ERASMUS UNIVERSITY ROTTERDAM

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Bachelor Thesis [Programme IBEB]

Effect of Advance Booking on Ticket Prices and the Role of Pricing Strategy: A Comparative Study between KLM and British Airways

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Abstract

Airlines may price differently according to consumer's booking time of a flight. Discounts are usually found on advance bookings, whereas last-minute bookings usually cost the most. Whether third-degree price discrimination based on booking time exists in the airline industry is the primary concern of this research. Moreover, due to the negative influence of Covid-19 on airline revenues, Royal Dutch Airlines (KLM), the biggest carrier in the Netherlands, decided to recover by applying a continuous pricing strategy that charges consumers based on individual maximum willingness to pay for a flight. Whether continuous pricing would strengthen the association between booking time and price refers to the other concern of this research. By analysing the price of KLM and British Airways (BA) flights, a negative association between advance booking and price is discovered. Every additional day between booking and departure could offer consumers a 1.93 USD discount on the purchasing price of their flights. The discount is greatest when a flight is booked between 4 and 14 days before departure. Furthermore, continuous pricing strategy turns out to weaken the timing effect on price: marginal discount of advance booking is greater in BA who applies the traditional stair-step pricing strategy than KLM who uses continuous pricing strategy. This is opposite to the hypothetical effect of continuous pricing.

Keywords: advance booking, continuous pricing strategy, price discrimination, airfare

Introduction

The presence and increase of low-cost carriers have pushed up competition in the airline industry and led to the day-to-day price variation of flight tickets (Mumbower et al., 2014). In a case study of Ryan Air pricing strategies, Malighetti et al. (2009) find the existence of discounts on advance booking fares. Ryan Air also offers greater discounts on ticket prices when the number of advance booking days increases (Malighetti et al., 2009). In the meantime, Pels and Rietveld (2004) observe an increasing purchasing price of a flight between London and Paris as the departure date approaches among both low-cost and conventional carriers. Whether there is a significant association between the timing of booking and the price of a flight ticket is the major question this research attempts to find out.

The outbreak of Covid-19 since the beginning of 2020 has led to severe negative effects on the global economy. The airline industry is affected not only because the pandemic is easily passed among passengers but also because international air transportation became largely prohibited by governments as a response to the virus as soon as the outbreak was declared (Maneenop & Kotcharin, 2020). Continuous pricing has become a new choice of several large airlines during the post-pandemic recovery. This pricing strategy allows airlines to learn the individual demand for air travel instead of the demand of a group of consumers and set prices according to individual maximum willingness to pay (Baker, 2021, April 30). Lufthansa has started to roll out such approach since October 2020 and Qantas is now considering adopting continuous pricing. In April 2021, Royal Dutch Airlines (KLM) announced that it would switch from the traditional rigid pricing to the more flexible continuous pricing approach to exploit greater incremental revenues (O'Neill, 2021, March 30). This raises the concern of what factors may lead to the difference in consumer demand for flights and ultimately the variation in ticket prices.

In the study of the price elasticity of demand for air travel, Brons et al. (2002) suggest that there may be a relationship between the booking date and the purchasing price of a certain flight, as travellers with demand for last-minute bookings usually have lower price elasticity and are more willing to pay for more expensive tickets. Price-sensitive consumers tend to purchase tickets early before the departure date (Mantin & Koo, 2009). Therefore, if artificial intelligence could continuously learn the dynamic consumer demand and reflect on ticket prices under continuous pricing, will last-minute bookings be charged the highest ticket price? Additionally, will the price be more or less sensitive to the timing of booking under continuous pricing? The influence of pricing strategy on the association between booking time and price consumers pay for a flight ticket is yet to be explored.

Existing studies include the examination of a certain pricing strategy applied by an airline company (Malighetti et al., 2009) and the determinants of airfare differences (Mantin & Koo, 2009; Pels & Rietveld, 2004). The closest analysis refers to Mantin and Koo (2009), which evaluates the extent to which airfare determinants are time-dependent. However, there are studies related to the effect of booking time on purchasing price of a flight. In the meantime, analyses related to the airline pricing strategies stick to a particular (type of) carrier. As mentioned in the previous paragraph, there is insufficient focus on the role of pricing strategy in the relationship between timing and price of a flight booking. Hence, the effect of advance booking (timing) on ticket price and whether such effect would be influenced by the pricing strategy of an airline will be the two gaps that this research seeks to fill in.

Research Question

The central questions to be explored in this research are:

Does third-degree price discrimination based on the booking time exist in airline industry? How does KLM's switch to continuous pricing strategy influence the relationship between booking time and price?

Specifically, 2 hypotheses will be tested:

H_1: *Advance booking has a negative effect on the ticket price of a flight*

H_2: *Effect of advance booking on ticket price is more negative under continuous pricing than under traditional stair-step pricing*

To study how the change in KLM's pricing strategy would affect the relationship between timing and price of a booking, this research conducts a comparative study: airlines who are using KLM's previous traditional pricing strategy refer to the control group. Specifically, British Airways (BA) is selected for comparison. BA has 170 international destinations in 70 countries and is ranked as the world's 19th best airline in 2019 (Skytrax, 2021). KLM has similar networks and rankings. It serves 172 international destinations in 70 countries and ranked 18th in 2019. Both airlines are full-service carriers and have headquarters and main hubs in Europe. More importantly, BA has not yet switched to the continuous pricing model and keeps using the traditional rigid pricing strategy. In this case, BA data is used to represent the price behaviours of KLM prior to its change in pricing strategy.

The hypotheses will be tested through an OLS regression model. The rest of the paper includes a conceptual framework which introduces the relevant variables that are involved in this research, followed by the methodology that is applied for evaluation. Empirical statistics such as the dynamic price information are presented, and the estimation results will be analysed and discussed to answer the central research question.

