Universidade do Minho
Escola de Economia e Gestão

Hugo Silva Gouveia

Price Competition between a Full-Cost Carrier and a Low Cost Carrier: The importance of Loyalty and Cost efficiencies

Master's Dissertation in Industrial and Firm Economics

Work developed under the supervision of

Professora Doutora Rosa-Branca Esteves

Professor Doutor Francisco Carballo-Cruz

October 2018

DECLARAÇÃO

Nome

Hugo Silva Gouveia

Endereço eletrónico: hugogouveia_123@hotmail.com Telefone: 965321688

Título dissertação □/tese □

Price Competition between a Full-Cost Carrier and a Low-Cost Carrier: The importance of Loyalty and Cost efficiencies

Orientador(es):

Professora Doutora Rosa-Branca Esteves

Professora Doutor Francisco Carballo-Cruz

Ano de conclusão: 2018

Designação do Mestrado ou do Ramo de Conhecimento do Doutoramento:

Mestrado em Economia Industrial e da Empresa

Nos exemplares das teses de doutoramento ou de mestrado ou de outros trabalhos entregues para prestação de provas públicas nas universidades ou outros estabelecimentos de ensino, e dos quais é obrigatoriamente enviado um exemplar para depósito legal na Biblioteca Nacional e, pelo menos outro para a biblioteca da universidade respetiva, deve constar uma das seguintes declarações:

1. DE ACORDO COM A LEGISLAÇÃO EM VIGOR, NÃO É PERMITIDA A REPRODUÇÃO DE QUALQUER PARTE DESTA TESE/TRABALHO

Universidade do Minho, ___/___/_____

Assinatura: _____

Acknowledgements

This past year was not easy marked by many uncertainties and insecurities however due to believing in myself as well as the help of many people in my life all of this became a possibility.

First and foremost, I would like to thank my Mother for all the sacrifices she made so as to support me in my endeavours. All the support I got from my brother and my dad which also helped me get to this point and I would like to thank them for that.

Equally as important, my Advisor and Mentor in this dissertation Professora Doutora Rosa-Branca Esteves for all the patient and availably she demonstrated whilst helping me complete this important step in my life. Special thanks as well to her husband, and my co-Advisor Professor Doutor Francisco Carballo-Cruz for supporting me and helping when I required help.

I would like to also extend a thank you, to my friends who travelled with me in this challenge, special thanks to Marco, Orlanda, Costa, Tomás e Liliana, for always being there, putting up a shoulder when I needed one. And for that, I cannot express enough thanks.

Finally, I would like to show gratitude to all of the people in my life who made this a reality. Every single interaction helped me get where I am today.

Thank you.

Resumo

Esta dissertação tem como objetivo investigar em que medida a existência de consumidores leais cativos a uma companhia aérea incumbente, a *Full-Cost Carrier* (FCC), bem como a eficiência em custos, pode condicionar a decisão de entrada de uma companhia *Low-Cost Carrier* (LCC) num mercado inicialmente monopolizado. Com este objetivo é proposto um modelo teórico de concorrência em preços, resolvido com base na teoria dos jogos. Examinamos os lucros da FCC após a entrada bem-sucedida da LCC, bem como os impactos ao nível da decisão de entrada da LCC. Com este modelo, conclui-se que, como esperado, a entrada da LCC será mais provável em mercados com uma proporção menor de consumidores cativos à FCC, o que se traduz numa maior procura potencial (mercado seletivo) para a LCC. A entrada será também mais provável quanto maior a vantagem de custos da LCC comparativamente à FCC.

No que diz respeito ao impacto nos lucros, conclui-se que a FCC enfrentará maiores perdas se a sua vantagem competitiva inicial (proporção de consumidores cativos) for pouco significativa e se deparar com a entrada efetiva de uma LCC muito eficiente. No que diz respeito à LCC conclui-se que existindo custo exógeno de entrada, a sua entrada é mais provável quanto maior a sua eficiência em custos em comparação com a FCC (i.e., quanto menos eficiente for a incumbente). Com estes resultados, conclui-se que se as FCC quiserem suavizar a concorrência em preços com uma LCC agressiva em custos, devem dedicar recursos a aumentar a lealdade dos passageiros. Por outro lado, as LCC interessadas em entrar num mercado devem garantir níveis de custos suficientemente baixos para colmatarem as desvantagens em concorrer com uma FCC com consumidores cativos.

Palavras-Chave: Monopólio, Duopólio, Tomada de Decisão, Discriminação de Preços, Consumidores Cativos.

Abstract

This dissertation aims to investigate the entry decision of a Low-Cost Carrier (LCC) in a market where the incumbent firm, the Full-Cost Carrier (FCC), has a competitive advantage due to the existence of captive loyal consumers, who are only willing to fly with this company. As the LCC is more efficient than the FCC in terms of operation costs, this dissertation investigates under which conditions for cost differences and dimension of FCC's captive segment, will the LCC entrance occur. With this goal in mind, a theoretical model of price competition is proposed and solved, using game theoretical tools. We conclude that, as expected, the entry of the LCC will be more likely in markets with a lower proportion of captive consumers to the FCC, which translates into a greater potential demand (selective market) for the LCC. The entry will also be more likely the greater the cost advantage of LCC compared to the FCC.

Regarding the impact on profits, we conclude that the FCC will face greater losses if its initial competitive advantage (proportion of captive consumers) is less significant and faces the actual entry of a very efficient LCC. With regard to the LCC, we show that the entry becomes more likely the greater the lower is its cost in comparison to the incumbent company. With these results, we conclude that if the FCC wants to smooth price competition with a cost-efficient LCC, it should devote resources to increasing passenger loyalty. On the other hand, LCCs interested in entering a market should guarantee cost levels low enough to address the disadvantages of competing with a FCC with captive consumers.

Key words: Monopoly, Duopoly, Decision-Making, Price Discrimination, Captive Consumers.

Contents

1. Introduction

The Airline Industry is an interesting market to study, as eluded by Gerardi and Shapiro (2009). The different price sensibilities and the ability of companies to recognize different types of passengers makes the airline market a suitable setting for the implementation of price discrimination strategies. The recent upsurge in available information and the devotion of companies to this information, called "Big Data", has made personalized pricing a reality. The track of consumers' behaviour means that first degree price discrimination is becoming increasingly possible. This can give firms incentives to gather data on consumers' tastes and behaviours.[1] As will be discussed, one can easily confirm the presence of personalized pricing within the airline industry, and further studying this thematic will therefore add to the comprehension of its complexity.

Excessive entry barriers reflect the importance to cherish every consumer that each company has. Thus, the practice of Loyalty Programs ("Frequent Flyer Programs" [FFP] in the airline industry) is becoming more predominant as time passes (Dowling & Uncles, 1997), and therefore, firms have increased their focus on consumer behaviour. As the knowledge on consumer behaviour improves, the airlines will be increasingly able to personalize their prices, thereby approaching first-degree price discrimination and the potential to extract more surplus out of consumers.

The presence of both full-cost carriers (FCC) and low-cost carriers (LCC) in the same market, and the existence of a multiplicity of different types of consumers[2], demonstrates the complexity of this industry as there is a diverse array of pricing strategies. For consumers, the emergence of LCCs brought upon lower fares, increasing their well-being due to the increased competition (Morrison, 2001). On the other hand, the use of FFPs by some airlines makes us ponder how important those programs are to airlines, especially for the traditional ones, which compete against lower prices from the LCC.

In airline markets, it is frequently the case that incumbent companies with a monopoly power in some part of the market, due to strong preferences from captive consumers, face the possibility of the entry by low-cost companies (LCCs) with no captive consumers, but

[1] Shiller (2014) refers to this as Imperfect First-Degree Price Discrimination – complexity of consumers' behaviour is hindering progress towards full personalization.
[2] With different price sensitivity to the prices practiced by the airline companies, Gerardi & Shapiro (2009).

with significant cost advantages. In this context, it is therefore important to find an answer to the following questions: What is the impact of the FCC's captive segment on the entry decision of LCCs? What is the effect of the LCC's cost advantage on its decision to enter into the market and to each firm's profits?

With these main research questions at hand, we develop a theoretical model solved using game theoretical tools. This dissertation looks at the competition between a FCC and a LCC. We assume that the FCC has a segment of captive customers - those who due to previous interactions with the FCC have such strong preferences for this airline that they are only willing to fly with this airline. The FCC competes with the LCC for the remaining consumers – the selective segment of consumers – whose horizontal preferences for both companies (FCC and LCC) are modelled using the standard Hotelling model (using for instance the time of the flight, airport location, to name few). Using the unit interval, we assume that FCC is located at 0 and LCC is located at 1, if it decides to enter into the market. Selective consumers are uniformly distributed on the interval $[0,1]$ and support a "disutility cost" of $t = 1$ per unit of distance when not flying with their preferred airline. Thus, at equal prices, consumers located near the FCC prefer to fly with that company, while the reverse happens to consumers located near the LCC.

Our aim is to understand how the segment of loyal captive consumers can influence the pricing decisions of the FCCs and price competition in the market. We assume that the LCC has no information to engage in price discrimination, so it charges a uniform price. In contrast, we assume that the FCC is able to distinguish a captive customer from a selective one and, being price-discrimination able, it can charge a different price to a captive consumer and to a selective consumer. In this case, the FCC charges one price targeted to captive customers and one targeted to selective customers; the LCC quotes a single price targeted at selective consumers. Note that to simplify the analysis the FCC can only discriminate between the price tailored to captive and selective consumers, and not on an individual basis, as would be the case under a perfect information gathering strategy (and perfect price discrimination).

This thesis highlights the importance of loyal consumers for the incumbent company. In fact, we show that the magnitude of the captive segment plays an important role for the FCCs's profitability facing the entry of low-cost airlines. If the entry of a LCC with a cost advantages is successful, the FCC has less demand on the selective market. Therefore,

the importance of the captive market is higher because it is the segment where the FCC can charge higher prices. In the case of the LCC, we show that when it enters into the market, the entry will be more successful the higher are its cost advantages. The LCC will always have a higher profit in the selective market than the FCC, the lower are its costs in comparison to the FCC.

This dissertation is organized as follows. Section two presents the more relevant literature. We will start with a brief introduction to personalized pricing, where we discuss its definition as well as its increasingly use over the years. We then discuss price personalization strategies within the airline industry, followed by the price mechanisms present in this industry. We will then proceed to evaluate some of the entry barriers this airline industry. To finalize, we will discuss the how consumer loyalty might act as an entry barrier in this market.

In section three, we present the model used in our dissertation. This section is the most important part of this research work. We solve the game using game theory tools. We look at the Nash equilibrium and then discuss the effects that the model parameters – the Full-Cost Carrier's consumer loyalty advantage and the Low-Cost Carrier's cost advantage – have on the results derived.

We then conclude the dissertation in section four, referring to all the bibliographic references in section five. An Appendix collects the proofs that were omitted from the text.

2. Related Literature

2.1. Personalized Pricing: a quick introduction

The introduction of personalized pricing has brought about a revolution to the way pricing is now seen. In recent years, this practice is fundamentally used in every event which implies a consumers' presence. The availability of information (the Big Data), allows an even bigger focus on this phenomenon as we leave a digital trail in everything we do on the Internet.[3] A competitive edge on its own, personalized pricing quickly became a plus for every entity wanting to impose itself on a competitive market.

