The impact of airport capacity constraints on air fares

Burghouwt, G.; Boonekamp, T.; Suau-Sanchez, P.; Volta, N.; Pagliari, R.; Mason, K.

Publication date
2017

Document Version
Final published version

The impact of airport capacity constraints on air fares

seo amsterdam economics

Amsterdam, 24 January 2017
Commissioned by ACI EUROPE

The impact of airport capacity constraints on air fares

Final report

Guillaume Burghouwt (SEO)
Thijs Boonekamp (SEO)
Pere Suau-Sanchez (Cranfield)
Nicola Volta (Cranfield)
Romano Pagliari (Cranfield)
Keith Mason (Cranfield)

seo amsterdam economics

Roetersstraat 29 - 1018 WB Amsterdam - T (+31) 20 525 1630 - F (+31) 020 525 1686 - www.seo.nl - secretariaat@seo.nl
ABN-AMRO IBAN: NL14ABNA0411744356 BIC: ABNANL2A - ING: IBAN: NL96INGB0004641100 BIC: INGBNL2A
KvK Amsterdam 41197444 - BTW NL 003023965 B

SEO Amsterdam Economics

"Solid research, Sound advice"

SEO Amsterdam Economics carries out independent applied economic research on behalf of national and international clients – both public institutions and private sector clients. Our research aims to make a major contribution to the decision-making processes of our clients. Originally founded by, and still affiliated with, the University of Amsterdam, SEO Amsterdam Economics is now an independent research group but retains a strong academic component. Operating on a nonprofit basis, SEO continually invests in the intellectual capital of its staff by granting them time to pursue continuing education, publish in academic journals, and participate in academic networks and conferences. As a result, our staff is fully up to date on the latest economic theories and econometric techniques.

Cranfield Centre for Air Transport Management

The Centre for Air Transport Management at Cranfield University is globally recognised as a leading centre researching and teaching in Air Transport Management, our work draws together airline and airport operations with management, economics, engineering and marketing. Our focus is worldwide and we share our expertise with students and businesses. Research areas include airline economics, airline and airport networks, airline marketing and the commercialisation of airports. Our applied research and consultancy is supported by access to extensive data sources rarely available at universities. As consultants, we enable the air transport industry to become more innovative in a complex, challenging and competitive market. We deliver innovative solutions to industry's real-life problems and create tailored training programmes to equip managers to address the key challenges the industry faces.

SEO-report nr. 2017-04

ISBN 978-90-6733-851-6

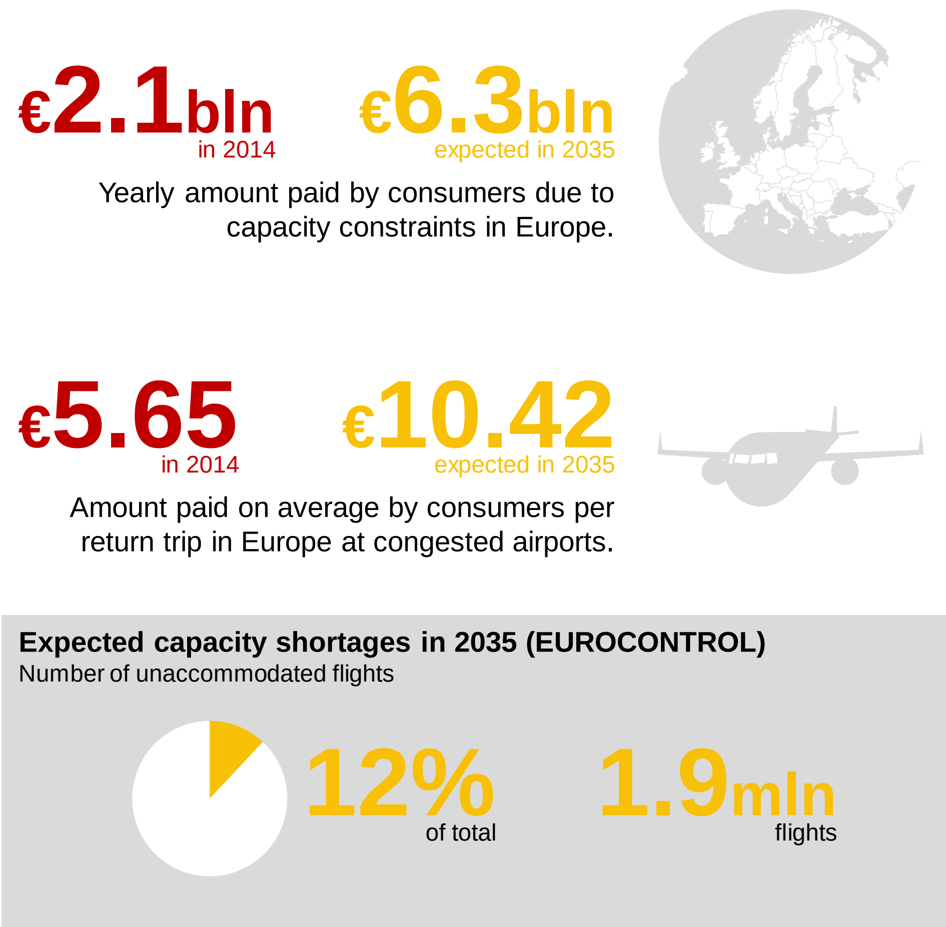
Executive summary

Economic theory predicts that air fares at congested airports will be higher when airport capacity is insufficient to accommodate all passenger demand, as that excess passenger demand allows airlines to increase their air fares. Using econometric analysis, we find that higher levels of capacity utilisation are indeed associated with higher air fares, all other things being equal.

We estimate this total additional fare premium at congested European airports at € 2.1 billion today. Airport capacity shortages in Europe are becoming increasingly severe. Based on EUROCONTROL's 'Challenges of Growth' forecasts, the total fare premium levied by airlines at congested airports is projected to reach € 6.3 billion by 2035.

In sum, it is the European consumer who ultimately pays for insufficient airport capacity in Europe. To reduce the negative impact of capacity shortages on consumer welfare, not only continued investments in airport capacity are required, but also regulatory reform to remove the incumbent airline's disincentives to support capacity expansion.

Figure S. 1 Capacity shortages at European airports result in fare premiums for passengers



Source: SEO & Cranfield analysis

Scarce airport capacity results in higher air fares for passengers

In a situation where passenger demand for airport capacity exceeds the supply, airport charges would be used to balance the level of demand with the capacity available. If the airport prices efficiently through its charges, scarcity will be reflected in higher (typically peak period) airport charges, hence in higher costs to the airlines and, in turn and depending on the market situation, in higher fares charged to passengers for travel at peak periods.

But for various reasons – and in particular due to regulatory oversight of airports – congested airports often charge airlines inefficiently low prices (Starkie 2004). Even when airport charges remain capped at a level below the market clearing rate, the profit-maximising airline will still maintain its fares at the higher 'market clearing levels'. This will result in higher fares compared to a situation with sufficient airport capacity, which do not reflect the underlying costs incurred by the airline. We call this mark-up on fares due to capacity shortages 'fare premiums' or 'scarcity rents'.

The presence of airline scarcity rents also means that increases/ decreases in airport charges at congested airports do not automatically result in higher/ lower ticket prices. This is because airlines will first absorb higher/ lower airport charges at the expense of their scarcity rents. I.e., airline profitability will decrease/ increase before air fares go up/ down. In such situations, passengers may not benefit from the efforts made by economic regulators to control levels of airport charges.

When airport capacity increases and demand remains equal, additional competition will compete scarcity rents away. As a result, air fares will fall, reducing the scarcity rent for the airlines to the benefit of the consumer. In other words, there will be a transfer of surplus from producers to consumers. This may however create a disincentive for airlines to support efforts to solve the congestion problem, as doing so would also take away their ability to charge passengers premiums on air fares.

Current and future impact of airport congestion on air fares

Higher levels of airport capacity constraint in Europe are associated with higher air fares

We find that a higher level of airport congestion is associated with higher average booked air fares. A 10% higher airport capacity constraint level is associated with a 1.4%-2.2%% higher average air fares. The impact of airport capacity constraints is larger on air services to and from non-liberalised markets compared to liberalised (mainly short-haul) markets –most likely due to the differences in market contestability.

Total air fare premium due to airport capacity constraints is estimated to increase to € 6.3 billion in 2035

According to EUROCONTROL, airport capacity shortages will increase further in the medium term. In 2035, around 1.9 million flights (accounting for 12% of the demand) cannot be accommodated in EUROCONTROL's 'most likely' scenario. Applying the elasticities derived from the econometric model to the EUROCONTROL forecast, we estimate that the total fare premium will rise to € 6.3 billion in 2035, equal to € 10.42 on an average ticket at constrained airports.[1]

The estimates for both the current and future impacts on air fares are for the overall aviation sector. However, the relationship between airport capacity constraints and air fares is likely to be exponential – with disproportionately higher air fares at the most congested airports, more minor fare premiums at moderately congested airports, and in all likelihood no scarcity rents on air fares at uncongested airports.

Policy recommendations

Addressing Europe's capacity crunch is the obvious answer

Expanding airport capacity is the obvious answer to the intensifying capacity shortfall at congested airports in Europe. Addressing the airport capacity crunch should be of primary importance for European policy makers and airports. Solving of airport capacity bottlenecks is also likely to enhance overall social welfare. This can be achieved through physical and operational measures, but also via policy measures, such as establishing the Single European Sky or streamlining local and national planning rules.

Removing the incumbent airline's disincentive to support expansion

Expanding airport infrastructure in European metropolitan areas is not easy, as the history of airport expansion projects in Europe shows. Expanding airport capacity is difficult for planning and environmental reasons, and sometimes for budgeting reasons.

Moreover, the presence of scarcity rents can be a disincentive for incumbent airlines to actively support airport expansion programmes (Gillen & Starkie 2016). Airport congestion may create a disincentive for incumbent airlines to solve that very same congestion.

There are a number of reasons for this dynamic:

- Airport capacity expansion will result in new airline entry. Scarcity rents of the incumbent airline will be competed away by the new airline entrants to the market;
- Investing in large and complex airport facilities may result in higher airport charges, which will be absorbed by the airlines at the expense of their remaining scarcity rents and profitability, instead of these higher charges being passed through via higher air fares;

[1] These numbers are based on average elasticities for a representative sample of markets from European airports. Figures will be higher or lower by individual airport.

- Incumbent airlines are restricted in the number of slots they can get when an airport expands, under the new entrant rule within the current European slot regime.

It is therefore important to develop solutions to take away the incumbent carriers' disincentive for airport capacity expansion. We see a number of avenues:

- The requirements to allocate half of the slots to new entrants could be temporarily suspended after major airport expansion at large hub airports. This would give incumbent airlines a larger stake in the benefits of the additional capacity created. However, this would also be at the risk of the incumbents using these slots to create barriers to entry against new entrants, allowing them to preserve their (remaining) rents. The overall welfare impact of this policy response is likely to be unclear and unpredictable, even on a local basis.
- Another avenue would be to allow airports to capture part of the scarcity rents through higher airport charges. This would effectively mean a transfer from the scarcity rents from the airlines to the airport, simultaneously removing their disincentive to invest. Any captured scarcity rents could be ring-fenced and directed towards airport capacity expansion investments – thus contributing towards the relief of the underlying problem of insufficient capacity;

Ensure existing policies do not create unnecessary barriers to airport expansion

Airline consultation and right of appeal to an independent regulator over airport charging decisions are very important, when an airport is in a position of significant market power. However regulators must remain aware of the incentives, which incumbent airlines may face at congested airports, which may not be aligned with socially optimal outcomes, and should not automatically rule out airport expansion on the grounds of incumbent airline opposition. One way forward could be to ensure that airline regulatory appeals on airport charges decisions do not afford incumbent airlines de facto veto power over efficiently-incurred and necessary airport capacity expansion at heavily congested airports.

Make policy makers aware of the existence of scarcity rents

Awareness among policy makers about the existence of scarcity rents may be a vital input in policy discussions on both airport expansion and the impact on passengers of the regulation of airport charges.

Monitoring of booked air fares at congested airports can be a simple measure to make transparent any fare differentials between congested and uncongested airports, when indeed scarcity of European airport capacity increases further. Preferably, this should be done by an independent body, such as a regulator or group of regulators.

Continue efforts to open up aviation markets

Consumers are the winners of aviation liberalisation. Our analysis underlines the benefits of the liberalised and the common European aviation market. Liberalisation has not only increased effective airline competition, but also the contestability of the market. Fares in liberalised markets are significantly lower than fares elsewhere.

In the current geopolitical environment, there is a risk that the longstanding trend of liberalisation and deregulation of aviation markets comes to stop or may even be reversed in some cases. This will be to the detriment of the consumer. The same holds true if airport capacity fails to keep up with aviation demand growth. Policy makers need to be aware of the value of liberalisation, airline competition and airport capacity for European welfare and the broader economy.

Table of contents

Part I: Explanation of the concept & previous studies

1 Background and purpose of the study

This report aims to provide a better understanding of the factors that influence the level of air fares in Europe, and specifically the impact of airport capacity constraints. In addition, the study considers the potential implications of the findings for current European aviation policy. To this end, we have performed econometric analysis on extensive air fare data at European airports.

1.1 Background and purpose

The changing European airport industry

For a long time, many inside and outside the air transport industry have considered airports to be natural monopolies, possessing substantial market power. The policy response was heavy-handed regulation of many airports across Europe.

However, a growing body of empirical evidence shows that many airports are no longer the natural monopolies they were considered to be (Copenhagen Economics 2012, UK CAA 2014, UK CAA 2007). Competition between airports has been increasing over the past decade, both in the market for passengers and in the market for airlines. This requires a more tailor-made approach towards airport regulation, based on a market power assessment of each individual airport. This shift from the old 'heavy-handed regulation' paradigm to a tailor-made approach seems to be taking place gradually, with the principle reflected within the recent Aviation Strategy of the European Commission.

Strong focus on upstream dynamics when confronting market power issues

Within that same paradigm, aviation policy discussions on airport capacity investments generally focus on any associated increases in airport charges and the assumed subsequent increase in airline cost levels – i.e. the upstream market. In these discussions, airports are seen as inherently monopolistic and the airline market as perfectly competitive. Consequently, there is an intensive focus upon the need for regulatory intervention in the setting of airport charges and oversight of airport investment decisions. However, there are no checks to ensure that end users (i.e. passengers) ultimately benefit and that any cost reductions will be passed through via lower air fares.

Impact on end users need to be considered as well

It is necessary to explicitly consider any potential market power issues in terms of the impact upon the end user, factoring in the structure and resulting dynamics of the downstream market (i.e. airlines) as well, as competition policy is applied to the European aviation sector in an increasingly coherent and forensic manner. As in other sectors, it is no longer sufficient to only examine upstream dynamics, when confronting any potential market power issues. Instead, an holistic overview of the overall market dynamic is necessary.

The oligopolistic nature of the airline industry

It is often overlooked that many airline markets are rather oligopolistic than (im)perfectly competitive, as the box below illustrates. This observation undermines the general assumption in many studies and regulatory frameworks of a full pass through of airline cost changes (such as changes in airport charges) to the end user.

Are aviation markets market (im)perfectly competitive?

It is often stated that aviation markets are (im)perfectly competitive and that market concentration is low. However, when considering the level of market concentration on airport-pair markets at a global scale, this is hardly the case, according to research by Koopmans & Lieshout (2016, p.5-6).

Koopmans & Lieshout calculated the Herfindahl-Hirschman Index (HHI) for all city-pair origin-destination markets worldwide, using passenger booking data. They corrected for multiple airports serving the same city. In addition, they not only considered market shares of airlines on direct flight options, but also passengers using indirect travel options via transfer hubs.

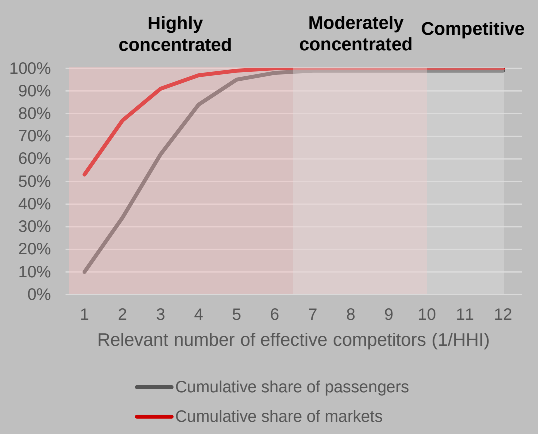
It is generally assumed that markets with an HHI below 1000 represent a competitive market. An HHI of over 1800 represents a highly concentrated market, while an HHI between 1000 and 1800 points reflects moderate concentration.

Figure 1.1 reveals that the average global city-pair market HHI is 4600. Only about 1% of airport-pair markets have a HHI below 1000 – the HHI level that indicates a competitive market. About 2% of worldwide passengers travel within these markets. The analysis also demonstrates that half of such markets are monopolies – being operated by just one airline. However these markets are generally small in size. Just 10% of passengers are travelling in such monopoly markets. Hence, most aviation markets can be described as oligopolies with product differentiation[2] (differentiated oligopolies).

[2] Markets with a limited number of competitors, which offer slightly different products in terms of (on-board) service, frequency level, legroom, baggage allowance and transfer time (in case of indirect travel).

Figure 1.1 Market concentration in global airport-pairs by share of passengers and number of competitors

Relevant number of effective competitors	Share of passengers	Share of markets	HHI (weighted average)
1	10%	53%	9643
2	24%	24%	5831
3	28%	14%	4177
4	22%	6%	3223
5	11%	2%	2479
6	3%	1%	2084
7	1%	0%	1557
8	0%	0%	1351
9	0%	0%	1137
10	0%	0%	945
11	0%	0%	918
12	0%	0%	885
Total	100%	100%	4612



Source: Koopmans & Lieshout (2016), p.6

The high level of market concentration has different causes. First of all, the majority of the worldwide origin-destination markets has just too little demand for multiple suppliers. Secondly, in many markets there are barriers to entry, including aeropolitical restrictions, dominant incumbent airlines and airport capacity constraints.

Impact of airport capacity shortages on air fares and implications for airport charges pass through

As this report demonstrates, airlines may be able to generate scarcity rents, where demand exceeds the supply of airport capacity – i.e. at congested airports. (see Section 2.2.2 for the full underlying economic theory.)

This is of relevance as European airport capacity is increasingly scarce. According to EUROCONTROL (2013b), a large portion of demand growth cannot be accommodated at Europe's airports without significant investments in airport infrastructure.

In such instances, air fares are more likely to be based on demand rather than underlying costs. Consequently, it is certainly not a given that decreases in airport charges are automatically passed-through to the final consumer via lower fares, when airlines have certain market power at capacity constrained airports. Neither may increases in airport charges at constrained airports necessarily result in higher ticket prices: it can well be that airlines absorb them at the expense of the scarcity rents they are generating (Koopmans & Lieshout 2016).

Purpose of the study

Against this background, this report aims to provide a better understanding of the factors that influence the level of air fares in Europe, and specifically the impact of airport capacity constraints, and to consider potential implications for current European aviation policy.

More specifically, the analyses in this report aim to determine:

- if air fares at constrained European airports are significantly higher than at unconstrained airports;
- the magnitude of the impact of airport capacity constraints at European airports on air fares, controlling for the impact of other factors that influence air fares;
- the overall annual impact of airport capacity constraints on air fares in Europe;
- the impact of these capacity constraints in 2035 as a result of EUROCONTROL's predicted 'airport capacity crunch'.

The findings of this study can help to inform the debate on the need for additional capacity at large European airports. It should also make policy makers aware of the possibility that airlines may exercise a certain degree of market power over the passengers at congested airports and that this has implications for how passengers are impacted by the current regulatory framework for airport charges.

Air fare analyses performed

To this end, we have performed empirical analyses to explain airfare levels at European airports and to isolate the role of airport capacity constraints. For this purpose, we use a data set on average booked fares at a large sample of markets at European airports. We support our analysis with various case studies, using both booked and offered fare data.

1.2 Structure of the report

Chapter 2: The theory behind scarcity rents at congested airports

We start with the fact that capacity at European airports is becoming increasingly scarce. In the event that airport capacity is not sufficient to meet demand, prices will need to increase to 'clear the market'. Airports are often not able to fully extract these rents: economic regulation of all airports in Europe with more than 5 million passengers per annum limits the charges that they can levy upon passengers and airlines.[3] Instead, airlines then clear the market by means of higher average ticket prices. This means that ultimately consumers pay the bill of scarcity of airport capacity via higher air fares. Chapter 2 presents the theory behind scarcity rents, as well as the evidence from past research on the existence of scarcity rents.

Chapter 3: Capturing airport capacity constraints

In order to be able to isolate the presence and magnitude of scarcity rents empirically, we need indicators to measure airport capacity utilisation – i.e. the degree of capacity constraints at individual airports. We present two different indicators to capture airport capacity constraints in

---

[3] Directive 2009/12/EC of the European Parliament and of the Council of 11 March 2009 on airport charges applies to all airports with more than 5 million passengers per annum, as well as the largest airport in a Member State, with many of the larger airports subject to more extensive regulatory controls at a national level, beyond the provisions of the Directive. In addition, smaller airports (below 5 million passengers per annum) are subject to economic regulation within individual jurisdictions.

Chapter 3: the Capacity Utilisation Index (CUI) and the number of Movements per Runway (MPR).

Chapters 4 and 5: Isolating the impact of scarcity on ticket prices

Many factors influence ticket prices. Constrained airport capacity is one of the many variables. We use an econometric approach to isolate the impact of airport capacity constraints on air fares. Empirical analyses have been carried out on average booked fares by origin-destination market. The scope of the econometric analyses and data are discussed in Chapter 4. Chapter 5 presents the results of the econometric work.

Chapters 6 and 7: Current and future ticket price mark-up due to scarcity in airport capacity

Using the results from the econometric analyses, we estimate the total fare premium paid by European consumers at this moment. This analysis is found in Chapter 6. We then estimate the potential fare premium paid in 2035 due to growing scarcity in airport capacity in Chapter 7 using EUROCONTROL forecasts.

Chapter 8: Policy recommendations

Finally, we assess the implications for aviation policy, of the fare premium due to growing excess demand for airport infrastructure. The policy recommendations are found in Chapter 8.

2 Airport capacity constraints in Europe

Capacity at European airports is becoming increasingly scarce. In the event that airport capacity is not sufficient to meet demand, prices will increase to 'clear the market'. Those airports with substantial market power, which would otherwise be able to fully extract these rents are likely to be prevented from doing so by economic regulation. Airlines instead clear the market by means of higher average ticket prices. This means that ultimately passengers pay the bill from scarcity of airport capacity.

2.1 The growing scarcity of airport capacity in Europe

Airport capacity congestion is already being felt in markets across Europe, and is expected to be one of the greatest bottlenecks for future growth of the aviation industry. Under the current policy framework, growth of airport capacity will not be able to keep up with aviation demand growth.

EUROCONTROL (2013b) predicts that by 2035 more than 30 European airports will be congested. These airports are operating at 80% or more of their capacity for more than 3 hours per day. In 2035, around 1.9 million flights (accounting for 12% of the demand) cannot not be accommodated in EUROCONTROL's 'most likely' traffic growth scenario. In Eurocontrol's highest growth scenario, this number rises to 4.4 million flights.

Table 2.1 In the 'most likely' EUROCONTROL scenario 1.9 million flights cannot be accommodated in 2035

Scenario	Unaccommodated flight demand (million flights)
Global Growth	4.4
Regulated Growth ('most likely')	1.9
Happy Localism	1.1
Fragmenting world	0.2

Source: EUROCONTROL (2013a)

Airport capacity shortages will not be spread equally across Europe. The UK, Turkey, Belgium and the Netherlands and a number of Eastern European countries are likely to be most heavily affected.

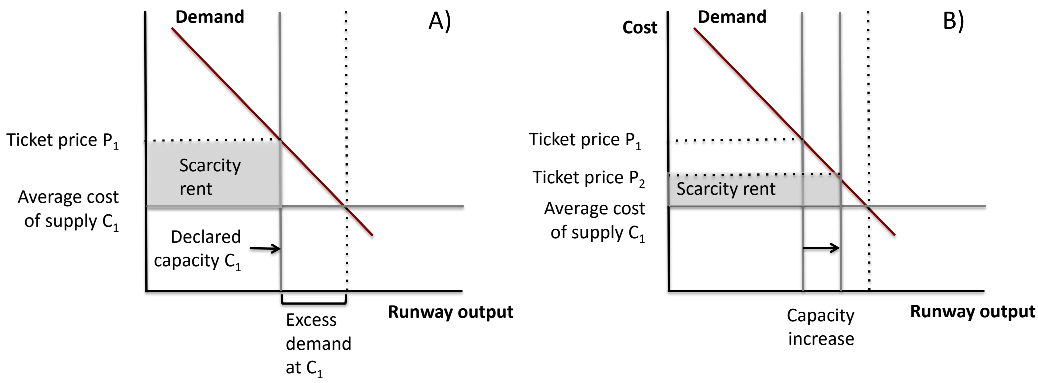
2.2 The impact of capacity constraints on air fares: theory

2.2.1 The theory of scarcity rents

In a situation where demand for airport capacity exceeds the supply of airport capacity, and where the airport is in a position of substantial market power in the passenger market, prices are used to balance the level of demand with the capacity available. If the airport prices efficiently through its airport charges, scarcity will be reflected in higher (peak period) charges, hence in higher costs to the airlines and, in turn and depending on the market situation, in higher fares charged to passengers for travel at peak periods.

But for various reasons - primarily regulatory oversight - congested airports often charge airlines inefficiently low prices (Starkie 2004). Airlines, as profit-maximisers, will maintain fares at market clearing levels even where airport charges are capped at a level below the market clearing rate. This will result in higher fares (Figure 2.1a) than without excess demand. In other words, airlines will charge what the market can bear and will make excess profits on the use of scarce slots (Starkie 1998; CAA 2005). It does not make commercial sense for the airlines to pass on sub-optimally low airport charges in the form of lower fares for passengers – as commercial entities their objective is to maximise return to their shareholders. So airlines have no incentive to compete the low airport costs away (Forsyth 2004; Gillen & Starkie 2016) and the air fares paid by passengers may be no different from a scenario where the airport was not regulated at all.

