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Muneki Yokomi*
* Corresponding author
Faculty of Business Administration, Osaka University of Commerce
4-1-10 Mikuriyasakae-machi Higashiosaka, Osaka, 577-8505, Japan
Phone: +81-6-6785-6312
E-mail: yokomi@daishodai.ac.jp

Phill Wheat
Institute for Transport Studies, University of Leeds
Institute for Transport Studies, 34-40 University Road, University of Leeds, Leeds, LS2 9JT, UK
Phone: +44-113-343-5344
E-mail: p.e.wheat@its.leeds.ac.uk

Jun Mizutani
Graduate School of Maritime Sciences, Kobe University
5-1-1, Fukaeminami-machi, Higashinada-ku, Kobe, 658-0022, Japan
Phone: +81-78-431-6265
E-mail: jun@maritime.kobe-u.ac.jp

The Impact of Low Cost Carriers on Non-Aeronautical Revenues in Airport: An Empirical Study of UK Airports

Abstract

The purpose of this study is to clarify the impact of low cost carriers (LCCs) on non-aeronautical revenues in 26 UK airports from 1999 to 2008. Increasingly non-aeronautical revenues have become an important source for airport revenue. Our literature review highlights that there is little consensus in empirical results concerning LCC impact on non-aeronautical revenues, some of these report positive impact while others show negative impact. We estimate a non-aeronautical revenue function which includes frequency share of LCC, Air Transport Movements (ATMs), number of passengers and population of hinterland of each observed airports as explanatory variables. In addition to this, we produce marginal revenue estimates for both the case of capacity constrained and capacity unconstrained circumstance in airports. As a result, in the case of a non-capacity constrained airport, on average, the marginal revenue of an additional LCC ATM is £147 while for non-LCC ATM it is £226. On the other hand, in the case of a capacity constrained airport, on average, substituting one non-LCC ATM with an LCC ATM reduces revenue by £79.

Keywords: Low cost carriers; Airport management; Non-aeronautical activities; Marginal revenue

1. Introduction

Increasingly, many airport operators in the world are trying to attract low cost carriers (LCCs) to enhance their traffic volume and to develop their financial performance. In such a competitive situation, airport operators tend to face strong downward pressure on airport charges, given that airport charges are a core cost element of LCCs which tend to maximize the utilization of their aircraft to keep costs as low as possible (CAA, 2007). Thus, to attract LCCs, airport operators tend to set their airport charges as low as possible, and to compensate, seek to manage the airport by enhanced non-aeronautical revenues as the result of increased passenger volume.

The UK Civil Aviation Authority (CAA) describes this procedure as a "virtuous circle" (Fig. 1). It means that pricing competitively and more actively seeking out new air services by airports, and consequent greater passenger throughput, allows the airport to increase its non-aeronautical revenue. This in turn means the airport can be less reliant on airport charges revenue and can price competitively to attract further air services. As such, non-aeronautical revenue is an important source for airport management and to understand how LCCs influence non-aeronautical revenues at airports has been very relevant for airport operators.

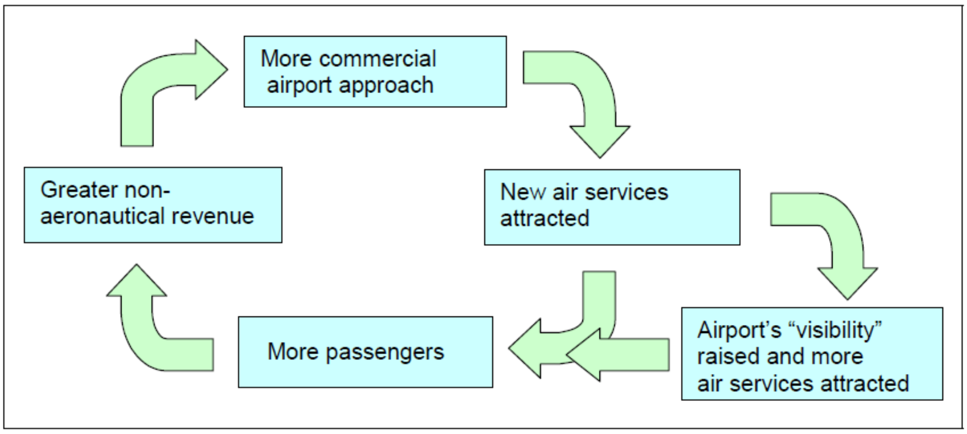


Figure 1: "Virtuous circle" of airport activity

Reproduced from CAA (2005, p.10).

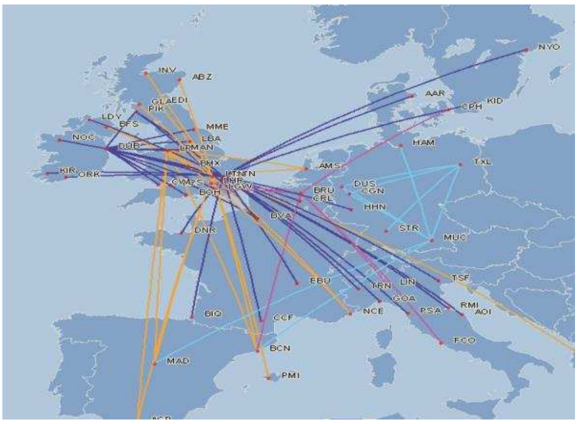
The purpose of this study is to examine the influence of LCCs on the non-aeronautical revenues of airports, by quantitative analysis using the dataset of the UK airports. Traditionally the literature has indicated that LCC passengers spend more at airport commercial facilities than other types of passengers, because they are not provided food and drink services inside an airplane. However, in a recent literature there is a counter argument that indicates non-aeronautical revenue per passenger maybe lower for passengers of LCCs than other types of passengers, given that LCCs appeal to price sensitive markets.

Our study advances the state of the art for a number of reasons. Firstly, we utilize a data set which includes the period of rapid expansion of LCC operators. Secondly, we consider the influence simultaneously of the number of air transport movements (ATMs) at an airport and the number of passengers per aircraft, in contrast to previous studies which have considered only passenger volumes. Thirdly, an important feature of our study is the ability to produce marginal revenue estimates for both the case where LCC substitutes for non-LCC operations (capacity constrained circumstance) and also for the case where LCC aircraft movements are incremented with no decrease in other aircraft movements (capacity unconstrained circumstance).