The general idea of this practice occurs when there are different prices for the same product, whereby the prices are adjusted for each individual consumer, Thisse & Vives (1988). Garbarino & Lee (2003) introduced the thematic of "willingness-to-pay" into the equation. For the authors, personalized pricing happens when the price is adjusted according to the consumers' expectation of the goods, thus conveyed into their willingness-to-pay. Reinartz (2002) argued that "*Dynamic pricing is the dynamic adjustment of prices to consumers depending on the value these customers attribute to a good*". As of now, the most complete definition attainable is provided by the Office of Fair Trading, as they state, "*we use the term personalised pricing to refer to the practice where businesses may use information that is observed, volunteered, inferred, or collected about individuals' conduct or characteristics, to set different prices to different consumers (whether on an individual or group basis), based on what the business thinks they are willing to pay*".[4]

Essentially, as stated by Yeoman (2016), price personalization is a history of increasing the consumers expectations. Additionally, the author details some attributes of personalized pricing:

- The persistence of price sensitivity even in the developed economies;
- The sophistication of the predictive abilities of Big Data within every market's consumer capabilities – this being one of the most important factors;

[3] Big Data is the presence of information left by our digital trace which is used to evaluate our personal preferences.
[4] This definition is presented in http://webarchive.nationalarchives.gov.uk/20140402165101/http:/oft.gov.uk/shared_oft/markets-work/personalised-pricing/oft1489.pdf – OFT, May, 2003.

- The lifestyle focused on the technology nowadays – the gadget addiction;
- The increase of online shopping;
- Price optimization corresponding to the specific location of the consumers.

According to Yeoman, these attributes allow us to have further understand personalized pricing whilst simultaneously looking at the consumer history.

In order to discuss personalized pricing in further detail, some groundwork on discriminatory pricing is required. The first mind to have approached this situation was Pigou (1920). The author referred to this practice with the assumption that the firms involved must have perfect information or, at the very least the firms must be able to distinguish some segments of consumers; in conjunction with the assumption that the consumers lack arbitrage – they cannot resell the goods acquired. According to Pigou (1920), there are three types of price discrimination:

- **1st Degree:** The consumer acquires the product at the maximum price that he is willing to pay (its price reservation) – in this, all the consumer surplus is extracted.
- **2nd Degree:** This degree of discrimination refers to the sale of a particular portion of products, that is, the price depends on the quantity sold.
- **3rd Degree:** It is the most common form of price discrimination and consists of charging distinct prices to different groups of consumers.

In today's economy, personalized pricing is trying to imitate what we know as 1st degree price discrimination – firms fix the price somewhere where they can extract more out of every single consumer.[5] Shiller (2014) refers to this phenomenon as Imperfect First-Degree Price Discrimination.

Conceivably, Shapiro & Varian's (1999) point of view portrays the most consistent way to regard this topic. They updated Pigou's definition to the new information markets, Hence, different terminologies were applied as mentioned below:

- 1st Degree Price Discrimination – now, Personalised Pricing: To sell to each consumer at a differentiated price;
- 2nd Degree, was renamed as *Versioning*, meaning to offer a product line and allow users to choose for themselves what is most fitting for them.

[5] This cannot be achieved at this moment because of the complexity that is human behavior and to price according to every single consumers' reservation value is nearly impossible.

- 3rd Degree Price Discrimination, in which the definition still stands as the same.

Armstrong and Vickers (2001) critically contributed to the available literature, clarifying the different forms of price discrimination: interpersonal discrimination and intrapersonal discrimination. Intrapersonal discrimination defines how the same consumer faces different prices across the range of purchased goods. However, the sole focus will be on interpersonal discrimination as it is the highlight of this study. We classify this variable as the appliance of different prices to different customers – this relates to the airline industry as different clients are charged different fares depending on when they buy the ticket. Within the interpersonal discrimination realm, firms can choose to apply different strategies for their benefit. One of them, is presented by Chen (1997) – the concept of *paying customers to switch*. This means that firms try to attract rivals' consumers by offering different deals generally better than of their rivals.[6] This is achieved when the firms generate profits from attracting their rivals' clients without hindering their profits from their loyal consumer base.

Amongst the pioneers to examine personalized prices were Thisse & Vives (1988), although many years before these prices flourished. They used a Hotelling Model, dealing with each customer as a separate market.[7] Thus, the firms could personalize the price for each consumer with the presumption that they have perfect information about each customer location on the line – having both firms with perfect information, allowed them to personalize the prices for each individual consumer.

Ulph & Vulkan's (2001) model had firms using the technology necessary to discriminate individually and to execute a total customization.[8] They conclude that the firms with the technological means to do first-degree price discrimination are better if they also apply a total customization, therefore leading to an extraction of a higher consumer surplus from those who are loyal consumers. This work is a subject of prisoners' dilemma as both firms would be better if they did not apply these results, as after application the profits would be lower than before – just like in Thisse & Vives's (1988) model.

[6] Fudenberg and Tirole (2000) refer to this phenomenon as *Customer Poaching*.
[7] This model considers two rival firms, one at each extreme of the model [0;1], and, consumers homogeneously distributed along the straight segment.
[8] The authors refer to this variable when the firms can supply a multiplicity of differentiated products with the same marginal costs without, however, adding fixed costs independently of the brand offered.

Through Netflix subscriptions' data, Shiller (2014) argued that the pathway to personalized pricing is according to the consumers' behaviour methods. When the company employed a personalized pricing consistent with their consumers' online behaviour, they had a profit increase of 12.2%. Whereas, the increase in profit was merely 0.8% when the pricing method was made by personalizing the price based on region. Hence, a more exhaustive information on consumers' behaviour can lead to an increase in profits.

As argued before, many of the discriminatory ways of pricing tend to be related to consumers' behaviour – the literature identifies this as Behaviour-Based Price Discrimination, or BBPD for short. Fudenberg & Villas-Boas (2007) defined this as the act of offering different prices and/or products when the firms have information regarding consumers' purchase history. This can be used to gain advantages against other companies, being termed competitive BBPD and ultimately increasing the importance of information.

This discussion brought new light to information along the lines of economic practices, allowing it to remain relevant until today, as companies use the information to personalize their prices.[9]

We begin our assessment on the BBPD literature, with the overview about price discrimination within dynamic settings.[10] Firstly, this literature will tour us through an overall look at the effect of switching costs. We will discuss Chen's (1997) two-period model with homogenous products and evenly distributed switching costs. Here in this model, the first period serves as an observatory period to absorb all the data, while the second period enables the firms to determine which is their "strong market" and "weak market". Where the strong market is their loyal customers, and the weak market, their rivals' consumers in the past period. As a result of the *paying to switch strategy*, the second period is an all-out competition which makes prices and profits lower when compared to the first period. All in all, Chen confirmed what Thisse & Vives (1988) highlighted – firms are worse off practicing price discrimination. Peculiarly, Chen (1997) concluded that by incurring switching costs, the first-time consumers pay less than the

[9] In the case of the Airline Industry, you can find how they personalize their prices in the Section denominated "Pricing Mechanisms in the Airline Industry".
[10] For an in-depth analysis of the all the literature involving BBPD, see Esteves (2009).

loyal consumers. This is due to the increase in pricing when the firms can observe their loyal base.

Now, we set our sights on models without the presence of switching costs. As an assumption, the moment the consumer chooses their product, the preference of that particular product should not change overtime. The information obtained from this serves a purpose as firms try to acquire customers from the other firm if price discrimination is allowed. Considering these assumptions, Fudenberd and Tirole (2000) developed a two-period model within a duopoly setting, reassembling the structure from Chen (1997). In the first period, there is an observatory period. In the second, firms may discriminate accordingly (try to poach the "weak market's" consumers with different pricing from their regular ones). Regular consumers pay more than the first timers, which means an intensified competition with price discrimination with an overall price drop. As a conclusion, Fudenberd and Tirole (2000) realized that price discrimination leads to lower profits for the firms, enabling a *prisoners' dilemma*.

Chen & Zhang (2009) added a loyalty component to the thematic at hand. So long as the consumers' reservation price is not surpassed, they remain loyal to the firm, and thus cannot be persuaded to shift firms. The rest of the consumers are named "switchers" as their reservation price is lower than the loyal ones and will always buy at the lowest price. Information is crucial for the first period. It is possible to discriminate the loyal from the selective consumer which allows the firms to compete for the selective consumers in the second period by monitoring the market. Chen & Zhang (2009) find that price discrimination, in this case, grants an increase in profits to the firms in the second period, as they expand their sales without damaging their loyal base income. This setting leads firms to higher prices in the first period so as to obtain the most out of their loyal customers while they perform a less aggressive pricing in the second period to poach rivals' consumers.

Resuming the loyalty analysis, in Chen & Pearcy's (2010) model, there is also, an "observation" period, and a second one which allows firms to poach their rival's consumers. This model withstands itself in correlated preferences across periods, as such the main point is that consumers are likely to remain with the same brand based on their past purchasing behaviour showing a high preference for that brand. Keeping in mind that their loyal consumers would not change preferences, firms can now poach their rivals' consumers with lower prices which leads to higher overall industry profits and lower

consumer surplus. As for when the past behaviour does not predict a repurchase, this leads to as Chen & Pearcy (2010) argued, "an industry equilibrium that rewards consumer loyalty.". This means that the incentive is to lower the prices and consequently have more repeat consumers, thus, leading to lower overall industry profits and a higher consumer surplus. This, as advocated by Chen & Pearcy (2010), helps explain the loyalty programs in the Airline Industry which are meant to force consumers to stay and fly with the same airline overtime.

The main consensus on the literature is that BBPD hinders profits from the firms and the whole industry in general. However, looking at the demand elasticity, Esteves & Reggiani (2014) argued that firms are indeed worse under BBPD compared to uniform pricing, although, the negative impact on profits shortens as demand elasticity increases, shedding a new light on the issue.

As it refers to well-being, Chen (2005) stated that personalized pricing can lead to increased earnings for both the consumer and the supplier. In fact, Thisse & Vives (1988) found that these practices lead to increased competition between the firms paving the way for a price decrease which benefits the consumer. Shiller (2014)'s contribution implies that personalized pricing is beneficial to the overall economy as it leads to innovation and differentiation. As for the case of BBPD, the common finding on the literature leads us to believe that this practice increases competition, hindering the profits from the overall industry, thus, allowing a better surplus for the consumers.[11] Chen (2005) describes this effect as positive for the welfare implications, as increased competition, leads to a reduction in prices thus increasing the consumers' satisfaction. Esteves & Reggiani (2014) refer to this well-being as independent to the elasticity of the demand.

2.2. Personalized Pricing in the Airline Industry

The Airline industry is a market innately opened to personalized pricing. Intrinsically, this industry has been the target of numerous studies since it has two essential factors for such to happen. According to Gerardi & Shapiro (2009) these two components are different price sensibilities from the consumers (e.g. leisure travellers[12] and business travellers[13]); and the airlines can distinguish these groups of passengers by applying

[11] see for e.g. Chen (1997) or Fudenberg & Tirole (2000)
[12] This group of travellers is the one that travels under the pretence of holidays – per USA Today.
[13] Business Traveller is the one that uses business as the basis for travelling.

market restrictions on the fares/tickets. The increase of data about said components has grown since the deregulation of the airline industry. Hence, making it easier for a diversity of models – especially those trying to understand the airline industry and its pricing models. However, due to the recency in this matter, studies about real personalized pricing have been scarce, with many regarding it as "the future". As such, we offer a look at the overall literature regarding price discrimination in the airline industry which paved, (or rather, will pave) the way for personalized pricing.

