1. Introduction

1.1 Overview of Qantas

Qantas Airways Limited is the largest Australia air transportation provider with operating both domestic and international flight destinations. The company totally owns the approximately 314 units of aircrafts in the three main divisions which are Qantas, Jetstar and QantasLink (IBISWorld, 2020). The Jester is a low cost carrier division while Qantas uses a high price strategy. Therefore, they can target the different customer segmentations. Mainly, the competitors for the two divisions are Tigerair Australia and Virgin Australia Airlines respectively.

1.2 Project Sunrise

As an extension to the non-stopping flight routes, Project Sunrise, which is also a part of Qantas' future network planning, is under testing and is expected to operate in reality by 2022. For the purpose of cutting down the overall time during the trips, the project aims to operate non-stop and regular flights from the east coast of Australia to London and New York (QANTAS TO OPERATE 'PROJECT SUNRISE' RESEARCH FLIGHTS – DIRECT NEW YORK & LONDON TO AUSTRALIA, 2019).

1.3 Types of Network

Basically, in the airline industry, there are mainly three types of network. The first one is point to point network that customers mainly are routed directly from one destination to another destination (West & Bradley, 2008). Secondly, Multi-hub is another type of airline network. This type of network can reduce the congestion costs and save passenger's time. However, it is argued that multi-hub is not cost efficient. Thirdly, Airline who operates the large hub-and-spoke network will have a competitive advantage. It is argued that this type of network will bring the high profitability (West & Bradley, 2008). Also, it is argued that this network will minimize the schedule delay totally (Janic, 2000).

1.4 Hypothesis

So far, Qantas has achieved its success in the Australian airline industry. In this report, it is assumed that the Qantas' airline network makes a significant contribution to its success.

According to Janic (2000), most of the airline networks in the world would operate as hub-and-spoke and this kind of network has several advantages such as reducing the operating cost. As a consequence, it can be reasonably assumed that Qantas takes advantage of the same hub-and-spoke network, and in the subsequent parts it would provide detailed discussion.

1.5 Graph Objective

As this report stands from the perspective of a Qantas' competitor, several graphs would be drawn on the purpose of analyzing the strengths and weaknesses of Qantas' airline network and demonstrating the hypothesis. After that, better strategies can be made by the competitor because it gains an entire comprehension about the airline operation of Qantas.

2. Data Management

2.1 Data Validation

(1) Validate existence: The data has been extracted from Qantas's website (Qantas, 2020). There are 1200 observations in total and 598 missing values in "Comments".

(2) Validate data type: The data type of all columns is string in the original data. The data type of "Distance" and "Time" should be Number (whole), which will be discussed below.

(3) Validate uniqueness: There is one duplicated observation in the data.

(4) Validate composition: “Distance” and “Time” contains string such as “1315km” and “2hr 15min”, which needs to be cleaned to “1315” (km) and “135” (minutes).

(5) Validate range: The range of “Distance” and “Time” is (0, +∞).

(6) Validate relation: There’s no deterministic relationship within variables.

2.2 Data Processing

(1) Extract Distance and Time

The data in “Distance” and “Time” has been extracted using regular expression. To extract distance, we use INT(REGEXP_EXTRACT([Distance], '(\d+)')) to extract any digits that are extracted, e.g. extract “1315” from “1315km”.

To extract time, hours and minutes are extracted separately. We use INT(REGEXP_EXTRACT_NTH([Time], '(\d+)\s?(h)', 1)) to extract the hour and INT(REGEXP_EXTRACT_NTH([Time], '(\d+)\s?(m\s?i?n?)', 1)) to extract the minute, e.g. extract “2” and “15” from “2hr 15min”.

Then time has been calculated according to hours and minutes. If hour is NA, the time is minute; if minute is NA, the time is hour multiplied by 60; else, the time is time is hour multiplied by 60 and added minute, e.g. calculate the time of “135” = 2*60+15 according to “2hr 15min”.

(2) Clean the Data of Jetstar

When we filter the operator “Codeshare”, we find some observations’ comment contains “This service is operated by Jetstar Asia” or “This service is operated by Jetstar Japan”. We group these observations’ operators as “Jetstar”.