Figure 2.1 How excess demand generates scarcity rents (A) and how an increase in airport capacity reduces scarcity rents (B)



Source: ITF & SEO 2015; Starkie (1998)

When airport capacity increases and demand remains equal, additional competition will compete scarcity rents away. New airlines will enter the market on new and existing routes and markets become more contestable. As a result, ticket prices will fall, reducing the rent for the airlines to the benefit of the consumer. Surplus is transferred from producers (the airlines) to consumers (the passengers).

Even assuming a specific level of excess demand, such fare premiums due to capacity shortages are not likely to be present in a homogenous way:

- airports/ airlines may face excess demand only at certain times of the day or certain times of the year;
- in certain markets served by airports with excess demand, there may be close substitute alternatives available from other airports in the catchment area for origin-destination passengers. In other markets, such alternatives may not be available. The possibility to exercise a certain degree of market power will possibly be larger in the latter case than in the first one. Hence, competition from adjacent airports with ample capacity limits the airlines' ability to capture scarcity rents.

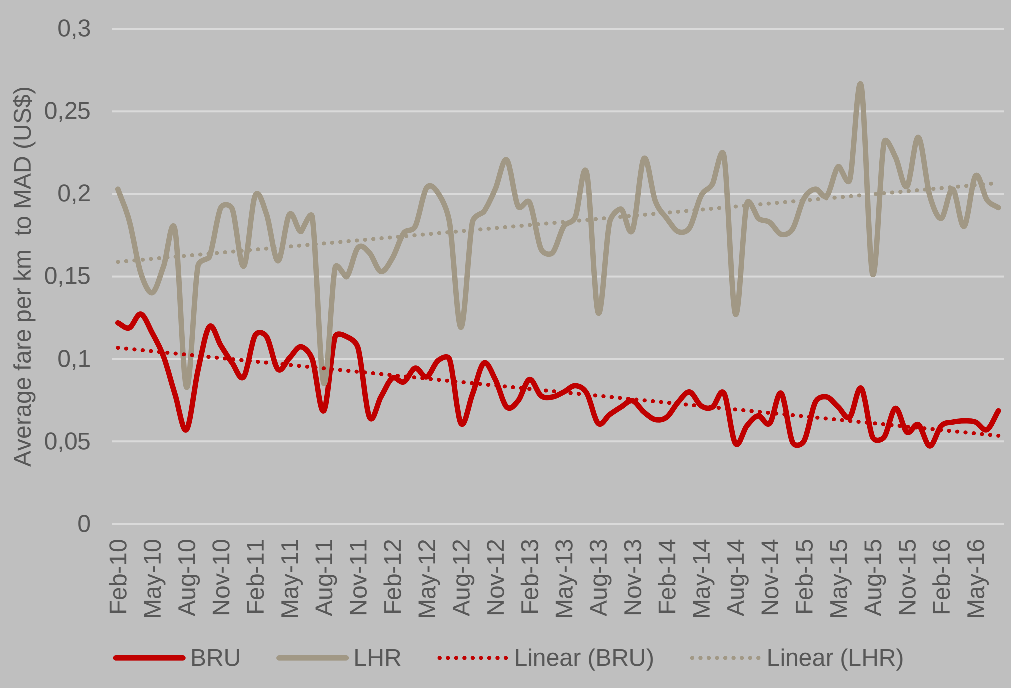
Illustration: fare levels in the Heathrow-Madrid and Brussels-Madrid market

We compare average booked and offered fares on flights to Madrid, from London Heathrow (with severe capacity restrictions) and Brussels (where capacity constraints are less severe). Both markets have similar characteristics. The great circle distance between London and Madrid is 1246 km, slightly shorter than the distance between Brussels and Madrid 1316 km. From Brussels, Iberia, Brussels Airlines, Air Europa and Ryanair together offer little over 10 flights per day. Ryanair also offers flights to Madrid from Charleroi. From London Heathrow, British Airways (BA) is the only active carrier offering more than 12 daily flights on average. However, BA faces competition from other carriers serving Madrid from Gatwick, Luton and Stansted.

Booked fares comparison

Flights from severely capacity constrained London Heathrow to Madrid have a higher average fare per km compared to flights from less capacity congested Brussels to Madrid. Furthermore, the analysis of average booked fares also shows a clear divergence, i.e., average fares are increasing at Heathrow and decreasing at Brussels. In addition, the decline in the average fare per km in August for London Heathrow could be a reflection of the higher volume of business traffic in the market between Heathrow and Madrid. I.e. there is a natural decline in demand for London-Madrid travel in August, which results in lower fares for this month. For those passengers that book shortly in advance, they will not be able to take advantage of lower fares compared to booking more than four weeks in advance, as shown in the analysis on offered fares below. See also the case study on fares from Milan Linate and Malpensa airports in Section 5.5.

Figure 2.2 Average fares to Madrid are higher from London Heathrow than from Brussels



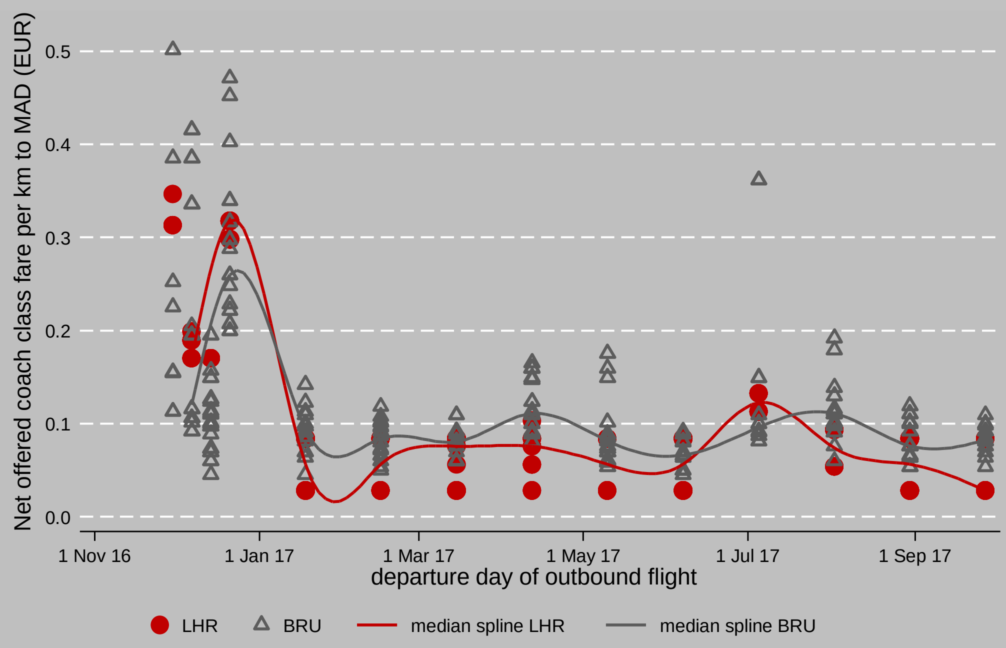
Note: Evolution of average one-way booked fare per km from BRU and LHR to MAD, non-stop direct flights only. 2010-2016. Excluding Ryanair fares from Brussels

Source: SEO & Cranfield analysis based on MIDT

Offered fares comparison

Figure 2.3 shows that offered coach class fares from Brussels are in general slightly higher than from London Heathrow, with respective average fares of € 158 and € 137. However, for flights booked within 4 weeks before departure, average fares from Heathrow are higher: € 293 versus € 264 from Brussels. As it is unknown which of these fares are actually booked, it is not known at which airports highest yields are obtained on the Madrid market. In a case where most passengers book shortly in advance due to the significant volume of business-based demand within the market, yields might be higher at Heathrow, which is supported by the analysis on booked fares as shown above.

Figure 2.3 Average coach class fares are generally higher from Brussels than at Heathrow, except for short-notice bookings



Note: Data collected on 29 November 2016, for flights departing on Wednesdays between 30 November 2016 and 27 September 2017, for a 2 night stay. Excluding Ryanair fares from Brussels. Coach class fares

Source: SEO & Cranfield analysis, QPX Express API

2.2.2 Growing airport capacity shortages has economic consequences

Current and future airport capacity shortages have various economic consequences. Looking at it from a welfare perspective, capacity shortages are likely to:

- result in additional delay costs (time, money) for both passengers and airlines;
- result in foregone user benefits of connectivity growth (i.e., less directly served destinations, lower flight frequencies, longer travel times);
- lead to air fare premiums at congested airports.

From a macro-economic perspective, the airport capacity crunch may result in foregone GDP and employment growth. In a study for ACI EUROPE, InterVISTAS estimates these foregone macro-economic benefits as a result of the capacity crunch for the European economy at 2 million jobs and almost 97 billion of GDP until 2035.

This study focuses on one aspect of the impact of capacity shortages: the impact on air fares. We expect fares to be higher at airports where the demand for capacity exceeds supply, all other things being equal. Capacity shortages may therefore result in negative impacts for society's welfare, as consumers and business pay more for their tickets and not all demand can be satisfied.

2.3 Empirical evidence on scarcity rents

A number of studies provide empirical evidence on the existence of scarcity rents at constrained airports, based on the analysis of actual fare data.[4] Although the majority of studies has been carried out in the US, a few studies demonstrate the presence of scarcity rents at European airports.

Table 2.2 Empirical evidence on scarcity rents, based on econometric analysis

Main findings	Sample	Type of analysis	Source
When airport capacity utilisation changes from an unconstrained to severely constrained level, average fares increase by 18%	Average fare revenue on routes at a selection of European airports	Fixed-effects	PWC (2013)
Due to capacity constraints, fares at Heathrow and Gatwick are 18% and 7% higher than at other London airports.	Average fares on routes at LHR, LGW, AMS, CDG, FRA and MAD	OLS	Frontier (2014)
Fares at some congested airports are significantly higher than at non-congested airports, but not at all congested airports. Fare premium of 3-5% at Chicago O'Hare	Fares on US domestic routes	OLS and 2SLS	Borenstein (1989)
Fares are significantly higher at some slot-controlled airports, but not at all slot-controlled airports	Fares on US domestic routes	OLS	Morrison (2001)
Ticket prices at slot-controlled US airports are 3-4% higher than elsewhere	Fares on US domestic routes	2SLS	Abramowitz & Brown (1994)
Scarce airport facilities augment an airline's pricing power at airports where it has a dominant position	Fares on US domestic routes	Fixed-effects	Evans & Kessides (1993)
Slot constraints lead to higher fares, but less delays	Average fares on US domestic routes	3SLS	Van Dender (2007)
Average yields are significantly higher at US airports with slot controls, gate constraints and high gate utilisation during peak hours	Average yield on top 500 US domestic city-pair markets	2SLS	Dresner et al. (2002)

Source: SEO & Cranfield analysis

The PWC study: 18% fare premium for severely constrained airports

In a study for the UK Airports Commission, PWC (2013) finds that airport capacity constraints are being associated with higher air fares for a selection of European airports. For all routes in the dataset, the study finds that fare revenue per passenger mile increases by 18% when the capacity utilisation increases from a non-constrained level to a severely constrained level (>95% capacity utilisation). PWC (2013) also finds that the fare premium in relative terms is higher at smaller airports than at larger airports. In addition, the study finds that the effect is strongest at airports operating at 99% of their stated runway capacity and less so at airports operating at around 80% of stated capacity. Below 80% of capacity use, the estimated effect on fares becomes stronger again.

4 In addition, many modeling studies *assume* the existence of scarcity rents on a theoretical basis. See for example, CPB (2002), ITF & SEO (2015) and UK Airports Commission (2015).

PWC uses a fixed effects panel data model to estimate the impact of changes in the congestion level on fares, where a value of 1 is applied when the origin airport is operating at above a certain level of its declared capacity and 0 when below this level.

The Frontier study: a 18% premium at Heathrow

In a study commissioned by Heathrow Airport, Frontier investigates the fare premium due to capacity shortages at London Heathrow and London Gatwick. The study finds that fares at Heathrow and Gatwick are respectively 18% and 7% higher than at other London airports. By 2030, assuming an increase in demand, expansion of capacity could reduce fares by 38% at Heathrow and 18% at Gatwick. The study concludes that the capacity constraints at Heathrow mainly affect the fares for long-haul destinations. Short-haul fares at Heathrow are not significantly different from the other London airports. The study explains this difference by the different inter-airport and inter-airline competitive circumstances on short-haul in comparison to long-haul.

Frontier uses an ordinary least squares regression to explain the fares at Heathrow, Gatwick and four other European hub airports (Amsterdam, Paris CDG, Frankfurt and Madrid). The study estimates the fare premium at Heathrow and Gatwick by using airport dummies. The model controls for factors such as distance, type of flight (long-haul/short-haul), frequency, passenger mix (business, VFR), presence of a low-cost carrier and the percentage of transfer traffic.

CAA on Heathrow

The CAA (2005) has argued that airlines operating out of Heathrow in particular gain a significant scarcity rent. It undertook research that showed that revenues from flights to a number of destinations from Heathrow greatly exceeded those from similar flights from Gatwick. It estimated, for example, that a BA short-haul flight operating out of Gatwick would show an additional profit of 2 million GBP per year at Heathrow. According to Starkie (2006), this difference, referred to as the Heathrow premium, does not take account of the higher operating costs experienced at Heathrow. Therefore, the net premium is likely to be less, but probably remains substantial.

Scarcity rents at US airports

In his study on ticket price premiums at US hub airports, Borenstein (1989) assesses the impact of various forms of market power on fares. One of these forms is congestion. Using 2SLS and OLS estimations, Borenstein finds scarcity rents for some congested US hub airports but not for all airports. For example, at Chicago O'Hare, fares were found to be 3-5% higher due to congestion. At some of the congested hub airports, the impact of congestion on fares appeared negative and significant. The study also found a significant fare premium at hub airports, due to the market power arising from hub and route domination of the hub carrier at its hub. Morrison (2001) reaches similar conclusions: air fares are higher at some slot-controlled airports, but not at all slot-controlled airports.

Abramowitz & Brown (1994) find that ticket prices at slot-controlled airports on US domestic routes are 3% to 4% higher than at other airports. In addition, the study finds a significant impact of congestion, defined as the average of the number of operations per runway at the endpoints of the route. In addition, the study shows that the presence of alternative travel options in the

catchment area can mitigate the scarcity rent effect. Also Van Dender (2007) finds that average fares on US domestic trips at slot-controlled airports are higher than at airports without such constraints.
According to Evans & Kessides (1993), fares are mainly affected by barriers that reduce the contestability of the market (airport capacity and airline dominance of an airport) rather than route dominance/concentration. 'The primary impediments to intra- and inter-route mobility within the industry are facilities [..]. Otherwise, aircraft could be easily and costlessly switched among alternate routes rendering them naturally contestable.' Hence, the authors find that scarce airport facilities augment an airline's local monopoly power that arises through dominance of an airport. In contrast with Borenstein (1989), the study finds that the route dominance does not give a carrier pricing power.

Slot values as a reflection of scarcity rents
Slots are traded at a number of European airports. Slot values at constrained airports represent the increase in yield airlines expect from using a constrained airport over other airports. As such, the slot values per passenger should reflect the scarcity rents.

Extensive data on slot values is not publicly available. As Gillen & Starkie (2016, p.158) point out 'airlines engaged in monetary trades at European airports have not been required to disclose the transaction price, but some information has leaked from time to time'. This is in particular true for Heathrow, one of Europe's most constrained major airports.

Using data gathered by CAPA (2013), Gillen & Starkie (2016) conclude that slot values for a pair of slots at Heathrow lie between 5 and 15 million GBP. Frontier (2014, p. 68) converts the slot values into a per passenger figures, using the same CAPA data. Using the high-end number, assuming an investment horizon of 10 years and a discount rate of 10%, Frontier estimates a 12% mark-up on the average Heathrow one-way air fare. Following the same methodology, one would expect a 4% mark-up using the low-end slot values.

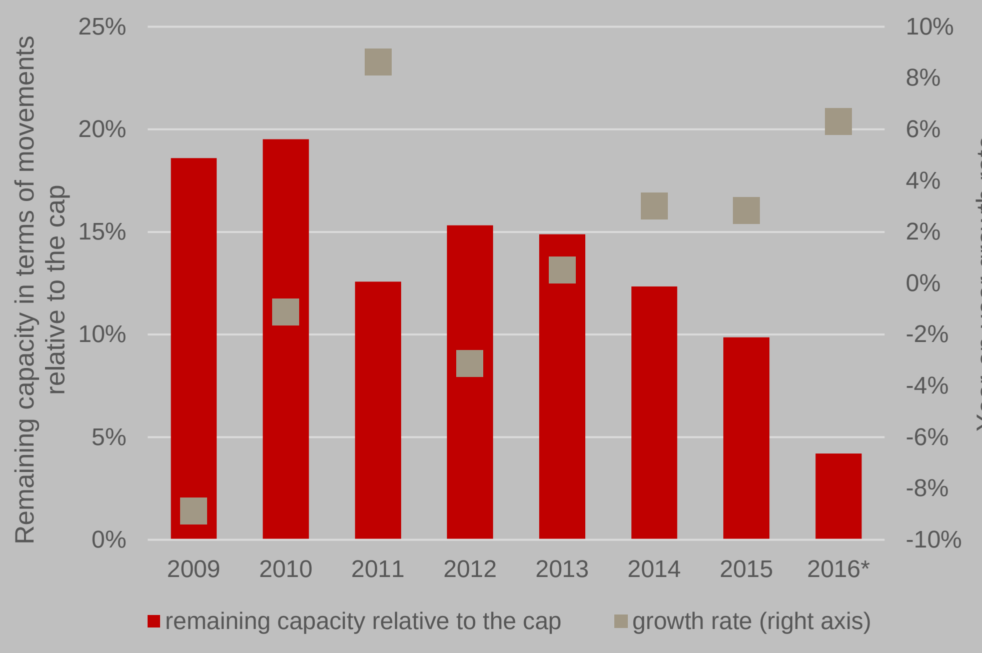
Reflecting increasing demand, slot prices at Heathrow have continued to rise. In early 2015, SAS sold a pair of slots at Heathrow for $60 million. Early 2016 Oman Air purchased a slot pair for US$75 million in a deal with Air France, KLM and Kenya Airways

What happens when an airport nears capacity limitations? The run on slots at Amsterdam

The capacity of Amsterdam Airport Schiphol is capped at 500 thousand movements per year until 2020. The capacity limitation is not caused by infrastructure bottlenecks, but was agreed upon by the relevant stakeholders (Amsterdam Airport Schiphol, KLM, local communities, local governments, and air traffic control). The capacity of 500 thousand movements was forecasted not to be sufficient to accommodate demand for airport capacity until 2020. Therefore, it was agreed that forecasted excess demand for Amsterdam Schiphol would be handled via a system of regional airports, most notably Eindhoven and Lelystad, where (environmental) capacity would be created.

Amsterdam Airport Schiphol is quickly reaching its capacity limitations. The airport is now expected to be fully utilised in 2017. The figure shows that the growth rate of the airport has been accelerating during the past few years. This cannot only be explained by the economic recovery and low fuel prices, as other large Western European hub airports show more moderate growth rates.

Figure 2.4 Growth rate increasing, available capacity quickly declining at Amsterdam Airport Schiphol since 2012



Note: * = preliminary figures for 2016
Source: SEO & Cranfield analysis; Traffic statistics Schiphol Group

The first explanation for this trend is a 'run' on remaining slots at the airport - airlines are trying to acquire new slots in anticipation of the capacity ceiling and in anticipation of scarcity rents due to congestion. Another possible explanatory factor is the decreasing trend in airport charges over the past few years. In 2017, the airport will significantly reduce its tariffs for the third year in a row. It now has the lowest charges in comparison to the other large European airports (SEO 2016). The low charges may have stimulated low cost carrier traffic growth.

Part II: Data collection & econometric analysis

3 Capturing airport capacity constraints

In order to assess the impact of airport capacity constraints on air fares, we first need to measure airport capacity constraints. We use two different indicators to capture airport capacity constraints. The Capacity Utilisation Index (CUI) estimates capacity utilisation based on the average runway utilisation relative to the peak hour capacity. The Movements per Runway (MPR) is defined as the average scheduled throughput per independent runway.

3.1 Two different indicators

Two different indicators were selected to measure airport capacity constraints or better, the level of airport capacity utilisation. The Capacity Utilisation Index (CUI) and the number of Movements per Runway (MPR).

It is challenging to define an accurate capacity utilisation/constraint indicator for a large sample of airports, as an input to an econometric analysis. All indicators have their advantages and disadvantages. Various indicators have been assessed and tested, as Table 3.1 shows. The CUI and MPR were selected as the best indicators for the following reasons:

- the resulting indicators are at a sufficient level of detail to distinguish between different levels of airport capacity utilisation;
- the input data are of sufficient reliability/objectivity;
- data needed to calculate the indicators are publicly available for all airports worldwide;
- the resulting indicators are overall intuitive and explainable at the airport level.

Throughout the main report, the CUI is used as the main capacity constraint indicator. Results using the MPR capacity indicator, as well as information on other indicators considered, can be found in the appendices.

Table 3.1 Comparison of different capacity utilisation indicators on relevant criteria

	IATA slot coordination level	Annual Capacity Utilisation Rate (EUROCONTROL data)	Capacity Utilisation Index (CUI)	Average number of Movements per independent Runway (MPR)
Input data publicly available for all airports worldwide	√	-	√	√
Overall intuitive and explainable results at the airport level	√	-	√	√
Sufficient level of detail	-	√	√	√
Reliability of input data	√	-	√	√
Captures environmental/ ATC constraints	-	√	-	-
Usable for all airport size classes	√	√	√/ -	√
Main drawback(s)	Not enough detail	Absence of harmonised method to determine declared capacity Availability of data too limited.	Overestimates capacity utilisation when airport operates significantly under maximum peak hour capacity during all hours of the year[5]	Sensitive to definition of number of independent runways

Note: See Appendix A for the description of the IATA slot coordination level and Annual Capacity Utilisation Rate, as well as a further quantitative comparison between the indicators
Source: SEO & Cranfield analysis

3.2 Capacity Utilisation Index (CUI)

The Capacity Utilisation Index (CUI) estimates capacity utilisation relative to the 5% busiest peak hour. In other words, we derive an indicator measuring the extent to which an airport operates at the maximum capacity, an approach proposed by Berster et al. (2011).

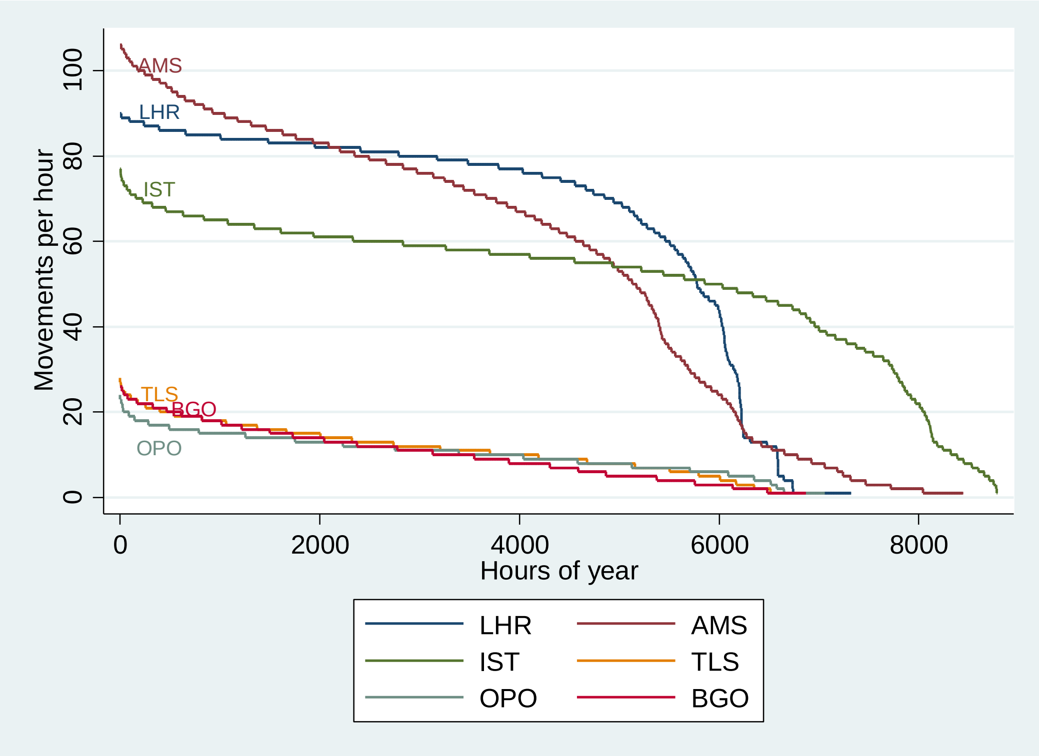
The 5% peak hour capacity of an airport is derived as follows: all the operational hours of an airport on a monthly basis are ranked in terms of the total number of flight movements, where the 1st hour is the busiest hour of the year. The 5% peak hour capacity is then defined as the capacity in the 5% busiest hour, or in other words the 95th percentile of the hourly frequency in one operational year. In order to prevent miscalculations due to limited capacity and demand during night hours, only the 16 busiest operational hours of each day are considered (see example calculations in Appendix B).

Figure 3.1 shows the traffic ranking curves of the largest and smallest European airports with over 70,000 annual movements, the three largest being London Heathrow, Amsterdam Schiphol, Istanbul Atatürk and the three smallest Toulouse, Porto and Bergen airports. Particularly for larger airports, the steepness of the traffic-ranking curve provides a good indication of the capacity utilisation of the airport. The curves for London Heathrow and Istanbul are much flatter

5 However, in practice lower CUI indicators were found for smaller and uncongested airports in the sample, indicating that this theoretical caveat did not adversely impact the indicator values, nor the results of the model.

than the curve for Amsterdam, indicating that the airport operates near maximum capacity more often throughout the year. For smaller (non-hub) airports without capacity constraints, the 5% peak hour capacity is often lower than its actual peak hour capacity, as its maximum capacity is never reached.

