Research paper

Determinants of air traffic volumes and structure at small European airports

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This study investigates the determinants of air traffic volumes and structure (carrier type) at lesser studied small European airports serving below one million passengers per annum. It discusses airport choice factors for airline customers and focuses on the characteristics of small airports and their catchment areas in order to explain variation in 2016 traffic volumes for 146 regional gateways in 21 EU countries. Through the application of multiple linear regression and correlation it is found that population size, airport charges and the need for capacity coordination are the most related to the number of passengers using these airports. Several different correlations are found with respect to the share of low-cost, full-service and charter carriers as a proportion of total airport traffic, which in most cases extends the findings of the limited number of other studies in the field of small regional airports. The research concludes that while certain relationships can be found, their statistical significance is moderate, leaving scope for a deeper study into a smaller samples of airports.

Introduction

Airport-airline relationships in Europe have been transforming in recent years (Starkie, 2012). As the Copenhagen Economics (2012) report for IATA summarises, there is increasing competition between airports for airline services.

Some airport operators have tried to make themselves more at- tractive to particular carriers by redeveloping their existing infra- structure or constructing new airports (e.g. Warsaw Modlin Airport) in a way that supports particular traffic types (Njoya & Niemeier, 2011). Also, regional authorities and private business entities have

subsidised air services, hoping that the resulting inbound traffic would propel the local economy and tourism (Bel, 2009; Francis, Fidato, & Humphreys, 2003).
The general framework of airport-airline relationships and airport route network development strategies have been explored by Graham (2014, 2013). Others have investigated causalities between airline traffic and more specific variables, such as catchment area expansion (Pantazis & Liefner, 2006), route volatility (Humphreys et al., 2006), airline negotiating power (Francis, Humphreys, & Ison, 2004; Gillen and Lall, 2003), airfare levels (Barbot, 2006; Malighetti, Paleari, & Redondi, 2009), incentive schemes (Starkie, 2012), airport commercial revenues (Lei and Papatherodou, 2010) and financial performance (Papatherodou and Lei, 2006; Graham & Dennis, 2007).

The network strategies of many airlines have been changing. It has been recently identified that European Low-Cost Carriers (LCCs) are increasingly focussed on major gateways, often at the expense of regional airports (Dobruszkes, Givoni, & Vowles, 2017; Dziedzic & Warnock-Smith, 2016). Moreover, there are some fully-operational, newly-opened regional airports that are struggling to find sufficient demand from airlines (e.g. Radom Airport in Poland). This demonstrates there is still not enough understanding of how airports can at- tract airlines. Given the fact that European carriers are increasingly footloose in their network decisions (Humphreys et al., 2006; Copenhagen Economics, 2012), the question arises as to how airport operators may secure an appropriate level of traffic in the years to come.

These trends are particularly problematic for regional airports, which are often expected by their local communities to establish new routes and connections around the world. On the other hand limited interest from the airlines and changing market dynamics make this task for regional airports very difficult to achieve. Also the problem of se- curing a minimum scale of traffic can be very troublesome for small regional airports, which are, due to their size, very exposed to airlines changing their route networks, sometimes at quite short notice.

The literature to date has focussed primarily on larger airports (Akar, 2013; Berechman & de Wit, 1996; Dobruszkes, Lennert, & Van Hamme, 2011; Dziedzic & Warnock-Smith, 2016; Welch & Wang, 2014)

yet smaller regional airports have their own problems and specificities, which make it worthwhile to explore them further with a view to dis- covering what they can do to attract traffic. Both the literature and the market trends leave scope for further study into the determinants and structure of airport traffic volumes at smaller airports. Given there is already a fledgling body of research into airport choice factors amongst European carriers, the geographical scope of this research into smaller airports will be restricted to Europe, leading to the following research objectives:

Investigate the importance of smaller airport choice factors for air- lines in the context of air traffic volumes Analyse traffic structure (carrier type) at the smaller European airports Investigate the relationship between airline-airport choice factors and airport traffic structure for smaller European airports

Examine traffic volatility among smaller European airports
The determinants of smaller regional airport traffic volumes and traffic structure were analysed through the use of multiple linear regression and correlation analysis respectively with the controllable (directly or indirectly) factors being focussed on when discussing managerial implications for smaller airport operators.
The process adopted for this piece of research is summarised below in Fig. 1.
The rest of this paper is broken down as follows: Section 2 reviews the literature involving airline and airport route network developments and categories of airport choice factors, introducing some real-industry examples. Section 3 presents the methodology with the obtained results being detailed in Section 4 covering regional airport traffic volumes, volatility and their relationship with airport choice factors. Section 5 discusses the current structure of airline networks at regional airports (2016), and determines the underlying causes of regional airport vulnerability, Section 6 summarises the research and presents implications for smaller airport operators.

Airport choice factors and airline-airport route network developments

Route network developments can be viewed from multiple perspectives – airlines, airports, regulators or individual markets. Most studies so far have focused on the two major market players in aviation, i.e. airlines and airports.

From a regulatory perspective, the first studies discussing how carriers develop their networks appeared after deregulation and the introduction of free market rules with respect to route network deci- sions. The contemporary, regulated environment received criticism and academics tried to propose the new optimal industry setting regarding the most advantageous location of hubs in Europe. For example, it was noticed that a new hub-and-spoke system had developed in Europe due to deregulation and that national carriers still maintained their posi- tions in the market (Burghouwt & Hakfoort, 2001). This changed a few years later, when Europe saw the rapid growth of LCCs. Owing to de- regulation, this sector of the market developed significantly and in- troduced new dynamics into the air transport sector. New carriers, through the development of European point-to-point networks, under- mined the status quo and reduced the role of many Full-Service Carriers (FSCs) (Starkie, 2008).
Route network developments have been compared among airline types. A general framework for airline business models was established, according to which LCCs operate to and from secondary airports, while primary gateways are used by FSCs (e.g. Barrett, 2004; Doganis, 2006). The rapidly changing nature of the market made this framework questionable. LCCs sought growth by expanding into primary markets, traditionally controlled by FSCs (e.g. Dziedzic & Warnock-Smith, 2016; Klophaus, Conrady, & Fichert, 2012). Instead of business models,