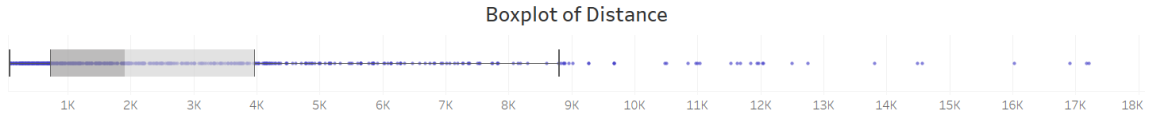
(3) Get Coordinates

We use Python to get coordinates of the departure cities and destination cities. Coordinates are collected in a form of (latitude, longitude), e.g. Adelaide’s coordinate is (-34.9281805, 138.5999312). Then the coordinates are split into “-34.9281805” and “138.5999312” in Tableau.

3. Visual Data Analysis

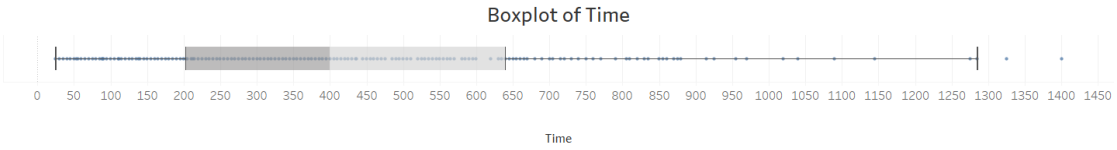
3.1. Distribution of Features

Distance: The skewness of distance is 1.874 which means the distance is not normally distributed and is right skewed. In addition, from the boxplot (Graph 1), we can see there are many extreme high values which means there are many long distance flights in Qantas flight network.



Graph 1

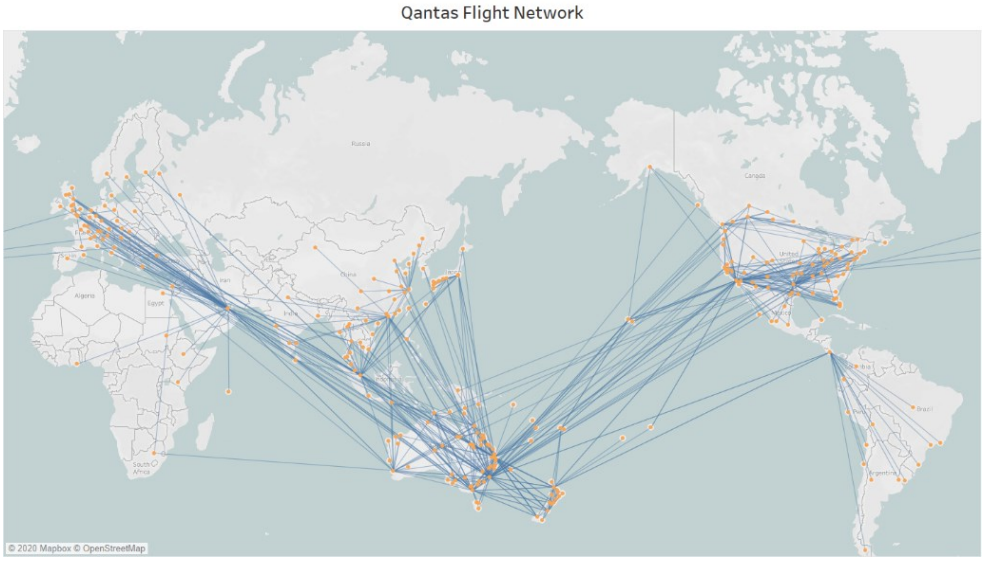
Time: The skewness of time is also not normally distributed and right skewed. According to the boxplot (Graph 2), it can be seen that there are also outliers in time. However, the extreme high values in time is less than that in distance.



Graph 2

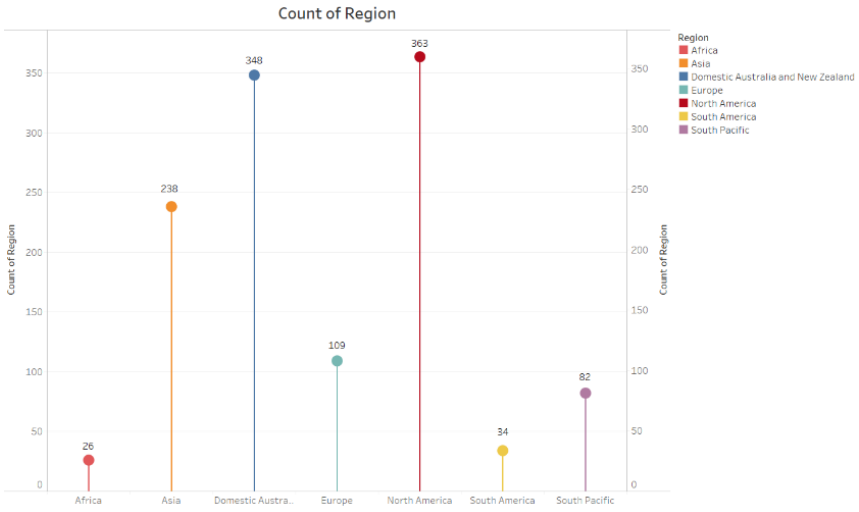
3.2 Flight Network Overview

The overview of the network is drawn by Tableau with the global map background (Graph 3). It can be seen that the route of Qantas is almost all over the world without any flight route in Russia.