Figure 3.1 Operation of largest and smallest airports[6] relative to their peak hour capacity



Source: Official Airline Guide (OAG); own calculations

The Capacity Utilisation Index (CUI) is defined as the average number of movements per hour divided by the 5% peak hour capacity. This indicates the extent to which an airport operates at maximum capacity. The CUI can be calculated at an annual basis as well as at a monthly basis. For the econometric analysis, monthly data have been used.

3.3 Average number of aircraft movements per runway (MPR)

A secondary indicator was constructed, which reflected the average number of aircraft movements per independent runway for each airport in the sample. See Appendix A for more details on this indicator.

6 For airports with more than 70 thousand aircraft movements per year

4 Capturing air fare data

Two sources of data have been used in this report. Booked fare data captures air fare data at the route level, based on realised passenger bookings. This data is used to determine whether airlines are able to extract higher revenues at more congested airports and to quantify to what degree. Offered fare data has been collected using web scraping, and contains more detailed offered air fares for particular travel itineraries. This data has been used to gain a deeper understanding as to the mechanism by which scarcity rents are collected. Offered fare data has been used in various case studies.

4.1 Booked fares and offered fares

4.1.1 Booked fares

Average monthly booked fares for specific pairs of origin and destination airports were derived from the Marketing Information Data Transfer (MIDT) dataset, as provided by OAG Traffic Analyser. Each average booked fare in the dataset also contains information on the published airline, as well as the points of origin and destination. The dataset also details connecting airports (if any, up to two intermediate stops) and the number of passengers. The average fare paid does not include additional charges or ancillary revenues.

The original sources of information for the MIDT dataset are Global Distributions Systems (GDSs) such as Galileo, Sabre, and Amadeus. According to ARG (2013), 44% of all bookings of major airlines were processed through GDSs in 2012. The proportion is 55% for network airlines, while low-cost carriers, that prefer direct sales, only sell 16% of their bookings through GDSs. In order to correct for that, the data provider (OAG Traffic Analyser) adjusts the market figures using mathematical algorithms based on frequencies and supplied seats in each flight sector. The reliability of these adjustments has been confirmed by Suau-Sanchez et al. (2016). Adjusted passenger bookings coverage is 100% of the market. Passenger ticket price coverage is around 40% of the market. Although data coverage for ticket prices is more limited, the large number of observations still allows for a reliable analysis of the impact of airport capacity constraints on air fares.

Our analysis on booked fares has been carried out for the year 2014, using fare data recorded on a monthly basis. The dataset covers all passenger flows between the airports as provided in Table 4.1. To ensure the quality of the sample used for the econometric analysis, we deleted bookings with zero values in the total average fare (i.e., bookings that had missing information on fares), and by removing the top and bottom 5% of fares to remove unrealistic values.

Table 4.1 presents the descriptive statistics for the final dataset used in the econometric analysis. The dataset consists of 64,055 city pairs, with on average 3,554 monthly passenger bookings, varying between 2 and 74,942 bookings per month. The total average fare varies between $ 70 and $ 1086, with an average of $ 319. The total average fare is the sum of the average net one-way fare for each booking class (discount, full economy, premium economy, business and first) weighted by the passenger bookings in each class. Therefore, it is possible that minimum and maximum values for full economy (Y) and for business class, that are later reported, are lower and higher than the minimum and maximum values in the total average fare. Figure 4.1 presents the frequency distribution of total average fare values.

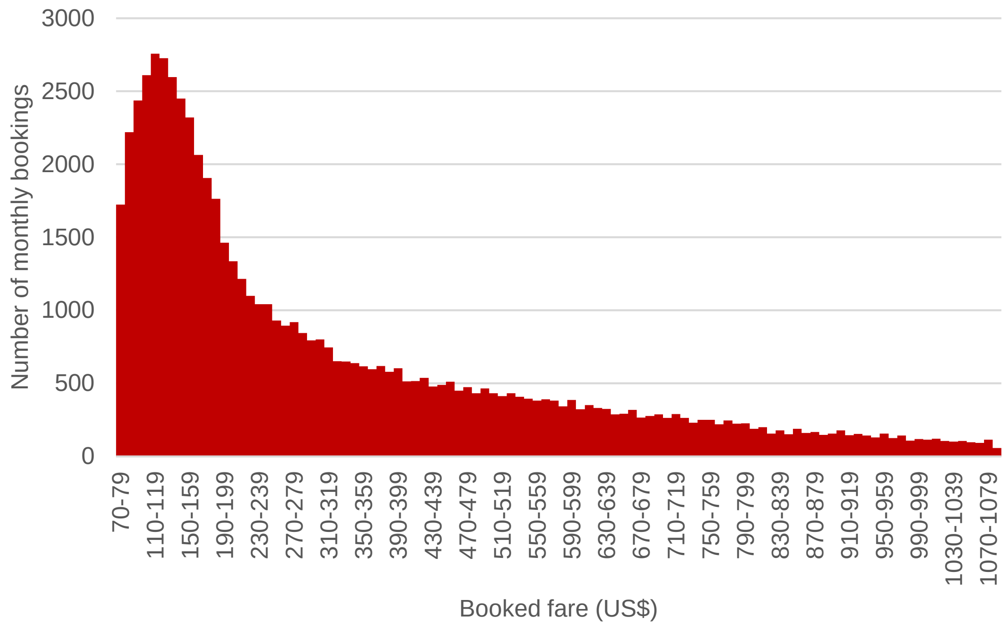
Table 4.1 The final dataset consists of over 60 thousand observations of booked fares

	N	Minimum*	Maximum*	Mean	Std. Deviation
Bookings	64,055	2	74,942	3,554.43	6,311.12
Total average fare (US$)	64,055	70	1,086	319.42	241.06

Note: * = minimum and maximum number of bookings per month; lowest and highest average fare per month

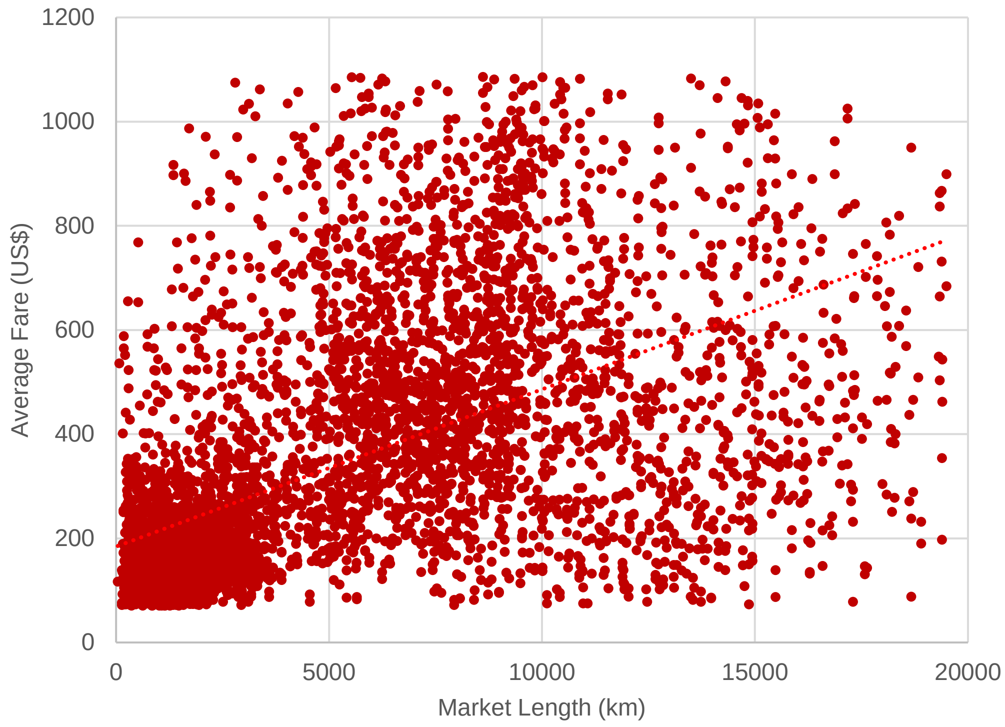
Source: SEO & Cranfield analysis based on MIDT

Figure 4.1 The fare distribution of the booked fare sample has a long tail of higher fares



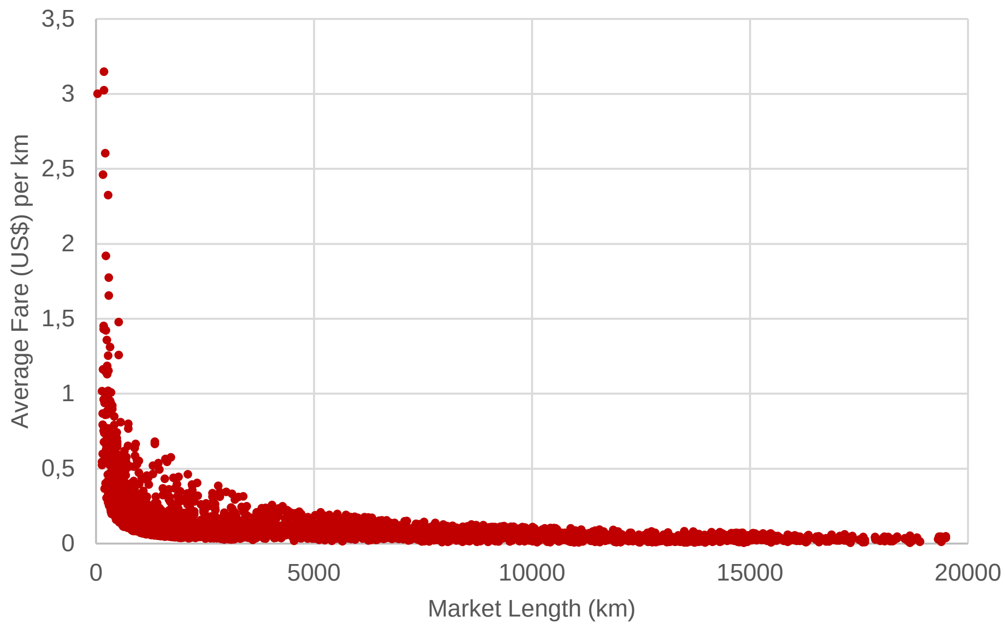
Source: SEO & Cranfield analysis based on MIDT

Figure 4.2 Fare and stage length are positively correlated



Note: Data for July, 2014
Source: SEO & Cranfield analysis based on MIDT

Figure 4.3 Average fare per km increases for shorter trip lengths



Note: Data for July, 2014
Source: SEO & Cranfield analysis based on MIDT

4.1.2 Offered fares

Offered fare data have been used for case study analysis and to investigate the mechanisms through which scarcity rents may arise.

Offered fares were collected using Google's QPX Express travel APIs (Application Programming Interface). This source enables the extraction of a rich set of fare data, which can be collected at a large scale. The QPX Express API provides fare data for a large number of currently available travel alternatives (up to 100 for a single origin-destination market on a single day in a single class). Each alternative contains an extensive itinerary description, including the airline, intermediate (transfer) airports (if any), departure/arrival times and connection times. In addition, a detailed fare breakdown is provided, into base fares, carrier surcharges and taxes.

Offered fare data were collected in two rounds (see Appendix G). In the first round, fares were collected for 3,881 city pairs, for three departure dates in October, November and December 2016. In the second round, fares for a smaller number of city pairs were collected for a larger number of different departure dates, to obtain more insight in the development of air fares throughout the booking period. In the second round, only coach class fares were collected.

A description of the data collection procedure of offered fares can be found in Appendix F.

4.2 Identification of sample of markets

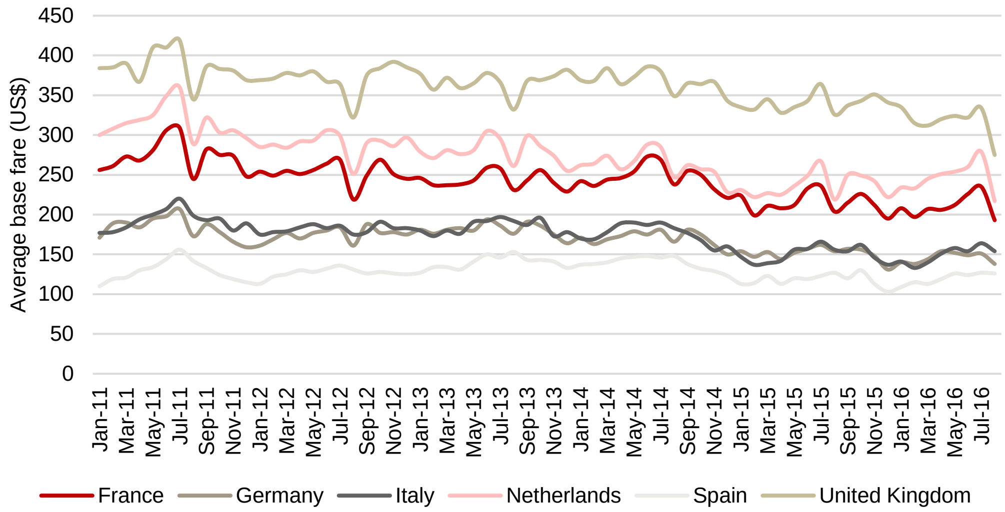
Since there is a practically infinite amount of data that can be collected from various sources, we need to bound the collection procedure to a representative sample. The main focus of the project is on capacity constraints in Europe, therefore the sample consists of a selection of markets between origin airports in Europe and a set of destination airports (European and non-European) for both booked and offered fares.

A selection of 38 European origin airports was made, assuring sufficient dispersion in terms of capacity constraints. For each of these origin airports, both booked and offered air fares were collected to 103 destination airports. This results in a total of 3,881 airport pairs. A full list of origin and destination airports is available in Appendix H. The same sample was used for the initial collection of offered fares data.

4.3 General observations: booked fares

Average one-way booked fares vary dramatically across some of the most important European air transport markets (Figure 4.4). The average booked fare is significantly more expensive for the British and Dutch consumers than for the Italians and Spanish. This partly has to do with differences in route composition, but also with structural difference in the fare per km paid. While base fares show a downward trend, the booked fare data does not include additional charges for use of credit cards, checking at the airport, checked in baggage etc., which have multiplied over the past decade. Therefore, the trend in terms of the net cost of air travel remains unclear from the data.

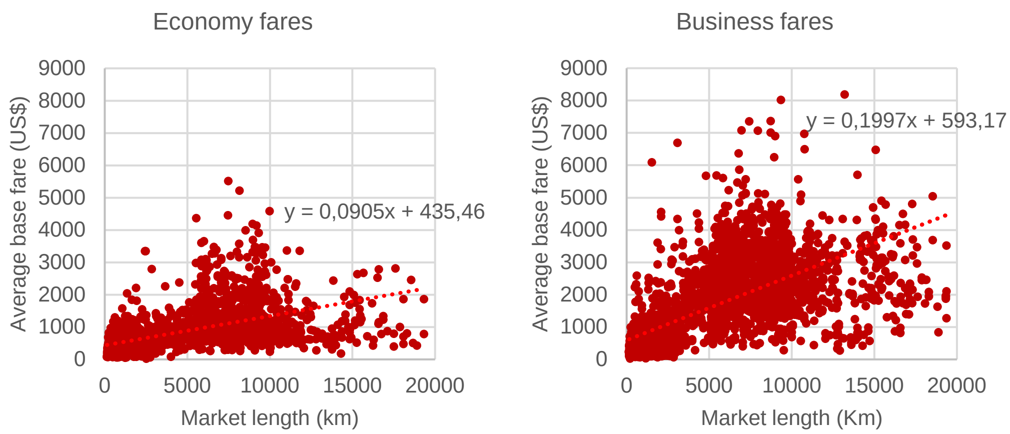
Figure 4.4 Average booked fares vary across the most important European air transport markets



Source: SEO & Cranfield analysis based on MIDT

Figure 4.5 compares average economy and business fares by market length from all routes in the six European markets. We can observe significant differences between average economy and business fares when we consider route distance. Some trends can be easily identified. Firstly, it is widely acknowledged that yields decrease with route distance (Figure 4.3). This is true for both economy and business fares.[7] However, the impact of distance on price is stronger for business fares, showing the inelasticity of business travellers. Secondly, the dispersion of prices is especially stronger on routes longer than 5,000 km. This is particularly true for business fares. The higher dispersion of prices for longer distances could be due to a larger diversity of travel options (i.e., direct versus indirect travel options) and a larger diversity of origin-destination markets with different degrees of airline competition within each.

Figure 4.5 Large differences are observed between average economy and business base fares



Note: Data for July 2014
Source: SEO & Cranfield Analysis based on MIDT.

[7] However margins are greater for long-haul flights, as costs are also more than proportionally lower.

4.4 General observations: offered fares

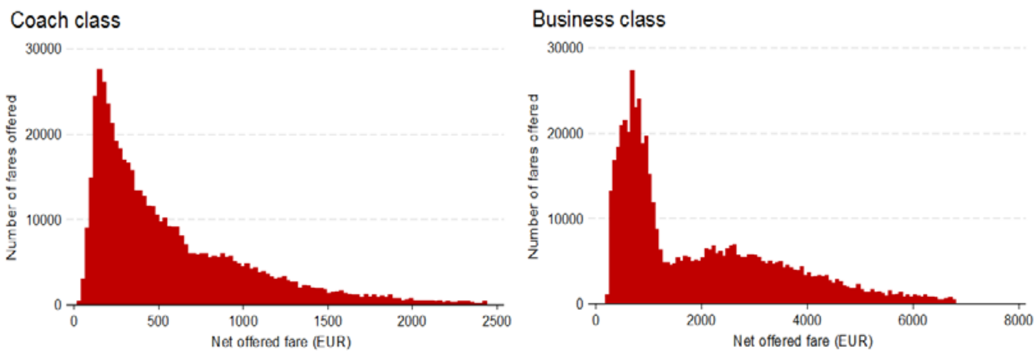
A first analysis of offered fares shows a strong price dispersion, varying between € 17 and € 6,802, depending on cabin class, route distance and type, carriers and departure or arrival times (Table 4.2). Offered business class fares are on average over three times as expensive as coach class fares.

Table 4.2 Net offered fares vary substantially

Net return fares in EUR (excluding passenger based taxes)					
Cabin class	**N**	**Mean (EUR)**	**Std. Dev. (EUR)**	**Minimum (EUR)**	**Maximum (EUR)**
Coach	541,705	572.38	464.25	16.51	2,439.28
Business	5,52,870	1,972.49	1,538.02	114.00	6,802.00
Total	1,094,575	1,279.58	1,338.47	16.51	6,802.00

Source: SEO & Cranfield analysis

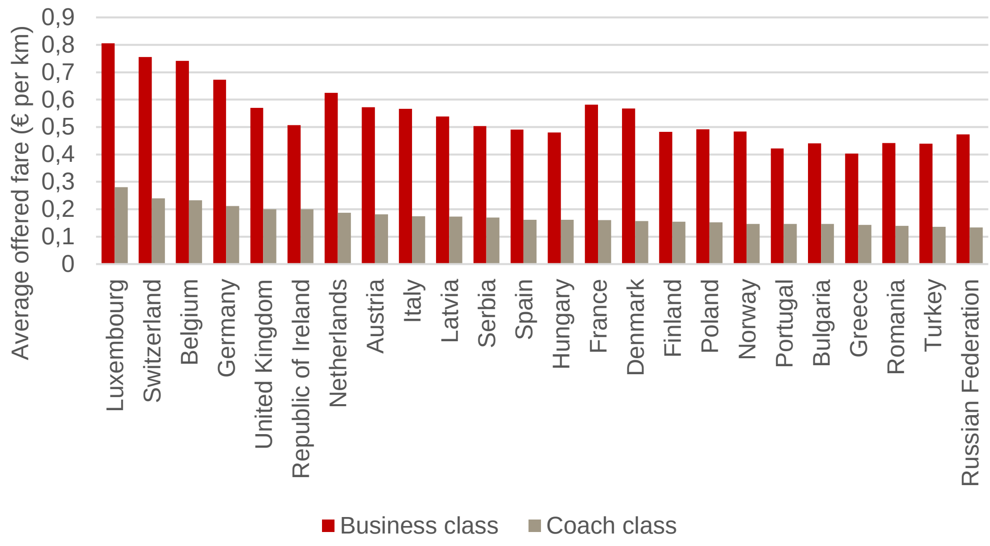
Figure 4.6 Fare distributions of coach and business class have a long tail of high fares



Source: SEO & Cranfield analysis

Looking at average return fares offered from airports per individual country, relatively high fares are observed for Luxembourg, Switzerland and Belgium, while offered fares appear to be relatively low in Turkey and Russia (Figure 4.7). The majority of air fares offered from the different countries lies between € 0.15 and € 0.20 per km for coach class, and between € 0.40 and € 0.70 for business class fares.

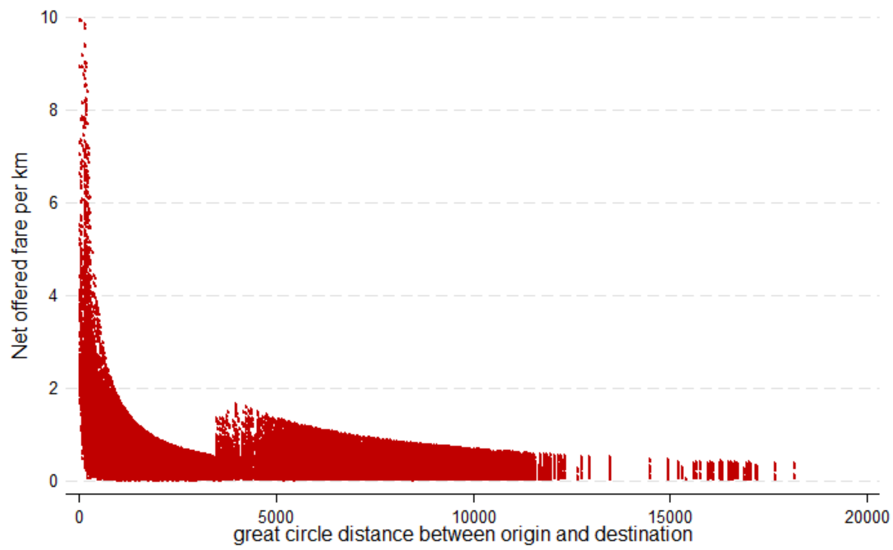
Figure 4.7 Average offered fares vary over the different countries



Source: SEO & Cranfield analysis

The relationship found between distance and offered fares is similar to the observed correspondence between booked fares and distance, as showed in Figure 4.8. Fares increase with distance. However, the relationship is not linear. The relative impact of distance upon air fares decreases for longer flights.

Figure 4.8 The relationship between fare per km and distance is not linear



Source: SEO & Cranfield analysis

5 Empirical analysis

This chapter presents empirical evidence of the impact of capacity constraints on air fares. Using a random effects Generalised Least Squares (GLS) model, we find that a 10% higher airport congestion level is associated with a 1.4%-2.2% increase in air fares. Effects are stronger in non-liberalised markets than in liberalised markets. In addition to the impact of airport capacity scarcity, we observe that distance, fuel price, travelling from a hub airport, GDP per capita and population also have an upward impact on fares for the overall sample. On the other hand, fares tend to be lower on markets with low-cost carrier presence.

5.1 Air fare determinants

Many different factors influence average air fare levels. Variables include route distance, presence of low-cost carriers, (potential) competition, fuel price, capacity constraints and market demand. Constrained airport capacity is one of the many variables that influence fare level.

A rich body of literature has emerged in the past decade on the factors that influence air fares. Most of the studies relate to the US market, where reliable fare data is publicly available. We will not discuss the findings from these studies in detail here, but we refer to the overview by Tretheway and Kincaid in the Journal of Air Law and Commerce (2005). The main factors that influence air fares and their expected signs are summarised in Table 5.1.

Table 5.1 Literature on the determinants of air fares is widespread

	Expected sign	Variables	Remarks
Supply side factors			
Concentration of airlines within city pair market (competition)	+/0	HHI, number of airlines, share of dominant carrier	The relevance of route concentration for explaining fares has been contested. Threat of potential entry/absence of barriers to entry may be more important (Evans & Kessides 1993). Nowadays, impact of full-service competition on fares may be limited, while the impact of low-cost carriers on fares is dramatic (Brueckner et al. 2013; InterVISTAS 2014b).
Concentration of airlines at origin and destination airports	+/0	HHI at endpoints airports, share of dominant airline	Early studies failed to correct for traffic and route mix, carrier identity, service quality, costs associated with hub systems and scarcity of capacity. Later studies found lower hub premiums or even absence of hub premiums when LCCs dominate an airport (Lee & Luengo-Prado (2005)).
Low-cost carrier presence	-	Carrier dummies, carrier market shares	Impact not only on the route the LCC serves, but also on parallel routes. Potential competition also affects fares.

Airport capacity constraints	+	Dummies for slot-controlled airports, variables using airport capacity utilisation	See Section 2.3.
Nature of the connection	-	Dummy for non-stop versus indirect (transfer) connection	
Hub status	+	Airport is used as an airline hub	
Flight frequency	+/-	Average frequency per week	
Aircraft size	+/-	Average number of seats per flight	
Demand side factors			
City pair market demand	-	(Instrumented) number of bookings, passengers	Most studies do not take into account market demand, but use a reduced-form equation
Strength of the market		GDP/capita	
Traffic mix in the market		Dummy for tourism destination, weather variables, share of business travel	
Airline cost factors			
Distance	+	Distance	
Fuel costs	+	Average fuel price	
Airport charges and taxes	+/-	Aeronautical charges per passenger	Depending on market and presence of scarcity rents. See Section 5.6.
Carrier-specific identity/ unit cost differences	+/-	Dummies for specific carriers	

Source: Abramowitz & Brown (1993); Borenstein (1989); Brueckner et al. (2013); Chi & Koo (2009); Dresner et al. (2002); Evans & Kessides (1993); Evans et al. (1993); Frontier (2015); InterVISTAS (2014); Lee & Luengo-Prado (2005); Morrison & Winston (1990); Morrison (2001); PWC (2014); Vowles (2000); Windle & Dresner (1995); Zhang et al. (2014)

5.2 Variable definition

In order to provide accurate estimates of the impacts of capacity constraints on air fares, we should control for other factors influencing air fares. Based on the preceding literature review, we defined the control variables as presented in Table 5.2.

