

Revenue Optimization for SAUDIA Transit Operation

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Abstract - People have been migrating to various locations in search of better living. This is why they began to adopt and innovate multiple modes of transportation since the dawn of civilization. In the modern era, airline sector has transformed into a convenient mode of transportation due to time limitations of passengers. Given the dynamics of the airline sector and drastically changing global environment, SAUDIA airline realized the need of the time to revamp its operational capacities and strategies to deal with fierce competition. SAUDIA serves both domestic and international markets with huge customer facilitation; however, recently it has gone through severe competition and a subsequent loss of market share due to its slow response to the dynamics of the market. Therefore, understanding the constituent elements to revamp its network is crucial for SAUDIA to regain its market share so that it may attain its desired revenues. Keeping in view, this study is an endeavor to propose a new schedule based on a synergy of SWOT analysis, waves for the SAUDIA schedule, premium market analysis and nested logit model to overcome these problems. The proposed framework utilizes the shape of the waves under specific constraints to generate improved schedule by calculating market share and to decide based on nested logit regression model. The implication of this new schedule requires meeting several constraints such as the availability of aircraft within allocated time-windows, minimum connection time and minimum usage rate per aircraft per day. Findings of the study suggest that the proposed schedule is expected to increase total transit traffic by 48 percent with a 30 percent increase in the number of sources and destinations by SAUDIA, whereas it will enhance the overall fleet utilization by 12.5 percent. Additionally, it is anticipated that the proposed schedule would surge the revenues by 17 percent as compared to SAUDIA's regular weekly plan.

Keywords: Forecasting, Scheduling, Multi nominal Logit Model, Air Travel Demand, Optimization.

I. INTRODUCTION

Companies adopt various business models to target different customer segments that vary in their characteristics and preferences in choosing any product or service. Like any other industry, the aviation industry is exposed to competition by different players. However, over the last few years, the

aviation industry has seen several changes in the Kingdom of Saudi Arabia, such as the entrant of new carriers in the market, which led to aggressive competition in the domestic and international market. With the fierce competition in the industry, the acquisition of customers becomes more complex, and each company is looking to get more customers and have a more significant share of the cake.

Furthermore, as people behave differently in every aspect of life based on numerous things, they choose an airline and purchase a ticket. Someone might prefer a flight based on its price while another chooses a flight based on the day of the week or time of the day or an interaction of both. Moreover, another vital factor plays a major role which is flight operation mode and whether it's a direct flight or a non-direct flight with a stop in between and for how long should someone wait in this stop plus the features of that airport. Additionally, some people might prefer purchasing a flight depending on the type of equipment operating in this flight, for instance, turboprop equipment isn't preferred to many as it's noisier than jet planes and many think it's not safe. However, all these factors affect the choice of purchasing a ticket or choosing a route rather than another in the airline industry. So, identifying all these preferences will help airline companies to understand their customers better and then offer better service which will reflect on financially.

SAUDIA has dealt with the needs of air travel in the past years and has played an important role in the growth of the airline sector in Saudi Arabia as a result of this phase, a massive base of operations has been established, complete with infrastructure, ground and flight equipment, and trained staff. SAUDIA currently has a total of 145 aircraft by end of 2020 for scheduled operations. Type of aircraft and their numbers are shown in Table 1.1: SAUDIA Total Fleet in 2020). SAUDIA has made a significant contribution to the growth of the airline market of the Kingdom of Saudi Arabia by connecting geographically dispersed population centers in a country the size of Western Europe, promoting social and economic cooperation between domestic and foreign regions. Furthermore, the fast transportation of foreign and Saudi workers on both international and domestic routes has considerably enhanced the Kingdom's industrialization. With an average of 571 departures per day, the new SAUDIA network consists of 89 stations (27 domestic, 62 international).