specific airlines could be also analysed. Müller, Hüschelrath, and Bilotkach (2012) analysed the network of LCC JetBlue and found that the carrier avoided concentrated airports and targeted dense routes when entering new markets. Also, network competition between dif- ferent airlines was analysed (e.g. Franke, 2004). It was shown that LCCs stimulate the market and attract new demand, thus acquiring large market shares (Pitfield, 2007). Entry of LCCs into the market was also found to lead to a reduction in the fares offered by other carriers, even on routes unaffected by direct competition (Windle & Dresner, 1999). Network developments have also been looked at from the perspec- tive of individual markets. Most research in this area has focussed on US and European markets (e.g. Burghouwt & Hakfoort, 2001), although some studies reviewed other continents (e.g. Cheng et al., 2008), or markets at a city or regional level (e.g. Lu & Mao, 2014). The geo- graphical scope is thus variable, and even though many similarities were found between different markets, each of them has its own spe- cifics. Europe historically has seen more international traffic compared to other continents and its largest traditional carriers play a significant role, especially on domestic routes (Alderighi, Cento, Nijkamp, & Rietveld, 2012; Reynolds-Feighan, 2010). Moreover, European net- works are constructed around a few node airports and carriers have avoided the American, pan-continental network type (Reynolds- Feighan, 2010). The Asian market is in turn characterised by larger aircraft types and less developed airport infrastructure, which limits the choice of new destinations airlines can serve (Chang, Hsu, Williams, & Pan, 2008).

From an airport perspective, more attention has been given to how the major airports are attractive to airlines. This is probably caused by their larger role in the market and data availability. Even in the few cases where regional gateways were researched, the authors tended to exclude the smallest airports (Zuidberg & de Wit, 2016). Of course, a few notable exceptions exist (e.g. Lian & Rønnevik, 2011; Adler, Ulku, & Yazhemsky, 2013; and Dobruszkes et al., 2017), although it can be generalised that small regional airports have not been in the main- stream of research.

Various methods and tools have been used to understand how air- lines choose airports. One of the most intuitive is to make judgments based on general observations of the market. For instance, Barrett (2004) and Doganis (2006) described how demands for the airport product diverge between different types of carrier. Such works do bring insights of the airline industry and are valuable for formulating gen- eralisations, although they require frequent updates as the market un- dergoes constant evolution.

Others chose direct contact with airport or airline operators, or a panel of experts, in order to understand actual industry practices. Classic questionnaires and surveys were the most commonly used in such cases. Warnock-Smith and Potter (2005) used them for an explorative study into the airport choice factors of LCCs, while Halpern and Graham (2016) found them appropriate for investigating the factors affecting route network developments and performance of small airports. Whilst providing information directly from the airline and airport units responsible for network development is a key advantage of such studies, they have been burdened with a rather low response rates and are specific to the scope of samples used.

Discrete choice modelling has been another employed method. An extensive piece of work using this approach was undertaken by Kupfer, Kessels, Goos, Van de Voorde, and Verhetsel (2016), who applied this method to categorise knowledge on origin and destination airport choices for cargo airlines. As a method, it simulates the real market situation and is likely to provide results that are similar to decisions made by airline and airport managers. On the other hand, difficulty related to the amount of time required and potential bias due to the participating airlines, are drawbacks of this method.

Airport choice and airline competition were also investigated using game theory. Barbot (2009) employed this method to analyse how airports cooperate with air carriers in order to compete against other.

Fig. 1. Research process map. See published version,

airport-airline pairs. A question arises, however, of whether airlines and airports are aware in advance of the reactions of competitors based on decisions made and whether game theory can solve the complexity of route network development.

Finally, statistical models have also been used to explain route network decisions. Work by Dobruszkes et al. (2011), which is the closest to this paper in terms of the research problem considered, adopted this type of methodology. By looking at factual, numerical market data and application of multiple linear regression, Dobruszkes

et al. (2011) established the determinants of air traffic volumes in larger European metropolitan areas (i.e. what makes an airport at- tractive to airlines). This method enables the use of extensive, real market data in order to detect trends and relationships between air traffic volumes and, for instance, local economies. Nonetheless, the shortlist of independent variables may lead of over-simplified interpretations of actual market complexity.

No standard method has been developed to analyse airport choice factors for airlines. It is possible to choose from several different and mutually complementary methods. Each method has its own limitations and advantages and therefore its usage should have justification in the specifics of the study being carried out.

A summary of airport choice factors as considered in the literature[1] is presented in Table 1.

Aside from the sheer number of factors cited (34) in the literature, the relative importance of these factors is also worthy of note. Demand was almost always recognised as crucial in establishing a new route. Adler and Berechman (2001), Boguslaski et al. (2004), Lawton and Solomko (2005), Muller et al. (2011), Lu and Mao (2014) and Dziedzic and Warnock-Smith (2016) uniformly found demand to be important. Intuitively, no demand equals no supply under free market conditions. Unless a route is served under a Public Service Obligation (PSO) scheme, an airline has no interest in operating low density routes. In this sense, the whole essence of route network development could be narrowed down to forecasting traffic and entering the most promising routes (e.g. Vasigh, Fleming, & Tacker, 2013). This approach focuses solely on the results of traffic forecasts, however, and ignores their drivers. Given the long list presented in Table 1, it appears that demand is driven by all the remaining factors and therefore cannot be simplified.

None of the studies specified whether it is volume or type of demand that matters. The presence of high-yield passengers, for example, can justify operations even in the case of lower load factors (Doganis, 2006). In other words, an airline may benefit from entering a thin route and still be profitable despite not fully utilising aircraft capacity. This is especially important for small regional airports, which by their very nature cannot generate high demand volumes. Furthermore, in some cases demand volumes are difficult to estimate and negligible in the short run. For instance, it was found that LCCs, having entered a market, generate new demand which would not have appeared if low- cost services were not available (Brandt, 2003; Doganis, 2006; Pantazis & Liefner, 2006). A lack of high demand on certain routes may not be a disqualifying factor for the regional FSC model. Through long-term presence on thin routes, the airline may generate transfer traffic vital for other routes and also build its position in the market in the long run (Pels, 2008). Therefore, demand is indeed a significant airport choice factor, although its understanding is clouded.