Conceptual Framework

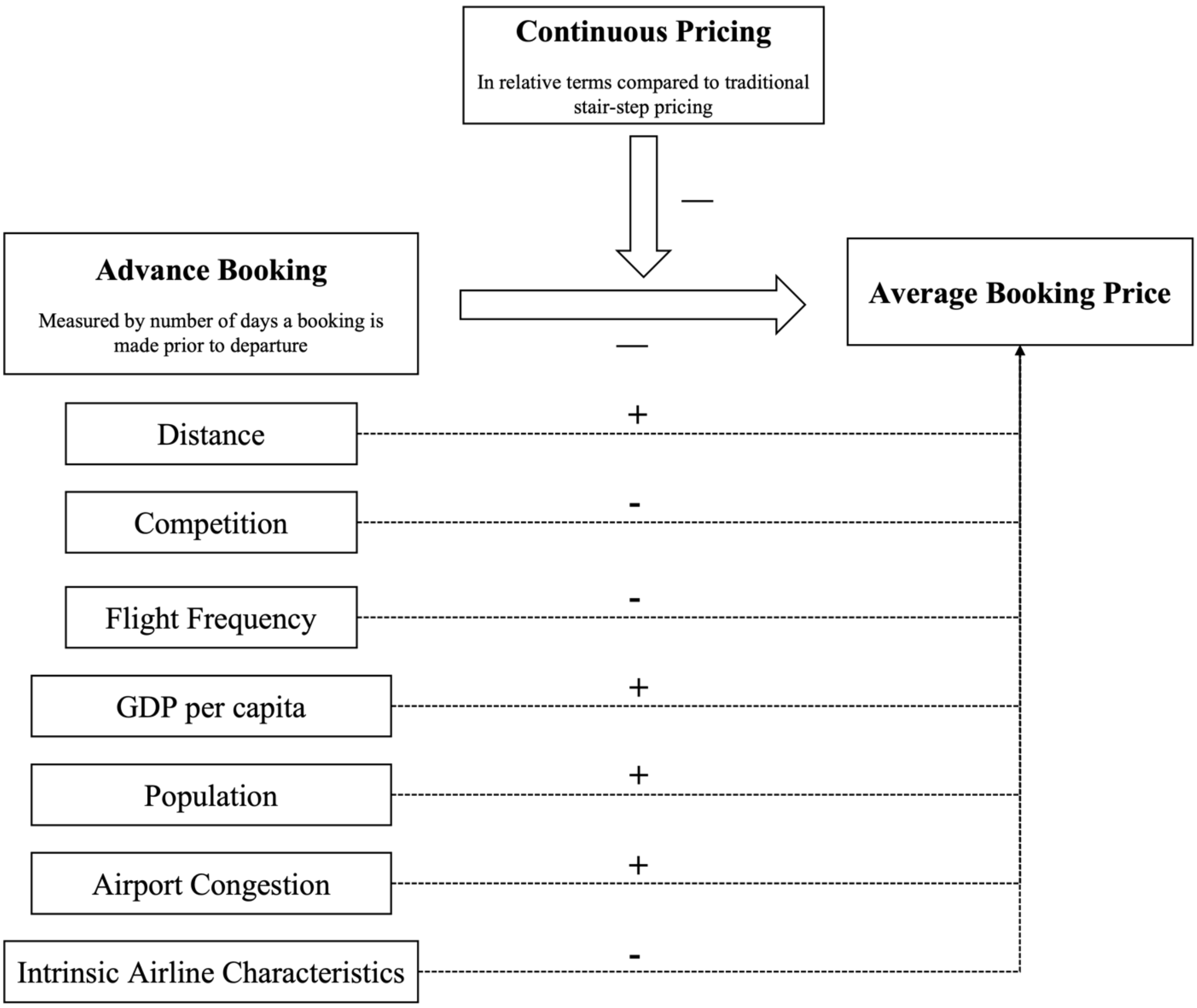

Figure 1 – Hypothetical relationship between explanatory variables and average booking price of a flight

Figure 1 illustrates the hypothetical relationship between advance booking and airfares, as well as the effect of pricing strategy on this relationship. Mantin and Koo (2009) discover that the average booking price of a certain flight varies within 90 days before departure, and consumers who make last-minute bookings are more likely to pay for the most expensive tickets. This supports the idea of a negative correlation between advance booking and the price of a ticket. In imperfect markets, firms may divide consumers into different groups and charge each group differently to maximise profits. This refers to third-degree price discrimination (Corts, 1998; Holmes, 1989). The central question to be tested in this research is whether such third-degree price discrimination exists in the pricing of flight tickets, in which airlines charge passengers differently according to their timing of booking. The hypothetical negative association between advance booking and price refers to Hypothesis 1.

As KLM introduced artificial intelligence to study the consumer demand for air travel after switching to continuous pricing (O'Neill, 2021, March 30), the airline could better learn about individual maximum willingness to pay. This may intensify the price discrimination according to advance booking. Whether this hypothetical negative effect of continuous pricing strategy on the relationship between timing and price of a booking exists refers to the statement of Hypothesis 2.

Furthermore, besides the booking behaviour of consumers, airfare variations are also related to many other factors that are route specific. According to Pels and Rietveld (2004), airfares are lower when competition increases on the same route especially when low-cost carriers exist in the market. Distance and flight frequency of a certain route would determine the discount on ticket prices and thus lead to airfare variation (Malighetti et al., 2009), and airport congestion would determine the cost of carriers and affect airfares (Morrison & Winston, 1990). In addition, consumers from areas with higher income and larger population reflect lower price sensitivity and less variation at a high airfare level (Mantin & Koo, 2009). These characteristics are also included in the analysis.

Data

Although KLM and BA are headquartered in different cities and only share the route between Amsterdam and London, most of their direct flights connect the two main hubs. Hence, to conduct the comparative research, the common direct destinations of KLM and BA are selected. Route-specific data is then studied through the regression model to estimate the price determination of each relevant factor. Rival airlines and their flight behaviours are accounted for in competition if they serve on the same route that connects the same airports as KLM or BA.

Variables

The dependent variable refers to the average ticket price of a flight departing on a certain date. The prices of KLM and BA's flights departing between June 1st and July 31th 2022 are measured daily from May 5th to May 30th 2022. As KLM has switched to continuous pricing since March 2021, the collected prices of KLM flights should be following the continuous pricing strategy. The independent variable refers to the timing of booking, which is the number of days a flight booking is made prior to departure. This allows to see how purchasing price would change as the departure date comes closer.

Furthermore, the interaction between timing and pricing strategy is also evaluated to answer whether pricing strategy matters for the price determination of advance booking. Since 'pricing strategy' refers to a dummy variable that distinguishes between the two airlines, the interaction effect would be measured on a relative term: compared to BA which uses traditional pricing, whether the timing effect on ticket prices is more or less in KLM which has switched to continuous pricing approach. The rest factors are considered as control variables to prevent omitted variable bias. It is noteworthy that the possible competition effect is studied in three dimensions: number of rival airlines, number of rival flights and whether low-cost rivals serve on the same route. By doing so, the impact of a rival airline's characteristics on average price of a flight served by a specific airline could be analysed.