Making the right schedule is crucial for an airline to increase revenue and then sustain and grow. This happens to be the problem of every airline in our world and SAUDIA is certainly one of them. SAUDIA is the biggest carrier in Saudi Arabia. It serves domestic and international markets through its main airports Jeddah and Riyadh. Lately, SAUDIA had a spilled market share due to the fierce competition in the industry. Therefore, SAUDIA wants to regain its market share and improve its revenue. Different service factors of an airline schedule affect its market share and therefore its revenue. For example, one passenger might choose an airline because of its fare for a given day and others might pay more to get in a specific time of the day. Therefore, SAUDIA needs to identify different attributes that affect the market share and then design a schedule with the optimum attributes to gain more market share and therefore improved revenue.

The scope of the work is to help SAUDIA Network Planning department restructure its network by identifying different service factors that affect the market share and helping them regain their lost market share by proposing a new schedule.

Airlines sell the value of time on their aircraft on specific dates for specific directions. In other words, the value of an airline is represented by its schedule because it has all the elements mentioned earlier and the type of equipment and different attributes. Therefore, passengers choose which airline based on the attributes of its schedule. In our research, identification of all the service factors that affect market share is made. This identification will help us redesign the SAUDIA schedule that will improve its market share and, consequently, its revenue. This study will provide SAUDIA a better understanding of the service factors that affect market share. It will provide SAUDIA with an optimized schedule to increase its market share revenue and improve aircraft utilization.

The main objective of the research is to identify different service factors that affect itinerary market share forecast. For this purpose, the study intends to predict itineraries market share for SAUDIA schedule of the identified market pairs with maximum coverage for O&D (Origin and Destination) passengers and with the optimum service factors to gain more market share in all the scheduled itineraries.

II. LITERATURE REVIEW

The network strategy determines the structure of a network in aviation. Historically, airlines were controlled by the government and serviced the public or political needs for air transportation infrastructure (Button & Taylor, 2000). According to O'Kelly (1998), following deregulation in the United States in 1978, highly centralized hub-and-spoke networks immediately emerged as the perfect solution for

servicing huge markets at low costs. In response to this approach, Low-Cost Carriers (LCCs) came up to take on hub-and-spoke networks by providing direct services when hub-and-spoke airlines only provided connection services through their network.

Goedeking (2010) states, "unfortunately, an airline cannot accommodate all passenger-timing preferences at the same time due to financial considerations or operational constraints." Correspondingly, the author further elaborates that "network airlines try to optimize connectivity, or the ability to arrive on one flight (edge) and connect to an outbound flight, thus creating a path." On the other hand, planners in the aviation industry must understand the specific criteria of the traveler which he uses to choose the most appealing connection. The traveler most likely weighs the overall trip duration, the airline's reputation, departure and arrival schedules, and the appropriate pricing (Mason, 2000; Proussaloglou & Koppelman, (1999). The traveler ultimately opts for one of these connections based on the relative relevance of these and other variables (Harvey, 1987).

While using a market share model, attempts to replicate this decision-making logic by measuring all relevant quality criteria and then applying suitable weighting factors to each criterion. Goedeking (2010) believes that one of the most used models is logit which "assesses the utility of a product or service along with a series of criteria if compared against competing alternatives."

Similarly, bank structure is considered as one of the factors in designing a connectivity-driven network. However, Goedeking (2010) explains that "a bank is "a temporal cluster of inbound and outbound flights, whereby the inbound flights all arrive within a relatively short and limited period, and the corresponding outbound flights depart within a short period once most or all of the inbound flights have arrived." Hence, it can be presumed that by creating a bank the likelihood of making more and quick connections increases. While airlines try to create a pattern of movement by creating waves, Goedeking (2010) elaborates a wave as "the combination of an inbound and a corresponding outbound bank, separated from other waves by periods of reduced activity."