Another key factor is airport costs and the availability of incentive schemes. Lower charges were especially expected by LCCs, as they re- duce overall operational costs (e.g. Bel, 2009; Graham, 2013). Today, however, this expectation has become common for other carriers as well, owing to European regulations, stating that airports cannot apply preferential charging policies to selected carriers and discriminate against others (Jones, Budd, & Pitfield, 2013). Furthermore, in the light of the LCCs' move towards more expensive, primary airports (Dziedzic & Warnock-Smith, 2016), the actual importance of airport charges ap- pears to be lower in practice. It should also be remembered that despite the charging scheme being publicly available, some of airport-airline agreements remain confidential. This may be the case for marketing support agreements, which involve payment to the carrier, effectively decreasing the actual cost of operating to an airport.

The next frequently mentioned factors were the turnaround time and availability of slots. Again, this traditionally focussed on LCCs, who prefer short aircraft stays on the apron and thus tend to operate from less congested airports (Lawton, 2002; Calder, 2003; Barrett, 2004). Also, it has been questioned whether the availability of capacity is enough for smaller airports to avoid leakage of traffic to main gateways (Dziedzic & Warnock-Smith, 2016; Lian & Rønnevik, 2011). On the other hand a lack of convenient slots can be an obstacle serious enough to block airline entry to airports (Czerny, 2008). A good example of this is charter and cargo carriers, which rely to a large extent on night

1 In line with the broader remit of this research, only studies that cover a wide range of airline choice factors are included in Table 1.

operations (Kupfer et al., 2016).

Other authors indicated airport location as another important factor. It can influence airline entry in two ways. First, distance to the nearest competitive airport may be considered (Chang et al., 2008; Dobruszkes, 2013). In this context, location is an indicator of the competition that airports face from neighbours, but also of airline flexibility to switch to another gateway without exiting the O&D market. On the other hand, airport location may be understood as proximity to the urban area it serves. Airports located closer to city centres were traditionally selected by FSCs serving business traffic, while remote ones were used by LCCs and Charter Carriers to cater for leisure and tourism traffic (e.g. De Neufville, 1995).

Considering distance to city centres, airports can try to reduce their impact by improving their ground transport accessibility (Chang et al., 2008; Warnock-Smith & Potter, 2005). Widening the modes of transport offered and increasing frequency or improving the standard of service may make it easier for potential passengers to reach the airport, which translates into higher potential demand and access to airline services.

The last of the frequently cited factors is airline competition. In this respect much depends on the airline's attitude to facing competition. As Mueller at al. (2012) noted, some markets may be simply too small to be served by more than one airline. Therefore, carriers typically avoid direct rivalry, with the presence of one airline on the route usually deterring other operators from serving it. Nonetheless, it cannot be ignored that competition in Europe is increasing (Copenhagen Economics, 2012) and it is a matter of time before carriers compete directly on more routes.

Finally, there are many other choice factors which appear sporadically in the literature. They can still be critical for a particular air- line's decision about launching a new route. It is, however, difficult to generalise the impact that these factors have, as their role usually de- pends on specific airports, airlines or routes.

The current body of literature shows a wide but rather disorderly picture of airport/airline route network developments. Airport choice factors for airlines have been analysed from various perspectives in the past. There are a few major limitations of the literature which this paper aims to address. Firstly, research undertaken so far appears fragmented. As shown in Table 1, different perspectives were applied in different studies, which resulted in a number of papers discussing different elements of the same subject, i.e. airport/airline route network developments, sometimes leading to inconsistent conclusions. Moreover, the variety in literature may also lead to vague conclusions. As different studies involve different factors, ultimately it may be difficult for an airport operator to understand how they are related to each other and how they are inter-related. Therefore this knowledge needs to be systematically framed and discussed jointly in one study in order to pro- vide a wide picture of airport choice factors and understand their relative importance. Secondly, large airports have received the greatest attention to date. This is due to the popularity of larger gateways and a lack of available data for smaller airports. Nonetheless, small regional airports constitute a significant group of airports in Europe and an analysis of their situation will assist in understanding the overall market. Thirdly, LCCs have been studied in relation to airport choice factors more often than other airline types. It is not surprising given the changes they have brought to the market, although other carriers should not be omitted. More attention should be directed at LCCs, FSCs and charter carriers, leaving scope for a wider study, which would compare different carrier types and verify the role of particular airport choice factors.

Data strategy and chosen methodology

Two main methods were applied in this study. The primary one was Multiple Linear Regression (MLR), which was used to examine the determinants of air traffic volumes at regional airports. The second was built around a correlation analysis - aimed to detect patterns in the

Table 1
Airport choice factors considered by a selection of previous studies spanning the period 2001–2016.

Author(s)	Adler and Berechman, 2001	Dobruszkes et al., 2013	Barrett (2004)	Boguslaski, Ito, and Lee	Lawton and Solomk	Warnock - Smith and	Chang et al.	Muller et al., 2011	Lu and Mao	Dziedz and Warnoc
Factor Key: AL = Airline AP = Airport A/C = Aircraft Pax. =	26 AP, big in W.Europ AL.	European metropolit areas	FSC LCC	Southwe US	Asian market	Europea LCCs	LCCs China	JetBlu US	LCCs Taiw	Europe LCCs
Passenger	X			X	X	X	X	X	X	X
AP location		X				X	X		X	X
Slot congestion	X					X		X	X	X
AP operating							X		X	
Environmental operations	X									
ATC aids	X				X		X		X	
AP	X		X	X	X	X	X	X		X
AP capacity						X	X			
Dedicated									X	X
A/C maintenance									X	
AP surface							X		X	
Pax. processing	X		X							
A/C turnaround	X		X			X			X	X
AP design and	X		X				X			
AL service						X				X
Non-aero						X				X
AP ownership						X				
Quality of labour	X									
Labour costs	X									
Cost of procuring services	X					X				
Delay data	X									
National admin		X								
International		X								
Economic		X								
Knowledge and research		X								
Tourism		X				X				X
GDP/income		X	X				X			
Unemployment							X			
Population		X	X				X		X	
AL competition			X		X	X	X			X
AP competition		X				X				X
Route length			X				X			
AP type			X				X			
Network compatibility with AL network	X		X				X			

sampled airports' traffic structures.

The MLR was run to estimate the impact of several factors, as identified in the previous section, on air traffic volumes received by smaller European airports. This method was chosen following other similar studies measuring determinants of location of air transport services, mainly Dobruszkes et al. (2011). Regression was carried out for 146 airports (observations), where the dependent variable was re- presented by the total number of passengers handled by the airport annually and 11 different independent variables, which related either the airport itself or the airport's catchment area (Table 2).