Morrison & Winston (1990) examined the impact of competition and market regulation on the fares. Although not exactly a study about personalized pricing, we found it important to refer to this study as it was one of the first post-liberalization study about the airline industry. They pointed out that there is a inverse relationship between competition and fares employed by the airlines. However, a paradox appeared within this study. With deregulation, the fares became an entry barrier to other companies. Since most markets were dominated by a large airline, it became impossible for a new competitor to arise, consequently hindering the competition and maintaining a high fare level. Different studies leading the way to personalized pricing surfaced came later. One of those was the study by Borenstein & Rose (1994). They concluded that the price dispersion is linked to market shares as well as market concentration. The greater the competition, the greater the price dispersion; and, the larger amount of flights supplied by the companies, the less price dispersion there is. These results were also confirmed in studies made by Stavins (2001) and Gaggero & Piga (2011).

Gerardi & Shapiro (2009) concluded differently – an increase of competition on a route makes the price dispersion smaller in the said route. However, they emphasized that the arrival of the low-cost carriers and the way the data was treated may have had influence on these results.

Airline companies' purpose on establishing fare differentiation is expected. The possibility of the increased profits from reaching a greater number of consumers with different willingness-to-pay is enticing. Belobaba *et al.* (2017) argued that price discrimination in this industry leads to increased profits due to the existence of a vast number of consumers with different reservation prices. The power of information becomes even more essential as the difficulty of obtaining statistics may hinder the growth. Nonetheless, the improvement of technology and information available takes us to new heights. Airlines must be prepared to improve as technology becomes available.

Specifically speaking, the difficulty of evaluating consumers' willingness-to-pay (WTP) hinders the evolution of the airline industry. WTP, according to Belobaba *et al.* (2017), is the maximum price that a consumer is available to spend before deciding against it. They continued by arguing that the evaluation of a said consumer changes according to the situations they are exposed to on a daily basis.[14] Belobaba *et al.* (2017) referred to this concept as one of difficult prediction, as such, all the predictive instruments available still require improvement before perfection.

2.3. Pricing Mechanisms in the Airline Industry

Today's technology permitted the emergence of algorithms capable of analysing efficiently the in-depths of the market. These algorithms are an endeavour of predicting what kind of consumers are expected to fly and their willingness-to-pay, formulating this way, the aggregate demand. This is a complex process where algorithms, such as, *Expected Marginal Seat Revenue* (EMSR) look to optimize the fares in real time (not only on a particular route but also on the airlines' whole network of routes).[15] For instance, if the algorithm finds that route to be a leisure route then it would increase the pricing in advance.[16] Whereas if it considered a business route, the pricing would only rise near the departure date. This pricing process also involves factors like the flight distance, number of days the trip is booked for, hours and day which the ticket is purchased, and the restrictions of the numerous countries.[17] The algorithm utilized by the major airlines, ATPCO,[18] takes into account all these variables in an attempt to anticipate consumers' behaviour[19] and adjust the fares towards the company's goals. The consideration about consumers' past behaviours ties this with the aforementioned Behaviour-Based Price Discrimination.

[14] For instance, if a consumer is exposed to two different airlines and has a willingness-to-pay of 500$. The said airlines fares are 300$ and 400$ respectively. Then, with all the rest *ceteris paribus*, the consumer's WTP is now 300$ because, according to the rationality laws, the consumer always wants to maximize its own utility, so it chooses the lowest fare.
[15] https://edition.cnn.com/travel/article/airline-pricing-secrets/index.html, July 16th of 2017 – accessed at December 11th of 2017.
[16] Leisure travellers tend to buy flight tickets in advance as seen before.
[17] For example, Aeroporto da Madeira (Cristiano Ronaldo Airport) is a difficult place to land at so, only the most experience pilots can fly there.
[18] Airline Tariff Publishing Company
[19] http://www.bbc.com/travel/story/20130405-how-airline-pricing-works, April 5th of 2013 – accessed at December 12th of 2017.

To summarize what was stated, Belobaba *et al.* (2017) referred that airlines companies use revenue management systems in order to select a fare based on certain rules and influences. According to them, some of the pointers are:

- The remaining capacity of the airplane;
- The time remaining till lift off;
- A prediction of the demand that is to come;
- And the presence of special events which influence said demand;

To obtain this data, companies often apply a screening[20] method to a certain market, especially to evaluate the demand. This method is composed, for example, by applying for instance *Frequent Flyer Programs,*[21] or by observing when the consumers purchase their tickets – Escobari *et al.* (2016). Nevertheless, sometimes the airlines believe it is reasonable to set for departure with an empty seat, instead of applying a discount on the available seat. This comes from the foundation that for the company, the consumers' purchase behaviour is most of the times more important than to profit on that seat. As stated by Sebastian Mikosz: *"Airlines cannot afford to suddenly have passengers change their buying behavior, if they do, it will destroy the pricing model!".*[22]

The current operative algorithm to reap information from the market is denominated *New Distribution Capability*[23] and it was introduced by *IATA.*[24] It has the objective of bestowing companies with a better method to allocate their products, as it allows an efficient personalization for the companies' distribution channels. This algorithm upgrades the flaws that had previously persisted, and now focuses on the dynamic side of the consumers and their interaction with the airline industry now.

The introduction of this algorithm allowed an advance on the data usage from companies, consenting them to respond to breaks on the demand more efficiently. Thus, authors like Westermann (2013) view this method as pioneer, paving the way for on-the-fly price adjustment.

[20] Screening refers to an observation of a certain market. This concept was first introduced by *Spence, A. M. (1973)* in *"Job Market Signaling". Quarterly Journal of Economics. 87 (3): 355–374.*
[21] More on this will be available within the next section.
[22] At the time of the interview, Sebastian Mikosz was the CEO at eSky.pl S.A.
[23] Also known by *IATA Resolution 787*.
[24] **International Air Transport Association** – consists in a group of 278 airline companies, roughly 83% of all the airline traffic available. Its main objective is to support all the activity of said airlines and to formulate standards and policies to this industry.

2.4. Entry barriers

Our dissertation also relies on the effects that entry barriers have within a firm's decision to enter a said market. Armstrong and Vickers (1993) argued that this decision may be influenced by price discrimination. They stressed that this type of practice leads to "less entry and perhaps none", because the incumbent firm would respond aggressively to an entry. The same train of thought is presented by Karlinger and Motta (2007) as they show in the context of their model that price discrimination can serve as an entry barrier.

But how would entry barriers affect the market directly? First, we will have to look upon the definition of "entry barriers". We start with Bain (1956), as he claimed that an entry barrier is an advantage that the incumbent firm has over the potential entrants, allowing firms to earn above average profits without any entry threat. Bain's arguments consisted of the distinction of four main barriers to entry. Primarily, the author mentioned the ability to differentiate products and/or invest in differentiation as an entry barrier. Secondly, he emphasized the benefit of the incumbent firm's costs advantage which is correlated to the large initial capital requirements that entry firms are subjected to. Finally, Economies of Scale, which are widely recognized as an entry barrier.

However, this definition is not as plausible as one would initially contemplate. Let us imagine a competitive market (with many incumbents) with no entrance possibility and some external factor, (e.g. Government restriction). Within Bain's definition, this market would have no entry barriers, as all the points made by Bain would not apply to this particular case.

Stigler (1968) defined an entry barrier as a "cost of producing (at some or every rate of output) which must be borne by firms which seek to enter an industry but is not borne by firms already in the industry". As such, he highlighted the differentials in costs between incumbents and entrants. To clarify, many authors pointed out the present tense of this definition as its own flaw since Stigler stated that only a cost that entrants support today is an entry barrier, even if the incumbents had to bear it in the past.

Gilbert (1989) brought sunk costs into equation with his definition and argued that the incumbent firms can employ a strategic behaviour to avoid entry, making sunk costs a "rent that is derived from incumbency", increasing losses in case of an unsuccessful entry.

According to Shepherd (1988) there are two kinds of entry barriers, exogenous or endogenous. Exogenous are intrinsic to the market, or "embedded deep in the nature of each industry", while the latter are created as the incumbent firms take actions through competitive behaviour against the entrants.

One can also make the distinction between Economic Barriers and Antitrust Barriers. Per McAfee *et al.* (2003), an economic one is a cost that is supported by a new entrant which does not apply to the incumbent. While an antitrust one is a cost that delays entry and thereby reduces social welfare relative to immediate but equally costly entry. An important note is that any economic barrier is an antitrust one whilst, some antitrust ones cannot be considered economics ones. Thus, making the antitrust concept wider than the economic one.

To synthesize all of the above, the bulk of the literature allows us to make an assumption – the traditional approach is to recognize entry barriers as fixed entry costs.

Naturally, the airline industry is hit heavily with entry barriers. The consensus on the literature is that multiple factors have an influence. Borenstein (1989) referred to Frequent Flyer Programs as one of those entry barriers (see also Nero (1999)). The position and size of the *Hub* (Morrison and Winston (1990), Reynolds-Feighan (2001), Borenstein & Rose (1994)), leads to monopoly power within that market preventing other companies to join, and is also considered an entry barrier. Borenstein (1989) also mentioned the heavy costs that having a fleet is underlying is an entry barrier, as well as the airport charges which are intrinsic to any airport. Some of these costs are incurred on the purchase of gates.[25] Airport's legislations and overall legislations also influence the entry of airlines in some markets (Morrison and Winston, 1990; Snider and Williams, 2011).

2.5. Loyalty Programs

"*If you give me a gift, I will feel better about you and I'll keep buying from you"*

Scott Neslin[26]

[25] According to the New York Times, a small number of major airlines control most of the gates at large hub airports, making it difficult for new airlines to get a foothold in these markets. Per Keith Evan (2007) in https://bizfluent.com/list-7576197-barriers-entry-airline-industry.html, accessed 15 of September, 2018.

[26] Marketing Professor – Tuck School of Business at Dartmouth College.

Loyalty programs were mentioned above simultaneously as a screening helper as well as an entry barrier. While that remains true, we left out what these programs are. Hence, in this section, we look to further understand loyalty programs and what determinates loyalty as a whole. This type of programs generally rewards the loyal consumers with potential bonuses accordingly with the value which they previously expended. In the airline industry, this type of program is named *Frequent Flyer Program* (FFP). All in all, loyalty programs are used as a tool to attract and maintain consumers as a motivation to be competitive in the markets, as said by Dowling & Uncles (1997).

As such, nowadays there is a connection between loyalty programs and several markets. For instance, one can use their accumulated mileage points to improve their stay within the flight or even at the hotel when arriving, therefore increasing their satisfaction with the airline. Intrinsically, as Dowling & Uncles (1997) pointed out, loyalty programs can improve a product's appreciation, thus improving the range of consumers interested – as long as this loyalty program is considered as differentiated within the market. While Darke & Dahl (2003) argued that consumers can be retained depending on their satisfaction, extracting a greater amount of surplus from these.