Table 5.2 Control variables used in the regressions

Variable	Definition	Source
$Fare_{ij,t}$	The average dollars paid for the base fare of the selected $i - j$ route in a specific month t. Include all passenger classes.	MIDT
$HHI\ route_{ij,t}$	Herfindahl-Hirschman Index of the selected $i - j$ route in a specific month t. The index is based on booking numbers. Direct and indirect connections are included as possible alternatives. Airlines belonging to the same alliance are considered as a unique entity. The variable controls for competition at route level.	MIDT – Own computation
$HHI\ airport_{ij,t}$	Sum of the Herfindahl-Hirschman Index at airports i and j in a specific month t. The index is computed considering the booking numbers per airline in the specific airport. The variable controls for competition at airport level.	MIDT – Own computation
GDP_{ij}	Sum of the GDP per capita in the countries i and j	World Bank
$Population_{ij}$	Sum of the populations of urban areas around airport i and j. The population around airport i is computed by the sum of population in urban areas in a range of 100 km around the airport.	United Nations
$Fuel_t$	Euro price per gallon for A1 Jet fuel in the specific month t.	Index Mundi
$Distance_{ij}$	The great circle distance in km between i and j. Note that this does not include the possible additional flying distance when transferring at a hub airport.	Own computation
$Congestion_{ij,t}$	Sum of the Capacity Utilisation Index at airports i and j in a specific month t.	Own computation
Hub_{ij}	Dummy variable with unity value when at least i or j is a hub airport.[8]	Own computation
$LCC_{ij,t}$	Dummy variable with unity value when a low cost airline operates the $i - j$ route.	Own computation
$Dummies_t$	A set of monthly dummies to capture seasonality effects	

Note: Airport charges per passenger were not available for the full sample
Source: SEO & Cranfield analysis

The Heathrow example

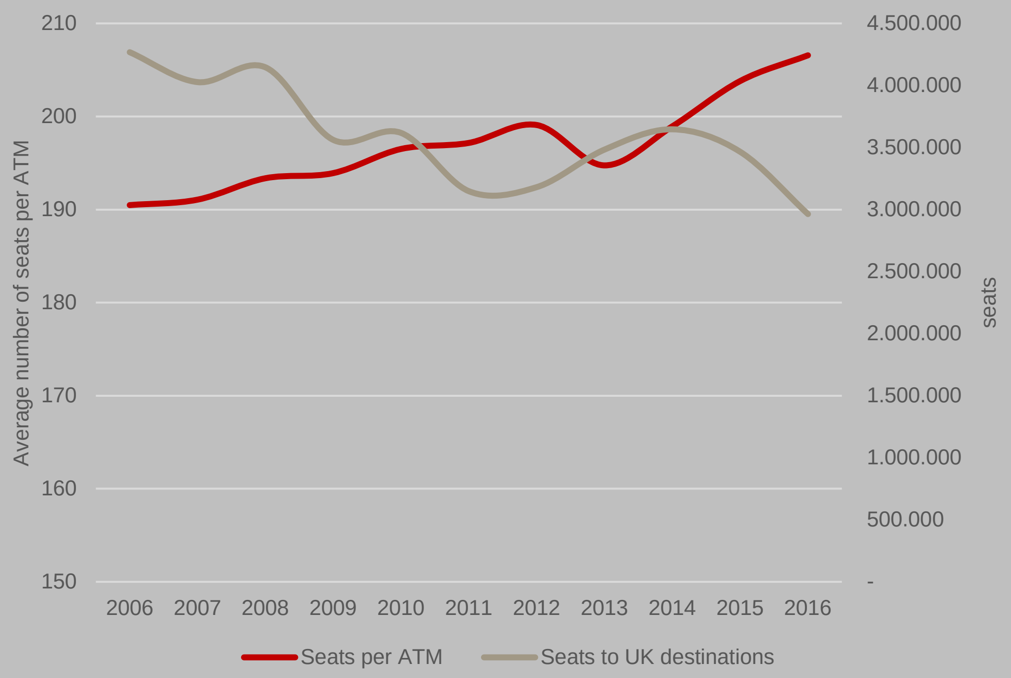
London Heathrow has been capacity constrained for many years. It is also an airport that is very popular as many airlines are drawn by the strength of the local passenger market and the higher yields that are generally secured. Higher airline yields are therefore both a cause and consequence of airport capacity. The capacity constraint has, over time, changed the composition of Heathrow's market as there has been a gradual displacement of regional domestic flights by connections to long-haul destinations as a result of the 'crowding out effects' of capacity scarcity (Figure 5.1) and in part incentivised by the structure of airport charges. Hence, scarce slots have increasingly been deployed on more profitable long-haul services.

8 An airport is categorised as 'hub' if it is a home base of at least one network carrier offering transfer connections via this airport.

As the volume of available slots decreases, especially those for peak hours, airlines are left to acquire slots on the secondary market. Since 2006, more Heathrow slots have been traded than have been allocated to airlines from the slot pool. Slot transfers experienced the most recent peak in 2013 (CAPA, 2016). The increasing volume of secondary trading in slots and the rising prices paid by airlines for access to the London Heathrow market shows the attractiveness of this market to airlines, due to the higher yields that can be extracted.

Other studies have also looked into the 'market leakage' consequences of limited capacity at London-Heathrow in the context of strong competition for connecting traffic. In this regard, the Independent Transport Commission (ITC, 2013) and Suau-Sanchez et al. (2016) highlighted increasing use by UK regional passengers of hubs other than London Heathrow to access international destinations (e.g. Amsterdam, Paris, Dublin, Dubai).

Figure 5.1 Evolution of average the number of seats per flight and UK seats to UK regional destinations served from London-Heathrow.

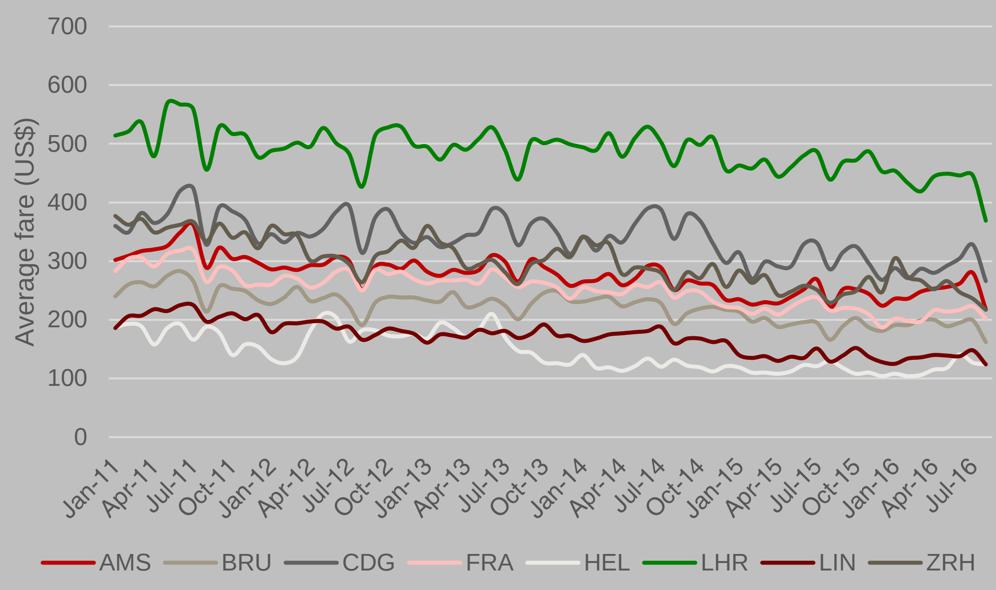


Source: SEO & Cranfield analysis based on OAG

Total booked base fares at London Heathrow are higher than at a selection of other large European airports. The difference has remained over time (Figure 5.2). This reflects higher fares per km, but also a route portfolio increasingly focussed on long haul markets.

Base fares show a decreasing trend over time. It must be borne in mind that this data excludes additional taxes and charges, and ancillary charges such as fuel surcharges. Therefore, any wider downward trend in base fares may not have resulted in lower overall net fares for European passengers.

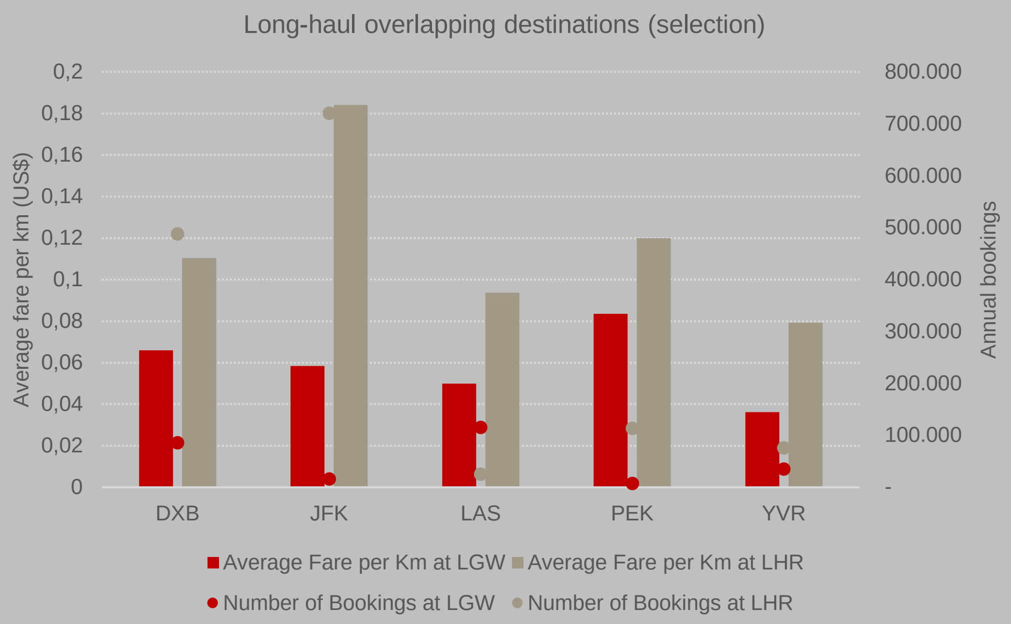
Figure 5.2 Evolution of average base fare at selected airports, 2011-2016

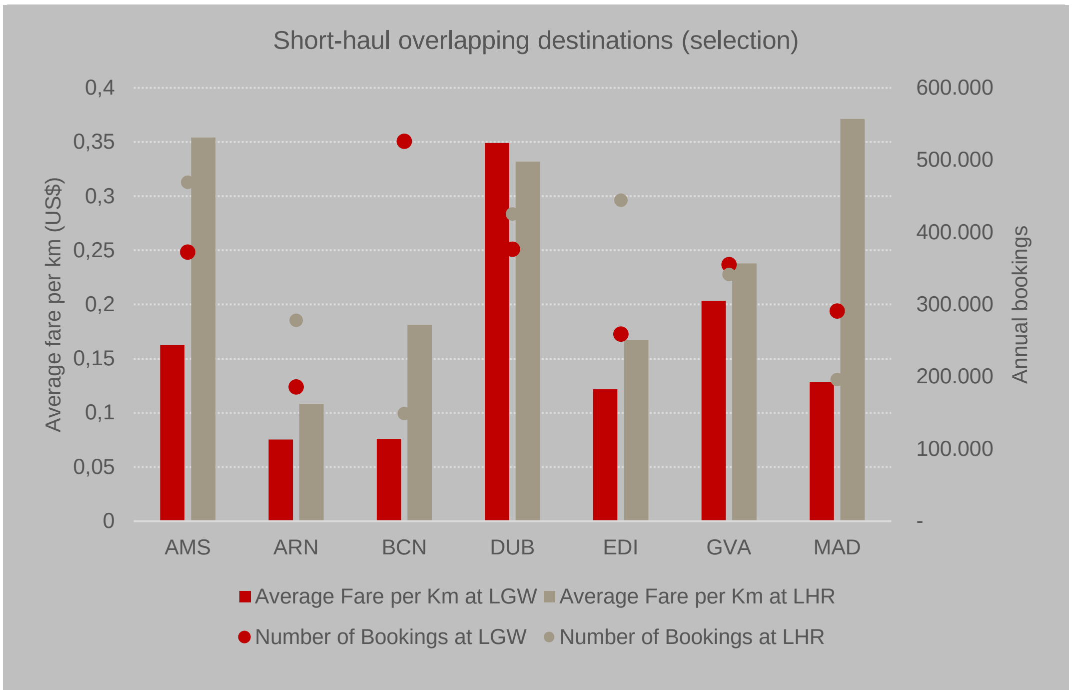


Source: SEO & Cranfield analysis based on MIDT

A further detailed analysis comparing average base fare per km by destination at London-Heathrow and London Gatwick reveals that in most of the cases, Heathrow passengers are paying a premium to reach the same destinations (Figure 5.3). Nevertheless, passenger numbers demonstrate that there is still strong demand for Heathrow, in spite of the higher fares.

Figure 5.3 Destination overlapping between Heathrow and Gatwick, fares and booking values for non-stop direct flights, 2014





Source: SEO & Cranfield analysis based on MIDT

5.3 Econometric analysis

To estimate the impact of airport capacity constraints on air fares, we undertake an econometric analysis on booked fares. Analysis on booked fare data was preferred over analysis on offered fare data. For offered fares it cannot be inferred which tickets were actually sold at what price on each flight. Following the basic principles of revenue management, airlines look for opportunities to charge higher fares and take advantage of high demand, better product, convenience of the airport, convenience for business travellers etc., and differentiate fares either by time of day, day of week or number of days to departure level. Sticking to these principles, airlines at congested airports can fill their aircraft in such a way that maximises possible revenues, compared to the wide range of possible ways of filling their aircraft with different passenger types. Essentially, the airlines can target those passengers who are most willing/able to pay. Given the 'crowding out' mechanism by which scarcity rents are accrued (see section 5.4) it is necessary to identify the distribution of tickets on flights to capture the scarcity rents in any econometric model. In addition, any econometric model based on offered fares would not be able to control for demand levels between the origin and destination, as offered fares are collected for future points in time.[9] Nevertheless, the offered fare data offer additional detail, which allowed a more precise identification of the mechanism by which scarcity rents are accrued – see Section 5.4.

5.3.1 Model specification

When using a basic estimation framework, the simultaneous inclusion of fare and demand into the regression causes an endogeneity problem (specifically, a reverse causality problem). The

[9] For completeness, a regression was also run on offered fares. As expected, this regression does not show evidence of scarcity rents, as demand distribution over the offered fares cannot be taken into account.

reciprocity between fare and demand can be taken into account using a simultaneous estimation approach (e.g. 2SLS, 3SLS) or applying a so-called reduced form. Given the scope of this research (i.e. no interest in fare elasticities) and the difficulties of identifying variables of sufficient quality, the latter approach is applied.

We consider as observations the existing services connecting two airports i and j in specific month t, where we can estimate an econometric model to analyse the effects of congestion on the fare levels. Our equation re-samples a reduced form where no endogenous variables appear as independent (i.e. right-hand side). We estimate the equation applying a random effects model and a clustering of the standard errors for the origin-destination pairs (i.e. solving for heteroscedasticity and autocorrelation). All the variables, with the exception of the dummies, are transformed in natural logarithms.

$$\begin{aligned}\ln(Fare_{ij,t}) = Constant + \ & \beta_1 \ln(HHI\ route_{ij,t}) \\ & + \beta_2 \ln(HHI\ airport_{ij,t}) + \beta_3 \ln(GDP_{ij}) + \beta_4 \ln(Population_{ij}) \\ & + \beta_5 \ln(Fuel_t) + \beta_6 \ln(Distance_{ij}) \\ & + \beta_7 \ln(Congestion_{ij,t}) + \beta_8 Internal_{ij} + \beta_9 Hub_{ij} + \beta_{10} LCC_{ij,t} \\ & + \beta_n Dummies_t + \varepsilon_{ij,t}\end{aligned} \tag{1}$$

Where variables follow the definition as specified in section 5.2. Descriptive statistics for the dependent variable are available in Table 4.1.

We estimate separate models for (i) liberalised markets and (ii) non-liberalised markets using the CUI as the constraint variable. The separate models reflect the fact that market dynamics are likely to be quite different in liberalised versus non-liberalised markets, with underlying demand and flexible supply being a much stronger determinant of price levels in the former, and less so in the latter. This chapter presents the results for the two core models using the CUI. For completeness, a model for the full sample is also estimated. Specifications of the models are similar, with the only difference being the inclusion of an $Internal$ dummy variable for the full sample model.

All models can be found in Appendix E. The same findings hold true for the results with MPR as the constraint variable, which yields similar results as the models using the CUI as the constraint variable.

5.3.2 Caveats

Whilst they do not affect the validity of our results, we acknowledge the following list of caveats:

- Our fare data observations represent monthly averages by origin-destination market. The use of averages avoids excessive fluctuations in ticket prices. In the context of this study, this does present us with some limitations. We believe that, if scarcity rents exist, they may be present at specific times of the day, on particular days of the week or even specific moments of the year. Therefore, the use of monthly data will disguise these effects, which could present us with a discrimination problem.

- Fare data are averaged by origin-destination market and are not differentiated by direct and indirect itineraries. Therefore, the distance variable does not account for the possible additional flying distance when transferring at a hub airport, but it reflects the great circle distance between initial origin and final destination.
- Data on GDP/capita and population are yearly values (i.e. no change between months) hence lowering model estimation performance. Nonetheless, changes in macroeconomic variables between months are not significant.
- Fuel is represented by the average spot market prices for a specific month. We assume an equal fuel price across different airlines and airports (i.e., we do not take into account the practice by airlines of fuel hedging).
- It is also likely that the relationship between airport constraints and air fares differs significantly from airport to airport, and may not be linear. For example in theory an airport could reach a CUI of 1 (indicating that the airport was 100% constrained) yet continued increases in underlying demand would result in a continued rise in air fares, even if the CUI remained constant at is maximum level. No airports in the sample are in such circumstances – nevertheless the linear relationship identified in the model should be used to assess overall relationships between capacity constraints and air fares across the sample, and not at the level of individual airports. See also the box in section 5.3.1, which examines a non-linear relationship between air fares and airport capacity. Appendix E shows the non-linear specification of the model.

5.3.3 Model results

Table 5.3 shows the regression results for the two models (liberalised and non-liberalised markets), using CUI as the congestion variable. The overall R^2 for the two samples are 0.4022 and 0.3461 respectively, which indicates that the models have sufficient explanatory power (goodness-of-fit). Most of the coefficients are significant and have the expected sign.

Our estimation shows that congestion has a positive impact on fares in both samples. An increase of 1% in the CUI variable (i.e. airport congestion) increases the fare by 0.14% in the liberalised sample and by 0.22% in the non-liberalised sample.[10]

As expected, the sign of low-cost carrier presence is negative. The impact of low-cost on non-liberalised (mainly long-haul markets) is not significant, probably as a result of the lack of substantial low-cost presence currently operating long-haul and in particular operating long haul to non-liberalised markets. As expected, hub status, an increase in fuel price, distance, GDP per capita and population have a positive impact on fare. For the full sample, results show that consumers travelling in liberalised markets benefit from lower fares than in non-liberalised markets, reflecting market contestability.

10 PWC found that fare revenue per passenger mile was 18% higher for severely constrained airports. Frontier found that prices at Heathrow are on average 18% higher than at other London airports. We note that these results cannot be compared with ours. Firstly, the definition of the capacity constraint variables is different, secondly different models are applied and thirdly, both studies work with (much) smaller airport samples and are not representative for the entire European market. In this respect, our results are more in line with the premiums found in studies for the entire US market, although some of the same remarks with respect to comparability apply.

Table 5.3 Estimation results using CUI as congestion variable

	Liberalised markets ('internal')		Non-liberalised markets ('external')	
Internal				
Hub	0.0015		0.1812	***
LCC	-0.0407	***	-0.0593	
Fuel	0.1034		0.1659	***
distance	0.2972	***	0.4080	***
HHIroute	0.0205		-0.0541	***
HHIairport	0.0139		-0.0297	***
CUI	**0.1367**	**	**0.2214**	***
GDP	0.3790	***	0.1680	***
POP	0.1555	***	0.0927	***
Time effects	yes		yes	
Constant	-3.7660	***	-1.4810	***
Number of observations	38,966		25,089	
R-squared (overall)	0.4022		0.3461	

Legend: ***: p<0.01; **: p<0.05; *: p<0.1
Source: SEO & Cranfield analysis

Table 5.4 and Table 5.5 show a set of examples of the impact of changes in CUI levels on air fares. The examples are reported for airport pairs with different hypothetical levels of congestion. We firstly assume a CUI change in only one of the two airports. Note that the impact on the fare is estimated at the sample mean (i.e., holding everything else constant). Considering the average route in the liberalised sample connecting two airports (i and j) with both a CUI level of 0.66, we estimate a one-way fare of $ 200. If one of the two airports sees the CUI increased to 0.9, the estimated fare will rise to $ 205.

Table 5.4 The impact of CUI level on the estimated fare in internal (liberalised) markets

	CUI level	% Change with respect to the mean	Estimated Fare (US$)	% Change with respect to the mean
	0.9	36.8%	205	2.3%
	0.8	21.6%	203	1.4%
	0.7	6.4%	201	0.4%
Sample Mean	0.66		200	
	0.6	-8.8%	199	-0.6%
	0.5	-24.0%	197	-1.7%

Source: SEO & Cranfield analysis

Table 5.5 The impact of CUI level on the estimated fare in external (non-liberalised) markets

	CUI level	% Change with respect to the mean	Estimated Fare (US$)	% Change with respect to the mean
	0.9	27.0%	365	2.8%
	0.8	12.9%	359	1.4%
Sample Mean	0.71		355	
	0.7	-1.2%	354	-0.1%
	0.6	-15.3%	348	-1.8%
	0.5	-29.5%	342	-3.5%

Source: SEO & Cranfield analysis

If both airports face a hypothetical increase in the CUI from the sample mean level (0.66) to a severely congested level (0.9), air fares would increase by 4.4% and 5.4% in the liberalised and non-liberalised market markets respectively.

Table 5.6 The impact of CUI level on the estimated fare in internal (liberalised) markets when both endpoints face change in the CUI

	CUI level	% Change with respect to the mean	Estimated Fare (US$)	% Change with respect to the mean
	0.9	36.8%	209	4.4%
	0.8	21.6%	206	2.7%
	0.7	6.4%	202	0.8%
Sample Mean	0.66		200	
	0.6	-8.8%	198	-1.3%
	0.5	-24.0%	193	-3.7%

Source: SEO & Cranfield analysis

Table 5.7 The impact of CUI level on the estimated fare in external (non-liberalised) markets when both endpoints face change in the CUI

	CUI level	% Change with respect to the mean	Estimated Fare (US$)	% Change with respect to the mean
	0.9	27.0%	374	5.4%
	0.8	12.9%	364	2.7%
Sample Mean	0.71		355	
	0.7	-1.2%	354	-0.3%
	0.6	-15.3%	342	-3.6%
	0.5	-29.5%	328	-7.4%

Source: SEO & Cranfield analysis

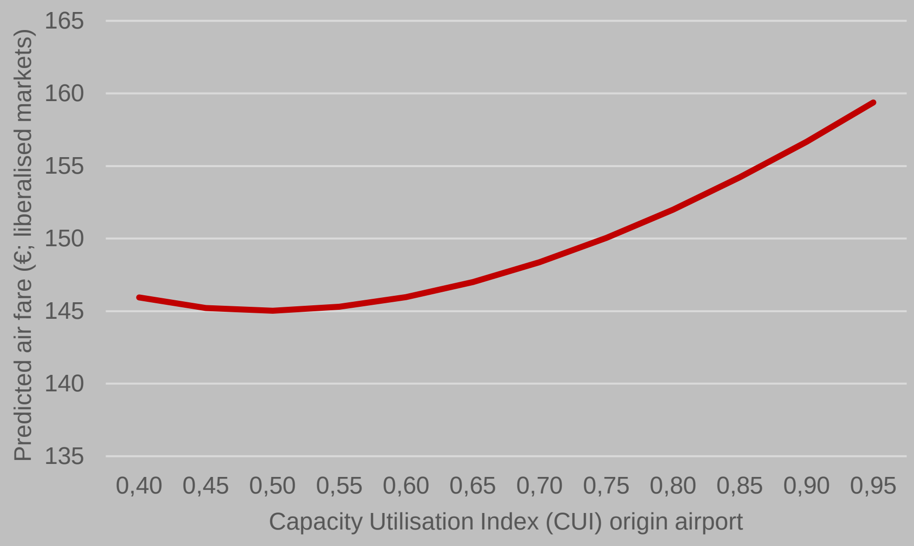
Airport congestion and air fares: an exponential relationship

Theory suggests that airport congestion should have stronger impacts on air fares if airports operate near or at their capacity limits, implying a non-linear relationship. This non-linear relationship was also tested, using CUI and CUI^2 as explanatory variables in our regression models.

The results indeed imply a U-shaped relationship between capacity constraints and air fares: the coefficient for CUI is negative and the coefficient for CUI^2 is positive. This implies that the largest scarcity rents are being earned at a smaller number of airports which are very congested.

Figure 5.4 presents the predicted air fares using the alternative model, for liberalised markets. We keep the congestion level of the destination airport at the sample mean level (0.66). For a CUI below 0.50, an increase in CUI leads to lower fares. On the other hand, impacts of congestion become stronger if the CUI level increases.

Figure 5.4 A U-shaped relationship between capacity constraints and air fares is found



Source: SEO & Cranfield analysis

This model is less appropriate for calculating the absolute amount of scarcity rents which are being earned by airlines across Europe, as the exponential relationship means that any absolute results would be disproportionately impacted by the choice of a counterfactual level of 'baseline' airport congestion (See Section 6.2 & Appendix F for the methodology behind the estimation of absolute impacts).