Data collection

Route networks and airport congestion

Flight Connection (2022), a website which includes air travel statistics such as the available route networks of a carrier and the schedules of a flight, is used to filter out the routes available for analysis. The database gathers information from each airline and offers daily updates of the information, therefore allowing the reliability of the research. Specifically, routes offered by KLM and BA are first reviewed, and those common direct destinations are selected for comparative analysis. Subsequently, Flight Connection (2022) divides all airports into three congestion levels based on the number of their connected direct destinations. Airports that connect to more than 50 direct destinations are levelled as the most congested, followed by moderately busy airports that connect to more than 10 direct destinations and the least busy airports with fewer than 10 connected direct destinations. This information is collected and used as the measure of airport congestion in the later analysis of variation in airfares.

Price

The study only considers the price of economy cabin tickets for direct flights, as business class tickets usually fluctuate less in price (Brons, 2002). Furthermore, for each flight, the lowest price is considered to avoid the difference in booking price due to optional additional services. Price data are collected from Google Flights (2022) which displays the daily price information of flights offered by a certain airline and is recorded in current USD.

Flight statistics

Since Google Flights (2022) includes daily price information of all available flights on a certain route on a specific date, the database also allows recording the frequency of flights on a certain route served by a selected airline. Hence the number of rival airlines and the flight frequency of not only a KLM or BA flight but also all other rival flights on each route are retrieved from Google Flights (2022).

Distance

The distance of a flight connecting two airports is collected using the Air Miles Calculator (2022). The database offers the distance (in kilometres) calculation of a certain route given the departure and destination airports or cities. Hence, the distance of each flight is recorded in kilometres according to such database.

Competition – existence of low-cost rivals

Following the flight information collected from Google Flights (2022), rival airlines observed on the same route as a KLM or BA flight are compared to the list of low-cost carriers created by International Civil Aviation Organisation (ICAO) (2017) to check whether low-cost carriers exist in the airline industry competition. The list includes all low-cost carriers that meet the low-cost definition in the globe, thus ensuring the reliability of data.

Demographic statistics

Demographic statistics such as the GDP per capita and population data of departure places are extracted through World Bank (2022), which contains the most up-to-date regional data in the globe. GDP per capita is recorded in 1,000 USD, and the regional population is recorded in 1,000 terms as the raw data is quite huge. In addition, as the airfare also variates when the direction of a flight changes (departure and return flights on the same route may have different prices), for each specific flight with irreversible direction, GDP per capita and population of the departure region is collected for analysis. In this case, the departure and return flights on the same route are studied as two individual flights.

Methodology

The collected statistics of KLM and BA flights are analysed respectively using the following regression model:

$$Y_{i,j,t,k} = \beta_0 + \beta_1\text{*Advance Booking Days}_{t,k} + \beta_2\text{*Advance Booking Days}_{t,k}\text{* KLM}_j + \beta_3\text{* KLM}_j + \beta_4\text{*Rival Airlines}_i + \beta_5\text{*Rival Flight Frequency}_i + \beta_6\text{*Low-cost Rival}_i + \beta_7\text{*Distance}_i + \beta_8\text{*Flight Frequency}_{i,j} + \beta_9\text{*Departure GDP per capita}_i + \beta_{10}\text{*Departure Population}_i + \beta_{11}\text{*Airport Congestion}_i + \varepsilon_{i,j,t,k}$$

Equation (1)

i: route of a flight, airport-to-airport

j: airline company, either KLM or British Airways

t: data collection date

k: departure date

$Y_{i,j,t,k}$: Average ticket price of route i departing on day k, offered by airline j, measured on day t, in USD

Advance Booking $Days_{t,k}$: Number of days prior to departure, measured on t

KLM_j: Dummy variable, 0 = British Airways, 1= KLM

Advance Booking $Days_{t,k}$* KLM: Interaction effect between airline (pricing strategy) and advance booking

Rival $Airlines_i$: Number of rival airlines serving on the same route i

Rival Flight Frequency$_i$: Total number of flights offered by rival airlines on the same route i per week

Low-cost Rival: Dummy variable, 0 = No rival airline is low-cost carriers, 1 = low-cost carriers exist among rival airlines

Distance$_i$: Length of route i, in kilometres

Flight Frequency$_{i, j}$: Number of flights offered by airline j on route i per week

Departure GDP per capita$_i$: GDP per capita of the departure city of a flight on route i, in 1,000 USD

Departure Population$_i$: Population of the two cities of route i, in 1,000

Airport Congestion$_i$: Congestion of the departure airport, (3 = busiest, > 50 direct destinations; 2 = moderate busy, > 10 direct destinations; 1 = least busy, < 10 direct destinations)

$\varepsilon_{i, j, t, k}$: Error term

The sign and magnitude of each determinant is illustrated by the parameter β_i, and the significance of each coefficient is evaluated. *Hypothesis 1* is true if the estimated β_1 reflects a significant negative value; on the other hand, *Hypothesis 2* is proved if the estimated β_2 reflects a significant negative value, showing that continuous pricing would bring KLM a more negative relationship between advance booking and purchasing price of a ticket than BA.

Descriptive Statistics

Destinations with direct flights

Apart from the headquarters (Amsterdam and London), KLM and BA share 94 destinations with direct flights. Most of the available direct flights connect between the main hubs of the two airlines (Amsterdam Schiphol and London Heathrow) and the destinations. Specifically, KLM offers 191 routes and BA offers 238 routes with an average distance of 2,912 and 2,654 kilometres (return trips are counted as two routes). Since BA serves 13 domestic destinations, some common international destinations connect to multiple UK cities and hubs, compared to KLM which only serves one domestic destination. This explains why BA offers a greater number of routes to the 94 shared destinations than KLM.

Flights

Among the 94 shared destinations, KLM serves 3,467 direct flights per week and BA serves 3,737 direct flights per week. Average number of flights offered on a specific route is 18 and 15 per week for KLM and BA respectively. Routes within Europe have the greatest frequency, where most European destinations have available daily flights. For KLM, routes with flight frequency greater than average all connect destinations in European countries; meanwhile, all intercontinental destinations except New York, San Francisco, Los Angeles and Toronto are reached by KLM with frequency between 3 and 8 flights per week.

A similar situation is also observed in BA: most routes with frequency greater than average involve European destinations and London Heathrow airport. Moreover, among BA's routes involving London, frequency of flights is greater when connecting with Heathrow airport compared with that of flights connecting with Gatwick or City airport. Intercontinental destinations are reached with frequency between 3 and 12 flights per week except New York, Los Angeles and Boston which have more than 20 flights per week. Furthermore, for both KLM and BA, the route between the two main hubs London Heathrow and Amsterdam Schiphol has the greatest flight frequency of 58 and 48 per week.