FFP's began their existence in 1980 with American Airlines as pioneer. Having been introduced right after deregulation, they quickly began to be seen as "an attempt to isolate themselves from competition", (Caminal and Claici, 2007). Rapidly, all the other companies adopted this system, as in order to compete, FFP's were considered a necessity. In fact, Lederman (2007) noticed that FFP's are correlated with the increased market shares as well as the increase in profits from the airline companies. As such, Chang & Hung (2013) emphasized the importance of these programs, considering them as fundamental for an established market share as well as higher ceiling in profiting. On a different note, Borenstein & Rose (2014) indicated that these types of programs are competition hinderers, due to the creation of switching costs originated by FFP's. Caminal and Claici (2007)'s view was the opposite, stating that, instead of competition hinderers, if the market is big enough, FFP's are pro-competitive steering the market into lower average prices and thus an increased consumer welfare.

The models designed by Chen & Zhang (2009) and Chen & Pearcy (2010) have included loyalty components to them as mentioned beforehand. Both agree that the loyal set of consumers are the key to success. In addition, Chen & Pearcy (2010) concluded that loyalty programs allow consumers to be less willing to switch airlines, as such allowing

airlines with already an established loyal base to poach their rivals' consumers with lower pricing. Moreover, Chen & Zhang (2009) specifies that these loyalty inducing programs allow an increase in profits. Thus, it remains true what was said above: these programs are essential for an airline company survival.

The Hub-and-Spoke Model which Full-Cost Companies employed to compete against low-cost carriers after liberation of the industry, also display some loyalty inducing components within them.[27] Besides the main objectives of this model, there are also the gains on consumer loyalty for an airline with an above average presence at a Hub, Nero (1999). This allows the airline to exercise some type of monopoly power through the presence of loyalty programs, protecting themselves from competition.[28]

The importance of loyalty is widely documented in the literature. The standard is, according to Gómez *et al.* (2006), that loyal customers are less sensitive to price changes. Suzuki (2007) pointed that consumers choose their airline in a two-step way. Consumers choose from a poll of airlines which they are comfortable flying, and then from this initial sample proceed to select the airline in which they are flying. This choice considers several key points (fares, flight frequency to the wanted destination and whether the consumer is a member of the *Frequent Flyer Program* employed by the company in question). Similarly, Hess *et al.* (2007) argued that the variables considered above are key in airlines' choices. However, for their model, they segmented the market, into business and leisure travellers, concluding that all the variables are considered relevant for both segments. We saw above that airline decision factors loyalty, however what determines this loyalty?

In a study where their dependent variable is loyalty, Dolnicar *et al.* (2011) concluded that the main factor which consumers consider is indeed membership in loyalty programs employed by the airline. In fact, those who have multiple loyalty programs, or no program at all, are less likely to be loyal to a single company. Correspondingly, those who only possess a single frequent flyer subscription are more likely to be loyal to that single airline. The same study was done for the business and leisure travellers' segregation. Business travellers' correlation to loyalty was consistent as reported above while the leisure travellers do not fall in this category.

[27] For further clarification about Hub-and-Spoke model, check Reynolds-Feighan (2001).
[28] Note that usually, each FCC has a Hub in a market where they most likely control.

Vlachos & Lin (2014) further elaborate this study, discussing that in a sample of business travellers, the price is non-significant as they are less price sensitive. As for the variables they employ, the conclusion arrived is that *Frequent Flyer Programs* and *Overall Satisfaction* are the most important variables for the consumer with intention of repurchasing, thus expressing their loyalty towards an airline.

As for leisure travellers and their relationship towards loyalty, Akamavi *et al.* (2015) when studying low-cost carriers distinguished pricing as its main variable. The authors argued that the most efficient way to promote loyalty towards this type of consumer is by applying prices which consumers find amicable. Satisfaction towards the service is also in high demand.

3. A model of competition between a FCC and a LCC

The presence of Full-Cost Carriers and Low-Cost Carriers, (LCC), in the same market and the existence of a multiplicity of different types of consumers[29] demonstrates the complexity of this industry as there is a diversity of price strategies. For consumers, the emergence of LCC brought upon lower fares, increasing their well-being, (Morrison, 2001). On the other hand, the use of loyalty programs by some airlines, Frequent Flyer Programs, (FFPs in short), makes us ponder how important are those programs to airlines, especially for the traditional ones, which compete against lower prices from the LCC.

As aforementioned our aim is to understand how the captive segment and differences in both companies' costs affect price competition and profits. With these goals in mind, a theoretical model is created and analysed using game theoretical tools. This model is presented in the subsequent subsection.

3.1. The Model

Consider a market with an Incumbent firm (A), we will consider this firm a Full-Cost Carrier (FCC). This firm has all the information required to personalize the prices as long as it is permitted. Suppose that firm B (the Low-Cost Carrier, LCC) has the possibility of entering into the market. As for the demand we assume that there is a large number of consumers and each of them by default only wishes to buy one ticket. As such, we assume that the mass is normalized to one. Each passenger has a reservation value, V, with V large enough as way to allow all passengers to buy one ticket. To simplify, this Model will have $t = 1$. The preference of passengers is given by x, with $x \in [0,1]$, modelled as in the Hotelling framework. Thus, we assume that A is located at 0 and B, if the entrance happens, is located at 1.

With this model we will study two pricing frameworks. In the first the FCC is alone and acts as a monopolist. Therefore, this firm chooses a price for all consumers. In this framework we have $p_A = p_M$, as we consider M for monopoly.

[29] With different price sensitivity to the prices practiced by the airline companies, Gerardi & Shapiro (2009).

The second pricing framework takes us to an entrance possibility by B. This entrance has an inherent fixed cost of F. In this case, we assume that A due to previous interactions with passengers before the entrance, it has α captive passengers, competing for the remaining passengers, $(1-\alpha)$, the selective passengers, with LCC.[30] The marginal costs are c_A and c_B for A and B respectively, with $c_A \geq c_B$. Specifically, we assume, $c_A = c$, while $c_B = c\beta$ with $\beta \in [0,1]$.

Additionally, we assume that the FCC can set different prices to captive and selective passengers, while the LCC sets a single price.[31]

3.2. Equilibrium analysis

3.2.1. Under a monopoly market

FCC chooses a price to all passengers p_M and obtains a monopoly profit of π_M. The FCC tracks information about the passengers which will be useful to set different prices in the price discrimination setting.

3.2.2. Under a duopoly market

The FCC faces the entry of a LCC. Despite this entry, we assume that the FCC has a segment of captive passengers α and competes for the remaining $(1-\alpha)$ passengers with the LCC. We name these last passengers, selective ones. This is only possible, taking into account the monopoly market phase, where the FCC was able to gather data about passengers.

We now analyse each true pricing decision to each segment of the market.

Look first at FCC's price target to captive consumer p_A^C.

FCC's profit from this segment is given by:

$$\pi_A^{Cap} = (V-c)\alpha$$

[30] This set of passengers has different reasons to choose to fly with either the FCC or the LCC. As Chen & Pearcy (2010) suggests "a consumer's preference for different airlines may change substantially between two trips, depending on the availability and schedule of flights to possible different destinations.". These are only some examples of reasons of consumers' preferences as what it respects to the airline industry.

[31] With uniform prices to both firms, the equilibrium would need to be studied under mixed strategies, which is beyond the scope of this masters.

It is straightforward to show that, $V = p_A^C$, as the information obtained before allows the FCC to extract the from each passenger. This profit depends on the number of captive passengers there are on the market.

Look next at both firms' price decision with respect to the selective market, respectively, p_A^S and p_B^S, following a Hotelling Model's structure we can show that $x = \frac{1}{2} + \frac{p_B - p_A}{2}$, as such:

$$D_A = (1-\alpha)(\tfrac{1}{2} + \tfrac{p_B - p_A}{2})$$

$$D_B = (1-\alpha)(\frac{1}{2} + \frac{p_A - p_B}{2})$$

Making the profits clear:

$$\pi_A^S = (p_A - c)(1-\alpha)(\frac{1}{2} + \frac{p_B - p_A}{2})$$

$$\pi_B^S = (p_B - c\beta)(1-\alpha)(\frac{1}{2} + \frac{p_A - p_B}{2}) - F$$

Considering that A chooses p_A in order to maximize π_A^S, and B selects p_B so as to maximize its π_B^S, their best response functions are given by:

$$p_A = \frac{p_B + c + 1}{2}$$

$$p_B = \frac{p_A + c\beta + 1}{2}$$

We can now state the following proposition:

Proposition 1. *When the Full-Cost Carrier competes with a Low-Cost Carrier by setting prices in a selective market the Nash Equilibrium prices are equal to:*

$$p_A^{S^*} = 1 + \tfrac{2c + c\beta}{3},$$

$$p_B^{S^*} = 1 + \frac{c + 2c\beta}{3}$$

and each firm's equilibrium demand and profits in this market are given by:

$$D_A^{S^*} = (1-\alpha)\left(\frac{1}{2} + \frac{c(\beta - 1)}{6}\right)$$

$$D_B^{S^*} = (1-\alpha)\left(\frac{1}{2} + \frac{c(1-\beta)}{6}\right)$$

$$\pi_A^{S^*} = \frac{1}{18}(1-\alpha)[c(\beta-1)+3]^2$$

$$\pi_B^{S^*} = \frac{1}{18}(1-\alpha)[c(1-\beta)+3]^2 - F.$$

As we should impose that $0 \leq D_B^{S^*} \leq 1-\alpha$ it follows that $c \leq \frac{3}{1-\beta}$. On the other hand, we should also impose that $0 \leq D_A^{S^*} \leq 1-\alpha$, which means that $c \leq 3$. Therefore, taking into account these conditions the model is solved for $c \leq 3$.

If we compute the difference between the two prices we find that $p_A^* - p_B^* = \frac{1}{3}c(1-\beta) \geq 0$ for $\beta \leq 1$.

Therefore, as expected as long as $\beta < 1$, the LCC offers a lower price than the FCC. In fact, the lower is β the lower is the LCC's price in comparison to FCC's price.

Note that firms will only compete in this market as long as $\alpha < 1$, as such, now $\alpha \in [0,1[$. Note also that $\beta = 1$ has an interesting effect – it makes the costs redundant to the equation, as in this case both firms are equal in terms of cost and would share the selective market. If $\alpha = 1$, there is no selective market, as the FCC has control over all of the captive market, as such this would lead to null profits in selective market.

Corollary 1. *The LCC company only enters into the market as long as F is below a threshold* $\hat{F}$*, with* $\hat{F} = \frac{1}{18}(1-\alpha)[c(1-\beta)+3]^2$*. If F>*$\hat{F}$ *it prefers to stay out of the market.*

We must take into account that the LCC company is only willing to enter into the market if $\pi_B^* > 0$, again with the assumption that $\alpha < 1$. Otherwise, rationality would prevent such an entrance. From this condition, we conclude that the LCC company only enters into the market as long as F is below a threshold $\hat{F}$, with

$\hat{F} = \frac{1}{18}(1-\alpha)[c(1-\beta)+3]^2$ specifically, as long as

$$\frac{1}{18}(1-\alpha)[c(1-\beta)+3]^2 > F.$$

3.3. Discussion of Results

We now discuss the results obtained above and we try to interpret them. We will start by analysing the effects that the model parameters – as the proportion of captive consumers α, and the LCC's cost advantage through β – have on prices, demand and profits of the FCC and on the entrance decision of the LCC.