The structure of this paper is as follows. Following this introduction, section 2 provides the context for why the UK is an interesting empirical case for understanding the impact of LCCs on airport non-aeronautical revenue, while section 3 clarifies the composition of non-aeronautical revenue vis-à-vis aeronautical revenue. Section 4 provides a review of the received empirical literature to date and section 5 outlines the data available for our study. Section 6 then outlines the econometric model selection process, while section 7 discusses the results. Section 8 concludes.

2. Development of LCC in the UK

There are two reasons why we focus on the UK in our study. The first reason is that the UK is the oldest, largest and most competitive market for LCCs in Europe (Lei & Papatheodorou, 2010). Figures 2 and 3 show the LCC network of Europe in 2000 and 2006 respectively. In 2000, a very small sized network only from London (operational hub of easyJet) and Dublin (operational hub of Ryanair) can be observed. However, these LCC networks have expanded all over Europe by 2006.



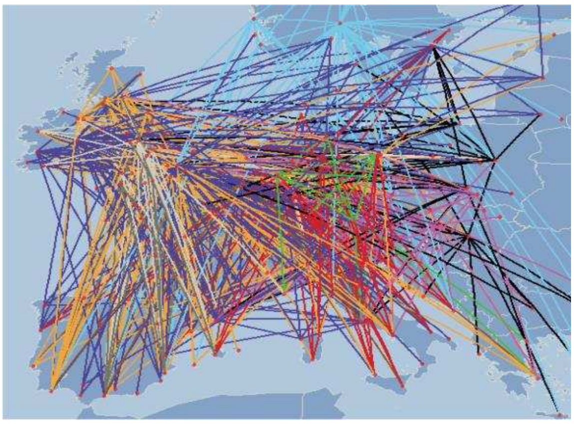


Figure 2: LCC network of Europe in 2000 Figure 3: LCC network of Europe in 2006

Reproduced from CAA (2006, Ch. 2 p. 3).

Figure 4 shows the frequency share of LCCs departing from UK airports for the period from 1997 to

2012. LCC share has increased rapidly since 2001 and reached almost 50% at 2010.

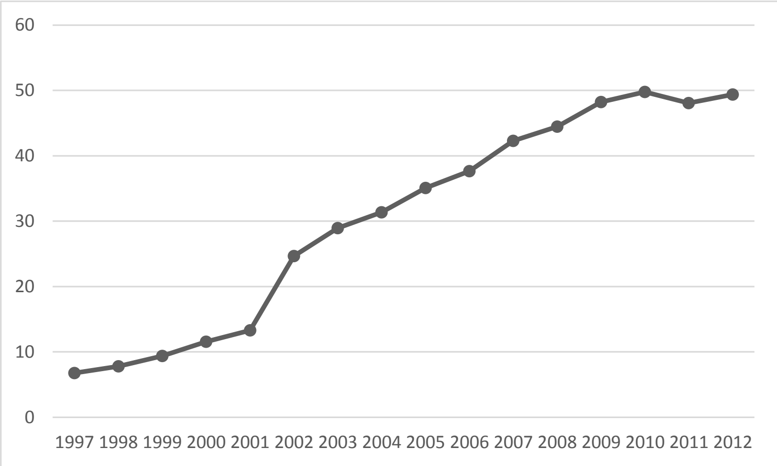


Figure 4: Frequency share of LCCs in the UK airports 1997–2012 (%)

Source: OAG.

The second reason is that a wide range of consistent and reliable statistics for airlines and airports can be obtained in the UK. Various types of traffic data for airlines and airports are downloadable at the CAA website and financial data from selected airports can be obtained by a series of "Airports Statistics" published by the Centre for the study of Regulated Industries (CRI) of the University of Bath[1].

3. Non-aeronautical activities in airports

Airport revenue is usually classified into two main categories, aeronautical and non-aeronautical revenues. Table 1 shows the breakdown of airport activities by revenue sources. Aeronautical revenues are those sources of income that arise directly from the operation of aircraft and the processing of passengers and freight. Non-aeronautical revenues are those generated by activities that are not directly related to the operation of aircraft, notably those from commercial activities within the terminal like retail, food and beverage, and rents for terminal space and airport land (Graham, 2014).

[1] It ceased publishing at the 2008/09 edition.

Table 1: Classification of airport activity by revenue sources

Aeronautical	Non-aeronautical
Landing fees	Retail
Passenger fees	Food and beverage
Aircraft parking fees	Car hire
Handling fees (if handling is provided by the airport operator)	Advertising
Terminal rental fees (e.g. in USA)	Car park
Other aeronautical fees (air traffic control, lighting, airbridges etc.)	Recharges (for gas, water, electricity etc.)
	Other non-aeronautical revenue (consultancy, visitor and business services, property development etc.)

Reproduced from Graham (2014, p.75).

Figure 5 shows the non-aeronautical revenue breakdown at European airports in the Airports Council International (ACI) by source in 2012. In general, there are three main sources, retail concessions, car parking and property and real estate income or rent, in the non-aeronautical revenue.

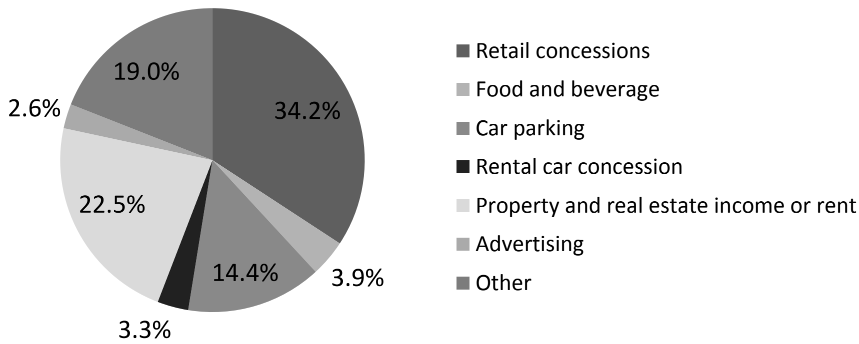


Figure 5: Non-aeronautical revenue breakdown of ACI European airports by source for 2012

Reproduced from ACI (2013), p.12.

