Regional air transport in Germany and Europe: Scope for revitalization after years of decline?

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Abstract

Unlike e.g. low cost air travel, regional aviation is only scarcely featured in the transportation research literature. This paper reflects and discusses the development, connectivity impact, and potential outlook of intra-European regional air services from Germany. First, we employ air transport supply data to illustrate the general decline of this market segment in the past 15 years and resulting connectivity losses for selected airports and regions. Second, we discuss potential drivers behind the observed trend, as well as possible starting points for a revitalization of regional air links, which could – at the same time – also help improving regional connectivity and the utilization (and financials) of small airports. We close the paper with a simple but straightforward exercise to quantify the demand potential for new, nonstop regional air services from Germany based on empirical indirect passenger flow data. From today's perspective, we identify a potential for 313 new routes with a potential for 2.2 million passengers.

Keywords: small regional air transport, regional airports, regional air traffic, air transport demand

1. Introduction

Unlike e.g. long haul or low cost air services, regional air transport is hardly tackled in the transport research literature (Gillen and Hazledine, 2015). This is somehow remarkable as this air transport segment has had to continuously reinvent itself over the past years in response to competitive pressure from e.g. fast-growing low cost carriers (LCC) – and a resulting higher price awareness of the passengers – and new high-speed train links. As a result, many regional airlines have either ceased operations or transformed into cheaper operating platforms for network carriers (Graham, 1997). Average aircraft size has increased, and many of those thinner routes that used to be served at relatively high frequencies by aircraft with less than +/- 50 seats have disappeared. As a result, many regions have lost air transport supply, especially since the odd, low-frequency low cost service, if available at all, does not always make a good substitute in terms of connectivity for business travellers and regional economies.

Against this background, a revitalization of regional air services, if economically feasible, could potentially help enhancing the connectivity of certain regions (and hence serve the cohesion goals and the EC Flightpath 2050 connectivity goal that 90% of journeys within Europe shall be completed, door to door, within 4 hours; see European Commission, 2011) and - at the same time - improve the utilization and regional impact of smaller airports.

The objectives of this paper are three-fold: First, we aim at illustrating the decline of regional air traffic in Germany and Europe and resulting connectivity impacts on selected airports and regions. Second, we discuss potential drivers behind this trend as well as operational and technological pillars that may help overcome this issue. Third, in a case-study approach for the German market, we present a simple but transparent approach to quantify the demand potential for new, nonstop regional air services based on empirical data for indirect passenger flows and on certain assumptions regarding e.g. supply-induced demand generation.

By this, we aim at adding new aspects to the relatively small literature on regional air transport. Previous papers on this market segment dealt e.g. with issues like network types, route choice and/or pricing issues (e.g.

Hanlon, 1992; Gillen and Hazledine, 2015), or with the impacts of new (jet) aircraft technologies (Dresner et al, 2002; Brueckner and Pai, 2009, and Fageda and Flores-Fillol, 2012). The latter also assessed the implementation and impact of low cost carrier supply in regional markets. Another string of papers tackled forms of external financing of regional, e.g. under the EU "Public Service Obligation" (PSO) or the US "Essential Air Service" (EAS) schemes. Recent examples are Grubesic and Wei (2013) and Merkert and O'Fee (2016).

2. Development of regional air links in Europe and resulting connectivity impacts

Passenger air transport in Europe, as in most other world regions, is split over four main, archetypal business models (see e.g. Ehmer et al, 2008; Bieger and Wittmer, 2002): scheduled continental and long haul flights by network carriers; holiday flights offered by dedicated leisure carriers on behalf of tour operators; regional air services, usually connecting small(er) airports with the main ones, or providing connections between regions; and low cost services which evoked towards the end of the 20th century following from market deregulation, and which are now aimed both at business, holiday and VFE (visiting friends and relative) travellers.