The second stage of the study involved a correlation analysis of the structure of regional airport traffic in Europe. A Pearson's Correlation was computed between the same 11 independent variables as in the case of the MLR. Instead of the absolute annual number of passengers being used, three other variables were added as additional independent variables. These were the percentage share of different types of airlines (i.e. CC, FSC and LCC) in the airport's total traffic as measured by their proportion of total seats available on departing flights (Table 3). Given there has been limited empirical research into the impact of airport/ catchment area variables on airport traffic structure (split in traffic between different airline business models), it was not appropriate to express a causal relationship using regression. It was therefore more appropriate to use correlation for this stage.

As shown in Table 2, the MLR included 11 independent variables that explain the dependent variable, i.e. the number of passengers served by the airport annually. In each case, the latest available data were used, although in some cases the base year was different. This is an issue experienced elsewhere in the literature (Dobruszkes et al., 2011) and does not significantly affect the results of the study, as respective factors show rather low fluctuations over the considered time span of 3–5 years.

The regression and correlation analyses included airport and catchment area related factors. This is because these factors are the most controllable for the airport operator and regional governments (Graham, 2014). This means that by influencing and stimulating these factors, the authorities and airport managers can try to grow traffic. Second, comparisons of these two categories should allow an ex- amination of whether it is the airport or the airport region that attracts airlines more. Most papers so far have investigated just one of these sides so this research will be the first to compare them extensively.

Group	Factor	Time	Data source
Dependent variable	Total number of passengers	2016	Respective CAAs
Airport related	Turnaround fee for short-range aircraft [€]	2017	airport-charges.com
	Turnaround fee for medium-range aircraft [€]	2017	
	Availability of incentives (0–1)	2017	Airport websites
	Capacity constraints (0–1)	2017	IATA list of coordinated airports
	Distance to the nearest competitor [km]	2017	Google Maps
	Motorway access (0–1)	2017	

	Rail access (0–1)	2017	
Catchment area related	Population	2016	Eurostat
	GDP per capita [€]	2015	
	Non-resident tourism arrivals	2015	
	Research and development expenditure per inhabitant [€]	2013	

Table 3
Variables used in the correlation analysis.

Group	Factor	Time	Data source
Airport related	Turnaround fee for short-range aircraft [€]	2017	airport-charges.com
	Turnaround fee for medium-range aircraft	2017	
	Availability of incentives (0–1)	2017	Airport websites
	Capacity constraints (0–1)	2017	IATA list of coordinated
	Distance to the nearest competitor [km]	2017	Google Maps
	Motorway access (0–1)	2017	
	Rail access (0–1)	2017	
Catchment area	Population	2016	Eurostat
	GDP per capita [€]	2015	
	Non-resident tourism arrivals	2015	
	Research and development expenditure	2013	
Traffic structure	LCC % share in airport traffic	2017	Flightradar24 database
	FSC % share in airport traffic	2017	
	CC % share in airport traffic	2017	

The selection of factors was limited to those coming out of the literature review. Data availability and lack of multicollinearity further constrained final selection. The former excluded some clearly important factors, such as airport terminal capacity. The latter aimed to eliminate those factors which are mutually related in order to avoid a double counting effect. For example, number of business units in the region was excluded as it showed high correlation with local GDP per capita. R &D spending was included in order to capture the scientific and academic potential of the region. Having a significant, internationally linked R&D base could increase the attractiveness of the airport not only because this sector tends to use air services frequently (e.g. when travelling for conferences), but also because it is a sign of a developing region, where companies may locate their business units in the future, generating additional business traffic flows.

One of the key limitations is related to airport catchment area. It was impossible to determine an actual catchment area range. Even though it is traditionally determined by a 2 h' drive time radius, the time people actually travel to use an airport can be longer and depends on the air fare or airline type (Pantazis & Liefner, 2006; Lieshout, 2012). Since catchment area range is not easy to measure, it is equally difficult to analyse its economy and population. For instance, it is un-attainable to establish how many business units exist in the catchment area, or what its GDP is. Therefore, some simplification is necessary. This study has assumed the NUTS2[2] region of the airport to be an approximation of its catchment area. NUTS2 regions are slightly different from the actual catchment areas in practice as an airport may be used by people from outside its NUTS2 region, especially if it is located on

2 Nomenclature of Territorial Units for Statistics - Second Level as regulated and developed by the European Union the regions' borders. This limitation has been overcome in previous research with the use of a similar or identical statistical unit to describe the airport's hinterland (e.g. Dobruszkes et al., 2011; Maertens, 2012). Regarding the correlation analysis, raw data on capacity was im- ported from Flightradar24 database, which provides the flight number (and thus, the airline name), origin and destination airport, frequency and aircraft type, for all flights. Airline name and type (LCC, FSC, CC) were added manually based on flight number and the airline's general business model. Assumptions about aircraft capacities were made based on airline manufacturer specifications. When selecting the European airport sample, the scope was to include all operative airports below 1 million passengers per annum (mppa) across the European Union. The detailed steps involved in de- fining the sample of airports to be used in this study are identified in Table 4.
The final sample includes 146 airports from 21 countries (Fig. 2). Most countries are represented with less than 10 airports. Greece, the United Kingdom, Finland, Sweden, Spain and France remain the most represented countries. The relatively high position of Finland and Sweden results from a well-developed airport infrastructure in remoter regions. Seven EU countries: Cyprus, Estonia, Ireland, Luxembourg, Latvia, Malta and Portugal remain unrepresented due to the size, nature of airports and/or data availability. Overall the presented geographical spread indicates a balanced coverage of regions in the European market.

The spread of airports in the sample by annual passenger traffic is shown in Table 5. The average size is 311,000 annual passengers reflecting the desired original focus of this study on smaller airports, with the smallest airport being Suceava airport in Romania (5726 passengers recorded in 2016). Although below the lower threshold, Suceava was chosen by Wizz Air for several connections in 2018, making the airportSteps involved in arriving at the final airport sample.

Step	Number of airports before	Types of airports excluded	Number of airports after
1	494	Airports serving above 1mppa	311
2	311	Airports without IATA code (Halli Airport)	310
3	310	Norwegian airports	268
4	268	Airports relying on PSOs for at least 50% of routes	220
5	220	Very small airports (Average number of passengers < 10,000	199
6	199	Recently downsized/closed airports	192
7	192	Airports serving different purposes (GA, military, SAR, AC	182
8	182	Airports with a runway shorter than 4675 feet	176
9	176	Not regional airports	171
10	171	Airports with missing data	146

Fig. 2. Geographical location of airports included in the sample.