The literature is well-abundant with studies that reviewed the relationship between airline service characteristics and the allocation of air volume. In a previous study, Dresner and Xu (1990) studied the effect of three customer service variables on customer satisfaction measures and corporate performance measures. The authors concluded that increasing customer service raises customer satisfaction and that increasing customer satisfaction improves corporate performance. While Morash and Ozmet (1996) discuss the strategic use of

transportation time and reliability for competitive advantage and determine how consumers consider time as the main reason for preferring a flight of a specific airline against another. Moreover, they describe that the airline industry differs from others in their approaches to time-based competition and its advantages on the community. They divided time advantages into two categories: internal and external. External time benefits are product/service-related, and it proposes providing clients with time-oriented service, which would improve their perception of service quality and, ultimately, their level of satisfaction. While the internal time advantages are network size, connectivity, and density. Their paper addresses several questions regarding strategies for consumers, levels of customer-perceived quality, outperforming the competitors, internal network advantages, and external time-competitiveness. The study also differentiates various external and internal time advantages to extract high-quality performers from the rest. They put these issues to the analysis using benchmarking technique. They conclude that both external time-based tactics and internal network-based tactics are significant for consumer perceived quality in the airline business.

Further, Demydyuk (2011) discovers the financial performers for the airline sector in compliance with the on-time reliability, frequency of service, and fulfillment of service. At the same time, Buhalis (2004) compares the statistically and substantially different factors of internal techniques from the average quality performance of external time-based techniques. Further, airline network density is most closely correlated with excellent performance in internal network-based tactics, network size, connectivity, and dimensions (Wojahn (2001); Caves et al., 1994). However, the external and internal time advantages most differentiate the top performers from the rest (Min & Joo, 2016).

In another study, Wooi Leng Ong and Andrew (2009) apply the logit analysis to assess the factors of airline choice between Malaysia airlines that offer full services on board and Air Asia, which is mainly a low-cost carrier at the Penang International airport. They looked for a set of socio-demographic explanatory factors, such as age groups, ethnic categories, gender, work sector, monthly income levels, and educational level, to investigate why people choose one airline over another. Using airport and airline choice variables, the research employs a two-level Nested Logit model to determine which characteristics have the greatest impact on passengers' choice of airport and airline. The authors observe that airline service factors affect passenger choices in the Seoul metropolitan area given the fierce competition. In a nutshell, the authors concluded that a traveler in the market is willing to pay to change the flight time by an hour and reduce the access time by an hour. Lowering flight time is more essential than

lowering access time for international long-haul travel. Furthermore, the model estimation shows that latent factors such as pricing, flight duration, frequency, access time, access cost, and airport access convenience considerably impact passenger airport choice behavior.

In addition to this, concerns about cost, flight schedules, method of booking, the purpose of the trip, and travel locations are also significant behavioral factors (Jung & Yoo, 2014). Meanwhile, Chen and Chao (2015) found that behavioral factors were more prominent than socio-demographic variables.

Additionally, in another study, Jung and Yoo (2014) examine the case in South Korea regarding passengers' choice behavior when traveling short-haul domestic routes. With the noteworthy growth of the low carriers LCCs in South Korea, the authors argue whether LCCs have generated new demand or destitute the full-service customers. In order to predict the probability that a decision-maker will choose among finite options, the discrete choice model has been employed. Moreover, the study explores the travel choice of the domestic traveler using the Multinomial Logit model which is a generalization of the binary logit model. The study also uses a nested logit model, a decision-making model that predicts the probability that an individual would choose one option from a collection of mutually exclusive and collectively exhaustive options. Using various estimation techniques, the authors investigate the changes in passenger decision behavior between business and non-business passengers for full-service carriers, low-cost carriers, and Korean fast trains. The result reveals that business travelers are more ready to pay to minimize access and journey time than non-business travelers. In addition to this, pricing, access time, and transit time have a substantial role in passenger selection and for short-hour domestic passengers, lowering access time is more essential than reducing route time.

