European Airport Charging: A Case Study on the selection of Dual Till versus Single Till charges

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Acknowledgment

Once upon a time, in a land not so far away (Lisbon, Portugal) I decided to become an aerospace engineer. With dreams of building flying cars that could relieve my parents of the morning traffic, that choice grew with me. Upon entering I.S.T. those dreams mostly disappeared, but one needs to adapt to reality and so I did. Fast forward three years and I was on the verge of quitting, thoroughly unfocused and spending more time doing something else (very specifically) than studying. Through the never ending support of my parents António and Helena, as well as my sisters Maria and Ana, adding to the will to not let them and my grandmother Maria down, I managed to choose the Master’s and completely quit my previous “hobby”. This was probably the hardest decision of my life so far, but one I don’t regret even though I still hear sometimes I took the wrong road.

The Master’s two years of classes flew by, and quite successfully since I was considerably more focused on the studies. This time with the Gaviónicos: Anabela, Arnaldo, Dário, Francisco, Gonçalo, Guilherme, Nuno, Pedro F., Pedro C. was truly unforgettable. Eventually, after a semester of 48 ECTS, only the thesis (and one subject) was left.

My search for a subject started, and eventually ended when I met Professor Rosário Macário. I can’t thank her enough for the opportunity, trust and help. After arriving at the University of Antwerp I then met Professors Eddy Van de Voorde and Thierry Vanelslander, who I have to thank not only for the incredibly hospitality but for all the counsel and availability provided. Also worth mentioning are the PhD fellows who gave many insights into my work and made lunch time that much more enjoyable.

Unfortunately after returning to Portugal the dissertation still needed a lot of work, and was even further delayed after an internship at a large FMCG company, despite the support of co-workers and especially my bosses Ricardo, Manuela, Pedro D., Pedro S. and Rita. After the internship I set myself to not take any further job until this dissertation was complete, and here it is!

A note of thank you as well to all those not mentioned above but who also supported me throughout, especially: Inês, Rui, Ismael, Andreia, Gonçalo, Francisco, Ana, Maria, Noel, António, Duarte, Tiago, Marcos, Miguel C., Luís, Éder and Saul.
Abstract

Airports, historically monopolies, are in most cases regulated to prevent market power abuse. While there are various ways of regulating airport charges, when determining maximum charge levels two large groups exist: Single and Dual till. Under a Single till the regulator considers all the airport’s revenues when calculating the maximum aeronautical charges, under a Dual till only the aeronautical revenues are considered. While a Single till is more common, especially in the European airports, privatization, increasing competition and other factors are leading airports to consider a dual till. Since in theory a dual till leads to higher charges, airlines in particular do not have compelling reasons to push for a dual till regulation.

In this dissertation a sample of European airports is analyzed on their charge level and the results show single till airports as having higher charges on average. Though variance is quite high, the simple fact that dual till airports present lower charges is groundbreaking. A series of other parameters are also measured against the charge level to further understand the reasons for the price difference. The amount of sub-contracting, for example, seems to be one of these causes, since it is significantly higher in the Single till sample.

Brussels airport is presented as a case-study in this dissertation, since it is transitioning from a single to a dual till. The transitioning period of 20 years is due to end in 2026, and most of the metrics analyzed are healthy and pointing in the right direction.

Keywords: Single Till, Dual Till, Airport Regulation, European Airports
Resumo

Aeroportos, historicamente monopólios, são regulados na maioria dos casos para prevenir abusos de mercado. Há várias maneiras de regular os aeroportos, mas para determinar o valor máximo das taxas aeroportuárias existem dois grandes grupos: Single e Dual till. Regulando com uma Single till, o regulador tem que considerar todas as receitas do aeroporto para calcular as taxas aeroportuárias, enquanto com uma dual till só as receitas da parte aeronautica são consideradas. Embora a Single till seja mais comum, especialmente na europa, tanto a privatização como o aumento da concorrência entre aeroportos, bem como outros factores, estão a levar os aeroportos a considerar cada vez mais a dual till. Como em teoria a Dual till implica taxas mais elevadas, principalmente as companhias aéreas não têm razões para pressionar aeroportos e reguladores a deixar a Single till.

Nesta dissertação um conjunto de aeroportos Europeus é analizado no seu nível de taxa, e em média os aeroportos com Single till são mais caros. Mesmo sendo a variância elevada, o facto que no grupo analisado os aeroportos Single till têm taxas mais elevadas é extremamente importante. Outros parâmetros foram também comparados com o nível das taxas aeroportuárias, por forma a tentar perceber melhor este resultado. A quantidade de sub-contratação, sendo muito mais elevada no grupo de aeroportos Single till, parece ser uma destas causas.

O aeroporto de Bruxelas é usado como caso de estudo, visto estar a mudar de Single para Dual till, e até agora tudo indica que está no caminho certo.

Palavras-chave: Single Till, Dual Till, Regulação de Aeroportos, Aeroportos Europeus
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List of Acronyms

ACCC – Australian Competition and Consumer Commission
ACI – Airports Council International
ADP – Aéroports de Paris
ATRS – Air Transport Research Society
CAA – Civil Aviation Authority
CIA – Central Intelligence Agency
CPI – Consumer Price Index
CUTE – Common Use Terminal Equipment
DRM – Dispute Resolution Mechanism
EC – European Council
FAA – Federal Aviation Authority
FSA – Full Service Airline
GDP – Gross Domestic Product
IATA – International Air Transport Association
ICAO – International Civil Aviation Organization
LCC – Low Cost Carrier
LTO – Landing Take Off
MAp – Macquarie Airports
MTOW – Maximum Take-Off Weight
PPP – Purchasing Power Parity
PRM – Passengers with Reduced Mobility
ROR – Rate of Return
RPI – Retail price index
WATS - World Air Transport Statistics
1. Introduction

Airports are the central point of the air traffic industry. They are used by passengers, airlines, cargo companies, and all sorts of supporting services (i.e. handling). Being such a key infrastructure in the air traffic sector, airports are very complex, and can serve other industries such as tourism, shipping, etc. All this complexity and multitude of services has a cost, and like other infrastructures in the transport industry (i.e. ports), airports require that a fee be paid by the user of the services. The scale of air traffic on modern society, especially passenger traffic, has deemed airlines (and consequently their passengers) the main users of airports. This reality has also made possible the appearance of other businesses, such as parking, shops, hotels, conference centers. These parallel businesses have grown to be an integral part of airport revenue. Even so, airlines remain the core entities who bring people to airports (being their nature), and as such they pay a fee for every airplane they land on the airport. This charge may not be (and often is not) set by the airport, since other entities such as a regulator may have power and choice in the matter. The purpose and need for a regulator is explained in greater detail in chapter 2.

The charge levied by the airport on the airline is generally broken down into smaller fees. These fees vary from airport to airport, although a landing and/or take off fee, as well as a passenger fee are present every time. For example, for Amsterdam Schipol airport the following sub-charges are paid by airlines:

- Landing fee
- Passenger fee
- Security fee
- Infrastructure fee
- Terminal navigation fee
- Noise fee
- Parking fee
- Airbridge

The sections in the graph only show the components that vary with the number of persons in airplane. The full breakdown:

<table>
<thead>
<tr>
<th></th>
<th>Landing</th>
<th>Passenger</th>
<th>Security</th>
<th>Infrastructure</th>
<th>T. Navigation</th>
<th>Noise</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value (EUR)</td>
<td>662€</td>
<td>1481€</td>
<td>1328€</td>
<td>40€</td>
<td>202€</td>
<td>173€</td>
<td>3886€</td>
</tr>
<tr>
<td>%</td>
<td>17%</td>
<td>38%</td>
<td>34%</td>
<td>1%</td>
<td>5%</td>
<td>5%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 1 - Breakdown of charges for AMS airport, Boeing 737-800 with 70% load factor.
When airplanes were first developed, grass and dirt fields were used for take offs and landing. The concept of airports started around 1910, and has evolved much since then. Especially in Europe, World War II served as a catalyzer for airport development, much like it was for airplanes. After the war, and with the increase in jet traffic in the 1960s, most countries converted military bases for public use, or built airports from scratch. Being expensive and new infrastructures, it only made sense for nations to have major airports on larger cities. For these historic reasons, airports were basically monopolies. As such, with no competition, prices for runway and terminal use could be set to whatever amount the airport deemed best. This lack of control can lead to an abuse of market power, leaving the user with no other choice than to pay the asked price or be left without the service. A third party entity that ensures no abuse of market power exists, called a regulator, can and should intervene in cases of suspicion of monopolistic practices that may jeopardize the final individual final consumer or society at large.

Figure 2 – Air traffic worldwide since 2000. Source: IATA.

Nowadays, with the ever increasing growth in passenger (as can be seen in Figure 2) and express cargo movements, the air traffic sector is an attractive and fast moving one. The airplane sector is also far from stagnant, and is moving away from the historic military-driven growth. With fuel costs rising, the pressure on airplane manufacturers for lower fuel consumption airplanes, as well as stricter noise and pollution regulations, is immense. This competitive airplane market brings the fight to the airlines, which have more choices for airplanes (and more affordable, both on airplane prices and fuel consumption). The pressure on the biggest airlines to keep fleets renewed also opens up the option for poorer countries and smaller airlines (with fewer and/or less demanded routes) to use
second hand airplanes, which further enables markets and routes that were not profitable in the past.

Airports need to keep up with this ever increasing air traffic and airline competition, or they may risk not being able to answer this demand due to lack of infrastructure (gates, runways, etc.), and become what is called “Capacity constrained”. This flexibility of capacity required from airports has made them very complex investments, but a highly rewarding sector.

An ever increasing tendency towards privatization, a constant expansion of existing and appearance of new airports prove these points. Mainly because of privatization, the fear of market power abuse is renewed and airports are commonly regulated by an external source, which usually determines the maximum prices they are allowed to charge for use of the airport. With new airports appearing and distances between them shortening, a passenger more often has a choice on the departure and/or arrival airport. Competition between these airports is therefore rising, and that is reflected upon prices of the charges, and one of the main reasons some airports remain economically unregulated. Another reason why some airports may not have enough market power to warrant regulation is when other modes of transport are available for the same route (such as high speed rail). The competition presented by rail is growing as more high speed lines are built. The (usually) cheaper price presented by rail companies, as well as the comfort of being able to arrive at the station 5 minutes before departure, are strong contributing factors for shorter distance travel. For example, the Civil Aviation Authority (CAA) of the UK has proposed in (CAA, 2007) that the Manchester and Stansted airports become regulated only by normal competition laws. The main reason is that CAA concluded these airports do not have sufficient market power to warrant regulation. The high percentage of long distance flights at Heathrow gives it a dominant position in that market, while Stansted and Manchester have to compete for most of their traffic, thus supporting CAA’s proposal.

The level of the charges collected by the airports, public or private, regulated or unregulated, is of great importance on the operation of airlines. Some authors (FU, Xiaowen et al., 2006) concluded that Low Cost Carriers (LCC) are much more affected by rises in the charge levels than Full Service Airlines (FSA). The growth in air traffic using low cost carriers has been significant in Europe, and they are now major users of the European airports, especially easyJet and Ryanair:

<table>
<thead>
<tr>
<th>Rank</th>
<th>Airline</th>
<th>Passengers (Thousands/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ryanair</td>
<td>57 647</td>
</tr>
<tr>
<td>2</td>
<td>Lufthansa</td>
<td>42 151</td>
</tr>
<tr>
<td>3</td>
<td>easyJet</td>
<td>35 417</td>
</tr>
<tr>
<td>4</td>
<td>Air France</td>
<td>32 508</td>
</tr>
<tr>
<td>5</td>
<td>British Airways</td>
<td>29 054</td>
</tr>
</tbody>
</table>

Table 2 - Scheduled International Passengers, from 53ed. WATS of IATA.
Ryanair, the biggest European LCC, is known for flying to smaller secondary airports (which usually have lower charges). Also, Ryanair negotiates the charges with these airports, only closing deals when charges are sufficiently low. Threats to lower the number of routes or leave the airport completely are also strategies used to prevent charges from rising. These smaller airports are rapidly becoming dependent on LCCs, because of the high number of passengers these airlines bring and the overwhelming share they can acquire when they open routes to these smaller airports.