Rivals

Routes served by KLM and BA also face competition from rival airlines. Among the focused 191 KLM routes, 126 routes also contain flights available from alternative airlines, and 84 of those competitive routes involve low-cost rivals. 132 of the focused BA routes are also served by rival airlines and 48 of them experience competition from low-cost carriers. Average number of rival airlines serving on the same route equals to 1.13 per KLM route and 0.82 per BA route. Rival airlines are most among the routes connecting the main hubs and destinations in Europe, followed by routes to the United States and other intercontinental destinations. In addition, each route served by KLM and BA faces an average of 13 and 14 flights available from rival airlines, and routes with greater flight frequency have more available flights offered by rivals. The greatest competition also appears on the route between London Heathrow and Amsterdam Schiphol where KLM and BA share the route with 60 and 84 flights from rival airlines every week.

Average price per route

By taking the average of all prices recorded for each route during the recording period, some characteristics are observed. Primarily, KLM routes have an average price of 435.81 USD. The most expensive ticket appears on the route between Amsterdam and Atlanta which reports an average price of 1,778.03 USD for each one-way flight. The cheapest route refers to Amsterdam to Manchester which reports an average price of 82.46 USD per single trip. More importantly, ticket prices are much higher when flights are taking off in June compared to flights taking off in July during the recording period. Average ticket price of a one-way KLM flight with a departure date in June equals to 447.29 USD, whilst this value drops to 424.90 USD when the departure date of the flight is in July, ceteris paribus. Both maximum and minimum average prices are higher in June than in July and appear on different routes: the most expensive flight in June refers to Amsterdam to Buenos Aires with a price of 1,830.74 USD, whereas the highest average price applies on the route between Amsterdam to Atlanta with an average price of 1,776.55 USD when the departure date is in July. The lowest ticket price among flights that are taking off in June is observed on the route between Amsterdam and London Heathrow airport which reports an average of 89.50 USD. The cheapest route changes to Amsterdam to Manchester when departure date is in July. This route reports an average price of 71.87 USD.

Average prices of flights served by BA reflect greater difference among the routes. The most expensive route refers to London Heathrow airport to Toronto with an average price of 2,948.31 USD among the flights taking off in June and July. The cheapest price belongs to the single trip between Southampton and Dublin with an average price of 42 USD. Average price of a flight served on BA's routes with a departure date between June and July equals to 496.67 USD. Similar to KLM, flights are more expensive when the departure date is in June: average price equals to 526.40 USD among flights that are planned in June, and such value decreases to 472.71 among flights that are planned in July. This is consistent with the first hypothesis that more advanced bookings could enjoy lower prices. Nevertheless, although the London Heathrow airport to Toronto and Southampton to Dublin routes contribute to the most expensive and cheapest routes in both months, the difference between maximum and minimum prices is less significant among the June flights (2,770.05 USD and 38.25 USD respectively) compared to those prices observed among July flights (3,140.45 USD and 45 USD respectively).

Trend Analysis - Average price per advance booking day

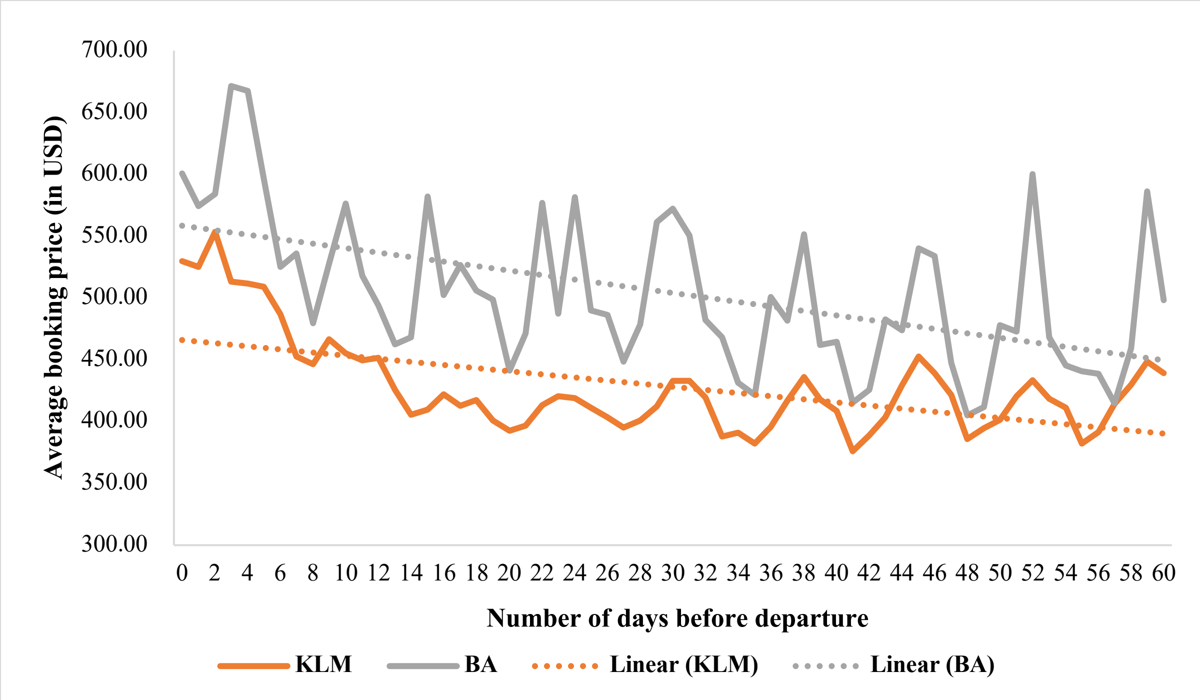

Figure 2 – Trend of average booking price as advance booking days change

Besides the comparison among routes, I also averaged the prices of flights according to the length of advance booking days prior to the departure date of a flight. Figure 2 visualises the relationship between advance booking and ticket prices of a flight. Primarily, both KLM and BA perform a downward trend of average booking price as the booking date is further prior to the departure date of a flight. Average price is highest when passengers book the tickets 2 days before the departure of a KLM flight and 3 days before the departure of a BA flight. Maximum booking prices are 1.29 and 1.33 times respectively of the average values observed over the 60 days prior to departure.

Subsequently, for KLM flights, average price follows a downward trend when booking is made from two days to two weeks prior to departure. It then becomes relatively stable and low when advance booking period is more than 14 days until 45 days prior to departure. When advance booking days is between 45 and 60 days prior to the departure of flights, ticket prices are slightly more fluctuated and more expensive compared to prices observed between 14 and 45 days prior to departure.