Gillen and Gados (2008) found that given the competition between both kinds, LCCs used strategies to attract customers by lowering ticket prices and operating efficiently to have decent corporate performance. However, an entry of a new market player could turn the table. For instance, Sun (2015) elaborates that competition in the domestic short-haul sector of Korea was enhanced due to the entry of Korea train express (KTX), which is preferable to air transportation as its journey times are shorter when traveling between cities.

A mixture of important time and cost variables was discussed in another strand of literature. Such as journey time (Tam et al., 2008), terminal waiting time (Tavalaie, 2020), and access time (Pels et al., 2009). In addition to this, authors highlight that passenger may pick a carrier based on several

variables, including the airline's market presence, scheduling convenience, affordable tickets, on-time performance, dependability, and frequent flyer program availability (Teichert et al., 2008).

Moreno (2006) examines the case study of Sao Paulo by applying the multinomial Logit model to address passenger choice behavior. There were two airports in the region, but many airline companies competed. It was believed that the airline choice was a tradeoff passengers face between flight cost, flight frequency, and carrier performance. The author applies the model to data obtained from the experiment of So Paulo-Congonhas Airport (CGH) and So Paulo-Guarulhos International Airport (GRU). The study's findings determine that the lowest fare is the best-described airline choice out of 15 selected variables. At the same time, direct flights provide a better explanation for airline choice rather than indirect

flights. Furthermore, customers traveling from GRU choose their airline based on price, but those going from CGH do not. Finally, older travelers value airline age more than younger customers. Although the study reveals that the fare was the best explanatory variable, the airline that offered the cheapest fare has not been picked due to insufficient capacity. So, it can be anticipated that offering only customer service to change customers' attitudes toward choosing an airline is insufficient. Hence, an airline should offer the adequate capacity to accommodate more customers and get a more significant piece of the cake.

III. MATERIAL AND METHODS

In order to help SAUDIA restructure its network, regain its lost market share, and increase revenue, different network structure pros and cons have been analyzed as illustrated in (Table.1 Pros & Cons of Network Structure).

Table 1: Pros & Cons of Network Structure

Network Structure	Pros	Cons
Hub & Spoke	Network Expansion with the same fleet size Cost efficient Capacity utilization	Flight time of Genuine traffic Flight times might be inconvenient for Genuine traffic
Point-to-Point	Convenient for Genuine traffic Aircraft Utilization	More aircraft & manpower required Seasonality & Directionality Constrained to mid and short-range flights

It is identified that one of the pros of the hub and spoke network structure is that network expansion with the same fleet. On the basis of SWOT analysis of SAUDIA's current situation, it is identified which network structure SAUDIA should adapt. Then it is observed based on the data by Direct Data Solutions identified that SAUDIA has high genuine traffic as one of its strengths while SAUDIA suffers from seasonality and directionality of the air travel demand originated from the Kingdom of Saudi Arabia as shown in (Figure.1 Air travel demand originated from KSA in Millions (2019) source: Direct Data Solutions).