3.3.1. Effects of changes in the LCC's cost advantage (β)

Taking into account the equilibrium prices and the demand we can show that $\frac{\partial P_A^*}{\partial \beta} = \frac{1}{3}c > 0$; $\frac{\partial P_B^*}{\partial \beta} = \frac{2}{3}c > 0$; $\frac{\partial D_A^*}{\partial \beta} = \frac{1}{6}c(1-\alpha) > 0$ and $\frac{\partial D_B^*}{\partial \beta} = \frac{1}{6}c(\alpha - 1) < 0$. Therefore, as the low-cost carrier entering into the market is more efficient (lower β), firms compete more aggressively in prices, which fall, and the low-cost carrier is able to capture a higher proportion of the selective market. In fact, we can show that for the maximum efficient level of the cost carrier in comparison to the full cost carrier ($\beta = 0$ and $c = 3$) the LCC would serve the whole selective market, while the FCC would only serve the captive market. For intermediate values of the parameters, as long as $\beta \neq 1$ the FCC would be able to capture part of the selective market but a lower proportion than the LCC.

Finally, we should stress that β has an important effect on the FCC's profits. Taking into account that $\pi_A^* = \frac{1}{18}(1-\alpha)(c\beta - c + 3)^2$, it follows that $\frac{\partial \pi_A^*}{\partial \beta} = \frac{1}{9}(1-\alpha)(c\beta - c + 3)$ which is always positive for $c < 3$.

With regard to the LCC as $\pi_B^* = \frac{1}{18}(1-\alpha)(c - c\beta + 3)^2 - F$ it is straightforward to see that as expected $\frac{\partial \pi_B^*}{\partial \beta} = \frac{1}{9}(\alpha - 1)(c - c\beta + 3)$ is always negative. Therefore, as β falls the LCC's cost advantage is higher, which means that this company sets a lower price, gets a higher demand and so a greater profit in the selective market. This conclusion is true for any value of c. In fact, $\frac{\partial \pi_B^*}{\partial c} = \frac{1}{9}(\alpha - 1)(\beta - 1)(c - c\beta + 3) > 0$, which means that as the LCC faces a less efficient competitor it is able to get higher profits in this market, and this tends to be higher the lower is β.

3.3.2. Effects of changes in the size of the selective market (1- α)

As expected we can show that both firms' profits from the selective market fall as the size of the selective market decreases. Specifically, we can show that $\frac{\partial \pi_A^*}{\partial \alpha} = -\frac{1}{18}[c(\beta - 1) + 3]^2 < 0$ and $\frac{\partial \pi_B^*}{\partial \alpha} = -\frac{1}{18}[c(1 - \beta) + 3]^2 < 0$. However, it is important to stress that for a fixed entry cost F, the entrance of firm B is more likely the higher is the size of this market, the derivative $\frac{\partial \hat{F}}{\partial \alpha} = -\frac{1}{18}[c(1 - \beta) + 3]^2 < 0$, proves such conclusion. Specifically, the lower is α, the larger is the selective market.

3.3.3. Entry decision of the Low-Cost Carrier

We now discuss how the parameters of the model affect the entry decision of the LCC into the market. We should take into account that this company supports an entry cost equal to F, and we already show that it will only be willing to enter into the market as long as $F \leq \hat{F}$, otherwise it prefers to stay out, with $\hat{F} = \frac{1}{18}(1 - \alpha)[c(1 - \beta) + 3]^2$. It is straightforward to show that $\frac{\partial \hat{F}}{\partial \beta} = \frac{1}{9}(\alpha - 1)(c - c\beta + 3) < 0$. The signal of this derivative proves that if β raises, firm's B cost advantage is smaller, thus experiencing a lower demand for the LCC. The entrance decision is also affected by the costs supported by the FCC, namely c as discussed. Thus, the entry is more likely when these costs are high, $\frac{\partial \hat{F}}{\partial c} = \frac{1}{9}(\alpha - 1)(\beta - 1)(c - c\beta + 3) > 0$.

Therefore, with a lower demand, the entry decision will be less likely. If for instance $\beta = 0$ and $c = 3$, the LCC is extremely efficient in comparison to the FCC and we can show that as long as the entry cost is below $2(1 - \alpha)$, firm B decides to enter into the market. If in contrast $\beta = 1$ and $c = 3$, then the LCC company would only enter if the entry cost were lower than $\frac{1-\alpha}{2}$, which is a more restrictive condition. This suggest that the LCC company can support a higher entry cost as long as its cost advantage is higher in comparison to the incumbent company and the size of the selective market is higher.

3.4. Airlines' profitability comparison conditional on LCC's entry

We now analyse under which circumstances can the LCC be more profitable than the FCC? We first look at the FCC's overall profit and then we look at profits in the selective market alone.

We now discuss the effects on each firm overall profit. For the FCC we have that:

$$\pi_A^T = \pi_A^{Cap} + \pi_A^{S^*}$$

which simplifies to:

$$\pi_A^T = (V - c)\alpha + \frac{1}{18}(1 - \alpha)[c(\beta - 1) + 3]^2$$

The LCC's profit in the selective market is

$$\pi_B^{S^*} = \frac{1}{18}(1 - \alpha)[c(1 - \beta) + 3]^2 - F$$

Next, we investigate under which conditions firm A's profit is higher or lower than B's, conditional on the entry of firm B, i.e., $\hat{F} = \frac{1}{18}(1 - \alpha)[c(1 - \beta) + 3]^2$.

So, we begin our assessment by studying under which conditions $\pi_A^T > \pi_B^S$:

$$(V - c)\alpha + \frac{1}{18}(1 - \alpha)[c(\beta - 1) + 3]^2 > \frac{1}{18}(1 - \alpha)[c(1 - \beta) + 3]^2 - F$$

$$\Leftrightarrow \alpha > \frac{3F - 2c(1 - \beta)}{c + 2c\beta - 3V}, with\ V - \frac{1}{3}c - \frac{2}{3}c\beta \neq 0\ and\ 0 \leq \frac{3F - 2c(1 - \beta)}{c + 2c\beta - 3V} < 1$$

The FCC's profits would naturally be better off the larger is its captive market, as this would imply a limited selective market. However, high costs would lead to a lower demand from the selective market, and consequently a lower profit in this market – a lower profit (due to higher costs) in the captive market would also occur. Thus, when the FCC is not efficient enough it requires a higher number of captive passengers to counteract this inefficiency in terms of costs, $\frac{\partial}{\partial c}\left(\frac{3F-2c(1-\beta)}{c+2c\beta-3V}\right) = \frac{3}{c+2c\beta-3V} > 0$. Nevertheless, we observe that the requirement for captive consumers decreases, as the other parameters increase. Specifically, $\frac{\partial}{\partial V}\left(\frac{3F-2c(1-\beta)}{c+2c\beta-3V}\right) = \frac{3F-2c+2c\beta}{(c+2c\beta-3V)^2} < 0, \frac{\partial}{\partial F}\left(\frac{3F-2c(1-\beta)}{c+2c\beta-3V}\right) = -\frac{3(F-2V+2F\beta+2V\beta)}{(c+2c\beta-3V)^2} < 0, \frac{\partial}{\partial \beta}\left(\frac{3F-2c(1-\beta)}{c+2c\beta-3V}\right) = -6\frac{c(F+V-c)}{(c+2c\beta-3V)^2} < 0$. In the case of high fixed cost supported by the LCC, as argued before, this would hinder the ability to join the selective market, so even if an entry occurs, the profit would naturally

be lower the higher the fixed costs are. This would lead to a lower requirement of captive consumers for the FCC, because of the lower profits experienced by the low-cost.

The same argument is valid when the FCC becomes more cost efficient. As the LCC becomes less efficient, it is more likely that the selective market is shared by the two companies. Thus, the LCC's demand falls and this translates into more profit for the FCC in this market. As such, the need for captive consumers is not essential as the selective market tends to be equally divided (when $\beta = 1$).

With respect to the reservation value, this would allow the FCC to obtain a higher profit in the captive market, thus, shortening the need for the captive consumers within this market.

For the LCC's behaviour on the selective market, we do the same exercise. Conditional on the LCC entrance, the LCC's profit is higher profit than the FCC in this segment, i.e., $\pi_B^S > \pi_A^S$ when:

$$\frac{1}{18}(1-\alpha)[c(1-\beta)+3]^2 - F > \frac{1}{18}(1-\alpha)[c(\beta-1)+3]^2$$

$$\Leftrightarrow \alpha < 1 - \frac{3F}{2c(1-\beta)}, with\ \frac{2}{3}c\beta - \frac{2}{3}c \neq 0\ and\ \frac{3F}{2c(1-\beta)} < 1$$

As exemplified before, the LCC is better off the higher the selective market is. Thus, represented above, is the number of captive consumers needed for the LCC's profits to be higher than the FCC's. Although, we had observed that $F \leq \hat{F}$, we now observe that for this setting, $F < \frac{2}{3}c(1-\alpha)(1-\beta)$, therefore, the LCC will only enter the market if $F < \frac{2}{3}c(1-\alpha)(1-\beta)$ since this last equation is more restrictive. Thus, being rational, the LCC would only enter the market if this equation is, in fact, true.

The effects here follow the same logic as before. The higher the fixed costs supported by the LCC, the less profit is available, therefore, a need for a larger selective market is implied, $\frac{\partial}{\partial F}\left(1 - \frac{3F}{2c(1-\beta)}\right) = \frac{3}{2c(\beta-1)} < 0$, allowing this firm to have a chance to obtain a larger profit. With a loss in cost efficiency by the LCC, a decrease in demand happens, decreasing the overall profits in the selective market for this company. Thus, a lower captive base on the overall market is needed as this would mean an increase in the selective market's size, $\frac{\partial}{\partial \beta}\left(1 - \frac{3F}{2c(1-\beta)}\right) = -\frac{3}{2}\frac{F}{c(\beta-1)^2} < 0$. High costs supported by the

FCC translates into a lower profit in both the selective market and the captive market. With this, the LCC faces a less efficient competitor and it is able to get a higher profit in the selective market because of the FCC's inefficiency, even if there is an increase on the number of captive consumer, $\frac{\partial}{\partial c}\left(1-\frac{3F}{2c(1-\beta)}\right)=-\frac{3}{2}\frac{F}{c^2(\beta-1)}>0$.

We prove the importance of the captive consumers for the FCC. As expected, when there is a higher captive consumer base, it would naturally translate into a higher captive's market profit, leaving a limited selective market in place, thus, diminishing the effects of a price war on this market. The requirement for a bigger selective market for the LCC is also underlined here. The possibilities are larger to obtain a higher profit when the selective market is indeed larger or, in turn, when the FCC is less efficient.

To study how the efficiency of costs relates to a higher profit for the firms is also required. To advance, we need to, again, reassemble the process that was made previously.

First, we start with the study of the FCC, and again with $\pi_A^T > \pi_B^S$:

$$\beta > \frac{2c+c\alpha-3F-3Va}{2c(1-\alpha)}, with\ \frac{2}{3}c-\frac{2}{3}c\alpha \neq 0, and\ 0 < \frac{2c+c\alpha-3F-3Va}{2c(1-\alpha)} < 1$$

When the LCC has a higher cost efficiency, the requirement for captive consumers is demonstrated by $\frac{\partial}{\partial \alpha}\left(\frac{2c+c\alpha-3F-3Va}{2c(1-\alpha)}\right)=-\frac{3(F+V-c)}{2c(\alpha-1)^2}<0$. A larger captive base compensates for a lower demand and higher prices when the FCC has deficient cost efficiency when compared to firm B, as there would be a limited selective market left when an increase of the FCC's captive consumers occurs – naturally the profits in captive market in this case are also larger.

