LCC impact on the US airport business[1]

Nadezda Volkova[2], Jürgen Müller

German Airport Performance Project (GAP), Berlin School of Economics and Law

ABSTRACT: Over the last few years, low cost carriers (LCCs) have become well established at airports all around the world. By increasing origin and destination (O&D) competition they have changed the airports' business model. To remain competitive, airports interested in attracting LCCs are likely to aim to keep charges low and to offer a fast turnaround. It is therefore important for them to explore the potential of additional traffic, which generates both aeronautical and non-aeronautical revenue, and especially the impact of LCCs on the airports' non-aeronautical income, if charges have to be lowered .

This paper first shows that for the categories retail, car rental and parking the average LCC passenger in the US contributes more revenues than the average non-LCC passenger does. Taking the regulatory and institutional environment of US airports into accounts the paper then finds statistically significant evidence for the hypothesis that for airports that serve LCCs and apply the residual rate-setting approach, such increases in non-aeronautical revenues lead to reductions in aeronautical revenues in the subsequent period. This suggests that cross-subsidisation from extra LCC revenues leads to reductions in charges, which are beneficial for both LCCs and traditional airlines.

Keywords: Low cost carriers, US airports, Airport charges, Non-aeronautical revenue, Panel data analysis

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[2] Corresponding authors: Volkova.Nadezda@googlemail.com, jmueller@hwr-berlin.de

1. Introduction

Against the background of a general trend of liberalisation and deregulation of the aviation market, that is affecting the airline as much as the airport market, airports have been facing rapidly changing circumstances. In the US and subsequently all around the world, the airline market liberalisation that has been associated with a strong rise in the number of low cost carriers (LCCs) also puts increased competitive pressure on airports.

At the same time the contribution of non-aeronautical activities to the airports' revenue has been growing significantly, often even exceeding that of aeronautical services that are related to an airport's primary activity of providing airline services. According to the Airport Council International's annual airport survey in 2008, non-aeronautical revenue (car rental, parking, retail, food & beverage (F&B)) accounts for 53% of the total revenue at North American airports.[3] .

This paper aims to look at these two developments and their possible interrelation, as the effect of an increase in the market share of LCCs is complex. LCCs tend to bring additional traffic to the airport, which is the main prerequisite for more non-aviation business. However, the impact of LCCs on non-aeronautical revenues equally depends on the spending patterns and preferences of LCC passengers that are likely to be different from those of full service airline (FSA) passengers. Assuming that LCCs are attracted by comparably low charges, a strategy which is very apparent in Europe, the question arises whether this lower revenue can be compensated by extra traffic – which increases both aeronautical and non-aeronautical revenue – and perhaps yields even higher per passenger non-aeronautical revenues. Depending on the regulatory regime as well as on the type of airport/ airline agreement, an increase in an airport's non-aeronautical revenue might also lead to a reduction in the level of airport charges – to the benefit of both LCCs and FSAs.. Hence, there can be contrary tendencies affecting the overall revenues of airports that may not be easily captured by purely descriptive statistics.[4]

By trying to analyse these tendencies separately using both descriptive statistics and thoroughly tailored econometric models, this paper goes beyond the existing literature in shedding light on the impact of LCCs on aviation and non-aviation revenue streams for US airports and the airport business as a whole.

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[3] The numbers are 50%, 47% and 28% respectively, for Asian/Pacific airports, European airports and Latin American/Caribbean airports.

[4] However, no price discrimination is allowed in the US; LCCs and FSAs pay the same level of charges, see Ch. 3. Indirect business activities, such as the development of nearby land for offices, hotels and shopping malls, have become a further source of additional revenues

Our analysis focuses on US airports, that have the longest LCC history as a consequence of the early deregulation of the airline industry. The US market also offers access to unique and very detailed non-aviation data that allows a comprehensive econometric analysis. However the regulatory and institutional settings specific to the US aviation market[5] do not allow immediate inferences to other countries.

The paper is structured as follows. A brief review of the existing literature is given before focussing on the possible effects of the growing LCC market on airport . The empirical section starts with a short note on the selection of LCCs and airports. This is followed by a descriptive analysis which indicates a positive relationship between an increasing LCC market share and rising non-aeronautical revenues. This is followed by estimating the effect of LCC and non-LCC passengers on the different components of non-aeronautical revenues. The first part of the econometric analysis also shows that the average LCC passenger generates higher non-aeronautical revenue than a FSA passenger does. Whether such increases in revenues lead to lower charges depends on the rate-setting approach for airlines, as suggested in an by the second econometric part. The paper finishes with some concluding remarks.

2. Review of the Literature

The emerging and increasingly booming LCC market has been addressed by a growing body of literature. However, the effect of the market on the airport business in general and the non-aviation sector in particular is seen ambiguously. Generally, the entrance of LCCs is associated with an increase in the total volume of passengers carried as air travel becomes more affordable. But LCCs also capture a share of passengers from general service airlines (GSAs) and from nearby airports. Quite often, LCCs choose to operate at secondary airports located relatively close to larger airports that tend to dominate the region. This heightened competition between primary and secondary airports has led to greater incentives for airports to improve allocative efficiency and service quality, to lower aviation charges and to provide attractive non-aeronautical activities (Humphreys and Francis 2006).

Barrett (2004), looking at European airports, argues that the introduction of LCCs to an airport with free capacity is attractive for the following reasons:

- LCCs have a strong track record in delivering business, even to virtually empty airports with low demand;

[5] For background information see Transportation Research Board, 2007.

- LCCs provide non-aeronautical revenue opportunities for airports, such as F&B services, which are normally provided in-flight by GSAs or full fare airlines;
- LCCs generate a greater than average per passenger use of car rentals at smaller airports.