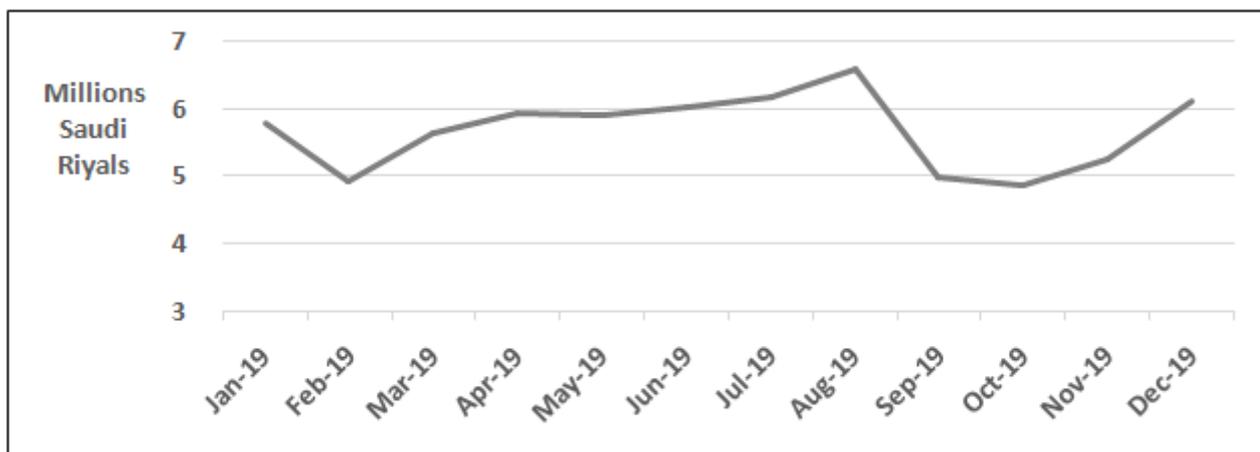


Figure 1: Air travel demand originated from KSA in Millions (2019) Source: Direct Data Solutions

So, capitalizing on one of its geographical locations and the availability of new airport, SAUDIA can get more transit traffic to reduce the effect of seasonality and directionality. Then it has been determined to restructure the network into three waves after taking into consideration future frequency plan & available fleet. Furthermore, the network redesigning was based on the demand between different regions in the SAUDIA network and identified premium markets of SAUDIA have been done to schedule them at convenient times, to keep the genuine traffic. Then the waves have been shaped based on the demand between different regions in SAUDIA network to gain more transit traffic. For instance, one of the top region pairs in terms of demand is Europe – South Asia including 23 thousand passengers on average originating from London Heathrow Airport, Paris Charle De Gaulle Airport and Manchester Airport to South Asia stations or vice versa every week in 2019. Moreover, by designing the SAUDIA network, several available aircraft, 145aircraft, minimum ground time in King Abdulaziz International Airport KAIA, which is 1 hour, and minimum utilization rate, which is 10 hours per aircraft per day, has been considered as constraints. An illustrated flow chart of our methodology is shown in (Figure.2 Methodology Flowchart).