In pre-deregulation times, most regional flights were served by specialized "niche" carriers, holding permissions for routes that were e.g. not of interest to major carriers. Examples include both independent operators like Eurowings and Crossair (before being sold to Lufthansa and Swiss, respectively), or the likes of Air Anglia, Manx Airlines, Air UK or Proteus Airlines, and subsidiaries of national carriers, such as Lufthansa Cityline, Eurowings (after its sale to Lufthansa), Crossair (after partly taken over by Swissair), Regional Airlines or BA Cityflyer.

Before the rise of the LCC, regional air traffic in Europe had grown well, with the number of weekly departures of 40-60 seater aircraft almost doubling from about 12k in 1993 to about 24k in 2000 (Source: OAG). One reason behind this trend was the emergence of new regional jet aircraft in the 90s (see e.g. Dresner et al, 2002), allowing for faster and quieter regional air transport at competitive unit costs. Existing regional subsidiaries were strengthened or new investments in regional affiliations were undertaken to establish cheap(er) operating platforms (Graham, 1997). From the early 2000s, then, the structure of regional air transport in Europe changed again, as the number of weekly flights operated by 40-60 seaters declined massively from about 26k in 2002 to only 15k in 2009 (Source: OAG). This trend is also illustrated in more detail in Figure 1 which shows the development of yearly intra-European departures by aircraft class from 2000 to 2016. The biggest losers in terms of market shares and absolute traffic volumes were the 1-20 and 21-50 seaters.

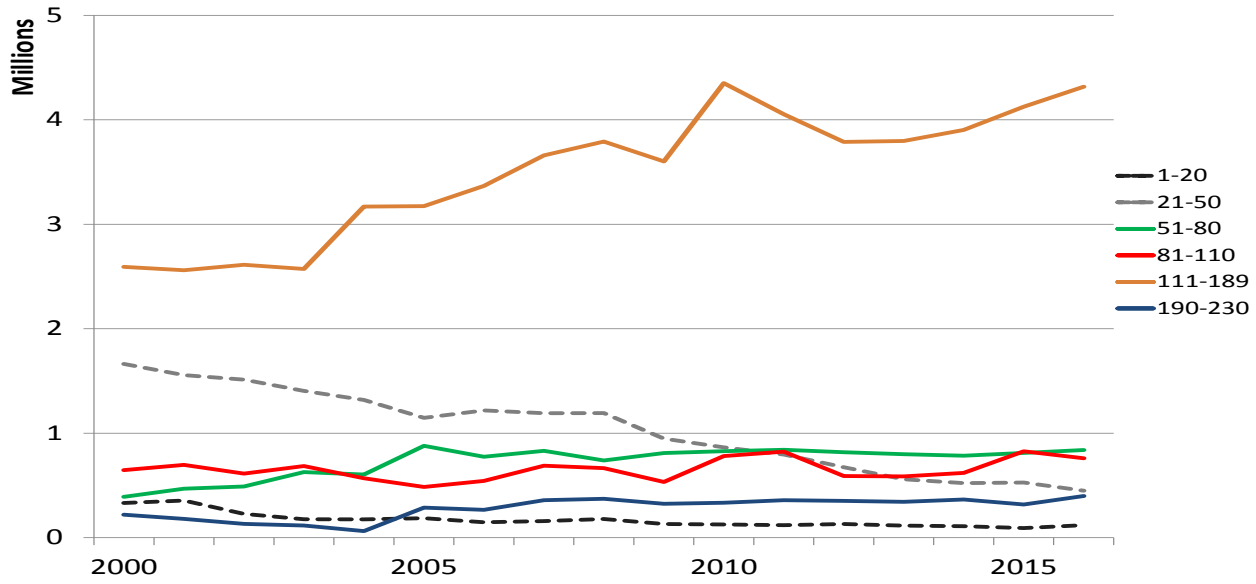

Figure 1. Annual departures in Europe by seat class, 2000-2016
(Source: Own figure based on Sabre Market Intelligence data)

Business model-wise, one can now differ between…

- contracted (affiliated) operations on behalf of legacy carriers on hub feeder or decentralized routes by either subsidiaries (e.g. Lufthansa Cityline, KLM Cityhopper, Eurowings, Hop!...) or financially independent franchise operators (e.g. BA Cityflyer, Air Nostrum…), and
- own operations of fully independent, mostly small to medium-scale regional airlines (e.g. Flybe, Air Baltic, Cityjet…).