The higher the overall costs supported by the FCC, the higher need for efficacy in costs by this firm is required. With a larger cost, firm A requires less efficiency by the LCC in order to obtain a better overall profit, $\frac{\partial}{\partial c}\left(\frac{2c+c\alpha-3F-3Va}{2c(1-\alpha)}\right)=-\frac{3(F+V\alpha)}{2c^2(\alpha-1)}>0$. This would represent a higher demand on the selective market for the FCC and, consequently, a better profit in this market, as it loses some of the profit on the captive market.

The damage to the LCC's profit caused by high fixed entry costs, was already documented, as such, larger values of fixed costs, would not require the FCC to be the most efficient, hence the negative effect, $\frac{\partial}{\partial F}\left(\frac{2c+c\alpha-3F-3Va}{2c(1-\alpha)}\right)=\frac{3}{2c(\alpha-1)}<0$.

For the reservation value, V, we obtain that with higher values of willingness-to-pay, the need for efficiency become less relevant for the FCC, as the effect obtained with a higher reservation value from the captive market exceeds the need for cost advantages in the selective market, $\frac{\partial}{\partial V}\left(\frac{2c+c\alpha-3F-3V\alpha}{2c(1-\alpha)}\right)=\frac{3}{2c}\frac{\alpha}{\alpha-1}<0$. Naturally, for the FCC, the selective market has less importance than the captive one.

As before, we now move to the discussion about the LCC. The same exercise is to be made, as for a higher profit, $\pi_B^S > \pi_A^S$:

$$\beta > 1-\frac{3F}{2c(1-\alpha)}, with\ \frac{2}{3}c\alpha-\frac{2}{3}c\neq 0, and\ \frac{3F}{2c(1-\alpha)}\leq 1$$

We show that a higher cost efficiency by the LCC would soothe the impact of the already documented effects of parameters like the fixed costs and the captive consumers, $\frac{\partial}{\partial F}\left(1-\frac{3F}{2c(1-\alpha)}\right)=\frac{3}{2c(\alpha-1)}<0, \frac{\partial}{\partial \alpha}\left(1-\frac{3F}{2c(1-\beta)}\right)=-\frac{3}{2}\frac{F}{c(\alpha-1)^2}<0$. In these cases, being efficient in terms of costs would allow the LCC to have a larger demand on the selective market practicing lower pricing that of its rival. Thus, even if the market is not large enough, it will always have larger profits than the FCC by being efficient.

The market with higher costs supported for the FCC, would naturally translate in a higher profit in the selective market for the LCC, as such, this company does not mind becoming less efficient, as long as, there is a chance of higher profitability present, $\frac{\partial}{\partial c}\left(1-\frac{3F}{2c(1-\alpha)}\right)=-\frac{3}{2}\frac{F}{c^2(\alpha-1)}>0$. This would stand for any value, as long as $\beta<1$.

We present once more, the overall importance of costs in this section, as cost inefficiency can be detrimental to both companies in pursuit of a better profit. This parameter, β, can be essential in concealing other parameters.

3.5. A note on consumer surplus

In this section, we look on consumer surplus effects. Thus, we will start by evaluating the consumer surplus on the captive market. We can show that in this market the FCC company is able to capture all the surplus from consumers:

$$CS^C = \alpha(V - V) = 0$$

From an earlier computation we have $V = p_A^c$, therefore, in this market we have all the surplus extracted a case of first-degree price discrimination.

Proceeding our evaluation, now we will look into the selective market:

$$CS^S = (1-\alpha)\left[V - \int_0^{x_A}(p_A^{s\,*} + tx)\partial x - \int_{x_A}^{1}(p_B^{s\,*} + t(1-x))\partial x\right]$$

With:

- x_A: Demand of firm A in the selective market
- $p_A^{s\,*}$: Price of firm A in the selective market
- $p_B^{s\,*}$: Price of firm B in the selective market

$$\begin{aligned} CS^S = (1-\alpha)(V - \frac{1}{36}(&24c + c^2\alpha^2 + c^2\beta^2 - 6c\alpha + 12c\beta + 9\alpha^2 + 6c\alpha^2 - 2\alpha c^2 \\ &- 2\beta c^2 + c^2 - 2\alpha c^2\beta^2 - 2\beta c^2\alpha^2 + 6\alpha c\beta + \alpha^2 c^2\beta^2 - 6c\beta\alpha^2 \\ &+ 4\alpha\beta c^2 + 45) \end{aligned}$$

Then, the overall consumer surplus of the selective market is given by:

$$\begin{aligned} CS^T = (1-\alpha)(V - \frac{1}{36}(&24c + c^2\alpha^2 + c^2\beta^2 - 6c\alpha + 12c\beta + 9\alpha^2 + 6c\alpha^2 - 2\alpha c^2 \\ &- 2\beta c^2 + c^2 - 2\alpha c^2\beta^2 - 2\beta c^2\alpha^2 + 6\alpha c\beta + \alpha^2 c^2\beta^2 - 6c\beta\alpha^2 \\ &+ 4\alpha\beta c^2 + 45) \end{aligned}$$

Observing the effects of the parameters on the consumer surplus we have that this is negatively influenced by α and β, as long as, we observe the restriction imposed on the model, that $c \leq 3$.[32]

[32] We will present the results of these effects in the appendix.

From these effects, we have that in the duopoly market the consumer surplus is affected by the size of the selective market. Obviously, the larger the selective market, the larger this surplus would be. This due to the fact, that the captive market section has its surplus all extracted.

Consequently, if firm B has a high cost efficiency, the consumer would be better as firm B would have a larger demand on the selective market – the LCC offers lower overall prices. On the contrary, if the firms split the selective market, prices would raise, and that would translate into less consumer surplus.

It is naturally that if the fixed costs are too high, the entry of firm B will not happen, therefore, we have no selective market. As elaborated, this would translate into no consumer surplus, as the captive market has all its surplus extracted. This would be the case where $\alpha = 1$.

4. Conclusion

This dissertation has looked at competition between a Full-Cost Carrier and a Low-Cost Carrier. The main goal was to understand how the FCC's captive segment and differences in both companies' costs affect price competition and profits. With these goals in mind, a theoretical model was created and analysed using game theoretical tools. More specifically we considered a market with an Incumbent firm, the Full-Cost Carrier. This firm has the required information to set different prices to captive and price sensitive travellers. The Low-Cost Carrier has the possibility of entering into the market. As for the demand, we assumed that there is a large number of consumers and each of them only wishes to buy one ticket.

With this model we studied two pricing frameworks. In the first, the Full-Cost Carrier is alone in the market and so acts as a monopolist. The second pricing framework takes us to an entrance possibility by the LCC. This entrance has an inherent fixed cost of F. In this case, we assumed that the FCC due to previous interactions with passengers, before the entrance, has a group of captive passengers, and competes with the LCC for the remaining passengers, the selective passengers. The marginal costs were c_A and c_B for FCC and LCC respectively, with $c_A \geq c_B$. Specifically, we assume, $c_A = c$, while $c_B = c\beta$ with $\beta \in [0,1]$. Additionally, we assumed that the FCC could set different prices to captive and selective passengers, while the LCC sets a single price.

After solving the model, we conclude that the Full-Cost Carrier will face greater losses if its initial competitive advantage (proportion of captive consumers) is less significant and faces the entry of a very efficient LCC, thus making the proportion of captive consumers a critical success factor for the incumbent. Therefore, we highlight that devoting resources to increase passenger loyalty is an important way of avoiding the negative effects of competition with a more efficient Low-Cost airline. Regarding the Low-Cost airline, we show that its entry becomes more likely the greater its cost efficiency compared to the incumbent airline (i.e., the less efficient the incumbent is). Thus, LCCs interested in entering into a market should guarantee cost levels low enough to address the disadvantages of competing with a FCC with captive consumers. Naturally, the consumers are better off with the entrance of LCCs in the

market. This would increase competition, lowering the overall prices, thus, increasing their surplus.

A natural extension of this model would be to analyse the implications of forcing the FCC to offer a uniform price to captive and selective passengers. Under this restriction, we could answer the following question. What are the main price, profits and welfare effects if the FCC's decides to serve only the captive segment? This would mean that a high enough loyal consumer base could stop the FCC from entering into price wars in the segment of price sensitive consumers. Under this hypothesis, we could determine under which conditions for the size loyal travellers' segment, would the FCC be willing to implement this strategy? This interesting question is, however, left for future research.

5. References

Akamavi, K. R., Mohamed, E., Pellmann, K., & Xu, Y. (2015). Key determinants of passenger loyalty in the low-cost airline business. *Tourism Management, 46*, 528-545.

Armstrong, M., & Vickers, J. (1993). Price Discrimination, Competition and Regulation. *The Journal of Industrial Economics, 41*(4), 335-359.

Bain, J. (1956). *Barriers to New Competition.* Cambridge, MA: Harvard University Press.

Belobaba, P. P., Brunger, W. G., & Wittman, M. D. (2017). *Advances in Airline Pricing, Revenue Management and Distribution: Implications for the Airline Industry.* PODS Research LLC.

Borenstein, S. (1989). Hubs and High Fares: Dominance and Market Power in the U.S. Airline Industry. *RAND Journal of Economics, 20*(3), 344-365.

Borenstein, S., & Rose, N. L. (1994). Competition and Price Dispersion in the U.S. Airline Industry. *Journal of Political Economic, 102*, 653-683.

Borenstein, S., & Rose, N. L. (2014). How Airline Markets Work…or Do They? Regulatory Reform in the Airline Industry. *National Bureau of Economic Research*, 63-135.

Caminal, R., & Claici, A. (2007). Are loyalty-rewarding pricing schemes anti-competitive? *International Journal of Industrial Organization, 25*, 657-674.

Chang, L.-Y., & Hung, S.-C. (2013). Adoption and loyalty toward low cost carriers: The case of Taipei–Singapore passengers. *Transportation Research Part E: Logistics and Transportation Review*, 29-36.

Chen, Y. (1997). Paying Customers to Switch. *Journal of Economics & Management Strategy, 6*(4), 877-897.

Chen, Y. (2005). *The Pros and Cons of Price Discrimination.* Konkurrensverket: Swedish Competition Authority .

Chen, Y., & Pearcy, J. (2010). Dynamic pricing: when to entice brand switching and when to reward consumer loyalty. *RAND Journal of Economics, 41*(4), 674-685.

Chen, Y., & Zhang, J. (2009). Dynamic targeted pricing with strategic consumers. *International Journal of Industrial Organization, 27*(1), 43-50.

Darke, P., & Dahl, D. (2003). Fairness and discounts: The subjective value of a bargain. *Journal of Consumer Psychology, 13*, 328-338.

Dolnicar, S., Grabler, K., Grün, B., & Kulnig, A. (2011). Key drivers of airline loyalty. *Tourism Management, 32*, 1020-1026.

Dowling, G., & Uncles, M. (1997). Do Customer Loyalty Programs Really Work? *Sloan Management Review, 38*(4), 71-82.

