capturing greater network activity and having more influence on network dynamics.*

In the literature, there are two centrality measures commonly used in network analysis that map closely to the two channels described above:

- **Closeness centrality, which measures how efficiently one city can reach all other cities in the global air network, is our theoretical measure of market access (i.e., Channel 1).** The intuition is that a new direct flight between a city pair will not just increase the efficiency of travel between the pair, but will also have an indirect impact on the flight distance to other unlinked cities if the new link facilitates shorter routes than previously available.

- **Betweenness centrality, which measures the frequency at which a city is situated on a shortest path between other cities within the network, proxies for the city's status as an air hub (i.e., Channel 2).** The intuition is that a city that is frequently on the shortest path will have a higher likelihood of passengers and cargo choosing flight routes via the city to improve travel efficiency. The introduction of a new direct flight between a city pair may increase the frequency at which the cities are situated on a shortest path within the network.

To construct the above centrality measures and quantify the economic impact of improved air connectivity, we put together an analytic dataset from three separate data sources: flight schedules data covering scheduled air routes and number of air passengers at the route level from a third party data provider, the Global Human Settlement Layer dataset containing city-level GDP (available in 5-year intervals) and geographic coordinates, as well as Orbis foreign investment data detailing the date, investment amount, project status and source and destination cities at the project level.[4] The merged dataset covers over 2,000 cities for a few selected years within the period of 2014 to 2024.

EMPIRICAL METHODOLOGY

First, we construct the two centrality measures as follows:

- **Closeness centrality.** We compute an equivalent measure based on the flight distance between cities in the global aviation network. Specifically, we compute the shortest flight distance $\rho_t(i, j)$ between cities i and j in year t, with a penalty term of 2,700 km for each intermediate stop on the route, to account for the additional time needed for stopovers.[5]

- **Betweenness centrality.** We use the distance measure $\rho_t(i, j)$ above to identify whether a city lies on the shortest path between every other city pair in the global aviation network, with the paths weighted by the GDPs of the cities at the endpoints of the path, to compute our measure of betweenness centrality.

Second, following other network studies in the literature (e.g., Bramoullé et al. (2020)), we model the degree of influence a source node has on another node[6] in the network as the product of:

- The size of the connection between the two nodes, which we measure using the distance measure $\rho_t(i, j)$; and
- The strength of the source node, which we proxy using the GDP of the source city, $GDP_{i,t}$.

4 We include only projects where the source and destination cities are in two different countries, and retain only projects that are confirmed (i.e., projects that are rumoured or announced are excluded).

5 This is equivalent to the distance covered by approximately three hours of flight time, which we estimated from dividing passengers' willingness to pay to avoid a stopover by the valuation of air travel time provided in Ennen et al. (2019).

6 In this study, our transmission channels are economic flows, and our nodes are the cities where the international airports are located.

Third, to assess the impact of improved market access, we exploit changes in $\rho_t(i,j)\cdot GDP_{i,t}$ (which captures changes in closeness centrality)[7] over time that can be attributed to changes in $\rho_t(i,j)$ by fixing the GDP of the source city at the base year, and estimate the following two-way fixed effects regression at the city pair level:

$$Y_{i\to j,t} = \beta \cdot \rho_t(i,j) \cdot GDP_{i,t_0} + CityPair_{i,j} + Year_t + \varepsilon_{i\to j,t}$$

where

- $Y_{i\to j,t}$ is the economic flow from source city i to destination city j in year t for air passenger arrivals, and across year t to $t+4$ for FDI flows.[8] It also represents the economic flow from destination city j to source city i across year t to $t+4$ for DIA flows;
- GDP_{i,t_0} is the GDP of source city i in base year t_0; and
- $CityPair_{i,j}$ and $Year_t$ are city pair and year fixed effects respectively. The city pair fixed effects account for time-invariant properties of city pairs such as the geodesic distance between cities, while the year fixed effects account for global economic trends that affect all city pairs.

We also run the regression separately for two subsamples to account for possible heterogeneity in impact based on the geodesic distance between the cities, arising from factors such as differences in traveller profiles and availability of other transport modes. Specifically, we segment city pairs based on whether they are more or less than 7,500 kilometres (km) apart.[9]

Fourth, to study the impact of enhancements to a city's air hub status, we use the betweenness centralities computed to estimate the impact of changes in a city's betweenness centrality over time on its GDP using the following two-way fixed effects regression at the city level:

$$\ln GDP_{i,t} = \beta\, Betweenness_{i,t} + \varsigma \ln GDP_{i,t-5} + City_i + Year_t + \varepsilon_{i,t}$$

where

- $Betweenness_{i,t}$ is the betweenness centrality of city i in year t;
- $GDP_{i,t}$ is the GDP of city i in year t; and
- $City_i$ and $Year_t$ are city and year fixed effects respectively. The city fixed effects account for time-invariant city-level variables such as geographic location, while the year fixed effects account for global economic trends that affect all cities.