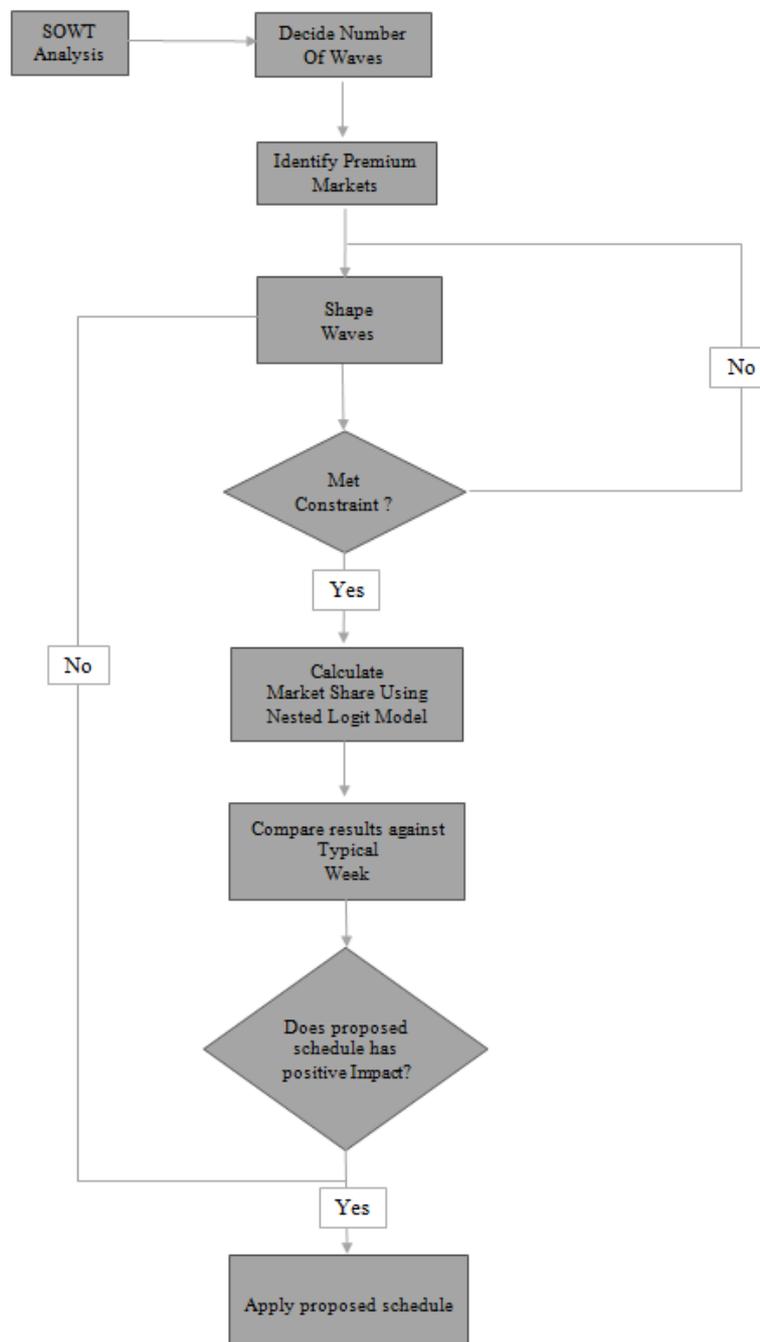


Figure 2: Methodology Flowchart

Lastly, an evaluation of the schedule is done using a nested Logit regression model in the Sabre Profit Manager system. The system builds all the possible connections by taking SAUDIA schedule and other airlines schedule for a given week using a set of rules which are:

- Minimum Connection Time
- Maximum Connection Time
- Circuity
- Operational Connections
- Code Share Connections
- Airline to Country Mapping
- Connection Exception
- Elapsed time editing
- Duplicating
- Overlapping
- Similar editing
- Share-based editing

Then the system uses Nested Logit model to predict the market share per passenger preferred departure time at the week which also known as the time of week curves which represent the probability of a passenger selecting to depart at a specific hour in a week among 167 possible departure times in a week and it assesses every itinerary in the scheduled based on 21 different attributes as follows:

$$MS(j) = \sum_{i=0}^{167} p(i) \frac{e^{\beta_1 x_1^i + \beta_2 x_2^i + \dots + \beta_n x_n^i}}{\sum_{k=0}^m e^{\beta_1 + \beta_2 x_2^k + \dots + \beta_n x_n^k}} \dots \dots \text{eq (1)}$$

- $MS(j)$ is Share of itinerary j
- i is departure hour
- $p(i)$ is probability of choosing departure hour i
- β_1, β_2, \dots are calibrated parameters
- x_1, x_2, \dots are itinerary attributes

Where the attributes are illustrated in (Table.2 Nested Logit Model Attributes).

Table 2: Nested Logit Model Attributes

Symbol	Definition
x_1	Elapsed time
x_2	Displacement of day of week
x_3	Displacement of time of day
x_4	Nonstop
x_5	Thru
x_6	Online connection
x_7	Interline connection
x_8	Codeshare nonstop
x_9	Codeshare online
x_{10}	Codeshare interline
x_{11}	Change of gauge
x_{12}	Change of airport
x_{13}	Origin point presence

x_{14}	Relative fare
x_{15}	Additional stop
x_{16}	Turbo prop
x_{17}	Regional jet
x_{18}	Large regional jet
x_{19}	Narrow body
x_{20}	Wide body
x_{21}	Extra wide body

Moreover, the system uses a spill and recapture rule where spill is the expected amount of passenger demand not accommodated on a flight due to capacity limitations or an airline's yield management practices and recapture which is the extent to which spilled passengers can be accommodated on other itineraries within the market.