For BA flights, when booking is made between 3 and 8 days prior to departure, average price is also much lower as the difference between booking and departure date of the flight increases. Average price remains within the range of 430 to 580 USD when advance booking is between 8 and 52 days before departure and reports a greater fluctuation when advance booking is between 52 and 60 days. It is noteworthy that average booking price of a BA flight is also relatively higher in the latter period compared to price of bookings made between 8 and 52 days prior to departure.

Overall, regardless of the timing of booking, average booking price is lower among KLM flights compared to the price of BA flights (428.09 and 503.98 USD respectively). This may be related to the distance of served routes, as the average distance of routes is shorter among KLM flights than BA flights. KLM also demonstrates less fluctuation in the average booking price as the timing of booking changes. Furthermore, for both airlines, average price of flights reaches a peak every 7 advance booking days.

Trend analysis – Average price per observed departure date

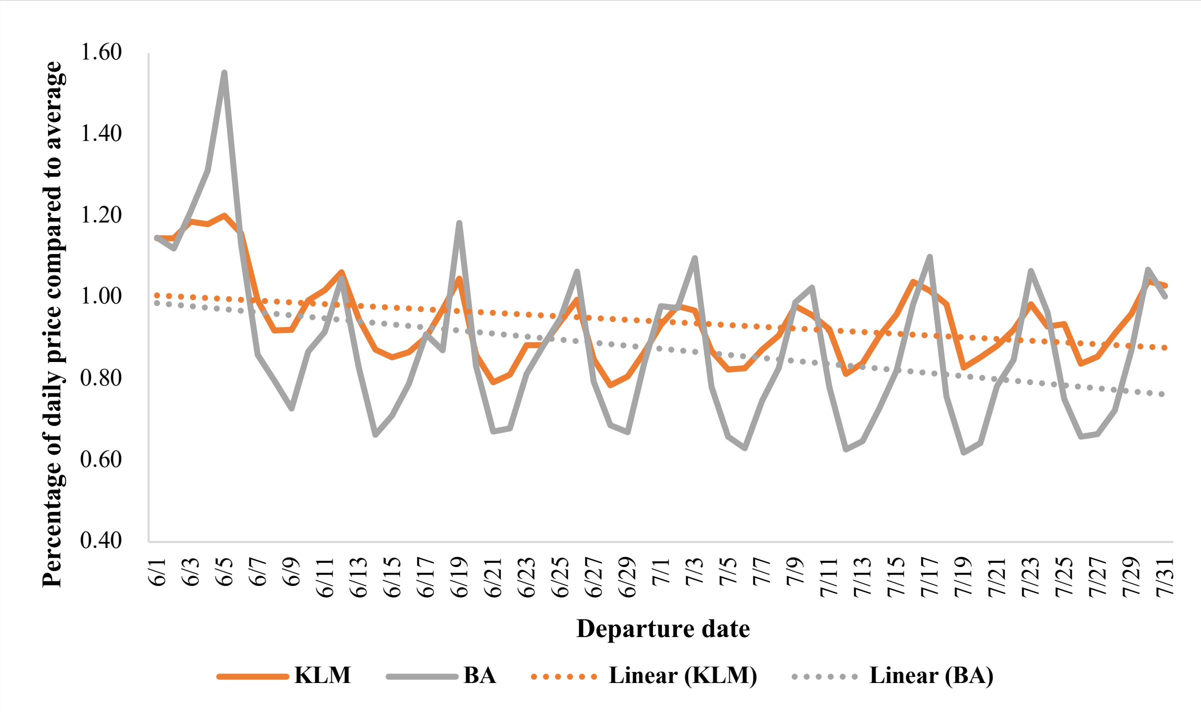

Figure 3 – Average booking price per departure date relative to the average of June and July prices

In addition to the dynamic price changes with respect to changes in the timing of booking, I observed that the booking price would also differ when the departure date changes. For each specific route, I measured the relative booking price of each departure date to the average price of that route in percentage terms and recorded the average relative price for each departure date between June 1st and July 31st. The intuition is based on Mantin and Koo (2009), who measure the price divergence of flight tickets over time in relative terms. The graphical results illustrated in Figure 3 show that the fluctuation of average flight prices repeats every week: peaks in prices are observed when the departure date is at weekend, especially Saturday. Price decreases most from Sunday to Monday flights and increases as it approaches the weekend again. Such characteristic of price changes is observed among both KLM and BA flights departing within June and July 2022, whilst the BA flights show a greater range of price fluctuation than KLM. Peak price of BA flights which depart during weekends equals to 1.06 times of the average price level and the lowest price discovered during weekdays equals to 0.68 times of the average. Average maximum and minimum prices observed on the same days are 1.02 and 0.85 times relative to the overall average price of June and July flights in KLM.

Results

Table 1 – Estimated relationship between relevant factors and average booking price

	Average Booking Price
Advance Booking	-1.93***
	(0.27)
Advance Booking * KLM	0.83***
	(0.31)
KLM	-128.80***
	(11.62)
Distance	0.16***
	(0.01)
Rival Airlines	64.91***
	(3.23)
Rival Flights	0.03*
	(0.16)
Rival Low-cost Carriers	-100.38***
	(5.09)
Frequency of Flights	0.57***

	(0.18)
Departure GDP per capita (1,000 USD)	3.59***
	(0.15)
Departure population (1,000)	2.76E-03***
	(0.61E-03)
Departure Airport Congestion	-32.05***
	(6.68)
Constant	28.48
	(23.95)
Number of observations	23,658

Note: Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1 summarises the regression results applied to *Equation 1*. Both the advance booking and the pricing strategy variables reflect statistically significant results, and the effect of control variables is also statistically significant. This shows that each variable involved in *Equation 1* has some explanatory power to the change in the average booking price of a flight.

Advance booking variable

Estimated coefficient of the advance booking days variable reports a value of -1.93 and is significant at the 1% level. This indicates a negative effect of advance booking on the purchasing price of a flight. Specifically, on average, passengers could pay 1.93 USD less for a flight ticket as a booking is made one more day in advance to the departure date, ceteris paribus. This is in line with the graphical result in Figure 2 as well as Mantin and Koo (2009)'s main finding of an overall decreasing trend of the average booking price as the length of advance booking increases. In this case, the first hypothesis is proved to be true.