Table 5
Number of sampled European airports by traffic volume.

Airport traffic (passengers yearly)	Number of airports
0-200,000	56
200,000–400,000	45
400,000–600,000	24

600,000–800,000	12
800,000–1,000,000	9
TOTAL	146

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worth considering in this study.
The following hypotheses were set for the variables used in the regression and correlations analyses prior to computation:

Regression model (overall traffic levels)

In line with the demand-price relationship, the more an airline pays for the operation, the less incentivised it is to use the airport. Therefore:

H01. Turnaround costs are not related to the level of airport traffic.
H1. Turnaround costs are related to the level of the airport traffic.
Wherever an incentive scheme is in place, airlines are more likely to use the airport. Therefore:
H02. Availability of incentive schemes is not related to the level of the airport traffic
H2. Availability of incentive schemes is directly related to the level of the airport traffic.
Capacity constraints would typically inhibit the level of traffic. However, such constraints are imposed on large airports rather than smaller ones. Thus, capacity is expected to be linked with airports receiving more traffic. Therefore:
H03. Need for capacity coordination is not related to the level of airport traffic.
H3. Need for capacity coordination is directly related to the level of airport traffic.
The further away an airport is from another airport, the lower the level of competition it faces and the more traffic it attracts. Conversely, airports laying in closer proximity to each other should find it more difficult to grow traffic. Therefore:
H04. Distance to competitor airports is not related to the level of airport traffic.
H4. Distance to competitor airports is directly related to the level of airport traffic.
Rail and road networks increase the airport catchment area and thus the potential number of passengers. Therefore:
H05. Landside accessibility is not related to the airport traffic level.
H5. Landside accessibility is directly related to the airport traffic level.
The higher the GDP/population number/tourism potential/R&D spending, the more attractive the region is and the more traffic it should generate for airlines. Therefore:
H06. No catchment area related factor is related to the level of airport traffic.
H6. Each catchment area related factor is directly related with the airport traffic levels.

Correlation analysis (traffic structure)

LCCs aim to minimise the overall costs of running an airline, a significant part of which is constituted by airport fees. Therefore:
H07. Airport fees/charges are not related to the LCC market share in airport traffic.
H7. Airport fees/charges are negatively related to the LCC share in airport traffic.
Developed regions generate business and conference traffic, which is associated with traditional carriers. Therefore:
H08. R&D spending per capita is not related to FSC market share

Table 6

	Passen Traffic	Populatio	GDP per capita	Non-arrivals 15	R&D inhabitant 13	Boeing charges	Dash a/c Charges	Distance to competitor
Mean	311,422	1,802,492	25,728	1,275,083	468	3579	1360	85
Standard	244,652	1,568,430	11,526	2,422,028	441	1967	748	33

H8. R&D spending per capita is positively related to FSC market share
Incentive schemes are a popular tool used by regional airports to attract traffic. LCCs have been the biggest beneficiaries of such schemes. Therefore:
H09. There is no relationship between incentive schemes and LCCs share in airport traffic
H9. The relationship between availability of incentive schemes and LCC share in airport traffic is positive.
Tourism traffic has been vital for growth in CC and LCC services in the regions. Therefore:
H010. Non-resident tourism arrivals are not related to the share of LCC and CC in airport traffic.
H10. Non-resident tourism arrivals are positively related to the share of LCC and CC in airport traffic.
Wealthier regions have stronger economies and generate traffic appropriate for traditional, full-service carriers. Therefore:
H011. GDP per capita is not related to FSC market share in airport traffic
H11. GDP per capita is positively related to FSC share in airport traffic.

Results and data analysis

Descriptive statistics are first presented for the selected dependent variable (annual passenger traffic) and the numerical independent variables used in both the regression and correlation analyses (Table 6). With the exception of non-resident tourist arrivals, standard de- viations are less than the means demonstrating a reasonable confidence level in the means. Non-resident tourist arrivals varied greatly de- pending on whether the sampled airport was located in an incoming tourism region or not. The average distance to a competitor airport of 85 km is also of interest given that, in the majority of cases, the potential for airport switching by both airlines and passengers is ever present for a large percentage of the observed small airports.

Results and data analysis (MLR)

The regression output is presented in Table 7. The multiple R of 0.54 indicates a moderate linear relationship between the independent variables and the level of airport traffic (Table 6). The model's explanatory power, measured by the R squared value, equals 0.29 suggesting that slightly more than a quarter of variation in airport traffic can be explained by the variables included in the final model. The standard error is high at 217,748. In other words, an estimation of traffic using the model can be different from actual traffic by more than 200,000 passengers, i.e. a fifth of the spread analysed. The explanatory power of the model [29%] is lower than those obtained in a similar study by Dobruszkes et al. (2011) involving larger metropolitan areas [70%]. The lower explanatory power means that regional airports are more diverse in terms of traffic drivers, which may be caused by the more intense competition that they face. The common point of these studies is that only a few factors were found to be significantly important for air traffic volumes. This confirms that while there are many trends in the industry, not all of them are strong enough to make generalisations regarding the determinants of air traffic. Also the industry appears to take note of this fact, as airports diversify their strategies and look for bespoke recipes for success.
Only three relationships are statistically significant in the model at the 95% confidence level i.e.: population size, Boeing turnaround fees and the IATA coordination dummy. Thus, there is enough support for the statement that the more people living within the airport's catchment area, the more traffic it attracts. Also, airports facing fewer operational constraints (through IATA slot coordination at smaller airports) may attract a significant positive effect on traffic. Finally, airports charging more for Boeing type aircraft turnarounds generally see more traffic. The significant variables are different between this and the Dobruszkez et al. (2011) study. While GDP, tourism, economic decision power and distance to the main air transport markets are more important for air- ports serving large metropolitan areas, it is population size, capacity and turnaround fees that show higher explanatory power with air traffic volumes at regional airports. Both analyses involved slightly different factors, although for the common ones, relationships were typically weaker in this study, indicating that trends among regional airports are more blurred.

