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Strengths and Weaknesses of Qantas's Flight Network

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Abstract: ***This article provides an in-depth analysis of the flight network of the famous Australian airline Qantas, aiming to reveal its strengths and weaknesses. Firstly, the performance of Qantas as Australia's largest airline in both domestic and international markets, as well as its relationship with its competitor Virgin Australia, were introduced. Secondly, the flight network of Qantas was visually analyzed using Tableau and Gephi software, aiming to gain a more intuitive understanding of its network structure and characteristics. By analyzing the nodes, edges, and attributes of the network, it was found that Qantas's flight network has advantages such as high concentration, wide coverage, and strong connectivity. However, there are also some shortcomings, such as overly concentrated routes and insufficient coverage in some areas. Finally, based on the analysis results, some targeted suggestions were proposed to develop more competitive strategies.***

Keywords: Qantas Flight Network; Airline Network Analysis; International Flight Route; Network Density and Centrality; Airline Network Efficiency; Tableau Visualization Analysis; Gephi Network Data Analysis; Business Analysis.

1. BACKGROUND INFORMATION

Qantas Airway Limited, i.e. Qantas is a famous flag carrier in Australia and is also the largest airline company in terms of fleet size, international flights and international destinations. Virgin Australia Airlines Pty Ltd, referred to as Virgin Australia usually, is another Australian airline and is one of the largest airline operations in Australia. Virgin operates well and satisfies the competition needs, but it is weak without continuous growth, however Qantas soared with its good performance domestically and internationally (Will Horton, 2020). Qantas is the largest competitor for Virgin so it is necessary to understand the situation of Qantas so that Virgin can get competitive advantages, especially during the travel restrictions caused by coronavirus. As a data consultant working for Virgin airline, a large amount of research has been done about Qantas's flights network, which is an important step to understand the weakness and the strength of Qantas. In this report, the graph objective is “the strength and weakness of Qantas's flight network”. Based on the data available in Qantas's official website, some techniques will be applied to visualise Qantas's network and some important indices will be analysed for a deep understanding of Qantas's network.

2. DATA MANAGEMENT

2.1 Data Overview:

Network dataset: The Network dataset is sourced from Route Map Dataset on Qantas website, which contains the routes information of Qantas and its patterner. Specifically, the 1200 routes connect 7 different parts over the world, including 348 routes of Australia and New Zealand, 109 routes of Europe, 239 routes of Asia, 28 routes of Africa, 363 of North American, 34 of South American and 82 of south pacific. Besides, each record provides route details in terms of departure airport, destination airport, flight time (hour and minutes), flight distance (km), operator (Airline company of the route) and comment (Airline company names for codeshare).

Airport dataset: This airport dataset sourced from the OpenFlights website. This dataset is applied to provide geographic information (latitudes and longitudes) of those airports in the Network dataset. And it was updated until January 2017. Latitude and longitude in this dataset use decimal degrees to six significant digits.

2.2 Data Validation:

The validation check was performed on both datasets. Network dataset is the combination of routes information from 7 different parts all over the world, which has the information of totally 1200 routes.

Uniqueness: the dataset is validated in terms of uniqueness of records. For airport dataset, each entry is a unique

record, which is identified by the airport name and city name. While for the Network dataset, there are 38 duplicated records, as a flight route might be categorized into different geographic area in terms of departure and destination airports.

Apart from that, there are also 72 records, which have exactly same departure airport and destination airport, but with different flight time, flight distance or operator. These records are also considered as duplicated, as the graph of flight airline is seen as routes and this information is not shown on network.

Missing values: As the airport dataset is generated at the year of 2017, there are 30 airports cannot find the matched geographical information without extra research. thus, those missed geographical information are manual recovered using Google Map and kept the same format (using decimal degrees, and 6 digits).

Data range: Firstly, the geographical data are validated in a reasonable range with latitude ranged from 53.0026 S to 61.2135 N and longitude ranged from 159.4800 W to 178.5601E. In terms of flight time, the longest flight is a 23-hour flight from Melbourne or Sydney to London, while the shortest one is 25 minutes of flight time. Flight distance in this dataset ranged from 81km (Blenheim – Wellington) to 17219km (Brisbane – Chicago). These variable ranges are validated to be reasonable with the existence of flight information.