The non-linear model also demonstrates that while scarcity rents are primarily earned at particularly congested airports, this phenomenon is not limited to only one or two individual airports. While the degree of congestion and regulatory set up (e.g. a specific framework for the secondary trading of slots) make Heathrow a good example to illustrate the dynamic, the empirical evidence makes clear that the phenomenon of significant airline scarcity rents is also present at other congested airports across Europe. See Table G.3 in Appendix G for the model results.

5.4 Mechanisms by which scarcity rents are accrued by airlines at constrained airports

It is important to consider that fare premiums on air fares due to capacity constraints may be accrued through various mechanisms and at various levels.

- Premium class passengers and in particular business class passengers crowd out economy passengers, and in particular leisure passengers. Airlines will use revenue management techniques, marketing and service timings to target the underlying 'premium' segment of demand on specific routes, instead of economy passengers.
- Routes with a higher share of business demand are also likely to crowd out routes with less business demand or leisure routes. As a result, the share of business class seats increases and correspondingly the share of economy class seats decreases. This effect pushes up fare revenue per passenger, leads to less affordable travel opportunities for leisure passengers.
- With growing excess demand, airlines' revenue management systems are likely to allocate more capacity to higher priced fare buckets and less capacity to lower priced fare buckets on a given flight. I.e., there will be a reduced number of cheaper seats available for those passengers who book well in advance. This is linked to the focus on business demand. Business passengers are more likely to book only shortly before departure date, and therefore are more likely to be obliged to pay higher air fares.
- Passengers at congested airports may see greater spikes in air fares for those tickets that are bought soon before departure date. See the Milan Malpensa/Linate case study in section 5.5.
- Low-cost carrier presence at severely constrained airports tends to be lower than at non-constrained airports. As low-cost carrier presence is an important driver of air fare levels in a given market, the low share of low-cost carrier traffic at constrained airports has an upward impact on average fares.[11]
- In multi-airport regions with a severely constrained airport, we often find lower yielding flights, low-cost carrier traffic and part of the short-haul flights at the secondary airports, as a result of the crowding out effects.
- Airlines can also choose to offer more flights in higher yield markets, rather than serving new routes. Increasing frequency to 'in-demand' destinations allows airlines to levy higher fares, as passengers will pay premiums to fly at optimal departure times. In effect, the airline is employing the equivalent to 'peak pricing' in airport charges. Figure 5.8 indicates that at congested airports, airlines offer a relatively high number of flights per destination. This may eventually limit the diversity of the airport's destination network.
- When excess demand increases at hub airports and airport capacity remains stable, network carriers have an incentive to focus on origin-destination traffic rather than transfer traffic. Yields tend to be higher for local origin-destination passengers than for

[11] There are various reasons for the low low-cost carrier shares: it is more difficult to find suitable slot pairs at constrained airports, constrained airports score less favourable on factors that are important for low-cost carrier operations (short turnaround times, short taxiing times, few delays)

transfer passengers as such passengers typically have more choice, and their cross-price elasticity is lower. Origin-destination passengers will pay higher air fares, all other things being equal.

- Long-haul routes tend to crowd out short-haul routes at constrained airports. This is because passenger yield and profitability of long-haul routes tends to be higher than short-haul routes. An increase in the share of long-haul routes will result in higher average fare revenue per passenger. An example of this crowding-out effect is the decrease in the number of UK regional destinations at Heathrow over time (see our Heathrow case study in section 5.3).
- It does not necessarily need to be the same airline changing its route portfolio and thereby making more efficient use of scarce airport capacity. As the London Heathrow case shows, it has been in particular secondary slot trading that induced average route length growth and average aircraft size growth (Cole 2006) (Table 5.8).

Table 5.8 More efficient ex-post use of traded slots at London Heathrow

	Before	After	Difference
Average number of seats	135	255	+ 90%
Average sector length	575 km	6800 km	x 12
ASK/ slot	77,625	1,734,000	x 22

Note: Based on a sample of slot trades at London Heathrow until 2006
Source: Cole (2006)

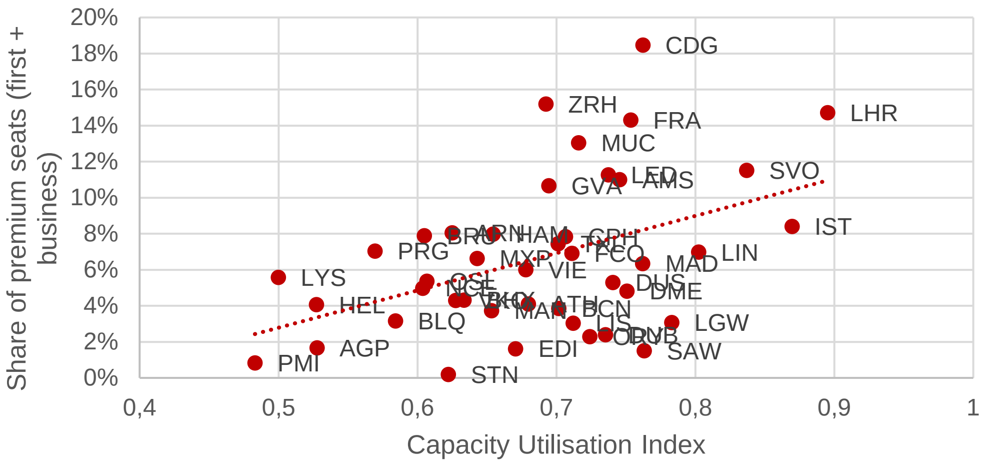
5.5 'Crowding out' effects at constrained airports

Airlines operating at constrained airports can benefit from the scarcity of airport capacity by targeting the highest-yielding passengers. In this section we illustrate different mechanisms through which airlines may be able to extract higher fares at more congested airports.

When interpreting the figures, we constantly need to bear in mind that heavily congested airports tend to be larger airports, often located in densely populated regions. This affects airline's network characteristics jointly with capacity constraints.

Share of business class seats at congested and non-congested airports
The share of premium seats (business and first class) is higher at congested airports than at non-congested airports (Figure 5.5). The correlation between an airport's Capacity Utilisation Index (CUI) and the share of premium seats is 0.45. Paris Charles de Gaulle, Zürich and Heathrow airports respectively offer 15.2%, 18.4% and 14.7% share of premium seats.

Figure 5.5 Congested airports generally offer more premium seats

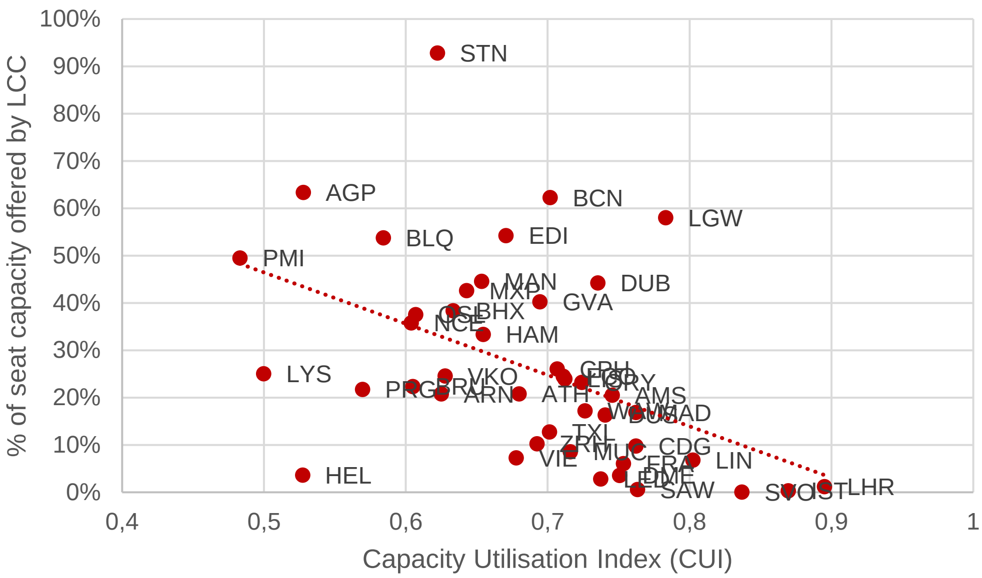


Source: OAG Schedules Analyser; analysis SEO & Cranfield

Lower low-cost carrier presence at congested airports

The share of low-cost carriers at congested airports is on average lower (Figure 5.6). While premium passengers drive up average air fares, low cost carriers (LCCs) tend to have a downward impact on air fares. There has been a limited number of high-profile entrances to relatively larger European airports by low-cost carriers in recent years. Figure 5.6 reflects these developments. It remains to be seen to what extent this is a wider trend or a limited case of individual developments.

Figure 5.6 Congested airports allow less room for LCC expansion

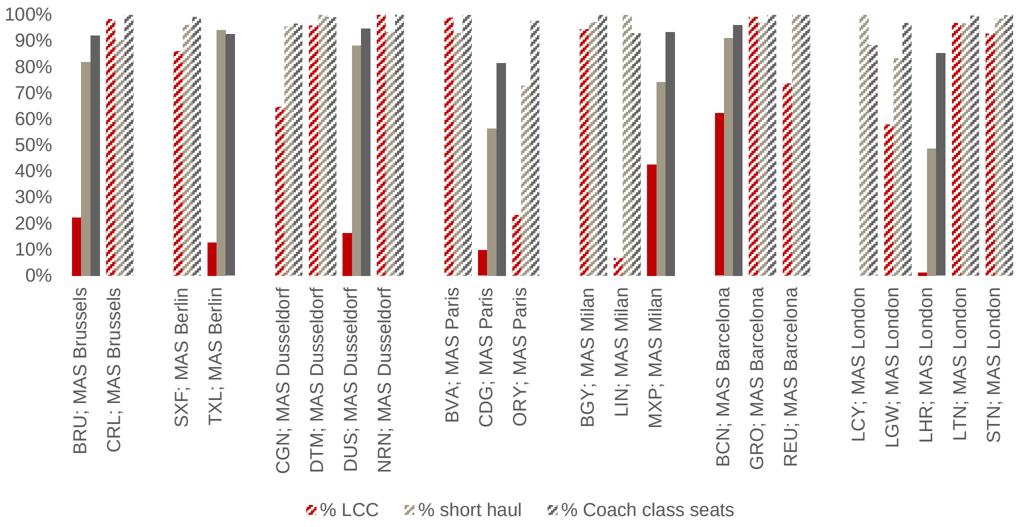


Source: OAG Schedules Analyser; analysis SEO & Cranfield

Utilisation of secondary airports

There are various examples where two or more airports serve the same metropolitan region. Particularly in the case where the primary airport in a Multi Airport System (MAS) is congested, airlines focus on secondary airports for economy and leisure traffic. Low cost carriers therefore tended to focus on these secondary airports. Almost all secondary airports have higher shares of low-cost traffic, short-haul traffic and coach class seats compared to the primary airport in the same Multi Airport System (Figure 5.7).

Figure 5.7 Primary airports in a Multi Airport System (MAS) tend to have a low share of LCC traffic, more long-haul traffic and a higher share of business class seats

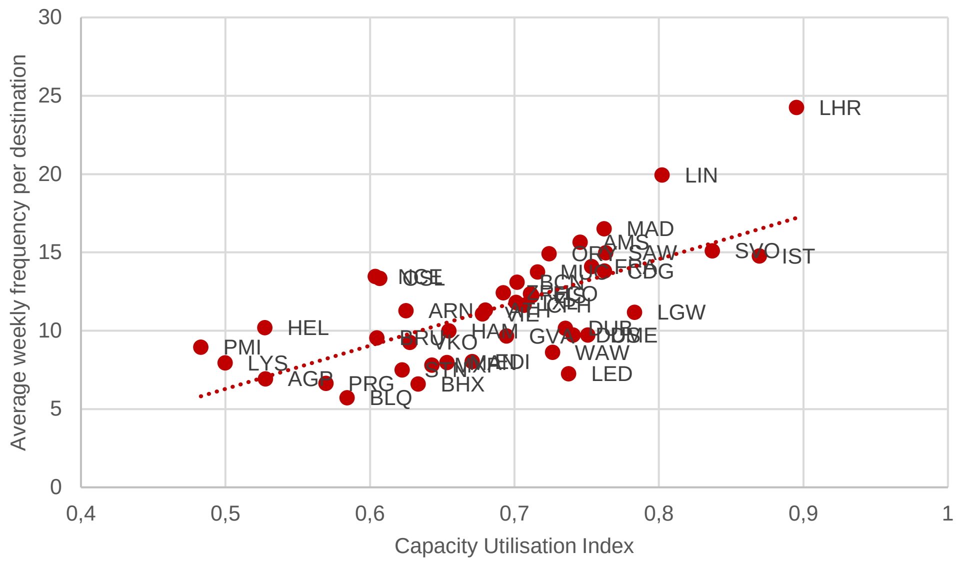


Source: OAG Schedules Analyser; analysis SEO & Cranfield

Higher average frequency to fewer destinations

Airport congestion can have a negative impact on the number of destinations served. If capacity is scarce, airlines might choose to offer more flights to higher yield markets, rather than serving new routes. Figure 5.8 indicates that at congested airports, airlines offer a relatively high number of flights per destination, which eventually can go hand in hand with a smaller range of destinations served at higher frequencies. Again, this is particularly the case for London Heathrow, offering on average 24 weekly flights per destination, but the trend is observed through the overall sample. Clearly the average frequency is strongly related to airport and market size, where larger airports offer more flights, but are also more congested.

Figure 5.8 Average flight frequency is higher at congested airports



Source: OAG Schedules Analyser; analysis SEO & Cranfield

Examples of fare premiums in offered fares

Offered fare data provided an additional source of insight into the mechanism by which scarcity rents are accrued, as airline revenue management systems are well equipped to discriminate between passengers with differing willingness to pay. We select certain examples to illustrate how airlines price their product.

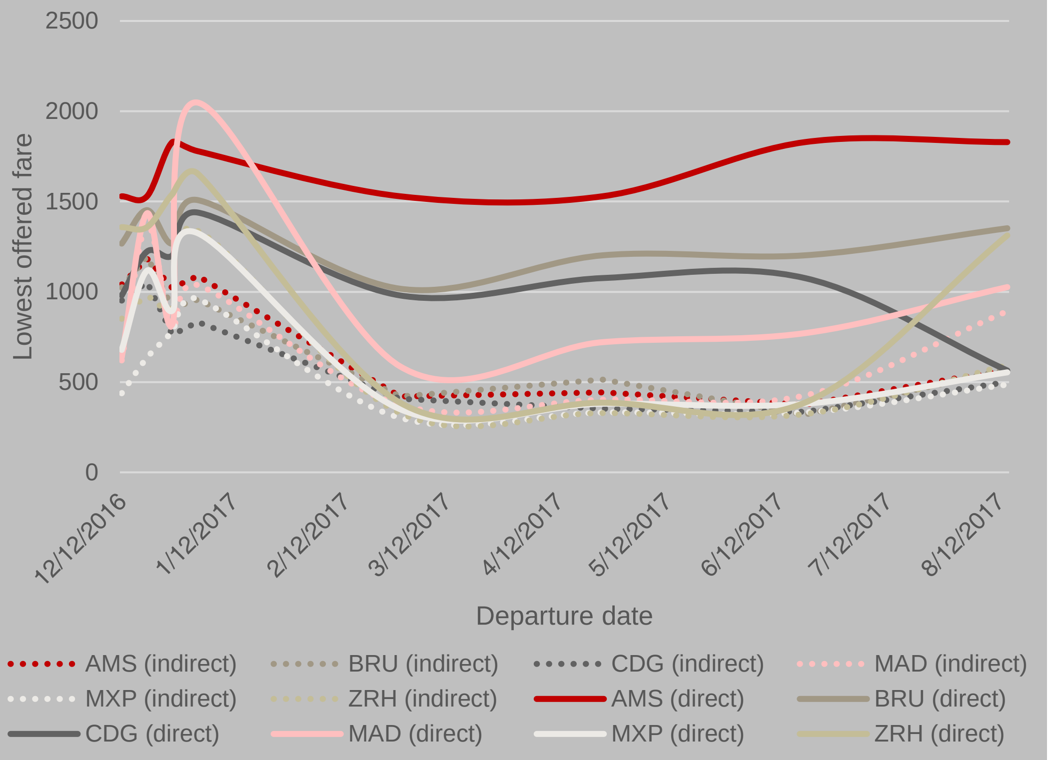
Flights to New York

Indirect flights are often cheaper then direct flights. More price-sensitive customers are willing to take a longer travel alternative in order to save money and there is typically greater airline competition as there is a wider range of transfer possibilities for such passengers Figure 5.9 presents the lowest offered air fares on direct and indirect travel alternatives to New York, from a selection of origin airports. In all cases, indirect alternatives are cheaper than the cheapest direct alternative, which are unlikely to reflect underlying cost savings by the airline

Particularly from Amsterdam, Brussels and Paris Charles de Gaulle direct fares are substantially higher than indirect fares. As the fares consider a three night mid-week stay in New York, passengers likely to book these trips are business passengers or people on a short city trip. Both have relatively little time to spend in New York, and therefore have a strong preference for the fastest alternative.

At Amsterdam Schiphol airport, the direct route to New York is offered by KLM and Delta (who operate a joint venture) to JFK, and by United Airlines to Newark. As such, competition on this direct route is limited. Comparing this to direct fares for the same departure dates from Milan Malpensa, one can observe fares are much lower. This is attributable to the higher competition level at that route. Alitalia, Delta Airlines, Emirates, United Airlines and American Airlines all compete on the Milan-New York market.

Figure 5.9 Indirect air fares are cheaper than direct fares



Note: Cheapest direct and indirect net return fares offered to New York JFK or EWR, for a 3 night stay, booked 9-12-2016

Source: SEO & Cranfield analysis, QPX Express API

Air fare differences between Milan Malpensa and Milan Linate

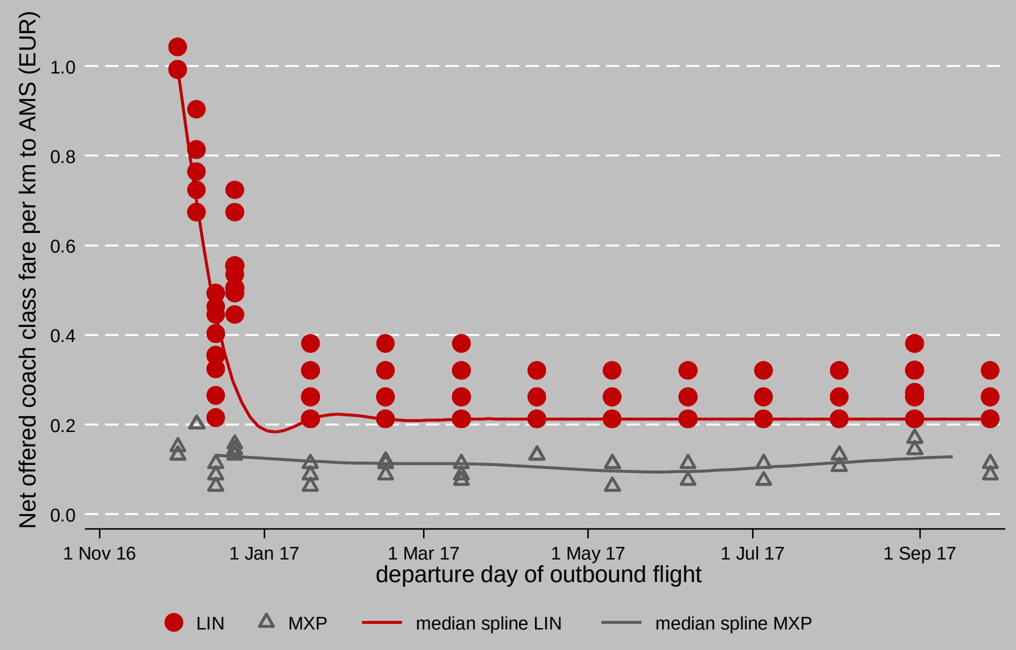
Offered fares

We compare average offered fares from flights to Amsterdam, from Milan Linate (congested) and Milan Malpensa (less congested). Both markets have similar characteristics in terms of travel distance, and both serve roughly the same Milan catchment area. From Milan Malpensa, Vueling and EasyJet together offer 31 weekly flights. From Linate, KLM, Alitalia and EasyJet offer 41 weekly flights.

Figure 2.3 shows that offered coach class fares from Linate are higher than from Malpensa, with respective average fares of € 255 and € 94. In particular flights booked shortly before departure are much higher from Linate: average fares in December from Linate are € 496 versus € 114 from Malpensa.

Linate is subject to capacity restrictions: a maximum of 20 flights per hour are allowed, which is utilised almost every daytime hour. On the other hand, Malpensa has a lot of free capacity and is not bound to the same restrictions. In parallel Linate is closer to the centre of Milan. Based on these characteristics one cannot definitely conclude whether higher fares are due to the lack of capacity at Linate or the inherent attractiveness of Linate over Malpensa. However, airlines do appear to be extracting higher yields from passengers due to the inherent characteristics of the airport – in a situation with no capacity restrictions at Linate, it would be expected that new entrants would compete these yields away.

Figure 5.10 Air fares to Amsterdam are higher from Linate

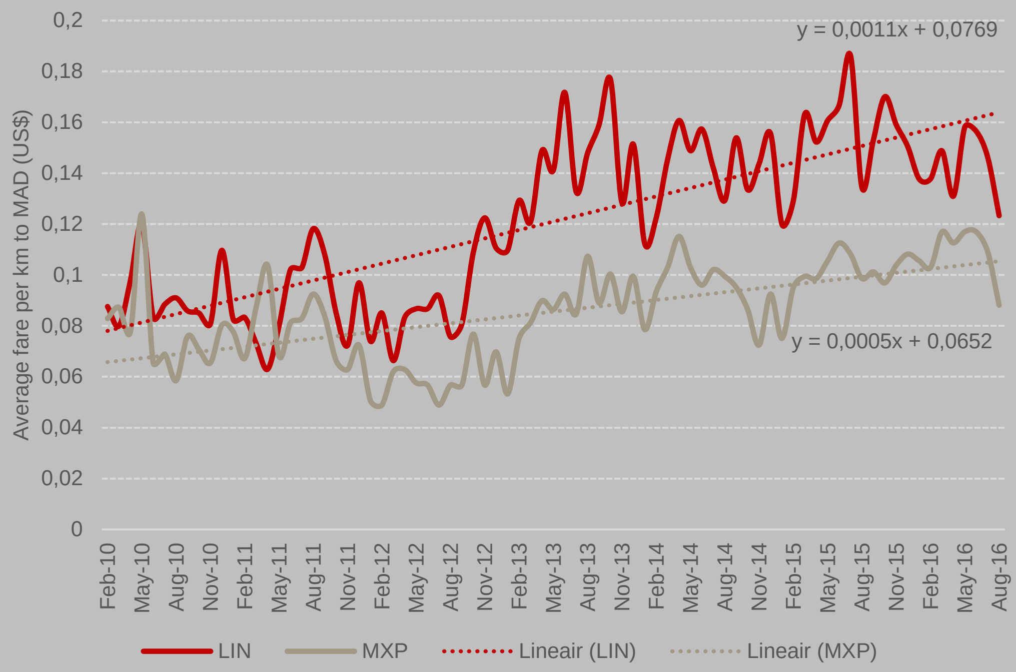


Source: SEO & Cranfield analysis, QPX Express API
Note: Data collected on 29 November 2016, for flights departing on Wednesdays between 30 November 2016 and 27 September 2017, for a 2 night stay. Excluding EasyJet fares. Coach class fares

Booked fares

Looking at a similar case (Figure 5.11) but then for booked fares, we can observe that air services departing from Linate are able to generate higher yields than equivalent departures from Malpensa in the Milan-Madrid market. Over the past 6 years, air fares at Linate have risen at twice the rate of air fares at Malpensa – potentially reflecting the impact of increasingly tight capacity constraints.

Figure 5.11 Evolution of average booked fare per km from Linate and Malpensa to Madrid, non-stop direct flights only, 2010-2016



Source: SEO & Cranfield analysis

5.6 Airport constraints and airport charges

Airports and governments may also be able to extract (part of) the scarcity rents that arise because of airport capacity constraints. They can do so through airport charges or aviation taxes. When airlines benefit from scarcity rents, higher charges or aviation taxes then represent a redistribution of scarcity rents from the airlines to the government/airport (unless the increases in charges were cost-based e.g. to pay for necessary airport investment), while the reverse is true for a decrease in charges/taxes.

This also means that an increase in airport charges/taxes does not necessarily lead to higher ticket prices at congested airports. Airlines can be expected to absorb the airport charges/taxes increase at the expense of the scarcity premium on their average fares (Starkie & Yarrow 2000). In other words, where air fares are at market clearing level at congested airports – higher charges or taxes will reduce the airline's share of the scarcity rent, but will not feed through to lower air fares. Conversely, decreases in airport charges will not lead to lower air fares but rather to higher rents for airlines.

Are airport charges higher at constrained airports?

Do we have indications that airport charges and taxes are higher at constrained airports? This would be an indication that airports/governments may extract part of the scarcity rents.

Figure 5.12 presents the average 'taxes and charges' component of the fare, per return passenger trip from the respective airport, relative to the degree of congestion at that airport. The 'taxes and charges' component of air fares is higher in absolute terms for intercontinental flights, but lower for intra-European flights. When taxes are excluded, the relationship between airport congestion and average aircraft-related airport charges is very weak (Figure 5.13).

For the majority of airports, the level of taxes and charges lies between € 20 and € 60 euros for a European return trip. For intercontinental flights, significantly higher charges are found for the airports in the UK. This is mostly due to the UK Air Passenger Duty, which adds up to 73-146 GBP for flights over 2000 miles.