In terms of direction of relationship population size, GDP per capita, region tourism attractiveness, Boeing turnaround fees, presence of incentive schemes, distance to competitor airports, absence of airport capacity constraints and ground accessibility are associated with higher traffic served by the sampled regional airports. On the other hand, R&D spending and Dash turnaround fees appeared to be negatively related to traffic volumes. Excluding R&D and Boeing turnaround fees it can be said that variables generally returned the expected signs. By showing a positive relationship between air traffic level and population size, the model extends applicability of the results from other studies (e.g. Mueller et al., 2011; Lu & Mao, 2014) to regional airports. Therefore, regional authorities should be advised to avoid over-ambitious plans of building an airport in scarcely populated regions, such as in the Ciudad Real airport in Spain, the population of which is approximately 75,000. Following Doganis (2006), the model indicates a direct relationship between air traffic volumes and GDP. According to the results, an in- crease of GDP per capita by €1 is associated with additional 2 passengers using the airport. Also Airbus (2016) forecasts indicate a clear and positive (albeit logarithmic) relationship between these variables. Small airports are thus no different and also benefit from the economic activity of the region.

Non-resident tourist arrivals show a direct relationship with levels of airport traffic. The more people visiting the region, the more passengers the respective airport can handle, which has been noted in other studies such as Graham et al. (2008). The relationship is weaker than one could perhaps expect – with each additional hundred non- resident visitors translating into nine additional passengers using the airport. This means that either tourism does not generate as many passengers, or that they come to the regions using other transport modes. The example of the Croatian markets suggests it is probably the latter. It was found that despite the significant distances and availability of a convenient air connections, Polish tourists prefer to drive to Croatia with their own car, even if it requires ferry transfer onto one of the Croatian islands (Goic, 2015). On the other hand, if the airport targets tourists from more distant regions, it would indirectly compete with stronger and more popular destinations. For example, a niche Romanian airport aiming to attract German tourists would face competition from well-known Spanish resorts, which are located at a similar distance from Germany and therefore equally accessible to potential

Table 7
MLR results.

Regression statistics		
Multiple R		0.54
R squared		0.29
Adjusted R squared		0.23
Standard Error		217747.8
Observations		146
Variable	**Coefficient**	**p-value**
Intercept	−17,843	0.86
Population	0.039	0.01**
GDP [€]	2.17	0.39
Tourism	0.01	0.36
R&D	−99.20	0.11
Boeing turnaround fee	35.48	0.01**
Dash turnaround fee	−12.64	0.70
Incentives	78,803.85	0.08*
Distance	190.11	0.77
Capacity (IATA slot co-	168,758.4	0.00**
Train	58,675.16	0.34

Motorway	17,323.85	0.68

**Significant at the 95% confidence level, * Significant at the 90% confidence level.

German tourists. Concluding, regional airports do not automatically benefit from tourism. They are limited by competition from ground transport on the one hand and by other tourism destinations on the other.

The negative R&D relationship with air traffic volume is different from that found for similar variables by Dobruszkes et al. (2011). This suggests that scientific research and academic activities in the regions do not translate to air traffic demand, although further studies should be carried out to make definitive conclusions.

Regarding turnaround fees, mixed results appear from the model - the result for Boeing is significant and directly related to traffic levels, while Dash aircraft turnaround fees show an insignificant and negative relationship. The former may suggest two phenomena. Firstly, airline demand for airport services is inflexible and higher airport costs does not usually stop a carrier from serving a destination, which has been noted by, for instance, Warnock-Smith and Potter (2005). Secondly, airports handling more traffic with generally larger aircraft gauges, face higher costs, which increases their pricing, in accordance with the general recommendation of IATA (2014). In essence, however, the re- sults show that pricing is not an effective tool for constructing air traffic at regional airports, contrary to the ideas presented by Graham (2014) – albeit using a sample of larger scale airports.

Incentive schemes are positively related to airport traffic volumes. The relationship is strong and indicates that when an airport offers discounts to its carriers, it is likely to serve more passengers. Such a finding fills the gap specified by Malina, Albers, and Kroll (2012) that incentive schemes effectively help airports generate traffic and air services. This postulation may naturally have its opponents who ques- tion the long-run sustainability of incentive schemes. Indeed, as Malina et al. (2012) noted, many new routes may disappear when favourable contract conditions terminate. According to the results of this study, however, airports operating such mechanisms statistically can serve 80,000 passengers more per year.

Airports having their slots coordinated by IATA is positively related to airport traffic volumes. In other words, airports attracting more traffic are more likely to be slot-coordinated. Moreover, those airports that are slot coordinated still maintain high traffic numbers, as airlines do not want to redirect services to alternative non-coordinated locations. Instead, operations are properly reorganised in order to still serve the desired airport. Thus, availability or lack of capacity will not affect the airline decisions as long as it is technically possible to use the air- port. Slot coordinated, smaller airports are still very likely to have surplus capacity for significant portions of the day anyway. This is an important finding for regional authorities who sometimes see development of new infrastructure as the main method to attract carriers.

Distance to the nearest commercially attractive competitor shows a direct relationship with airport traffic volumes. The further the airport is from its competitors, the higher the potential for monopoly and the more traffic it can attract. This is consistent with the results obtained for bigger metropolises (Dobuszkes et al., 2011). On the other hand, this means that construction of new airports in areas, which already have one is not easily justifiable. Neighbouring regions should work together to promote one airport rather than construct new infrastructure and compete against each other. This is particularly true for the regions which are served by a major airport and which experience sudden LCC or charter growth at smaller gateways. The results indicated that traffic in such places may decrease as quickly as it increases. To give an ex- ample, Lleida airport in Spain was built by the Catalan government in lieu of Girona airport's popularity, with an ambition to accommodate part of the traffic increases. Eventually airlines concentrated more on the main Barcelona El Prat airport, and left the smaller gateways, as in many other regions of Spain, under-served (Dziedzic & Warnock-Smith, 2016).

Last but not least, even though both rail and motorway/highway access show a positive relationship with airport throughput, the cor- relation is too low to claim they increase the airlines' interest at a particular destination. This confirms previous findings that generally air carriers do not focus much on the non-aviation part of their passengers' journey (Dziedzic & Warnock-Smith, 2016). Also, one may notice that many airports with less developed ground transport links perform better than those with convenient rail and motorway access. Hence, good accessibility is not a decisive factor in determining air traffic volumes.

Having examined the determinants of smaller regional airport traffic volumes and traffic structure using a multiple linear regression, we now move on to discuss the structure of regional airport traffic in Europe using a correlation analysis.