4. Literature review

There are many previous studies focused on the differences of passenger characteristics between LCCs and full service carriers (FSCs). With respect to qualitative studies, Chiou & Chen (2010) focused on factors influencing LCCs and FSCs passengers and made comparisons between both types of passenger. Forgas et al. (2010) focused on passenger loyalty of LCCs and FSCs, and made comparisons between both types of passenger. Martinez & Royo (2010) conducted segmentation on LCC passengers in Spanish airports by cluster analysis. More recently, Kim (2015) examined the impact of perceived value on satisfaction and purchase intention for LCCs and FSCs in South Korea and showed that a passenger's perceived value was different for both types of carriers. Rajaguru (2016) investigated the influence of service quality and value for money on customer satisfaction and behavioural intention of LCCs and FSCs passengers. This revealed that while the LCCs depend strongly on value for money, FSCs survive on the balance between value for money and service quality.

On the other hand, with respect to studies which focus on the relationship between LCC and airport non-aeronautical activities, only a few literatures have been found. Traditionally, we have believed that LCC passengers spend more at airport commercial facilities than other types of passengers like that of FSCs.

According to Graham (2014), LCC passengers are particularly good users of the food and beverage services because of the lack of free in-flight refreshments. In addition to this, LCC passengers tend to utilise more car parking because of the relative remoteness of some secondary airports.

Some earlier previous studies supported these hypotheses. Gillen & Lall (2004) referred that there are some arguments that LCC passengers are different and spend more money at airport concessions because they are not provided meals during their flight. Although their study has no evidence to support this view, they pointed out that, if this is true, then it is just an added bonus for the airport, and this could provide a net benefit to the airport even if landing charges have to be reduced to make the airport more attractive to LCCs. In fact, they illustrated that at Albany County Airport in New York, although airline revenue per enplaned passenger decreased from US $7.24 in 1998 to US $5.92 in 2000 when Southwest Airlines (a LCC) started service at the airport, non-airline revenue per enplaned passenger increased from US $7.60 in 1998 to US $10.55 in 2000.

Similarly, Francis, Humphreys, Ison (2004) found in their survey at the London Luton airport that food purchases are important to low-cost passengers. This airport became the first UK base for easyJet in 1995. Subsequently, while passenger throughput at the airport has grown from 2.4 million in 1995 to 6.5 million passengers per annum in 2002, the proportion of revenue from non-aeronautical sources at the airport rose from 45% to 59% between 1995 and 2001.

As in the studies given above, traditionally the marginal effect of LCC passengers on non-aeronautical revenue at an airport has been thought to be higher than other types of passengers like FSCs. However, in more recent studies, the evidence concerning non-aeronautical revenue from LCC passengers is inconsistent with this earlier evidence (Graham, 2014). Lei & Papatheodorou (2010) investigated the effect of LCCs on commercial revenue of airports. They conducted regression analysis using panel data on the UK's 21 regional airports over the period between 1995 to 2003, and pointed out that each additional LCC passenger boosts airport commercial revenue by

£2.87, while each additional other carrier passenger raises commercial revenue by £5.59.

In addition to this, Fasone et al. (2016) also found similar results by using ridge regression and partial least squares. They investigated the determinants of non-aeronautical revenue in 15 German international airports using pooled data for the 2009-2012 period. The results suggest both share and number of LCC passengers have negative impact on non-aeronautical revenue per passenger and per square metre, but in the case of non-LCC, passenger share has positive impact on non-aeronautical revenue per passenger and per square metre. Moreover, from the viewpoint of operating efficiency of an airport, Choo & Oum (2013) clarified, by using a panel data of 63 U.S. airports for the 2007-2010 period, that the share of LCC passengers has a negative impact on Variable Factor Productivity (VFP) of the airport.

Therefore, as opposed to the traditional hypothesis, their results maintain that the marginal effect of LCC passengers to non-aeronautical revenue at an airport is lower than other types of passengers like that of FSCs.

4.1 Building on the state of the art

Given the discussion above, two key papers to be built on for the specific purpose of studying the impact of LCC carriers on non-aeronautical revenue are Lei & Papatheodorou (2010) and Fasone et al (2016). Although these studies are pioneering and each sophisticated works in this field, both studies have several points to be improved upon in terms of the empirical aspects.

Firstly, with respect to the Lei & Paptheodorou study, the volume of LCC traffic is relatively small in their sample period (1995-2003). In order to improve this, we set the sample period from 1999 to 2008 which contains a sufficient volume of LCC traffic (see Fig.4). In addition, we use the OAG as a source of LCC traffic data. OAG is the most reliable source for flight timetables all over the world.

Similarly, the Fasone et al study utilizes a relatively small sample which yields statistical challenges for that study and motivates the use of ridged and partial regression. In our study we are able to exploit both the between group and within group variation in our data to estimate parameters without recourse to the "peculiar empirical strategy" (p36, Fasone et al (2016)) (which introduces a degree of bias) of Fasone et al. Furthermore, we are able to utilize panel data modelling techniques which control the influence of time invariant unobserved heterogeneity on parameter estimates, further increasing the robustness of our estimates.

Secondly, the Lei & Paptheodorou study includes two key explanatory output variables i.e. the number of LCC passengers and other passengers. However, from the point of view of airport management, ATMs are the significant factor, because, unlike the number of passengers, ATMs are one of the controllable factors by airport operators. Hence, we adopt ATMs in the variables of our analysis, as well as passengers per ATM.

Thirdly, the Lei & Paptheodorou study used a London airports dummy variable to take into consideration some locational characteristics in London. In contrast to this, we adopt the population of hinterland of each airport in the variables in order to introduce the differences in each airport size to our empirical model.

Fourth, and again with respect to the Lei & Paptheodorou study, they did not include charter flights in the LCC variables. However charter flights should be included in the LCC variables, because they usually perform low cost operations, as such the CAA calls charter flights and LCCs as "no-frills carrier". Therefore we include charter flights in the LCC variables.

Finally, our study produces estimates of marginal revenue for both the case of capacity constrained and capacity unconstrained circumstance. This could be very useful as airports become capacity constrained and thus have to make choices between competing carriers.

5. Data

Table 2 shows the sample of airports in our study. We use 26 UK airports over a 10 year period from 1999 to 2008 in the analysis. The number of observations is 238. Certain years for certain airports are excluded because of lack of data availability (Blackpool, Coventry, Doncaster Sheffield[2], London Luton and Durham Tees Valley[3]) or, in the case of the first 4 observations for Blackpool, very low average passengers per aircraft[4]. Thus, we have an unbalanced panel, however this is not an undue constraint to the empirical analysis given the method we employ.