Most of the European regional airline seat capacity is currently represented by affiliated operations (415 aircraft or 62% of the European fleet if only those European regional airlines that are among the global Top100 as reported by Airline Business (2013) are counted), be it on a franchise basis or by subsidiaries, while independent regional networks only account for 256 aircraft and hence about 38% of the European fleet out of the global top 100.

The described trends towards large regional air traffic also mirrors in the manufacturers' fleet forecasts for regional aircraft which are summarized in Table 1. While the forecast values are difficult to compare as different aircraft size classes are applied it is quite obvious that smaller aircraft do not play a major role. Only ATR considers the 40-60 seats segment at all (which comes with no surprise as the ATR42 model is one of the main remaining aircraft being still in production here), and both ATR, Bombardier and Embraer see much more potential for larger regional aircraft. Boeing does not at all differentiate within the group of regional aircraft and only considers jets. Aircraft below 40 seats are not considered in any of the forecasts.

Manufacturer	Timeframe	Small a/c	Medium a/c	Large a/c
ATR[1]	2016-2035	40-60 seats: 600	61-80 Seats: 2,200	n/a
Boeing[2]	2015-2034	Regional Jets: 2,490		
Bombardier[3]	2015-2034	n/a	60-100 Seats: 5,700	100-150 Seats: 7,000
Embraer[4]	2016-2035	n/a	70-90 seat jets: 2,300 70+ seats turboprop: 2,040 Total: 2,340	91-130 seat jets: 4,100

Table 1. Future deliveries of regional aircraft as currently estimated by manufacturers
(Own compilation)

The following table shows how the groups of regional hub feeder flights and regional "non-hub" flights have developed between 2000 and 2012. All flights within Europe (EU, NO, CH) with aircraft of less than 120 seats have been considered. Out of these, flights from, to or between the following airports have been classified as hub feeder flights: AMS, BRU, CDG, CPH, FCO, FRA, LHR, LIS, MAD, MUC, VIE, ZRH. The results underline the overall decline of regional air transport and here in particular of the smallest aircraft segments. In relative terms, decentralized routes have declined slightly more than hub feeder routes.

0-120 seats			
Year	**Feeder**	**decentralized**	**Total Flights**
2000	110231	169405	279636
2006	100510	140185	240695
2012	81580	114976	196556
Change 2012/2000	-26%	-32%	-30%
0-50 seats			

[1] See: http://www.ainonline.com/aviation-news/aerospace/2016-07-11/atr-confident-continued-market-dominance (retrieved 11 August, 2016).
[2] See: http://www.boeing.com/resources/boeingdotcom/commercial/about-our-market/assets/downloads/Boeing_Current_Market_Outlook_2015.pdf (retrieved 11 August, 2016).
[3] See: http://www.bombardier.com/content/dam/Websites/bombardiercom/supporting-documents/BA/Bombardier-Aerospace-20150614-Commercial-Aircraft-Market-Forecast_2015-34_V13.pdf (retrieved 11 August, 2016)
[4] See http://www.embraermarketoutlook2016.com/ (retrieved 11 August, 2016).

