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Diploma Thesis

Airfare Analysis: Time and Seasonality as Determinants of Price Change

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DIPLOMA THESIS ASSIGNMENT

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Airfare Analysis: Time and Seasonality as Determinants of Price Change

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Objectives of thesis

This thesis was written in order to provide readers with an extensive analysis of the effects of different time variables on the price of air tickets. Seasonality, advanced purchase, length of stay plus date of departure and return are considered. The goal of the thesis is to examine how these variables affect the price in time and detect the factors that influence the change. Furthermore, the thesis aims to build an econometric model that can help travellers with decision when to buy their ticket.

Methodology

In order to achieve the aim of the thesis, various methods were applied.

Firstly, an extensive Literature Review focusing mainly on the aviation industry, air travel demand and airline pricing strategies was conducted, followed by a six-month internship within a global distribution system (GDS), which provided the author with practical insights about specifics of the industry and its trends.

The Empirical Part of the thesis was based on the data and information obtained during the internship within the GDS. Furthemore, the autor collected data neccessary to create an econometric model that examined the correlations of different time variables. This model was built in order to compare the findings from the literature review with the analysis and to disclose whether these findings confirm the hypothesis.

Schedule for processing

May 2013 - September 2013 - Defining objectives and methodology of the thesis

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Aviation, airfares, price, dynamic pricing, prediction, analysis, econometrics, seasonality, global distribution system

Recommended information sources

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Declaration

I declare that I have worked on my diploma thesis titled Airfare Analysis: Time and Seasonality as Determinants of Price Change by myself and I have used only the sources mentioned at the end of the thesis.

In Prague on 25th March, 2014 ____________________

Ondřej Aška

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I would like to thank to Ing. Petr Procházka, Msc, Ph.D. for his helpfulness, flexibility and support during my work on this thesis. I especially value this support given the fact that most of the cooperation was on distance. In addition, I would like to thank to Nicolas Christopoulios for providing me with guidance on data-mining regarding airline pricing.

Analýza cen letenek: čas a sezónnost jako faktory ovlivňující změnu cen

Airfare Analysis: Time and Seasonality as Determinants of Price Change

Souhrn

S vývojem revenue managementu v leteckém průmyslu byly vyvinuty specifické metody, které mají za cíl maximalizovat příjmy leteckých společností. Tyto metody se změnily v systémy, které leteckým spolčnostem umožňují dynamicky měnit ceny v reálném čase v závislosti na tržní poptávce. Sytémy používající dynamickou tvorbu cen mohou zapříčinit prodej stejné služby za rozdílnou cenu díky správnému urcření ochoty platit.

Cestující jsou těmito změnami v cenách znepokojeni a nejsou ochotni platit více než ostatní za stejnou službu. Kormě toho, se zvýšeným konkurenčním tlakem v rámci leteckého průmyslu, nárůstem letenek prodaných on-line a příchodem on-line cestovních agentur, většina cestujících je ochotni zaplatit pouze nejnižší možnou cenu.

Tato diplomová práce se zabývá tématem jak se ceny letenek mění v čase a detekuje významnost faktorů ovlivňujících tyto výkyvy a navrhuje ekonometrický mode, který kvantifikuje zvažované fakory: sezónnost, délka pobytu, den odjezdu, návratu a den koupě letenky. Dále tato práce doporučuje cestujícím kdy a zda koupit letenku nebo vyčkat až cena poleví.

Klíčová slova:

Letectví, letenky, cena, dynamická tvorba cen, predikce, analýza, ekonometrie, sezónnost, globální distribuční systém

Summary

With the development of revenue management systems in the aviation industry, specific data-mining methods have been developed in order to maximize the revenue of airline companies. These methods turned into systems that allow airlines to change prices dynamically in real time depending on the market demand.

Travellers are concerned with these price changes and are not willing to pay more for the same service than others. Furthermore, with an increased competitive pressure within the aviation industry, increased number of air travel tickets sold online and the arrival of online travel agencies, majority of travellers are willing to pay only the lowest possible price.

This thesis deals with the topic of how airfares fluctuate in time, detects the significance of factors influencing these changes and proposes an econometric model that quantifies the considered factors: seasonality, the length of stay, the departure day, the return day and the purchase day of the week. Furthermore, the thesis advises travellers to make their decisions on when and whether to buy their tickets or wait with the purchase.

Keywords:

Aviation, airfares, price, dynamic pricing, prediction, analysis, econometrics, seasonality, global distribution system

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1 Introduction

Given the fact that the aviation industry has undergone through many changes in past years, the business model of airlines is constantly evolving and the competitive pressure increases. The Airline Deregulation Act (1978) has made the ability to determine passenger demand for air travel essential in order to maintain a profitable business. It was because of this act that dynamic pricing and revenue management systems were broadly put in place. The Airline Deregulation Act eliminated strict rules between the price – distance relationship that airlines had to obey before that time. After the deregulation airlines could have set prices that were not connected to their operating costs or even the distance travelled, which has resulted in the emergence of low-cost carriers. [Rubin, Mantin, 2012].

Since airlines have to keep up with low-cost carriers, they need to regulate demand. That means that in each time there is a high demand, the airfare rises and each time the demand decreases, the airfare decreases as well. This strategy is applied in order to sell the maximum possible amount of seats even in cost of a potential overbooking.

As an effect of applying revenue management systems and dynamic pricing strategies, price discrimination might occur. In fact, the system aims to sell the same ticket at several different price levels depending on the occupancy of the aircraft and current market demand.

The purpose this paper is to analyse of how airfares change over time and what are the driving factors influencing the change. This research is done by an intense

In addition to that an econometric model, which advises travellers to make their decisions on when and whether to buy their tickets or wait with the purchase, is presented in the Empirical Part. It can be difficult to build an accurate model since the fluctuations in airfares are not always completely rational. In fact, same conditions might present different outcome i.e.: having identical values for all variables might result in an increase of price in one scenario and in a decrease for another scenario. There are limitations to this work as it is impossible to obtain some data needed to determine the correlation between all variables, i.e. the amount of unsold seats is strictly confidential information that airlines do not provide. Nonetheless, the fact that the author has spent several months working in a Global Distribution System has provided him with priceless insights on the processes behind revenue management systems and valuable data regarding airfares evolution, thus it is assumed the results of the analysis will be of high quality, accuracy and applicable to travellers aiming at reducing their expenditures.

2 Objectives

This thesis was written in order to provide readers with an extensive analysis of the effects of different time variables on the price of air tickets. Seasonality, advanced purchase, day of purchase, length of stay, and date of departure and return is considered.

The goal of the thesis is to examine whether and how these variables affect the price in time and detect the factors that influence the change. Furthermore, the thesis aims to build an econometric model that examines and quantifies the effect of the proposed variables on the price of air tickets. The model and therefore the analysis is based on the itinerary Prague-Nice, since the author of the thesis spent his internship in both of these locations and was fascinated by the fluctuations of airfares on this itinerary.

Finally, the analysis within the thesis advises travellers with their decision making process of whether and when to buy their ticket. These recommendations are based both on extensive literature research and the econometric model.

3 Methodology

In order to achieve the aim of the thesis, various methods were applied. Given the fact that the topic of dynamic pricing within the aviation industry has been widely discussed, qualitative methods were applied in order to gain sufficient information about the topic and possibilities of analysis. Therefore, firstly an extensive Literature Review focusing mainly on the aviation industry, air travel demand and airline pricing strategies was conducted, followed by a six-month internship within a Global Distribution System (GDS), which provided the author with practical insights about specifics of the industry and its trends. This combination of different qualitative methods provided the author with an understanding of what are the real challenges of the topic and to which direction the quantitative (empirical) part needs to be directed.

The Empirical Part of the thesis was based on the data and information obtained during the internship within the GDS. Before obtaining the data, intense investigation and discussions with industry experts that work in the field for a significant period of time were conducted. It is necessary to mention that without the guidance of these experts, especially Mr. Christopoulios, the selected data would probably not be the best fit for the purpose of the model. Furthermore, the author collected the data necessary to create an econometric model that examined the correlations of different time variables. This model was built in order to compare the findings from the literature review with the analysis and to disclose whether these findings confirm the hypothesis.

4 Literature Review

Air Travel Demand

The aviation market has gone through significant transformation in recent years, caused by the Airline Deregulation Act in 1978, massive entry of low-cost carriers, high volatility of oil prices and the emergence of new information technologies and the Internet. Despite these considerable changes, the aviation market has experienced constant growth over past decades. This growth results in increased competitiveness that affects pricing strategies of airlines that offer their services to travellers. [42]

This thesis examines how airlines adjust their pricing strategies over a period of one year, while adhering to the importance of seasonality and other time-affecting variables and what conclusions can be drawn from this analysis for travellers.

Nowadays, airlines are facing constantly rising competitive pressure and pressure on costs at the same time. The cost pressure is inevitable as oil prices rise over past few years, airports' charges increase constantly and further governmental taxes are being imposed. All these factors lead to higher prices for air travellers and change in air travel demand.

„*The demand for air travel has expanded substantially since the 90s. Passenger numbers rose by an average annual growth rate of about 6% over the past two decades, which was considerably faster than traffic growth in most other developed aviation markets. Much of the growth in recent years has been accounted for by outbound leisure travel that has shown remarkable resilience in the face of a series of momentous adverse events*." [33]

It is indeed remarkable that the air travel regained its pre-recession levels before macro economical data showed a broader economic recovery. In terms of European air travel, the pre-recession levels of the 2008 peak were exceeded in the second half of 2012 as shown on the Figure 1. [2]

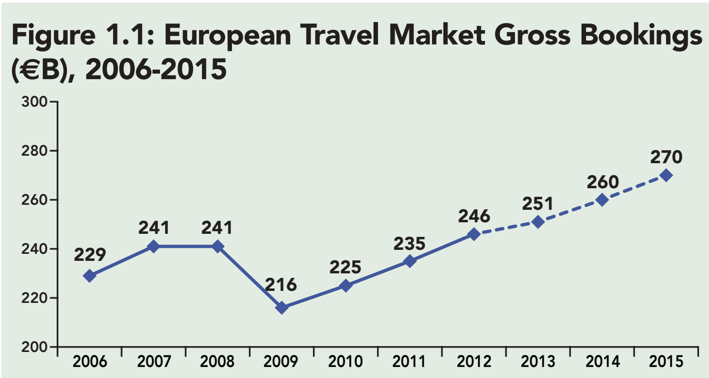

Figure 1: European Travel Market Gross Bookings (€B), 2006 - 2015;
Source: European Online Travel Overview, Ninth Edition, 2013.

„*Despite such an impressive growth record some industry observers have expressed concerns about the future traffic developments. They argue that although the industry is doing well in volume terms, this is only because airlines are heavily discounting and that this situation might not be sustainable for much longer. Rising fuel prices, airport taxes and possible environmental regulation of the industry all suggest that air fares, at least on short haul, are unlikely to continue on the present downward path for much longer, and may even start to increase. Once this happens, the argument goes, there will be too much capacity and not enough demand, and both airlines and airports will need to adjust their growth aspirations accordingly*.“ [37]

The importance of airfares has undoubtedly increased in past years from the viewpoint of separate airlines because of better transparency and more the possibility of having more substitutes. [22] Consumers nowadays have greater choice in terms of destinations, service providers and flexibility, and are able to make better-informed decisions about different offers available to them. However, it is also true that the airfares have fallen dramatically in recent years on short haul and that as a result the overall demand for air travel may increasingly be influenced by other demand drivers such as the costs of other components of travel abroad, or economic growth, which are largely outside the influence of the industry and policymakers. [12] [31]

"*The demand for air travel is sensitive to changes in air travel prices and incomes. However, the degree of sensitivity (i.e. its demand elasticity) will vary according to different situations. To ensure that air transport policies are effective, reliable estimates for demand elasticities are essential*." [38]

Demand Elasticities

Demand elasticity illustrates how sensitive a demand for specific good is in relation to other economical variables. In fact, it measures the difference between quantity of a good demanded and a proportional change to other variable such as income, price, price of a subsidy or taxes, etc. Elasticity greater than one is defined as "elastic", elasticity lower than one is defined as "inelastic" and lastly elasticity equal to one is " unit elastic". [38] [8]

In following section, 3 types of demand elasticities are described: price elasticity, cross price elasticity and income elasticity.

Price Elasticity

Price elasticity measures how sensitive are the changes in demand to the change in price. It is defined as:

$$\frac{\text{\% Change in Quantity Demanded}}{\text{\% Change in Price}}$$

In reality when price elasticity of demand is elastic, goods are considered to have a price sensitive demand. This means that increase in price will result in revenue decrease for the producer as the revenue gained from the price increase will be lower than the revenue lost from decreased quantity of good sold.

When price elasticity of demand is inelastic the increase in price will cause revenue increase. This is caused by the fact that the revenue gained from the price increase is higher than the revenue lost from decreased quantity of good sold.