The coefficient of interest β represents the relationship between betweenness centrality and GDP. The inclusion of city and year fixed effects allows us to control for city-specific characteristics that do not change over time, as well as macroeconomic trends that are common to all cities. We also include lagged GDP (five years prior) to account for pre-existing GDP trends.

Finally, we use our findings from the analyses above to simulate the economic impact to Singapore from the introduction of new direct air links between Singapore and currently-unconnected cities. The simulations will allow us to identify cities and regions that currently have low air connectivity to Singapore, and if connected to, can strengthen Singapore's connectivity and generate significant economic benefits. We carry out the simulations in two steps:

- Step 1: We compute the changes in flight distance (ρ) for all city pairs in the global aviation network, as well as Singapore's betweenness centrality, if a direct air link is introduced between Singapore and a currently-unconnected city. The computation is carried out separately for every city with an international airport that Singapore is currently not connected to.

7 *Specifically, our regressor appears in the denominator of the weighted closeness centrality* $\frac{\sum_{i\neq j} GDP_i}{\sum_{i\neq j}\rho_t(i,j)\cdot GDP_i}$ *. The closeness centrality can therefore be viewed as a measure of the ability of a node to interact with the rest of the network.*

8 *FDI and DIA flows are aggregated across five years to smooth out volatile changes.*

9 *The cutoff of 7,500km is chosen as it is approximately the median distance between cities, across all city pairs in our sample.*

- Step 2: For each of these cities, we then simulate the economic impact to Singapore of introducing a direct air link between Singapore and that city arising from the overall reduction in flight distance for Singapore (i.e., reduction in distance between Singapore and the city connected to, as well as between Singapore and all other unconnected cities) and improvement in Singapore's air hub status (as measured by betweenness centrality). We do so by multiplying the overall reduction in flight distance and improvement in betweenness centrality for Singapore derived in Step 1 with (i) the historical relationships between flight distance and economic flows (FDI, DIA and air passenger arrivals), as well as the relationship between these flows and GDP;[10] and (ii) the historical relationship between betweenness centrality and GDP, respectively.

RESULTS AND DISCUSSION

Channel 1: Improved Market Access

Our analysis shows that improvements in market access arising from enhanced air connectivity (i.e., reductions in flight distance) are associated with statistically significant increases in cross-border investment flows (i.e., FDI and DIA) as well as air passenger arrivals, and the effects are stronger for city pairs that are geographically closer [Exhibits 1 and 2].

Specifically, we find that a 1-unit reduction in GDP-weighted flight distance, expressed as the product of the source city's GDP (in billion USD) in the base year and the flight distance measure ρ (in km), is associated with higher FDI inflows of US$490 and DIA outflows of US$1,250 over five years, as well as an additional 0.008 air passenger arrivals per annum, for the destination city, if the source city is less than 7,500 km away from the destination city by geodesic distance. As for source cities that are at least 7,500 km away, the impact is estimated to be an increase of US$192 and US$100 in FDI inflows and DIA outflows respectively over five years, as well as an additional 0.003 air passenger arrivals per annum, for the destination city.

The stronger investment response for geographically closer cities could be because these cities are more likely to be linked through regional production networks and existing trade and investment relationships, supported by regional integration initiatives and trade agreements. Improved air connectivity may reinforce these established linkages and generate a stronger increase in investment flows. Similarly, the stronger air passenger arrivals response for geographically closer cities may reflect the greater sensitivity of travel demand for short-distance travel to improvements in journey time and increased convenience, or regional tourism being seen as discretionary travel and hence having a more elastic demand.

The increase in FDI and DIA from enhanced air connectivity in turn translates to higher GDP by adding to capital formation and productive capacity in recipient economies, and enabling investing firms to expand their operations and enter new markets (Borensztein et al., 1998).