IV. RESULTS

By restructuring the network and redesigning the schedule, we made 3 waves and distributed our flights on these waves based on the criteria mentioned earlier. Since our three waves are bound with departure and arrival times for each of them, it won't show the entire transit traffic gained in Jeddah compared to the base schedule. Therefore, we will compare transit traffic and revenue gained in our proposed schedule against our SAUDIA base schedule. SAUDIA carried 51,160 transit passengers per week each way for our proposed schedule in Jeddah compared to 34,579 passengers every week each way in the base schedule with an increase of 48%.

As shown in (Table.3 traffic comparison by region) , restructuring our network improved total transit traffic in Jeddah. Restructuring our network improved total transit traffic in Jeddah, we notice from the table.3 that evens our Domestic – Domestic traffic will increase by 14%. Moreover, transit traffic originating or destinating from Domestic stations to International regions will improve by 50% as result of clustering International flights in bounded waves which will help SAUDIA improves its market share across the network.

Furthermore, if we look to our region pairs Europe – South Asia traffic will increase by 53%, East Asia – Europe will increase with 9%, America – South Asia will increase by 127%, East Africa – Europe has increased with 72% while SAUDIA lost 38% Europe – South Africa in this region pair. Additionally, restructuring our network improved regions paired with domestic region with total 44% increase from 26,496 to 38,032 passengers per week each way; this is resulted from having high domestic operation and restructuring SAUDIA domestic operation.

Table 3: Traffic Comparison by Region

Region Pair	Traffic for Base Schedule	Traffic for Hub schedule	Change %
South Asia – Domestic	10,721	14,332	34%
East Asia – Domestic	3,269	5,380	65%
East Africa – Domestic	4,463	4,818	8%
Domestic – Domestic	3,989	4,529	14%
Europe – Domestic	1,373	3,364	145%
Domestic – America	172	2,974	1628%
South Asia – Europe	1,770	2,708	53%
East Asia – East Africa	789	1,928	144%
South Asia – America	767	1,755	129%
North Africa – Domestic	1,195	1,702	42%
Europe – East Asia	945	1,032	9%
South Asia – East Africa	383	1,002	162%
Gulf – East Africa	798	728	-9%
South Asia – Middle East	168	521	210%
North Africa – Gulf	337	410	22%
Europe – East Africa	208	357	72%
East Africa – America	147	351	138%
Gulf – Domestic	557	343	-38%
South Africa – Domestic	273	306	12%
Middle East – Domestic	478	288	-40%
Gulf – Europe	336	278	-17%
Middle East – East Asia	57	269	371%
Gulf – America	132	256	93%
North Africa – East Asia	137	225	64%
Middle East – East Africa	188	197	5%
South Asia – Gulf	80	165	107%
Middle East – America	64	144	127%
South Asia – North Africa	47	133	186%
South Africa – Middle East	16	133	720%
South Africa – Europe	191	119	-38%
North Africa – Middle East	23	88	283%
East Asia – America	34	83	146%
North Africa – East Africa	19	67	252%
Gulf – East Asia	91	46	-49%
Middle East – Gulf	70	42	-40%
South Africa – East Africa	6	18	183%
South Africa – Gulf	3	18	450%
South Asia – South Africa	191	13	-93%
North Africa – America		7	
East Africa – East Africa	15	6	-57%
South Africa – North Africa	6	3	-51%
Middle East – Europe	11	-	-100%
South Africa – America	22	-	-100%
South Africa – East Asia	29	-	-100%

Moreover, restructuring SAUDIA network has improved revenue by 17% compared to the base schedule. Furthermore, an increase of 7% of available seats kilometer ASK will be in the hub schedule compared to base which means that

SAUDIA will increase its production in the hub schedule. (Figure.3 ASK Comparison)