Table 3 shows the data descriptive statistics of our analysis. NAREV denotes non-aeronautical revenue for each observed airport deflated by the relevant Retail Price Index (1987=100). LCC denotes the frequency share of LCC (LCC ATMs / Total ATMs) of each observed airport. ATM denotes the air transport movements of all scheduled movements, including those operated empty, loaded charter and air taxi at each observed airport. As a prelude to the multivariate analysis, we have investigate the bi-variant relationship between LCC and NAREV. The correlation is low and negative at -0.246. Whilst this is a low correlation, the negative relationship does support our multiple regression findings outlined in section 7.

PAX denotes the total number of passengers on air transport movement flights including charter and transit for each observed airport. POP denotes the population of hinterland (catchment area of airports) which is basically defined in the resident population of the local authority where each airport is located and other local authorities in the vicinity (see Table 2 for more detail). All variables except LCC are transformed into logarithms. We normalize all the data except LCC to the sample

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2 Doncaster Sheffield Airport was reopened in 2005 on the site of the former RAF Finningley air base.

3 Teesside Airport was renamed Durham Tees Valley Airport in 2004.

4 Essentially for these early years Blackpool airport operated a limited set of services mainly for private clients.

mean, so as to be able to interpret coefficients on first order variables as elasticities at the sample mean.

The data of NAREV and PAX are provided by CRI (2001-2010). ATM is provided by CAA (1999-2008). POP is provided by Office for National Statistics (1999-2008). We aggregate frequency of LCCs at each observed airport at each year and calculate their ratio against the total frequency of each airport using the OAG database . With regard to the definition of LCC we use the “List of Low Cost Carriers” by CAA (2011) and the websites of each airline as necessary to decide which airlines are LCCs. easyJet, Jet2.com and Flybe are examples of LCCs in the UK. Moreover, as mentioned above, charter carriers such as Monarch Airlines, Thomson Airways and Thomas Cook Airlines which operate scheduled flights are included in the LCC.

Finally in this section, we determine the extent to which the explanatory variables are correlated together. Table 4 shows the bivariate correlations between variables. These show all variables have relative low correlation with each other and so should contribute unique information to the revenue model.

Table 2: Sample airports

Code (IATA)	Name	Definition of hinterland (catchment area of airports)
ABZ	Aberdeen	Aberdeen City, Aberdeenshire
BFS	Belfast International	Antrim, Ards, Banbridge, Belfast, Carrickfergus, Castlereagh, Craigavon, Lisburn, Magherafelt, Newtownabbey, North Down
BHX	Birmingham International	West Midlands (Herefordshire, County of UA, Shropshire UA, Stoke-on-Trent UA, Telford and Wrekin UA, Staffordshire, Warwickshire, West Midlands (Met County), Worcestershire)
BLK	Blackpool	Blackpool UA, Fylde, Preston
BOH	Bournemouth	Bournemouth UA, Dorset (Christchurch, East Dorset, North Dorset, Purbeck, West Dorset, Weymouth and Portland)
BRS	Bristol	Bristol, City of UA, Gloucestershire (Cheltenham, Cotswold, Forest of Dean, Gloucester, Stroud, Tewkesbury)
CWL	Cardiff International	Carmarthenshire, Swansea, Neath Port Talbot, Bridgend, The Vale of Glamorgan, Cardiff, Rhondda, Cynon, Taff, Merthyr Tydfil, Caerphilly, Blaenau Gwent, Torfaen, Newport
CVT	Coventry	Coventry
DSA	Doncaster Sheffield	South Yorkshire (Met County) (Barnsley, Doncaster, Rotherham, Sheffield)
EDI	Edinburgh	East Lothian, Edinburgh, City of, Falkirk, Fife, Midlothian, West Lothian
EXT	Exeter	Devon (East Devon, Exeter, Mid Devon, North Devon, South Hams, Teignbridge, Torridge, West Devon)
LGW	Gatwick	Inner London (Camden, City of London, Hackney, Hammersmith and Fulham, Haringey, Islington, Kensington and Chelsea, Lambeth, Lewisham, Newham, Southwark, Tower Hamlets, Wandsworth, Westminster), Outer London (Barking and Dagenham, Barnet, Bexley, Brent, Bromley, Croydon, Ealing, Enfield, Greenwich, Harrow, Havering, Hillingdon, Hounslow, Kingston upon Thames, Merton, Redbridge, Richmond upon Thames, Sutton, Waltham Forest)
GLA	Glasgow	Dumfries & Galloway, East Ayrshire, East Dunbartonshire, East Renfrewshire, Glasgow City, Inverclyde, North Lanarkshire, Renfrewshire, West Dunbartonshire
LHR	Heathrow	Inner London (Camden, City of London, Hackney, Hammersmith and Fulham, Haringey, Islington, Kensington and Chelsea, Lambeth, Lewisham, Newham, Southwark, Tower Hamlets, Wandsworth, Westminster), Outer London (Barking and Dagenham, Barnet, Bexley, Brent, Bromley, Croydon, Ealing, Enfield, Greenwich, Harrow, Havering, Hillingdon, Hounslow, Kingston upon Thames, Merton, Redbridge, Richmond upon Thames, Sutton, Waltham Forest)
HUY	Humberside	Kingston upon Hull, City of UA, North Lincolnshire UA
LBA	Leeds Bradford	West Yorkshire (Met County) (Bradford, Calderdale, Kirklees, Leeds, Wakefield)
LPL	Liverpool	Merseyside (Met County) (Knowsley, Liverpool, St. Helens, Sefton, Wirral)
LCY	London City	Inner London (Camden, City of London, Hackney, Hammersmith and Fulham, Haringey, Islington, Kensington and Chelsea, Lambeth, Lewisham, Newham, Southwark, Tower Hamlets, Wandsworth, Westminster), Outer London (Barking and Dagenham, Barnet, Bexley, Brent, Bromley, Croydon, Ealing, Enfield, Greenwich, Harrow, Havering, Hillingdon, Hounslow, Kingston upon Thames, Merton, Redbridge, Richmond upon Thames, Sutton, Waltham Forest)
LTN	London Luton	Bedford UA, Central Bedfordshire UA, Luton UA, Peterborough UA, Cambridgeshire (Cambridge, East Cambridgeshire, Fenland, Huntingdonshire, South Cambridgeshire), Buckinghamshire (Aylesbury Vale, Chiltern, South Bucks, Wycombe)
MAN	Manchester	Greater Manchester (Met County) (Bolton, Bury, Manchester, Oldham, Rochdale, Salford, Stockport, Tameside, Trafford, Wigan)
NCL	Newcastle	Tyne and Wear (Met County) (Gateshead, Newcastle upon Tyne, North Tyneside, South Tyneside, Sunderland)
NWI	Norwich	Norfolk (Breckland, Broadland, Great Yarmouth, King's Lynn and West Norfolk, North Norfolk, Norwich, South Norfolk)
EMA	Nottingham East Midlands	East Midlands (Derby UA, Leicester UA, Nottingham UA, Rutland UA, Derbyshire, Leicestershire, Lincolnshire, Northamptonshire, Nottinghamshire)
SOU	Southampton	Portsmouth UA, Southampton UA, Hampshire (Basingstoke and Deane, East Hampshire, Eastleigh, Fareham, Gosport, Hart, Havant, New Forest, Rushmoor, Test Valley, Winchester)
STN	Stansted	Inner London (Camden, City of London, Hackney, Hammersmith and Fulham, Haringey, Islington, Kensington and Chelsea, Lambeth, Lewisham, Newham, Southwark, Tower Hamlets, Wandsworth, Westminster), Outer London (Barking and Dagenham, Barnet, Bexley, Brent, Bromley, Croydon, Ealing, Enfield, Greenwich, Harrow, Havering, Hillingdon, Hounslow, Kingston upon Thames, Merton, Redbridge, Richmond upon Thames, Sutton, Waltham Forest)
MME	Teesside / Durham Tees Valley (2005-)	Durham, Sedgefield, Wear Valley, Darlington UA, Hartlepool UA, Middlesbrough UA