Year	Feeder	decentralized	Total Flights
2000	43944	105655	149599
2006	33630	76942	110572
2012	17237	53780	71017
Change 2012/2000	-61%	-49%	-53%
51-80 seats			
Year	**Feeder**	**decentralized**	**Total Flights**
2000	14213	23051	37264
2006	25745	32384	58129
2012	23722	37021	60743
Change 2012/2000	67%	61%	63%

Table 2. Number of annual frequencies by aircraft size and route type (intra-Europe), 2000/2006/2012 (Source: OAG)

While – at the aggregated, Europe-wide level – we can assume this reduction in regional air services to have been overcompensated by e.g. new low cost services, actual connectivity impacts at the airport and regional levels turn out to be more diverse. In the last 10-15 years, many regions have lost regional air connectivity to other regions – which may probably contradict the above-mentioned EC Flightpath 2050 connectivity goal.

From the early 00's, many regional airports suffering from overcapacities have started to focus on low cost carriers and reduced airport charges, which has in many cases boosted overall capacities and passenger numbers at the airport level, often at the expense of former regional operations. At the route-level, however, LCC-frequencies are usually lower than those of regional airlines (see Table 3), meaning that many daily or double-daily services suited for business travelers have vanished. What is more, at many smaller airports, LCC supply has not really proofed to be sustainable as many former LCC bases have now been abandoned in exchange for larger airports, resulting in a stagnation of capacities at the original, smaller LCC airports (Malighetti et al, 2016).

Airline	Type	avg weekly frequency per route, 2015	Airline	Type	avg weekly frequency per route, 2015
Ryanair	*LCC*	*4.1*	Flybe	Regional	7.9
easyJet	*LCC*	*5.9*	LH Cityline	Regional	8.5
Twinjet	Regional	5.9	BA Cityflyer	Regional	9.5
BMI	Regional	6.0	KLM Cityhopper	Regional	16.5
AIS Airline	Regional	6.1	People Vienna Airline	Regional	17.1
Sun Air of Scandinavia	Regional	6.8			

Table 3. Average number of weekly frequencies by route of selected low cost and regional airlines in 2015 (Source: Sabre-ADI).

The resulting decline of reliable, regional "business" connections can however have adverse impacts on a region's connectivity and, potentially, its economic development. Also, airport subsidies could become more difficult to justify if declining connectivity levels result in lower catalytic effects for the region. The following figure exemplarily depicts the decline of former high-frequency (daily/double-daily) routes at selected German regional airports. For example, at Nuernberg (NUE), the number of destinations served at least daily / twice daily has plummeted from 20/18 in 2000 to 11/10 in 2014. Similar – or even worse developments can be observed for Bremen (14/12-10/8, BRE), Dresden (12/9-10/5, DRS), Leipzig (13/9-10/9, LEJ), Muenster/Osnabrueck (12/8-5/4, FMO), Dortmund (15/11-9/4, DTM), Paderborn (7/6-2/2, PAD) and Saarbruecken (6/5-4/3, SCN). Berlin Tempelhof was closed down in 2008.