If the elasticity coefficient equals to one, demand is unit elastic and the percentual change in demand will equal to the percentual change in price.
Oppositely, when coefficient equals to zero, demand is perfectly inelastic and there is no change in demand when price changes. [38] [8]

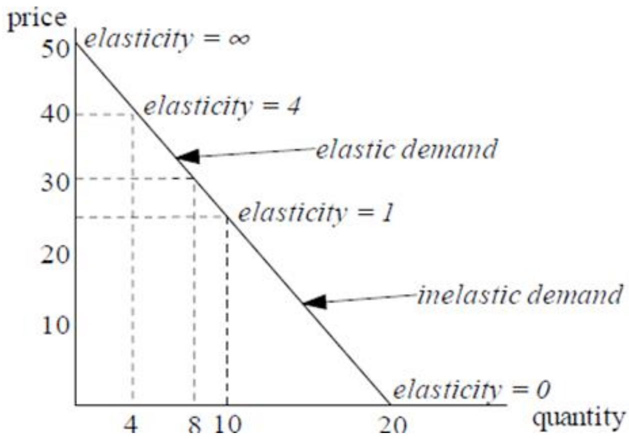

Figure 2: Price Elasticity;
Source: assignmenthelp.com

Cross Price Elasticity

Cross price elasticity measures how sensitive are the changes in demand of one good to the change in price for a different good. It is defined as:

$$\frac{\%\ \text{Change in Quantity Demanded of Good A}}{\%\ \text{Change in Price of Good B}}$$

In case that cross price elasticity is positive, it means that both goods are substitutes (e.g. butter and margarine). This means that increase in the price of the Good A will cause demand to increase for the Good B.

When is cross price elasticity negative, it illustrated that goods are complementary to each other (printer and ink cartridge). In this scenario, increase in the price of Good A will cause demand to decrease for both goods. [38] [8]

If the elasticity coefficient equals to zero, both goods are independent on each other and there is no interrelation effect.

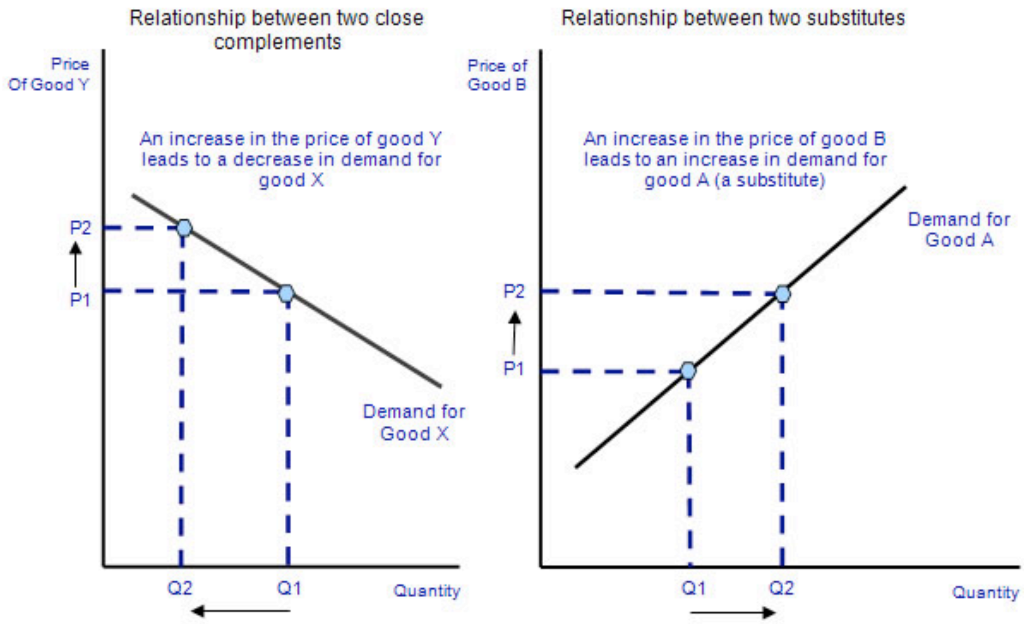

Figure 3: Cross-price elasticity;
Source: Geoff Riley, Economics Blog, tutor2u.com

Income Elasticity

Income elasticity measures how sensitive are the changes in demand for a good with regards to income of groups demanding the good. It is defined as:

$$\frac{\%\ \text{Change in Quantity Demanded}}{\%\ \text{Change in Income}}$$

When income elasticity ranges between 0 and 1 it illustrates that as income rises, more good is demanded at each price level. Therefore it indicates a normal good.
Whilst for luxury goods elasticity greater than 1 is typical. For luxury goods demand increases by greater proportion as income rises. This is explained by the fact that as society or a group becomes wealthier, it can afford to buy higher standard goods. However, it does not mean that these goods are exclusively purchased by the wealthiest.

The last group is inferior goods, having income elasticity of less than 0 (negative). For this group of goods demand decreases as income increases as illustrated on the Figure 4 Typical example of inferior good within the industry would be a bus travel. As consumers' income increases, their preferences might be to travel by car, plane or even a train if more convenient. Therefore, bus as a cheapest mean of transport would experience a decrease in demand. [38] [8]

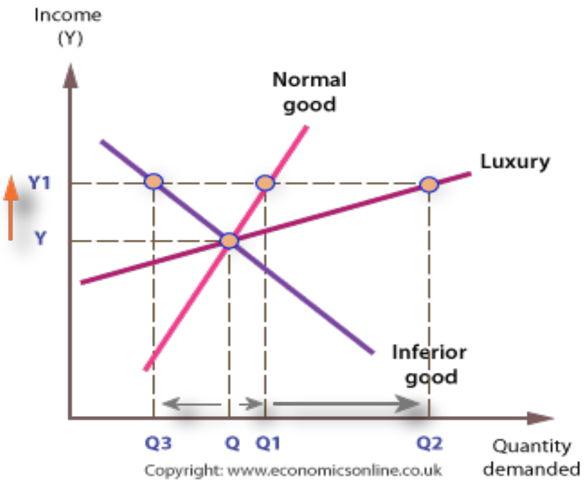

Figure 4: Income elasticity for normal, luxury and inferior goods; Source: economicsonline.com

Implication for the Aviation industry

"*The growth of incomes, often proxied by GDP, has been found to be the fundamental driver of the demand for air travel. During the past twenty years global passenger traffic has expanded at an average annual growth rate of 5.1%, while global GDP grew by an average annual rate of 3.7% over the same period. That implies an average income elasticity of 1.4, similar to the average estimated above for developed economies. The implication is that economic growth can explain most of the expansion in air travel seen in the past twenty years. The fall in real air travel prices has played a part, but mostly in diverting travel between airlines and markets rather than significantly boosting overall travel volumes. In addition, economic growth is now increasingly being driven by developing economies, where income elasticities are higher. Therefore, the underlying drivers for overall air travel growth are likely to remain strong for the foreseeable future*." [38]

If all airlines on a wide set of routes increase travel prices by roughly similar amounts (e.g. due to the imposition of new market-wide taxes or to the working through of higher fuel or security costs) then the decrease in traffic may be less or much less than proportional to the increase in fares. National or Supra-National increases in airline travel prices that take place across a broad range of markets, are price inelastic. [23]
Thus, the particular elasticity value to be used for analysing price effects in airline markets depends on the question being asked. The narrower the applicability of a price change, the more elastic (i.e. larger) the change in demand. The more general the applicability of a price change (perhaps due to higher costs or taxes) the less elastic (i.e. smaller) the change in demand. [38] [8]

Seasonality

Seasonality is a characteristic of a market, product, or promotion that shows a pattern of variation with changes in seasons. [16]

Travel industry and aviation in particular is highly affected by seasonality. This paper is aims to analyse and quantify the impact of the seasonality factor. However, without putting this factor in context the result of the analysis might be misleading.

"*Seasonality has long been viewed as one of the most unique and worrisome facets of the tourism industry. It can be defined as a cyclical pattern that more or less repeats itself each year. It usually refers to a temporal imbalance in the demand, and may be expressed in terms of the number of tourists, their expenditure, and bed nights (Butler 1994). It has been held responsible for difficulty in gaining access to capital, for fluctuating returns on investment, and for subsequent high risk of investment, primarily due to the instability of tourism revenues over seasons and under-or-over utilization of the same resources and facilities (Butler, 1994 and Hinch and Jackson, 2000). Accordingly, great efforts should be made to mitigate the troublesome seasonality in destinations through a variety of approaches. However, although many suggestions have been made for measuring the problems of seasonality, it seems that only limited efforts have been devoted to methods of overcoming them. There also seems to be a scarcity of research exploring quantitative approaches to smooth out this demand fluctuation. In this light, destination marketers should pay attention to the financial portfolio theory, which can serve as an effective tool for reducing seasonality*." [26]

Seasonality is a strong determinant in the air travel industry but due to Jang (2012), strong empirical evidence that would illustrate the effect on price is missing.
The impact of seasonality and its linkage to demand fluctuation is well explained by Spotts & Mahoney (1993). These fluctuations are usually connected to climate and changes in weather, therefore different periods of the year. Travellers have individual preferences that need to be distinguished accordingly to the location and the purpose of

the travel. When we consider locations such as Cote d'Azur, which is the subject of the analysis within this thesis, the purpose of the travel is in majority of cases leisure – sun and sea. Therefore looking at the demand perspective, we would expect high seasonality pattern during the high season, which is spring and especially summer. The results of the analysis are discussed in within the Empirical part of the thesis. Assuming that the rest of the year is off-season, there is a significant impact for the travel providers as the demand decreases for more than half a year. Many studies aim at identifying and examining the effect of policies that try to mitigate the negative effect of seasonality. Off-season deals are one of the ways in which travel providers try to stimulate the demand and motivate travellers to purchase fares. Another common strategy is the organization of special events and festivals, which is typical example for the Cote d'Azur. Festival of Nice in February kicks off the season followed by the International Film Festival and the Grand Prix Formula being held in the early season. [26] [10] [11]

The thesis does not deal with ways of mitigating or reducing seasonality but rather looks at it from a quantitative point of view and analyses its relevance with other price affecting factors.

Despite the fact the mitigating seasonality is not the main topic of the Thesis, we will illustrate how airlines actually soften the impact of seasonality on their business by applying revenue management and use of precise pricing models as described in the following section. This illustration is provided because it simply has an impact on the airfares and therefore on the traveller as well.

Dynamic Pricing

The majority of the literature related to pricing has been focused on the primary market and traditional cost-oriented, fixed ticket pricing. This does not apply to the tourism and travel industry and especially not to the airfares where prices fluctuate depending on a number of factors. In order to maximize the potential yield, a technique called dynamic pricing is used. Online retailers utilize this approach as a way to keep pace with fast development of e-commerce as described by Rishe and Mondello (2004). [15] [17]

Dynamic pricing (often called real-time pricing) is a technique how to determine and set a cost for a good or service that is highly flexible. The approach of dynamic pricing allows company to adjust its prices quickly (real-time) in response to a current market demand. [7]

The adjustments are made by complex algorithms that are part of software programs, which adjust the pricing according to pre-set business rules and data gathered. Business rules can vary a lot. In example they can consider buyer's location, time of the year, the day of the week, time of the day or even browser's cookies. Nowadays, every individual leaves huge amount of information about himself/herself on the Internet. Information about large quantities of individuals are a part of a big data that enables companies to analyse each customer's buying patterns and eventually his/her willingness-to-pay.
To define one's willingness-to-pay is an essential success factor in dynamic pricing.

Willingness to pay

The willingness-to-pay is the maximum amount a person is willing to pay for a good or a service. In our case it is the willingness of a traveller to pay a maximum fare for a ticket. In fact, willingness to pay measures the marginal benefit of a traveller or the demand curve. Any passenger will accept to pay a trip with a fare lower than his willingness-to-pay. In practice, knowing the real willingness to pay of a passenger is very challenging. Every individual consumer is specific and unique. Moreover, if the fare is higher than the willingness-to-pay of a traveller, he will simply not purchase the ticket. Oppositely, the amount traveller actually pays for the fare does not necessarily needs to be the maximum that the passenger is willing to pay for the ticket. [32]

The difference between travellers willingness to pay for the ticket and the actual price (market price) is a consumer surplus. In fact, consumer surplus measures the welfare the traveller receives from his/her consumption of the good or service or the benefit received from the purchase. The level of consumer surplus is illustrated on the Figure 5 below. Consumer surplus is the area of below the demand curve and above the market price (ABC area). [24] [9]

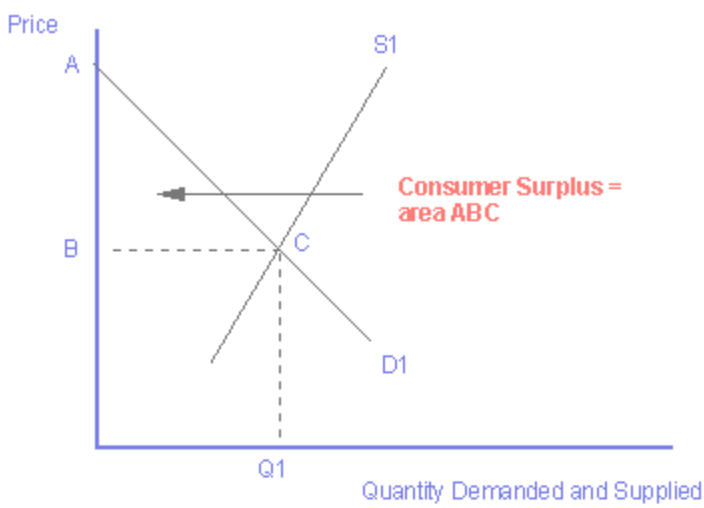

Figure 5: Willingness to pay: consumer surplus;
Source: Geoff Riley, Economics Blog, tutor2u.net

Let's assume that the demand on Figure 6 represents a demand for air transport. The initial airfare is represented by price P and the quantity of this airfare demanded by travellers is Q_1.