2.3 Data Protocol:

2.3.1 Delete duplicate records and routs:

As mentioned in the data validation parts, there are 110 records duplicated with others. these data entries are deleted in the first step. After that there are still 1090 records of routes in the dataset. More importantly, the dataset is used to graph the flight network of Qantas and patterners. Therefore, only one route would be retained for go-return routes. For this reason, 528 other routes are deleted and the remained 562 data entries are applied in the network graphing.

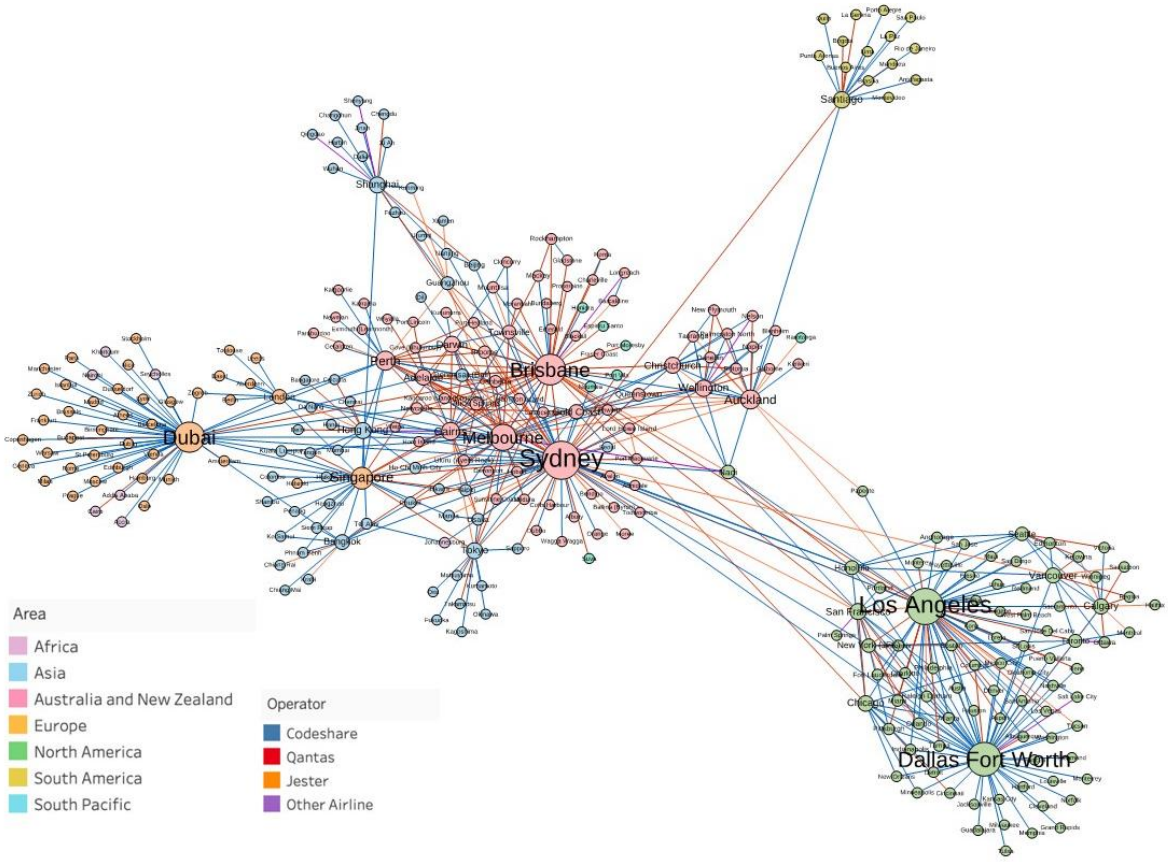
2.3.2 Data format adjustments:

In order to make the datasets applicable for Gephi, a node CSV sheet and an edge CSV sheet are required. CSV sheet for edges requires the name for departure airport to be source, and target for destination airport. For the Node sheet, it contains the Nodes, Label, latitude and longitude of the nodes. Table 1 below shows the format adjustments for the two excel files. Besides, the original unit measures for flight distance and time are removed, which allows Gephi to plot the edges and nodes with different weights.