* The names of local authorities listed above are based on the Office for National Statistics (2008).

Table 3: Descriptive statistics

	NAREV	LCC	ATM	PAX/ATM	POP
Mean	29,400,000	0.408	80,300	82.3	2,540,000
Median	7,100,000	0.349	44,400	82.4	1,510,000
Maximum	337,000,000	1	473,000	146	7,670,000
Minimum	1,210,000	0	2,510	23.2	305,000
Std. Dev.	64,500,000	0.352	100,000	34.1	2,480,000
Observations	238	238	238	238	238

*Rounded by 3 Significant Figures.

Table 4: Correlation coefficients between explanatory variables

	LCC	ATM	PAX/ATM	POP
LCC	1			
ATM	−0.274	1		
PAX/ATM	0.416	0.512	1	
POP	−0.169	0.680	0.377	1

6. Methodology

Eq. (1) below represents our final empirical model. Of the two papers on which this paper builds - Lei & Papatheodorou (2010) and Fasone et al (2016) – one uses 'Revenue' as the dependent variable, the other uses 'Revenue per Passenger'. As such, we do not think that there is consensus as to what the dependent variable should be. Furthermore, because we have multiple outputs (ATM, PAX) we choose to avoid the use of an arbitrary divisor for our dependent variable. We also recognize that, given our dependent variable and explanatory variables are in logarithms, adopting either formulation would yield the same model in terms of implied relationships between revenue and the drivers of revenue.

As mentioned in section 4, we adopt ATMs as the key output explanatory variable in the model, because, unlike the number of passengers, ATMs are the controllable factors by airport operators. Together with this, we also include PAX in the explanatory variables, because it has a direct relationship with non-aeronautical revenue. However, to aid the computation of marginal revenue per ATM, we adopt 'PAX per ATM' (PAX/ATM) as the explanatory variable in the model[5]. In addition,

[5] Given the log-log functional form, the underlying model estimated is the same irrespective of whether variables are included as ratios or in levels. This follows from the rules of logarithms (e.g. log(A/B)=log(A)-log(B)). The only reason for including the variables in ratios is to aid model interpretation. Here we can consider the impact of increasing ATMs holding passengers per aircraft the same by interpreting only β_2 rather than having to consider a more elaborate set of coefficients if passengers were included in levels rather than ratios.

population of the hinterland (POP) of each airport is included in the explanatory variables, allowing us to take into consideration locational advantage or disadvantage.

We take the logarithm of both sides of the equation except the LCC. As the LCC variable ranges from 0(%) to 100(%), it is impossible to take logarithms.

$$\mathrm{lnNAREV_{it}} = \beta_1 \mathrm{LCC_{it}} + \beta_2 \mathrm{lnATM_{it}} + \beta_3 \ln\left(\frac{\mathrm{PAX_{it}}}{\mathrm{ATM_{it}}}\right) + \beta_4 \ln\left(\frac{\mathrm{PAX_{it}}}{\mathrm{ATM_{it}}}\right)^2 + \beta_5 \mathrm{lnPOP_{it}} + \varepsilon_{\mathrm{it}} \quad (1)$$

$$\varepsilon_{it} = \delta_i + \tau_t + \upsilon_{it}$$

The subscript i denotes the ith airport, and the subscript t denotes the tth year. The specification of the residual error is a two-way panel formulation with airport effects (δ_i), time effects (τ_t) and random noise (υ_{it}). Furthermore, we have conducted a Hausman-Wu Test (Greene, 2012) as to whether to assume the effects are uncorrelated with the regressors. The result p-val=0.017 indicates strong support for correlation, hence we model the airport and time effects as fixed effects (dummy variables), dropping one of each to maintain the constant in the model. While the coefficients of the fixed effects are not directly of interest, including them does purge the other coefficient estimates of systematic bias due to potential correlation with unobserved factors. We also utilize robust standard errors to account for any residual autocorrelation/heteroscedasticity in errors. See Greene (2012) and Wooldridge (2010) for a comprehensive treatment of panel data econometrics.

The specification of Eq. (1) was determined through a general to specific methodology. We started with a Translog function and examined the influence of the second order terms on the parameter estimates. Our final formulation is a balance between general to specific testing 'down' using t statistics on specific coefficients and sense checks of the implied elasticities, including that the revenue elasticity relating to ATM and PAX/ATM were positive as this is an important a priori requirement. This is because an increment of ATM and PAX/ATM should boost non-aeronautical revenue at airports as increasing either (holding the other equal) imply more passengers using the airport. The final model includes square terms on the passenger load variable only. For this variable, data are normalized to the sample mean implying the coefficient on the first order variable is the elasticity of revenue to passenger load at the sample mean. Overall, this approach yields a model which provides a flexible description of the revenue relationship with its key drivers and produces sensible levels and variations in the elasticities.

If our results support the 'traditional' hypothesis (marginal effect of LCC passengers to non-aeronautical revenue at airport is higher than for other types of passengers), then the sign of LCC should be positive. On the other hand, if our results do not support this hypothesis (consistent with the findings of Lei & Papatheodorou (2010) and Fasone et al. (2016)), the sign of LCC is expected to be negative.