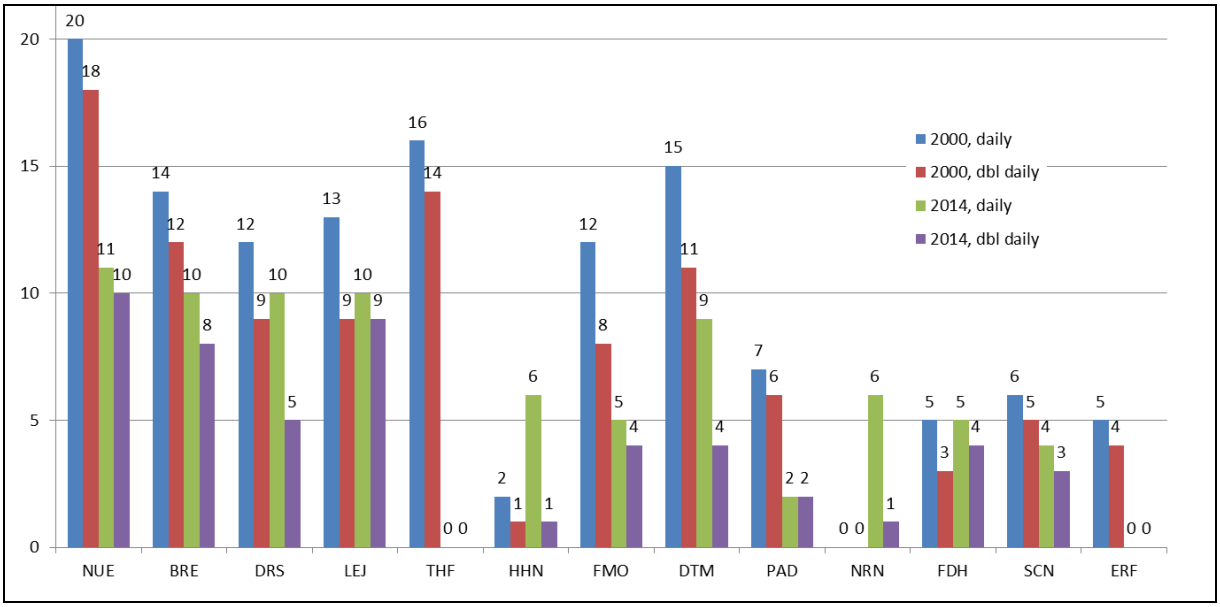

Figure 2. Number of „high-frequency"-destinations by airport, 2000 vs. 2014
(Source: Sabre-ADI)

3. Reasons behind downfall of regional air traffic and starting points for revitalization

We first identify a number of supply-side, i.e. cost-related drivers behind the increasing use of larger aircraft, which has resulted in the withdrawal of many smaller regional routes. In general, aircraft operating costs grow disproportionately with aircraft size, resulting in decreasing unit costs (see e.g. Swan and Adler, 2006). This does e.g. apply to capital and maintenance cost as major components (cockpit, wings, engines, tail, flaps, gears, etc.) are identical within a given aircraft family, independent from the number of seats. The same applies to fuel cost (aircraft weight usually develops disproportionately with size, e.g. 422kg MTOM per seat for the ATR42 compared to 331kg for the larger ATR72), and to flight deck crew expenses. Finally, at some airports, unit landing fees decline with increasing aircraft size: E.g., at Dusseldorf airport a flat fee of 178 EUR per movement applies to all aircraft between 10 and 40 tons MTOM (Dusseldorf Airport, 2015), which equals to 4.05 EUR per seat for a 44-seat ATR-42 and 1.98 EUR per seat for a 90-seat CRJ 900.

Apart from this, the increased use of larger aircraft even on regional routes might be explained by demand-related and other outside factors. First, given the rise of the low cost carriers, we can assume an increased price awareness of the passengers, making it more difficult for regional carriers to stick to their "small aircraft – high fares" formula. Second, 6-15% of global air traffic is operated in capacity-constrained conditions (Gelhausen et al., 2013), especially in Europe and the US. The obvious way to push passenger numbers at congested airports is to increase average aircraft size, although e.g. Givoni/Rietveld (2009) have shown that aircraft size is more influenced by route characteristics, such as distance, demand and competition, rather than by airport characteristics like the number of runways and the capacity situation. Nevertheless, small regional aircraft (and especially slow(er) turboprops) have almost completely disappeared from the most capacity-constraint airports in Europe.

What is more, regional operations seem to suffer from other adverse operating conditions which do not only occur at the congested hubs but at many, if not most airports: Given the relatively high price level compared to ground transport modes, it is reasonable to assume that regional air services will only be successful if they come up with a competitive advantage, e.g. a significant reduction of total travel time, which also depends on airport access time and airport passenger processing. However, most airports have yet failed to provide time-conscious passengers with real opportunities for quick check-in, security control, boarding and de-boarding processes. Even at small airports, regional flights are often time-consumingly boarded by bus, and check-in deadlines hardly undercut 30 minutes. All this may easily translate a 40min regional flight into a 2-3 hours door-to-door trip, encouraging potential passengers to use alternative transport means instead. In contrast,

airports (or better airfields) where short handling times could easily be achieved tend to suffer from insufficient airfield infrastructure, ruling out most commercial air services in the current regulatory regimes.