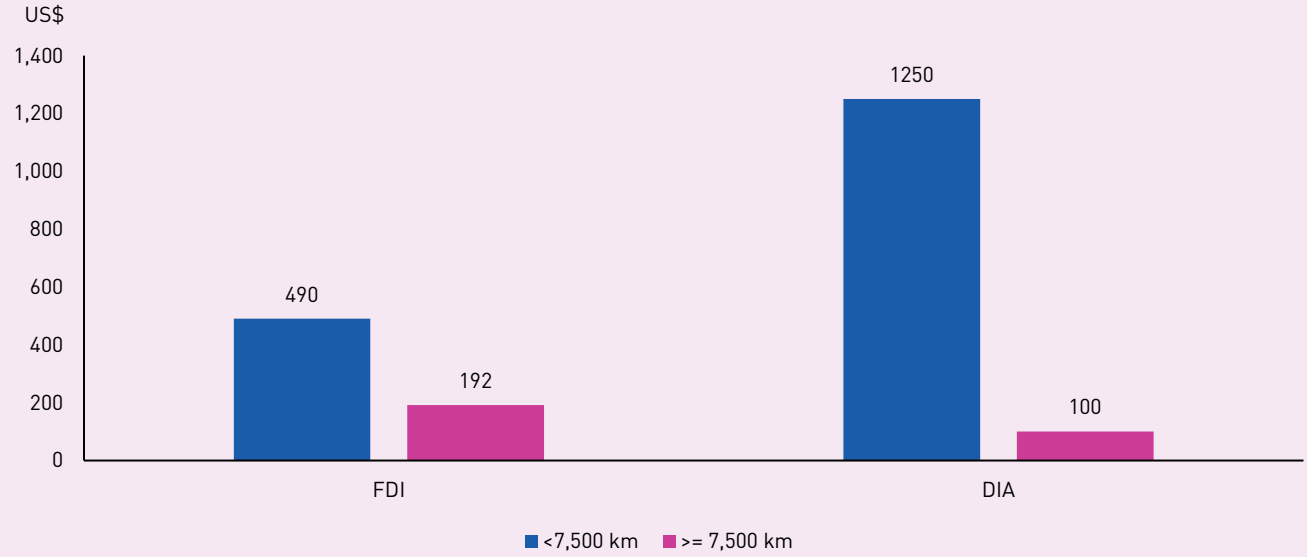
To put our technical estimates in context, eliminating a stopover along a flight connection (which results in time savings of three hours on average, or equivalent to shortening a flight by 2,700 km) to an economy of the same size as Singapore that is within 7,500 km of Singapore is estimated to lead to increases in FDI and DIA flows of approximately S$200 million (or 0.083 per cent of the historical average annual increase in FDI) and S$520 million (or 0.050 per cent of the historical average annual increase in DIA)[11] per year respectively, for Singapore. It will also likely increase air passenger arrivals to Singapore by 3,100 per annum (or 0.0089 per cent of our annual air passenger arrivals).

10 The elasticities used to convert FDI and DIA flows into GDP are based on estimates in the literature (e.g., Borensztein et al. (1998), Vu (2025)) and other studies. As for the increase in air passenger arrivals, we convert them into expected tourism value-added (VA), using historical tourist expenditure data and VA multipliers generated from DOS' Input-Output tables.

11 These are computed as the average annual increase in FDI and DIA stocks over the period of 2019 and 2024.

Based on elasticities from the literature, the increases in FDI and DIA are estimated to directly contribute S$160 million and S$65 million in value-added (VA) per annum respectively to the Singapore economy (or around 0.021 and 0.0085 per cent of Singapore's GDP respectively). Beyond these direct contributions, FDI flows may also generate broader economic benefits to the rest of the economy. For instance, a MTI study found that EDB-supported firms generated positive spillovers to other firms in Singapore, including higher VA, productivity, employment and wages.[12] Similarly, increased air passenger arrivals can support Singapore's air transport industry[13] and facilitate greater visitor spending in Singapore, thus benefitting other tourism-related sectors in the economy such as the accommodation, food & beverage and retail trade sectors.[14]

Exhibit 1: Impact of a 1-unit decrease in GDP-weighted flight distance on investment flows over 5 years



Source: Authors' estimates

Exhibit 2: Impact of a 1-unit decrease in GDP-weighted flight distance on air passenger arrivals per annum

Source: Authors' estimates

12 *Tan et al. (2025) reported positive spillover effects of EDB-supported firms on the VA and productivity of other firms that were driven mainly by the labour market channel. Technology space spillovers also contributed positively to local employment and wages by facilitating improvements in firms' production and organisational processes.*

13 *The air transport segment accounts for close to 10 per cent of the nominal VA of the transportation & storage sector in 2024, and includes Singapore-based airlines that provide air passenger and air cargo services, as well as firms that support the operations of airlines at the airport (Ngoh, 2025).*