Airports near large cities tend to have a relative higher volume of international and/or longer haul passengers, as such these airports are able to achieve higher non-aeronautical revenue. In that case, the sign of the POP is expected to be positive. On the other hand, airports closer to smaller cities (regional airports) tend to highly rely on the non-aeronautical revenue because they usually try to attract airlines by relative lower aeronautical charge. In this case, the sign of POP is expected to be negative.

In addition, we also tried to include various kinds of traffic mix variables in the model to examine the impact of passenger characteristics on the non-aeronautical revenue. These are the ratio of passenger, such as scheduled or charter, EU or non-EU and international or domestic in total ATMs of each airport. However, all of these variables were found to be insignificant.

6.1 Computation of marginal revenue from different carriers

Our model specification allows us to derive the marginal revenue associated in an increase in LCC and non-LCC flight movements, under two circumstances, and both for circumstances full derivation is in the Appendix. These are:

1) The airport operates without a capacity constraint. In this circumstance, LCC ATM (ATMLCC) can be incremented without reduction in non-LCC ATM (ATMNLCC). This implies that both the coefficients on the LCC variable and ATM variables are of interest in computing the marginal revenue effect given both increase following an increase in LCC ATM in this case.

$$\frac{\partial NAREV}{\partial ATMLCC} = \frac{NAREV}{ATMLCC}.LCC\ [\beta_1\{1 - LCC\} + \beta_2] \qquad (2)$$

For non-LCC operations the equivalent marginal revenue measure is:

$$\frac{\delta NAREV}{\delta ATMNLCC} = \frac{NAREV}{ATMLCC} \cdot LCC\ [\beta_1\{-LCC\} + \beta_2] \qquad (3)$$

2) The airport operates at the capacity constraint. This implies that LCC ATM can only be increased by decreasing the ATM of non-LCC operators. In this case, we can derive the growth in revenue from examining the coefficient on the LCC variable. Given that LCC is a proportion variable, the marginal revenue associated with a one unit increase in LCC ATM (assuming non-LCC ATM falls also by one unit) is:

$$\left(\frac{\partial NAREV}{\partial ATMLCC}\middle|\Delta ATM = 0\right) = \frac{NAREV}{ATMLCC}.LCC\ .\beta_1 \qquad (4)$$

Eq. (4) is equivalent to Eq. (2)-(3); that is the capacity constrained case corresponds to the marginal revenue gain from the extra LCC ATM less the revenue loss from the reduction in non-LCC ATM.

7. Results

Table 5 represents the results of the estimation. All the variables are highly significant at the 1% level. The model, unsurprisingly giving the logarithmic functional form and the two way fixed effects panel specification, has a R^2 of 0.985. We do not claim that this is a positive or negative feature of our model, since R^2 is simply a measure of association. Instead, what we are interested in is the partial effects, which are given by the coefficient estimates or combinations thereof.

In addition, as the larger airports such as Heathrow and Gatwick have a much higher number of revenues and ATMs than all the other airports, we produced further estimates by excluding Heathrow and/or Gatwick to check whether our results are robust. The results show there are no material changes from excluding these airports.

Table 5: Results of the regression analysis

	Coefficient	Std. Error	t-Statistic	Prob.
C	7.785567	0.692419	11.24402	0.0000
LCC	-0.281095	0.091531	-3.071037	0.0024
LOG(ATM)	0.663771	0.079790	8.319006	0.0000
LOG(PAX/ATM)	1.333202	0.156580	8.514522	0.0000
LOG(PAX/ATM)^2	0.355046	0.104445	3.399356	0.0008
LOG(POP)	-4.851328	1.515149	-3.201882	0.0016

Cross sectional and Time fixed effects are not reported, but included in the model. The number of observations is 238 and number of regressors is 40 (= 6 [above] + 9 [time fixed effects] + 25 [cross sectional fixed effects]), R^2 = 0.98548. PCSE period weights robust covariance matrix used. Estimation using Eviews.

Before focusing on the impact of LCC carriers, we first describe the revenue impact of the other explanatory variables in our model.

Firstly, the coefficient on the ATM variable represents the elasticity of revenue with respect to ATM. 0.66 indicates that a 1% increase in ATM increases revenue by 0.66%. As such, the model indicates that accommodating more and more ATM increases revenue at a decreasing rate (marginal revenue is below average revenue).

Secondly, airports where the PAX/ATM is greater have higher revenue for a given level of ATM.

This is clearly intuitive given passengers, not aircraft, yield the NAREV (noting however that ATM is actually what airports have under their control), so more PAX/ATM implies greater revenue. At the sample mean of the data, a 1% increase in PAX/ATM increases NAREV by 1.33%. Furthermore, this elasticity increases as PAX/ATM increases, as indicated by the coefficient on the square term of log(PAX/ATM). Figure 6 shows a graph of the estimated elasticities of revenue with respect to PAX/ATM over our sample. Importantly, all elasticities are positive, which is reassuring as more PAX implies no reduction in revenue (ATM is held constant).

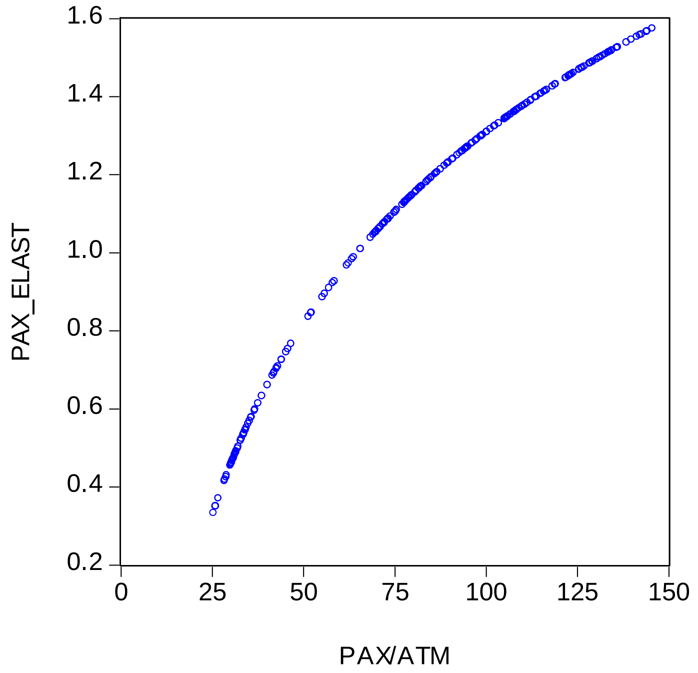

Figure 6: Elasticity of Revenue with respect to PAX (PAX_ELAST) across the sample

Thirdly, the interpretation of the coefficient on the population variable is difficult given the inclusion of cross sectional (airport) fixed effects. However, the coefficient estimate is statistically significant and so we retain this in our model. This result might partly reflect that airports near smaller cities (regional airports) tend to highly rely on the non-aeronautical revenue because management in regional airports usually try to attract airlines by relative lower aeronautical charges, and to compensate, seek to manage the airport by enhanced non-aeronautical revenues as the result of increased passenger volume.