Bases on these findings, we can derive the following pillars that should be tackled by specific stakeholders – including policy-makers – to re-vitalize the (small) regional air transport market:

Technological view (vehicle-perspective)
Given the high level of competition and the increased price awareness, bringing down the unit costs of regional air transport can be regarded as a prerequisite for re-vitalizing this segment. New concepts like the Cleansky Green Regional Aircraft are currently under development, aiming at reducing the weight and emissions (and thus major cost drivers) of small regional aircraft (Cleansky, 2015). In the shorter run, existing cost disadvantages of the sector could probably be reduced to some extent by employing the newest generation of fuel-efficient regional aircraft such as the ATR-600 series, which apparently allows for unit costs savings of about 30% compared jet aircraft (ATR, 2014). From a policy-perspective, other, more fundamental innovations regarding the reduction of unit costs in regional air transport are of particular interest. Policies that would e.g. allow for single-crew cockpits, as for instance envisaged by Thales and Embraer (Flightglobal, 2010), or single-engine regional aircraft (which could probably emerge from Pilatus' PC-12) could drive down unit costs considerably.

Operational view (system-perspective)
While it is not straightforward to re-design existing airports in a way that they would better meet the needs of regional air services (e.g. short access and handling times), policy measures and financial means could e.g. be applied to allow for the creation of terminal and ramp areas dedicated to regional aircraft where e.g. boarding by walk would be allowed. Other measures could allow for an increased use of airfields for commercial scheduled flights. Potential areas of innovation here may e.g. tackle e.g. the terminal airspace level, where e.g. GLS (GBAS) could be implemented instead of more expensive ILS. Other, simpler measures could be joined use and hence financing of airport fire brigades together with nearby communities, or relaxed operational rules for smaller aircraft.

4. Demand potential for new regional services from Germany

We conclude our analysis in assessing the potential demand for new, decentralized regional flights using a simple approach based on origin-destination (OD) demand and segment supply data available from Sabre Market Intelligence for 2015. For each of a total of 7,698 unique ODs within Germany and from Germany to Europe, we assess the passenger number that could be captured by new regional air services as follows, based on a number of assumptions and simplifications (Figure 3).

First, we derive the distance, and the total, nonstop and indirect passenger numbers, respectively, for each OD from Sabre MI's "OD" module. We then retrieve the average weekly number of direct flights (if applicable) for each OD from Sabre MI's "leg" module. On routes with many direct flights, almost all travellers tend to fly nonstop. On other relations, however, all or most OD-demand is only carried indirectly, be it due to the lack of (a sufficient number of) nonstop flights or for other reasons such as inconvenient departure times of the nonstop option(s).

We regard a minimum of 7.7 average weekly direct flights in each direction as pre-requisite for a successful regional air transport operation. This figure is based on an assumed 40 relevant weeks per year (not counting low-demand summer and x-mas periods when regional flights are often cancelled) multiplied by 10 flights per week (double week-daily) divided by 52 weeks. In other words: We assume that all ODs currently served nonstop by existing carriers at an average weekly frequency of 7.7 or more would not be chosen as new regional routes as existing flight supply is already satisfactorily for most travellers. We hence regard the current indirect demand volume on each OD with less than 7.7 average weekly direct flights as potential demand for a new regional air service, provided that the distance remains below 1,500km (862 of all 878 intra-European routes served by regional aircraft from Germany in 2015 remain below this frontier). A (not yet empirically backed) 25%-multiplier is finally applied to our estimate to account for any supply-induced demand.