At least two reasons why parking and car rental tend to be more important for LCC passengers have been identified: airports dominated by LCCs are often secondary airports, which are generally located further away from city centres and offer less frequent and fewer varieties of public transportation and, in comparison with more established airlines, LCC flights are often scheduled at less convenient times when public transport may not be running. On the other hand, the typically lower budget of LCC passengers compared to FSA and customers needs to be contrasted with such arguments.

Moreover, Humphreys et al. (2006) note that the volatility in the low cost sector is likely to render the benefits of attracting LCCs uncertain and short-lived: LCCs withdraw much more often all or part of their operations from an airport in order to serve different, more profitable routes than FSA airlines. Moreover, there is no guarantee that non-aeronautical revenue will improve, since the purchasing preferences and spending habits of LCC passengers could be different from those of FSA passengers.

Graham (2009), pointing to the LCCs' strengthened efforts to control their costs due to intensified competition, argues that LCCs as well as GSAs have been exerting a growing pressure on airports to reduce their aviation charges. In line with this contention is the observation of Graham and Dennis (2007) who show that since 1998 LCCs have been largely responsible for the strong passenger growth at a number of UK and Irish airports. At the same time, these airports tend to have decreasing unit revenues, especially for the aeronautical part of the revenue. Francis et al. (2004) even note that some LCCs are pushing for prices below the airports' marginal costs. In such a situation, relying on the potential revenues of non-aeronautical activities is the only way to continue serving LCCs profitably.

While it could be argued that an increase in traffic is by itself a worthwhile goal, with an eye towards improved accessibility to and from a region or the utilisation of underemployed infrastructure (Humphreys et al., 2006; Graham and Dennis, 2007) it is of foremost importance from the airport's perspective to be able to compensate for a potential decreases in aeronautical revenues. However, the empirical evidence on the impact of LCCs on non-aeronautical revenues is still sparse and mainly focussed on Europe. In a survey of more than 20,000 passengers at seven Spanish regional airports, Castillo-Manzano (2010) does not find a statistically significant difference between LCC and traditional FSA passengers in making the initial decision to purchase or consume food and beverages before a flight. However, once passengers decide to spend money, LCC passengers of that survey spend 7% less on average than those who fly with a traditional airline.

These findings are confirmed by those of Lei and Papatheodorou (2010), who look at British regional airports. According to their results an LCC passenger generates on average an additional GBP 2.87 of commercial revenue, while an additional FSA passenger increases commercial revenue by GBP 5.59. Nevertheless, Lei and Papatheodorou (2010) conclude that LCC passenger growth, i.e. additional traffic, is desirable in the case of idle capacity at an airport.

Yet, in addition to the above mentioned general objectives of an airport, the impact of a growing LCC market share strongly depends on the regulatory framework of the airport as well as on airline/ airport arrangements. The remainder of this paper tackles the US airport market and takes the corresponding institutional and regulatory settings as a basis for that framework.

3. The Case of US Airports

In the US most airports are publicly owned and funded, which puts restrictions on the use of airport revenues (Transportation Research Board, 2007). Airport charges are regulated under Federal Aviation Administration (FAA) rules. The FAA Authorization Act of 1994 sets four statues that regulate the use of airport revenue, the main principles of which are the following:

- All revenue generated by the public airport should only be used to cover airport related costs that are "directly related to the actual transportation of passengers or property" (Section 511(a)(12), Airport and Airway Improvement Act (AAIA) of 1982). As also subsequently stated by the FAA Authorization Act, this excludes the use of revenues for activities such as general economic development or promotion that is unrelated to the direct airport business.[6]
- While in general FAA regulation allows the joint promotion of new services with airlines, providing incentives to attract new airlines or to encourage new air services that discriminate between airlines may infringe grant assurances which prohibit unjust discrimination (Department of Transportation, 1999). Thus, for instance

- [6] The so-called ''grandfather'' provision of the AAIA (modified in the Airport and Airway Safety and Capacity Expansion Act of 1987) permitted a number of ways for using airport revenues for non-airport purposes. While this provided airports little incentives to generate profits, the FAA Authorization Act at the same time required airports with a state grant to be "as self-sustaining as possible."

airport fee waivers and discounts for certain types and levels of services are permitted only for a promotional period and must be offered to all users.

- US airports experience not only regulatory pressure from the FAA but many critical issues of their relationships with airlines are settled in *airport/ airline agreements*, in particular how the aviation charges that airlines pay is set.

- The two primary rate-setting approaches for determining airport charges are the residual approach and the compensatory approach (Transportation Research Board, 2010):
    - Under the residual rate-setting approach airlines bear the overall financial risk of the airport operation as any (residual) revenues missing for the airport to break even are covered by the airlines. That means that with increasing traffic the lacking residual becomes smaller and aviation charges would be lowered as soon as it disappears. On the other hand, in the case of traffic reduction charges would have to be increased. At the same time airlines benefit from an increase in the airport's non-aeronautical revenue: extra revenues from non-aviation services must be used to lower aviation charges (similar to single till regulation of airport charges).
    - Under the compensatory arrangement aeronautical operations of an airport cannot be subsidised by non-aeronautical revenues (similar to dual till regulation of airport charges). As the airport operator assumes the overall financial risk of the airport operation, the approach often results in higher charges (Tretheway, 2001). Revenues higher than required to cover total costs are not transformed into reductions in charges. Rather, since US airports are at the same time subject to non-profit requirements, extra income tends to go towards financing capital projects.

The overview of the regulatory framework of airports in the US confirms the need of airports to understand the impact of LCCs on non-aeronautical activities as well as on the airport business in general, since they are required to be self-sustainable, Whether the average LCC passenger generates more non-aeronautical revenues is difficult to establish, as our literature review has indicated and must therefore be explored empirically. The impact of higher non-aeronautical revenues on charges is however much more determined by regulatory settings and needs to be deliberated carefully.