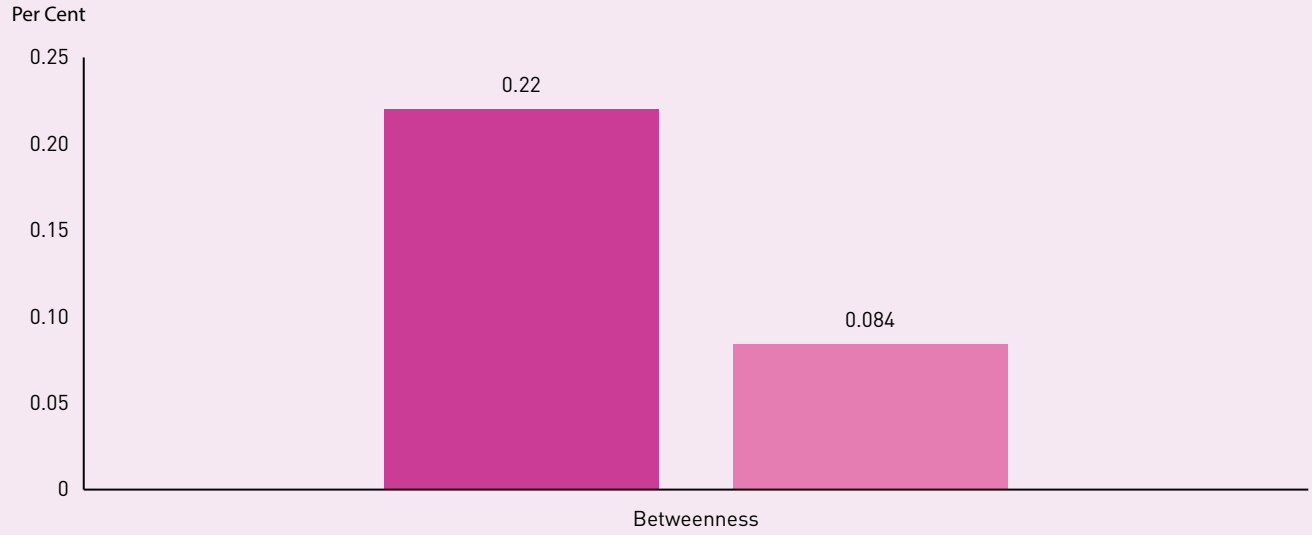
14 *Tourism contributes to the VA of several sectors, including accommodation, arts, entertainment & recreation, food & beverage services, retail trade, and transportation & storage. In 2024, tourism was estimated to account for 6.0 per cent of Singapore's services exports (Ngoh and Abdul, 2025).*

Channel 2: Enhanced Air Hub Status

Our analysis shows that a 1 percentage-point (pp) increase in betweenness centrality is historically associated with a 0.22 per cent increase in GDP [Exhibit 3]. Even among cities with GDP comparable to Singapore's[15] and would already be more connected globally, the same 1 pp increase in betweenness centrality is still associated with a 0.084 per cent increase in GDP.

Improvements in betweenness centrality contribute to GDP growth as the strengthening of a city's position as an air hub allows the city to benefit from the increased flow of passengers and cargo through its airport. Having a large volume of flows also facilitates agglomeration and economies of scale (e.g., airlines can maintain a higher flight frequency due to transfer demand), which further boost GDP.

Exhibit 3: Impact of a 1-pp increase in betweenness centrality on GDP



Source: Authors' estimates

Simulations of New Air Links for Singapore

Lastly, we conduct simulations on the existing global aviation network to identify cities and regions with which Singapore could potentially establish new direct air links with to best increase our closeness and betweenness centralities, and hence GDP.

As Singapore is already well-connected with most advanced economies, we find largest improvements to our centrality scores if there are new non-stop flights to developing and emerging regions, such as Latin America, Africa and Central Asia. These new air links will benefit our economy by facilitating access to new markets for investment and trade, particularly if we anticipate that these markets will enjoy sustained economic growth in the years ahead. Our simulations also identify selected cities in North America and Europe where introducing new direct flights could generate significant economic gains.

Concomitantly, the new direct flights will enhance Singapore's air hub status. By improving connectivity from these regions to Southeast Asia and Oceania via Singapore, Singapore could attract more passenger and cargo flows to route through Singapore.

While our analysis identifies the new air links with significant economic potential, we caveat that the feasibility of establishing these links will also depend on a range of operational, commercial and regulatory considerations. These include the availability of suitable aircraft (e.g., range and payload) to serve the route economically, airlines' assessments of the commercial viability of operating the route (e.g., potential yields, presence of competition, contribution to airline's network), and the availability of the relevant traffic rights.

15 We define comparable cities to be those whose GDP is at least one-tenth of Singapore's GDP.

CONCLUSION

In summary, this study finds that improvements to Singapore's air connectivity can generate economic benefits by improving market access and strengthening Singapore's air hub status. The findings highlight the importance of considering network effects when assessing new air links, as the economic value of a connection extends beyond direct traffic flows and improves connectivity across the wider network. Our simulations suggest that stronger links with less well-connected and growing regions yield significant economic gains.

More broadly, the study highlights how network analysis can deepen our understanding of the economic gains associated with air connectivity, including the gains arising from Singapore's position as a global air hub. As a small and highly open economy, Singapore's continued ability to connect with and be a connector between different markets will remain important for our economic resilience, competitiveness and long-term growth.

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