Table 1: The data format for Gephi document

Edge CSV Sheet format					*Nodes CSV Sheet format*			
source	**target**	**Distance**	**Time**	**Operator**	**Nodes**	**Label**	**Latitude**	**Longitude**
Aberdeen	London	648	1.58	Codeshare	Aberdeen	Aberdeen	57.2019	-2.1978
Adelaide	Darwin	2620	3.58	Qantas	Accra	Accra	5.6052	-0.1668
Adelaide	Cairns	2132	2.92	Jetstar	Addis Ababa	Addis Ababa	8.9779	38.7993
La Paz	Santiago	1905	4.33	Other Airline	Auckland	Auckland	-37.0081	174.7920

3. NETWORK VISUALIZATION



Note: The color of nodes is encoded by area, and the color of edges is encoded by operators; Sizes of nodes encode degrees. Qantas and patterners' route network data retrieved from: https://www.qantas.com/travel/airlines/route-maps/global/en.

The graph above is the network implantation of Qantas and patterners' flights routs. The number of nodes (vertices) in the network is 291, and each node represents an airport or a city of destination. The nodes in the graph above also encode the location of the specific city or airport. The number of edges in the graph is 562, which means the accessible routes of Qantas and the company's patterner is 562.

3.1 Visualisation Choices

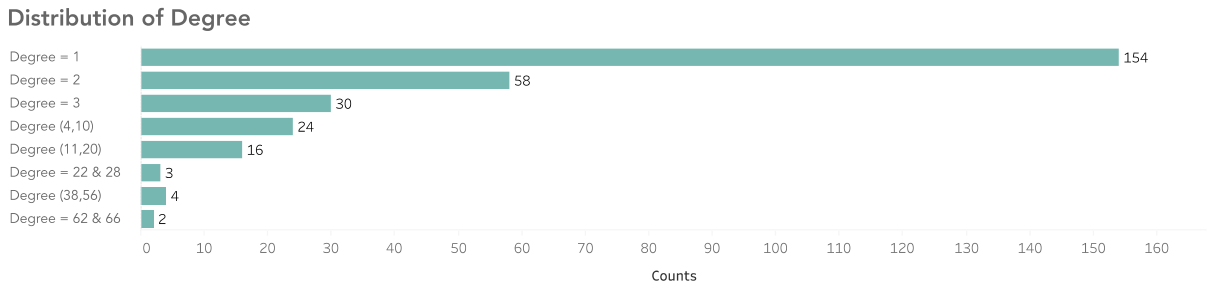
The Qantas' network uses line and point visual implantations to encode edges (routes) and vertices (airports) information. The Qantas' flight network uses two retinal variables. The first retinal variable is the colour retinal variable. In this network figure, the colour of nodes encodes region information. There are 7 colours representing 7 regions including Africa, Asia, Australia and New Zealand, Europe, North America, South America, and South Pacific. The colour of edges encodes operator information. The four colours represent Codeshare, Qantas, Jester, and other airlines. Codeshare refers to Qantas' partner airline companies such as American Airlines. The second retinal variable is the size of vertices. It represents the degree of network which is the extend of connectivity between vertices. The large size of the node indicates that the airport has many connections with other cities' airport.

3.2 Network Characteristics

Density: the density of a network is the proportion of edges that exist to the total number of possible edges and the number in this graph is 0.013. In a flight route network, the density measures the connections between airports, the larger the density, the better-connected airports over the world.

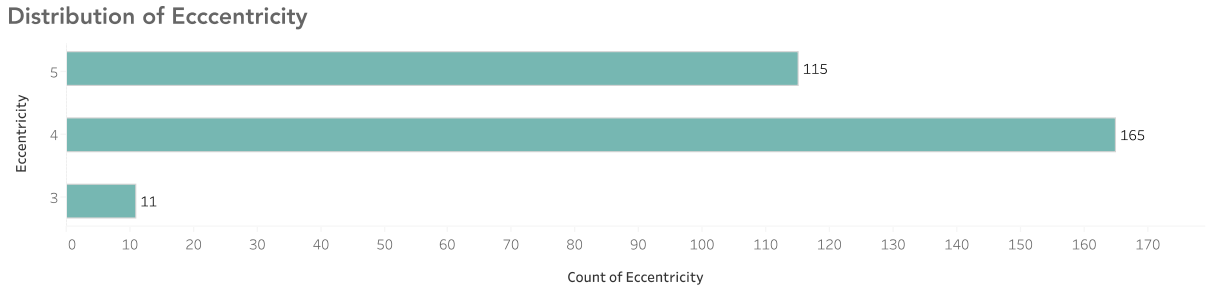
Average shortest path length: this is the average distance of all shortest paths in the graph, and the number for this graph is 3.154. Path in the airline network measures the number of trips from one airport to any other airport in the world. Therefore, the average shortest path length means that the average transfer times from one airport to any other airport through Qantas is 3.154.