In contrast to some European airports FAA regulation does not allow US airports to discriminate in the level of charges between LCCs and FSAs. Thus, if LCCs negotiate lower charges, this will apply to all airlines, making the need to identify alternative sources of revenues even more urgent for airports. Even if lower charges are not negotiated initially, they might result from higher non-aeronautical revenues that have to be redistributed. As the above overview has indicated, whether such an effect takes place, is likely to depend on the rate-setting approach. Only in the case of the residual approach can non-aeronautical profits be used to subsidise the aeronautical sector and thus to allow a lowering of charges. Therefore, provided that the growing LCC market is associated with increasing non-aeronautical revenues, the hypothesis of this paper is that in the case of the residual rate-setting approach this tends to result in lower charges, to the benefit of both LCCs and FSAs. Consequently, airports serving LCCs and using the residual approach are likely to have comparably lower charges than those without LCCs and/ or those using compensatory agreements.

4. Empirical Part

4.1. Selection of LCCs

Before selecting specific LCCs for the empirical analysis of this paper, the term LCC needs to be defined properly. For a long time, the term "No-frills airlines" was a synonym for LCC. However, many companies considered as LCCs do add some frills to their services such as frequent flyer programs, special products for corporations and business travellers, or flights from primary airports. For example, Lei and Papatheodorou's (2010) who assess the strategies of a wide range of European LCCs[7] find that the range of strategies and services offered by them are very diverse, influencing the customer profile and purchasing behaviour of passengers.

Graham and Dennis (2007) also point to the problem of a proper LCC definition. They mention that some LCCs use primary airports and established regional airports, whereas others operate at smaller secondary airports only. This means that LCCs have customers with varying price sensitivities as well as different traffic characteristics, and that these profiles are likely to affect an airport's performance differently. For instance, there is an increasing share of business passengers on LCC flights for which the LCCs' relatively high availability and frequency, more convenient schedules and/ or a wider variety of destinations or flights to both

[7] Such as Ryanair, EasyJet, Switzerland, Bmibaby, Go, MyTravelLite, Jet2, FlyGlobespan, Flybe, Astraeus (Iceland Express), Air Berlin, Deutsche BA, Norwegian Air Shuttle, Sky Europe, Basiq Air and Hapag-Lloyd Express.

secondary airports and primary airports are possible reasons (Reed, 2009). On the other hand US full service airlines, such as Delta, American, United, Continental and US Airways similarly adjust their product profile to competition from the LCCs, reducing services on board and lowering fares on competitive routes. They collectively offer more seats at discount prices than LCCS:

While the notion LCC is not always clearly demarcated, characteristics like low ticket prices and few frills still constitute a specific group of airlines that has had a significant and enduring impact on the development of the airport business. Therefore, keeping problems of demarcation and the high variety of LCCs in mind, an analysis of the airline segment "LCCs" may well lead to highly meaningful results. Yet, it is important to look at the customer profiles of the LCCs in question. For instance, if a LCC offers connecting flights or serves corporations, this implies that it has transfer and business passengers whose purchasing behaviour could be different from that of origin and destination (O&D) or leisure passengers.

Table 1 gives an overview of all US LCCs for 2008. The entire sample of the empirical analysis includes data for the period from 2000 to 2008. As Table 1 shows, Southwest, AirTran and JetBlue are the leading US LCCs in terms of passenger numbers. In 2008 the three airlines accounted for 13.71%, 3.31% and 2.94%, respectively, of total US international and domestic traffic. Since other US LCCs are unlikely to have enough volumes to significantly influence average industry trends, our analysis is limited to Southwest, AirTran and JetBlue and the term "LCC" refers to only these airlines for the remainder of the paper.

4.2. Selection of Airports

The FAA defines airports by categories of major airport activities, such as commercial services, primary, cargo services, reliever and general aviation airports.[8] For this paper only commercial service airports are relevant, having 2,500 or more enplaned passengers per year from scheduled passenger services. In 2008, there were 503 such airports in the US.[9]

[8] The main data sourceis the US Department of Transportation's Bureau of Transportation Statistics and the main source for all airport-related data is the FAA.

[9] Aviation activity in the US accounts for approximately 40% of all commercial aviation and 50% of all general aviation activity in the world (FAA, 2010).

Table 1. US LCC traffic in 2008

LCC	Domestic enplaned passengers*	International enplaned passengers**	Total enplaned passengers	International traffic as a percentage of total traffic	Market share in domestic traffic out of total domestic traffic controlled by US carriers	Market share in international traffic out of total international traffic controlled by US carriers	Market share in total traffic controlled by US carriers
AirTran	24 586 032	2 638	24 588 670	0.01%	3.76%	0.00%	3.31%
Allegiant Air	4 263 157	29 275	4 292 432	0.68%	0.65%	0.03%	0.58%
Frontier	10 096 403	544 138	10 640 541	5.11%	1.54%	0.61%	1.43%
Horizon Air	6 480 805	909 094	7 389 899	12.30%	0.99%	1.01%	0.99%
JetBlue	20 517 934	1 345 466	21 863 400	6.15%	3.14%	1.50%	2.94%
Midwest	3 004 083	1 323	3 005 406	0.04%	0.46%	0.00%	0.40%
Southwest	101 965 552	0	101 965 552	0.00%	15.60%	0.00%	13.71%
Spirit	5 500 761	1 319 114	6 819 875	19.34%	0.84%	1.47%	0.92%
Sun Country	1 270 630	202 182	1 472 812	13.73%	0.19%	0.22%	0.20%
USA 3000	809 307	698 562	1 507 869	46.33%	0.12%	0.78%	0.20%
Virgin America	2 564 629	0	2 564 629	0.00%	0.39%	0.00%	0.34%
All LCCs (including those not displayed)	653 816 163	89 901 130	743 717 293	12.09%			

* – Contains domestic enplanements reported by US air carriers when both O&D airports are located within the boundaries of the US and its territories.