In terms of the period (time) effects, Figure 7 shows that there is a general upward trend in real terms in NAREV, all other things equal. Examining the point for 2008 implied by the linear trend line, 0.32 indicates that the NAREV is 38% (=1-exp(0.32)) greater in real terms in 2008 than in 1999 all other things being equal. This is partly as a result of the greater competition in the airline market, so that airport operators face strong downward pressure on aeronautical charges, and to compensate, seek to increase non-aeronautical revenues. Importantly, this growth in revenue is over and above any growth from increasing ATM and PAX which are controlled for explicitly in the revenue model.

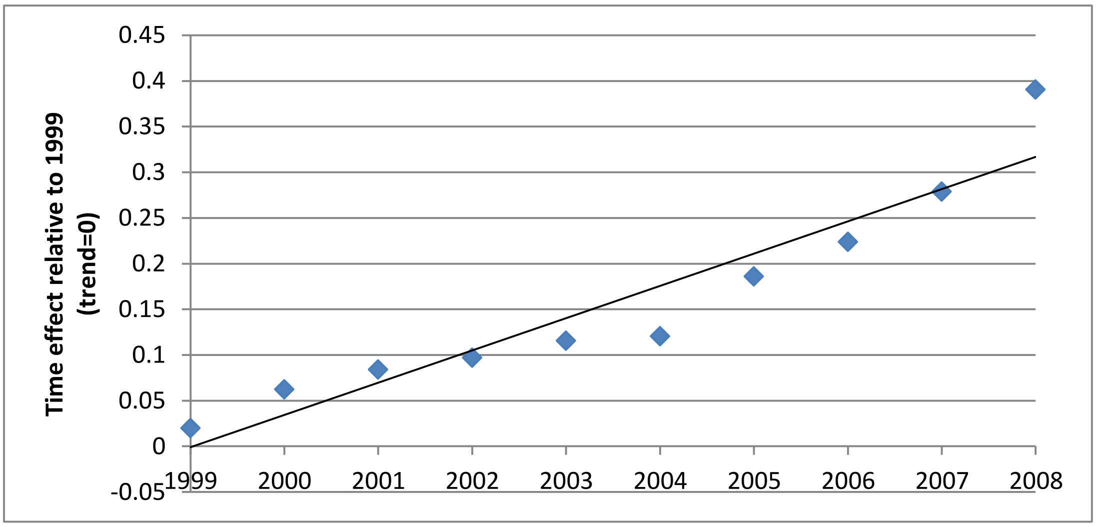

Figure 7: The impact of the time dummy variables

7.1 Marginal revenue impacts of LCC

We now turn to our findings on the impact on NAREV of increasing LCC ATM. Of relevance here are the coefficient estimates on the LCC variable (the proportion of ATMs which are LCC ATMs) and the ATM variable.

Firstly we consider the case of non-capacity constrained airport in terms of the number of ATM that can be accommodated at airports. We compute the marginal revenue as given in Eq. (2) for LCC ATMs and Eq. (3) for non-LCC ATMs. On average the marginal revenue of an additional LCC ATM is £147 while for non-LCC ATM is £226. Therefore, an additional LCC ATM results in 35% less revenue than a non-LCC ATM (on average). The above is calculated holding passengers per aircraft constant.

Secondly, we consider the case of a capacity constrained airport. Given that in the methodology section it was identified that the marginal revenue effect from substituting a non-LCC ATM for a LCC ATM was simply the difference between the two marginal revenue effects, it is no surprise that we find increasing LCC at the expense of non-LCC reduces NAREV. In this case, the relevant coefficient in the model is that on the LCC proportion variable. The sign on this variable is negative. Since ATM is included within the model separately, this implies that a change in LCC means that non-LCC ATM is substituted for LCC ATM (total ATM remains constant). This drives our overall result that revenue from LCC is less per ATM than for non-LCC. The coefficient of -0.28 indicates that a one percentage increase in LCC[6] results in a fall in revenue of 0.245% ((1-exp(-0.28))/100). To monetize this, we transform by Eq. (4). On average, substituting one non-LCC ATM with an LCC ATM reduces revenue by £79.

Overall, our results broadly support the findings of Lei & Papatheodorou (2010) and Fasone et al. (2016) that LCC contributes less at the margin to NAREV than non-LCC operations as measured by the number of air transport movements.

8. Concluding remarks

In this paper, we have examined the influence of LCCs on non-aeronautical revenues of the UK airports. We constructed a model so as to yield estimates of marginal revenue arising from LCC and non-LCC carriers for both the case of an airport with and without capacity constraint. Our paper advances the state-of-the-art in a number of ways. Firstly, we utilize a data set which includes the period of rapid expansion of LCC operators. Secondly, we consider the influence simultaneously of the number of air transport movements at an airport (ATM) and the number of passengers per aircraft (PAX/ATM), in contrast to previous studies which have considered only passenger volumes. This allows us to isolate the component of non-aeronautical revenue which differs due to the unique features of LCC operators.

Our study also shows that, on average, the marginal revenue of an additional LCC ATM is £147 while for non-LCC ATM is £226. Given this difference, in a capacity constrained airport such as Heathrow, where non-LCC ATM would have to be substituted for LCC ATM, a one percentage increase in LCC results in a fall in revenue of 0.245%. Contrary to the ‘traditional’ hypothesis, this result shows that additional LCC, at the expense of non-LCC flights, would have a negative impacts on an airport’s non-aeronautical revenues.

Overall, our results broadly support the findings of Lei & Papatheodorou (2010) and Fasone et al. (2016) that LCC contributes less at the margin to NAREV than non-LCC operations as measured by the number of air transport movements.