The charges levied by airports on airlines (and subsequently passengers) are only a part of the total revenue generated by airports. By leasing space for (or operating) shops, restaurants, car parks, conference rooms, hotels, there is a very significant portion of non-aeronautical revenue generated at airports. So significant, in fact, that at some airports it will be higher than the revenue generated by aeronautical related activities, as Figure 3 shows:

![Figure 3 - Percentage of revenues from aeronautical activities at European airports in 2008. Source: ATRS 2010.](image-url)

The airports shown in Figure 3 are the ones that will be further analyzed in Chapter 4, and the reasoning behind their selection is explained then. In the above graph, only 4 out of 12 airports have higher than 50% of revenues from aeronautical sources. This conclusion is a reflection of the evolution of airport businesses, mainly driven by the traffic increase. It also brings to the forefront the problem at hand (explained in Chapter 2), in the sense that these very significant revenues generated by landside activities could be (and sometimes are) used to reduce charges on airlines/passengers, while at the same time trying to generate more traffic.
Not only is this revenue generated by airports a large part of the total, it also has different components, which can vary a lot from airport to airport.

In Figure 4 such an example is presented:

![Figure 4](image)

**Figure 4 - Commercial revenue by source at London Heathrow 2006. Source: Competition Commission 2007.**

Other airports may have a larger infrastructure, making use of airport grounds for conference complexes, hotels, retail parks or other major concessions. No longer do airports explore only businesses located in the terminals, but are further making use of adjacent grounds to increase their revenues.

This dissertation takes all these mentioned aspects of airport business to address the problem of the “Single vs. Dual till”. To fully understand this issue, two main aspects of airport business will need to be understood:

- Regulation, what it is, why it is needed and how it works
- Airport Charges, what they are, how are they defined and how they vary.

As is explained in the next chapter, airports are for the most part regulated by an external entity, to ensure prices are fair. This regulation (or lack of) has profound effects on the way airports are run, and how they need to adjust their business to turn a profit (or meet other goals). The other main aspect we will be focused on is the Airport Charges, which are the various fees the airlines (and consequently passengers) need to pay when using the airport. In Chapter 3 the breakdown of these charges is looked at in more detail. After having understood how and why airports are regulated, as well as how charges come into the picture, the “Single vs. Dual till” question will be explained. In very simple terms, regulation will limit
the charge levels of an airport. As airports also make money from non-aeronautical businesses, and the revenues generated from this are directly related to the number of passengers using the airport, some regulators consider the airport as a single "source" when determining maximum charge levels. Thus, even if the aeronautical part is not self-sufficient (able to pay for its expenses through aeronautical-side revenues, mostly charges), there will be no problem from the regulator's point of view if the non-aeronautical revenues compensate the loss. This type of regulation where the airport is viewed as a whole is called a "Single till". The reverse, where the regulator separates the aeronautical revenues from the rest, is called a "Dual till", and in theory forces the aeronautical side to try to be economically self-sufficient.

More detailed in the next chapter, this choice between a Single or a Dual till is very complex, and there is no universally accepted "best choice". This dissertation takes a different approach than usual to the problem, and "reverse engineers" it, analyzing the actual Charge levels of European airports, in an effort to find relations between the multiple parameters that define airports (capacity, traffic, privatization %, etc.), with the ultimate goal of finding which (if any) is better between a Single and a Dual till.

The Brussels airport was chosen as a case study, due to its current transition from a Single to a Dual till.

To reach the conclusions detailed in Chapter 6 multiple steps were taken, and the structure of this dissertation follows the logical order of these. First and foremost, a fundamental understanding of airport business as well as infrastructure regulation is needed and presented throughout this introduction and the next chapter. Once the problem (namely Single vs. Dual till) is understood, it needs to be put into context, not only on how it has been handled before, but also how it is present nowadays. To achieve this, Chapter 3 starts of by dissecting the most relevant literature on the subject. This literature review is narrowed down to the problem at hand, as airport business and even regulation is a broader subject than might be perceived at first sight. Some degree of scope must be kept however, since to take relevant conclusions one must relate the findings to other aspects of the bigger picture. Further still in Chapter 3, airport charges are explained in more detail, as well as the current situation at Brussels airport versus other European airports.

After understanding the theory pertaining to airport business, regulation and its history, as well as the current constitution of airport charges and the state of Brussels airport, Chapter 4 presents the charges of a series of European airports for a chosen airplane (A-319) with 80% occupancy. All these charges were calculated by collecting each airport's pricing guide, present on their websites. Two groups were formed, single and dual till airports, and then a series of parameters was compared. Both the criteria utilized for airplane and airport selection is explained in the same chapter.

Brussels airport is separately compared to the sample of airports (in Chapter 5), as not to make the information from the Single vs. Dual till analysis overwhelming.
Finally, in Chapter 6, the different comments on previous results are linked together for a general conclusion, both for the main dilemma of the Single vs. Dual till, but also on how Brussels airport currently fits in this subject.
2. Regulation

Transports, similarly to other services, are often subject of a conflict between profits and public welfare. These infrastructures, namely airports, are developed and run with a multitude of goals in mind. It is certainly naïve to think the only goal is to serve as a hub for air traffic, since to achieve that there needs to be “enough” revenue generated to fund those operations. Like all businesses, depending on who owns an airport, profits might be expected. With their so-called monopolistic nature, airports are becoming attractive ventures for private investors, backed by the fact that air traffic is consistently on the rise.

Since air travel is no longer a luxury but a part of functioning modern society, governments need to ensure this type of transport remains accessible and isn’t target of unjustified price increases. Therefore economic regulation has been used worldwide to ensure, even on government owned airports, prices are not unjustifiably raised.

Regulation is the process through which the Regulator ensures the Regulated entity abides to and applies certain stipulated rules. In the case at hand, airports are regulated by entities which are usually appointed by (or part of) the governments of their respective countries.

Since airports have historically been labeled monopolies, whether true or not, the risk of market power abuse leads the Regulator to ensure prices are kept at “reasonable” levels. Naturally, there can be disputes by the airport owner and the regulator on what a “reasonable” level is.

Since airports generate revenue from multiple sources, from charges related to aircraft movements to concessions to shops in the terminal, the scope of regulation can vary, but on most cases takes into account the full revenue generating activities the airport conducts.

Airlines, while not directly involved in the regulation process, are probably the most affected by regulatory decisions, especially on charges related to airplane movements and their passengers. As they have to pay to use airports, airlines suffer the consequences of regulation. Should airlines be regulated too? Since one of the main motivators is to keep end-user prices at a reasonable level, and airlines being the ultimate responsible for ticket prices, why not regulate them too? The answer is quite simple: as there are multiple airlines per airport, simple laws of competition are enough to ensure prices stay at reasonable levels, since if one airline dared to raise prices too much, it would definitely lose market share to now-cheaper competitors.

There are then two main points to be covered in the regulation of airports: Type (as in how the regulation is actually applied) and Scope (What is regulated).

As for type, how the regulation is applied can vary in multiple ways. It can be done in a pro-active or re-active way, usually called ex-ante or ex-post regulation (NIEMEIER, Hans-Martin, 2009), depending on when the regulatory action is applied.
Ex-ante regulation has been widely used and is in place when the regulator reviews the charge levels of the airport, as well as costs and revenues, so that a level deemed fair by the regulator can be set as the maximum charge levied. This price review is mostly based on historic prices for that airport, but a benchmark with other airports’ charges is expected, and inflation is usually taken into account in some form. Maximum charge prices can then be set, and as they are public there is little risk these limits are broken. Even so, the regulator should stay informed about the practiced prices as so to conduct periodic reviews, to adjust for inflation or other changing factors.

Ex-post regulation refers to the case where the regulator has a reactive role, that is, only after the charges have been set by the airport will it intervene (if necessary). This kind of regulation is usually dependent on proven market abuse (NIEMEIER, Hans-Martin, 2009). While it leaves more freedom for the regulated entity to do as it will price-wise, the consequences of abuse are usually more severe. The threat of regulation can be enough to ensure the airport keeps prices competitive, and as such places less work and responsibility on the regulator.

2.1. Types of regulation

The three most used types of regulation are Rate of return (based on costs), Price cap and Light-handed regulation. The first two are ex-ante, while the latter is ex-post. Revenue sharing agreements are also in practice at some airports, and can also be considered as ex-ante regulation. To grasp the differences in these types of regulation, and how they impact different aspects of airport economy, they are explained in more detail below.

Rate of return (or cost-based) regulation – This type of regulation sets the charge at a level that is just enough to cover the total costs, including inflation, and a standard rate of return. While simple in concept, applying it in practice is very complex and not without problems. The first problem arises from the simple fact that every charge needs to reflect its cost, lending to complicated regulation in cases where the charge structure is overly detailed. These charges should be set according to ICAO’s principles of cost relatedness. The lack of incentives to reduce costs is perhaps the main issue with Rate of Return regulation, leading to a disregard on airport expenses, and consequently leading to an inefficient pricing structure. This happens mainly because if the airports costs go up so will the charges, to accommodate the fixed return on capital. It is plain to see how this structure easily leads to lack of control on costs, and possible even less competition between companies who supply services for the airport, as cost may cease to be a large factor.

Peak pricing – when airport prices vary throughout the day/season, usually to control demand on congested airports – is common practice at many airports, and an effective instrument. Cost based
regulation does not benefit from peak pricing; it rather sets an incentive for airports to flatten prices by raising off-peak ones, with capital assets as a basis (which will be higher than they should due to no incentive for efficiency).

**Price cap regulation** – This type of regulation is based on allowing a price increase, modified by a value commonly referred to as “X”. The allowed price increase is usually based on price indexes such as the RPI (Retail price index) in the UK, or the CPI (Consumer price index) in most other countries (GILLEN, David and Niemeier, Hans Martin, 2008). These indexes can be seen as a measure of inflation, and are calculated based on a basket of commonly purchased products, with respect to their price fluctuations (usually early). The “X” can be based on a number of variables, but the most prominent one is an expected productivity growth, either on the regulated airport or by a benchmark of other airports. The regulator has some flexibility setting X, and can set it as such as to incentivize the airport to reduce costs, for example.

The formula CPI – X is then widely adopted to determine the maximum level charges may rise each regulated period (5 years being common). As there is no relation to cost, and the maximum price is set, any savings can be seen as profit kept by the company during the regulated time period, and as such there is an incentive to maximize efficiency. These profits can lead to lower charges in the next regulated period, favoring the end user. A possible consequence of these lower charges can be that the price cap of the next regulated period is lower, giving no incentive for the airport to become more efficient if it aims to keep prices high for long periods of time. This is rarely the case as massive efficiency gains are very hard to achieve and rather long periods between cap reviews do not incentivize this practice.

A common concern with this type of regulation is the effects it has on big investments or expansions of airports, since the returns gained by these will only come on the future, and the CPI and X will not change during the period defined initially.

Two types of price-caps can be considered, pure and hybrid (NIEMEIER, Hans-Martin, 2009). A pure price cap may set X based on a benchmark of various airport costs (but never solely on the regulated airport’s costs) while a hybrid price cap sets the X based on a regulated cost base. The later is usually adopted since it strives to take the future into account, while a pure price cap is solely based on historic data.

**Revenue sharing agreements** – In an effort to let the airport expand their business, and not block its growth when it is not doing well, this type of regulation relates the level of charges with traffic growth. It can be implemented as a price cap (with the actual cap changing value when traffic levels change). This form of regulation will relate the charge levels to predicted demand growth. This means that if predicted passenger traffic rises, the charge level will be able to be raised as well (probably not by the same amount). As the name suggests, part of these agreements can be a direct revenue share between airports and airlines, although this makes more sense in the
extremes of the passenger growth (unexpectedly high increase or decrease). Due to this sensitivity in charge levels based on demand elasticity, Sliding Scales is a common name for this type of regulation.

Unlike rate of return regulation, which is a simple reflection of costs, these revenue sharing agreements have the adaptability to work well after the airport makes any changes, to improve efficiency for example. Like a CPI-X price cap there is an underlying incentive to improve efficiency, and unlike traditional rate of return regulation these changes are easily incorporated in the regulatory scheme.