Graph 3

According to the bar chart of the region (Graph 4), it can be seen that most flights are in domestic Australia and New Zealand, as well as in North America. However, in Africa and South America, there are only few routes which is almost 10% of that in North America. Therefore, the company's main markets are in North America, domestic and Asia.



Graph 4

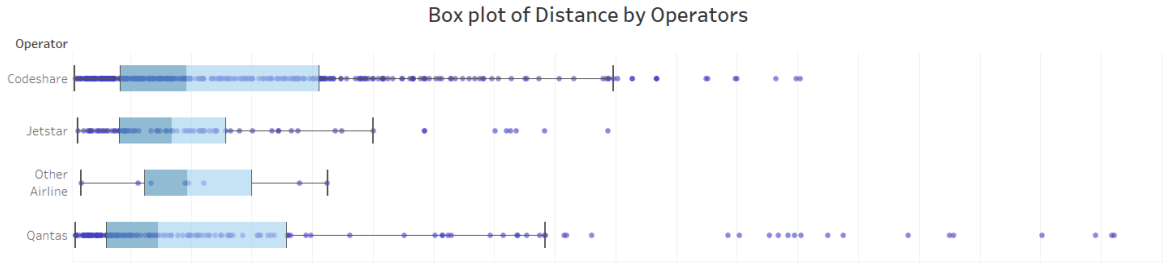
3.3 Word Cloud

Using Tableau to draw word cloud (Graph 5) of departure (left) and destination(right) separately, it can be seen that high occurrence airports are almost the same between departure and destination. Los Angeles and Sydney are the major cities in the flight network.

Graph 5

3.4 Operators

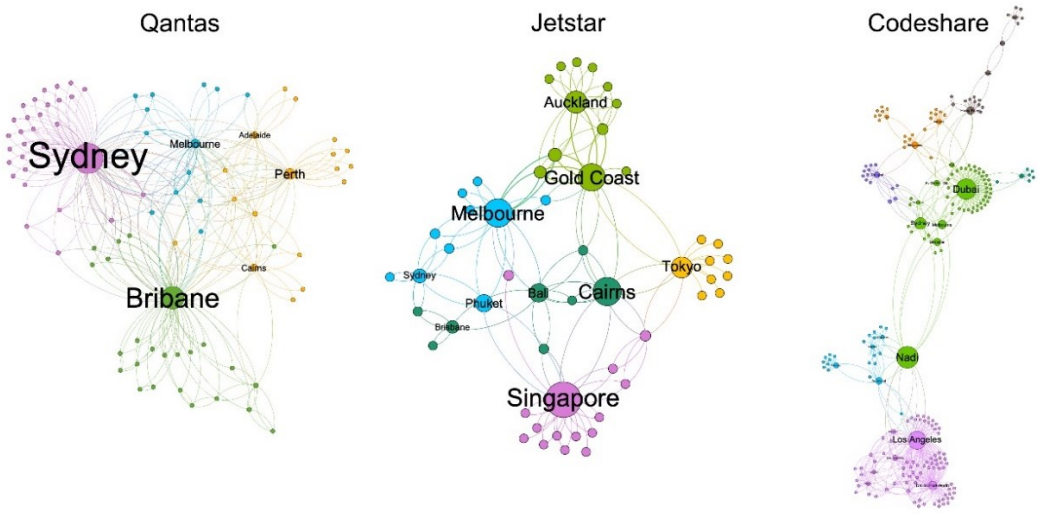
From Graph 8 in APPENDIX, we can see Codeshare takes the largest part of the Qantas's flight network which is 696 routes (58% of total) and Qantas itself also has large proportion which is about 27.8%. According to Graph 6, it can be seen Qantas itself has more outliers in the 4 operators which means most of the long distance routes are operated by Qantas. This is in line with the research that Qantas increased long distance routes since 2017.



Graph 6

4. Network Analysis

Using Gephi, the Graph 7 is drawn to show three networks of the Qantas group, which are Jetstar, Qantas and the Codeshare network.