** – Contains international enplanements reported by US air carriers when at least one point of service is in the US or one of its territories. Flights with both O&D in a foreign country are not included.

Source:

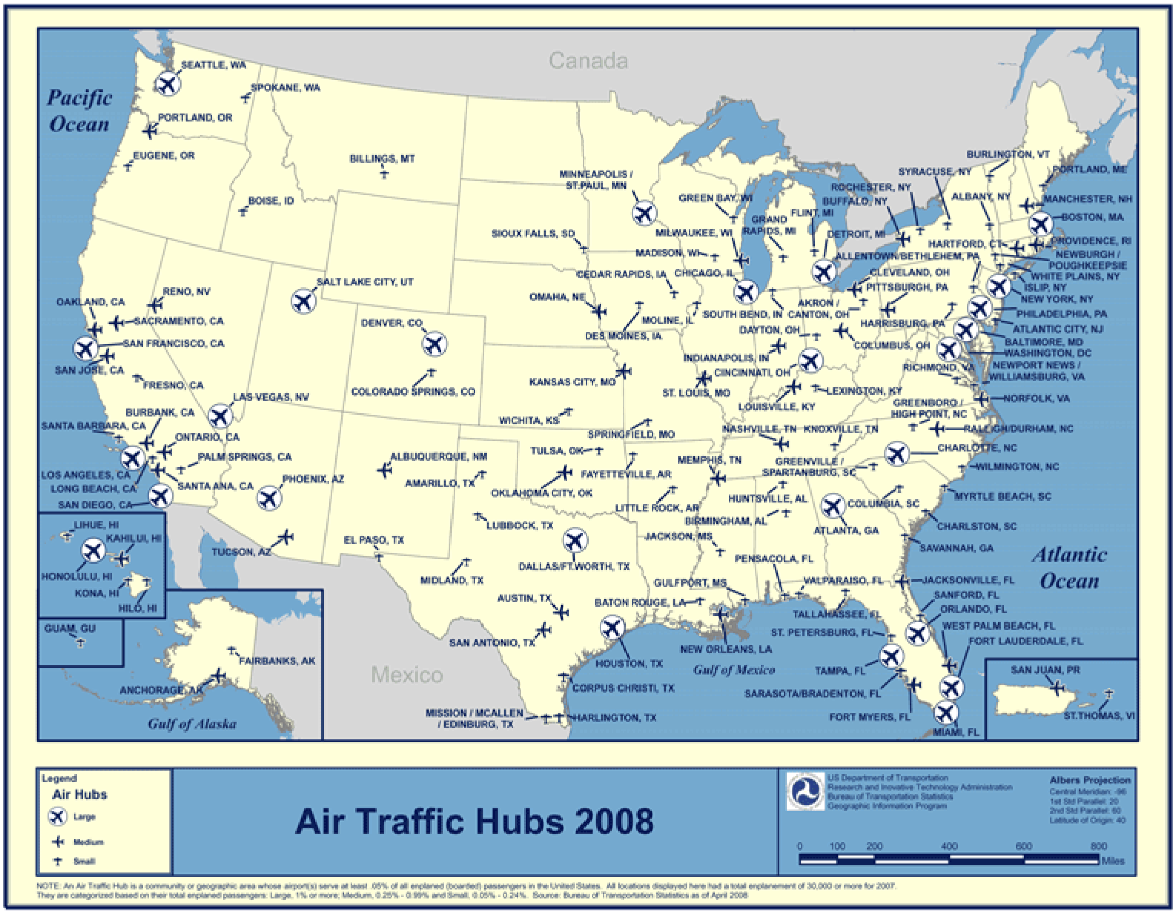
This sample of airports is further divided into primary and non-primary airports, with the latter having less than 10,000 passengers per year. In 2008, 382 airports out of the 503 airports selected were classified as primary airports.[10] Primary airports, again, are categorised into large, medium and small hubs, and non-hub primary. The focus of this paper are the hub airports. As shown in Table 2, our sample includes 89 hub airports for the years 2004–2008 and covers all large hubs, 95% of the medium hubs and 35% of the small hubs in the US. These hub airport systems are also shown in Figure 1. . Since for some airports the data was not available for the entire analysed period (2004-2008), the data panel used in the analysis is unbalanced.

Table 2. Primary airports – categorisation and sample coverage

Category	Hub type: percentage of annual passenger boardings	Total number in the US in 2008	Total number in the sample in 2008
Large Hub	**Large:** 1% or more of all enplaned (boarded) passengers in the US	**29**	**29**
Medium Hub	**Medium:** At least 0.25%, but less than 1% of all enplaned (boarded) passengers in the US	**37**	**35**
Small Hub	**Small:** At least 0.05%, but less than 0.25% of all enplaned (boarded) passengers in the US	**72**	**25**

Figure 1. US air hubs (Source: US Department of Transportation, 2008)

[10] This number changes slightly from year to year. For example, in 2007 388 airports were categorised as primary airports, in 2006 it was 382.