Current structure of airline networks at regional airports

Description of small airport market structure

Before proceeding to examine the structure of airline networks at regional airport (section 5.2), it would be necessary to provide a brief

Table 8
Capacity offered from the considered airports split by airline type.

Traffic type	Weekly seats	Seats % share	Weekly departures	Departures % share
Charter	123,338	15%	725	10%
Full-	339,725	40%	3693	53%
Low-	371,517	45%	2525	36%
Totals	834,580	100%	6943	100%

Note: Average a/c capacity = 120 seats (FSC = 89 seats, LCC = 147, CC = 170).

Table 9

Most popular airlines at observed regional airports.

Airline	Weekly seats offered
Ryanair	120,582
Wizzair	47,740
Flybe	36,216
Iberia	29,616
easyJet	28,752
Air France	26,822
Vueling	26,792
Thomson Airways	25,578
SAS	25,232
Lufthansa	23,856

description of small airport market structure. In presenting descriptive statistics about the traffic structure across 1423 small European airports, FSCs and LCCs control an almost equal share of departing seats (Table 8), which contradicts the possible belief that LCCs dominate small regional airports. Charter traffic is responsible for the remaining average 15% of capacity offered over the reference period. Interestingly, despite offering just 40% of capacity, FSCs operate more than half of all the flights. This is due to the smaller aircraft they use and greater frequency of operations to the regions in order to feed their hubs.

It is possible to compare departure splits with the European average for all the airports provided by Eurocontrol (2015), according to which CCs, FSCs, LCCs operate 4%, 63% and 33% of flights respectively. While the LCC share among smaller airports is similar, the share of CCs is surprisingly high. 10% of flights departing from small airports are charter services, 6% more than the average. This shows that charter traffic is clearly of greater importance for smaller regional airports than it is for larger gateways. To make definitive judgments, however, a longer period should be analysed in order to exclude charter seasonality, as lower charter traffic throughout the rest of the year could neutralise this result.

Table 9 takes a closer look at individual airlines and presents the top 10 carriers according to the capacity offered from the small airports studied. Two ultra LCCs, Ryanair and Wizzair, offer the highest number of seats. The third largest airline at small airports is a regional FSC, Flybe. The remaining positions are occupied mainly by FSCs, but also by LCCs easyJet and Vueling and CC TUI, which all offer between 20 and 30 thousand seats weekly.
Ryanair is an undisputable leader in the regions; this airline alone offers more capacity than the next three carriers combined and as much as 14% of the total sum of seats. It is therefore understandable that LCCs, and especially the Irish carrier, is the first thought for airports wishing to attract traffic. On the other hand, the position of FSCs is remarkable. Despite the size of their networks and greater frequencies, they are not leaders in their regions. This, combined with the results of the previous two tables, show that the days when regional airports were reliant on the domestic carrier's faith are now gone and nowadays foreign carriers, especially LCCs, can effectively serve these airports. Thus, conclusions on the effects of deregulation on the aviation market are also applicable to small and medium regional airports (e.g. Starkie, 2006).
Considering the most popular destinations offered from regional airports, London Stansted comes out top (32,589 weekly seats), al- though Madrid Barajas and Stockholm Arlanda are serving similar ca- pacity. This is due to the fact that while Iberia and FSCs generally connect airports directly with just one hub, LCCs can offer non-stop point-to-point flights to any airport in Europe. Therefore, Stansted is linked with more airports but the connections of Madrid and Stockholm see higher frequency. Interestingly, Palma de Mallorca is ranked fourth with over 27,000 arriving from regional airports. The result is driven by German tourists. 13 thousands weekly seats are offered on flights to German airports, although the UK-bound capacity is not far behind.

Correlation results (structure)

Correlations between the analysed variables and shares of different airline types are presented below in Table 10. Colours indicate the strength of correlation, appropriately to its absolute value, i.e. white and green denote low and moderate correlations respectively. Table 11 provides further information on the statistical significance of each correlation. Values lower or equal to the accepted significance level (95%) are highlighted.
The percentage share of LCCs at the considered airports show weak correlations overall with the discussed variables. It is positively correlated with population size, regional tourism potential, incentive schemes and distance to the competing airport. GDP and R&D levels, along with slot coordination and ground accessibility show an inverse correlation with LCC share. Relationships with population, GDP, R&D and capacity are statistically significant. Correlations between the variables and the share of CC traffic reveal similar patterns as LCCs. Population size shows almost no relation, while GDP and R&D spending per capita are negatively correlated with CC share. Lastly, tourism shows a positive correlation with CC traffic. Considering airport variables, airport costs show almost no correlation. Negative relationships were found for the share of CCs and the presence of incentive schemes and distances to competitor airports. Contrarily, slot coordination and ground accessibility were linked with a higher CC share in airport traffic. Only capacity was significantly related to the share of CC traffic. Out of all the airline types, FSC traffic has the strongest correlations with airport catchment area features. A weak inverse correlation for population size and tourism attractiveness was found. For all airport characteristics, the derived correlation rates remain close to zero. This means that there is hardly any relationship between the airport offer and the share of FSCs. Correlations between FSC share and population, R&D and GDP are statistically significant.
Population size appears to have the strongest correlation with LCC traffic share, which is consistent with previous studies in this segment of the market (e.g. Boguslaski et al., 2004; Mueller et al.,

2012; Lu & Mao, 2014). In more populated regions, LCCs offer more capacity than other airlines.[4] Such a correlation means that really small airports in sparsely populated areas should not expect intense interest from LCCs and should cooperate with regional focused FSCs, most likely the national carrier. The negative relationship between FSC share and population size further confirms this point.

Opposite conclusions can be drawn with respect to GDP per capita level and R&D expenditures. Stronger economies appear to be more favoured by FSCs while avoided by LCCs and CCs. This numerically confirms general statements made elsewhere in the literature (e.g. Dobruszkes, 2006) that FSCs focus on richer regions. If the other end of the spectrum is to be considered, less economically developed regions

3 Due to unavailability of traffic data, the sample for descriptive statistics was reduced by 4 airports compared to the sample used in the MLR.

4 Note that this study considers airports of below 1mppa only. Therefore, FSCs may still dominate gateways over 1mppa located in the same, more populous regions.