There are more similarities to a price cap, as the terms of the agreement are usually set for a defined period, causing the terms to stay the same until the end of the contract period when the next review happens. Short contracts will offer more volatility in charge levels, while contracts with longer terms will tend to have more stable prices over time. Unlike a traditional CPI-X price cap and cost based regulation these sliding scales offer some stability in case demand fluctuates. This aspect is sometimes overlooked, and a strong factor in favor of this type of regulation at airports with a more volatile demand. If demand plummets, the airport can adapt the charges in order to cover costs. In cases of excessive demand for the present capacity, the airport can also adapt the charge level in order to best solve the situation, at least until demand lowers or more capacity is installed.

Like other types of regulation, revenue sharing agreements have flaws. One of the main ones is there is almost no incentive for cost reductions or capacity increase, since a congested airport will lead to stable high charges (despite the fact that increasing capacity would bring more potential revenues, due to the expansion of the business). In fact this problem is very similar to the cost-based regulations, although in this case there is the possibility for higher charges (and higher profits for the airport) as they are not directly related to costs. Although they can be implemented in various ways, a linear sliding scale ensures the airport has the same revenue independently of output. What this means is with low traffic the charges will be allowed to rise and with high traffic they will be forcefully lower, leading to the same revenue in the end. This conclusion inherently leads to very low incentives to increase output (as charges will be lower despite more costs/work), and as such linear sliding scales should be avoided, at least when dealing with prices for high output. Despite this fact, the demand elasticity of the airlines would be very low, since they could transfer the cost increase to the ticket price, while the per-capita effect would be diluted by aircraft and load factor sizes.

Light-handed regulation – Unlike the previous explained regulation types, this one is ex-post-regulation, meaning the regulator does not interfere with pricing unless it finds a reason to do so. In this sense, a light-handed regulated airport may at first sight seem to behave as an unregulated airport, with the added benefit of the regulator being able to step in and correct any wrongdoing. As
it is pretty rare, there is no “norm” or consensus on how exactly a light-handed regulation should work and what results it should specifically produce. Australia has applied light-handed regulation to its major airports since 2002, following an enquiry by the Productivity Commission. This move was following privatization of said airports, previously regulated under a price-cap. A Monitor – Review – Sanction type regulation was put in place, in which the regulator (AUSTRALIAN COMPETITION AND CONSUMER COMMISSION, 1997) monitors prices, costs, profitability, efficiency, etc. and holds a review every five years. If there is a case against the current regulation, the reviewing entity can recommend re-regulation. Previously Australian airports were regulated under a price cap, and there were serious concerns that it was degenerating into cost-plus regulation. Since the previous system was bringing increasingly bad results, the threat of returning to a price-cap regulation is held as enough incentive for the airports to keep charges at reasonable levels. Since 2002 Australian airports have risen in profitability and in cases where charges rose significantly there were investments involved. This type of regulation leads itself to easier dispute over charge levels. As there is no defined way for charges to be set, airlines will tend to complain charges are too high, as expected. Another problem is on how the price review is conducted, since the regulator may revert to a cost-plus calculation during the review period, indirectly applying the rate of return regulation problems and not incentivizing efficiency gains. This observation is only a problem if the regulator acts on a cost-plus base (since if prices are not too far off from the calculation, under light-handle regulation the default option will be to not take action). Investment is always a big factor in the airport industry, since traffic tends to grow and infrastructures need to keep up with rising demand or face congestion. Light-handed regulation leaves the door open for the airports to invest as they see fit, since they can justify rises in charge levels with capacity expansion, for example. As there is no ceiling to how much airports can invest in new facilities, and how much they can raise charges consequently, there is a risk of excessive investment causing problems. Airlines may not necessarily have a problem with charge rises due to (moderate) investment, since they can usually pass these directly to the passengers. It then becomes only a factor of what a government wants to pressure towards: lower charges (and consequently lower price tickets = more traffic) or bigger/better airports. Airlines affected by the Australian airport’s light handed regulation are actually against re-regulation, but they stand by the introduction of a DRM (dispute resolution mechanism) (SCHUSTER, Dominic, 2009). As it stands now, if they feel charge levels are not fair they have to wait until the next review period presents itself. With a DRM in place there would be less freedom for airports to invest freely, as large investments would always be disputed. This might be a good thing, since the cost-effectiveness of new investments would always be questioned by airlines. The main factor against a DRM is that it is a slight move away from pure light-handed regulation, and may easily lead to a cost-based type of regulation.
In summary, a light-handed regulation has been working for Australian airports, and the problems that are emerging have proposed solutions, namely incentives for efficiency and profitable investment.

### 2.2. The Single-till vs. Dual-till

The regulating entity, when setting the maximum charge levels (as happens on a price cap type of regulation, for example) can take into account all the revenues the airport generates, both aeronautical and non-aeronautical. If this is the case, it is called a single till. On the other hand, if only aeronautical revenues are taken into account when setting airport charges, the system is called dual till (STARKIE, David, 2002).

A Single-till is therefore when the regulator takes into account the profits from the commercial activities to determine the “fair” prices of the aeronautical charges. Historically this is what has been done, the main argument being that revenues from commercial activities are directly related to the amount of people on the airport, which in turn is related to the success of the aeronautical activities. Usually, this has the effect of reducing aeronautical charges, acting as a “subsidy”. In practice, since non-aeronautical business is mostly based on concessions (shops, car-parks, etc) the upkeep costs are pretty low, resulting in much higher profit margins than on aeronautical operations. These profits from non-aeronautical activities serve to justify financially the worse results of the aeronautical side and prevent charges from rising.

Under a strict dual-till there is a total separation from aeronautical and non-aeronautical revenues and they are regulated separately (the non-aeronautical revenues may even be unregulated!).

There is also a step in-between, usually referred to as “adjusted single-till” or “hybrid single-till”, which is neither a pure single-till (because not all commercial revenues are taken into account, for example) nor a pure double-till (because some of the non-aeronautical business may still be regulated together with the aeronautical one). This adjusted single-till is usually in place when an airport tries to operate a transition from a single to double-till, or vice versa.

In the following table we can see a breakdown of the regulation in the largest European airports:
Cost based regulation refers to regulations such as the Rate of return previously mentioned, where the levels of charges are set as to cover the costs (and still make a profit). Incentive regulation refers to other Price-cap type regulations, where there is an incentive for airports to increase efficiency (STARKIE, David, 2002).

As can be seen from Table 3, the regulation form, till type, independency of regulator and percentage of private ownership are seemingly unrelated, which shows that there is no consensus on what are the “best” options. In the literature part of the next chapter, these characteristics of airports are discussed from the viewpoint of various authors. Furthermore, with such a broad range of options, a consensus that regulation should be defined on a case by case basis can start to take shape (instead of pursuing a one-size-fits-all solution).

The Brussels airport, while not part of the previous table, is currently using an adjusted single-till, and that recent fact is part of the reason for this dissertation.
Table 3 would have looked much different some decades ago. The single till was widely used, since airports were state owned for the most part, and a single till has been credited to have lower charges for the end user (airline passengers). As more studies were conducted on the subject, mainly driven by privatization of airports, the option of the dual-till started to be considered, and thus some airports are transitioning to (or already have) a double-till. The advantages and disadvantages of each one are explained in the next chapter from the point of view of various authors, and they highly depend on factors such as the position of the parties involved.

The airlines may prefer one and the airport manager might prefer the other. The airport owner and the state on which the airport is located might also have an opinion. Each of these entities has its own objectives (i.e. profits, lower aeronautical charges, etc) therefore the decisions on which type of regulation to implement are never easy.

It is therefore the purpose of this dissertation to clarify the advantages and disadvantages of the single and dual till, from the points of view of the various entities involved. Information relating to various airports will then be used to understand why they have their current model, and with what objectives, so the conclusions from the theoretical analysis can be validated. Special attention will be paid to the Brussels airport, which operates currently under an “Adjusted Single-Till”, being the pioneer in Europe using this type of regulation.

As explained in the introduction, this dissertation focuses on facing the charge levels versus a series of parameters, for a group of single and another of dual till airports. By finding how these relate, conclusions may be taken based on the actual reality of the European airports, and any anomalies can then be compared to what is written in the literature.
3. State of the Art

3.1. Literature

One of the centerpieces of the literature is written by (STARKIE, David and Yarrow, George, 2000). Historically, single-till was the predominant option. In this paper, the authors advise against a single-till. Still, the concept of using profits from non-aeronautical activities to offset high prices in the aeronautical charges is seen as beneficial. As such, although the authors recommend against a pure single-till, they do not mention a dual-till or other specific solution, just that the single-till has problems which can be avoided.

It also mentions deregulation is an option that should be considered, since the reasons for regulating in the first place are offset by increasing competition between airports (and in some cases other means of transport as well).

The Civil Aviation Authority also wrote a paper on the subject, (CAA, 2000). In this consultation paper, the CAA thoroughly goes through the arguments for and against a single-till, and how to implement a dual-till.

For example, CAA brings up a point against single-till on the basis that bringing the non-aeronautical revenues into the equation is beyond the scope of the regulation. They believe regulation should be kept to the set of services that warrant it due to substantial market power.

It believes that one of the traditional arguments in favor of the single till, that the commercial revenues are directly linked to the number of passengers, is not enough to risk problems with the regulation.

The general conclusion is that the single-till is far from optimal, but a dual till does not provide clear solutions to the problems of the single-till and should be further studied.

A basic premise is that economic regulation should only be applied to the monopolistic part (aeronautical activities in the case of airports). Economic efficiency seems to be the main factor in favor of a single till but in congested airports there seems to be a strong case against it, since it doesn't present incentives to solve the supply and demand problem. Even in uncongested airports there is no strong incentive in favor of a single till, although the problems of congested airports are not present. This “failure” of the single till to perform as historically expected is the basis on which the CAA advises for a better study on how a dual till could be implemented, and its effects.

A number of authors focus mostly on pricing, such as (ABEYRATNE, Ruwantissa, 2001). In this paper the author deals mostly with the pricing aspects of privatized airports, from the regulator’s point of view. Regarding the dual-till vs. single-till argument, points are made in favor of dropping the single-till, as this hinders the capacity for the airport to make profits. This limitation is due to the
fact that aeronautical revenues should be used to lower airport charges (and try to stimulate demand). As this cross-subsidy also does not incentivize efficiency gains, there is an obstacle to potential profits the airport could make if no such cross-subsidy existed. The author also argues that the public welfare should also always be a concern, and a single-till is not usually used to drop charges for the end-user. Competition is briefly mentioned, stating that a competitive environment would not welcome a single-till.

There is literature that while not dealing directly with the problem at hand (single-till vs. dual-till), still have important conclusions for the subject. (ZHANG and Zhang, 2003) is one of these cases, concluding that it is better for the social welfare to let the airport profit from concession operations (non-aeronautic revenues). This will reduce charges, which will still be highest at a private airport, lower at a financially restrained public airport and lowest at a welfare maximizing airport. It also concludes that the three airport types would add capacity in the inverse order (first on a welfare maximizing airport, then on a financially restrained public airport and lastly on a financially restrained private one).

Some years later (MCHARDY, Jolian and Trotter, Stephen, 2006) looked at the option of deregulation, relying on competition to keep prices under check. It is concluded that deregulation can be prejudicial, as competition in the departure airport may be offset by prices at an unregulated arrival airport. They specifically mention the single-till vs. dual-till concern: it is stated that even airports regulated under a dual-till will tend to show price increases in the overall charge under airline competition, as non-aeronautical charges will be raised in compensation to a lower aeronautical charge.

Once again a move from single to dual till is stated as not being a clear solution for governments or regulators seeking to lower the end price for the consumer, although some form of regulation is advised.

In (GILLEN, David, 2007) the author analyzes a breakdown of worldwide airport regulation. In the United States, the Federal Aviation Administration was given power by the congress to regulate the fees of airports. This regulation, unlike in Europe, should only be used to ensure the airside fees imposed on airlines are just enough to cover the costs of airside activities. As these airports are operating as a non-profit venture, there is little incentive for charges to rise above costs, and as such regulation is rarely enforced. Being the largest market for air traffic in the world, it is quite surprising the "stagnation" of regulation currently present in the U.S. Between the power of the airlines, long term contracts and project funding through FAA, this creates a situation where there is no incentive to increase efficiency, and charges do not rise above costs.