At the price level P, the consumer surplus is illustrated by the area APB. However, when the airline decreases the price to the level P_1, the quantity demanded for this airfare increases to Q_2. This has an increasing effect on the level of consumer's surplus, which enlarged into the area AP_1C. [24] [9]

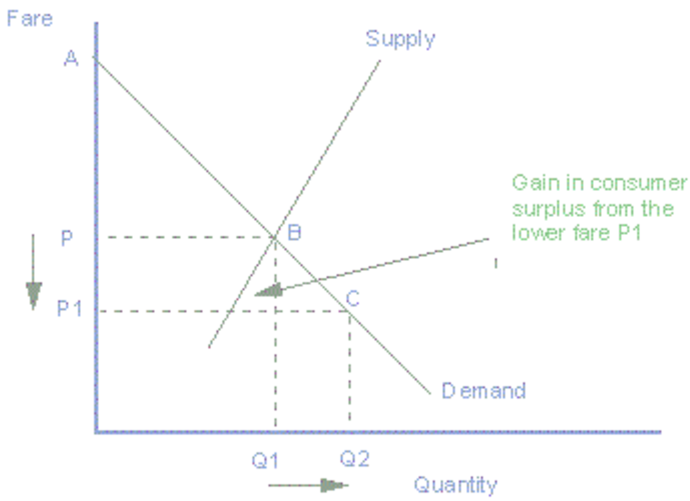

Figure 6: Willingness to pay: consumer surplus;
Source: Geoff Riley, Economics Blog, tutor2u.net

The principle of willingness to pay and consumer surplus is widely used when applying the dynamic pricing approach.

Dasu and Tong (2010) studied the correlation and pointed out very interesting fact that can be applied to the travel industry market as well. The characteristics of optimal dynamic pricing policies and the ability of the firm to extract consumer surplus are significantly altered when consumers anticipate pricing policies. For one thing, it is costly for the firm to ignore such behaviour when developing pricing policies. Pricing schemes that account for strategic buyers are qualitatively different. The gap between the lowest price and the highest price is reduced. If consumers are not strategic, it is well known (Gallego and van Ryzin (1994)) that dynamic pricing will increase a firm's revenues if there is uncertainty in the customer arrival process. On the other hand, if buyers are strategic then even if there is uncertainty in demand, dynamic pricing need not increase the firm's revenues. For dynamic pricing to be useful it is essential that consumers anticipate a shortage. Static pricing is optimal regardless of whether or not demand is uncertain, as long as buyers are assured of supply. Further, when buyers are strategic and shortages are perceived, dynamic pricing is better than static pricing even if demand is deterministic. [21] [15]

The difference between uniform and dynamic pricing is well illustrated on the Figure 7 below. When an airlines applies the uniform pricing, it can successfully sell seats for business class but it will most probably discourage leisure customers, who still account for majority of the market. The uniform pricing approach might therefore cause unused capacity, which could be again solved by lowering the price of the fare.
The optimal pricing strategy is one that can act as equilibrium. This means that it aims to fill leisure seats but it allows saving seats for high-margin business customers at the same time.

The graph shows that uniform pricing sets higher price in advance of the departure day compared to the dynamic pricing which tends to increase the price closer to the departure day. The fact that the price is relatively high well in advance but relatively low closer to the departure day results in a different reallocation of seats over time.
Regarding to study of Kevin R. Williams (2013), 17% fewer leisure seats are purchased when using the uniform pricing. [15]

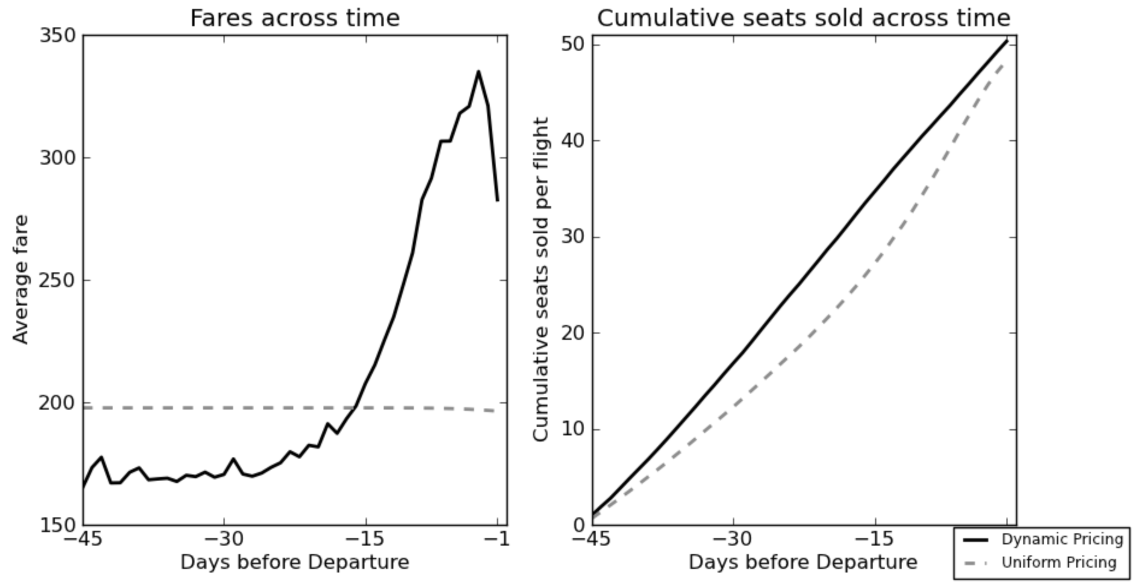

Figure 7: Dynamic pricing: dynamic vs. uniform pricing;
Source: Dasu & Tong, 2010

In addition to that, Dasu and Tong (2010) state that when prices can be changed limitlessly, expected revenues are not affected by whether or not buyers are aware of the number of units remaining unsold. However, when the number of price changes is finite information about the sales and inventories influence expected revenues. Based on our numerical examples we conjecture that the firm should reveal the number of units that are available for sale at the beginning of the season, but subsequently conceal the inventory levels. This approach began to be widely used by airlines after the Airline Deregulation Act in 1979 and it is a part of their revenue management as described in the following section. [21] [15]

Revenue Management

Revenue management is an application of disciplined analytics that predict consumer behaviour and optimize product availability and price to maximize revenue growth. The essence of this discipline is in understanding customers' perception of product value and accurately aligning product prices, placement and availability with each customer segment. The Revenue management has significantly changed since it was developed by airlines in the early 80s. Nowadays, it is being widely adopted in many online segments. [27]

"Revenue management is concerned with demand-management decisions and the methodology and systems required to make them. It involves managing the firm's interface with the market as it were – with the objective of increasing revenues. Revenue management can be thought of as a complement of supply-chain management, which addresses the supply decisions and processes of a firm, with the objective (typically) of lowering the cost of production and delivery.

Other roughly synonymous names have been given to the practice over recent years – yield management (the traditional airline term), pricing and revenue management, pricing and revenue optimization, revenue process optimization, demand management, demand chain management (favoured by those who want to create a practice parallel to supply-chain management) – each with its own nuances of meaning and positioning.

However, we use the more standard term revenue management to refer to the wide range of techniques, decisions, methods, processes, and technologies involved in revenue and demand management." [40]

Revenue management can be utilized within a market that consists of different segments and different customers with different willingness to pay as we described in the previous section. However in order to for revenue management to be applicable, few conditions must be fulfilled:

- There is a limited (fixed) capacity of the resource
- The product/resource is perishable (it is a subject to spoilage or decay)
- There is a uncertain demand
- There is a possibility to control and differentiate the price of the product/resource

The product offered should be perishable and usually works with uncertain future demand and often has a finite capacity and high fixed cost.

Revenue management aims at maximizing the yield and profitability of a specific flight by offering and selling the right amount of tickets (seats) at various price levels regarding to the forecasted demand and the price elasticity of the customers. We mentioned that to calculate the exact price elasticity is nearly impossible but the closer airline can get, the higher the profit is. [40]

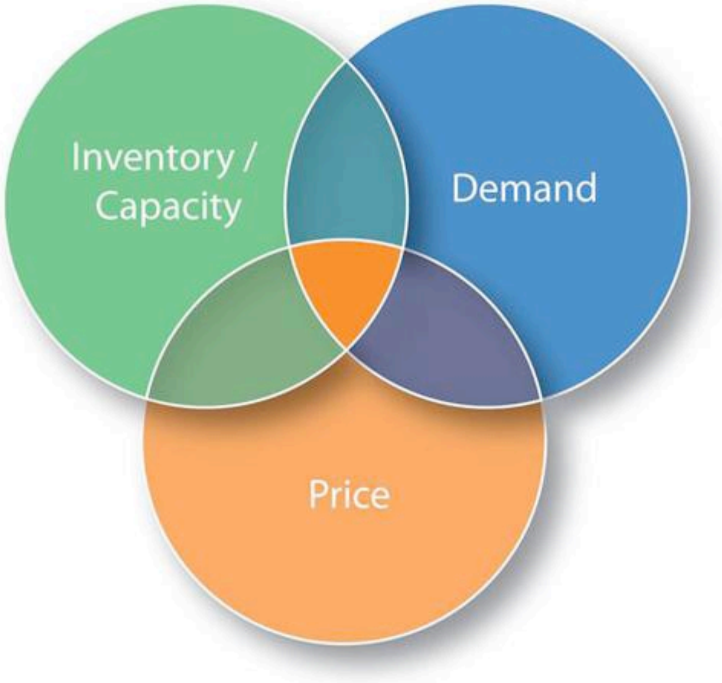

Figure 8: Elements of revenue management;
Source: Paul Achkar, 2012

The amount of seats available for sale at the time of publishing the fare is known as individual carriers have specific number of seats. However, as soon as the fare is available for sale and the trade begins, there is absolutely no chance to get the exact information on the number remaining seats. The only possibility is to know whether the flight is fully booked or not by purchasing the ticket and receiving either confirmation or cancellation. Even if one can look at the seat map and selects from different seats, there is no guarantee that all the seats were not sold already. There might be cases of travellers who bought the ticket but for some reason did not select a specific seat. The very same principle applies for tickets from consolidators. One of the reasons airlines apply this strategy is to accommodate higher yield travellers such as business-class passengers, and also, to entice ordinary passengers to buy a premium class ticket.

Airline companies do not provide the data on unsold seats even retrospectively, after the flight was processed. These data would represent very significant variable in our model; however, airlines' privacy policies do not allow obtaining these data. [27] [1]

Despite the fact that the topic of airfare prices and dynamic pricing is very interesting, there are limited literature resources that would deal with this topic. One of the main reasons that were stated above is the discretion policy from the side of airlines. Traveller than might seem to be fully in hands of the airlines and their precise revenue management analytical tools that allow them to determine the highest price for which they can sell him the desired ticket.

Nonetheless, there are several related works that aim at providing travellers with advices whether an when to buy the air ticket. These advices are based on analysing both airlines pricing strategies and demand for airfares. Following section of the thesis deals with these models.

Related Models

In order to fully grasp the idea behind the analytical models, we need firstly to introduce and explain basic methods of searching for an airfare and options that are offered to a traveller.

Traditional web searches for an airfare offer several options to narrow down the search such as: origin, destination, date for departure and return, flight class, etc. The Figure 9 below illustrates a classic web search input that needs to be filled in by a traveller in order to proceed with a search of an airfare. When completed, the traveller is offered by different options of travel solutions that are available to be booked immediately.