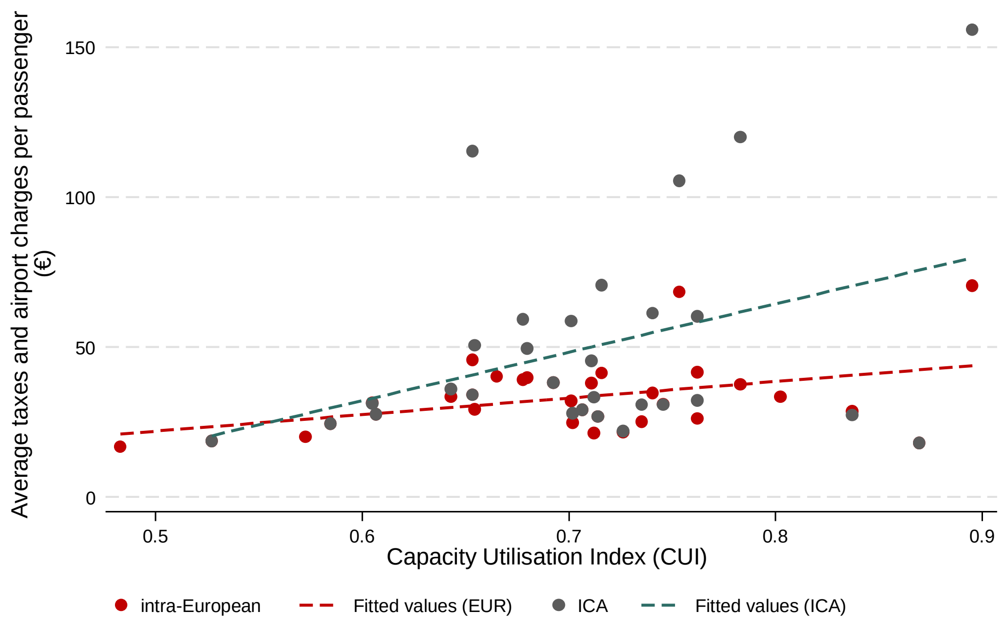
The figure suggests that governmental taxation may be capturing some of the scarcity rents through taxation, but that airports are less likely to capture rents through their charges. This is intuitive – the economic regulation to which all larger European airports are subject to is specifically designed to prevent airports with substantial market power from gathering rents via airport charges.

Variables that influence airport charges

Bel & Fageda (2010) have econometrically assessed the importance of various factors that influence airport charges in Europe. Using data for more than 100 airports in Europe, the study finds that charges are higher when airports accommodate more passengers. They also find that competition from airports in the catchment area and from other transport modes poses a competitive constraint on airport charges levels. Low-cost carriers and airlines with a dominant market share seem to provide countervailing power. Different organisational structures and the existence of regulatory oversight also impact air fares.

The Bel & Fageda study is interesting as the passenger number variable may be a proxy for airport capacity scarcity. This would indicate that also airports reap part of the scarcity rents. However, the authors themselves (Bel & Fageda 2010, p.158) state this finding could be the result of 'higher extraordinary rents' but also of 'higher overall costs' at larger airports. Crucially, Bel & Fageda's study also pre-dates the implementation of the EU Airport Charges Directive. All other things being equal, economic regulation should prevent the airport operator from collecting scarcity rents.

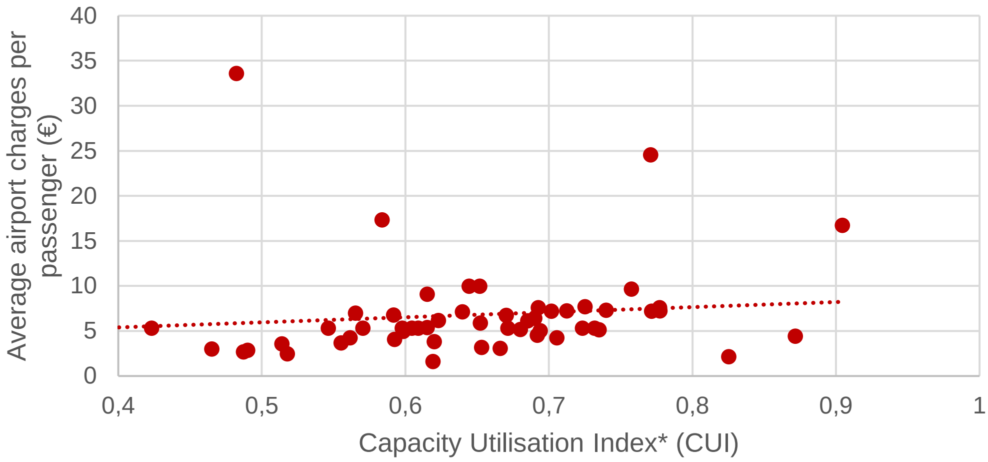
Figure 5.12 There is strong variation in the level of charges and taxes. Average per passenger charges and taxes are higher at constrained airports, but only for intercontinental flights



Source: SEO & Cranfield Analysis[12]

[12] The charges depicted in Figure 5.13 are derived from two combined sources. Firstly, aircraft based airport charges – translated into per passenger-based charges – were provided by ACI. These charges include the three main cost components, being landing charges, parking charges and boarding bridge charges. In addition, all passenger-based charges as well as government taxes were derived from the collected offered air fare data (see chapter 4). This list contains (but is not limited to) air passenger departure tax, passenger service charge, airport improvement fee, noise charge and security charge. It cannot be confirmed that

Figure 5.13 Relationship between average aircraft-related airport charges per passenger versus congestion indicator appears to be weak



Source: SEO & Cranfield analysis

The impact of airport charges on air fares

As airport charges data were not available for the full sample of markets, inclusion of airport charges was not possible. When the regression model is estimated on a reduced sample only including the airports for which airport charges data were available, we still find a similar impact of airport capacity constraints upon air fares, controlling for the differences in the per passenger airport charges between airports (Appendix E).

The reduced sample model demonstrates a positive relationship between airport charges and air fares. This is expected and in line with what economic theory predicts at the majority of airports, which lack substantial market power and which are not strongly capacity constrained.

It is not possible from the model to determine whether on aggregate changes in airport charges are fully or only partially passed through to higher/lower air fares, as this would require data as to the proportion of airline costs which correspond specifically to the airport charges captured in the model. However, even if this were possible, any aggregate figure would in all likelihood encompass very different dynamics at individual congested and uncongested airports.

these additional charges fully relate to the actual identified costs incurred by airlines, and may also reflect to a degree the airline's ability to set ticket prices.

Part III: Results and implications

6 Findings

Airport capacity constraints have a significant and positive impact on air fares. A 10% higher airport congestion level is associated with 1.4-2.2% higher average booked fares. Consumers at congested airports are paying a total fare premium of € 2.1 billion in 2014 compared to a scenario in which all congested airports were operating at Europe's median capacity utilisation level.

6.1 Summary of findings

By means of econometric analysis on booked air fares, empirical evidence was found that air passengers pay higher fares at congested airports. This supports the economic theory on scarcity rents, which suggests that prices increase in a scenario where supply is not able to match demand.

We find that a 10% higher airport congestion level is associated with 1.4% higher fares in liberalised markets and with 2.2% higher fares in non-liberalised markets. In addition to the impact of airport capacity scarcity, we observe that distance, fuel price, travelling from a hub airport, GDP/capacity and population also have an upward impact on fares. On the other hand, fares tend to be lower on markets with low-cost carrier presence and in liberalised markets.

In this chapter we use the empirical results to estimate the total amount of scarcity rents currently paid in the European air transport market due to existing airport congestion. As the model is estimated on a representative sample, we can apply the regression models to all European airports.

It is important to note that our findings are averages for a broad sample of markets across Europe. It is likely that scarcity rents arise most at those airports with some form of market power and with significant capacity constraints, and within airports, during specific moments of the day or the year and for specific passenger segments. The average results imply that a growing congestion level at an average airport does not automatically mean that airlines operating at those airports can exercise a certain market power in terms of pricing. To identify if scarcity rents are present at specific airports, detailed, tailor-made analyses are needed at an individual airport-basis.

6.2 Total amount of additional fare revenue paid by consumers due to capacity constraints

Our empirical analysis on booked fares shows that airport congestion leads to additional capacity constraints. The total amount of additional rents currently paid at European airports adds up to € 2.1 billion. This corresponds with an average air fare premium of € 5.65 per return ticket at congested airports.

Table 6.1 Consumers pay on average € 5.65 more for a return ticket due to congestion

Total additional fare premium paid (2014)	€ 2.1 billion
Total departing passengers (2014)	626 million
Passengers departing from airports with congestion level higher than the benchmark	366 million
Additional fare premium per return passenger at airports with congestion level higher than the benchmark	€ 5.65

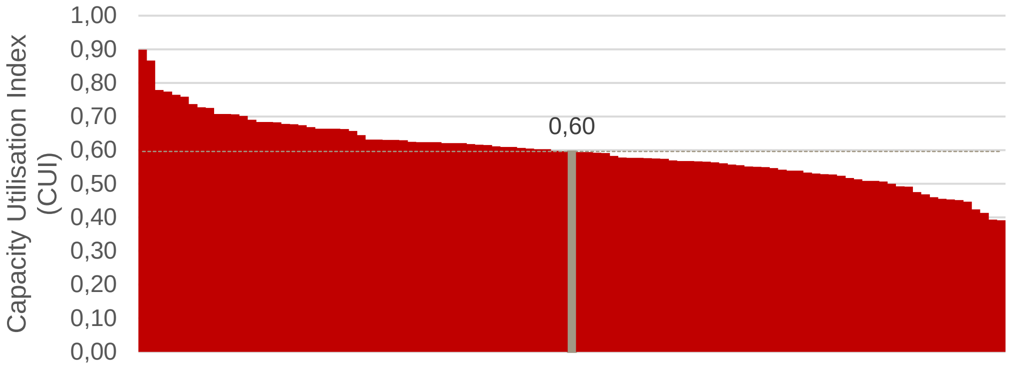
Source: SEO & Cranfield analysis

The total fare premium is calculated as the increase in fare level at congested airports with respect to a certain benchmark level. The congestion benchmark level is set at 0.596, the median CUI of all European airports with over 30,000 annual movements in 2014 (see Figure 6.1). This level is comparable with the congestion level of airports such as Brussels Zaventem or Stockholm Arlanda.

Theory suggests that such scarcity rents can only be collected by airlines at airports with substantial market power, at least at some points in time (peak hours and/or peak season). As airport market power tests have not yet been implemented on a consistent basis across Europe, it was not possible to control for this within the model. It is therefore likely that airline scarcity rents are likely to be greater than the model suggests for those airports with market power and which are heavily congested, and absent at all other airports. We therefore apply the 'average impact' as identified in the models, to all airports across Europe, so as to calculate the overall impact. This means that the scarcity rents at individual airports cannot be identified via this model. This approach does not imply that all airports have such market power.

As the regression results present an impact of the summed CUI of the origin and destination airports, we have to incorporate a certain congestion level of the destination airport as well. Our parameter of interest is the impact of the congestion level of European airports. We estimate the impacts of having a higher condition level by leaving all other parameters equal (ceteris paribus). Therefore, we leave the congestion level of the destination airports constant at 0.632 for liberalised markets and 0.745 for non-liberalised markets, which is the median level of all airports in the sample of airports in the two respective markets.

Figure 6.1 The congestion benchmark level is set at the median CUI of European airports with more than 30,000 movements per annum



Source: SEO & Cranfield analysis

For each airport, we determine the current fare premium with respect to the benchmark level. We use the sum of the individual airport premiums to estimate the total European fare premium.

We refer to Appendix F for the details on the estimation of the fare premium for an example airport.

7 Future fare impacts of capacity constraints

Capacity limitations are expected to be an increasing problem over the coming decades. EUROCONTROL forecasts that by 2035 1.9 million flights cannot be accommodated due to capacity shortages. Using the empirical evidence from this study, these capacity shortages are expected to increase average air fares by € 10.40 at congested airports, leading to a total fare premium of € 6.3 billion.

7.1 Total future fare premium due to increasing capacity constraints

By 2035, 33 airports will have an increased congestion level in comparison to their current congestion level. At the other airports, there is likely to be sufficient room for increased peak-hour utilisation to leave the CUI at a similar level to the base year 2014.

At these airports, return fares are expected to increase by € 0.20 - € 46.96, depending on the current congestion level and the type of route (liberalised/non-liberalised markets). This leads to a total fare premium of € 6.3 billion to be paid by air passengers at European airports. On average, air fares at congested airports are expected to increase by € 10.42.

Table 7.1 By 2035, capacity constraints are expected to lead to an average fare increase of € 10.42

Total additional fare premium paid in 2035	€ 6.269 billion
Total departing passengers (2035)	1,298 million
Passengers departing from congested airports (2035)	602 million
Additional fare premium per return passenger at congested airports	€ 10.42

Source: SEO & Cranfield analysis

7.2 Methodology

In order to estimate to what extent future air fares increase due to capacity constraints with respect to the base year of 2014, we need to estimate the total number of flights and resulting capacity constraints in 2035. We base this analysis on EUROCONTROL's traffic forecasts. The most likely EUROCONTROL scenarios were used, which is the 'Regulated Growth' scenario for the long term forecast and the 'Base' scenario for the seven-year forecast.

First, the number of scheduled flights in 2016 is extrapolated to 2020 levels, based on EUROCONTROL's base forecast for the short-term (EUROCONTROL, 2016). For the period between 2020 and 2035, EUROCONTROL's most likely long-term traffic forecast is used (EUROCONTROL, 2013a).

As we want to estimate the total impacts of capacity constraints, the results are based on an unconstrained forecast. However, EUROCONTROL provides constrained forecasts while presenting the (aggregate) level of unaccommodated demand. These unaccommodated demand levels are allocated over individual airports, proportionally to the flight frequencies of these airports.

Based on the resulting unconstrained forecasts, we estimate future congestion levels by updating the CUI. The CUI is the quotient of two frequency-related metrics, being the average hourly frequency and the 5% peak-hour capacity. The average hourly frequency is increased by the same rate as the total frequency growth, as described above. The 5% peak-hour capacity is increased to a certain maximum level. For single-runway airports, a maximum peak-hour capacity of 40 movements per runway is assumed. For airports with multiple runways, peak-hour capacity figures from EUROCONTROL's airport corner were used, which were available for 28 of the 30 European airports with more than one runway. For the others, a peak-hour capacity of 80 movements was assumed.

In case the peak-hour capacity at an airport is reached, the (theoretical) CUI starts to increase. Using the CUI elasticity from our econometric analysis, we estimate the fare impact of the increased CUI. Similar to the analysis of the current fare impacts, an average CUI of destination airports of 0.632 is used for liberalised markets and an average CUI of 0.745 for non-liberalised markets. The resulting fare increase per airport is estimated in a similar fashion as described in section 6.2.

In line with the methodology applied in Chapter 6, future impacts are based on results for the two separate models for liberalised and non-liberalised markets. We assume that the share of passengers travelling to liberalised or non-liberalised markets remains constant over time.

8 Policy recommendations

Passengers pay the bill for airport capacity shortages via higher air fares. To reduce the negative impact of capacity shortages on consumer welfare, not only investments in airport capacity are required, but also regulatory reform to remove the incumbent airline's disincentives to support capacity expansion. In addition, monitoring of booked fares by an independent body to raise awareness among policy makers and regulators on the existence of scarcity rents, could be useful.

8.1 Conclusions

The consumer pays the bill for airport capacity shortages via higher air fares
The preceding chapters have shown that airport capacity shortages lead to higher air fares than otherwise would have been the case. A 10% increase in the cumulative CUI (i.e. airport capacity) of a route results in 1.4% higher fares in liberalised markets and 2.2% in non-liberalised markets. The total fare premium for European passengers adds up to over € 2 billion euro in 2014, representing a € 5.65 premium on an average return ticket at congested airports.

As capacity shortages are expected to grow in the next twenty years – in line with EUROCONTROL's warning about a capacity crunch – so will the total fare premium. We estimate that the total fare premium in Europe will reach over € 6 billion a year by 2035, which is € 10.42 on average per return ticket at congested airports. In sum, it is the European consumer who ultimately pays for airport capacity shortages in Europe.

Our analysis also reveals that airlines at congested airports may exercise a certain degree of market power over the passengers and generate scarcity rents. We note however, that our findings are averages for a broad sample of markets across Europe. It is likely that fare premiums are largest at severely congested airports and at airports with substantial market power. Within airports, fare premiums may be present or differ during specific moments of the day or the year, or on specific routes or markets. The average results imply that a growing congestion level at an average airport does not automatically mean that airlines operating at those airports can exercise a certain market power in terms of pricing. To identify if scarcity rents are present at individual airports, specific analyses are needed at an individual airport-basis.

Based on our results, we have formulated a number of recommendations.

8.2 Policy recommendations

8.2.1 Addressing Europe's capacity crunch is the obvious answer

Expanding airport capacity is the obvious answer to the capacity shortfall at congested airports that Europe is increasingly facing. Addressing the airport capacity crunch should be of primary importance for European policy makers and airports themselves. Solving of airport capacity bottlenecks through infrastructure and operational measures, but also by establishing the Single European Sky, is likely to enhance overall social welfare. Responses should be provided at whichever level is most appropriate. For example at a local or national level, putting in place appropriate planning frameworks & ensuring sufficient political support will help, while on a European level there may be scope to leverage the EU Observatory on Airport Capacity & Service Quality, or the monitoring provisions of Regulation 598/2014. Of course, there is no one-fits-all solution for all airports. Airport capacity investments should be supported by sound analysis of benefits, (financial) costs and outputs and fit within the local frameworks.

8.2.2 Remove incumbent airlines' disincentive to support expansion

Expanding airport infrastructure in European metropolitan areas is not easy, as the history of airport expansion projects in Europe shows. Expanding airport capacity is difficult for planning and environmental reasons, and sometimes for budgeting reasons.

Moreover, the presence of scarcity rents can be a disincentive for incumbent airlines to actively support airport expansion programmes (Gillen & Starkie 2016). Congestion creates a disincentive for incumbent airlines to solve congestion. There are a number of reasons for this paradox:

- airport capacity expansion will result in additional supply and therefore reduce scarcity rents;
- investing in large and complex airport facilities can result in higher airport charges, which will be absorbed by the airlines at the expense of the scarcity rents, before these higher charges result in higher fares – reducing airline profitability;
- incumbent airlines are restricted in the number of slots they can get under the new entrant rule under the current European slot regime.

In the words of Gillen & Starkie (2016, p.159) 'it is little wonder, therefore, that the case of building new runways at congested hub airports in Europe has proved rather difficult to implement.'

It is therefore important to develop solutions to take away the incumbent carriers' disincentive for airport capacity expansion. We see a number of avenues:

Temporarily suspend new entrant rule after major airport expansion
Incumbent airlines are restricted in the number of slots they can get under the new entrant rule under the current European slot regime. Requirements to allocate half of the slots to new entrants could be temporarily suspended after major airport expansion at large hub airports, as Gillen & Starkie (2016, p.162) suggested. This would give incumbent airlines a larger stake in the benefits of the additional capacity created. The risk here is that incumbent airlines use newly created slots as a barrier to prevent new entry. Such a policy response could improve the prospects of airport expansion, but with the consequence that rents could potentially remain with the incumbent airline. The overall impact on passenger welfare is therefore ambiguous and unpredictable – even in specific circumstances.

Introduce measures to redistribute scarcity rents from airlines to other stakeholders
One measure would be to allow specific 'airport infrastructure funds' to capture part of the rents through airport charges. This would effectively mean a transfer from the scarcity rents from the airlines, taking away the disincentive to invest, and allow funds to be collected to be directed towards relief of the underlying capacity problem.

This could entail higher airport charges overall, or – where feasible and appropriate – the use of peak pricing.[13] Higher airport charges would reduce the scarcity rents of incumbent airlines and redistribute them to the airport infrastructure fund. If the scarcity rents were ring-fenced and used for airport capacity expansion investments, the disincentive of airlines to support expansion is further reduced.

However, this is all more easily said than done. Isolating the overall scarcity rents for European airports in general (as we have done in this study) is one thing, but accurately measuring the scarcity rents at a single airport is another. In addition, the calculation of robust charges based on the marginal costs of runway use on different moments of the day, has proven to be difficult (Starkie 2003, p. 55).

8.2.3 Ensure existing policies do not become an unnecessary barrier to airport expansion

The EU Airport Charges Directive requires that airports consult with airlines on new infrastructure, and that any related charges increases can be appealed by airlines to an Independent Supervisory Authority. This provides considerable influence over airport expansion plans to airlines currently operating at the airport.

Such a regulatory arrangement works on the basis that the interests of airlines represent an appropriate proxy for the interests of end users, and that the consultation requirement and right of appeal will therefore lead to more socially optimal outcomes.

While this is the case in the majority of cases, our findings make clear that incumbent airline interests concerning capacity expansion at congested airports may not always be aligned with those of the passenger, and therefore may not deliver a socially optimal outcome. Specifically airlines may be incentivised to retain limited airport capacity, so as to continue to collect scarcity rents and to prevent new competitors from entering the market. The outcome for passengers would be higher fares, poor airport service quality and a reduced range of destination choices.

In such circumstances, this should be reflected in any regulatory decisions concerning airport capacity expansion. Airline opposition to an expansion project should be taken on board by the regulator, but should not automatically lead to the regulator refusing to allow an expansion project to proceed. Otherwise the regulatory framework would be handling a de facto veto to incumbent airlines, over potentially socially beneficial airport expansion.

---

13 In theory, aviation taxation by governments could be used in the same way. However, there is a greater risk that revenues will not be ring-fenced for future investments in airport-related infrastructure, up to the point that revenues create a disincentive for governments to support expansion. In addition, it may not be possible to impose direct taxes at specific airports from a legal perspective.

8.2.4 Make policy makers aware of the existence of scarcity rents

Price re-regulation of aviation markets is definitely not the answer to fare premiums at congested airport facilities. But awareness among policy makers about the existence of scarcity rents may be a vital input in policy discussions on airport expansion, as well as for discussions on airport charges.

Monitoring air fares at congested airports can be a simple measure to make fare differentials between congested and uncongested airports transparent. Preferably, this should be done by an independent body, such as a regulator or group of regulators.

This will facilitate consideration of potential market power issues that are present in the downstream market and which affect the consumer, the end user of air transport. It may help to move away from the policy focus on upstream dynamics only, in which the airports are seen as inherently monopolistic and the airline market as (im)perfectly competitive.

8.2.5 Continue efforts to open up aviation markets

Consumers are the winners of aviation liberalisation. Our analysis underlines the benefits of open market access. Liberalisation has not only increased effective airline competition, but also the contestability of the market. Fares in liberalised markets are significantly lower than other fares. In addition, the presence of low-cost carriers in liberalised markets goes hand in hand with lower fares. Many other studies (e.g. InterVISTAS 2015) have demonstrated the economic value of liberalising aviation agreements.

In the current geopolitical environment, there is a risk that the longstanding trend of liberalisation and deregulation of aviation markets comes to stop or may even be reversed in some cases. This will be to the detriment of the consumer. The same holds true if airport capacity also fails to keep up with aviation demand growth. In other words, policy makers need to be aware of the value of liberalisation, airline competition and airport capacity for European welfare and the broader economy.

Literature

Abramowitz, A. D., & Brown, S. M. (1993). Market share and price determination in the contemporary airline industry. *Review of Industrial Organization*, *8*(4), 419-433.

ARG (2013). Atmosphere's Global Travel Industry Executive Survey, Q3 2012. (http://www.iata.org/whatwedo/stb/Documents/future-airline-distribution-report.pdf)

Bel, G., & Fageda, X. (2010). Privatization, regulation and airport pricing: an empirical analysis for Europe. *Journal of Regulatory Economics*, *37*(2), 142-161.

Berster P., Gelhausen M. & Wilken D. (2011). Do airport capacity constraints have a serious impact on the future development of global air traffic? Paper presented at the 2011 World Conference of the Air Transport Research Society, Sydney, June 29 – July 2, 2011.

Borenstein, S. (1989). Hubs and high fares: dominance and market power in the US airline industry. *The RAND Journal of Economics*, 344-365.

Brueckner, J. K., Lee, D., & Singer, E. S. (2013). Airline competition and domestic US airfares: A comprehensive reappraisal. *Economics of Transportation*, *2*(1), 1-17.

CAA (2005). Airport regulation: price control review & consultation on policy issues. Cited by Starkie (2006).

CAPA (2013), Heathrow Airport's slot machine: hitting the jackpot again?, Available: http://centreforaviation.com/analysis/heathrow-airports-slot-machine-hitting-the-jackpot-again-108646

CAPA (2016). Gulf airlines in London Heathrow: slot purchases expand capacity further, improving connectivity. URL: http://centreforaviation.com/analysis/gulf-airlines-in-london-heathrow-slot-purchases-expand-capacity-further-improving-connectivity-267222

Chi, J., & Koo, W. W. (2009). Carriers' pricing behaviors in the United States airline industry. *Transportation Research Part E: Logistics and Transportation Review*, *45*(5), 710-724.

CPB (2002). Gevolgen van de uitbreiding van Schiphol. Een kengetallen kosten-batenanalyse (in Dutch).

Cole, J. (2006). Experiences of secondary slot trading in the UK. Retrieved from http://www.cohor.org/wp-content/uploads/upload_old/James%20Cole.pdf .

Copenhagen Economics (2012). Airport competition in Europe. Study commissioned by ACI EUROPE.

Van Dender, K. (2007). Determinants of fares and operating revenues at US airports. *Journal of Urban Economics*, *62*(2), 317-336.

Dresner, M., Windle, R., & Yao, Y. (2002). Airport Barriers to Entry in the US. *Journal of Transport Economics and Policy (JTEP)*, *36*(3), 389-405.

EUROCONTROL (2013a). Challenges of Growth 2013. Task 4: European Air Traffic in 2035.

EUROCONTROL (2013b). Challenges of Growth 2013. Task 6: The Effect of Air Traffic Network Congestion in 2035.

EUROCONTROL (2016). EUROCONTROL seven-year forecast. Flight movements and service units 2016-2022. September 2016. Edition Number: 16/09/26-98.

Evans, W. N., & Kessides, I. N. (1993). Localized market power in the US airline industry. *The Review of Economics and Statistics*, 66-75.