In Europe, the regulation norm is usually either ROR (Rate of Return) or CPI-X (Price-cap). This tendency is mainly due to the incentive set for airports to reduce costs, seeing as a ROR regulation just regulates profits, as inefficient as the airport may be. The question (if considering a price-cap)
arises if a single or dual till should be used. Considering all the airport revenues when determining the cap (single till) has been the type of till used historically throughout Europe (as shown throughout this dissertation, and stated by the other various authors stated), but arguments towards a dual till have gained ground, as shown in (CAA, 2000), and various airports in Europe are now being regulated under this till (see Table 3 for the main ones).

Under a single till, non-aeronautical revenues such as food and parking are still considered for setting the price cap. In capacity constrained airports, this creates a perverse situation, where an airport is having a surplus of revenues from the non-airside business, and as such airport charges would be reduced if a price review came. This creates a conundrum, where in face of congestion the prices tend to be lowered instead of being raised (to help restoring traffic to normal and/or fund capacity investment). Therefore the single till seems to give no direct incentive to capacity expansion when capacity constrained (so when expansion would be most required!).

In the non-constrained case, the airport already has every incentive to lower the price of the aeronautical side charges, seeing as this will increase demand (and revenue). We are then posed with the question if the single till was needed in the first case to achieve this result.

The dual till would usually bring higher airside charges. This would not necessarily translate to higher prices for the passengers, as the higher elasticity of demand would result in a greater portion in the charge increase absorbed by the airlines.

Another possibility used in some European airports is to have agreements where there is a share of revenue between the airports and airlines, for example by allowing charges to rise if there is projected growth in passenger traffic. These “sliding scales” are applied for example in Dusseldorf and Frankfurt on top of a Rate of Return regulation. This arrangement simulates a price-cap regulation in some ways, for example by setting incentive for expansion. It also serves to offer some stability by allowing charges to reflect changes in future demand. It is not without fault like previously referred methods of regulation, since if charges stabilize with projected growth (like is the case in most airports), it will be just like a Rate of Return regulation, with the added increase in charges from the projected growth.

Unregulated airports also exist, like is the case in New Zealand. After privatization in mid 1990s, the main airports in the country stayed unregulated, with the minister having the power to call for a study to be conducted to assess the charges at any time. Although at least one study has been conducted already, the airports remain unregulated, showing their charges are not out of line, and as such that regulation is not needed everywhere.

In Australia, also in the mid-1990s, some of the major airports were privatized, and a dual till price cap regulation put in place, with a 5 year review period. Facing economic turbulence in the airport industry in, the price cap was choking the flexibility airports needed to fight this crisis. As such, in 2001 the Australian Productivity Commission recommended an end to price cap regulation. In 2002
the Government honored this recommendation by changing all seven major airports to a “light handed” regulation, and ending regulation for all other airports. This type of regulation also is not without fault, as there is little incentive for investments in the airport to improve efficiency. Also, by definition, it does not provide guidelines to penalize the airport, thus not leaving clear when sanction should be passed on the airport. A common thought would be to regulate based on costs, but this would lead to an ineffective cost-plus regulation.

More recently, (CHARLTON, Andrew, 2009) states that the recent ICAO Charges Guidelines does not comment on the single vs. dual till. It also shows that competition is playing an increasing role in the sector, and as an example states that UK airports have not been able to charge up to their price cap. This evidence brings more relevance to the aspect of revising the regulation.

3.2. Brussels Airport

Being the main focus of the dissertation, as it is moving from a single to a dual till, the recent situation of Brussels airport should be looked at. The Brussels airport left a single till based regulation in 2006 to move towards a dual till, over a period of 20 years. In this timeframe, it will use an “adjusted dual till” (also referred to as “adjusted single till”). This type of till consists in leaving out of the single till some part of the commercial activities (deemed to have no significant market power, for example). ADP (Aéroports de Paris) is also leaning toward an adjusted till, having a single till in place with the option to take out part of the income from non-aeronautical activities from the till in the next regulatory period (2011 to 2015). These are the main two cases where an adjusted till is considered, and, as such, it is a fairly new topic. Used by the Brussels airport as a step towards a single till, it is necessary to understand if a direct change to a dual till would not be better. As are most of the European airports, Brussels airport was owned by the government, until recently. The Government has almost 30% ownership of the airport, and MAp (Macquarie Airports) leads a consortium of the Macquarie Group that in 2004 purchased 70% of the ownership, and in 2009 purchased a further 1.5%. The regulation in place is a price cap in the form of CPI-x, with 5 year intervals between reviews in prices. The regulator chose to use a “light-handed” regime, leaving the setting of the charge levels to negotiation between the airport and the airlines. In case there is no agreement, the regulator will intervene. When the initial 20 years were set to reach a dual till, there was an option to accelerate the transition if the airport managed to stay competitive. So far that has been the case, and as such the timeframe for the transition might be shortened.
Furthermore, Brussels stands in a competitive area, with the Amsterdam Schiphol airport to the north and Charles de Gaulle in Paris to the south as two major competitors. The smaller Charleroi airport, to where Ryanair has over 50 routes, also ensures competition, especially to similar low-cost carriers flying to Brussels like Easyjet.

Is the presence of competition from other airports, as well as the importance of having major airlines choose Brussels as a hub, enough to guarantee that market power is not abused?

If it is, is there a need for regulation? This dilemma is common to various countries and their airports, but most governments enforce regulation, based on history and fear of abuse. If there was no regulation the airport would be more vulnerable to market failure, with no easy way to detect or correct it. This regulation, however, can be more “light-handed” than usual. Currently at Brussels airports this is not the case, and an *ex-ante* regulation is in place. With an *ex-post* regulation, usually more “light-handed”, airport users (airlines) negotiate charge prices directly with the airport operator, and the regulator only steps in only when it deems necessary, be it from market failure or from complains from one of the parties.

**Adjusted Till**

Currently an adjusted till is in place in the Brussels airport, with the intent to move towards a dual till. A dual till can be seen as an adjusted till where the cross subsidization between the commercial and aeronautical revenues is zero.

The way airports are implementing an adjusted till is by not considering different factors of the non-aeronautical activities in the “cross subsidy”. This can be seen in the following figure, where ADP plans to take non-airport real estate and the commercial activities out of the regulation.

![Figure 5 - Plans for the regulation of Aéroports de Paris (ADP) Source: ADP.](image-url)
On the right side, under the Non-aeronautical activities we can see they are all present in the regulated scope. When the real estate and commercial activities (marked in light blue) become unregulated in 2011 an adjusted till will be in place, since only part of the non-commercial activities will be regulated by then.

3.3. Airport Charges

An airport charge is made up by several smaller parts, which together form the total charge paid by the airline. Some of these smaller charges can be applied to each landing and/or take off, while others can be applied for the total aircraft movement. Parking charges, for example, will refer to the time between landing and take-off.

For comparison purposes, this dissertation will consider the total charge as the sum of all smaller charges applicable in each LTO (Landing + Take Off) cycle. The number of passengers considered, for all charges which depend on it, will be the same on landing and take-off.

Some parts of the charge may be imputable to the passenger through the ticket, although most are collected directly from the airline. As they both represent a charge from the airport to the airline, both will be considered when calculating the total charge for one LTO cycle.

Most of the following components of charges are common to all the airports analyzed, although in some cases they take different names or are different altogether.

Passenger Charge
This charge relates to the use of the airport terminal by the passengers. It scales based on the number of passengers in the considered aircraft movement. A fixed fee is paid for each departing (usually) passenger on an airport, and it can vary by the type of passenger (departing, transfer or transit) since the amount of terminal facilities used varies.

Security Charge
The security charge serves to cover the costs of airport security, such as luggage controls, security staff and equipment. This charge also scales directly with the number of departing passengers, and may also be different based on the type of passenger (since transit passengers may not be required to go through luggage controls, for example). Especially since 9/11 this charge has become one of the most expensive at most airports.

Landing/Take- Off Charge
This charge is sometimes divided in a landing charge and a take-off charge, but for all purposes the sum of the two parts is the amount paid by the airline to the airport for the movement part of the LTO cycle. It is levied based on the aircraft type, and usually scales directly of the MTOW in some form (with a fixed price for aircrafts under a certain weight). Some airports apply a discount on this
charge if the airplane in question is on the lower end of polluting gas emissions. Reversely, if its engines are particularly polluting, some airports will impose a higher landing charge.

**CUTE fee**
CUTE stands for: Common Use Terminal Equipment. This charge is paid for the use of said equipment, usually charged on all the departing passengers.

**Noise Charge**
The Noise charge is not in place in all airports analyzed, although it may sometimes be part of the Landing/Take-Off charge. Engine type is usually the main factor determining the level of the charge. Newer airplanes tend to be the less polluting and this charge is one of the many factors pressuring aircraft manufacturers to use more efficient/less polluting engines, since the resulting aircraft will also pay less at airports.

**Parking Charge**
Most airports do not charge for the first hour/two hours of parking, and after that time the charge is usually in increments for each 30min/1h. Some airports only factor the time spent parked, not MTOW (maximum take-off weight) or passengers. Others have a fee that scales based on MTOW. The time of day and place of parking can also have an impact on the amount of the charge.

**Air Bridge Charge**
If used, the air bridge connection to the terminal incurs a fee, contrary to other kinds of parking. This charge can be based on time spent using the bridge, or just on the single aircraft movement.

**Electricity Charge**
The use of electricity to fill the airplane batteries and power up systems has a specific charge in most airports, usually calculated based on time spent charging (and as such indirectly on power consumption).

**Ground Handling Charge**
Some airports separate the ground handling from the passenger charge, and on those that do this charge is calculated based on the number of passengers.

**PRM Charge**
Following REGULATION (EC) No 1107/200 form the European Council, airlines have to pay the “Passengers with Reduced Mobility (PRM)” fee to the airports, to cover part of the cost of the infrastructures needed to ensure the normal circulation of these passengers. This charge is paid based on the total number of passengers on a given departure, and is levied even if no passengers with reduced mobility are present in a given flight.
3.4. Example of an airport charge calculation

In this exercise, the following premises were used:

- The Brussels airport was chosen, mainly based on the complexity of the charge, and also because it is the airport mostly focused in this dissertation.
- The airplane:

<table>
<thead>
<tr>
<th>Model</th>
<th>Airbus A319</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTOW</td>
<td>75.5 tons</td>
</tr>
<tr>
<td>Maximum number of passengers</td>
<td>156</td>
</tr>
<tr>
<td>Occupancy</td>
<td>80%</td>
</tr>
<tr>
<td>Total number of passengers</td>
<td>124</td>
</tr>
<tr>
<td>Number of engines</td>
<td>2</td>
</tr>
<tr>
<td>Flight route</td>
<td>Intra-Schengen</td>
</tr>
</tbody>
</table>

Table 4 - Airbus A319 airplane data used for charge calculations.

- The turnaround time is 1 hour.

Landing charge

In Brussels, the landing charge is calculated using the following formula:

\[
\text{Landing Charge} = U \times W \times E \times D ,
\]

where:

- \( U \) – Unit tariff: 2,17€
- \( W \) – Weight factor, where:
  - If MTOW < 25 ton, \( W = 25 \)
  - If 25 < MTOW < 175 ton, \( W = \text{MTOW} \)
  - If MTOW > 175 ton, \( W = 175 \)
- \( E \) – Environmental factor
  - Category 1 – 1,70
  - Category 2 – 1,20
  - Category 3 – 1,00
  - Category 4 – 0,9
- \( D \) – Day/night factor
  - Between 8:00 and 21:00 this parameter is always 1, and we consider the flight in question to be during that time window.
Parking charge

\[ Fee = 0.62€ \times MTOW \times n^0 of \ hours \]

(first 2 hours free for aircraft under 100 tons, 4 hours for over 100 tons).

Boarding bridge

14.69€ per hour, starting from the moment of docking. Only levied on aircrafts who are docked for 6 hours or more.