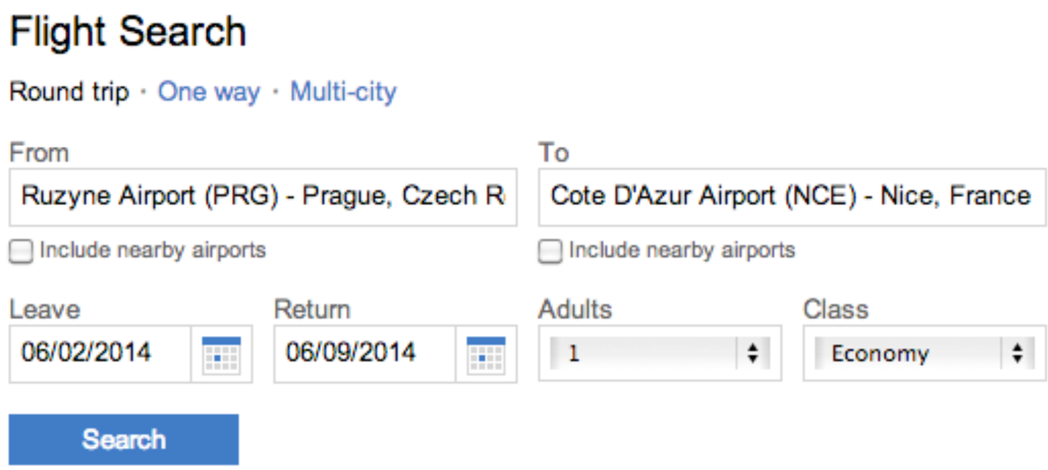

Figure 9: Typical search input;
Source: bing.com

This kind of web search is called "transactional" meaning that there is only one independent inquiry of price information for each independent request. Since, within this search mode, the traveller has to change and adjust the arguments and resend the inquiry in order to find the desired flight, the outcome efficiency is quite low, as the user has to go back and forth. This is shown on the Figure 10 illustrated below. [36]

Figure 10: Transactional web search with single airfare option; Source: easyjet.com

Nowadays, airfare web searches offer much more options and flexibility on different conditions such as the cheapest days to travel that provide the traveller with effective view on the cheapest possible options of travel. This is illustrated on Figure 11, which shows the cheapest das to travel and enhances traveller's experience and satisfaction by offering several options with less effort. [36] [6]

Figure 11: Popular web search illustration of the cheapest day to travel; Source: easyjet.com

In recent years, even more innovative ways of searching for air travel have been developed, especially for leisure travel. For example, the potential traveller may specify a budget instead of a destination, and is then presented with a map showing the different destinations that are accessible to him or her given the budget as shown on the Figure 13. Some airlines offer a combination of budget-oriented and target search based on how traveller wants to spend his time, shown on the Figure 12. As for an example, in case you would like to spend weekend by sightseeing in a historical city, the search will show you a several options with return flights to cities available for the weekend. [36] [18]

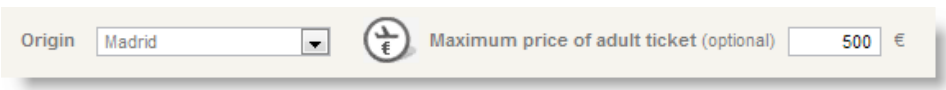

Figure 12: Budget-oriented search inquiry; Source: bing.com

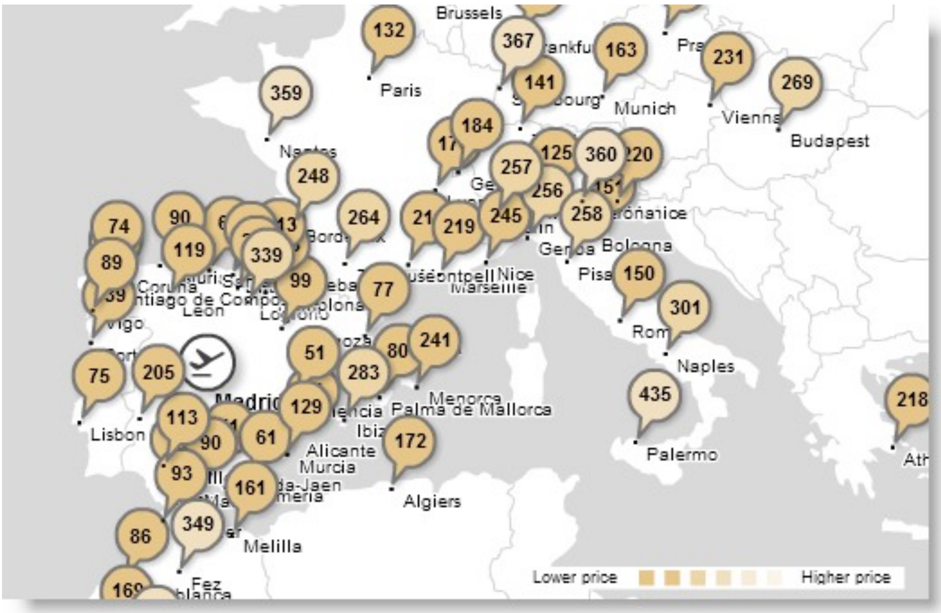

Figure 13: Budget web search offering different destination based on traveller's budget; Source: bing.com

Price predictors

The airline industry is one of the most sophisticated in its use of dynamic pricing strategies in an attempt to maximize its revenue. So, the prices are going down and up frequently (even though they often tend to go up while the departure date approaches).

This phenomenon is very interesting from both theoretical and practical point of view. However, the literature describing such topic is very limited. This is mostly caused by the fact that airlines in almost all cases implement discretion policies.

The following part deals with several examples of price predictors that use different data mining tools to analyse and predict whether and when possibly to buy the desired aifare ticket. [5] [20]

HAMLET

One of the very first projects dealing with this phenomenon was the Hamlet project. It tried to analyse time series through data mining analysis, Q-learning, and Rule learn method. By applying follow mentioned methods it recommended either to buy or wait. The project dealt with around 12,000 price observations over a 41-day period. [20]

For performance measures, the Hamlet project does not give any information about how accurate the predictor was. Instead, it only illustrated how much money using the model could have been saved.

The project claims to have saved $198,074 in total to 341 simulated passengers. Overall, this represented 4,4% of the ticket price on average. [5] [20]

FARECAST

Another early project was Farecast.com. Farecast was founded in early 2003 and it claimed it has collected over 175 billion airfare (only) observations as of 2007. Based on these observations, complex algorithms were built to predict the movement of airfare prices. [14]

BING

Microsoft search engine *Bing* made an acquisition of both the Hamlet and Farecast project and started to offer their service in the American market. The predictor gives an advice whether to “book now” or “wait”. There is also the option of buying with specific percentage of confidence. [6] [5]

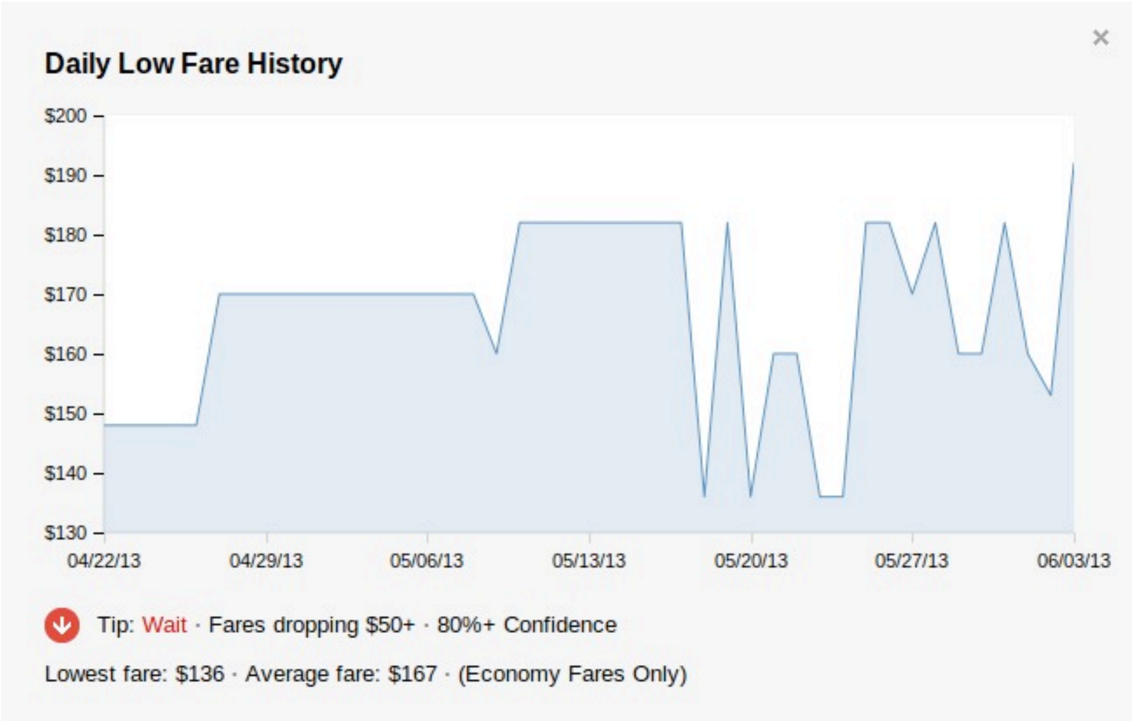

Figure 14: Bing Travel: Tip is to wait as the fare price might drop by more than $50 with 80% confidence in following weeks; Source: bing.com

Figure 14 Bing Travel: Tip is to wait as the fare price might drop by more than $50 with 80% confidence in following weeks. [6]

Microsoft claims that independent studies show that the predictor is accurate in more than 74%. The Seattle Times (the project was a Seattle start-up before it was bought by *Bing*), runs its own tests and found different results: ”A review of nearly 30 plane trips found an accuracy rate about 61%”. [35]

Based on Hamlet and Farecast predictor, *Bing* did not publish any paper to describe the theory behind the blended software they use.

Kayak:

The price predictor provided by Kayak is very similar to Farecast, described above. At the beginning it aimed only at American market but nowadays there are significant efforts to extend it to other markets. [19]

Figure 15: Kayak - Tip is to buy now as the fare price might increase by more than $20 with 85% confidence in the following week; Source kayak.com

As illustrated in the Figure above, Kayak, similarly to Bing also gives the advice for buying or waiting and the certainty of the prediction itself. [5]

Oppositely to Bing, which adopted both Hamlet and Farecast, there is no independent study, which would evaluate the accuracy of the Kayak predictor. However, there are claims estimating its accuracy to 74.5%. [19]

Application

This section deals with possible applications of price prediction software for different interest groups. These groups are divided into: travellers, travel agencies and travel search engines.

Travellers

A group utilizing price prediction models the most are travellers. It is not surprising since the most important driver in the market is price. Economy flights account for the majority of airfares and travellers prefer to save money rather than save time. This is not valid for business travellers who, on the other hand, focus on travelling from point A to point B within the shortest time frame. However, as mentioned above, majority of users seek the lowest price when they look for an airline ticket. [2] [5]

For travel search engines

The most important business objective for the travel search engines is to attract as many visitors that can potentially book an airfare through their website, providing the travel search engine with a commission fee. The competition within online travel industry is fierce and price prediction software is a strong competitive advantage. Majority of travel search engines still does not utilize this feature and loose the opportunity to offer extra service to its customers. So far, only Kayak and Bing have started to offer such service. [5] [19]

Travel agencies

Travel agencies can use the price predictor as a source of new revenue streams. Assuming that the price predictor is fairly accurate, travel agency can incorporate it as a part of its revenue management. In case that the price predictor would forecast a drop in an amount of 10€, the travel agency would be able to sell the ticket discounted by 2,5€ and wait for the actual drop before effectively booking the ticket. However, such application in revenue management needs very accurate forecast model, otherwise it might drive the company to lower yields. [5]

This thesis aims at creating a similar analysis as the ones presented in the previous section. It also uses data-mining techniques and regression analysis to examine the correlations within historical observations and presents a recommendation when is the best time to purchase the ticket and which parameters might have a significant impact on the price.

The analysis conducted within this thesis is based on data obtained from the Amadeus Global Distribution System. Global Distribution Systems play very important role within the travel and aviation industry and act as a data repositories for airlines to publish their fares and prices in. These data are than available to all the competitors allowing them to adjust their pricing strategies. However, the role of Global Distribution Systems in the price determination is more complex than that and its simplified explanation is provided in the following chapter.

Amadeus – A Global Distribution System

Amadeus is one of the biggest global distribution systems and a leading provider of technology solutions for the global travel and tourism industry. It operates as an international network for processing services to the travel industry and directly interacts with several customer groups such as travel providers (airlines, hotels, car rentals, rail and cruise operators), travel distributors (online and offline travel agencies, consolidators, websites etc.) and travel buyers as well (travel management companies and corporations). [3]

As a Global Distribution System, Amadeus plays an important role within the travel industry by seamlessly gathering all data entries from over than 700 airlines out of which more than 400 bookable within its system. These fares information are stored within its database and are visible to all airlines that operate with the Amadeus system (special platforms) pressing the levels of competitiveness a step higher. Amadeus also offers complete revenue management solutions along with dynamic pricing algorithms for airlines, which were described in previous chapters. Noting the role and its importance within the industry, brief description of the development of the major GDSs is outlined in the following chapter. [3]

Following part is dedicated to the origins of Global Distribution Systems and Amadeus respectively.

Origins of Global Distribution Systems

1930’s

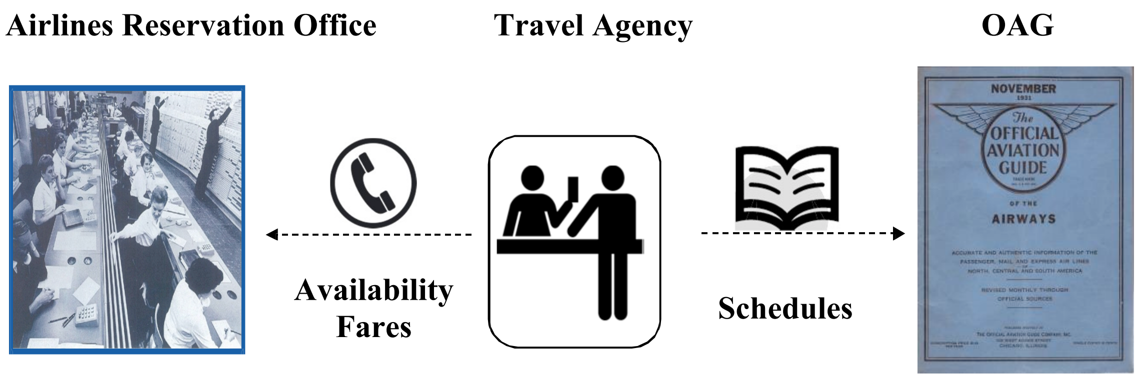

Figure 16: Travel booking scheme;
Source: Amadeus

Travel Agent Booking Process:

As seen on the Figure 8.1, schedules were manually checked in guide published by OAG – Official Aviation Guide. Nowadays, OAG still exists but only as an electronic database. Prices and Availability were obtained by calling the Airlines reservation office.