Interaction effect variable

Subsequently, the interaction term shows the way pricing strategies affect the marginal effect of advance booking on the price of a flight. The estimated coefficient shows an opposite sign to that of the advance booking variable, indicating that the average booking price of a flight served by KLM would be 0.83 USD higher than that of a BA flight as the number of advance booking days increases by one, ceteris paribus. Therefore, the overall effect of advance booking on price is less negative among KLM flights than BA flights. This means that the second hypothesis of this research should be rejected, since the association between advance booking and price of KLM's flights is reduced by the effect of its continuous pricing strategy. The relationship between timing and price of a booking is more negative among BA's flights. This result is in line with the graphical illustration of the price trend in Figure 2, where the slope of BA's flight prices is more negative than that of KLM's prices.

Distance variable

According to Table 1, the distance variable reports an estimated coefficient of 0.16 and is statistically significant at the 1% level. This indicates a positive relationship between the distance and price of a flight, in which every 1 additional kilometre of flight distance would lead to an average increase of 0.16 USD in the price of a flight ticket, ceteris paribus. One possible explanation for this result is that the distance variable represents the operating costs of a route, and relevant operating costs would increase as the distance of a flight is greater (Swan & Adler, 2006), leading to an increase in the purchasing price of consumers.

Competition variable

Competition effect on the average booking price of a flight measured in three dimensions reports the following results: 'rival airlines' shows an estimated coefficient of 64.91 and is statistically significant at 1% level; the rival flights variable shows an estimated coefficient of 0.03 and is statistically significant at the 10% level; finally, the dummy variable low-cost rivals shows an estimated coefficient of -100.38 and is statistically significant at the 1% level. Regarding the rival airlines variable, the regression result indicates that on average, the booking price of a flight ticket would increase by 64.91 USD when there is one additional airline serving on the same route. Similarly, the rival flights variable also reports a positive coefficient of 0.03, showing that on average, one more flight served by rival airlines on a specific route would lead to an increase of 0.03 USD on the average purchasing price of a flight on that route.

Interestingly, the increase in number of rival carriers leads to an unexpected price increase under the fiercer competition. This might be related to the level of substitutability, in which passengers' demand for a flight served by a specific airline would not change much if the services offered by rivals are of varying quality (Brons et al., 2002). Moreover, the increase in number of rival air carriers may be understood as a supplier response to the high and inelastic demand for air travel on a specific route. In this case, passengers would need to pay for more expensive flight prices when the carriers serving on the route cooperate to increase the average price.

In the meantime, the negative coefficient of the dummy variable 'low-cost rivals' implies that when rival airlines exist on the route of a specific flight, the average price would be 100.38 USD lower if low-cost carriers are involved in the rival airlines than the situation of only full-cost rival carriers, ceteris paribus. Therefore, when the total number of rival airlines competing on the route and the number of alternative available flights offered are relatively small and low-cost carriers serve on the same route, the effect of the existence of low-cost rivals is likely to outweigh the total effect of the former two variables, vice versa. The overall competition effect would be negative, and the average price of a flight could be lower in this case.

Carrier characteristic variable

According to *Trend Analysis,* the average booking price of KLM flights appears to be lower than that of BA flights within the 60-day estimation period, regardless of the booking time. The dummy variable 'KLM' offers a solution. Estimated coefficient of -128.80 indicates that the average price of a KLM flight is 128.80 USD lower than that of a BA flight when all else are kept the same. Such negative effect of the intrinsic carrier difference outweighs the positive effect of KLM's continuous pricing strategy. Hence, KLM demonstrates an overall lower average booking price than BA.

On the other hand, the coefficient of 'flight frequency' determines the relationship between the volume of flights offered by a carrier and the average purchasing price passengers pay for travelling on a specific route. The estimated result of 0.57 with statistical significance at 1% level implies that the more flights offered by the airline on a route, the higher the average price passengers need to pay for a flight served by that airline. The frequency of flights served by an air carrier might be related to the market demand for air travel, and the greater number of flights may result in additional relevant operating costs for air carriers which would together bring up the airfare.

Demand variable

Primarily, the GDP per capita of residents in the departure country performs an estimated coefficient of 3.59 with statistical significance at the 1% level. This implies that on average, every additional 1,000 USD increase in the per capita income of residents from the departure country would lead to an increase of 3.59 USD in the price of a flight. Since the GDP per capita indicator serves as the proxy of purchasing power and higher-income people are more likely to consume air travel (Mantin & Koo, 2009), flights on routes connecting higher-income places may have greater demand. Average price for those flights is hence likely to be higher.

Subsequently, the population of departure cities of each flight reflects an estimated coefficient of $2.76*10^{-3}$. This variable also has the power to explain the price variations of flights as it is statistically significant at the 1% level. The regression result suggests that every additional 1,000 residents in the departure city would bring up the average price of a flight by $2.76*10^{-3}$ USD, ceteris paribus. Although the coefficient is relatively small compared to that of the other explanatory variables, the population data (in 1,000 terms) performs on a greater scale than the other variables. Thus, the influence of change in population size of departure city on the price of a flight starting from there would not be insignificant. According to Mantin and Koo (2009), population would reflect the potential market size of a route. Therefore, the demand for air travel is likely to be higher in places with greater population, and the average price of flights including such departure cities would be pushed up by the consumer demand.

Airport characteristic variable

Finally, the measure of airport congestion level which reflects the airport characteristic relevant to a flight reports a statistically significant coefficient of -32.05. This implies that the average price of a flight taking off at the most congested airport would be 32.05 lower than the price of a flight taking off from a less congested airport, ceteris paribus. Since the airport congestion is categorised according to the number of direct destinations available from the airport, the most congested airports (i.e. connect with most direct destinations) may reach economies of scale in relevant operating costs of direct flights. This might be one possible explanation for the positive correlation between congestion of the departure airport and the flight price.

Explanatory power of variables during different booking periods

Table 2 – Estimated regression results during different booking periods

	T = 0 - 3	**T = 4 - 14**	**T = 15 - 60**
Advance Booking	-10.02	-15.67***	-1.25***
	(25.58)	(3.23)	(0.40)
Advance Booking * KLM	10.64	7.24**	1.09***
	(31.89)	(3.92)	(0.45)
KLM	-104.56*	-177.27***	-167.08***
	(69.72)	(41.15)	(18.44)
Distance	0.17***	0.17***	0.16***
	(0.01)	(0.01)	(0.01)
Rival Airlines	61.26***	68.39***	64.04***
	(16.85)	(8.35)	(3.56)
Rival Flights	-1.12*	0.31	0.04
	(0.67)	(0.38)	(0.18)
Rival Low-cost Carriers	-92.26***	-113.88***	-97.89***
	(25.06)	(13.22)	(5.61)
Frequency of Flights	0.14	1.23***	0.48***
	(0.92)	(0.43)	(0.20)
Departure GDP per capita (1,000 USD)	3.79***	3.02***	3.71***
	(0.89)	(0.46)	(0.16)
Departure population (1,000)	5.78E-03*	0.27E-03	3.13E-03***
	(3.63E-03)	(1.84E-03)	(0.61E-03)
Departure Airport Congestion	-85.51*	-67.56***	-20.86***
	(50.06)	(21.91)	(6.16)
Constant	209.12*	251.11***	-27.28*
	(168.80)	(79.07)	(24.19)
Number of observations	1,114	4,147	18,397