Electricity charge

Charged even if not used, per 15 minutes of parking, based on certified seating capacity:

<table>
<thead>
<tr>
<th>Number of seats</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 160 seats</td>
<td>6.50€</td>
</tr>
<tr>
<td>160-239 seats</td>
<td>10.32€</td>
</tr>
<tr>
<td>240 or more</td>
<td>14.19€</td>
</tr>
</tbody>
</table>

Table 5 – Electricity charge breakdown.

Passenger charge

Per passenger depending on the type of journey:

<table>
<thead>
<tr>
<th>Type of passenger</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Originating passenger</td>
<td>17.10€</td>
</tr>
<tr>
<td>Transfer passenger</td>
<td>8.39€</td>
</tr>
<tr>
<td>Transit passenger</td>
<td>3.31€</td>
</tr>
</tbody>
</table>

Table 6 – Passenger charge breakdown.

Security charge

Per passenger depending on the type of journey:

<table>
<thead>
<tr>
<th>Type of passenger</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Originating passenger</td>
<td>7.96€</td>
</tr>
<tr>
<td>Transfer passenger</td>
<td>7.66€</td>
</tr>
<tr>
<td>Transit passenger</td>
<td>1.99€</td>
</tr>
</tbody>
</table>

Table 7 – Security charge breakdown.

Regulator fee

0.88€ per movement.

Slot coordination fee

1.95€ per movement.

Air traffic control charge

\[ \text{Landing Charge} = U \times W \times E \times D \]
where:

$U$ – Unit tariff: 2,17€

$W, E$ and $D$ – Same as in the landing charge.

**Ground handling fee**

0,35€ per passenger.

**CUTE fee**

<table>
<thead>
<tr>
<th>Type of passenger</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local departing passenger</td>
<td>0,3748€</td>
</tr>
<tr>
<td>Departing transfer passenger</td>
<td>0,2124€</td>
</tr>
</tbody>
</table>

*Table 8 - CUTE fee breakdown.*

**Total charge for the reference airplane**

<table>
<thead>
<tr>
<th>Charge</th>
<th>Amount (€)</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landing</td>
<td>196,60</td>
<td>5,5</td>
</tr>
<tr>
<td>Parking</td>
<td>0</td>
<td>0,0</td>
</tr>
<tr>
<td>Boarding bridge</td>
<td>0</td>
<td>0,0</td>
</tr>
<tr>
<td>Electricity</td>
<td>26</td>
<td>0,7</td>
</tr>
<tr>
<td>Passenger</td>
<td>2120,40</td>
<td>59,5</td>
</tr>
<tr>
<td>Security</td>
<td>987,04</td>
<td>27,7</td>
</tr>
<tr>
<td>Regulator</td>
<td>1,76</td>
<td>0,05</td>
</tr>
<tr>
<td>Slot coordination</td>
<td>3,90</td>
<td>0,1</td>
</tr>
<tr>
<td>Air traffic control</td>
<td>139,24</td>
<td>3,9</td>
</tr>
<tr>
<td>Ground handling</td>
<td>43,40</td>
<td>1,2</td>
</tr>
<tr>
<td>CUTE</td>
<td>46,48</td>
<td>1,3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>3564,82€</td>
<td>100</td>
</tr>
</tbody>
</table>

*Table 9 - Total charge breakdown for Brussels airport.*
4. European Charges Overview

4.1. European Airports

A group of airports needed to be selected for a deeper charge study. This group should be as varied as possible: having multiple airports from the same country, regulator or owner would probably cause a bias towards those airports charge levels.

<table>
<thead>
<tr>
<th>Airport</th>
<th>Passengers in 2007</th>
<th>Type of till</th>
</tr>
</thead>
<tbody>
<tr>
<td>LONDON HTW</td>
<td>68,068,304</td>
<td>single</td>
</tr>
<tr>
<td>PARIS CDG</td>
<td>59,922,177</td>
<td>single</td>
</tr>
<tr>
<td>FRANKFURT</td>
<td>54,161,856</td>
<td>dual</td>
</tr>
<tr>
<td>MADRID</td>
<td>52,122,702</td>
<td>single</td>
</tr>
<tr>
<td>AMSTERDAM</td>
<td>47,794,994</td>
<td>dual</td>
</tr>
<tr>
<td>LONDON LGW</td>
<td>35,218,374</td>
<td>single</td>
</tr>
<tr>
<td>MUNICH</td>
<td>33,959,422</td>
<td>single</td>
</tr>
<tr>
<td>ROME</td>
<td>32,855,542</td>
<td>dual</td>
</tr>
<tr>
<td>BARCELONA</td>
<td>32,794,575</td>
<td>single</td>
</tr>
<tr>
<td>PARIS ORY</td>
<td>26,440,736</td>
<td>single</td>
</tr>
<tr>
<td>ISTANBUL</td>
<td>25,561,435</td>
<td>n/a</td>
</tr>
<tr>
<td>MILAN</td>
<td>23,885,391</td>
<td>dual</td>
</tr>
<tr>
<td>LONDON STN</td>
<td>23,777,277</td>
<td>single</td>
</tr>
<tr>
<td>DUBLIN</td>
<td>23,287,438</td>
<td>single</td>
</tr>
<tr>
<td>PALMA DE MALLORCA</td>
<td>23,223,970</td>
<td>single</td>
</tr>
<tr>
<td>MANCHESTER</td>
<td>22,362,106</td>
<td>single</td>
</tr>
<tr>
<td>COPENHAGEN</td>
<td>21,356,134</td>
<td>dual</td>
</tr>
<tr>
<td>ZURICH</td>
<td>20,682,094</td>
<td>n/a</td>
</tr>
<tr>
<td>OSLO</td>
<td>19,043,800</td>
<td>single</td>
</tr>
<tr>
<td>VIENNA</td>
<td>18,768,468</td>
<td>dual</td>
</tr>
<tr>
<td>MOSCOW</td>
<td>18,755,098</td>
<td>n/a</td>
</tr>
<tr>
<td>STOCKHOLM</td>
<td>17,968,023</td>
<td>single</td>
</tr>
<tr>
<td>BRUSSELS</td>
<td>17,838,214</td>
<td>hybrid</td>
</tr>
<tr>
<td>DUSSELDORF</td>
<td>17,832,849</td>
<td>single</td>
</tr>
<tr>
<td>ANTALYA</td>
<td>17,795,523</td>
<td>n/a</td>
</tr>
<tr>
<td>ATHENS</td>
<td>16,518,851</td>
<td>dual</td>
</tr>
<tr>
<td>MOSCOW</td>
<td>14,039,843</td>
<td>n/a</td>
</tr>
<tr>
<td>MÁLAGA</td>
<td>13,577,585</td>
<td>single</td>
</tr>
<tr>
<td>LISBON</td>
<td>13,392,059</td>
<td>single</td>
</tr>
<tr>
<td>BERLIN</td>
<td>13,357,741</td>
<td>single</td>
</tr>
</tbody>
</table>

Table 10 - Top 30 European airports by traffic in 2007. Source: ACI Europe
From Table 10, the following airports were chosen:

<table>
<thead>
<tr>
<th>Airport</th>
<th>Type of till</th>
<th>Country</th>
<th>GDP/capita(ppp)</th>
<th>Private Ownership Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>LONDON HTW</td>
<td>single</td>
<td>England</td>
<td>$34.800</td>
<td>100%</td>
</tr>
<tr>
<td>PARIS CDG</td>
<td>single</td>
<td>France</td>
<td>$33.100</td>
<td>33%</td>
</tr>
<tr>
<td>FRANKFURT FRA</td>
<td>dual</td>
<td>Germany</td>
<td>$35.700</td>
<td>47%</td>
</tr>
<tr>
<td>MADRID MAD</td>
<td>single</td>
<td>Spain</td>
<td>$29.400</td>
<td>0%</td>
</tr>
<tr>
<td>AMSTERDAM AMS</td>
<td>dual</td>
<td>Netherlands</td>
<td>$40.300</td>
<td>0%</td>
</tr>
<tr>
<td>ROME FCO</td>
<td>dual</td>
<td>Italy</td>
<td>$30.500</td>
<td>97%</td>
</tr>
<tr>
<td>MILAN MXP</td>
<td>dual</td>
<td>Italy</td>
<td>$30.500</td>
<td>1%</td>
</tr>
<tr>
<td>DUBLIN DUB</td>
<td>single</td>
<td>Ireland</td>
<td>$37.300</td>
<td>0%</td>
</tr>
<tr>
<td>COPENHAGEN CPH</td>
<td>dual</td>
<td>Sweden</td>
<td>$36.600</td>
<td>77%</td>
</tr>
<tr>
<td>OSLO OSL</td>
<td>single</td>
<td>Norway</td>
<td>$54.600</td>
<td>0%</td>
</tr>
<tr>
<td>VIENNA VIE</td>
<td>dual</td>
<td>Austria</td>
<td>$40.400</td>
<td>50%</td>
</tr>
<tr>
<td>BRUSSELS BRU</td>
<td>hybrid</td>
<td>Belgium</td>
<td>$37.800</td>
<td>75%</td>
</tr>
<tr>
<td>LISBON LIS</td>
<td>single</td>
<td>Portugal</td>
<td>$23.000</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 11 - Airport sample selection. Source: CIA Factbook and ACI Europe

Due to the predominance of single till airports, all the dual till airports were selected except for Athens, which had disproportionally high charges (potentially because of the economic crisis). The same number of single till airports was chosen. The sample was assembled with diversity in mind, country wise.

Italy has two airports chosen due to the lack of more dual till airports in the top 30, and as they have two distinct owners this should not create a significant bias.

Since these airports range in yearly traffic from 13,3M passengers to 68 M, the integrity of the sample should be checked first. If airport charges depend on traffic levels, different tiers of traffic will have to be considered separately.

Expanding this airport sample would bring a few other problems. Multiple airports from the same countries, under the same ownership and/or regulator would introduce a bias towards that type of regulation. As it is our goal to gather as much information about the differences from single to dual till airport characteristics, this bias could distort the results. Furthermore, the scarcity of airports regulated under a dual till leads to a similar number of single till airports being used. If more single till airports were considered, having already covered the biggest airports by traffic, as well as most European countries, the next airports to be included would be in the same country/under the same regulator, again leading to said bias. Smaller airports will also tend to be dominated by low-cost carriers (in the present list only Milan MXP can be considered to be in this position), leading to
Specific airport characteristics also prone to introducing a bias. Since only one of the airports is in this position it contributes to the variety of the sample instead of distorting it.

4.2. Airport charges for the selected airports

For all the following analyzes, charges were calculated using the airplane from Table 4 (Airbus A319 with 80% occupancy). The choice of airplane stems from the fact that we are considering only European airports, intra-European flights, and both full service and low cost carriers use this category of airplanes. The following round-trip charge levels were calculated for the sample airports, from 2010 data:

<table>
<thead>
<tr>
<th>Airport</th>
<th>Charge</th>
<th>Till</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heathrow</td>
<td>4.466 €</td>
<td>Single</td>
</tr>
<tr>
<td>Lisbon</td>
<td>2.433 €</td>
<td>Single</td>
</tr>
<tr>
<td>Madrid</td>
<td>1.821 €</td>
<td>Single</td>
</tr>
<tr>
<td>Paris CDG</td>
<td>2.698 €</td>
<td>Single</td>
</tr>
<tr>
<td>Oslo</td>
<td>4.065 €</td>
<td>Single</td>
</tr>
<tr>
<td>Dublin</td>
<td>2.506 €</td>
<td>Single</td>
</tr>
<tr>
<td>Brussels</td>
<td>3.565 €</td>
<td>Hybrid</td>
</tr>
<tr>
<td>Amsterdam</td>
<td>3.756 €</td>
<td>Dual</td>
</tr>
<tr>
<td>Milan MXP</td>
<td>1.730 €</td>
<td>Dual</td>
</tr>
<tr>
<td>Frankfurt</td>
<td>2.579 €</td>
<td>Dual</td>
</tr>
<tr>
<td>Rome FCO</td>
<td>2.205 €</td>
<td>Dual</td>
</tr>
<tr>
<td>Copenhagen CPH</td>
<td>2.834 €</td>
<td>Dual</td>
</tr>
<tr>
<td>Vienna VIE</td>
<td>3.201 €</td>
<td>Dual</td>
</tr>
</tbody>
</table>

Table 12 - Airport charges for the sample airports. Source: Own calculation.