Although the reasons why additional LCC flights would have lower marginal non-aeronautical revenues are still open to discussion, we suppose that with regard to the retail concessions, LCC passengers might face relative low budget constraints in the airport retail, food and beverage outlets. In addition, LCC passengers are generally the passengers who are terminating their journey not the transit passenger who tends to spend more in their transit time at commercial facilities in the airport. Torres et al. (2005) points out by their empirical study on Spanish airports that there is a clear relationship between consumption in the commercial area of the airport and the length of stay prior to boarding. Furthermore, with regard to the property rent, LCCs basically don't have their dedicated

[6] By one percentage increase in LCC we mean a 0.01 increment in the LCC variable (which is itself a proportion).

passenger lounge in the airport, and tend to use airport facilities at the cheaper rates. LCC terminal or Budget terminal are such examples.

The policy implications for airports are twofold. Firstly, retention of non-LCC carriers is important in order to maintain non-aeronautical revenue, given LCC carriers add less non-aeronautical revenue per ATM. Secondly, the study findings should not preclude the encouragement of new LCC carriers to an airport, particularly in the capacity unconstrained case; such a decision depends on the marginal revenue versus marginal cost. However, as with the Lei and Papatheodorou (2010) and Fasone et al. (2016) studies, our study is still important to debunk the suggestion that reductions in aeronautical revenue will automatically be filled by increases in non-aeronautical revenue.

Finally, the impacts of LCCs and LCC passengers on airport activities could vary depending on their country, origin and destination, purpose of travel and flight characteristics such as international or domestic. We consider that these factors need to be addressed in future research, as more data becomes available following the further expansion/establishment of LCCs.

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Appendix – Derivation of marginal revenue effects

Marginal revenue in a model with proportions and a composite output.

$$lnNAREV = \beta_0 + \beta_1 \text{LCC} + \beta_2 \ln(ATM) + \beta_3 lnY$$

$$lnNAREV = \beta_0 + \beta_1 \left(\frac{ATMLCC}{(ATMLCC + ATMNLCC)}\right) + \beta_2 \ln(ATMLCC + ATMNLCC) + \beta_3 lnY$$

$$NAREV = \exp\left[\beta_0 + \beta_1 \left(\frac{ATMLCC}{(ATMLCC + ATMNLCC)}\right) + \beta_2 \ln(ATMLCC + ATMNLCC) + \beta_3 lnY\right]$$

$$NAREV = \exp[\beta_0] \cdot exp\left[\beta_1 \left(\frac{ATMLCC}{(ATMLCC + ATMNLCC)}\right)\right] \cdot (ATMLCC + ATMNLCC)^{\beta_2} \cdot Y^{\beta_3}$$

$$\begin{aligned}\frac{\delta NAREV}{\delta ATMLCC} = {} & \beta_2 \cdot (ATMLCC + ATMNLCC)^{(\beta_2 - 1)} \cdot \exp[\beta_0] \cdot exp\left[\beta_1 \left(\frac{ATMLCC}{(ATMLCC + ATMNLCC)}\right)\right] \\ & \cdot Y^{\beta_3} + \exp[\beta_0] \cdot (ATMLCC + ATMNLCC)^{\beta_2} \cdot Y^{\beta_3} \\ & \cdot exp\left[\beta_1 \left(\frac{ATMLCC}{(ATMLCC + ATMNLCC)}\right)\right] \\ & \cdot \left(\beta_1 \cdot \left\{\left(\frac{1}{(ATMLCC + ATMNLCC)}\right) - \frac{ATMLCC}{(ATMLCC + ATMNLCC)^2}\right\}\right)\end{aligned}$$

$$\begin{aligned}\frac{\delta NAREV}{\delta ATMLCC} = {} & \beta_2 \cdot (ATMLCC + ATMNLCC)^{(-1)} \cdot \text{NAREV} + \text{NAREV} \\ & \cdot \left(\beta_1 \cdot \left\{\left(\frac{1}{(ATMLCC + ATMNLCC)}\right) - \frac{ATMLCC}{(ATMLCC + ATMNLCC)^2}\right\}\right)\end{aligned}$$

$$\begin{aligned}\frac{\delta NAREV}{\delta ATMLCC} = {} & \frac{\text{NAREV}}{ATMLCC} \cdot \left(\frac{ATMLCC}{(ATMLCC + ATMNLCC)}\right) \\ & \cdot \left[\beta_1 \cdot \left\{1 - \left(\frac{ATMLCC}{(ATMLCC + ATMNLCC)}\right)\right\} + \beta_2\right]\end{aligned}$$

Now $\left(\frac{ATMLCC}{(ATMLCC+ATMNLCC)}\right)$ is referred to as LCC proportion (LCC), so

$$\frac{\delta NAREV}{\delta ATMLCC} = \frac{\text{NAREV}}{ATMLCC} \cdot LCC \cdot [\beta_1 \cdot \{1 - LCC\} + \beta_2]$$

For ATMNLCC:

$$\frac{\delta NAREV}{\delta ATMNLCC} = \beta_2 \cdot (ATMLCC + ATMNLCC)^{(\beta_2 - 1)} \cdot \exp[\beta_0] \cdot exp\left[\beta_1\left(\frac{ATMLCC}{(ATMLCC + ATMNLCC)}\right)\right] \cdot Y^{\beta_3} + \exp[\beta_0] \cdot (ATMLCC + ATMNLCC)^{\beta_2} \cdot Y^{\beta_3} \cdot exp\left[\beta_1\left(\frac{ATMLCC}{(ATMLCC + ATMNLCC)}\right)\right] \cdot \left(\beta_1 \cdot \left\{-\frac{ATMLCC}{(ATMLCC + ATMNLCC)^2}\right\}\right)$$

$$\frac{\delta NAREV}{\delta ATMNLCC} = \beta_2 \cdot (ATMLCC + ATMNLCC)^{(-1)} \cdot \mathrm{NAREV} + \mathrm{NAREV} \cdot \left(\beta_1 \cdot \left\{-\frac{ATMLCC}{(ATMLCC + ATMNLCC)^2}\right\}\right)$$

$$\frac{\delta NAREV}{\delta ATMNLCC} = \frac{\mathrm{NAREV}}{ATMLCC} \cdot \left(\frac{ATMLCC}{(ATMLCC + ATMNLCC)}\right) \cdot \left[\beta_1 \cdot \left\{-\left(\frac{ATMLCC}{(ATMLCC + ATMNLCC)}\right)\right\} + \beta_2\right]$$

$$\frac{\delta NAREV}{\delta ATMNLCC} = \frac{\mathrm{NAREV}}{ATMLCC} \cdot LCC \cdot [\beta_1 \cdot \{-LCC\} + \beta_2]$$