Graph 7

In the subsequent analysis, some indexes would be calculated to describe the networks quantitatively and compared with those in the Australian Flight Network Overview. The result is in Table 1.

	Jetstar	Qantas	Codeshare	Australian Flight Network Overview
		Directed		
Nodes	54	86	227	131
Edges	142	300	670	586
Average shortest path	3.272	2.399	4.466	2.9
Modularity	0.573	0.392	0.629	/
Average degree	2.63	3.488	2.952	9.1
Density	0.05	0.041	0.013	/
Average clustering coefficient	0.118	0.42	0.219	0.5

Table 1

Node: A node is a point that distributes network routes (Margaret, 2020). The nodes in the flight network are the airports that distribute flight routes. Qantas's network has 86 nodes, which means there are 86 airports in its flight network. Qantas's network size is bigger than Jetstar's with 54 airports but smaller than Codeshare with 227 airports. According to Hossain et al. (2013), Qantas's network size is smaller than Australian Flight Network Overview with 131 airports.

Edge: An edge is the connection between nodes in the network (Nykamp, 2020). The edges in the flight network are the flight routes that connect airports. Qantas's network has 300 edges, which means there are 300 flight routes in its network. Jetstar has only 142 flight routes while there are 670 flight routes in Codeshare. Australian Flight Network Overview has 586 flight routes, which is more than Qantas and Jetstar since it combines all airlines, but it's less than Codeshare's because Codeshare covers not only Australian airlines.

Graph Type: A directed graph is a graph where all the edges are directed from one node to another (Nykamp, 2020). Jetstar, Qantas and Codeshare's flight network graphs are all directed graphs. Every flight route is directed from a departure city to a destination city.

Average Shortest Path: Average shortest path is the average number of steps along the shortest paths for all possible pairs of network nodes (Mao & Zhang, 2013). It can measure the efficiency of mass transport on a flight network. The smaller average shortest path, the less need to transfer flights to get to other cities. Qantas has the smallest average shortest path of 2.399, which means the least need to transfer flights to get to other cities.

Codeshare has the largest average shortest path of 4.466 since its flight network is sparse across the world and customers need to transfer a lot to get to other cities.

Modularity: Modularity is used to describe the nodes and edges falling within sub-groups (Newman, 2006). Higher modularity indicates more clusters. In the hub-spoke network model, the centers of clusters can be considered as hubs. Qantas has the smallest modularity of 0.392 with 4 hubs (Sydney, Brisbane, Perth and Melbourne). Jetstar has a modularity of 0.573 with 5 hubs (Singapore, Gold Coast, Melbourne, Tokyo and Cairns). Codeshare has the largest modularity of 0.629 with 7 hubs (Log Angeles, Dubai, Auckland, Singapore, Hong Kong, Shanghai and London). Qantas's hubs are all in Australia, Jetstar's hubs are in Australia and Asia, while Codeshare's hubs are all over the world.

Average Degree: Degree of one node is measured as the number of edges that one node has, and the average degree is the average number of edges per node in a single graph (Hossain & Alam, 2017). The larger the degree of node is, the more important the node is. In the flight network, the nodes with larger degree are considered as hubs, and the average degree reveals the busyness of the nodes. From the chart, it can be seen that the nodes of Qantas own on average 3.488 edges, which is the largest among the three groups ,and it indicates that the nodes in Qantas' network are the most bustling. However, the average degree of Codeshare's network, which equals to 2.952, is not as large as the graph shows, with a possible reason that the number of nodes with small degree (smaller than 2) are relatively high. And as the Australian benchmark contains all the airport networks in Australia, the average degree, 9.1, is much higher than any network that this report discusses.

Density: Density of a graph is the proportion of existing edges to all the possible edges (Jilbert, n.d.). In airline networks, it reveals the busyness of the whole network, since a higher density means more connections among the nodes. The data shows that Jetstar has the highest density, 0.05, among the three groups, because the number of its nodes is small, and these nodes are well-connected. On the contrary, the density of Codeshare network, which is 0.013, is the smallest since its connections are the most scattered compared with the other groups.

Average Clustering Coefficient: Clustering coefficient measures the degree of which the nodes tend to aggregate together, and its average evaluates the completeness of the cluster in the entire network, as higher the average clustering coefficient means the more complete of the network (Watts & Strogatz, 1998). For example, if the average clustering coefficient equals to one, the network is complete and would be described as a clique. The average clustering coefficient of Qantas, 0.42, is the highest which approximates to the Australian benchmark, 0.5, which reveals the busyness and complexity of the Qantas' network with the operating airlines. And the average clustering coefficients of the other two groups are much smaller. For Jetstar, the connections could be improved. And the hubs play the key role in the Codeshare network since the number of airlines is high, but the average clustering coefficient is relatively small.