For the selected sample, we obtain the following average charge level results based on till type:

<table>
<thead>
<tr>
<th>Measure</th>
<th>Dual</th>
<th>Single</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>2.718 €</td>
<td>2.998 €</td>
</tr>
<tr>
<td>Absolute deviation</td>
<td>865,24 €</td>
<td>1.032,60 €</td>
</tr>
</tbody>
</table>

Table 13 - Airport charges for the sample by till type.

This is a very important and surprising result. Dual till airports, contrary to what the literature leads us to believe, have lower charges than single till airports! Their charge levels also vary significantly less (about 15%) than single till airport charges.
Lower charges for the end user are certainly important, as it will almost always lead to lower ticket prices and increased traffic. Airlines are certainly more inclined to lower prices if charges are lower. Meanwhile, airports will seem to receive less income if charges are lower. While this might be the case it will not necessarily translate to fewer profits, since under a dual till there will be more pressure to keep the aeronautical side of the business profitable, while giving more freedom to the landside business to prosper without having to help the airside one.

To try and validate this result, a serious of factors which may influence it will be analyzed next. Since the goal is to compare single to dual till airports, and later see where Brussels airport fits, in the following graphics the airports will only be labeled by till type, and not individually. This both makes the graphics much easier to read and leads to clear macroscopic conclusions.

To keep consistency, dual till airports will be marked in blue square and single till airports in green diamond shape. The airports are not labeled so as not to clutter the graphic, and since this is a single vs. dual till overview, and not an individual airport analysis.

![Charge vs Traffic](image)

**Figure 6 - Charge level (2010) versus Traffic (2010) for selected airport sample.**

From Figure 6, the first observation is that there is no relation between charge and traffic levels.
Both the Dual till and single till group of airports have a mostly scattered pattern, even in the two visible groups (above and below 40 million yearly passengers). These two groups serve to show that there are few airports in the largest traffic category (>40M passengers), and that dividing the sample into smaller clusters of airports would lead to much more inconsistent results. Since traffic is the quantifiable aspect that varies the most between airports, and no relation was found to the charge level, the chosen airport sample is used for the rest of the analysis. If there had been a noticeable relation between charge and traffic levels, different groups based on approximate traffic levels would have to be considered instead.

**Figure 7 - Charge level versus Private ownership % for the airport sample.**

In Figure 7 we can see the privatization % per charge. The first aspect we can take out of this graph is that there are more dual till airports with significant private share than single till ones. Since the sample size is small, this observation should not be expanded upon, but nevertheless it is a logical conclusion that private airports would be more open to push towards a dual till type of regulation. The main takeaway from this graphic is that there is no direct relation between charge level and private share. Still it is noteworthy that both extremes of ownership, public and private, have charges that vary significantly more than shared ownership airports. Airports with shared ownership seem to have a more consistent charge level.
To draw further conclusions and to try to confirm the current ones, the question of whether Gross Domestic Product (GDP) affects charge levels is evaluated next. Since all airports have been treated equally, and as services in richer countries tend to be more expensive, it is a logical thought that airports in more expensive countries would have higher charges. If this assumption is true, then the already analyzed data can be biased. For example, the reason single till airports have higher charges (as shown in Table 13) could be that they are from more expensive countries.

![Charge vs GDP/capita(PPP)](image)

**Figure 8 - Charge level versus GDP per capita (adjusted for purchasing power parity).**

Figure 8 shows that there is in fact a correlation between charge level and GDP/Capita (adjusted for purchasing power parity (ppp)). This relation is especially notable on the Dual till airports. The meaning is that richer countries tend to have higher charge levels, which is a natural assumption. In light of this finding, and since GDP is fixed for each country, we can try and standardize the charges irrespective of country. To this effect, a new parameter was created, Q.

\[
Q = \frac{\text{Charge Level}}{\text{GDP per capita (ppp)}} \times 100
\]

With this parameter in use there ceases to exist a bias in charge level depending on GDP. The multiplication by 100 is so the final values are higher than 1, for a more natural analysis. Since we
will be measuring the values relative to each other, this multiplication does not affect the results. Also, if different currencies are used for charge level and GDP, there will be an exchange rate present, which will be a constant since time is fixed. To keep the sample coherent, the same currency has to be used between all airports’ charges, and between all countries’ GDP/capita(PPP).

<table>
<thead>
<tr>
<th>Airport</th>
<th>Charge</th>
<th>Till</th>
<th>GDP/capita(PPP)</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heathrow</td>
<td>4.466</td>
<td>Single</td>
<td>$34.800</td>
<td>12.83</td>
</tr>
<tr>
<td>Lisbon</td>
<td>2.433</td>
<td>Single</td>
<td>$23.000</td>
<td>10.58</td>
</tr>
<tr>
<td>Madrid</td>
<td>1.821</td>
<td>Single</td>
<td>$29.400</td>
<td>6.19</td>
</tr>
<tr>
<td>Paris CDG</td>
<td>2.698</td>
<td>Single</td>
<td>$33.100</td>
<td>8.15</td>
</tr>
<tr>
<td>Oslo</td>
<td>4.065</td>
<td>Single</td>
<td>$54.600</td>
<td>7.45</td>
</tr>
<tr>
<td>Dublin</td>
<td>2.506</td>
<td>Single</td>
<td>$37.300</td>
<td>6.72</td>
</tr>
<tr>
<td>Brussels</td>
<td>3.565</td>
<td>Hybrid</td>
<td>$37.800</td>
<td>9.43</td>
</tr>
<tr>
<td>Amsterdam</td>
<td>3.756</td>
<td>Dual</td>
<td>$40.300</td>
<td>9.32</td>
</tr>
<tr>
<td>Milan MXP</td>
<td>1.730</td>
<td>Dual</td>
<td>$30.500</td>
<td>5.67</td>
</tr>
<tr>
<td>Frankfurt</td>
<td>2.579</td>
<td>Dual</td>
<td>$35.700</td>
<td>7.22</td>
</tr>
<tr>
<td>Rome FCO</td>
<td>2.205</td>
<td>Dual</td>
<td>$30.500</td>
<td>7.23</td>
</tr>
<tr>
<td>Copenhagen</td>
<td>2.834</td>
<td>Dual</td>
<td>$36.600</td>
<td>7.74</td>
</tr>
<tr>
<td>Vienna</td>
<td>3.201</td>
<td>Dual</td>
<td>$40.400</td>
<td>7.92</td>
</tr>
</tbody>
</table>

Table 14 - GDP per airport country and Q calculation for the selected airports.

Charge level was calculated in Euros (since it is the predominant currency of the countries in question). The GDP/capita was taken from the CIA World Factbook and Q calculated directly without resorting to an exchange rate. In the end Q could be seen as €/$, but since time is fixed we could consider Q unit-less, because €/$ is a fixed exchange rate.

With this new unit, charges can be compared against an assortment of parameters, without fear of bias because how rich is the originating country. Although from Figure 6 we concluded there was no relation between charge and traffic level, in light of this new parameter this integrity needs to be check again, since it could have been a coincidence generated from the disparity of GDP across countries. Similarly, Figure 7 can also generate some new conclusions if adjusted for GDP (although the main observation was that dual till airports tend to have higher private shares of ownership, and this conclusion stays the same independently of charge level).

Most of the parameters in the following analyzes will be checked twice, once versus the charge level and another versus Q. Since our main goal is to see the impact on charges for dual and single
till airports from various parameters, having a measure of airport charges is paramount to the validity of the conclusions.

![Q vs Traffic](image-url)

**Figure 9 - Q parameter versus Traffic level for the selected airport sample.**

Following the observations taken in Figure 6, there is still no relationship between charge and traffic levels. This result is true for both the single and dual till groups, and also for the total airport group. With this information we can conclude that both GDP and traffic levels have no direct influence on charge levels, further validating that the chosen sample can be treated together.

There is still the privatization aspect that can bring some unexpected result from the introduction of the parameter Q. If it does not, Q will be considered a valid parameter and the resulting analysis will use it to try to reach significant conclusions.
When looking at Figure 10, it is noticeable that single till airports still have a wider range of charge levels than dual till ones. From this result we can further conclude that while GDP does affect charge level (as seen in Figure 8), it does so in a broad enough way throughout countries and their respective airports that no distortion is created towards the single or dual till charge levels.

A distortion effect could appear in this stage of the analysis if multiple airports from a few countries had been selected in detriment of other countries. As only one country is represented twice (Italy), this effect is quite diminished.

Finally, let us look at Q for both the single and dual till airports and respective deviation from the sample:

<table>
<thead>
<tr>
<th>Measure</th>
<th>Dual</th>
<th>Single</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>7,52</td>
<td>8,65</td>
</tr>
<tr>
<td>Absolute Deviation</td>
<td>1,19</td>
<td>2,56</td>
</tr>
<tr>
<td>Variance</td>
<td>1,41</td>
<td>6,54</td>
</tr>
</tbody>
</table>

Table 15 - Q obtained for the sample airports by till type, and respective deviations.
From these results, the disparity between single and dual till airports becomes even more noticeable than when first analyzed at Table 13. The difference in the average is greater, while the difference in absolute deviation between both till types is much higher than when we first compared the simple charge levels.

There are many implications of this surprising result. First and foremost dual till airports will tend to have lower charges for the airlines, which will in turn certainly reflect on the end user in lower total ticket prices, while not cutting on the airline profits if it so desires.

Without a cross subsidy from the landside airport business, dual-till regulated airports have the pressure to be more self-sufficient in regard to the airside business. Seeing as they have lower charge levels overall, the result from Table 15 leads us to believe that there is in fact a much larger operational gain in terms of efficiency. Furthermore, as the gap in charge absolute deviation between till type rose when GDP was taken into account, we can conclude that charge levels are much more closely related to GDP in dual till airports than single till ones. Long term, this may be a very interesting result for airlines, especially when planning potential routes, where flying to more dual-till regulated airports will not only have lower overall charges but also a much more stable effect on expense balance sheets.

![Charge vs % of international traffic](image)

**Figure 11 – Charge level versus % of international traffic for the airport sample.**
Due to lack of data, two of the dual till airports are not shown in the graph (MXP and VIE).

What can be observed in this graph is quite interesting. In the dual till airports, and to some extent in the single till airports, there is a relation between charge level and % of international traffic. This is an interesting realization, and a logical one, since airports more focused towards international traffic should have larger expenses. From stricter security, to larger runways and infrastructures, it all makes sense. Also, the more expensive airports could be considered to have charges high enough to be “immune” to this variation based on international traffic. The fact that they are both single till airports may be a factor from which to draw further conclusions.

\[ Q \text{ vs } \% \text{ of international traffic} \]

**Figure 12 - Q level versus % of international traffic for the airport sample.**

Figure 12 serves to solidify the conclusions taken with the pure charge level, since the trend in the dual till airports is still for the charge to go up with the % of international traffic. Single till airports also follow this trend, now more clearly. The previous observation about the two outliers does not seem to have much fundament, since only one of them kept its position relative to the other airports.

Due to the reduced number of dual till airports, it is not very correct to comment on the variation, but nevertheless the dual till airports show a much more defined trend than the single till ones in both figures. A reason for this may be the underlying nature of charges under a dual till, since they tend to follow more directly what goes on the aeronautical part of the business. Naturally, the commercial
side is also affected by the type of passengers (national or international) since duty free shops, car parks, hotels, etc. will all vary in demand. The key point is that under a dual till the charges are more transparent in what they really reflect since a landing charge should be able to cover the full costs of the runway. As has been discussed, it is logical that charges are higher as international traffic goes up due to higher costs, and the dual till airports present in the graph clearly reflect this trend.