Table 10
Correlation analysis results. See published version

Table 11
Statistical significance of correlation results. See published version

should build their networks based on the low-cost and holiday links mainly. The same principle applies to airports located in tourism-at- tractive locations. Such airports mainly handle CCs and LCCs, while FSC share is negatively correlated with the number of non-resident tourism arrivals to the region. Thin, low-yield markets are not central to FSC strategies. Airports should pay attention, however, to the fact that the relationship is nearly the same for LCCs and CCs, indicating that they could transfer market segments. In other words, CCs do not monopolise leisure traffic in the regions and can be substituted by LCCs.

A marginal correlation occurs between the turnaround fees and the share of each airline type in airport traffic. This indicates that prices are not discriminatory and assure fair treatment of all types of airlines. On the other hand, the results negate suggestions that airports could use tariffs as a tool not only to grow traffic as such, but to develop particular types of traffic (e.g. Graham, 2014). Airport managers should be aware that current EU State Aid regulations hardly leave any scope for such practices. Instead, it needs to be recognised that while airport charges should correspond to actual operating costs, the level of charges is in fact of moderate interest to the airlines. This challenges much of the research carried out so far, although it supports those authors who openly state that complaining about airport charges is somehow natural for airlines (Adler and Berechman, 2001) and that eventually carriers are able to pay the price if the potential gains are large enough.

Availability of incentive schemes, was found to be negatively correlated with CC share and positively correlated with the FSC and LCC share. This is because such schemes usually favour scheduled traffic (Jones et al., 2013). On the other hand, it is symptomatic that this relationship is stronger for FSCs than for LCCs. If we assume that FSC networks are usually more stable over a period of years (Copenhagen Economics, 2012), this would suggest that incentive schemes can be associated with the long-term, sustainable growth of the number of routes. This is definitely good news for regional airports, yet requires further study to allow for a definite answer to the question raised by Malina et al. (2012) regarding the efficiency of incentive schemes in establishing long-run air transport services.

An airport's distance to the nearest competitor demonstrates mixed correlations according to types of traffic. The further an airport is from its competitor, the less dominated it is by charter traffic. This is prob- ably due to the fact that many tourism attractive regions are served by several airports located close to each other. Very weak relationships were found with respect to LCCs and FSCs, suggesting that it is the latter that operate a higher share of capacity at remoter airports, although the results are rather inconclusive.

CCs were found to be more active at slot-coordinated airports, which has not been discussed in the literature so far. Thus, airports willing to focus on this leisure segment of the market should look to be IATA slot coordinated. Small airports should especially care about maintaining good relationships with local inhabitants so that possible night operations would not face intense opposition.

Finally, airport ground access did not show significant correlations with the share of any airline type. It is especially the case for motorways and highways, which suggest that a small regional airport can be served by less developed road systems. According to the gathered data, there are 47 airports without railway or motorway/highway access, although it should be remembered that some of them are located on islands, which usually do not require a highly developed road infrastructure.

Conclusions and study limitations

The vulnerability of many of the observed smaller airports in Europe cannot be understated. European airports such as Reus, Munster, Grenada, Jerez, Durham Tees Valley, Paderborn, Tampere, Vigo, Rimini and Bournemouth to name a few have all seen substantial drops in traffic over a 10 year period to 2016 with Reus seeing the biggest drop of 888,998 (52% reduction) from a high of 1.7 million to just 817,000. For airports like Durham Tees Valley, traffic almost dropped to zero (734,000 down to 131,487) highlighting the need for smaller airports to understand the requirements of their airline customers both in terms of the overall factors they look for in the route network decision making process (MLR) and in terms of any variation in requirements by carrier type (Correlation analysis). A staggering 95 of the observed 146 air- ports are beholden to one air carrier for 50% or more of total traffic, adding to the rationale for a thorough assessment of how smaller air- ports in particular can tap into airline preferences to aid a more sustainable future in the medium to long-term.

The main finding of this study is that small regional airports in Europe constitute a complex part of the air transport market. There are few factors that can help to determine traffic volumes at these airports, the most important of which is population size living within the con- fines of the airport catchment area. Airport charges and capacity constraints are also significantly related to the number of passengers using the airport, although it appears they may be considered a result, rather than a determinant of volume.

Several relationships between airline preferences to specific airport profiles have been confirmed. In many cases, factors that attract LCCs to small European airports are a deterrent to FSCs and vice versa. Airports serving more populous areas are more likely to attract LCC traffic while those located in more economically developed regions can expect higher FSC growth. Naturally, regions where tourism is developed are likely to serve more charter traffic. Smaller airports should be extremely careful when building route networks, however, as recent years have shown that airports focusing only on tourism traffic experienced more rapid downturns. Other factors studied in this paper, such as GDP and R&D spending per capita, tourism attractiveness, airport competition, airport ground accessibility or availability of incentive schemes also show some correlation with airport traffic volumes. These relationships should be studied further, however, in order to draw specific conclusions as they are not statistically significant.

In terms of the 12 stated hypotheses configured for testing in Section 3, Table 12 provides an overview of the main findings.

This study had a number of limitations. The statistical significance in both the MLR and correlation computations was moderate, leaving scope for a deeper study into smaller samples of regional airports. It assumed the NUTS2 region of the observed airports to be consistent with their catchment area. Undoubtedly, a geopolitically created statistical unit cannot correspond exactly to the actual geographical region an airport serves. Nevertheless, due to availability of reliable data on a pan-European scale and the usage of the same method in similar studies, this approach is currently the most feasible for broader research of this kind. Secondly, the study focuses on a very narrow group of air- ports in terms of traffic served. Bearing in mind that the largest airports in Europe serve around 75 mppa, those handling just a tiny fraction of this (i.e. 0–1 mppa) may not necessarily show strong patterns in terms of traffic trends. On the other hand, the study still provides a valuable insight into what is a significantly under-researched market segment covering the lion's share of all small commercial airports across Europe. Future research should focus on a deeper analysis of the airport choice factors found not to be statistically significant as it is possible they do reveal some patterns within specific countries or different regions of the world. For instance, other research methods, such as direct interviews or time-series analyses, or a focus on smaller, specific airport groups (e.g. on country level), could capture these potential trends. Another area worthy of consideration is the viability of alternative strategies for airports to secure their position in the market. It seems that airports dominated by one carrier, could try to balance their growth, for instance, by developing cargo traffic or constructing aircraft maintenance and Fixed Based Operator (FBO) infrastructure. Finally, this study can be replicated in the future if new market dynamics appear.

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