5. Empirical Part

5.1. Trends in the US Airport Market

This paper tackles two trends that have characterised the airport market during the last decades: an increasing LCC market share and the rising significance of the non-aeronautical sector. Concerning the first point, we find an increasing market share for LCCs at the three hub groups, with the exception of the small hubs in 2008 (Figure 2). The market share of the top three US LCCs (Southwest, AirTran and JetBlue) is highest for the medium hubs[11] and is above 10% in all hub groups. Concerning the second point, we observe in Figure 3 the proportion of aeronautical to non-aeronautical revenue. Aeronautical revenue arises from aviation-related services which are provided by the airports. Non-aeronautical revenue refers to all other airport services that are not directly related to aviation. Both aeronautical and non-aeronautical revenue together constitute an airport's operating revenue. For the sample airports, operating revenue accounts for roughly 70% of total airport revenue, with the remaining 30% accruing to non-operating revenue, the three main components of which are interest income, grant receipts and passengers' facility charges. Figure 3 clearly shows a

[11] Average annual number of enplaning passengers in medium hub group during 2004–2008 was four million.

decreasing share of aeronautical revenues during the period from 2004 to 2008, with non-aeronautical revenues accounting for more than half of the airports' total operating revenue in 2008.

Figure 2. US LCC market share for different hubs

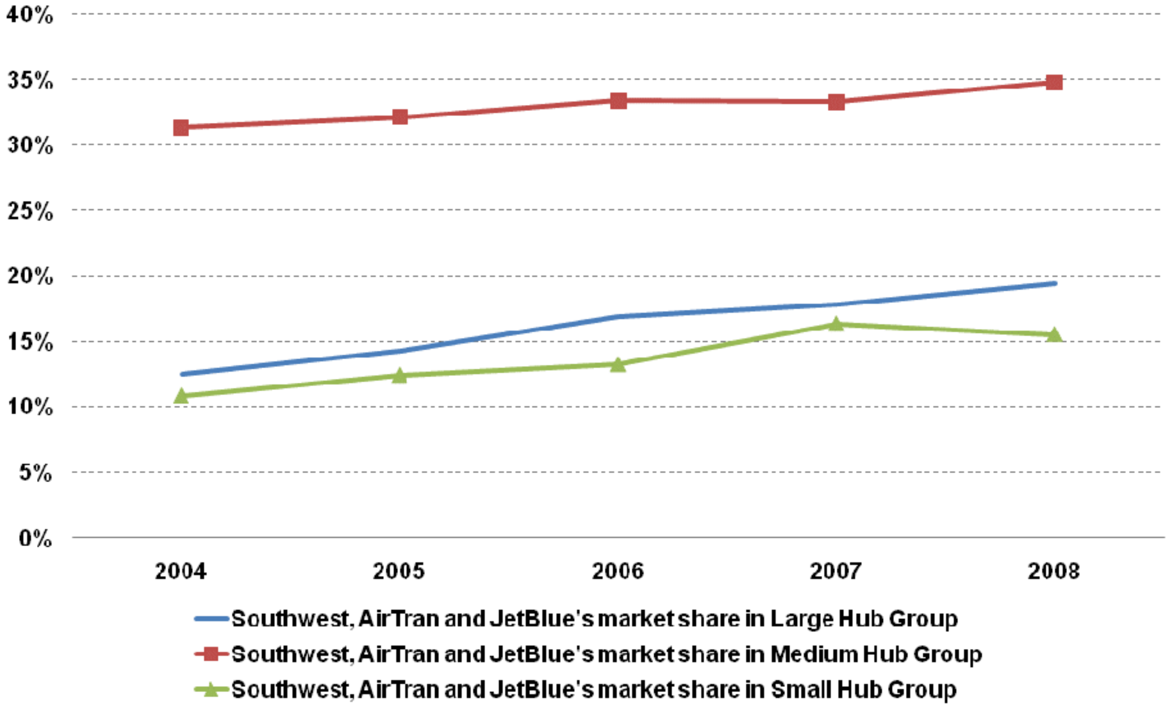


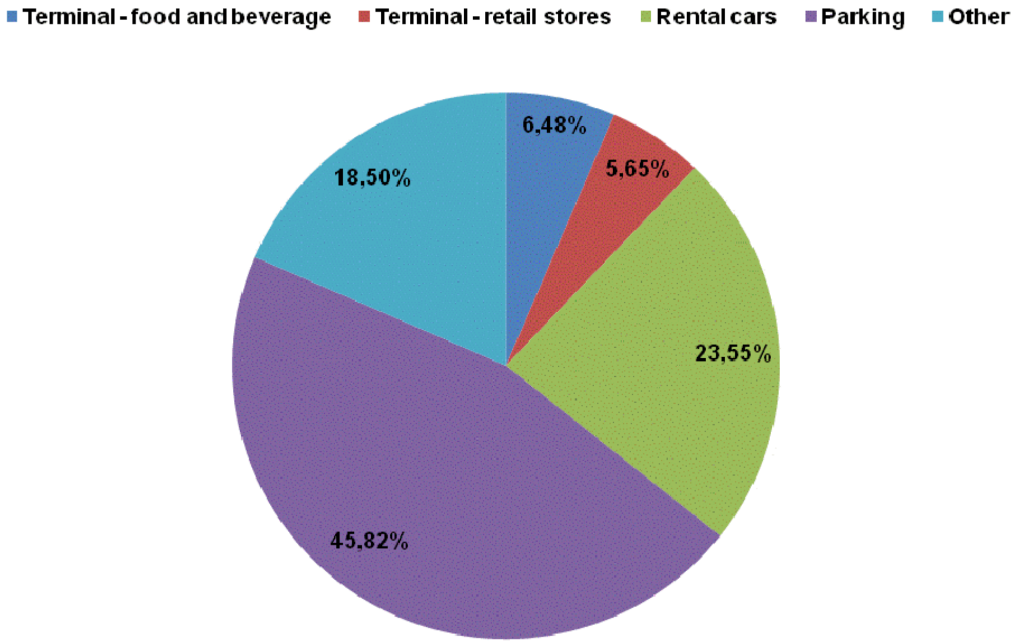
Table 3. Airport charges per passenger by different levels of LCC share in airport's traffic (in 2008)

	Landing Fees per enplaning passenger	Terminal charges per enplaning passenger
When total share of LCCs in the airport is equal or lower than 15%	4.55	5.46
When total share of LCCs in the airport is higher than 15%	3.17	4.07

Impact of LCCs on airports' non- aeronautical revenue

Looking in Figure 4 at the composition of non-aeronautical revenues at the sample airports in 2008, parking with a share of 45.8% can be identified as the largest component, followed by income from rental cars, F&B and retail stores. How the spending patterns of LCC passengers matters for those categories will be examined in the following section.