**Figure 13 – Charge level (2010) versus total number of aircraft movements (2008) for the airport sample.**

Although very similar to Figure 6, the reasons for this graphic are twofold. First and foremost, since output is ultimately the defining characteristic of an airport, having a second measure is important for consistency reasons. The fact that aircraft movements or passenger traffic have the same relation to charge levels further emphasizes the point that a lack of relation between output and charge level validates the airport sample. Secondly, and not so obviously, the very similar positions between points on both graphs serve to show that the average person per airplane travelling from each airport measure is not a factor against the whole analysis. By both measures of output, the considered airports basically maintain their place in the ranking. Both these conclusions are true for the single and dual till airports, as well as the sample as a whole.
Even when compensating for GDP there is still no evident relation between the charge and the nº of aircraft movement. This is as far as we will go concerning output comparisons to charge level.

A curious observation from Figure 14 is that the dual till airports seem more compressed on the Y-axis, while the single till ones stay basically the same (when compared to Figure 13). This compression effect happens in the graphics presented since on most parameters we are showing two graphs that only vary in the Y-axis: one for the pure charge and one for Q. The interesting fact is that this compression effect is more present in the dual till airports. The natural conclusion from this observation is that dual till airports are priced even closer when corrected for GDP than when the pure charges are considered.
Having analyzed the charge against output, type of traffic and airport public/private ownership, some measure of installed capacity should be looked at. The most natural measure for this metric is the number of gates, since airport size can vary greatly based on how it is measured (and even restricted to terminal size can vary greatly). Runways would be too hard to compare, since they may not all be ready for use (or usable at once). The number of gates is therefore probably the best measure of installed capacity, even if the airport may not actually be able to run all its gates at once.

Figure 15 therefore illustrates this measure. Heathrow airport is again the outlier, and is farthest from the rest more so in this comparison than on the others. The conclusion is that it should be far from capacity constrained, at least concerning the number of gates.

The sample as a whole seems to show there is no relation between the number of gates and the charge level. While somewhat supported by the single till airports, it may be argued that for the dual till ones there is a slight downtrend. This trend may have some fundament to it, especially since the airports in question are under a dual till. Since under this type of regulation there is more pressure for the aeronautical business to be sustainable, having more gates should lead to a lower price per gate, on a simple basis of supply and demand. Economies of scale also support this argument, since the cost of running double the gates should be double at maximum.

Let us look at the Q graph to see if further conclusions can be drawn:
The dual till airports keep the same pattern, and the downtrend still continues as the number of gates increases. Curious to note, a small cluster of three single till airports formed, with around 60 gates and previously unrelated charge levels. As expected, Heathrow continues to be the outlier. Sadly, there is no clear measure to base a capacity expansion analysis on. Number of gates is a measure of installed capacity, and there is no clear way to measure capacity expansion and its impact on charges. Despite this fact, the slight trend downwards in charge levels as capacity increases, especially in dual till airports, is a good indicator that a dual till regulation more clearly reflects its price limitations in the charge level. Relating to capacity expansion, the dual till airports have somewhat more freedom since they can spread expansion costs through existing charges directly, i.e. making current gates pay for future ones. On single till airports, the cross-subsidy coming from non-aeronautical revenues may lead to a more complex pricing scheme, and since, as has been shown, prices are already higher at single till airports, may also lead to an overall disincentive for investment.
The first striking observation from Figure 17 is the clear separation from dual till airports from single till ones. The reasoning behind the inclusion of this metric is to try and have some measure of efficiency. The number of passengers per employee is probably not the best characteristic of an airport to demonstrate efficiency, since it directly depends on how many services, such as ground handling, are sub contracted. Even despite this fact, it is the most accessible measure of efficiency, and one that could be obtained for all the airports.

Dual till airports clearly require more employees per annual passenger, but it is important to note that half the considered single till ones are very near the dual till range (but at the top end).

Perhaps the most interesting aspect about Figure 17 is what would happen were one of the right hand single till airports to change to a dual till. Would it radically change its hiring policies?

From this point on it will be assumed that this measure shows a higher level of sub-contracting on single-till airports. Even if this is not the case, and they are simply much more efficient, the fact that charge levels are higher on single till airports than on dual till ones leads us to believe this “efficiency” is not having a true impact on lowering charge levels.

A trend for less sub contract of airport services would definitely be in order, but the key factor here is to understand why. By every measure analyzed so far, a dual till has come out on top, but it is in fact surprising that dual till airports tend to have more employees.
Since dual till airports have complex pricing structures, the simple fact of having more employees seems to add even more unnecessary complexity. But the data points in this direction. What is probably happening is that to achieve a deeper level of control over aeronautical services, dual till airports simply can’t afford to sub contract as much. Having everything run in-house leaves much more degree of adjusting to the airport, and is probably a “necessary evil”. Sub-contracting adds a cost (the profit of the third party) that can be directly cut by the airport running the service itself.

The overall conclusion from this graphic is that to run an airport under a dual till it may be necessary to keep sub-contracts to a minimum, in order to have greater control over prices.

Figure 18 - Percentage of private share (2008) versus number of passengers per employee (2008) for the airport sample.

An interesting comparison that allows us to draw further conclusions in the dilemma of single versus dual till is the private share versus passengers/employee. As has been concluded from Figure 17, passengers/employee can be seen much more a measure of the amount of sub-contracting than of efficiency per-se.

In the above graph it is blatantly obvious the fact that public single till airports tend to have a much greater amount of sub-contracting (through having a significantly higher number of passengers per employee). This is a conclusion not to be overlooked, since as we’ve seen throughout this airport overview a single till leads to much more erratic parameters, higher charges, and overall worse results. The complete disparity on the number of passengers per employee definitely points towards much more sub-contracts, which is therefore a strong contender to one of the main causes of the single till “failure”.
Another very strong conclusion is that there are cases where a single till has a similar amount of passengers/employee to dual till airports. This at least leaves hope for single till airports who want to push towards a dual till, since trying to break too many sub-contracts could prove too unfeasible.

4.3. Statistical Analysis

With the intent of validating the already presented data, a simple statistical analysis was conducted. The first step was to check the Charge level for normality, since it is a requirement for a linear regression, as well as various other tests.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charge</td>
<td>.947</td>
<td>13</td>
</tr>
</tbody>
</table>

Table 16 – Shapiro-Wilk normality test results

Since the Sig. value is above 0.05 the data can be considered to follow a normal distribution.

This result in graphic form:

![Normal Q-Q Plot of Charge](image)

Figure 19 – normal Q-Q plot for the charge level
To confirm the linear relation between Charge and GDP/capita(ppp) presented in Figure 8, a linear regression test was conducted:

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.647</td>
<td>.419</td>
<td>.366</td>
<td>685,817</td>
</tr>
</tbody>
</table>

Table 17 – Linear regression overview for Charge level dependent on GDP/capita(ppp)

R is the simple correlation and therefore shows a somewhat strong dependence of the charge level on GDP/capita(ppp). The $R^2$ value indicates that almost 42% of the charge level is directly explained by the GDP/capita(ppp).

The ANOVA (analysis of variance) table yields the following results:

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>3734814,801</td>
<td>1</td>
<td>3734814,801</td>
<td>7,941</td>
<td>.017</td>
</tr>
<tr>
<td>1 Residual</td>
<td>5173792,122</td>
<td>11</td>
<td>470344,738</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8908606,923</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Since Sig. <0.05 the regression model applied is considered statistically significant, and this concludes that GDP is a really strong measure of the charge level.

The linear regression curve:

![Linear Regression of Charge dependent on GDP/capita(ppp)](image)

Figure 20 – Linear Regression of Charge dependent on GDP/capita(ppp)
Next, a Pearson’s correlation was conducted between the different parameters presented throughout section 4.2. The full table is presented in the Annex, here is presented the part with relevant correlations:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Result</th>
<th>Charge</th>
<th>Passengers</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP/capita</td>
<td>Pearson Correlation</td>
<td>.647</td>
<td>-.145</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.017</td>
<td>.635</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>aircraft movements</td>
<td>Pearson Correlation</td>
<td>.070</td>
<td>.954</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.820</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>number of gates</td>
<td>Pearson Correlation</td>
<td>.399</td>
<td>.713</td>
</tr>
<tr>
<td></td>
<td>Sig. (2-tailed)</td>
<td>.177</td>
<td>.006</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>13</td>
<td>13</td>
</tr>
</tbody>
</table>

Figure 21 - Pearson correlation between the analyzed parameters

GDP per capita shows a high correlation with the charge, as seen previously. Logically measures of traffic (aircraft movements and number of passengers) show a very strong correlation, and capacity/passengers also show a strong correlation.

Finally, an independence t-test was conducted to see the significance of the difference in charge level between single and dual till airports:

<table>
<thead>
<tr>
<th>Till</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charge</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>6</td>
<td>2997,83</td>
<td>1032,690</td>
<td>421,594</td>
</tr>
<tr>
<td>Dual</td>
<td>6</td>
<td>2717,00</td>
<td>719,180</td>
<td>293,604</td>
</tr>
</tbody>
</table>

Table 18 – Single and Dual till airport charge data

This table is the same as Table 13, now with the standard error mean. Applying this information in the independence t-test yields the following results:

<table>
<thead>
<tr>
<th>Levene's Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Sig.</td>
<td>t</td>
</tr>
<tr>
<td>---</td>
<td>------</td>
<td>---</td>
</tr>
<tr>
<td>Charge</td>
<td>Equal variances assumed</td>
<td>1,452 .256</td>
</tr>
<tr>
<td>Charge</td>
<td>Equal variances not assumed</td>
<td>.547 8,926</td>
</tr>
</tbody>
</table>

Table 19 – Independence t-test for single and dual till airport charge levels
Variances are assumed to be equal for both the dual till and single till samples, since the Sig. value in Levene’s test is over 0.05.

The main takeaway from the t-test for the equality of means is that the Sig. (2-tailed) parameter is well over 0.05. This is the value that defines the statistical significance of the difference of means between single and dual till airports.

Since the mean value of the dual till charge and the single till one are not different to a point of statistical significance, the results presented in the charge analysis need a larger sample to take statistical significant conclusions. This observation in no way voids the results obtained, since overall the dual till total charge is still lower than the single till one, on average.

Throughout Chapter 4 a series of metrics was compared, especially against the airport charge levels. The calculated Q charge was especially important in withdrawing conclusions. The single most important realization was that single till airports present a higher total charge than dual till ones, and Q confirmed this was not just a coincidence based on country GDP. Since this is an unexpected result, the main objective then becomes trying to understand how this price disparity came to be. To that effect most of the Figures present in this chapter try either to validate the sample choice, the charge calculation or to show probable causes and consequences of the higher single till charge level.

The airports that form the dual till sample showed lower variance in the vast majority of the analysis, and also clearer trends when these were present (Figure 17 for example). There was not a single metric where single till airports as a group placed “better” than dual till ones. Adding to the fact that the charges are also higher for a single till, and the general conclusion is that a dual till offers both better prices for the airlines (and indirectly the passengers), as well as leading to more efficient and overall more stable airports.

Complexity of the regulation is therefore the most significant downside to a dual till, which should not be enough reason to stay in a single till, assuming regulation is needed at all.

The amount of subcontracting, out of the metrics discussed, seems to be the largest difference in the way dual and single till airports are run, and therefore seems to be affecting charge prices in some way.
5. Brussels case

Brussels airport, as explained in section 3.2, started moving from a single to a dual till by adopting an “adjusted till” type of regulation in 2006. By progressively removing non-aeronautical businesses from the same regulation as the aeronautical ones, it plans to reach a dual till after 20 years. This chapter pretends to show how a series of metrics, especially airport charges, vary from single till to dual till, and how Brussels airport fits in between.

Most of these metrics has already been commented on in some form in chapter 4, but always against another metric (especially charge level).

The line graphs present in this chapter always have present the sample of single and dual till airports, as well as Brussels. The leftmost and rightmost points on each line represent the minimum and maximum values of that sample; the point between these represents the average.

Starting by the airport charges:

![Single and dual till airport charge breakdown](image)

**Figure 22 – Single and dual till airport charge breakdown (average for the airport sample).**

![Brussels airport charge breakdown](image)

**Figure 23 - Brussels airport charge breakdown.**
There is a considerable difference between the single and dual till charges breakdown, as Figure 22 shows. While the passenger charge is the largest sub-charge in both cases, in the single till one it is roughly the same as the LTO charge + security. In the dual till breakdown this is far from the truth, and the passenger charge takes over 50% of the total.