Escobari, D., Rupp, N., & Meskey, J. (2016). *Dynamic Price Discrimination in Airlines.*

Esteves, R.-B. (2009). A Survey on the Economics of Behaviour-Based. *NIPE - Working Papers. Universidade do Minho*.

Esteves, R.-B., & Reggiani, C. (2014). Elasticity of demand and behaviour-based price discrimination. *International Journal of Industrial Organization, 32*, 46-56.

Fudenberg, D., & Tirole, J. (2000). Customer poaching and brand switching. *RAND Journal of Economics, 31*(4), 634-657.

Fudenberg, D., & Villas-Boas, M. J. (2007). Behavior-Based Price Discrimination and Customer Recognition. *Economics and Information Systems, 1*.

Gaggero, A., & Piga, C. (2011). Airline Market Power and Intertemporal Price Dispersion. *The Journal of Industrial Economics, 59*(4), 552–577.

Garbarino, E., & Lee, O. F. (2003). Dynamic pricing in internet retail: Effects on consumer trust. *Psychology and Marketing, 20*(6), 495-513.

Gerardi, K. S., & Shapiro, A. H. (2009). Does Competition Reduce Price Dispersion? New Evidence from the Airline Industry. *Journal of Political Economy, 117*(1), 1-37.

Giardino-Karlinger, L., & Motta, M. (2007). Exclusionary Pricing and Rebates When Scale Matters. *Discussion Paper No. 6258*.

Gilbert, R. (1989). Mobility Barriers and the Value of Incumbency. *Handbook of Industrial Organization. ed. R. Shmalensee and R.D. Willig*, 475-535.

Gómez, B. G., Arranz, A., & Gutiérrez, C. (2006). The role of loyalty programs in behavioral and affective loyalty. *Journal of Consumer Marketing, 23*(7), 387 – 396.

Hess, S., Adler, T., & Polak, J. W. (2007). Modelling airport and airline choice behaviour with the use of stated preference survey data. *Transportation Research Part E., 43*, 221-233.

Lederman, M. (2007). Do Enhancements to Loyalty Programs Affect Demand? The Impact of International Frequent Flyer Partnerships on Domestic Airline Demand. *The RAND Journal of Economics, 38*(4), 1134-1158.

McAfee, R. P., Mialon, H. M., & Williams, M. A. (2003). *Economic and AntiTrust Barriers to Entry.* Department of Economics: University of Texas at Austin.

Morrison, S. A. (2001). Actual, Adjacent, and Potential Competition: Estimating the Full EOEect of Southwest Airlines. *Journal of Transport Economics and Policy, 35*(2), 239-256.

Morrison, S., & Winston, C. (1990). The Dynamics of Airline Pricing and Competition. *American Economic Review, 80*(2), 389-393.

Nero, G. (1999). A note on the competitive advantage of large hub-and-spoke networks. *Transportation Research Part E: Logistics and Transportation Review, 35*(4), 225-239.

Pigou, A. (1920). *The Economics of Welfare.* London: MacMillan and Co., Limited.

Reinartz, W. (2002). Customizing Prices in Online Markets. *SYMPHONYA, Emerging Issues in Management*, 55-65.

Reynolds-Feighan, J. A. (2001). Traffic distribution in low-cost and full-service carrier networks in the US air transportation market. *Journal of Air Transport Management, 7*, 265-275.

Shapiro, C., & Varian, H. (1999). *Information Rules: A strategic Guide to the Networl Economy.* Boston, Massachusetts: Harvard Business School Press.

Shepherd, W. G. (1988). Entry barriers, contestability, and predatory pricing. *Revue d'économie industrielle*, 1-20.

Shiller, B. (2014). *First-Degree Price Discrimination Using Big Data.* Brandeis University: Department of Economics and International Businesss School.

Snider, C., & Williams, J. (2011). Barriers to Entry in the Airline Industry: A Regression Discontinuity Approach.

Stavins, J. (2001). Price Discrimination in the Airline Market: The Effect of Market Concentration. *The Review of Economics and Statistics, 83*(1), 200-202.

Stigler, G. (1968). *The Organization of Industry.* Chicago, IL: University of Chicago Press.

Suzuki, Y. (2007). Modeling and testing the ‘‘two-step’’ decision process of travelers in airport and airline choices. *Transportation Research Part E, 43*, 1-20.

Thisse, J.-F., & Vives, X. (1988). On The Strategic Choice of Spatial Price Policy. *The American Economic Review, 78*(1), 122-137.

Ulph, D., & Vulkan, N. (2001). *E-Commerce, Mass Customisation and Price Discrimination.*

Vlachos, I., & Lin, Z. (2014). Drivers of airline loyalty: Evidence from the business travelers in China. *Transportation Research Part E*, 1-17.

Westermann, D. (2013). The potential impact of IATA’s New Distribution Capability (NDC) on revenue management and pricing. *Journal of Revenue and Pricing Management, 12*(6), 565-568.

Yeoman, I. (2016). Personalised price. *Journal of Revenue and Pricing Management*, 1.

6. Appendix

6.1. Preposition 1: Selective Market

The Hotelling model is described by:

$$V - p_A - tx = V - p_B - (1 - x)t, \qquad with\ t = 1$$

$$\Leftrightarrow\ x = \frac{1}{2} + \frac{p_B - p_A}{2}$$

As such the Selective Market would be modelled as:

$$D_A = (1 - \alpha)x$$

$$\Leftrightarrow D_A = (1 - \alpha)(\frac{1}{2} + \frac{p_B - p_A}{2})$$

$$D_B = (1 - \alpha)(1 - x)$$

$$\Leftrightarrow D_B = (1 - \alpha)(\frac{1}{2} + \frac{p_A - p_B}{2})$$

This because, the selective market only competes for the selective passengers.

Making it linear for price calculation,

$$\pi_A^S = (p_A - c)(\alpha + (1 - \alpha)(\frac{1}{2} + \frac{p_B - p_A}{2}))$$

$$\frac{\partial}{\partial p_A}((p_A - c)\left((1 - \alpha)\left(\frac{1}{2} + \frac{p_B - p_A}{2}\right)\right) = 0$$

$$\Leftrightarrow p_A = \frac{p_B + c + 1}{2}$$

$$\pi_B^S = (p_B - c\beta)(1 - \alpha)(\frac{1}{2} + \frac{p_A - p_B}{2}) - F$$

$$\frac{\partial}{\partial p_B}((p_B - c\beta)(1 - \alpha)(\frac{1}{2} + \frac{p_A - p_B}{2}) - F) = 0$$

$$\Leftrightarrow \frac{1}{2}(1 - \alpha)(p_A - 2p_B + c\beta + 1) = 0$$

$$\Leftrightarrow p_B = \frac{p_A + c\beta + 1}{2}$$

To obtain the equilibrium prices we know need to substitute in a systematic way.

$$\begin{cases} p_A = \dfrac{p_B + c + 1}{2} \\ p_B = \frac{p_A + c\beta + 1}{2} \end{cases}$$

$$\begin{cases} p_A = \dfrac{\dfrac{p_A + c\beta + 1}{2} + c + 1}{2} \\ p_B = \dfrac{p_A + c\beta + 1}{2} \end{cases}$$

$$\begin{cases} p_A = 1 + \dfrac{2c + c\beta}{3} \\ p_B = \frac{1 + \frac{2c + c\beta}{3} + c\beta + 1}{2} \end{cases}$$

$$\begin{cases} p_A^* = 1 + \dfrac{2c + c\beta}{3} \\ p_B^* = 1 + \dfrac{c + 2c\beta}{3} \end{cases}$$

Therefore, we have the equilibrium prices given by:

$$p_A^{S^*} = 1 + \frac{2c + c\beta}{3}$$

$$p_B^{S^*} = 1 + \frac{c + 2c\beta}{3}$$

Which substituting in the profits from earlier will present to us, the equilibrium profits:

$$\pi_A^{S^*} = (1 - \alpha)\left(\frac{c\beta - c}{3} + 1\right)\left(\frac{c\beta - c}{6} + \frac{1}{2}\right) = \frac{1}{18}(1 - \alpha)[c(\beta - 1) + 3]^2$$

$$\pi_B^{S^*} = (1 - \alpha)\left(\frac{c - c\beta}{3} + 1\right)\left(\frac{c - c\beta}{6} + \frac{1}{2}\right) - F = \frac{1}{18}(1 - \alpha)[c(1 - \beta) + 3]^2 - F.$$

Substituting $p_A^{S^*}$ and $p_B^{S^*}$ on the demands we have:

$$D_A^{S^*} = (1-\alpha)\left(\frac{1}{2} + \frac{c(\beta-1)}{6}\right)$$

$$D_B^{S^*} = (1-\alpha)\left(\frac{1}{2} + \frac{c(1-\beta)}{6}\right)$$

And we can now impose that:

$$0 < (1-\alpha)D_B^{S^*} \leq 1-\alpha \text{ and } 0 \leq (1-\alpha)D_A^{S^*} \leq 1-\alpha$$

Studying this, we have:

$$0 < (1-\alpha)\left(\frac{1}{2} + \frac{c(1-\beta)}{6}\right) \leq 1-\alpha$$

$(1-\alpha)\left(\frac{1}{2} + \frac{c(1-\beta)}{6}\right) > 0$; and $(1-\alpha)\left(\frac{1}{2} + \frac{c(1-\beta)}{6}\right) \leq 1-\alpha$

$\Leftrightarrow c(1-\beta) > -3$, this one is always true for any value of $\beta \in [0,1]$

$\Leftrightarrow c \leq \frac{3}{(1-\beta)}$, is the solution

As for:

$$0 \leq (1-\alpha)\left(\frac{1}{2} + \frac{c(\beta-1)}{6}\right) \leq 1-\alpha$$

$c(\beta-1) \geq -3$ and $c(\beta-1) \leq 3$

if $\beta = 0$, we have $c \leq 3$

if $\beta = 1$, we have $0 \geq -3$, which is always true.

Therefore, $c \leq 3$ is the solution

With the equilibrium prices, we can now check the relations between V and the prices:

$$V - t - p_A^{S^*} > 0 \text{ and } V - t - p_B^{S^*} > 0$$

$$V - 2 - \frac{2c+c\beta}{3} > 0 \Leftrightarrow V > 2 + \frac{2c+c\beta}{3} \text{ and } V - 1 - 1 - \frac{c+2c\beta}{3} > 0 \Leftrightarrow V > 2 + \frac{c+2c\beta}{3}$$

Therefore:

$$V > 2 + \frac{2c+c\beta}{3}$$

6.2. The Variables Effects

6.2.1. Captive Market

We star our analysis with the effects that α has on the FCC's profits starting with the captive market.

$$\pi_A^{Cap} = (V - c)\alpha$$

$$\frac{\partial}{\partial \alpha}\big((V - c)\alpha\big) = V - c$$

As expected this effect is positive if $V > c$, that is, if the reservation value that the captive consumers are willing to pay is higher than the costs supported by the FCC.