Based on the analysis, it can be concluded that the networks of Jetstar and Qantas share the same advantage, well-connected, but Jetstar tends to be a simple one and Qantas' network is more complex. As for the Codeshare network, since the flight routes are cooperated with other airlines, the network is scattered with some hubs and the connections among the nodes are not as good as Jetstar or Qantas.

5. Insight

In Qantas's flight network, there are mainly 3 operators: Qantas (including QantasLink), Jetstar and Codeshare.

5.1. Codeshare

A large amount routes of Qantas are operated as Codeshare. Although many indicators of Codeshare are higher than Qantas and Jetstar, it doesn't mean the network of Codeshare is more completed than the other two. It's mainly because there are many cooperation companies with different network structures and hubs. This type of operation has significant strengths as well as some weaknesses.

Strength:

- Reduce the operational cost while expending customers. Qantas can improve their flight network and overcome the barriers of some countries' aviation markets without investing too much. It can also attract new customers by expanding new market and provide service as the actual operators for other companies.
- It can also reduce the risk. Without the initial and operational cost, Qantas will lose less when crisis happens. Situation in 2020 is a good example. Because of the COVID-19, many airlines are shut down. If all the routes are operated by Qantas, the risk for them will be larger.

However, there might be some weakness. If the customer only wants to experience the service and flight provided by Qantas, when he or she find the actual operator is the other company, the customer may reduce their favorability of Qantas.

5.2. Qantas

Strength:

- Focusing on providing better service. One of the excellent services is less transferring. As mentioned before, Qantas has many long distance routes and will increase some non-stop and long distance flight. In addition, it has the smallest number of average shortest path which means lowest transferring.
- Powerful hubs. Qantas has the largest figure for average degree which means the nodes of Qantas's hubs has great number of customers and it can maximize the freight efficiencies.
- Complete network. The average clustering coefficient of Qantas is the largest among the three operators which means Qantas can satisfy more customers.

Weakness: Qantas relies heavily on the specific four domestic hubs. If one of them break down, the transferring will unavailable around that hub and the whole network will be influenced magnificently.

5.3. Jetstar

Strength:

- Focusing on serving budget customers. Jetstar is a low-cost airline and customers care economical cost more than time cost. Jetstar has the second largest number of average shortest path, and it means customers need to transfer more which is in line with company's positioning.

Weakness: Jetstar has a low number of average clustering which means the network is not complete. As a company aims to provide low-cost airline, Jetstar needs to have more connections between different airports.

6. Conclusion

In this report, visual data analytics is implemented to reveal the information of Qantas' network, which indicates its complexity. As a consequence, Qantas' network has been discussed in three parts, Qantas (including Qantaslink), Jetstar and its Codeshare network. In the network analysis, it is found that the networks of Jetstar and Qantas are both well-connected, but the one of Qantas is more complex than that of Jetstar. And the Codeshare network is much more scattered. Thus, each of them has different strengths and weaknesses. In short, based on the analysis, one can gain the overview of Qantas' network and implement better strategies when competing with Qantas.

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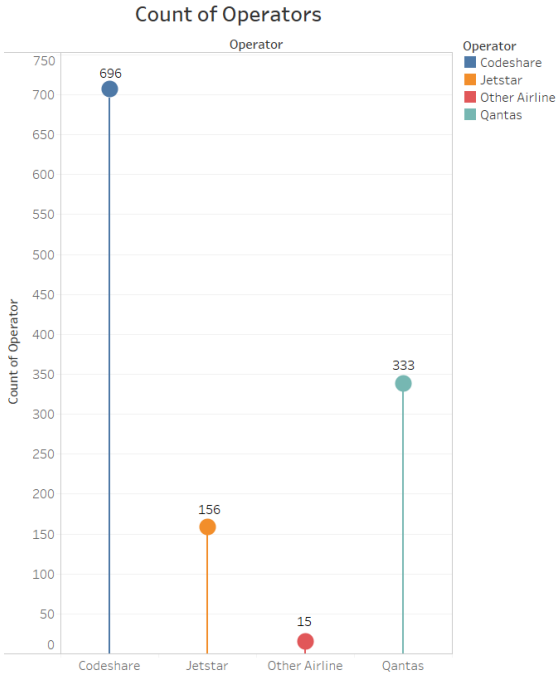
Appendix



Graph 8