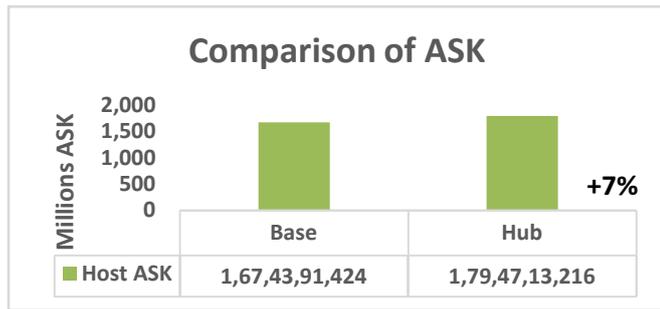


Figure 3: ASK Comparison

This increase of seats in the hub structure will result in an increase of revenue passenger kilometer RPK with 13% which means that SAUDIA revenue passenger will also increase in the hub structure as shown in the following (Figure.4 RPK Comparison)

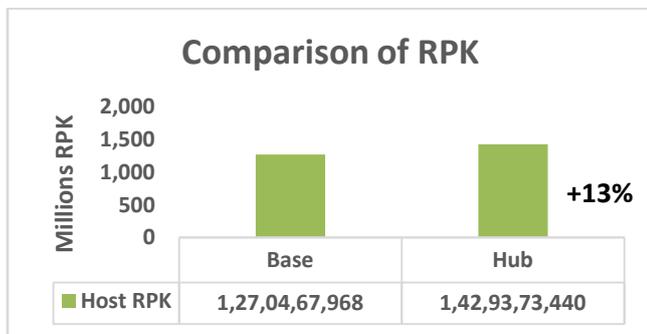


Figure 4: RPK Comparison

Finally, our proposal schedule must enhance SAUDIA utilization by aircraft by unit. So, the following table shows that restructuring SAUDIA network will enhance the utilization rates. (See Table.4 Utilization Rate Comparison)

Table 4: Utilization Rate Comparison

Aircraft Family	Daily Utilization Rate by Family by Unit	
	BASE (Hour/Day)	HUB (Hour/Day)
320 Family	11.95	12.30
330 Family	10.30	13.37
777 Family	12.69	13.23
780 Family	11.52	14.39

V. CONCLUSIONS AND RECOMMENDATIONS

In this study, air travel demand is explored in the Kingdom by forecasting market share of SAUDIA and competing airlines. We reviewed several studies that discussed market share forecasts for airlines and identified the factors that affect market share forecasts in the aviation industry. Moreover, the pros and cons of network structure are identified, and SWOT analysis is conducted to the SAUDIA

situation. Then, constraints are identified that prohibit from restructuring the proposed schedule. Number of waves that need to be used are fixed based on the feedback from the Network Planning Department and then identified premium markets for SAUDIA. Additionally, we aligned our schedule with the 2024 frequency plan and decided the number of waves and how we shaped our waves. Based on this analysis along with number and shape of the waves, the Nested Logit Model is applied to calculate the market share through Sabre Profit Manager system that SAUDIA employs for its scheduling. Then we explored and analyzed market size between different stations in the SAUDIA network by region pair for 2019.

In this study, we evaluated our proposed schedule for a week using the Nested Logit Model to forecast market share and consequently the revenue. Then we compared it to SAUDIA's one-week base schedule. Later, we explored revenue and traffic for each wave in our proposed schedule. Finally, we explored the total revenue and traffic of the proposed schedule and compared these against the SAUDIA-base schedule. The proposed schedule improves revenue by 17%, and an increase of transit traffic of SAUDIA by 48% in Jeddah. Keeping in view the findings, the study proposes the following recommendations.

- The nested Logit Model is more appropriate method to evaluate the quality of an airline schedule and forecast its market share and revenue than the existing one.
- Following a hub and spoke network structure will help SAUDIA serve more markets and increase its revenue.
- Improving operation for transit passengers will reduce demand fluctuation that affects SAUDIA's financial performance.

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