Figure 4. Composition of non-aeronautical operating revenue at US airports in 2008



5.2. The Impact of LCCs on Non-Aeronautical Revenues

Table 3 gives an overview of per passenger non-aeronautical revenues by category for all passengers. F&B and retail income is calculated per enplaning passenger. Because transfer passengers do not use parking and car rental services, airport income from these two services must be calculated per O&D passenger only. Given the very different shares of transfer passengers for LCCs and legacy carriers – with 5% for the former contrasting 31% for the latter in 2008 – unadjusted results are otherwise likely to be biased.

Table 3. Non-aeronautical revenue per passenger by source in 2008 (84 airports)

	Mean	Standard deviation	Min	Max
Parking revenue per O&D passenger (in $)	7.26	2.74	0.97	15.42
Car rental revenue per O&D passenger (in $)	3.57	1.33	0.91	8.29
F&B revenue per passenger (in $)	0.65	0.34	0.01	2.26
Retail store revenue per passenger (in $)	0.56	0.49	0.00	2.89

How do LCC passengers contribute to these revenue streams? By regressing the sum of LCC passengers and the sum of non-LCC passengers on the real revenue for each category this contribution is estimated in the following. Thus, the following estimation is run for each category:

REG 1: $(Category\ real\ revenue)_{it} = \alpha_0 + \alpha_1 * (LCC\ pax)_{it} + \alpha_2 * (FSA\ pax)_{it} + u_i + \varepsilon_{it},$

where *category real revenue* is F&B, retail, parking or car rental nominal revenue divided by the CPI.
LCC pax refers to the sum of Southwest, JetBlue and AirTran passengers at the airport,
FSA pax is the number of passengers from airlines other than the top three LCCs.
All airport specific effects are denoted by u_i. i and $t \in [2004;2008]$ denote the individual airport effects and time effects, respectively.

The sample of the analysis is an unbalanced panel of 89 hub airports for the years 2004–2008. Given the panel structure of the data, the model can be estimated in a number of ways, namely as a pooled, random effects or fixed effects model. Whereas the pooled model assumes that there are neither significant airport-related effects nor significant temporal effects, the fixed and the random effects model account for individual heterogeneity. Hence, if differences between airports that cannot be measured or temporal changes such as amendments in federal regulations are expected to have a significant impact on airport performance, the fixed or random effects model should be used. While the fixed effects model controls for time-invariant differences between airports, the random effects model assumes the variation between airports to be random. For each revenue category the analysis starts with an estimation of the pooled model (1) followed by the random (2) and fixed effects model (3). The preferred model is chosen on the basis of the results of the relevant tests. Table 4 shows the estimation results for the contribution of LCC and FSA passengers to F&B revenue.

To decide which model describes the data best the F test, Breusch-Pagan test and Hausman test are used. With a test statistic of 13.31 and a p-value of zero the null hypothesis of the F test that all airport-specific effects (ui) are zero can be rejected, which indicates that the fixed effects models (3) is preferable to the pooled model (1).

The Breusch and Pagan Lagrangian multiplier has a test statistic 441.52 and p-value of zero. Thus, the null hypothesis of no significant difference across airports, i.e. no panel effect, can be rejected too, showing that the random effects model (2) is more appropriate than the pooled model (1).

Table 4. F&B revenue analysis

	(1) Real F&B revenue b/se	(2) Real F&B revenue b/se	(3) Real F&B revenue b/se
LCC pax	0.920***	0.650***	-0.165
	(0.11)	(0.17)	(0.29)
FSA pax	0.739***	0.703***	0.256**
	(0.03)	(0.04)	(0.13)
Constant	-992850.641***	-338800.708	4003011.965***
	(297188.19)	(493120.07)	(1044376.49)
Adj. R-sq	0.7345		
R-sq overall		0.7332	0.6234
F test that all u_i=0	13.31***		
Breusch and Pagan Lagrangian multiplier test statistic		441.52***	
Hausman test statistic			21.42***
Observations	388.000	388.000	388.000

* p<0.10, ** p<0.05, *** p<0.01

Given the restrictive assumptions of the pooled model, these results are not surprising. Choosing between the random and fixed effects models is always less conclusive. A formal indication is the Hausman test. With a test statistic of 21.42 and zero p-value the null hypothesis that the estimators of the fixed and random effects model do not differ substantially can be rejected, suggesting that the fixed effects model is more appropriate. This is consistent with the circumstance that the airlines and airports of the sample are not randomly drawn from a larger sample but were deliberately chosen.

Based on the results of the fixed effects model, the LCC passenger variable is insignificant, which means that LCC passengers have no statistically significant impact on the F&B income of the airports in the sample. By contract, the coefficient of the FSA passenger variable is statistically significant, indicating that the average FSA passenger contributes \$0.26 to F&B income.

An explanation of this result could be the transformation of in-flight catering services during the period under analysis (2004–2008). Some FSAs have restricted or stopped serving free food during flights. American and US Airways were among the first of them. Consequently, FSA passengers who used to have food during their trip may now start to spend money in the terminal.

Table 5 shows the estimation results for the airports' income from retail activities.