Due to an exponential increase of Airlines and serviced city pairs (only 35 Airlines in 1931, more than 1,000 airlines today), it was clear that the model needed to be more efficient and automated. [4]

1969+

The first “modern” Airline Reservation System was developed in 1969 by IMB. This system was based on a standard IBM mainframe (computing hardware) and it consisted of an operating system and two applications modules (reservation + inventory originally). [13]

Figure 17: IBM's Airline Reservation System; Source: Amadeus

Airline systems boom

1970+

There was a significant worldwide expansion of the main three reservation systems (MMARS – RTB, PARS, Unisys) during 1970's. Each of the system implementation was always customized and adapted to an individual airline and market needs.

Their respective market coverage is illustrated on the Figure 17.1 below. [13]

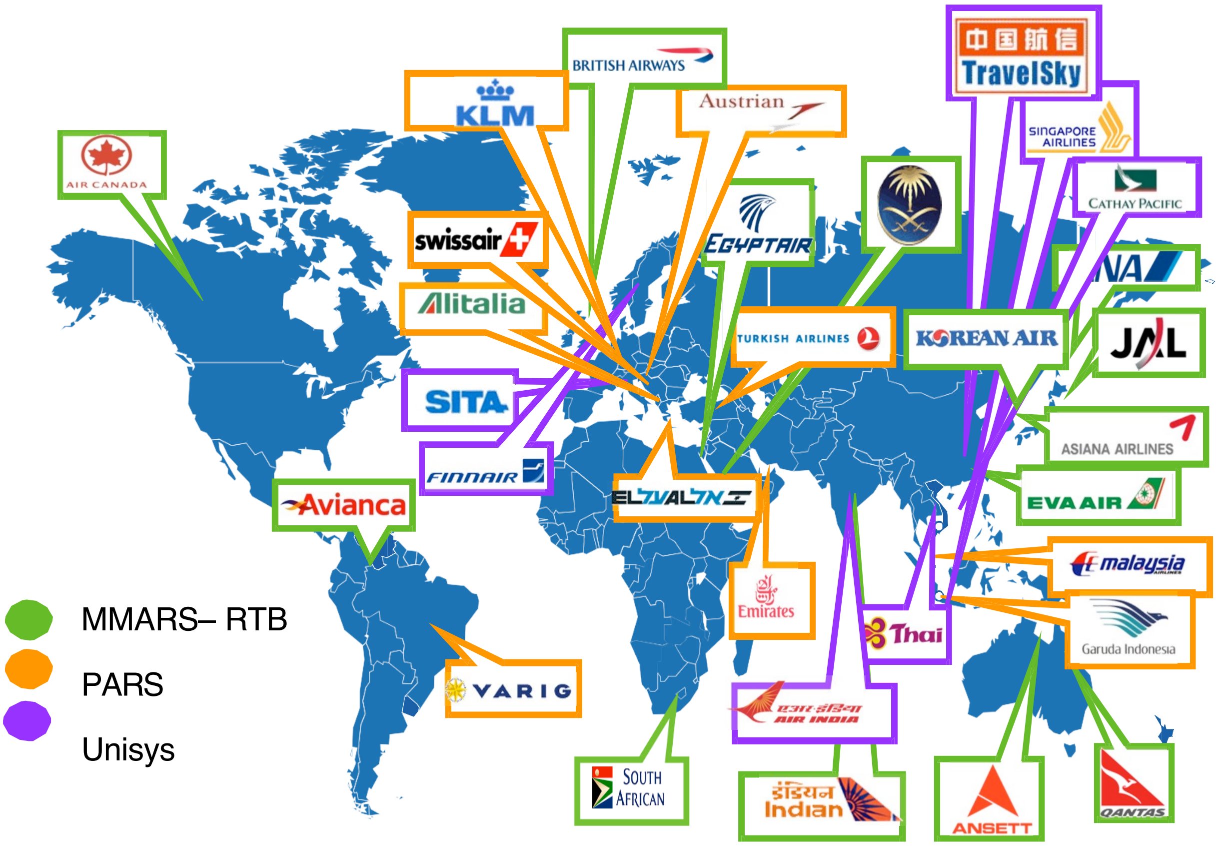

Figure 17.1: Airline reservation systems in 1970';
Source: Amadeus

Birth of first CRS / GDS

1969+

It proved very impractical for each Travel Agent to use only one single terminal for each airline system in order to create bookings.

Therefore, the natural solution was to consolidate several Travel Agencies Reservation Systems into single one, giving birth to first CRSs/GDSs.

The timeline below illustrates when was each CRSs/GDSs created and which airlines contributed to the emergence of the CRS/GDS. [4] [30]

Figure 17.2: Historical developments of Global Distribution Systems; Source: Amadeus

How does a GDS work?

Previous chapter deals with the history, origin and the motives for creating GDS. This part demonstrates how does GDS work and what is the business model behind.

Firstly, definition of key players in the business model is provided:

Travel Providers

- Airlines – network airlines, regional airlines and low cost/leisure carriers
- Hotels – chains, representation companies and independent hotel companies
- Car rentals – car rental and fleet companies
- Rail – railway companies
- Maritime – ferry and cruise lines
- Insurance – insurance companies specialized on travel insurance

Travel Management Companies

- Online travel companies
- Business travel companies
- Leisure travel companies
- Single-site agencies
- Consolidators
- Airline sale offices and Airlie websites connected directly to Amadeus

Illustrated on the figure below, Amadeus receives the content from the Travel Provider, incorporates the content into its system, and then it distributes it to all the Travel Management Companies. [4] [30]

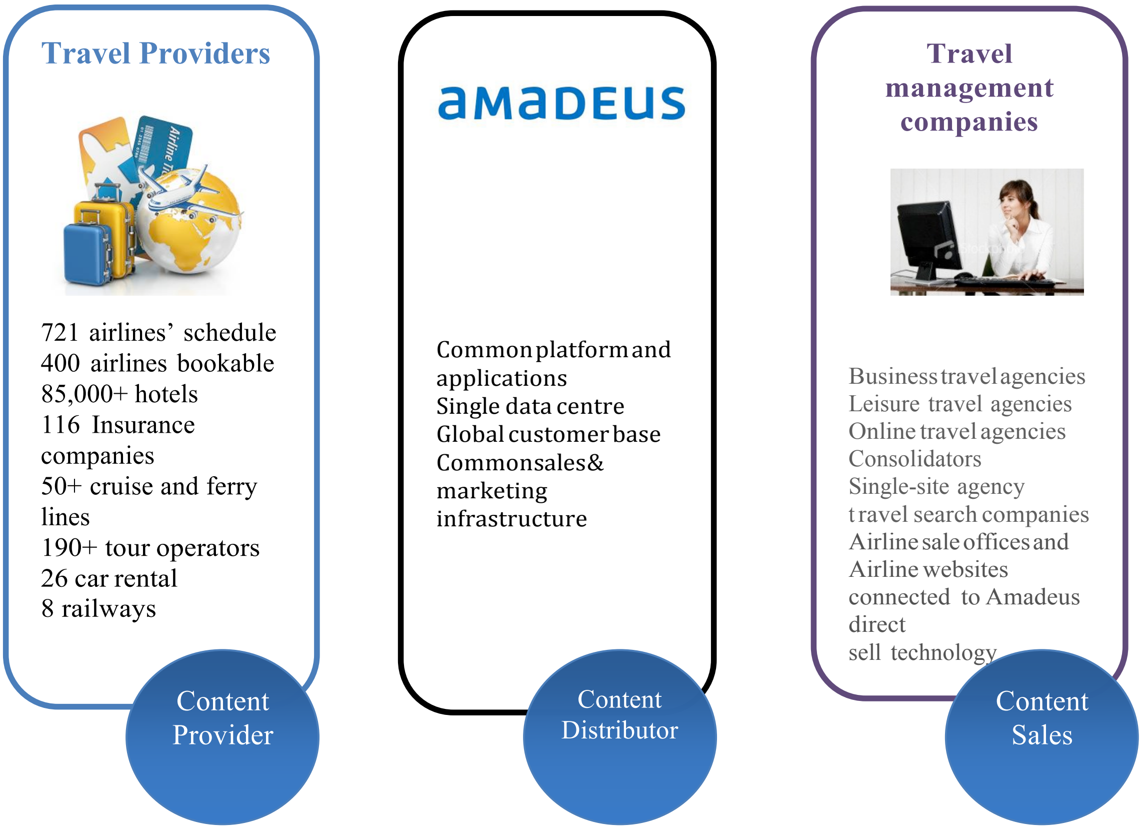

Figure 17.3: Illustration of GDS functionality; Source: Amadeus

Amadeus

Amadeus is one of the biggest global distribution systems and a leading provider of technology solutions for the global travel and tourism industry. It operates as an international network for processing services to the travel industry and directly interacts with several customer groups such as travel providers (airlines, hotels, car rentals, rail and cruise operators), travel distributors (online and offline travel agencies, consolidators, websites etc.) and travel buyers as well (travel management companies and corporations).

The Amadeus IT Group has worldwide presence with central sites in Madrid (corporate headquarters), Nice – Sophia Antipolis (research and development) and Erding (operations), followed by 73 local offices – Amadeus Commercial Organisations (ACO). The Group employs over 10,000 employees and for the fiscal year 2012 reported revenues of 2.910,3 million euros. The Group is listed on the Spanish Stock Exchange as "AMS.MC" and it belongs to the IBEX 35 index. [3]

Amadeus' Business Model

Travel Agencies and Travel Management Companies equipped with the Amadeus software have to pay for the system in majority of markets. Whenever a travel agent makes a booking, the airline company is paying Amadeus a fee and Amadeus gives the Travel agents an incentive. There is a possibility for the airline company to work with several GDS in order to maximize its market reach. On the other hand, travel agencies can book a ticket only through one booking system.

In past years GDSs have started an incentive approach in order to attract new travel agencies. This has caused quite a significant burden for their cash flow, as the cost representing by incentives is high, and still increasing. There are even cases, where travel agencies were created only for the reason to receive incentives in advance and than close without actually going to business. This is obviously illegal but it shows the gravity of the trend that is nowadays in the travel industry. For an illustration, the incentive given by a GDS can be even up to 2 euros per booking. Imagine that medium-sized travel agency makes 15,000 bookings per month, representing a 30,000 cost each month for the GDS. [3]

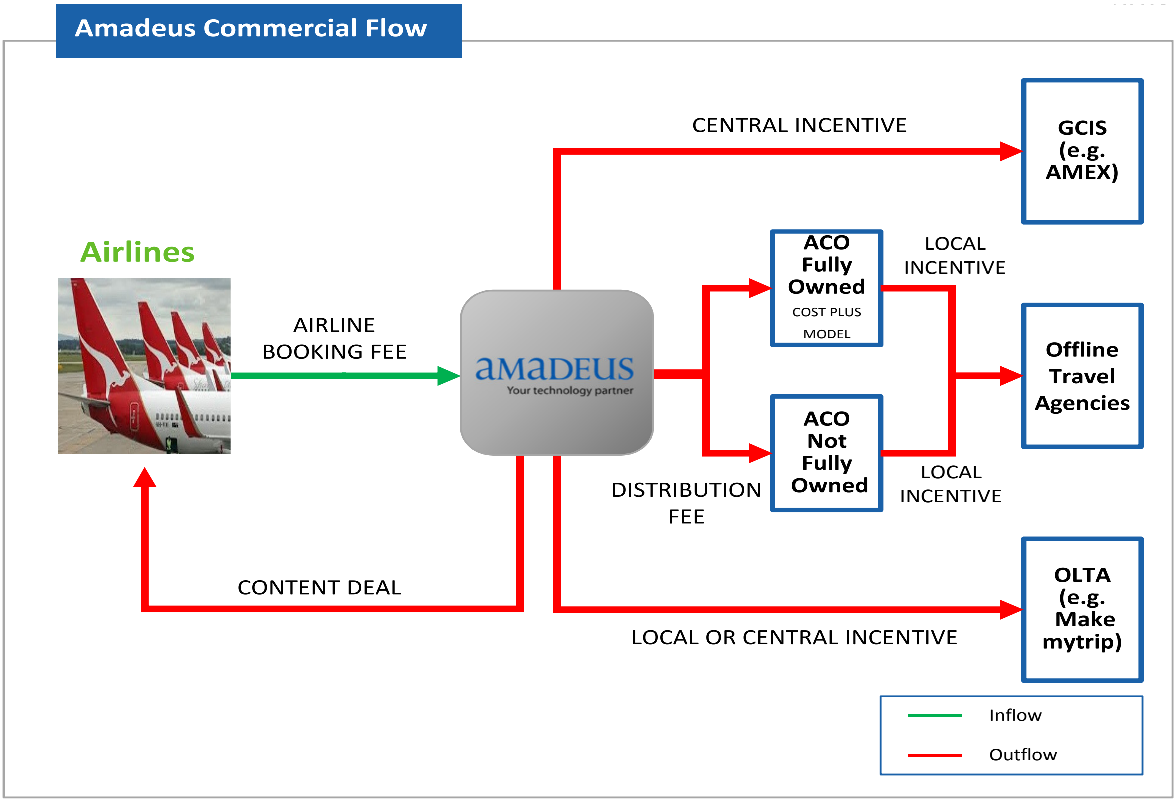

Figure 18: Business model of Amadeus; GCIS = Global IT Solutions; OLTA = Online Travel Agencies; ACO = Amadeus Commercial Organization; Source: Amadeus

5 Empirical Part

This chapter of the Diploma Thesis proposes an econometric model that examines the effects of time affecting factors on the price of air tickets on the itinerary Prague – Nice during the past year 2013. There are over 11,000 data entries considered in the model. The model quantifies the correlations and their magnitude out of which conclusions and recommendations for travellers are drawn. Detailed information about the selection of data, its collection and formatting procedures is provided as well. Nevertheless, firstly we need to clearly define a hypothesis that results from both the initial literature research and the practical experience from the placement within Amadeus.