Degree: the degree measures the extend of connectivity between vertices, calculated as the number of edges each vertex has. It indicates that how well a vertex is connected to others. A higher degree is expected in the airline network since it means that the cities are connected with many other cities directly and the passengers can take a non-stop flight to many destinations. In the Qantas's airline network, the degrees for each airport ranges from 1 to 66. The average for the whole network is 1.933, showing that each airport only has 1.933 edges. Although it is a small value, it is reasonable because an international network is analysed. In more detail, the maximum degree of the network is 66 for Sydney, and the minimum degree is 1, a mode in this network. It represents that passengers can fly from Sydney to many cities without transfer and transfer at Sydney to their destinations. In addition, some other cities such as Brisbane, Dubai, Dallas Fort Worth and Los Angeles also have high degree which are 49,48,56 and 62 respectively. These airports with high degrees are very important. If airport malfunction happens in these places, both Qantas and its customers are likely to have cost and inconvenience. It can be visualised from the network graph above, some small cities only have connection with one big airport, just like a star network in that area which is very fragile. The degree distribution gives the audience an overview of the probability density of the degrees in the network, which is shown below.



Note: the Node with largest degree is Sydney (66), and second large degree is Los Angeles (62)

Eccentricity: the eccentricity of a node measures the greatest distance between itself and any other vertex that is most distant in the network. This property can indicate the relative location of a vertex. For example, a vertex with higher eccentricity that is described as peripheral vertices could imply that the location of this vertex is far away from the centre. On the opposite, vertices with low eccentricity that are known as central vertices tend to sit on the central of the network indicating that it takes less effort from this vertex to go to any other vertex. Diameter refers to the maximum eccentricity which is the eccentricity of vertex that is the most peripheral. In the context of airline route network, the diameter is the maximum distance taken from one airport to its the most far away airport. The concept of diameter is very important for assessing whether the airline company's network is efficient or less efficient.



In terms of Qantas's flight network as shown in the graph, the diameter of this network is 5 indicating the flight network may not be efficient. From the distribution of eccentricity, the majority of airports (165) have eccentricity of 4 and there are 115 airports with eccentricity of 5. Only 11 airports have eccentricity of 3, which is the minimum in this network. For example, the diameter of 5 indicates that it takes 5 times of transit for a customer to travel from Berlin to the farthest cities in the network. Cities such as Sydney, Auckland, Los Angela's etc. with the lowest eccentricity of 3 imply that these cities are on the central of the network.

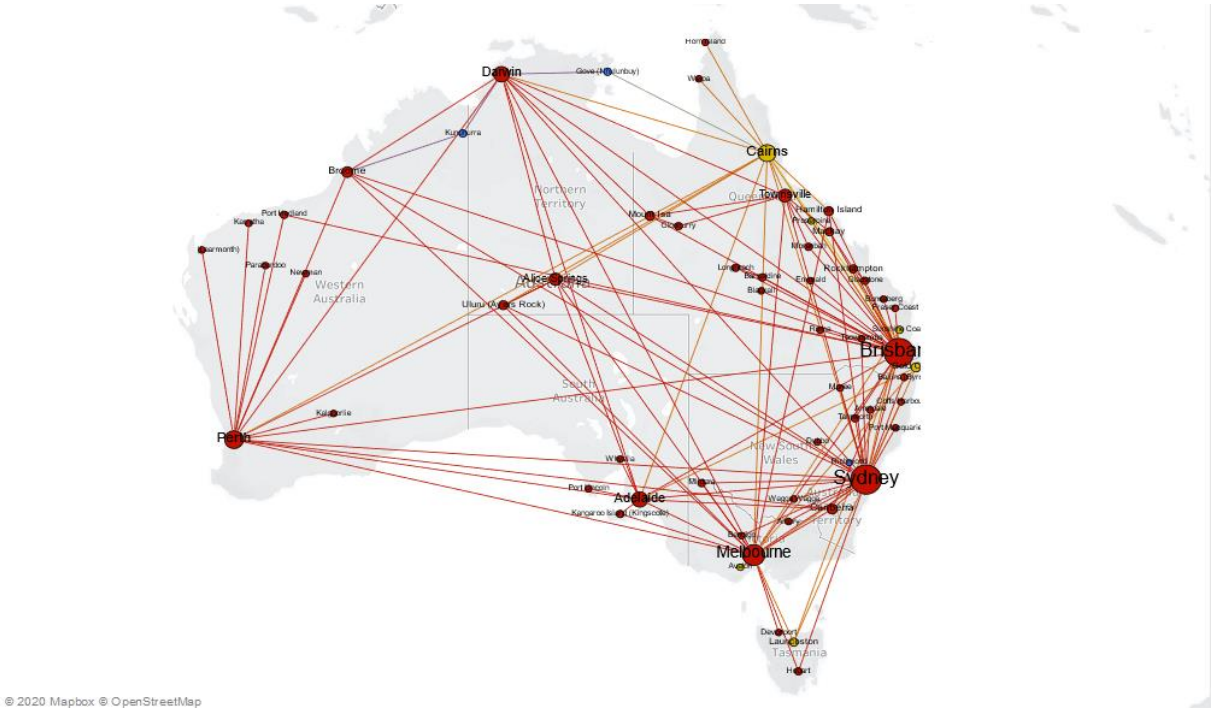
Centrality measures: centrality measures are used to calculate how quickly information flows across the network in either direction or to which extend the information influences other vertices. It is used to identify important nodes and help identify node influence. The main centrality measures regarding degree centrality, betweenness centrality and closeness centrality will be classified.