Table 5. Retail revenue analysis

	(1) Real retail revenues b/se	(2) Real retail revenues b/se	(3) Real retail revenues b/se
LCC pax	0.123	0.967***	1.763***
	(0.22)	(0.32)	(0.48)
FSA pax	0.722***	0.550***	-0.090
	(0.05)	(0.09)	(0.21)
Constant	-95620.113	-113633.161	3164536.460*
	(582554.23)	(986695.79)	(1700570.25)
Adj. R-sq	0.3647		
R-sq overall		0.3345	0.0008
F test that all u_i=0	20.79***		
Breusch and Pagan Lagrangian multiplier test statistic		540.74***	
Hausman test statistic			21.34***
Observations	388.000	388.000	388.000

* p<0.10, ** p<0.05, *** p<0.01

As in the case of F&B, the test results support the choice of the fixed effects model. While this model does not show a statistically significant relationship between the number of

FSA passengers and income from retail activities, it indicates an average contribution from LCC passengers to retail services revenues of $1.80.

With 23.55% and 45.82% respectively car rental and parking constituted far more significant parts of the airports' non-aeronautical revenue in 2008. Therefore, the analysis of those two categories is of particular importance. Taking into account that only O&D passengers use these services, as already noted above, the passenger numbers of LCCs and FSAs are adjusted for transfer passengers. Table 6 shows the estimated contribution of FSA and LCC passengers to car rental revenues.

Table 6. Car rental revenue analysis

	(1) Real car rental revenues b/se	(2) Real car rental revenues b/se	(3) Real car rental revenues b/se
LCC pax	2.113***	2.631***	2.499***
	(0.22)	(0.31)	(0.47)
FSA pax	2.453***	2.156***	0.950**
	(0.10)	(0.17)	(0.44)
Constant	946197.280*	1294832.454	5819591.119***
	(503427.69)	(862071.94)	(1874157.48)
Adj. R-sq	0.6940		
R-sq overall		0.6880	0.5987
F test that all u_i=0	25.89***		
Breusch and Pagan Lagrangian multiplier test statistic		589.99***	
Hausman test statistic			10.82**
Observations	388.000	388.000	388.000

* p<0.10, ** p<0.05, *** p<0.01

Again, the F-test, Breusch-Pagan test and Hausman test results indicate the superiority of the fixed effects model. For both LCC passengers and FSA passengers a statistically significant contribution to car rental revenues was estimated. Yet, whereas according to the model results the average FSA O&D passengers spends only $0.95 on car rental, the LCC O&D passengers'average contribution to this revenue category is $2.50.

Finally, Table 7 shows the results of the estimation of airport revenue from parking.

Table 7. Parking revenue analysis

	(1) Real parking revenues b/se	(2) Real parking revenues b/se	(3) Real parking revenues b/se
LCC pax	0.789*	6.388***	7.897***
	(0.47)	(0.54)	(0.66)
FSA pax	6.124***	4.506***	3.041***
	(0.21)	(0.35)	(0.62)
Constant	4177314.798***	2477048.240	6168146.421**
	(1051494.37)	(1876117.04)	(2637116.02)
Adj. R-sq	0.7106		
R-sq overall		0.5911	0.4531
F test that all u_i=0	61.05***		
Breusch and Pagan Lagrangian multiplier test statistic		623.14***	
Hausman test statistic			94.24***
Observations	388.000	388.000	388.000

* p<0.10, ** p<0.05, *** p<0.01

As in the previous three cases, the fixed effects model is found to describe the data best. While again the results indicate that all passengers make a statistically significant contribution to the airports' parking income, that of LCC passengers is with $7.9 more than twice as high as that of FSA passengers with only $3.04.

As suggested in the literature review, at least two factors are likely to explain the results for car rental parking: LCCs are often operating at airports that are further away from city centres and during rather inconvenient time slots, i.e. LCCs tend to make the use of cars more often necessary.

Summing up these results, we find that for the three categories retail services, car rental and parking a statistically significant positive relation between the number of LCC passengers and income from these activities could be identified. Moreover, for income from car rental and parking, which accounts for almost 70% of total airport non-aeronautical revenue, the average spending by LCC O&D passengers is much higher than is that by FSA O&D passengers (approximately $10 versus $4).

Given that LCCs are legally required to pay the same level of aeronautical charges as FSAs, we conclude that those US airports of the sample benefit from the entrance of LCCs since they more than proportionally contribute to non-aeronautical revenues. and of course proportionally to aviation charges However, as explained above, because of the specific regulatory arrangements, non-aeronautical revenues may well have an impact on the level of aeronautical charges and thus the airport business as a whole too, as we can see in the next section.

5.3. The Impact of LCCs on Aeronautical Revenues

In 2008 aeronautical revenue constituted on average 48% of total operating revenue for the airports in the sample. The two main components are landing fees and terminal/international arrival rental charges (terminal charges), which accounted in 2008 for 35% and 43% of aeronautical revenue, respectively. But for several reasons aggregated aeronautical revenue has to be used for the analysis. First of all, airport strategies to set charges are not uniform, their structure may differ: airports that have relatively low landing fees can compensate for these with higher terminal charges, thereby maintaining the total sum of aeronautical charges. In this situation, a separate analysis of aeronautical revenue components, such as landing fees, terminal rental and other charges, could lead to wrong or contradictory conclusions. Moreover, aeronautical charges have different bases for calculation, such as aircraft weight for landing fees or terminal space for terminal rental, which make comparisons more difficult. Eventually, there are differences in the charges for signatory and non-signatory airlines and the typical lack of such data prevents a detailed non-aggregated analysis.

We have argued about, that the rate-setting approach(compensatory versus residual) determines whether the increases in non-aeronautical revenues from LCCs affect the level of aeronautical charges and thus aeronautical revenues: for the residual approach non-aeronautical revenues have to be used to subsidise the aeronautical part of the airport operation. Thus increases in those revenues should be used to reduce aeronautical charges.