Evans, A., & Schäfer A. (2011). The impact of airport capacity constraints on future growth in the US air transportation system. *Journal of Air Transport Management* 17.5: 288-295.

Forsyth, P. (2004). Locational rents at airports: creating them and shifting them. *Journal of Air Transport Management 10*, 51-60.

Frontier (2014). Impact of airport expansion options on competition and choice. A report prepared for Heathrow Airport.

Gillen, D., & Starkie, D. (2016). EU Slot Policy at Congested Hubs, and Incentives to Add Capacity. *Journal of Transport Economics and Policy (JTEP)*, 50(2), 151-163.

Givoni, M., & Rietveld, P. (2009). Airline's choice of aircraft size – Explanations and implications. *Transportation Research Part A: Policy and Practice*, *43*(5), 500-510.

IATA (2015). Worldwide Slot Guidelines. 7th Edition. www.iata.org/wsg.

Index Mundi. Jet Fuel Monthly Price – Euro per gallon. Accessed from http://www.indexmundi.com/commodities/?commodity=jet-fuel&months=60&currency=eur

InterVISTAS (2014). Economic impact of European airports. Report prepared for ACI EUROPE.

InterVISTAS (2014b). The importance of airport competition for air fares paid by consumers. Report prepared for Gatwick Airport.

InterVISTAS (2015). The Economic Impact of Air Service Liberalization.

ITC (2013). Flying into the Future: Key Issues for Assessing Britain's Aviation Infrastructure Needs. Independent Transport Commission, London.

Koopmans, C., & Lieshout, R. (2016). Airline cost changes: To what extent are they passed through to the passenger? *Journal of Air Transport Management*, *53*, 1-11.

Lee, D., & Luengo-Prado, M. J. (2005). The impact of passenger mix on reported" hub premiums" in the US airline industry. *Southern Economic Journal*, 372-394.

Morrison, S. A. (2001). Actual, adjacent, and potential competition estimating the full effect of Southwest Airlines. *Journal of Transport Economics and Policy (JTEP)*, *35*(2), 239-256.

Morrison, S. A., & Winston, C. (1990). The dynamics of airline pricing and competition. *The American Economic Review*, *80*(2), 389-393.

PWC (2013). Fare differentials. Analysis for the Airports Commission on the impact of capacity constraints on air fares.

PWC (2016). Aviation industry dynamics and air fares. Presentation for the ACI EUROPE Economics Committee. London, 29 April 2016.

SEO & ITF (2015). Market Response to Airport Capacity Expansion: Additional estimates airline responses. SEO report 2015-43. Amsterdam: SEO. Commissioned by UK Airports Commission.

SEO (2016). Benchmark of airport charges and government fees. Study commissioned by the Dutch Ministry of Infrastructure and the Environment (in Dutch). SEO reportnr. 2016-23.

Starkie, D. (1998). Allocating airport slots: a role for the market? *Journal of Air Transport Management 4*, 111-116.

Starkie, D. (2004). Testing the regulatory model: the expansion of Stansted Airport. *Fiscal Studies* 25(4), 389-413.

Starkie, D. (2006). Investment incentives and airport regulation. *Utilities Policy* 14, 262-265.

Starkie, D., & Yarrow, G. (2000). The single-till approach to the price regulation of airports. Civil Aviation Authority, London, UK (available at www. caaerg. co. uk).

Suau-Sanchez, Voltes-Dorta, A., Rodriguez-Deniz, H., 2016. The role of London airports in providing connectivity for the UK: regional dependence on foreign hubs. *Journal of Transport Geography 50*, 94-104.

Tretheway, M. W., & Kincaid, I. S. (2005). Effect of Market Structure on Airline Prices: A Review of Empirical Results, *The. J. Air L. & Com.*, *70*, 467.

United Nations, Department of Economic and Social Affairs, Population Division (2014). World Urbanization Prospects: The 2014 Revision, custom data acquired via website.

UK Airports Commission (2015). Final Report. ISBN: 978-1-84864-158-7.

UK CAA (2007). De-designation of Manchester and Stansted airports for price control regulation. The CAA's advice to the Secretary of State. July 2007.

UK CAA (2014). Market power determinations for Heathrow, Gatwick and Stansted. Various documents. https://www.caa.co.uk/Commercial-industry/Airports/Economic-regulation/Licensing-and-price-control/Airport-Market-Power-Assessment/

Vowles, T. M. (2000). The effect of low fare air carriers on airfares in the US. *Journal of Transport Geography*, *8*(2), 121-128.

Windle, R., & Dresner, M. (1999). Competitive responses to low cost carrier entry. *Transportation Research Part E: Logistics and Transportation Review*, *35*(1), 59-75.

Zhang, S., Derudder, B., & Witlox, F. (2014). The determinants of full-service carriers airfares in European hub-to-hub markets. *European Journal of Transport and Infrastructure Research*, *14*(4), 449-467.

Appendix A Other capacity indicators considered

Average number of aircraft movements per runway (MPR)

The average number of aircraft movements per runway allows for comparing airports on their average throughput per runway. For each airport worldwide, the number of runways was collected from data in the public domain (ourairports.com), providing detailed information of runways at all airports worldwide.[14]

To obtain a fair comparison between airports, we need to define a number of runways at an airport that can be operated simultaneously. Only paved runways of over 1500m are taken into account. We follow the simple rule that runways are considered to be independent if they are in parallel direction and the centre lines are at least 760m apart. For a subset of airports with a more complicated runway layout the number of runways that can be used simultaneously was adjusted manually.

The average number of movements per day is obtained by dividing the annual number of scheduled movements by 365 and by the number of simultaneously operated runways. In turn, the average number of daily movements per runway is distributed over operating hours during daytime (as most airports are not operating 24 hours per day), by dividing the number of average movements per day by 16.

IATA slot coordination level

The IATA slot coordination level provides information on the extent to which an airport is slot controlled. For the purposes of airport coordination, airports are categorised by the responsible authorities according to the following levels of congestion:

Level 1: Airports where the capacity of the airport infrastructure is generally adequate to meet the demands of airport users at all times.

Level 2: Airports where there is potential for congestion during some periods of the day, week, or season, which can be resolved by schedule adjustments, mutually agreed between the airlines and facilitator. A facilitator is appointed to facilitate the planned operations of airlines using or planning to use the airport.

Level 3: Airports where capacity providers have not developed sufficient infrastructure, or where governments have imposed conditions that make it impossible to meet demand. A coordinator is

14 The number of movements per runway has been used as congestion variable in earlier studies as well. Abramowitz and Brown (1993) used movements per runway as congestion variable in explaining airline prices on domestic airline routes in the United States.

appointed to allocate slots to airlines and other aircraft operators using or planning to use the airport as a means of managing the declared capacity

For the purpose of this study, this indicator is too aggregated. From the 59 European airports with over 70,000 movements per year, 49 are categorised as level 3 airports and 8 as level 2 airports. As such, this indicator provides too little variation in the degree to which airports are congested.

Annual Utilisation Rate (AUR)

EUROCONTROL publishes annual capacity in its 'Airport Corner' for a limited number of European airports (66 in total). ACI EUROPE contacted their members for additional information on annual capacity, formulating the question in the exact same way as EUROCONTROL does for the 'Airport Corner' data. Using this additional information we could extent the data availability to 76 European airports in total.

Regarding the reliability of the data in the airport corner, EUROCONTROL was consulted about the source and quality of this data. According to EUROCONTROL, the airports provide information, which is coordinated information between the airport operator and Air Traffic Control (ATC). The yearly forecast capacities should take into account environmental and regulatory constraints and others such as available hours of ATC service provision, fire services and possibly many other constraints. It is not purely based on the physical runway capacity.

The reason that the data is available only for a limited number of airports, is that not all airports participate in the Airport Corner process. EUROCONTROL first invited the most constraining airports (top 20), then it was expanded with an additional set of most constraining airports.

The Annual Utilisation Rate has two major drawbacks. Firstly, the reliability/comparability of the data is sometimes questionable, as there is no standardised technique for the estimation of annual capacity – particularly when while controlling for non-physical restrictions. Some airports calculate the capacity by multiplying the declared peak hour capacity by 24 hours per day and 365 days per year to obtain a theoretical maximum. Others provide estimates taking into account other factors such as opening hours, legislative constraints and other limits of service provision. This makes it difficult to compare actual capacity constraint levels between the different airports.

A second drawback is the availability of the data. As we want to estimate impacts of capacity constraints on air fares using a large sample of airport pares, data on capacity constraints is required for both endpoints of the trip. However, data is only available for a selection of European airports, and is not available for non-European airports.

Comparing the indicators

Ideally, strong correlation should exist between the various capacity measures, if all were good indicators of capacity utilisation. Table A.1 shows correlation between the different indicators, calculated for European airports over 70,000 movements per year. The comparison excluded the IATA schedule coordination level, due to the categorical nature of this variable.

The two CUIs present strong correlations, while the CUI is moderately correlated to the Movements Per Runway (MPR) indicator and the Annual Utilisation Rate (AUR).

Table A.1 CUI is moderately correlated with MPR and AUR

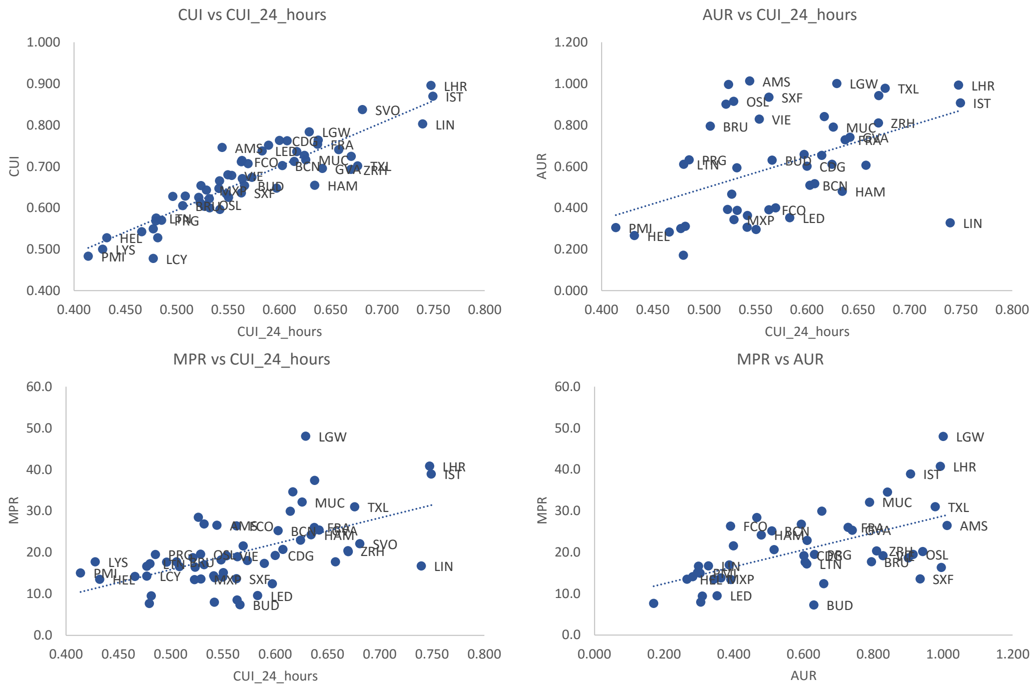
	CUI_24_hours	CUI	MPR	AUR
CUI_24_hours	1	0.896	0.523	0.469
CUI		1	0.563	0.495
MPR			1	0.532
AUR				1

Note: CUI = Capacity Utilisation Index; CUI_day = Capacity Utilisation Index excluding night operations; MPR = movements per runway; AUR = Annual Utilisation Rate
Source: SEO & Cranfield analysis

The indicators show ambiguous individual results for some airports. Milan Linate (LIN) for instance ranks high on CUI, but low on AUR. Linate is restricted to 20 movements per hour, which is reached in a large number of operational hours, leading to a high CUI score. On the other hand, EUROCONTROL publishes a global yearly capacity of which exceeds this limit, leading to a low AUR level within the sample.

For other airports, legislative restrictions are included in the EUROCONTROL data. For Amsterdam for example the global yearly capacity is set at 459000 – even lower than the existing capacity limit of 500000 movements – leading to a high AUR. On the contrary, the CUI is relatively low, as the airport has ample physical runway capacity.

Figure A.2 All indicators are positively correlated



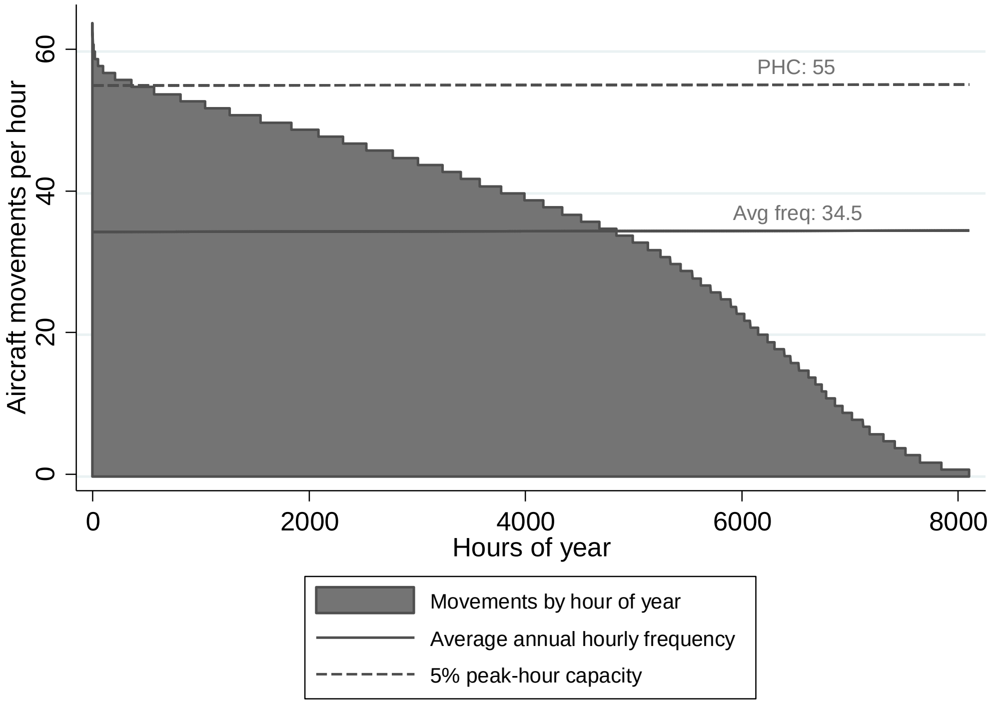
Source: SEO & Cranfield analysis

Appendix B Illustration of the calculation of the CUI

The Capacity Utilisation Index (CUI) at London Gatwick (LGW)

As an illustration we show the determination of the CUI for London Gatwick assuming 24 hour operations (i.e. CUI_24_hours). Figure B.1 shows the traffic-ranking curve of Gatwick for the year of 2016. The 5% peak hour capacity is equal to the frequency in the 5% busiest hour, which is the 404th hour in the case of Gatwick. In this hour 55 departing and arriving flights are scheduled. The average frequency is obtained by taking the mean over all operational hours of the airport in 2016, resulting in an average of 34.6 movements for Gatwick. As a result, Gatwick has a CUI_24_hours of 34.6/55 = 0.629 over the full 24 hours.

Figure B.1 The CUI is obtained by dividing the average hourly frequency by the 5% peak hour capacity



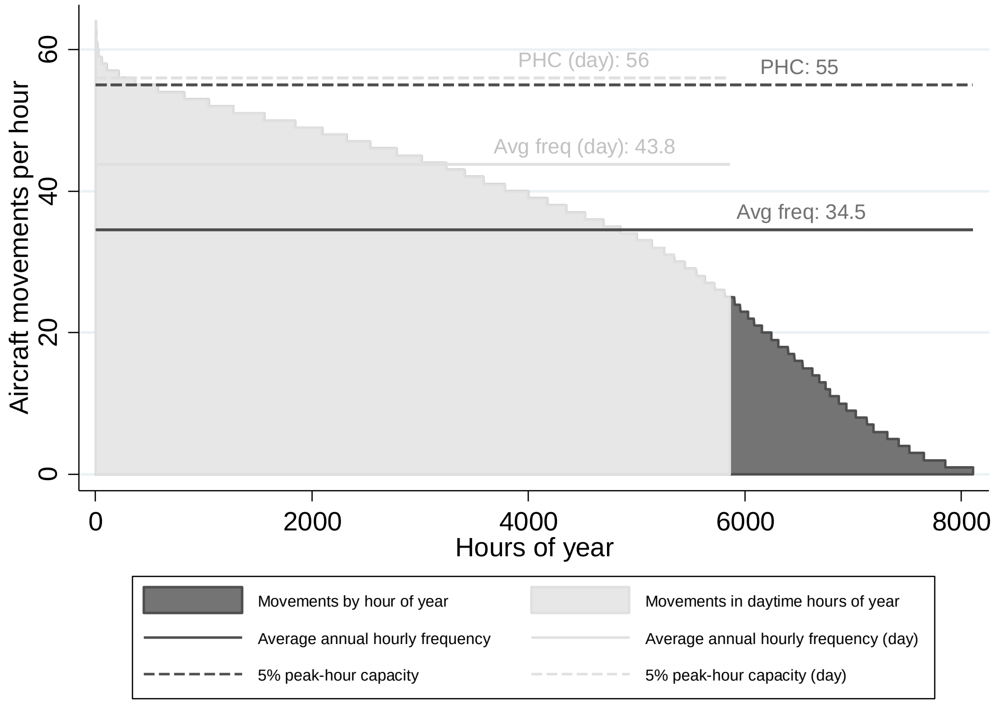
Note: PHC = 5% peak-hour capacity
Source: SEO & Cranfield analysis

A limitation of the CUI_24_hours as calculated above is that it might underestimate congestion levels for airports with a cap on flights at certain periods of the day. For example London Gatwick has a cap on night flights, which is fully utilised. As a result of this cap, a number of operational hours at night-time have relatively few movements per hour. The CUI_24_hours treats these operational hours the same as all other hours, indicating that capacity is not met at these hours, bringing down the CUI_24_hours level.

As a comparison, Figure B.2 presents the calculation of the CUI over daytime hours only (shaded in light-grey). The 5% peak hour capacity is only slightly higher than in the original CUI_24_hours calculation (56 instead of 55), but the average frequency increases by 9.3 flights (from 34.6 to 43.9). This results in a final CUI of 43.9/56 = 0.783.

To minimise the risk of possible errors due to a different treatment of night flights, we use the CUI calculated over daytime hours throughout the report – i.e. CUI_24_hours is not used.

Figure B.2 A higher CUI is found for LGW when only daytime hours are considered



Note: PHC = 5% peak-hour capacity
Source: SEO & Cranfield analysis

Appendix C Overview capacity constraint indicators in 2016

Airport code	Airport name	Country	IATA coordination level	CUI_24_hours	CUI	# independent runways	MPR	AUR
AGP	Malaga Airport	Spain	3	0.482	0.528	2	9.4	0.310
ALC	Alicante Airport	Spain	3	0.466	0.542	1	14.1	0.282
AMS	Amsterdam	Netherlands	3	0.544	0.745	3	26.5	1.012
ARN	Stockholm Arlanda Apt	Sweden	3	0.521	0.625	2	18.7	0.900
ATH	Athens (GR)	Greece	1	0.550	0.680	2	14.0	
AYT	Antalya	Turkey	3	0.480	0.569	2	7.6	0.170
BCN	Barcelona Apt	Spain	3	0.603	0.702	2	25.2	0.509
BHX	Birmingham Airport	United Kingdom	2	0.548	0.633	1	18.1	
BRU	Brussels Airport	Belgium	3	0.506	0.605	2	17.7	0.794
BUD	Budapest	Hungary	2	0.566	0.653	2	7.3	0.629
CDG	Paris Charles de Gaulle Apt	France	3	0.600	0.762	4	19.2	0.601
CGN	Cologne/Bonn Apt	Germany	2	0.542	0.665	2	7.9	0.305
CPH	Copenhagen Kastrup Apt	Denmark	3	0.569	0.707	2	21.5	0.399
DME	Moscow Domodedovo Apt	Russian Federation	2	0.590	0.751	2	17.3	
DUB	Dublin	Ireland Republic of	3	0.617	0.735	1	34.5	0.841
DUS	Duesseldorf International Airport	Germany	3	0.658	0.741	2	17.6	0.604
EDI	Edinburgh	United Kingdom	2	0.564	0.671	1	18.9	
ESB	Ankara Esenboga Apt	Turkey	2	0.509	0.628	1	16.5	
FCO	Rome Fiumicino Apt	Italy	3	0.563	0.711	2	26.4	0.390
FRA	Frankfurt International Apt	Germany	3	0.637	0.753	3	26.0	0.728
GLA	Glasgow International Airport	United Kingdom	2	0.550	0.625	1	15.1	0.295
GVA	Geneva	Switzerland	3	0.642	0.695	1	25.3	0.740
HAM	Hamburg Airport	Germany	3	0.635	0.654	1	24.2	0.479
HEL	Helsinki-Vantaa	Finland	3	0.432	0.527	2	13.5	0.266
IST	Istanbul Ataturk Airport	Turkey	3	0.749	0.870	2	38.9	0.907
LCY	London City Apt	United Kingdom	3	0.477	0.477	1	14.3	
LED	St Petersburg Pulkovo Apt	Russian Federation	2	0.583	0.737	2	9.5	0.352
LGW	London Gatwick Apt	United Kingdom	3	0.629	0.783	1	48.0	1.001
LHR	London Heathrow Apt	United Kingdom	3	0.748	0.895	2	40.8	0.992
LIN	Milan Linate Apt	Italy	3	0.740	0.802	1	16.7	0.327
LIS	Lisbon	Portugal	3	0.615	0.712	1	29.9	0.653

LPA	Gran Canaria	Spain	3	0.477	0.549	1	16.6	0.299
LTN	London Luton Apt	United Kingdom	3	0.480	0.575	1	17.2	0.609
LYS	Lyon St-exupery Apt	France	3	0.428	0.500	1	17.7	
MAD	Madrid Adolfo Suarez-Barajas Apt	Spain	3	0.608	0.762	3	20.7	0.516
MAN	Manchester (GB)	United Kingdom	3	0.524	0.653	2	16.3	0.995
MRS	Marseille Provence Apt	France	3	0.541	0.646	1	14.3	
MUC	Munich International Airport	Germany	3	0.626	0.716	2	32.1	0.789
MXP	Milan Malpensa Apt	Italy	3	0.529	0.643	2	13.5	0.343
NCE	Nice	France	3	0.527	0.604	1	28.4	0.466
OPO	Porto	Portugal	3	0.597	0.647	1	12.4	0.658
ORY	Paris Orly Apt	France	3	0.670	0.724	2	20.2	0.942
OSL	Oslo Gardermoen Airport	Norway	3	0.529	0.607	2	19.5	0.914
OTP	Bucharest Henri Coanda Apt	Romania	1	0.564	0.714	2	8.5	
PMI	Palma de Mallorca	Spain	3	0.414	0.483	2	15.0	0.303
PRG	Prague Ruzyne	Czech Republic	3	0.486	0.569	1	19.5	0.631
SAW	Istanbul Sabiha Gokcen Apt	Turkey	3	0.638	0.763	1	37.4	
STN	London Stansted Apt	United Kingdom	3	0.532	0.622	1	26.8	0.593
STR	Stuttgart Airport	Germany	3	0.532	0.599	1	17.0	0.387
SVO	Moscow Sheremetyevo International Apt	Russian Federation	3	0.681	0.837	2	22.0	
SXF	Berlin Schoenefeld Apt	Germany	3	0.563	0.636	1	13.6	0.934
TLS	Toulouse	France	3	0.523	0.612	1	13.4	0.391
TLV	Tel Aviv-yafo Ben Gurion International	Israel	3	0.573	0.673	1	18.0	
TXL	Berlin Tegel Apt	Germany	3	0.676	0.701	1	31.0	0.978
VCE	Venice Marco Polo Apt	Italy	3	0.542	0.596	1	13.8	0.363
VIE	Vienna International	Austria	3	0.554	0.678	2	19.1	0.828
VKO	Moscow Vnukovo International Apt	Russian Federation	3	0.496	0.628	1	17.6	
WAW	Warsaw Frederic Chopin	Poland	3	0.624	0.726	1	22.9	0.610
ZRH	Zurich Airport	Switzerland	3	0.670	0.692	2	20.3	0.810

Appendix D Definition of internal & external markets

Countries in internal / liberalised sample	Countries in external / non-liberalised sample
Austria	Angola
Belgium	Argentina
Bulgaria	Australia
Canada	Brazil
Croatia	China
Czech Republic	Colombia
Denmark	Dominican Republic
Finland	Egypt
France	Ghana
Germany	Hong Kong (sar) China
Greece	India
Hungary	Indonesia
Iceland	Japan
Republic of Ireland	Korea Republic of
Israel	Lebanon
Italy	Malaysia
Latvia	Mexico
Luxembourg	Qatar
Morocco	Russian Federation
Netherlands	Singapore
Norway	South Africa
Poland	Thailand
Portugal	Turkey
Romania	Ukraine
Serbia	United Arab Emirates
Spain	
Sweden	
Switzerland	
United Kingdom	
USA	

Appendix E Additional regression results

Full-sample model (booked fares)

Table E.1 Estimation results using CUI as congestion variable

	Full sample		Internal/liberalised markets		External/non-liberalised markets	
d_internal	-0.2414	***	.		.	
Hub	0.0675	***	0.0015		0.1812	***
LCC	-0.0394	***	-0.0407	***	-0.0593	
Fuel	0.0803	***	0.1034		0.1659	***
Distance	0.3199	***	0.2972	***	0.4080	***
HHIroute	-0.0119		0.0205		-0.0541	***
HHIairport	-0.0117	*	0.0139		-0.0297	***
CUI	**0.0790**	*****	**0.1367**	******	**0.2214**	*******
GDP	0.2803	***	0.3790	***	0.1680	***
POP	0.1451	***	0.1555	***	0.0927	***
Time effects	yes		yes		yes	
Constant	-2.5460	***	-3.7660	***	-1.4810	***
Number of obs	64,055		38966		25089	
R-squared (overall)	0.4564		0.4022		0.3461	

Legend: ***: p<0.01; **: p<0.05; *: p<0.1
Source: SEO & Cranfield analysis

Movements per runway (MPR) as congestion variable

Table E.2 Using MPR yields similar results as found using CUI as congestion variable

	Full sample		Internal (liberalised) markets		External (non-liberalised) markets	
d_internal	-0.2467	***				
Hub	0.0445	***	-0.0210		0.1615	***
LCC	-0.0495	***	-0.0491	***	-0.0706	*
Fuel	0.0639	**	-0.0080		0.1629	***
Distance	0.3214	***	0.2991	***	0.4056	***
HHIroute	-0.0086		0.0232	*	-0.0505	***
HHIairport	-0.0105		0.0156		-0.0304	***
MPR	0.1364	***	0.1472	***	0.1667	***
GDP	0.2538	***	0.3409	***	0.1473	***
POP	0.1210	***	0.1349	***	0.0719	***
Time effects	yes		yes		yes	
Constant	-2.2966	***	-3.4689	***	-1.3894	***
Number of obs	64055		38966		25089	
R-squared (overall)	0.4568		0.4006		0.3443	

Legend: ***: p<0.01; **: p<0.05; *: p<0.1
Source: SEO & Cranfield analysis

The full sample proved less suitable due to the significantly different dynamics with the separate 'internal' and 'external' markets, which are associated with different interactions between explanatory variables in the various models. For example, the LCC dummy only has a significant impact on the price in liberalised markets. Moreover, the regression constants for the two subsamples are very different, indicating that the average fare levels are different between the two groups.