Table 2: Hub, broker and monitor in the network

Hub	Degree Centrality	Sydney
Broker	Betweenness Centrality	Dubai, Singapore, Shanghai, Brisbane, Santiago, Los Angeles, Dallas Fort Worth
Monitor	Closeness Centrality	Melbourne, Auckland

Centrality is used in the airline route network to measure the diversity of routes and the importance of airports. Sydney has the highest degree centrality, which acts as a kind of 'hub' for flight network. The route from Sydney can be connected to several other major airports including Melbourne, Brisbane, Los Angeles, Dubai and so on. Dubai, Singapore, Shanghai, Santiago, Brisbane, Los Angeles and Dallas Fort Worth have the highest betweenness centrality, which act as a kind of 'broke'. For example, passengers to Europe must transfer at Dubai Airport, to North America must transfer at Los Angeles and to China must transfer at Shanghai Airport. They have routes that other airports do not have. These airports are very important. Without these airports, passengers will not be able to travel further. Melbourne and Auckland have the highest closeness centrality because they have the shortest distance from all other airports. They are in the best position of international routes.

3.3 Domestic



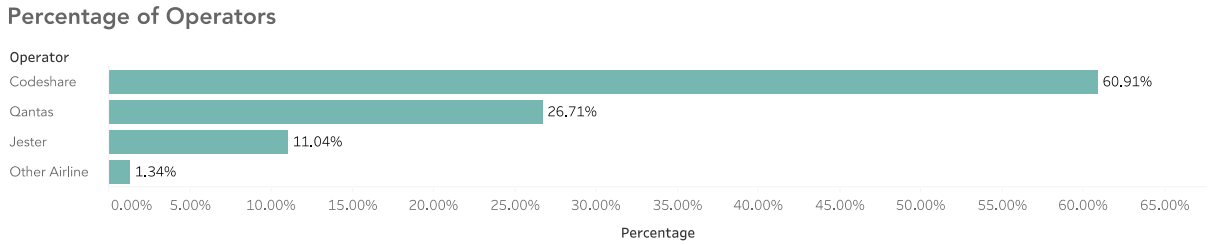
This is domestic flight network of Qantas. There are two essential components to building Qantas's domestic flight network. The number of edges is 121 and the number of nodes is 62. This means that Qantas has 121 routes in 62 airports in Australia. Given edges and nodes we can calculate some important network characteristics. Firstly, the density is 0.064. The greater the density, the more routes, and the greater the connection between airports. Secondly, the average shortest path is 2.381, which means from one location to another requires at least 2.381 routes on average. In other words, on average, passengers need to make one transfer from one location to another. Thirdly, the average degree is 1.952, which means that each node has an average of 1.952 nodes that can be connected. This illustrates that passengers can take Qantas Airlines from one location to another two locations on average. Finally, Sydney and Brisbane have the highest degree centrality because their airport is the closest to other airports and plays a pivotal role. Perth, Adelaide, Melbourne and Cairns have the highest betweenness centrality, because these four airports are connected to some small airports, and they have the only one route between them. Alice Springs has the highest the closeness centrality because it is very close to other airports from Alice Springs Airports.