Based on the combination of different research methods within the Literature Review we defined our hypothesis as following:

"*The fluctuations of airfares on the Prague-Nice itinerary over time are more affected by other time-affecting factors such as: day of departure and return, purchasing day, length of stay and advanced purchase, rather than by seasonality*."

In order to examine whether is the hypothesis correct or incorrect and also to be able to draw any conclusion and recommendations, a quantitative analysis with tangible and statistically significant results had to be provided. Following chapter describes how were the results obtained and which methods were used in order to verify the importance of the outcome.

Econometrics

To determine the correlations between different factors on the airfares previously mentioned and to prove or disprove the hypothesis, the author decided to use applied econometrics. Econometrics is:

"The application of statistical and mathematical methods in the field of economics to describe the numerical relationships between key economic forces; it is described as the branch of economics. It is a set of statistical tools that allows economists to test hypotheses using really world data." [25]

While the first definition describes the general definition of the term econometrics the following quotation explains possibilities of the usage of econometrics that are applicable for the purpose of this Thesis:

"The term econometrics was coined to describe the study of metrics related to the economy or to the theory of economics in general. Theoretical econometrics concerns the concepts, ideals, and patterns surrounding economic measurements. Applied econometrics, on the other hand, concerns using economic metrics and measurements in a functional way. This might include studying economic benchmarks over a period of time to uncover trends or analysing a set of specific metric points across several markets to determine probable outcomes in a given set of circumstances. Applied econometrics allows governments, financial institutions, and businesses to determine production requirements, project future needs, and align themselves with emerging trends." [28]

The study and analysis of benchmarks over a specific period of time to detect and uncover potential trends is the reason why the author decided to use this method. Following chapter is related to the collection, classification and formatting of the data gathered.

Data

The source data needed for the analysis of the air tickets price were obtained from the Amadeus distribution and transaction database. This database consists of all data recorded from every day transaction processes of the whole Amadeus Distribution System. These transaction processes are recorded into so-called logs.

Logs are large files that are generated by the back-end processes of the Amadeus Distribution System and contain extensive amount of information. Each separate log can provide many values such as the geographical details of the ticket itinerary (country and airport origin, transfers etc.), general details of the ticket itinerary (number of tickets issued, ticket classes – adult, child or infant, airline company providing the flight, etc.), ticket numerical details (price of the ticket, total time elapsed of the flight, total distance travelled, etc.) and details about the time and date of the ticket (date of booking, departure and return).

There are several different classes of information that can be found in the System statistics but they are technically focused and not convenient for the purpose of the thesis.

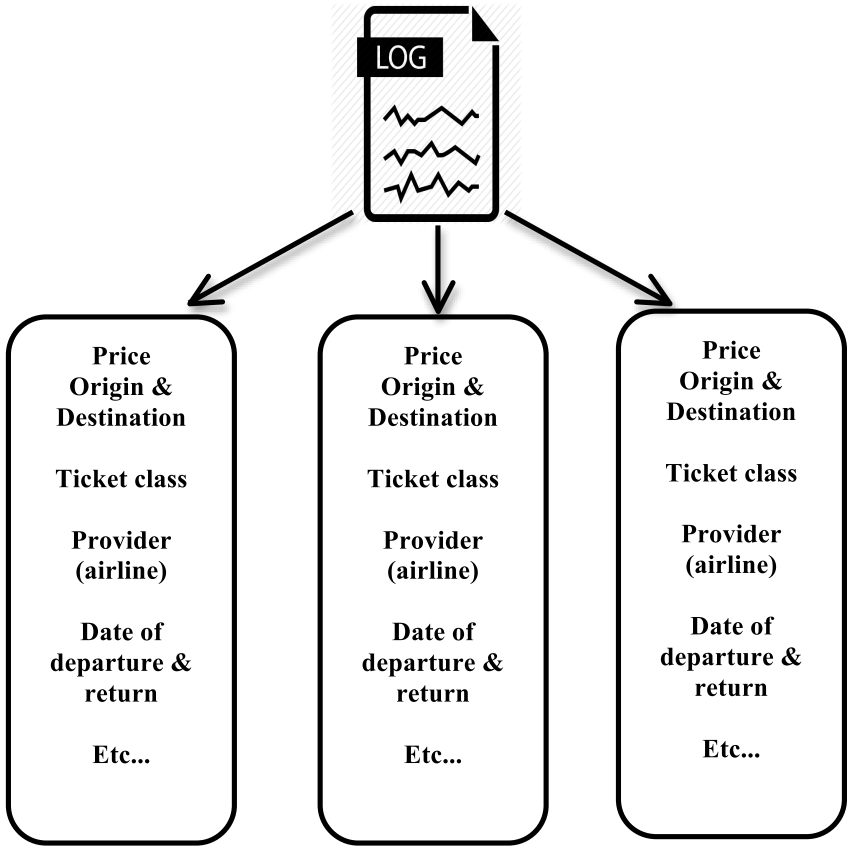

Figure 19: Log files;
Source: Amadeus

All logs are stored in a coupon CSV files. CSV or Comma-separated-values are files that store data in plain-text form, also called "tabular data". Therefore all these data had to be carefully extracted and formatted before obtaining data in right format that were applicable for the model. Sample of the CSV file is illustrated below.

```
1^131202^17^A^131219^4^PRG^NCE^FR^Europe^0^1786^210^210^210^210^PRG^893^1^OK^2^2^B^PAROK08CC
1^131202^2^T^131204^3^PRG^NCE^CZ^Europe^0^1891^465^315^465^315^PRG^893^1^LX^2^4^B^LYSFT210S^FR
2^130312^32^A^130413^6^PRG^NCE^CZ^Europe^0^1774^220^220^220^220^PRG^887^1^OK^2^2^B^PAROK08CC
1^130329^20^A^130418^4^PRG^NCE^FR^Europe^0^1774^220^220^220^220^PRG^887^1^OK^2^2^B^PRGOK08CC
```

Figure 19.1: Sample of CSV file;
Source: Excel & Amadeus

When the extraction from source CSV files was done, necessary formatting in Excel was needed. For instance, the price of a single ticket was not provided in the original extract, therefore additional math calculations were needed. The reason for the log being recorded in this was is that all data are transaction based. Transactions are made based on itineraries, not on single tickets and often the itinerary includes several travellers or even a group of travellers.

Date of purchase, departure and return was also inconsistent and additional formatting into an "*yy.mm.dd*" format was needed in order to capture and record possible trends of the time series. Similar additional formatting was performed to transform the date of purchase, departure and return into a specific date of the week. In order for us to be able to calculate the correlation of the price with the weekday we had to transform each day into a numerical value (Monday = 1, Tuesday = 2, etc.).

When all time series were formatted in a proper way that fitted the model we were able to construct be model and begin to analyse the data to approve or disprove our hypothesis. In order to examine the relevancy and strength of each single variable we used the Linear Regression Model.

Linear Regression Model

The linear regression model is an elementary tool, which is however one of the most utilized within the field of econometrics. The tool allows us to analyse a relationship between dependent variable and one or more independent variables within the defined model. *Linear regression attempts to model the relationship between two variables by fitting a linear equation to observed data. One variable is considered to be an explanatory variable, and the other is considered to be a dependent variable. For example, a modeller might want to relate the weights of individuals to their heights using a linear regression model*. [39]

The general form of model is following:

$$y_t = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + \ldots + \beta_k x_{kt} + \varepsilon_t$$

Where:

y_t, is the dependent variable

x_t, is the explanatory variable

β, is the coefficient of the parameter

ε_t, is the error term

The efficiency of the linear regression model can be measured by the coefficient of determination. The coefficient of determination (R^2) is a statistical measure that measures the accuracy and explanatory value of the model. It is expressed as a value between 0 and 1 where one means that the regression line fits perfectly the data while zero means the opposite.

Variables Selection

There are several different factors that have an effect on the price of airfares. These factors, variables are used to build the algorithm of price predictors mentioned in previous chapters. Realistically, calculating and quantifying the significance of all of them would be simply impossible. For instance, as explained in previous chapters, airlines strictly prohibit publishing data stating the amount of seats unsold. Furthermore, it is impossible to obtain the class distribution, in other words, the number of seats assigned to each specific class (economy, business, first class). Discounts and tickets bought through frequent flyer points and other affiliate programs are not considered in the model as well. Given the fact that it is impossible to quantify all the possible features that have an effect on the price, the thesis focuses on the relevancy of time-affecting variables available.

The data considered in the following model are for the itinerary Prague – Nice. The selection of this itinerary was chosen simply out of author's curiosity as his internship mission was based in Nice (Sophia-Antipolis – Amadeus research and development headquarters) while his home university being placed in Prague. The results of the model might be therefore applicable for the audience at the Czech University of Life Sciences in Prague.

There are in total 11,315 values examined within the model, representing same amount of air tickets purchased / travellers during the year 2013. It is important to mention that this amount of travellers is distributed among several airlines that operate on this route. Both direct and indirect (flights with transfers) are analysed in the model to obtain the most unbiased result that would be applicable for broad audience (no distinction between leisure and business travellers).

The selected dependent and independent variables examined in the model are following:

(P_t) **Price of the ticket**	-	total price paid for the ticket with VAT, in EUR
(A_p) **Advance purchase**	-	difference between the purchase date and the d ate of departure; represented in days (0 – 365)
(D_{date}) **Departure date**	-	the time of the year (130101; in a format of yy.mm.dd)
(L_s) **Length of stay**	-	difference between the departure and return date; represented in days (0- 365)
(D_{day}) **Departure day**	-	day of the week when departing (Monday, Tuesday...; values in range of 1 - 7)
(R_d) **Return day**	-	day of the week when returning (Monday, Tuesday...; values in range of 1 – 7)
(P_d) **Purchase day**	-	day of the week when purchasing the ticket (Monday, Tuesday...; values in range of 1 – 7)

The following chapter deals with the results of the model and implications resulting from the results.

Results

The suggested equation of the model is:

$$P_t = 112{,}778 - 0{,}643A_p + 0{,}0030D_{date} - 0{,}3506L_s - 1{,}2475D_{day} + 0{,}426R_d - 0{,}283P_d$$

Variable	R2 = 0,63; adjusted R2 = 0,60			
	Coefficient	Std. Error	t-stat	Prob.
Const.	112,778	4,216	3,164	0,0000
A_p	-0,643	0,017	-4,115	0,0000
D_{date}	0,003	0,006	1,451	0,0016
L_s	-0,351	0,049	-6,373	0,0143
D_{day}	-1,248	0,378	-8,522	0,0000
R_d	0,426	0,233	2,586	0,0097
P_d	-0,283	0,692	-7,843	0,0001

Statistical verification of the model

Our model shows R^2 of 0,63 that provides us with relatively satisfactory accuracy considering the fact that there are several purposely omitted variables that have direct influence on the price of the airfare (oil price, operating costs, etc.). Furthermore, we can see that all our variables are statistically significant as all probabilities are lover than 0,05.

There is no multicolinearity among the explanatory variables based on our correlation matrix and therefore all the explanatory variables are independent from each other and there is no need to solve multicollinearity.

The normality check of residuals proved that residuals follow a normality law of distribution. This check was verified by the Jarque-Bera Test, which showed a value of 0,294, where any value higher than 0,05 is satisfactory (at 95% confidence level that we count with).

Finally we checked whether the residual variance of variables is constant, which is the homoscedasticity of residuals. For this purpose we used the Halber White's Test, which showed value lower than 0,05 that allows us the rejection of heteroscedasticitty (at 95% confidence level we count with).

Departure day

The result from our model indicates that the departing day is the most determining variable of the model. It has a strong negative effect on the price of the ticket. In other words, the later we depart, the cheaper the ticket gets. This is valid with a slight exception of Friday, where is an upward trend in the price development as illustrated on the figure below. We used moving average to detect and extract the trend from all the data entries we observed.