6.2.2. Profit evaluation

This appendix proves the results obtain on the section where we study the profits.

$$\pi_A^T = \pi_A^{Cap} + \pi_A^S$$

$$\pi_A^T = (V - c)\alpha + \frac{1}{18}(1 - \alpha)[c(\beta - 1) + 3]^2$$

$$\pi_B^S = \frac{1}{18}(1 - \alpha)[c(1 - \beta) + 3]^2 - F.$$

We start by studying the variables in which the FCC would have a higher profit.

$$\pi_A^T > \pi_B^S$$

$$\Leftrightarrow (V - c)\alpha + \tfrac{1}{18}(1 - \alpha)[c(\beta - 1) + 3]^2 > \tfrac{1}{18}(1 - \alpha)[c(1 - \beta) + 3]^2 - F$$

$$\Leftrightarrow \frac{1}{3}\alpha(3V - c - 2c\beta) > \frac{2}{3}c(1 - \beta) - F$$

$$\Leftrightarrow \alpha > \frac{3F - 2c(1 - \beta)}{c + 2c\beta - 3V}, with\ V - \frac{1}{3}c - \frac{2}{3}c\beta \neq 0\ and\ 0 \leq \frac{3F - 2c(1 - \beta)}{c + 2c\beta - 3V} < 1$$

To prove the effects, we have the following:

$\frac{\partial}{\partial F}\left(\frac{3F-2c(1-\beta)}{c+2c\beta-3V}\right)=\frac{3}{c+2c\beta-3V}$, this effect is negative because, as we seen before, $V>c$;

$\frac{\partial}{\partial c}\left(\frac{3F-2c(1-\beta)}{c+2c\beta-3V}\right)=-\frac{3(F-2V+2F\beta+2V\beta)}{(c+2c\beta-3V)^2}$, We consider that this effect is positive as long as $V>F$;

$\frac{\partial}{\partial \beta}\left(\frac{3F-2c(1-\beta)}{c+2c\beta-3V}\right)=-6\frac{c(F+V-c)}{(c+2c\beta-3V)^2}$, this effect is negative because $V>c$;

$\frac{\partial}{\partial V}\left(\frac{3F-2c(1-\beta)}{c+2c\beta-3V}\right)=\frac{3F-2c+2c\beta}{(c+2c\beta-3V)^2}$, negative because again $V>c$.

Now we go to the study of β:

$$(V-c)\alpha+(1-\alpha)\frac{1}{18}(1-\alpha)[c(\beta-1)+3]^2>\frac{1}{18}(1-\alpha)[c(1-\beta)+3]^2-F$$

$$\Leftrightarrow -\frac{2}{3}c\beta(\alpha-1)>\frac{2}{3}c-F-V\alpha+\frac{1}{3}c\alpha$$

$$\Leftrightarrow \beta>\frac{2c+c\alpha-3F-3Va}{2c(1-\alpha)}, with\ \frac{2}{3}c-\frac{2}{3}c\alpha\neq 0, and\ 0<\frac{2c+c\alpha-3F-3Va}{2c(1-\alpha)}<1$$

To prove the effects, we have the following:

$\frac{\partial}{\partial \alpha}\left(\frac{2c+c\alpha-3F-3Va}{2c(1-\alpha)}\right)=-\frac{3(F+V-c)}{2c(\alpha-1)^2}$, the effect is negative, because, $V>c$;

$\frac{\partial}{\partial c}\left(\frac{2c+c\alpha-3F-3Va}{2c(1-\alpha)}\right)=-\frac{3(F+V\alpha)}{2c^2(\alpha-1)}$, we consider this effect positive as $\alpha-1<0$;

$\frac{\partial}{\partial V}\left(\frac{2c+c\alpha-3F-3Va}{2c(1-\alpha)}\right)=\frac{3}{2c}\frac{\alpha}{\alpha-1}$, there is a negative effect as $\alpha-1<0$;

$\frac{\partial}{\partial F}\left(\frac{2c+c\alpha-3F-3Va}{2c(1-\alpha)}\right)=\frac{3}{2c(\alpha-1)}$, this effect is negative because $\alpha-1<0$.

Now the same study will be made for the LCC's profitability equation,

$$\pi_B^S>\pi_A^S$$

$$\Leftrightarrow \frac{1}{18}(1-\alpha)[c(1-\beta)+3]^2-F\ >(1-\alpha)\frac{1}{18}(1-\alpha)[c(\beta-1)+3]^2$$

We will proceed as before.

$$\Leftrightarrow -\frac{2}{3}c\alpha(1-\beta)>F-\frac{2}{3}c+\frac{2}{3}c\beta$$

$$\Leftrightarrow \alpha<\frac{2c-2c\beta-3F}{2c(1-\beta)}$$

$$\Leftrightarrow \alpha < 1 - \frac{3F}{2c(1-\beta)}, with\ \frac{2}{3}c\beta - \frac{2}{3}c \neq 0\ and\ \frac{3F}{2c(1-\beta)} < 1$$

$\frac{\partial}{\partial F}\left(1 - \frac{3F}{2c(1-\beta)}\right) = \frac{3}{2c(\beta-1)}$, negative effect because of $\beta - 1 < 0$;

$\frac{\partial}{\partial c}\left(1 - \frac{3F}{2c(1-\beta)}\right) = -\frac{3}{2}\frac{F}{c^2(\beta-1)}$, same logic as before, $\beta - 1 < 0$, makes this effect positive;

$\frac{\partial}{\partial \beta}\left(1 - \frac{3F}{2c(1-\beta)}\right) = -\frac{3}{2}\frac{F}{c(\beta-1)^2}$, this effect is negative as $(\beta - 1)^2$is always positive.

Transitioning to β we have:

$$\frac{2}{3}c\beta(\alpha - 1) > F - \frac{2}{3}c + \frac{2}{3}c\alpha$$

$$\beta > 1 - \frac{3F}{2c(1-\alpha)}, with\ \frac{2}{3}c\alpha - \frac{2}{3}c \neq 0, and\ \frac{3F}{2c(1-\alpha)} < 1$$

$\frac{\partial}{\partial F}\left(1 - \frac{3F}{2c(1-\alpha)}\right) = \frac{3}{2c(\alpha-1)}$, a negative effect happens because $\alpha - 1 < 0$;

$\frac{\partial}{\partial c}\left(1 - \frac{3F}{2c(1-\alpha)}\right) = -\frac{3}{2}\frac{F}{c^2(\alpha-1)}$, The effect is positive because $\alpha - 1 < 0$;

$\frac{\partial}{\partial \alpha}\left(1 - \frac{3F}{2c(1-\beta)}\right) = -\frac{3}{2}\frac{F}{c(\alpha-1)^2}$, as $(\beta - 1)^2 > 0$, the effect is always negative.

We already study these effects extensively in our dissertation, therefore, here we only deemed correct to present the calculations.

6.3. The Consumer Surplus

Under the Duopoly Market

Captive Market

$$V = p_A^C$$

$$CS^C = \alpha(V - V) = 0$$

Selective Market

$$p_A^* = 1 + \frac{2c + c\beta}{3}$$

$$p_B^* = 1 + \frac{c + 2c\beta}{3}$$

$$t = 1$$

$$x_A = (1 - \alpha)\left(\frac{1}{2} + \frac{p_B - p_A}{2}\right) = (1 - \alpha)(\frac{c - c\beta}{6} + \frac{1}{2})$$

$$CS^S = (1 - \alpha)\left[V - \int_0^{x_A} (p_A^{s^*} + tx)\partial x - \int_{x_A}^1 (p_B^{s^*} + t(1 - x))\partial x\right]$$

$$\int_0^{x_A} (p_A^{s^*} - tx)\partial x = \int_0^{x_A} \left(1 + \frac{2c + c\beta}{3} - x\right)\partial x = \left[x + x\left[\frac{2c + c\beta}{3}\right] - \frac{x^2}{2}\right]_0^{x_A}$$

$$= \frac{1}{72}(1 - \alpha)(c - c\beta + 3)(9c - 3\alpha - c\alpha + 3c\beta + c\alpha\beta + 15) - 0$$

$$= \frac{1}{72}(1 - \alpha)(c - c\beta + 3)(9c - 3\alpha - c\alpha + 3c\beta + c\alpha\beta + 15)$$

$$\int_{x_A}^1 \left(p_B^{s^*} + t(1 - x)\right)\partial x$$

$$= \int_{x_A}^1 \left(1 + \frac{c + 2c\beta}{3} + 1 - x\right)\partial x = \left[2x + x\left[\frac{c + 2c\beta}{3}\right] - \frac{x^2}{2}\right]_{x_A}^1$$

$$= \left[\frac{2c - c\beta}{3} + \frac{3}{2}\right] - \left[\frac{1}{72}(1 - \alpha)(c - c\beta + 3)(7c + 3\alpha + c\alpha + 5c\beta - c\alpha\beta + 21\right]$$

$$= \frac{1}{72}(c - 3\alpha - c\alpha + c\beta + c\alpha\beta - 3)(-7c - 3\alpha - c\alpha - 5c\beta + c\alpha\beta - 15)$$

$$CS^S = (1-\alpha)\left[V - \int_0^{x_A}(p_A^{s*} + tx)\partial x - \int_{x_A}^{1}(p_B^{s*} + t(1-x))\partial x\right]$$

$$= (1-\alpha)\left[V - \frac{1}{72}(1-\alpha)(c - c\beta + 3)(9c - 3\alpha - c\alpha + 3c\beta + c\alpha\beta + 15) - \frac{1}{72}(c - 3\alpha - c\alpha + c\beta + c\alpha\beta - 3)(-7c - 3\alpha - c\alpha - 5c\beta + c\alpha\beta - 15)\right]$$

$$\Leftrightarrow CS^S = (1-\alpha)(V - \frac{1}{36}(24c + c^2\alpha^2 + c^2\beta^2 - 6c\alpha + 12c\beta + 9\alpha^2 + 6c\alpha^2 - 2\alpha c^2 - 2\beta c^2 + c^2 - 2\alpha c^2\beta^2 - 2\beta c^2\alpha^2 + 6\alpha c\beta + \alpha^2 c^2\beta^2 - 6c\beta\alpha^2 + 4\alpha\beta c^2 + 45)$$

Total selective market surplus would be:

$$CS^T = (1-\alpha)(V - \frac{1}{36}(24c + c^2\alpha^2 + c^2\beta^2 - 6c\alpha + 12c\beta + 9\alpha^2 + 6c\alpha^2 - 2\alpha c^2 - 2\beta c^2 + c^2 - 2\alpha c^2\beta^2 - 2\beta c^2\alpha^2 + 6\alpha c\beta + \alpha^2 c^2\beta^2 - 6c\beta\alpha^2 + 4\alpha\beta c^2 + 45)$$

Effect of the parameters on the consumer surplus:

$$\frac{\partial CS^T}{\partial \beta} = \frac{1}{18}c(\alpha - 1)(3\alpha - c + 2c\alpha + c\beta - 3\alpha^2 - c\alpha^2 - 2c\alpha\beta + c\beta\alpha^2 + 6$$

This effect is negative, if $c \leq 3$.

$$\frac{\partial CS^T}{\partial \alpha} = -\frac{1}{12}(12V - 10c - 6\alpha - c^2\alpha^2 - c^2\beta^2 + 8c\alpha - 2c\beta - 9\alpha^2 - 6c\alpha^2 + 2\alpha c^2 + 2\beta c^2 - c^2 + 2\alpha c^2\beta^2 + 2\beta c^2\alpha^2 - 8\alpha c\beta - c^2\alpha^2\beta^2 + 6c\beta\alpha^2 - 4\alpha\beta c^2 - 15)$$

Again, this effect is negative, if $c \leq 3$.