Note: Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

As mentioned in *Trend Analysis*, average booking price of a flight fluctuates over the 60 days before departure date. Such non-linearity leads to the limited accuracy of the OLS estimation. To solve this issue, I divided the whole 60-day period into three stages with observed different trend characteristics and applied the same regression model to each stage. Table 2 displays the estimation results. It is noteworthy that in the latest booking period (booking within three days prior to departure), neither the timing of booking (number of advance booking days) nor its interaction with the airline's pricing strategy is statistically significant, although the signs of the effects are the same as estimated using the whole 60-day data. This means that within three days before departure, average booking price would be highest on the departure date and lowest when there are three days ahead, although no causal relationship could be proved.

Advance booking reflects a negative estimation of -15.67 on the average booking price of flights between 4 days and two weeks before departure. This refers to the decreasing trend of price led by advance booking, and consumers could enjoy lower prices if they make the booking as early as possible within this period.

In addition, when a booking is made even earlier before the departure date (15 to 60 days in advance), a negative association of -1.25 between the timing and price of a booking is proved. Booking prices will decrease by 1.25 USD on average when consumers book a flight one day earlier during this period. This estimated marginal effect is much smaller (in absolute value) than the estimations in the previous two periods, indicating that the average price of a flight fluctuates less according to the timing of booking when there are more than two weeks before departure. This regression result is consistent with the empirical findings as discussed in *Trend Analysis*.

Another remark is the difference in interaction effect between advance booking and pricing strategy of airlines over different periods. Despite the insignificant estimation during the latest booking period, the interaction between the length of advance booking and the pricing strategy used by airlines presents positive values in all three periods, showing that the KLM flights are on average less price sensitive (negative) to the timing of booking compared to BA. More importantly, the magnitude of such effect (in absolute values) increases as booking is made closer to the departure date. Hence, consumers may enjoy a greater discount on early bookings of BA flights compared to KLM and the difference in price discrimination would be greatest among last-minute bookings.

Effect of distance, the number of rival airlines, the existence of low-cost rival carriers and the income of departure city on the average booking price of a specific flight remain stable over the three periods. The intrinsic difference between KLM and BA is most negative when consumers book a flight between 4 and 14 days prior to departure. This indicates that the airline characteristics have the most explanatory power for the lower average price of KLM compared to BA during this period. Furthermore, the estimated coefficient of the congestion level at the departure airport decreases in absolute values as the number of advance booking days increases. This states that the negative influence of departure airport congestion becomes less important on the price variation when consumers book flights earlier before departure.

Discussion and Conclusion

Overall, the empirical results provide evidence to support Hypothesis 1. Third-degree price discrimination based on the timing of booking exists in the airline industry. Advance booking is proved to have a negative effect on the price of a flight ticket. Average booking price is 1.93 USD lower when consumers book their flights one day earlier. Meanwhile, the comparative study between KLM and BA indicates that Hypothesis 2 is rejected. The positive coefficient of interaction between advance booking and airline suggests that the marginal effect of advance booking on price is smaller (less negative) in KLM which uses continuous pricing than in BA which uses traditional pricing strategy. This refers to the opposite situation of Hypothesis 2.

Subsequently, average booking price of a flight is highest within three days before departure. In this stage, the estimated coefficient of advance booking is negative but no longer significant. Hence, no explanatory power of booking time on price could be concluded. The effect of advance booking is most negative and significant when a booking is made between 4 and 14 days before departure. Average booking price is most sensitive to the booking time during this period and decreases as a booking is made more in advance to departure. Finally, when a flight is booked more than two weeks prior to departure, the marginal effect of early booking is also negative and significant but is smaller than in the second stage. Booking price becomes more stable and remains at a low level during this period.

Regarding the influence of pricing strategy, the interaction between advance booking and airline pricing strategy becomes smaller as the number of advance booking days increases. This suggests that the timing effect on airfares would be less influenced by the pricing strategy of carriers among early bookings, and the power of price discrimination in KLM should be more similar to that in BA when a booking is made more in advance, ceteris paribus.

In *Trend Analysis*, I observed that both KLM and BA reach price peaks every 7 advance booking days. This points out a limitation of the OLS regression model applied in this research, as the relationship between timing and price of a booking is in fact not always linear. Despite the three separate periodical analyses in previous discussions, the 7-day price fluctuation remains to be solved. The current model only addresses the effect of intrinsic differences between airlines but fails to consider the time-specific price fluctuations experienced by both airlines. Future relevant studies need to include such 'peak' analysis in the model to improve the quality of estimation.

Moreover, data of BA is used to represent the price behaviour of KLM before it switched to continuous pricing for analysing the effect of pricing strategy on the relationship between timing and price of a booking. Nevertheless, the regression outputs could only indicate the between-carrier difference in price sensitivity to booking time. The influence of different pricing strategies on the marginal effect of advance booking cannot be concluded. Ideally, such effect needs to be tested through an intertemporal comparison of KLM price behaviours before and after it switched to continuous pricing. The role of pricing strategies in the marginal effect of advance booking on price could be further analysed in future relevant studies if pre-treatment data is accessible.

In addition, within the 60 days prior to departure, the most significant price change appears around 4 days before departure, in which the price starts to decrease from the highest position observed within three days before departure. The average booking price falls into a relatively low and stable range when consumers book their flights more than 14 days before departure. In a similar study conducted by Mantin and Koo (2009), booking prices over the 90 days prior to departure are analysed, and the paper finds a price rebound between the 65 and 90 days before departure. Since there is insufficient price data for flights three months ahead in my research, this price trend is not detected. Once more airline-specific price information is available to retrieve, studying for a longer period may better illustrate the relationship between the timing of booking and the price of a flight.