The reason for tickets being most expensive on Monday is given by the fact that we explained within the Literature Review section. The start of the business week is the strongest determinant of according to our analysis. Furthermore, as explained by Chellappa et al. 2011, business travellers tend not to begin their business flights during a weekend and rather prefer to travel along with the working week schedule (opposite trend emerging when returning from business travel). On the contrary, he states that there is a different trend when considering leisure travellers. The majority of short haul trips departs on Friday pushing the price high with a favourable return day on Sunday, causing the same effect for the price on return day (next chapter).

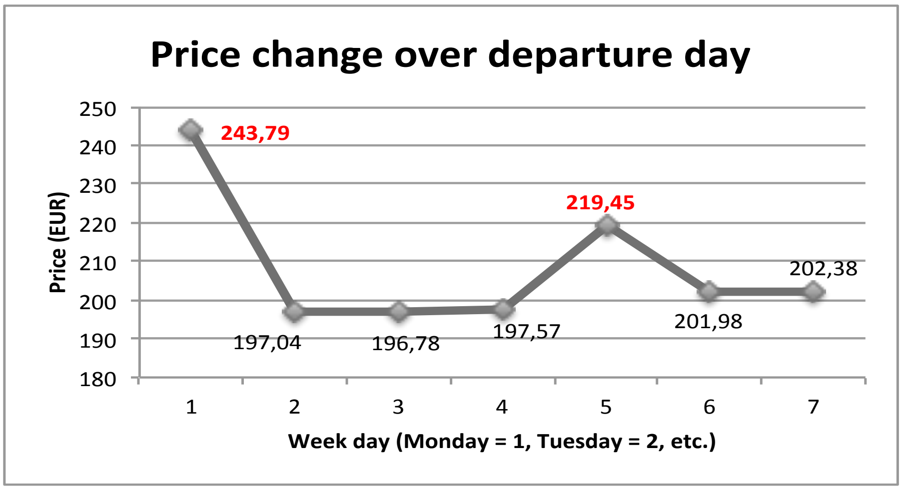

Figure 20: Price change over departure day; Source: own illustration & Excel

Return day

Having a slightly lower statistical significance than the departure day, return day is still important factor determining the price of the ticket. Having a positive value, the day of the week when returning from the trip, shows a trend that the later during the week we return, the higher the price will get. This trend is again illustrated by the average trend on the Figure below. The observation advices best days for return as Monday and Saturday, oppositely to Friday and Sunday with highest charges. The fact that price is highest when returning on Friday and Sunday is not surprising as simply the demand for return flights is highest during these two days. Despite the trend discussed in the Literature Review chapter, Friday as a return day is still most convenient time for most of the business travellers, while Sunday is being predefined day of return for majority of leisure trips. Nonetheless, it will be interesting to analyse and measure the price change in following years as business travel is becoming connected with leisure travel. This trend results from the fact that business travellers tend to prolong their trips and start to return during the weekend.

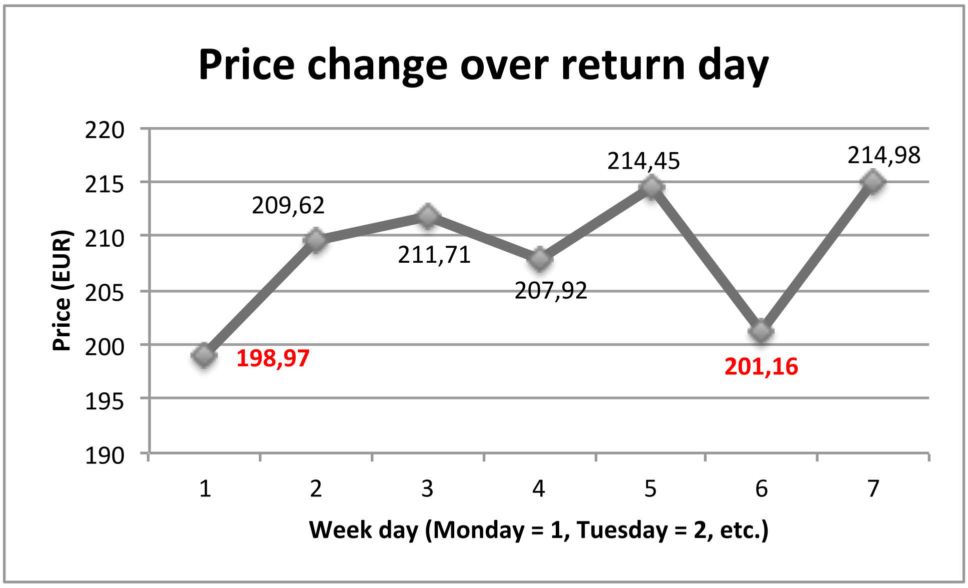

Figure 21: Price change over return day;
Source: own illustration & Excel

Advance purchase

The hypothesis the earlier we purchase the ticket prior to the departure date, the cheaper it gets, was confirmed in this model. The parameter shows significant negative value meaning that with increasing number of days to departure we buy the ticket, the price will tend to decrease. The trend is captured on the figure below. We used moving average and place a linear trend to illustrate that the highest price is at the date of the departure and it slowly decreases wish the date being distant. It is also interesting to observe that majority of travellers purchase tickets not earlier than 30 days before the departure. It is not common for airlines to set high prices long time prior to the departure of the flight, as they need to capture a part of the market share in order to fill a specific amount of seats so they can breakeven and offer seats to business travellers for an increased price shortly before the flight.

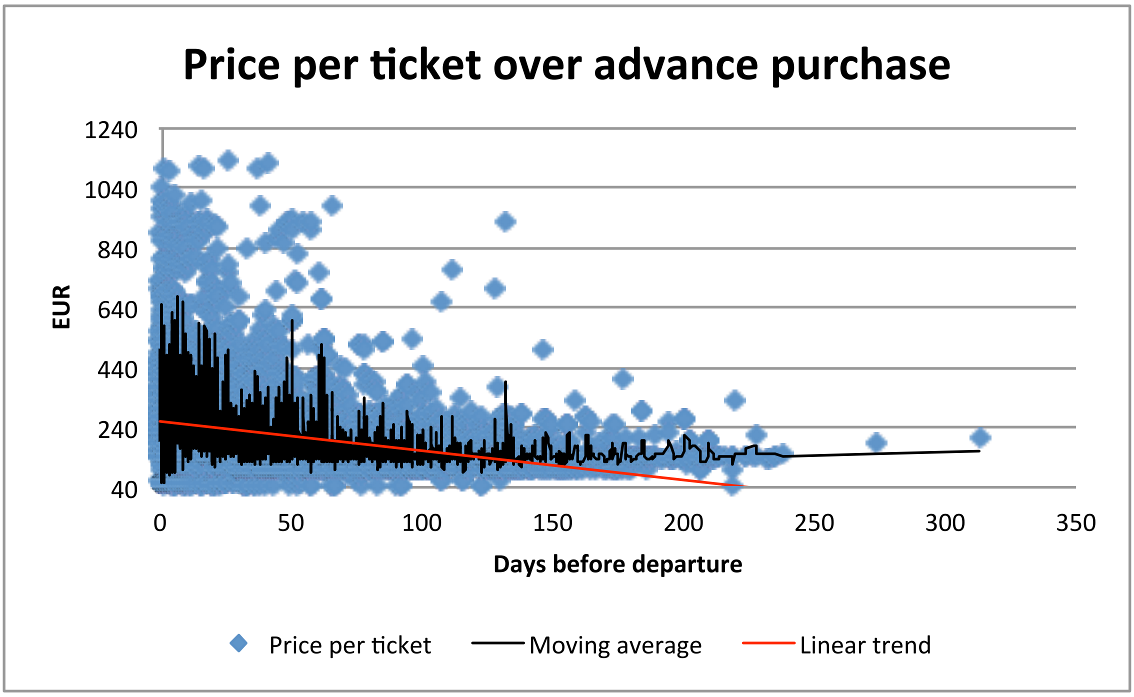

Figure 22: Price per ticket over advance purchase;
Source: own illustration & Excel

Purchasing day

Interesting observation is the fluctuation of prices during the week. This is illustrated on the figure below. Due to the model, the highest airfare prices are on Monday with huge drop on Tuesday followed by quite flat fluctuations during the rest of the working week days and resulting into an increase during the weekend. The fact that many airlines publish their new inventories on Mondays may account to this trend along with the unwillingness of business travellers to search for their travel on Sunday can be a reason too. There is an advice from the CEO of *farecompare.com (price predictor mentioned in the Chapter X.X)*, Rick Seaney to buy their tickets on Tuesday and our model can relate to his advice as well. Rick Seaney based his recommendation as well on analysing historical airfare pricing data and is confident that purchasing on Tuesday at approximately 15:00 Eastern Time (19:00 GMT). Unfortunately the data provided in our model does not have detailed specifics to validate this recommendation.

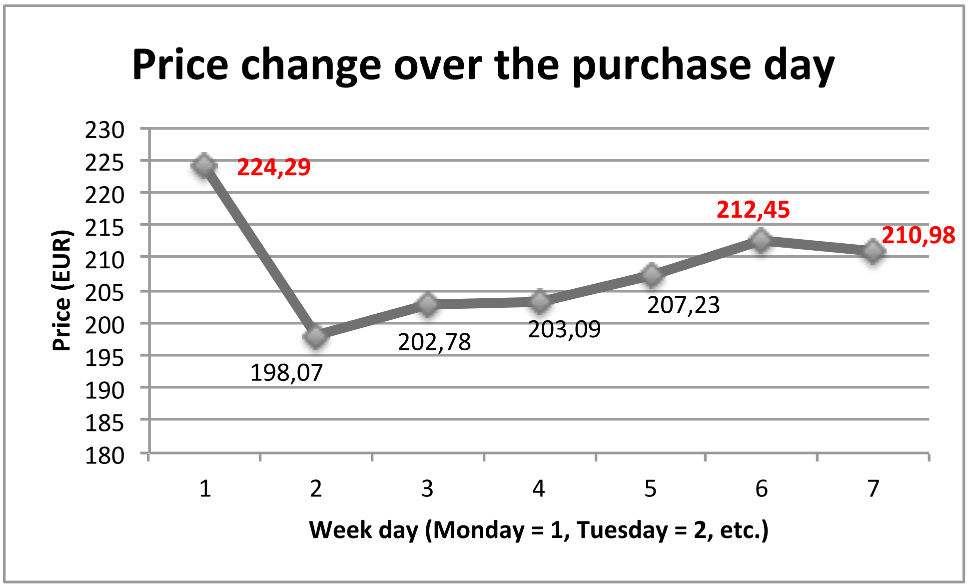

Figure 23: Price change over the purchase day;
Source: own illustration & Excel

Length of stay

The variable measuring the number of days between departure and return date proved to be significantly important as well. Similarly to the previous variables – it has negative effect on the price of the ticket meaning the longer we stay the less we pay. The linear trend shows that higher flexibility in terms of dates and length of stay allows us to get much better rates. The scatter diagram along with the decreasing scale of moving average clearly shows how the airfare price decreases with increasing length of stay.

It is apparent from the data sample we analysed that the vast majority of travellers stay less than 14 days in the destination where the price does not offer high flexibility. For precision the highest amount of tickets purchased was with length of stay lower than 7 days, which seems rather surprising as this itinerary is considered to be leisure-oriented and longer stay would be expected.

According to our results, the higher the flexibility of the length of stay is, the lower price of the ticket will be. There is a smaller need for an airline to change and increase price of an airfare with longer time frame between departure and return date as the demand for such itinerary will be low. [23]

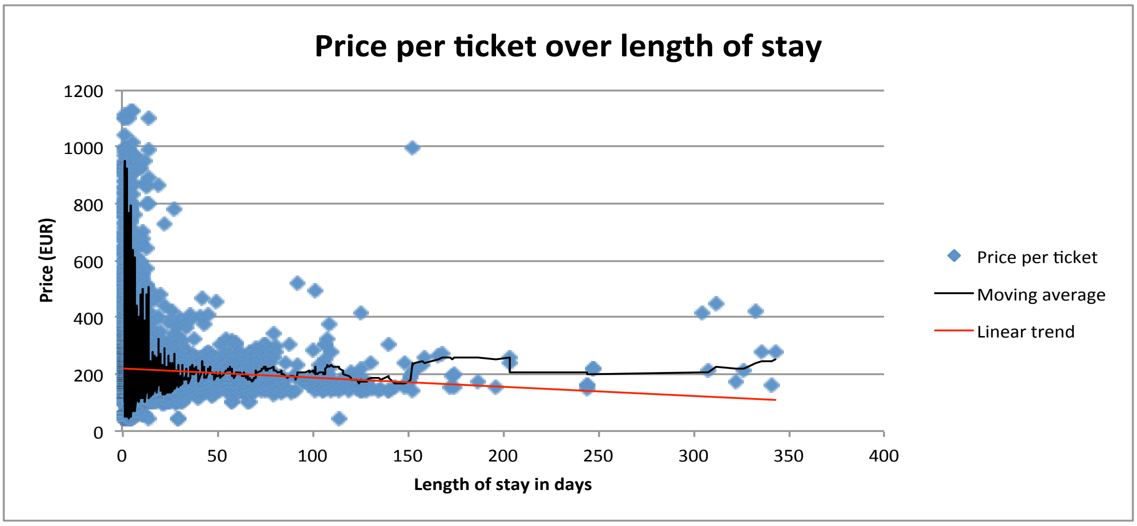

Figure 24: Price per ticket over length of stay;
Source: own illustration & Excel

Departure date

The variable that showed the lowest value and therefore the lowest impact on the price of the ticket confirmed our hypothesis that nowadays it is not as relevant as it used to be whether we travel during the high season or not. In todays globalized world with increasing numbers of business travel and the trend of combination of business travel with leisure, the time of the year and seasonality does not have the importance as it used to. This trend was examined previously in the Literature Review where we described how airlines use dynamic pricing along with detailed information about the demand and willingness to pay of the customers being able to determine the optimal prices for which they should sell their tickets in order to maximize their revenues. Revenue management along with careful seat and occupancy management allows airlines to act flexibly and mitigate potential impact of seasonality, i.e.: overbooking or cancelling scheduled fares to avoid losses from capacity issues. Surprising observation is that there is a decrease in price at the beginning of the season – in the first half of June. This short decrease might be caused by increased competition resulting in higher number of substitutes, and higher purchasing power and lower willingness to pay on the side of traveller. In addition, we can spot an increasing tendency prior to the end of the year, which can be explained by increased travel migration due to the Christmas holidays.