Some coefficients for the full sample where not between the estimates for the two individual markets – this is a common phenomenon in statistics known as the Simpson's paradox.

Non-linear impacts of congestion variable (booked fares)

Table E.3 Including a quadratic form of the congestion variable (CUI²), indicates that scarcity rents are in particular present at airports with high congestion levels

	Full sample		Internal (liberalised) markets		External (non-liberalised markets	
d_internal	-0.2362	***				
Hub	0.0717	***	0.0039		0.1874	***
LCC	-0.0354	***	-0.0395	***	-0.0543	
Fuel	0.0773	***	0.0068		0.1647	***
Distance	0.3172	***	0.2950	***	0.4036	***
HHIroute	-0.0141		0.0192		-0.0552	***
HHIairport	-0.0136	*	0.0131		-0.0306	***
CUI	-0.5079	***	-0.2436		-0.7200	***
CUI²	1.1919	***	0.8540	***	1.5621	***
GDP	0.2803	***	0.3747	***	0.1749	***
POP	0.1417	***	0.1521	***	0.0969	***
Time effects	yes		yes		yes	
Constant	-2.4251	***	-3.6183	***	-1.4733	***
Number of obs	64055		38966		25089	
R-squared (overall)	0.4604		0.4060		0.3894	

Legend: ***: p<0.01; **: p<0.05; *: p<0.1
Source: SEO & Cranfield analysis

Regression including airport charges per passenger (reduced sample)

Table E.4 Regression on a reduced sample including per passenger aircraft-based airport charges

	Full sample	
d_internal	-0.1055	***
Hub	0.1049	***
LCC	-0.0460	***
Fuel	0.0886	***
Distance	0.3386	***
HHIroute	-0.0146	
HHIairport	-0.0205	**
CUI	0.2179	***
GDP	0.2497	***
POP	0.1771	***
Charge	0.0992	***
Time effects	yes	
Constant	-3.2663	***
Number of obs	36815	
R-squared (overall)	0.4822	

Legend: ***: p<0.01; **: p<0.05; *: p<0.1
Source: SEO & Cranfield analysis

Regression results CUI and MPR (offered fares)

These tables present auxiliary regressions on offered fares, which show that offered fares are not an appropriate indicator to capture scarcity rents, as demand distribution over offered fares is not taken into account. Airlines capture scarcity rents by 'selecting' their passenger mix via revenue management techniques. In contrast, the offered fares data were determined by the data collection parameters of this analysis, and not by airlines via revenue management techniques. Therefore offered fare data is not appropriate to capture scarcity rents present.

The table below presents the explanatory variables used in the regressions. As congestion variables, we use the sum of the MPR and CUI at both endpoints of the trip. Next, we control for other airport and route related factors. The airport control variables include:

- Competition at airport level: Herfindahl-Hirschman Index (HHI) of passenger numbers by airline (or airline alliance) travelling from the respective airport. The HHI is a measure of competition determined by the sum of squared market shares.
- Hub dummy: indicator whether the airport is a hub airport.
- Frequency: total number of flights offered from the airport.
- Frequency competing airport: total number of flights offered from competing airports within a 100km radius.
- GDP per capita: GDP per capita in the country in which the airport is located
- Population: population in urban areas within a 100km radius around the airport.

Additionally, route specific characteristics are included in the model:

- Distance: great circle distance between the origin and destination. To correct for possible non-linearity of the distance variable, we also include squared distance in the model.
- Competition at route level: HHI of passenger number by airline (or airline alliance) travelling on the respective route.
- Detour factor: in case of indirect flights, the duration of the trip with respect to the fastest available trip option.
- Direct flight dummy: indicator whether the route option is direct
- Peak hour dummy: indicator whether the flight departs at the peak hour (between 6 and 8 AM)
- Departure date dummies: Dummy variable for each departure date, capturing effects of price level changes at different departure dates.

Table E.5 Variables used in the offered fare regressions

Variable	Description
logMPR_sum	Movements per runway (MPR): ln(MPR_ori + MPR_dest)
logCUI_sum	CUI_day: ln(CUI_ori + CUI_dest)
logHHI_OD_sum	Competition at airport level: ln(HHI_ori + HHI_dest)
d_hub_OD	Dummy: 1 = one of origin / destination airports is a hub ; 0 = neither are hubs
logFreqTot_OD_sum	Frequency offered from origin and destination airport: ln(annualFreq_ori + annualFreq_dest + 1)
logFreqCompApts_OD_sum	Frequency offered from airports within 100km radius: ln(annualFreqCompApts_ori + annualFreqCompApts_dest + 1)
distance	Great circle distance between origin and destination
distance2	Great circle distance between origin and destination (squared)
logHHI_alliance_route	HHI at route level (mean of outbound and return flight) (log)
d_LCC	Dummy: 1 = LCC competes on route; 0 = no LCC competition
logMeanDetourFactor	Detour factor (travel duration / shortest possible travel duration) (mean of outbound and return flight)
d_direct	Dummy: 1 = direct alternative; 0 = indirect alternative
d_peakhour	Dummy: 1 = departure between 6 and 8 AM; 0 = departure at other hours of day
depDay dummy (w.r.t. departure 10 Oct 2016)	
16 Nov 2016	Departure date 16 November
23 Dec 2016	Departure date 23 December
logGDPpc_OD_sum	GDP per capita at origin and destination: ln(GDP_ori + GDP_dest)
logPOP_OD_sum	Population in a 100km radius around origin and destination: ln(POP_ori + POP_dest)
Constant	Regression constant

Table E.6 Regression results offered fares with CUI variable

	Coach class				Business class			
	Internal		External		Internal		External	
logCUI_sum	-0.4198	***	-0.4363	***	-0.1077		-0.2143	
logHHI_OD_sum	0.1021	***	0.1064	***	0.0873	***	0.0826	**
d_hub_OD	-0.0234		0.0554		-0.0329	*	0.0844	**
logFreqTot_OD_sum	-0.0173		-0.0727	**	-0.0677	***	-0.0396	
logFreqCompApts_OD_sum	-0.0049	**	-0.0141	***	0.0023		-0.0110	***
distance	0.0004	***	0.0003	***	0.0003	***	0.0003	***
distance2	0.0000	***	0.0000	***	0.0000	***	0.0000	***
logHHI_alliance_route	0.0546	***	0.0370		0.0098		0.0331	
d_LCC	-0.0439	***	-0.5081	***	-0.0706	***	-0.3299	**
logMeanDetourFactor	0.0195		0.0983	***	0.0539	***	0.0045	
d_direct	-0.2194	***	0.0372		-0.0085		0.1719	***
d_peakhour	0.0043		0.0721	***	0.0003		-0.0073	
depDay dummy (w.r.t. departure 10 Oct 2016)								
16 Nov 2016	-0.5485	***	-0.4221	***	-0.1845	***	-0.2200	***
23 Dec 2016	-0.0536	***	0.1252	***	-0.1773	***	-0.0920	***
logGDPpc_OD_sum	0.0767	***	-0.0030		0.2076	***	0.0636	***
logPOP_OD_sum	-0.0359	***	0.0043		0.0307	**	-0.0642	***
Constant	5.4236	***	6.2317	***	4.3420	***	7.3039	***
Number of obs	351765		187516		355761		195596	
R-squared	0.6725		0.6101		0.6712		0.6402	

Legend: ***: p<0.01; **: p<0.05; *: p<0.1
Source: SEO & Cranfield analysis

Regressions using MPR as congestion variable

Table E.7 Regression results offered fares with MPR variable

	Coach class				Business class			
	Internal		External		Internal		External	
logMPR_sum	-0.1185	***	-0.1905	***	-0.1121	***	-0.1707	***
logHHI_OD_sum	0.0964	***	0.1072	***	0.0888	***	0.0889	***
d_hub_OD	-0.0239		0.0614	*	-0.0336	*	0.0849	**
logFreqTot_OD_sum	-0.0063		-0.0379		-0.0264		0.0217	
logFreqCompApts_OD_sum	-0.0053	**	-0.0143	***	0.0022		-0.0108	***
distance	0.0004	***	0.0003	***	0.0003	***	0.0003	***
distance2	0.0000	***	0.0000	***	0.0000	***	0.0000	***
logHHI_alliance_route	0.0566	***	0.0448	*	0.0108		0.0362	
d_LCC	-0.0386	**	-0.4845	***	-0.0676	***	-0.3126	**
logMeanDetourFactor	0.0243		0.1014	***	0.0568	***	0.0073	
d_direct	-0.2147	***	0.0416		-0.0059		0.1755	***
d_peakhour	0.0051		0.0709	***	-0.0002		-0.0089	
depDay dummy (w.r.t. departure 10 Oct 2016)								
16 Nov 2016	-0.5487	***	-0.4230	***	-0.1846	***	-0.2204	***
23 Dec 2016	-0.0535	***	0.1253	***	-0.1772	***	-0.0915	***
logGDPpc_OD_sum	0.0947	***	0.0091		0.2170	***	0.0706	***
logPOP_OD_sum	-0.0524	***	-0.0074		0.0285	**	-0.0689	***
Constant	5.6405	***	6.3930	***	4.1453	***	7.0954	***
Number of obs	351765		187516		355761		195596	
R-squared	0.6720		0.6116		0.6720		0.6426	

Legend: ***: p<0.01; **: p<0.05; *: p<0.1
Source: SEO & Cranfield analysis

Appendix F Calculation of total fare premium

The CUI of our example airport in 2014 is 0.737. On an average route in the liberalised market, the summed CUI from this airport is 0.737 + 0.632 = 1.369. At the CUI of the benchmark level, the summed CUI equals 0.596 + 0.632 = 1.228. This means that the summed CUI is 11.5% higher than the benchmark level. In our regression analysis we found that the elasticity between the summed CUI and air fare, on liberalised markets, equals 0.1367. Taking this elasticity into account, fares at the example airport are 0.1367 * 0.115 = 1.6% higher due to airport congestion.

The observed average return fare from our example airport is € 301. In the case that this airport would not have been congested, average return fares would be € 301 / (1+0.016) = € 296.4. This implies the current fare premium is € 4.65 per passenger. Multiplying this by the total number of return passengers on liberalised markets (8.2 million in our example case), all passengers together pay an additional € 38 million due to congestion.

In a similar way the congestion premium – both in liberalised and non-liberalised markets – is calculated for all airports[15] in Europe.[16]. This adds up to a total impact of € 2.1 billion in Europe, an average of € 5.65 per return passenger at airports with a congestion level higher than the benchmark.

[15] Only airports with over 30,000 movements per annum were considered. Fare impacts were only calculated for airports with a congestion level higher than the benchmark levels, negative fare impacts due to less congestion were not taken into account to reflect the fact that in reality the impact of airport constraints on air fares is not symmetrical – airlines will not limit the amount of scarcity rents they will collect, at constrained airports, however they will stop operating services if the yields from a route do not cover the associated costs.

[16] All airports in the EUROCONTROL area were taken into account, consisting of all European countries excluding Russia. The regression model is estimated on a subsample of routes and airports. In this calculation we generalise our results for all routes from European airports, assuming impacts are identical for airports outside the sample. This is a valid approach, as the model is estimated on a large, representative sample.

Appendix G Collection of offered air fare data

Data collection procedure

Offered air fare data is collected from the QPX Express API, which is a service offered by Google designed for online travel intermediaries. The API collects fare data from ATPCO[17], world leader in collection and distribution of airline fare data.

The API allows for collecting up to 500 air fares for each query. A query is a fare request, supporting the following inputs:

- One-way, round-trip, and multi-city itineraries
- Passenger counts (adults, children, infants-in-seat, infants-in-lap, seniors)
- Maximum price
- Refundability
- Solution count (maximum 500)
- Sales country

For each origin-destination pair, QPX Express also supports specifying:

- Departure date and time-of-day range
- Maximum stops
- Maximum connection time
- Preferred cabin
- Permitted and prohibited carriers
- Permitted alliance (Star Alliance, SkyTeam, oneworld)

We collected air fares for round trips on a set of origin-destination pairs, for a single adult. Maximum price or refundability criteria were not enforced. For each query 100 solutions were collected. The sales country was assumed to be the same as the country of the origin airport. Data were collected for different departure dates, varying between one day after booking up to 10 months after the booking day. For each itinerary, a maximum of one intermediate stop was allowed, with no limitations on the maximum connection time. Fares were collected for both coach class and business class. No limitations were placed on the permitted carriers.[18]

Selection of routes, classes and departure dates

Two rounds of data collections were performed: one at the end of September/beginning of October, and one at the end of November/beginning of December.

17 http://www.atpco.net/products/data-collection/fares

18 The QPX Express API does not provide data for all carriers. Some carriers – among others Ryanair, EasyJet and Delta Airlines – do not allow their fares to be distributed via this channel.

Data collection run 1

The first run of data collection considers 38 origin airports and 103 destination airports, allowing for good comparison of fares offered from different kinds of airports and different kind of routes. The following data collection parameters were applied:

- Booking date: 29 September, 3 and 4 October
- Departure date: 10 October 2016, 16 November 2016 and 23 December 2016
- Length of stay:
  - European flights: 3 days to business destinations, 7 days to leisure destinations
  - Intercontinental flights: 5 days to business destination, 14 days to leisure destination
- Cabin class: both coach class and business class for all city pairs

Appendix F presents the origins and destinations used in the sample. Data were collected for all flights between these origins and destinations, resulting in data for 3,881 citypairs. For each city pair, 100 travel alternatives were collected for three departure dates and two booking classes, yielding an initial number of over 2 million observations.

Table G.1 Subset of variables included in the QPX Express API[19]

Variable name	Description
Origin	Origin airport
Hub	Connection point
Destination	Destination airport
Carrier	Designator of the carrier
Aircraft	Aircraft type per segment
Cabin class	Cabin booked for each flight segment
Departure time	Scheduled time of departure
Arrival time	Scheduled time of arrival
Duration	Duration of the flight in minutes
Connection duration	Duration of the connection in minutes
Booking code	The booking code or class for this segment
Booking code count	The number of seats available in this booking code on this segment
Mileage	The number of miles per flight leg
Sale fare	The total fare in the sale or equivalent currency
Sale tax	The taxes in the sale or equivalent currency
List of taxes and carrier surcharges	The taxes used to calculate the tax total per ticket

Source: QPX Express API

Data collection run 2

The second run of data collection considers 16 origin airports and 31 European destination airports, collected for 14 different departure date. This allows to observe how offered fares change when booked longer in advance, as well as to see whether fares are higher in the summer period, which is generally more busy. The following data collection parameters were applied:

- Booking date: 29 November
- Departure date: 30 November 2016 until 27 September 2016, weekly in December and every four weeks in 2017. Departures on Wednesdays.

19 A full list of variables can be found at https://developers.google.com/qpx-express/v1/trips/search

- Length of stay: 2 days
- Cabin class: coach class for all city pairs

Appendix H presents the origins and destinations used in the sample. Data were collected for all flights between these origins and destinations, resulting in data for 478 city pairs. For each city pair, 100 travel alternatives were collected for 14 departure dates, yielding an initial number of over 650,000 observations.

Data cleaning process

The offered air fare data contains some results which are rather unrealistic or unlikely to be booked. Once all the data is collected, data was cleaned based on the following criteria:

- Itineraries with a total travel time of more than three times longer than the fastest travel option were removed
- Interline travel options were removed (i.e. itineraries were flights are offered by carriers belonging to different alliances)
- 5% highest fares overall, separately for long-haul and short-haul flights

Table G.2 Over 2.5 million air fares were collected

	Number of city pairs	Booking date	Departure dates	Cabin class	# air fares before cleaning	# air fares after data cleaning
Round 1	3881	3 October 2016	3 (Oct, Nov, Dec 2016)	Both	2,038,798	1,094,575
Round 2a	478	29 November 2016	14 (Nov '16 – Dec '17)	Coach	659,394	321,786
Round 2b	160	9 December 2016	8 (Dec '16 – Aug '17)	Coach	127,781	92,149

Source: SEO & Cranfield analysis

Appendix H Sample markets

Booked fares / Offered fares scraping run 1

Origins

IATA code	Name	Country	IATA code	Name	Country	IATA code	Name	Country
AMS	Amsterdam	Netherlands	LGW	London Gatwick	United Kingdom	TXL	Berlin Tegel	Germany
BCN	Barcelona	Spain	LHR	London Heathrow	United Kingdom	VIE	Vienna	Austria
BRU	Brussels	Belgium	LIN	Milan Linate	Italy	WAW	Warsaw Frederic Chopin	Poland
BUD	Budapest	Hungary	LIS	Lisbon	Portugal	ZRH	Zurich	Switzerland
CDG	Paris Charles de Gaulle	France	LUX	Luxembourg	Luxembourg	ATH	Athens	Greece
CPH	Copenhagen	Denmark	MAD	Madrid	Spain	OTP	Bucharest	Romania
DUB	Dublin	Ireland Republic of	MAN	Manchester	United Kingdom	RIX	Riga	Latvia
DUS	Duesseldorf	Germany	MUC	Munich	Germany	BSL	Basel	Switzerland
FCO	Rome Fiumicino	Italy	MXP	Milan Malpensa	Italy	BEG	Belgrade	Serbia
FRA	Frankfurt	Germany	OSL	Oslo Gardermoen	Norway	EDI	Edinburgh	United Kingdom
HAM	Hamburg	Germany	PMI	Palma de Mallorca	Spain	BHX	Birmingham	United Kingdom
HEL	Helsinki	Finland	SOF	Sofia	Bulgaria	CGN	Cologne/Bonn	Germany
IST	Istanbul Ataturk	Turkey	SVO	Moscow Sheremetyevo	Russian Federation			

Destinations

IATA code	Name	Country	IATA code	Name	Country	IATA code	Name	Country
CAI	Cairo	Egypt	FCO	Rome Fiumicino	Italy	KRK	Krakow	Poland
CMN	Casablanca	Morocco	FRA	Frankfurt	Germany	LED	St Petersburg	Russian Federation
JNB	Johannesburg	South Africa	GLA	Glasgow	United Kingdom	OTP	Bucharest	Romania
LAD	Luanda	Angola	GVA	Geneva	Switzerland	PRG	Prague	Czech Republic
ACC	Accra	Ghana	HAM	Hamburg	Germany	RIX	Riga	Latvia
DEL	Delhi	India	HEL	Helsinki	Finland	SVO	Moscow Sheremetyevo	Russian Federation
BKK	Bangkok	Thailand	IBZ	Ibiza	Spain	WAW	Warsaw	Poland
CGK	Jakarta	Indonesia	IST	Istanbul Ataturk	Turkey	WRO	Wroclaw	Poland
KUL	Kuala Lumpur	Malaysia	KEF	Reykjavik	Iceland	ZAG	Zagreb	Croatia
SIN	Singapore	Singapore	LCY	London City	United Kingdom	PUJ	Punta Cana	Dominican Republic
HKG	Hong Kong	Hong Kong (sar) China	LGW	London Gatwick	United Kingdom	MEX	Mexico City	Mexico
HND	Tokyo Haneda	Japan	LHR	London Heathrow	United Kingdom	BOG	Bogota	Colombia
ICN	Seoul Incheon	Korea Republic of	LIN	Milan Linate	Italy	EZE	Buenos Aires	Argentina
NRT	Tokyo Narita	Japan	LIS	Lisbon	Portugal	GIG	Rio de Janeiro	Brazil
PEK	Beijing	China	LPA	Gran Canaria	Spain	GRU	Sao Paulo	Brazil
PVG	Shanghai	China	LPL	Liverpool	United Kingdom	AUH	Abu Dhabi	United Arab Emirates

AGP	Malaga	Spain	LTN	London Luton	United Kingdom	BEY	Beirut	Lebanon
AMS	Amsterdam	Netherlands	MAD	Madrid	Spain	DXB	Dubai	United Arab Emirates
ARN	Stockholm	Sweden	MAN	Manchester	United Kingdom	DOH	Doha	Qatar
ATH	Athens (GR)	Greece	MUC	Munich	Germany	TLV	Tel Aviv	Israel
AYT	Antalya	Turkey	MXP	Milan Malpensa	Italy	ATL	Atlanta	USA
BCN	Barcelona Apt	Spain	NCE	Nice	France	BOS	Boston	USA
BGO	Bergen	Norway	OPO	Porto	Portugal	EWR	Newark	USA
BHX	Birmingham Airport	United Kingdom	ORY	Paris Orly Apt	France	IAD	Washington Dulles	USA
BIO	Bilbao	Spain	OSL	Oslo Gardermoen Airport	Norway	JFK	New York J F Kennedy	USA
BRU	Brussels Airport	Belgium	PMI	Palma de Mallorca	Spain	LAS	Las Vegas	USA
CDG	Paris Charles de Gaulle	France	STN	London Stansted	United Kingdom	LAX	Los Angeles	USA
CGN	Cologne/Bonn Apt	Germany	STR	Stuttgart Airport	Germany	MCO	Orlando	USA
CPH	Copenhagen	Denmark	TFS	Tenerife Sur	Spain	MIA	Miami International	USA
CTA	Catania	Italy	TXL	Berlin Tegel	Germany	ORD	Chicago	USA
DUB	Dublin	Ireland Republic of	VCE	Venice	Italy	SFO	San Francisco	USA
DUS	Duesseldorf	Germany	VIE	Vienna	Austria	YUL	Montreal	Canada
EDI	Edinburgh	United Kingdom	ZRH	Zurich	Switzerland	YYZ	Toronto	Canada
ESB	Ankara	Turkey	KBP	Kiev	Ukraine	SYD	Sydney	Australia
FAO	Faro	Portugal						

Offered fares scraping run 2

Origins

IATA code	Name	Country
LHR	London Heathrow Apt	United Kingdom
LGW	London Gatwick Apt	United Kingdom
TXL	Berlin Tegel Apt	Germany
ZRH	Zurich Airport	Switzerland
AMS	Amsterdam	Netherlands
LIN	Milan Linate Apt	Italy
ORY	Paris Orly Apt	France
BCN	Barcelona Apt	Spain
CDG	Paris Charles de Gaulle Apt	France
VIE	Vienna International	Austria
MXP	Milan Malpensa Apt	Italy
BRU	Brussels Airport	Belgium
FCO	Rome Fiumicino Apt	Italy
HEL	Helsinki-Vantaa	Finland
MAD	Madrid Adolfo Suarez-Barajas Apt	Spain
BLQ	Bologna Guglielmo Marconi	Italy

Destinations (Europe)

IATA code	Name	Country	IATA code	Name	Country
LHR	London Heathrow	United Kingdom	ARN	Stockholm Arlanda	Sweden
LGW	London Gatwick	United Kingdom	CPH	Copenhagen Kastrup	Denmark
TXL	Berlin Tegel Apt	Germany	DUB	Dublin	Ireland Republic of
ZRH	Zurich Airport	Switzerland	MUC	Munich	Germany
AMS	Amsterdam	Netherlands	PMI	Palma de Mallorca	Spain
LIN	Milan Linate	Italy	ATH	Athens (GR)	Greece
ORY	Paris Orly	France	LIS	Lisbon	Portugal
BCN	Barcelona	Spain	NCE	Nice	France
CDG	Paris Charles de Gaulle	France	OSL	Oslo Gardermoen	Norway
VIE	Vienna International	Austria	DUS	Duesseldorf	Germany
MXP	Milan Malpensa	Italy	FRA	Frankfurt	Germany
BRU	Brussels	Belgium	GVA	Geneva	Switzerland
FCO	Rome Fiumicino	Italy	IST	Istanbul Ataturk	Turkey
HEL	Helsinki-Vantaa	Finland	MAN	Manchester (GB)	United Kingdom
MAD	Madrid	Spain	BUD	Budapest	Hungary
BLQ	Bologna Guglielmo Marconi	Italy			

Destinations (ICA)

IATA code	Name	Country
BKK	Bangkok Suvarnabhumi	Thailand
PEK	Beijing Capital	China
NRT	Tokyo Narita	Japan
DOH	Doha	Qatar
DXB	Dubai	United Arab Emirates
JFK	New York J F Kennedy	USA
EWR	Newark Liberty	USA
MIA	Miami International	USA
ORD	Chicago O'Hare International	USA
SIN	Singapore Changi	Singapore

seo amsterdam economics

Roetersstraat 29 . 1018 WB Amsterdam . T (+31) 20 525 16 30 . F (+31) 20 525 16 86 . www.seo.nl