Appendix

Table 3 – Summary statistics of KLM

Statistic	Mean	St. Dev.	Min	Max
Price	435.81	456.30	82.46	1,778.03
Price_June	447.29	466.20	89.50	1,830.74
Price_July	424.90	455.33	71.87	1,776.55
Distance	2,912.23	3,166.65	158.00	11,437.00
Flight frequency per week	18.15	12.15	3.00	58.00
Number of rival airlines	1.13	1.21	0.00	5.00
Number of rival flights	13.02	15.01	0.00	60.00
Low-cost rivals	0.44	0.50	0.00	1.00
Departure GDP per capita (1,000 USD)	44.36	17.78	1.88	116.36
Departure population (1,000)	2,602.00	4,380.63	27.00	32,065.76
Departure airport congestion level	2.96	0.20	2.00	3.00

Table 4 – Summary statistics of BA

Statistic	**Mean**	**St. Dev.**	**Min**	**Max**
Price	496.67	652.10	42.00	2,948.31
Price_June	526.40	697.61	38.25	2,770.05
Price_July	472.71	648.66	45.00	3,140.45
Distance	2,654.00	2,883.21	243.00	11,631.00
Flight frequency per week	15.70	11.76	1.00	48.00
Number of rival airlines	0.82	1.01	0.00	6.00
Number of rival flights	13.85	18.92	0.00	84.00
Low-cost rivals	0.20	0.40	0.00	1.00
Departure GDP per capita (1,000 USD)	39.67	16.62	1.88	116.36
Departure population (1,000)	6,182.64	5,001.72	26.63	32,065.76
Departure airport congestion level	2.87	0.34	2.00	3.00

Reference:

Air Miles Calculator (2022). *Flight Distance.* Retrieved May 5, 2022, from https://www.airmilescalculator.com/distance/

Baker, M. B. (2021, April 30). Airline 'continuous pricing' gains traction, but widespread use a ways off. Business Travel News. Retrieved May 5, 2022, from https://www.businesstravelnews.com/Procurement/Airline-Continuous-Pricing-Gains-Traction-but-Widespread-Use-a-Ways-Off

British Airways | Flight Information (2022). *Our Route Network: Flight Information: British Airways.* Retrieved May 5, 2022, from https://www.britishairways.com/en-gb/information/flight-information/our-route-network

Brons, M., Pels, E., Nijkamp, P., & Rietveld, P. (2002). Price elasticities of demand for passenger air travel: a meta-analysis. *Journal of Air Transport Management*, *8*(3), 165–175. https://doi.org/10.1016/s0969-6997(01)00050-3

Corts, K. S. (1998). Third-Degree Price Discrimination in Oligopoly: All-Out Competition and Strategic Commitment. *The RAND Journal of Economics*, *29*(2), 306. https://doi.org/10.2307/2555890

Flight Connections (2022). *Route map British Airways*. Retrieved 30 April, 2022, from https://www.flightconnections.com/route-map-british-airways-ba

Flight Connections (2022). *Route map KLM*. Retrieved 30 April, 2022, from https://www.flightconnections.com/route-map-klm-kl

Google Flights (2022). *Flight Prices.* Retrieved May 5, 2022, from https://www.google.com/travel/flights

Holmes, T. J. (1989). The effects of third-degree price discrimination in oligopoly. *The American Economic Review*, *79*(1), 244-250. https://www.jstor.org/stable/1804785

International Civil Aviation Organisation (ICAO) (2017). *List of Low-Cost-Carriers (LCCS) - ICAO*. Retrieved May 5, 2022, from https://www.icao.int/sustainability/Documents/LCC-List

KLM Royal Dutch Airlines (2022). *KLM Royal Dutch Airlines Route Map – Europe*. Retrieved May 5, 2022, from https://www.airlineroutemaps.com/maps/KLM_Royal_Dutch_Airlines/Europe

Malighetti, P., Paleari, S., & Redondi, R. (2009). Pricing strategies of low-cost airlines: The Ryanair case study. *Journal of Air Transport Management*, *15*(4), 195–203. https://doi.org/10.1016/j.jairtraman.2008.09.017

Maneenop, S., & Kotcharin, S. (2020). The impacts of COVID-19 on the global airline industry: An event study approach. *Journal of Air Transport Management*, *89*, 101920. https://doi.org/10.1016/j.jairtraman.2020.101920

Mantin, B., & Koo, B. (2009). Dynamic price dispersion in airline markets. *Transportation Research Part E: Logistics and Transportation Review*, *45*(6), 1020–1029. https://doi.org/10.1016/j.tre.2009.04.013

Morrison, S. A., & Winston, C. (1990). The dynamics of airline pricing and competition. *The American Economic Review*, *80*(2), 389-393. https://www.jstor.org/stable/2006606?casa_token=vS06O8C6_jMAAAAA%3AzgTl-OfSbsZckMOuD1KpgZeFjbJagU0iKTTlnEazNWcipQFQWbnpqEhUUZZHKeAACJ-b9wN3Ykons8v3bFOQSoWsuJdwBs-sa_0vz0qtMi-QWQ6QL7Sa&seq=1

Mumbower, S., Garrow, L. A., & Higgins, M. J. (2014). Estimating flight-level price elasticities using online airline data: A first step toward integrating pricing, demand, and revenue optimization. *Transportation Research Part A: Policy and Practice*, *66*, 196–212. https://doi.org/10.1016/j.tra.2014.05.003

O'Neill, S. (2021, March 30). Air France-KLM joins airlines getting ahead of fare wars by mimicking uber. Skift. Retrieved May 5, 2022, from https://skift.com/2021/03/30/air-france-klm-joins-airlines- getting-ahead-of-fare-wars-by-mimicking-uber/

Pels, E., & Rietveld, P. (2004). Airline pricing behaviour in the London–Paris market. *Journal of Air Transport Management*, *10*(4), 277–281. https://doi.org/10.1016/j.jairtraman.2004.03.005

Skytrax (2021). The World's Top 100 Airlines of 2021. Retrieved May 5, 2022, from https://www.worldairlineawards.com/worlds-top-100-airlines-2021/

Swan, W. M., & Adler, N. (2006). Aircraft trip cost parameters: A function of stage length and seat capacity. *Transportation Research Part E: Logistics and Transportation Review*, *42*(2), 105–115. https://doi.org/10.1016/j.tre.2005.09.004

United Nations (2022). *UN Data | Record View | City Population by Sex, City and City Type.* Retrieved May 5, 2022, from https://data.un.org/Data.aspx?d=POP&f=tableCode%3A240

World Bank (2020). *GDP per capita (current USD).* Retrieved May 5, 2022, from https://data.worldbank.org/indicator/NY.GDP.PCAP.CD

World Bank (2020). *Total Population.* Retrieved May 5, 2022, from https://data.worldbank.org/indicator/SP.POP.TOTL

World Population (2022). *World City Populations 2022*. Retrieved May 5, 2022, from https://worldpopulationreview.com/world-cities