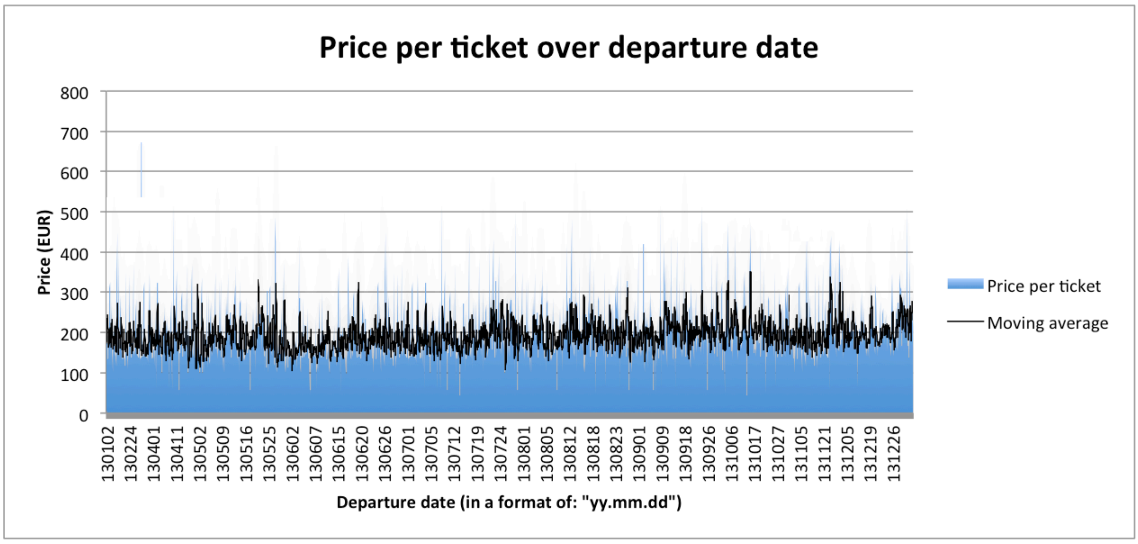

Figure 25: Price per ticket over departure date; Source: own illustration & Excel

Limitations of the Model

There are of course other factors and features that are relevant when considering factors affecting the price of the air ticket. However, since this thesis examines the relationship between price and time-affecting factors, we did not include other variables into the model.

Nonetheless, it is important to mention that there are other omitted variables that would help explain the model better. Some of these variables are highly relevant and have direct effect on the airfare. The most important determinants are described below:

Oil price certainly belongs among these variables as one of the leading determinants (not true for all markets) of the price. The challenge of including the oil price into the model is that airlines usually tend to purchase large quantities of oil in advance – typically between 6-9months – and therefore the correlation between the oil price and the price of the ticket might not be accurate.
In addition, some airlines are not affected by the price of oil, as they are owned by a government (Qatar Airways, Emirates Airlines, etc.) that has large supplies of oil and therefore the price is less relevant factor when compared to other airlines making the model generally non-applicable.

Number of unsold seats is a crucial determinant of the price of the air ticket. This number would definitely help to make the model more accurate with regards to the advance purchase. However, this kind of data is strictly held confidential by the airlines as a business secret. Nowadays, the trend of last-minute flights is gone as the revenue management along with dynamic pricing provides airlines with highly advanced automatized technology that does not leave many seats unsold. Airlines actually prefer to overbook rather than fly with empty seats. Nonetheless, empty seats occur but do not result in last-minute discount. Airlines do not simply want to get travellers used to last-minute deals, as it would result in high last-minute purchases at the cost of decreased advance purchases. [Mantin & Rubin, 2013]

State of competition is a part, which defines airfares prices strategy and drives the price as well. Until the 1978 when the Airline Deregulation Act was signed, airlines used to set their rates mostly based on the distance of the route. After the Act, distance is far less relevant than it used to be and it is not surprising that long, international hauls might end up being cheaper than short hauls within the same country. Since all airlines enter their rates within Global Distribution Systems, all competitors are equipped with minute-to-minute information about others and are allowed to set their rates accordingly to their competition, supply and demand on specific route they operate.

Operating costs including fuel (determined by oil prices) such as salaries, airport rents, ground equipment, landing costs, administration costs and others have a significant impact on the price as well. An example of airline operating costs is provided on the figure below.

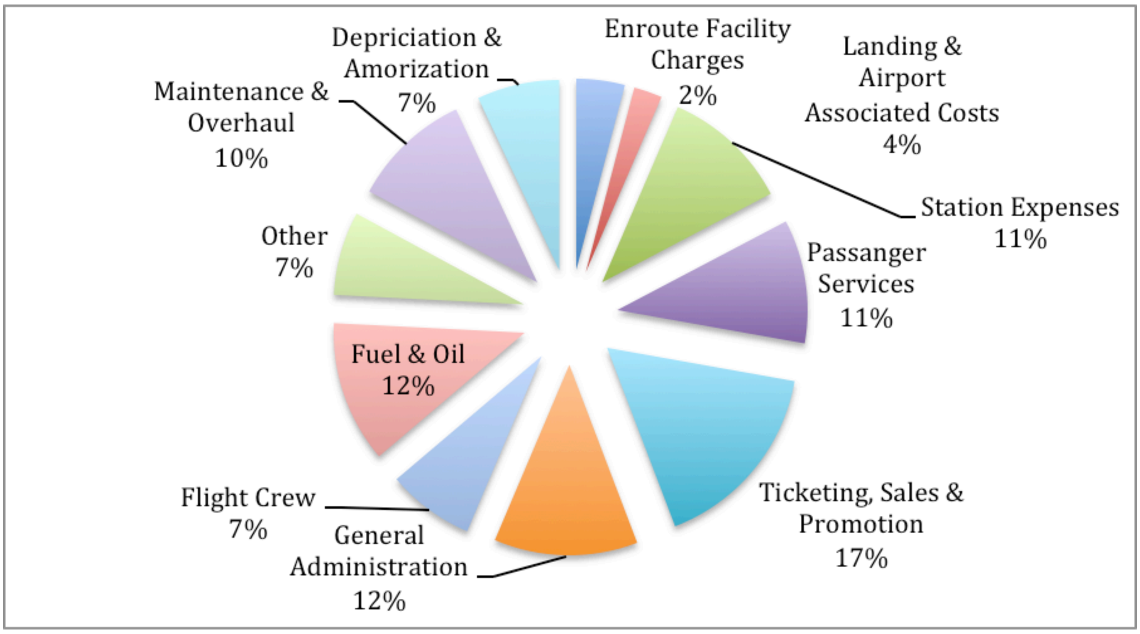

Figure 26: Operating costs of the Airline X;
Source: own illustration, Excel & Amadeuss

6 Conclusions

This part of the Master Thesis concludes the research by recapitulating the main findings from both the Literature Review and the Empirical part of the Thesis. Furthermore, recommendations for travellers are presented after the end of this chapter.

Through reviewing the Literature Review on the topic of pricing within the airline industry, the Thesis finds out that the demand for air travel is substantially growing since the milestone of the Deregulation Act in 1978 along with the emergence of low-cost carriers. The emergence of low-cost carriers and advent of Internet caused that travellers have nowadays much greater choice in terms of choosing a provider, desired destination and the time frame of their travel. This allows travellers to be highly flexible, well informed and make better-informed decisions when making their purchase. In addition to that, airfares on short hauls have decreased significantly in past years. All these factors put airlines into pressure. This competitive pressure is dramatically increasing due to factors and trends mentioned above as well as owing to rise in costs.

Airlines' costs are obviously strong factor affecting the price of their services. While the demand for air travel and the volume of travellers transported is increasing, there is a high pressure being put on airlines to reduce prices of their services. Therefore, rising fuel prices, increased airports' charges and additional governmental or environmental taxed imposed on the industry make even higher pressure on airlines' costs.

According to literature research, the Thesis finds out that in order to operate in such dynamic and competitive environment, revenue management is utilized among all the airlines to remain profitable and sustainable. Applying revenue management systems allows airlines to sell the right fare to the right customer at the right time by identifying customers' willingness to pay. Complex algorithms that are based on collection of big data do this estimation and offer a price to the traveller.

Given the fact that revenue management systems are such powerful tool, traveller might therefore seem to be completely in hands of airlines and their pricing strategies with little or no possibility to receive a better deal or to affect the price of the air ticket.

Further investigation shows that the use of revenue management even mitigates the relevance of seasonality and causes a diminishment of last-minute cheap offers. However, other time-affecting factors still act as price determinants. This hypothesis is confirmed within the Empirical Part of the Thesis.

The proposed model in the Empirical part finds out that there are factors that can affect the price of the airfare and the traveller can use them in his/her advantage.
In fact, there are five factors that can be considered as a price determinant: (1) departure day; (2) return day; (3) advance purchase; (4) purchasing day and (5) length of stay.

The departure day the most important factor (in the model) that affects the price of the ticket. It showed strong negative effect due to airfares being the most expensive on Monday. As the week continues, price declines with an exemption of Friday, which is a common day for the beginning of a leisure oriented short-haul itineraries such as Prague-Nice.

The return day is also significant factor that has, on the other hand, a positive effect on the price. This means that the earlier in the week we return, the cheaper the price gets. The model indicates that the cheapest days for a return are Monday and Saturday oppositely to Friday and Sunday with highest charges. Besides that, as reviewed within the Literature research, a new trend is emerging. Business travellers nowadays tend more often to return during the weekend rather than at the end of the working week. Combination of business and leisure travel is becoming more popular and might cause an increase of prices for tickets with returns on weekend days.

Unsurprisingly, the earlier we purchase the ticket, the cheaper it gets. The advance purchase as a factor showed a strong negative effect on the price. Despite well knowing this fact, majority of travellers do not purchase tickets earlier than 30 days prior to the departure. However, what the Literature research revealed is that airlines do not offer anymore (very rarely) last minute deals just before the departure as they used to. In fact, airlines prefer to take a loss rather than sell the ticket below desired price and provide the traveller with a hope that he/she might have similar option for the next time.

Interesting observation derived from the model is that the day we purchase the ticket has an effect on the price as well. The model showed that tickets are the cheapest when purchased on Tuesday while being the most expensive on Monday. This result is supported by the fact that new fares are being published on Mondays. We can only speculate whether the majority of business travellers make their purchase on Monday, driving the price high. Nonetheless, the result of the model is also supported by Rick Seaney, CEO of *farecompare.com* (airfare predictor), who advises to buy tickets on Tuesday at 19:00 GMT.

Finally, the model shows that the longer we stay, the lower the price gets. Therefore the more flexible traveller can be, the better for his wallet. Prices are low for longer lengths of stay due to the uniqueness of the itinerary, which is also a factor for the dynamic pricing algorithms within the revenue systems. However, not all travellers have the advantage of being able to be flexible on the length of their stay as illustrated on the data sample. Majority of travellers on the examined itinerary stay less than 7 days.

Last and least important factor is the departure date. This variable supports the hypothesis that even on a leisure-oriented itinerary with strong seasonal demand, the price is not highly affected by the part of the season. The data sample used shows no seasonal trend and only very little impact on the price. The use of revenue management systems allows airlines to operate at high efficiency and mitigate seasonality by providing them with information about the demand and willingness to pay of the customers and allowing them to act in a very flexible way. As a result, airlines might cancel or overbook flights accordingly to the situation.

7 Recommendations

This Thesis presented a general model that examines how airfares change over time and identified factors that influence these changes. It is important to mention that there are important variables affecting the price that were omitted since the model focuses only on the relationship between the price and time-affecting factors. Therefore, the result and recommendations arising from this model should not be taken as a perfect guideline, since the airfares depend on more factors.

Firstly, the model proposes to purchase the ticket on Tuesday, preferably around 19:00 GMT. The ideal day to begin the trip should be also Tuesday, however avoiding Monday and Friday is most important, as there is only little difference between other days. The most convenient day to return from the trip should be either Monday or Saturday as the demand for return is lowest during these days. The difference between departure and return should be as long as possible but greater than 7 days already decreases the price significantly. Finally, the golden rule is to purchase the ticket as much in advance as possible.

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9 List of Figures