There could be a number of factors for these differences, but the more complex dual till probably reflects the cost reality better, since each of the sub-charges aims to be economically self-sufficient. The fact that Brussels airport already has a charge breakdown strikingly similar to a dual till one is surprising, in a good way. While not all airports are equal, they all develop similar businesses and operate in very similar ways, with basically no disruptive innovation in processes or infrastructures. This natural tendency towards the "norm" leads to very similar costs and, between airports under the same type of regulation, also to very similar pricing structures.

As the dual till type of regulation tries to closely control each sub-charge as to directly represent its expenses and revenues, the above dual-till charge breakdown can also be looked at as a measure of airport expenditure related to passengers, security and landing/take off costs.

While Brussels airport still has a long time to go until the dual till is fully implemented in 2026, the fact that it’s pricing structure already closely resembles a dual till airport’s one is definitely a sign in the right direction.

Looking at the charge level:

![Figure 24 - Charge levels for single and dual till airport samples, as well as Brussels airport.](image)

The charge level of Brussels airport, while being inside the range of both the single and dual till airports, is well above the average of both. There are airports as expensive as Brussels, but it is certainly an expensive airport to fly to and out of.

Figure 24 also clearly shows the argument supported throughout this dissertation that single till airports are slightly more expensive than dual till ones, charge wise.

Akin to what was done in chapter 4, GDP will now be taken into account in an effort to standardize charge levels irrespective of a country’s richness.
The above graph is just for reference, since we are interested in analyzing airports and not their countries. Still it clearly shows that there are no dual till airports at both ends of the spectrum, which in itself may be a conclusion noteworthy of further investigation.

As was also discussed earlier, Figure 26 illustrates even better the fact that charges, even corrected for GDP, have a clear tendency to be higher under a single till. Seeing Brussels airport outstepping the dual till range in this case is a sign that it’s charges, while maintaining a dual till-type breakdown (Figure 22, Figure 23), are probably more expensive than can be achieved. The next figures should help to shed some light into why this is the case.
Figure 27 is used to show the private share of Brussels airport, which is well above the average for the airport sample. The fact that it has an even higher private share than the dual till average is a strong point in the transition from the single to dual till, since under private ownership the necessary changes usually face fewer barriers in their way to implementation.

Figure 28 – Number of passengers for single and dual till airport samples, as well as Brussels airport.

Figure 29 – Percentage of international passengers for single and dual till airport samples, as well as Brussels airport.

To illustrate the amount and type of passenger traffic at Brussels airport, Figure 28 and Figure 29 have been included. The amount of traffic of Brussels airport, while having room to grow, is directly hindered by its location, since it competes with Amsterdam, Frankfurt, Heathrow and Charles de Gaulle for long-haul traffic. The excellent rail infrastructure of the Benelux region, and its connections to Germany, France and England generate very strong competition for shorter routes, which coincidentally are very high demand ones.

The small size of the country, excellent rail infrastructure and Brussels central location in Belgium all lead to basically non-existent domestic air travel.

This is not necessarily a problem, since this naturally imposed limitation leads that every effort in running Brussels airport should be towards international traffic, simplifying processes and infrastructures that might have to be separate.
A very healthy metric is shown above in Figure 30, since despite being in the low end of traffic numbers of the samples, the present installed capacity of Brussels airport is right on the average of the sample. Together these measures point to no capacity constrain, and as such there is room to grow traffic without stepping in the area of capacity constrained airports, which as section 3.1 covered, are cause for much debate regulatory wise.

Capacity, like traffic, is a measure that cannot be directly and fairly compared between single and dual till airports.

Like was discussed at length in the previous chapter, especially after Figure 17 and Figure 18, the number of passengers per employee should not be looked at directly as a measure of efficiency, but as a measure of the level of sub-contracting.

Again, it is staggering the difference in range from the single to dual till airports. The fact that Brussels airport is under the single till sample average is noteworthy, but it is still significantly above the dual till airport sample range.

Lowering the level of sub-contracting, while hard to achieve quickly, is definitely a step in the right direction. Until 2026 there is plenty of time to take measures with long term results. The key result is that if Brussels aims to try and reduce charges well into the dual range, it should definitely look with serious eyes into reducing the level of sub contracts.
The metric shown in Figure 32 is very relevant to the single versus dual till problem, and Brussels airport is at a very peculiar position. Dual till airports are clearly concentrated on a lower level, while single till airports seem to have in general a higher percentage of aeronautical revenues. Since this graphic shows revenue and not profit, the theory that dual till airports tend to have more efficient aeronautical activities is supported by this graphic.

Single till airports show a higher percentage of aeronautical revenues, which also leads to question if they are developing their commercial activities as well as they should. The fact that the single till regulation bundles everything together is a very probable hindrance to the development of commercial activities (while also not pushing for efficient aeronautical ones).

Brussels airport seems to be placing low emphasis on this metric, and like the amount of subcontracts, this seems a very key step that can be taken gradually over the adjusted till period.

The fact that all the traffic at Brussels airport is international probably ties into the types of commercial revenues that the airport should aim for, since these directly depend on the type of passenger.

To conclude the analysis of the Brussels airport, the charge breakdown is presented in value next.

Figure 32 – Percentage of aeronautical revenues for single and dual till airport samples, as well as Brussels airport.

Figure 33 – Landing plus take-off charge for single and dual till airport samples, as well as Brussels airport.
As explained earlier when the charge calculations were presented in Chapter 4, some airports have a Landing charge while others also have a take-off one. The charge presented here is therefore the sum of the landing and take-off charges (or just the landing when only this is present).

The disparity of the landing and take-off charge between single and dual till is quite staggering, but Brussels is very near to the dual till average. As Figure 24 showed, Brussels has a significantly higher total charge level than the dual till average, and since the landing charge is so close to the average, the rest of the charges will have to be higher:

![Diagram](image)

**Figure 34 – Passenger charge for single and dual till airport samples, as well as Brussels airport.**

As predicted, Brussels has a significantly higher passenger charge than the dual till average. Even though it is at the edge of the dual till range, it is probably desirable that this passenger charge be reduced slightly. To keep the charge breakdown of Figure 23 close to the dual till one, both the security and Landing charge would both be reduced, achieving the end result of a lower total charge.

![Diagram](image)

**Figure 35 – Security charge for single and dual till airport samples, as well as Brussels airport.**

The curious thing about the security charge is that it has a larger variance on the dual till sample than on the single till one. Brussels airport fits in the dual till range, but just outsteps the single till one. Nevertheless, it is still significantly above both the averages, also pointing towards the need for charge level reductions.
Brussels airport has until 2026 to change from a single to a dual till, and in the above Figures the general situation has been shown. The total charge levels are above the average for the airport sample, but the weight of the main charges (landing, passenger and security) already follows a dual till. This shows that Brussels airport should try to cut charges proportionately, so as to keep the ratio from Figure 23 - Brussels airport charge breakdown.

Reducing the level of sub-contracts should be the change that can bring the most impact on reducing charge levels. Overall this seems one of the main differences in the way single and dual till airports are run, to the detriment of single till ones. To compensate any profit losses, Brussels airport should seek to raise the revenue share of commercial activities, which at the moment is much too low, even for single till airports. The fact that all the traffic at Brussels airport is international should play a key role in determining the types of commercial activities that should be developed.
6. Conclusions

6.1. Regarding single vs. dual till and Brussels airport

Regulation, in particular of airports, is a complex subject and very subjective, especially due to the number of parties and interests involved. The fact of whether or not regulation is necessary in the case of European airports was not expanded upon in this dissertation, since the main goal is to delve into the question of single versus dual till.

The single most important conclusion reached is that charges under a single till are not lower than dual till ones. The airport sample considered is varied considering the European continent, and the results were also checked for validity based on GDP and Airport traffic amount. All the obtained results point in the same direction, and charges for dual till airports were on average lower than single till ones, especially so when standardized for GDP. Since the literature that defended the single till stated lower charge levels as one of the main reasons in its favor, this result is not only surprising but also incredibly relevant. Variance on the charge level is also considerably lower on the dual till airport sample, which also leads to welfare gains, since airlines should be more open to flying between airports with more stable charge levels (and lower!).

Few metrics are able to show the performance of airports, and lead to comparisons, but on most metrics analyzed such as installed capacity (in the number of gates), dual till airports tend to show much less variance and clearer trends whenever these are present. Competitive markets tend to follow a path towards efficiency, and competitors tend to show similar results and metrics when scaled for size. The fact that dual till airports follow this principle more closely is surely a sign of them optimizing for efficiency, especially reflected in the lower charge levels. The higher variance of single till airports in most metrics is definitely a sign of disregard towards its competitors, and in the end towards any serious efficiency gains.

Behind the higher variance and overall higher charge levels of single till airports is certainly the overall higher average public ownership share. Public ownership, especially backed by the regulators, should aim for lower charges so air traffic is stimulated and overall welfare gains are achieved. This principle is clearly flawed, as the charge level results show. In fact, single till airports show a much higher level of passengers/employee which is probably due to a higher level of subcontracting. Since there is such a great disparity between single and dual till airports in this metric, if it was truly a measure of efficiency then there should be an equally large impact on reducing charge levels, which there isn’t.
This apparent resort to sub-contracting, especially common in large public-owned enterprises, makes it much harder to control costs and is quite possibly the single most important cause of higher single till charges. Since a single till bundles all the revenues together, it is much easier to justify and “hide” overspending on sub-contracts (which are usually more expensive than doing the work in-house anyway).

The specific case covered, Brussels airport, seems to be in the right track, having made the decision to gradually adopt a dual till until 2026. Charges are still higher than the dual till airport benchmark, but the charge breakdown is very similar to the dual-till average. The two metrics where Brussels is farthest from the dual till range are the passengers/employee and % of aeronautical revenues.

The recommendation should be to try and reduce sub-contracting and follow other dual till airports in developing those services. Once these changes are in place charges should be able to be reduced due to lowering expenditure. The actual very high percentage of aeronautical revenues points toward an underdeveloped commercial business, and there seems to be plenty of room to grow the business, especially at a capacity unconstrained Brussels airport. The fact that it is not capacity constrained also allows it to handle significant demand elasticity, and non-aeronautical businesses should try to prepare for that.

All in all, single till airports should pay very strong attention to developments at Brussels airports, since this dissertation proves that a dual till is the stronger option for the airport, airlines, passengers and the respective government. The fact that the outdated single till is still so common shows that this information needs to reach the decision makers. Political interests are probably at work in disfavor of the previously mentioned parties but, at the current time of European crises, changes for the best can certainly fit at least in some political agendas.
6.2. Future work

Due to the limited amount of information available, only the metrics presented in this dissertation were able to be analyzed. If warranted, the ground is set for expanding the analysis, but it has been shown charges are higher under a single till type of regulation, without much ground for dispute. The natural continuation of the work done here should be to understand why. The amount of sub-contracting that single till airports engage in is definitely a good starting point, but there may be other factors leading to these higher charges.

Australian airports, under their light handed regulation, are worthy of note since this dissertation only focused on an ex-ante type of regulation. How they compare to the European airports in the metrics presented here, as well as other ones, may shed some light into the dilemma of the need for regulation at all.

Single versus dual till was the main focus of this dissertation, but airports under these ways of regulating can follow a cost based model, sliding scales, price cap, etc. Since this dissertation did not distinguish between these types of regulating, a similar work can be developed focusing on these instead of separating airports between single and dual till. Perhaps some of the characteristics of airports presented in this dissertation are really a consequence of the type of regulation, and not if it follows a single or dual till. Understanding if this is the case should therefore also lead to further conclusions regarding the single vs. dual till matter.

Brussels airport has a direct interest in investigating the conclusions presented further, since despite knowing the move from a single to a dual till is the right one, it should ensure it reaches appropriate charge levels by 2026, and that it somehow does not stagnate in its current adjusted till.
7. Bibliography


8. Annexes

8.1. Airport charge calculations

Due to the nature of the calculations, a spreadsheet was developed, on which the input is the aircraft parameters. The results are the charges for the airports considered. A list can be found in Table 11 - Airport sample selection.

The spreadsheet can be found at:

https://dl.dropbox.com/s/akhdi2q2ljxv66s/Taxas.xlsx?dl=1
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* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).