This leads to the following hypothesis: if LCC passengers contribute more to non-aeronautical revenues than FSA passengers do and an airport has a residual agreement with airlines, the airport should have comparably lower charges than airports without LCCs or operating under a compensatory agreement. The hypothesis is tested by estimating the following model:

$$\text{REG 2: } ARev_{it} = \alpha_0 + \alpha_1 * ARev_{i(t-1)} + \alpha_2 * NARev_{i(t-1)} + \alpha_3 * NARevResidualLCC_{i(t-1)} + u_i + \varepsilon_{it}$$

where *ARev* and *NARev* refer to the total real aeronautical revenue and the total real non-aeronautical revenue respectively. *NARevResidualLCC* is a cross dummy variable that equals one multiplied by the total real non-aeronautical revenue if both is true, the airport has a residual agreement with airlines and LCCs operate at this airport. Otherwise the dummy is equal to zero. As usual, i denotes individual terminal effects and $t \in [2004;2008]$ refers to the time effect.

The logic behind this model is the following. Since airports most probably use the level of charges of the previous year as a benchmark for setting the current level of charges, it is reasonable to use a lag of aeronautical revenue as an independent variable. The other two explanatory variables are the first lag of total non-aeronautical revenue and a cross dummy variable. The total non-aeronautical revenue variable reflects a general trend between aeronautical and non-aeronautical revenues and the cross dummy variable (*NARevResidualLCC*) indicates whether this trend is different for airports that serve LCCs and have residual type agreements with airlines. Both of these variables are also lagged as the correction of charges by airports is most likely done on the basis of the previous year's non-aeronautical revenues and the overall performance. Using lagged variables also tackles the causality problem in the analysis of aeronautical charges: while LCCs are able to reduce charges by increasing the airport's capacity utilization and efficiency, it is also possible that a negative correlation between the LCC market share and the level of charges simply reflects that LCCs choose airports with low charges. Looking at changes in the level of charges subsequent to the entrance of LCCs implies that the latter is at least not the only source of the correlation.

Since cross-subsidisation of the aeronautical part of the airport business by non-aeronautical revenues in the case of residual type agreements with airlines leads to lower aeronautical charges and consequently lower aeronautical revenues, a negative relation between the *NARevResidualLCC* variable and dependent variable is expected.

Considering that a lagged dependent variable is used as the explanatory variable, the model is estimated by the Arellano–Bond estimation technique[12] The results of the two-step Arellano–Bond estimation of the model are presented in Table 8.

Table 8. Aeronautical revenue analysis

	(1) Total real aeronautical revenue b/se
Lagged total real aeronautical revenue	0.624**
	(0.26)
Lagged total real non-aeronautical revenue	0.347
	(0.24)
Lagged NARevResidualLCC dummy	-0.199*
	(0.11)
Constant	12108442.448
	(36320436.58)
Sargan test of overidentifying restrictions	2.667999
Arellano-Bond test for zero autocorrelation in first-differenced errors	Order z Prob > z 1 -1.4416 0.1494 2 1.0125 0.3113
Observations	100

* p<0.1, ** p<0.05, *** p<0.01

The null hypothesis of the Arellano–Bond test for zero autocorrelation in the first-differenced errors of no autocorrelation cannot be rejected. Hence, the absence of autocorrelation can be inferred. The failure to reject the null hypothesis of the Sargan test of overidentifying restrictions that tests the validity of the instruments leads to the conclusion that the instruments are valid.

[12] . Roodman (2006) summarises the main features of Arellano–Bond estimations as follows: "general estimators designed for situations with "small T, large N" panels, meaning few time periods and many individuals; with independent variables that are not strictly exogenous, meaning correlated with past and possibly current realizations of the error; with fixed effects; and with heteroskedasticity and autocorrelation within individuals."

The coefficient of *NARevResidualLCC* is statistically significant and shows the expected negative sign. The hypothesis of the model cannot be rejected. Thus, the results indicate that for the average airport of the sample that serves LCCs and uses the residual rate-setting approach, an increase in non-aeronautical revenue leads to reductions in aeronautical revenues in the subsequent year. By contrast, the statistically insignificant coefficient of the total non-aeronautical revenue variable suggests a general independence from the preceding year's non-aeronautical revenues. As expected, aeronautical revenues of the previous period have a statistically significant, large positive impact on aeronautical revenues in the current period.

6. Conclusion

This paper provided comprehensive insights into the impact of the growing LCC sector on the US airport market. Examining a sample of the three top US LCCs (Southwest, AirTran and JetBlue) and 89 hub airports for the years 2004-2008, the paper looked first at the contribution of LCC passengers to different non-aeronautical revenue streams compared to FSA passengers. Therafter the perspective was broadened to also look at the effect on the aeronautical part of the airport business:, the hypothesis was that in the case of a residual rate-setting approach, other airlines are also likely to benefit from an increase in non-aeronautical revenues caused by the presence of LCCs, as US airports are obliged to use them to cross-subsidise the aeronautical side of the airport business, thereby reducing charges.

The first part of the empirical analysis clearly showed that the US airports in our sample had benefitted from higher per passenger non-aeronautical income for LCC passengers in the categories retail and particularly car rental and parking, with the two latter alone accounting for almost 70% of the average sample non-aeronautical revenues.

The subsequent analysis indicated that in the case of residual type rate setting this positive impact is beneficial for airlines. We found a statistically significant decrease in aeronautical revenue of the sample airports that serve LCCs and have residual type agreements subsequent to an increase in non-aeronautical revenue. This can be interpreted as leading to a reduction in aeronautical charges since US airports cannot generate profits and FAA regulation does not allow discriminating between airlines, FSAs equally benefit from such reductions in charges. However, given the specific characteristics of airport regulation and of airline/ airport agreements in the US, the results of this paper cannot be easily applied to other airports that operate under different regulatory regiems.

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