4. NETWORK INSIGHTS

4.1 Strength of Qantas' Network

From the degree of centrality measure, we notice that Qantas tends to build transit centres in cities such as Dubai and Shanghai that are politically stable as brokers to expand the flight network from domestic to international, which is considered as a strength of Qantas's flight network. Qantas has begun to cooperate with Emirates for expanding its European market since 2013 (Flynn, 2012). This includes the route from Australia to London with one-stop at Dubai (Flynn, 2012). According to al-Mehairi (2016), there are three factors affecting the location of airports, which are technical, physical, and economic factors. The geographic importance of Dubai which is a major port city in the Gulf allows it to become an efficient linkage between Australia and Europe (al-Mehairi, 2016). Moreover, many countries' economy was affected by the global financial crisis in 2008 leading to a 3.7% decrease for the number of aircraft in Dubai, but increased by 9.6% in 2010, which indicates the high demand of passengers travelling through Dubai airport (al-Mehairi, 2016). In addition, Qantas has been in alliance with Shanghai-based China Eastern Airlines to expand its Asian market since 2015. Shanghai is a politically stable city and has been developed as a leading financial and shipping centre in China. It becomes a well-known global city for holding World Expo (Steinbock, 2010). Therefore, considering these cities as a broker to build Qantas' international transit centre is beneficial.

From density measure, the density of airlines in North America and domestic is high, indicating that the airports in North America and domestic are connected-well. According to the international flight network, Qantas has many routes around the world, especially in the North American market. Qantas operates in 14 countries/27 destinations in Africa, America, Asia, Europe and Oceania, and provides more than 200 other destinations with codeshare partners. The codeshare operator of international flight accounts for 59.96% of all operators. Codeshare allows companies to achieve industry cooperation, which is a beneficial way for passengers and both sides airlines to operate. Based on the codeshare airlines, passengers have more choices to go to more destinations, and it is more convenient to travel or work.



According to the domestic flight network, Qantas has performed well in the domestic market, with operations in more than 50 destinations in Australia, including all Australian capital cities, metropolitan areas, and many regional hubs. In addition, Qantas accounts for more than 61% of Australia's domestic market share and approximately 15% of the country's international travel (Bhasin, 2019). Strong domestic presence shows Qantas' competitive advantage in the country.

4.2 Weaknesses of Qantas' network

Even the cooperation of Qantas with joint ventures makes it approachable of customers to most places in the world, the efficiency of the Qantas' airline network is still in doubt. It can be firstly evident from the average shortest paths (3.154). this means a traveller needs to transact averagely at least 3.154 times if he wants to transfer from one airport to any other airport with Qantas or the cooperated airline. Meanwhile, from the distribution of eccentricity, the majority of airports (280) have eccentricity larger than 3, this also means a large number of connections during a single journey. However, transferring over 3 times in a single journey is not only exhausted, but also has the risk of missing sequent flights. Getting off a plane and walking to a distant departure gate can easily condense a 30-minute connection into almost nothing. Even if one can make it in time, the experience can be stressful, and the situation would be even worse when the experience repeats over 3 times in a single journey. Thus, the inefficiency in transferring could be a drawback of Qantas airlines and might lead to a decline in customer satisfactions.

It is also obvious from the dataset that Qantas runs an ultra-long-haul flight route between Australia and the UK, which takes 23 hours and 20 minutes flying in the air. This route was touted as a game-changer for the Australian tourism industry, but the 17,174 kilometers journey is doubted in terms of safety issues (Schneider, 2018). It claimed that staff operating the direct flights had an average duty period of 19 hours, and an average rest period of 25 hours in a hotel before hopping on board a flight home. However, this is insufficient and conductive to fatigue. Hence, the safety concern because of the over fatigue crew on the route has become another weakness of Qantas' network.

In addition, from the distribution of degree, a large number of airports (282) have degrees below 20, and 154 airports only have 1 degree. As viewed on the graph, the star-shaped network appears in different areas. This means that those cities with only one degree cannot be reached if the airport in the star centre breakdown. This not only indicates the inefficiency of the network, but also means a high cost to maintain the daily operation of the centre airports due to the high reliance on them.

Actually, Qantas has been encountering huge pressure to operate international flights. The profits on international flights are very low or even cannot achieve break even. Beside the safety concern, the long-distance flights between Australia to Europe are found to have difficulties in balancing profitability and demand in terms of reasonable pricing strategy (Hitesh Bhasin, 2019).

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Data Resource:

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