We finally assume that a minimum of 8 passengers per flight would be required to successfully operate a small regional aircraft, e.g. the 16-seats Jetstream 31(or, in future, a new model of similar size) with a 50% load factor. Consequently, we also do not count all ODs with an estimated demand per flight below 8. As a result, we identify a market potential of 313 new routes from Germany, which could generate an additional 2,264,182 passengers per year. This equals an average 7,233 annual passengers per route or 18 passengers per flight.

2	Route	Dis-tance	Pax nonstop	Paxe Connect	Share nonstop	Freq/ Week	Cap/f light	Relevant annual demand	incl. 25% supply-induced demand	relevant annual demand per flight	relevant annual demand per flight adj (min = 8)
1074	TXLVNO	1108	5378.77	10282	34%	1	76	10282.12	12852.65	32.131625	32.131625
1075	MUCNTE	1012	5526.43	4047	58%	1	125	4047.36	5059.2	12.648	12.648
1076	MUCPOZ	580	5493.44	1086	83%	14	88	0	0	0	0
1077	MUCOPO	2256	2689.76	12993	17%	1	165	0	0	0	0
1078	TXLSVO	1599	5455.38	717	88%	1	256	0	0	0	0
1079	DUSDBV	1310	5420.81	2478	69%	1	145	2478.04	3097.55	7.743875	0
1080	PADBHX	718	5394	94	98%	0	0	93.59	116.9875	0.29246875	0
1081	TXLBLL	446	5364.92	2350	70%	5	50	2350.35	2937.9375	7.34484375	0
1082	TXLGVA	896	2.93	17229	0%	0	0	17228.5	21535.625	53.8390625	53.8390625
1083	HAMLUX	613	2.07	7436	0%	0	0	7436.24	9295.3	23.23825	23.23825
1084	SXFFNC	3284	0	5430	0%	0	0	0	0	0	0
1085	BRETLS	1189	5332.71	6043	47%	4	49	6043.49	7554.3625	18.88590625	18.88590625
1086	FRAKLU	853	0	5353	0%	0	0	5352.77	6690.9625	16.72740625	16.72740625
1087	SXFACE	3444	5211.71	262	95%	0	180	0	0	0	0
1088	HAMINN	719	5202.37	6704	44%	1	144	6703.69	8379.6125	20.94903125	20.94903125
1089	DUSPOZ	706	5199.11	3117	63%	4	88	3117.07	3896.3375	9.74084375	9.74084375
1090	MUCCWL	1139	5192.13	621	89%	1	118	620.54	775.675	1.9391875	0

Figure 3. Market potential calculation (screenshot)

The above assessment shall serve as a very first approach as several aspects have not (yet) been considered, such as the consumers' willingness to pay and resulting achievable fares for (potential) direct regional flights; assumptions for those passenger volumes that would still fly one-stop despite of the introduction of a new, direct regional service; and the actual degree of supply-induced demand at the route level. In this context, our methodology is also not capable of delivering demand estimates for airport-pairs which are currently not served indirectly. We also have not considered both demand and (potential) supply from other airports serving the same origins and destinations.

What is more, we have not (yet) tackled the cost side and hence could not assess if actual aircraft operating costs would be low enough to successfully offer flights on the identified routes. In this context, we have also not considered future/envisaged aircraft technologies and suggested operational enhancements that might – one day – help bring down unit costs to significantly lower levels which could help exploit new markets.

5. Summary and outlook

This paper reflected and discussed the development and potential outlook of intra-European regional air services. We found that…

- Regional air traffic in Europe is a declining sector, especially on decentralized routes.
- Average aircraft size of regional operators has been increased considerably.
- More and more regional air transport links have disappeared, leaving many small(er) airports without any, or with fewer high-frequency (business) routes, contradicting e.g. the EC Flightpath 2050 connectivity goal and reducing catalytic effects for local businesses.

We then identified technological and operational pillars that could help reducing unit costs of small air transport services and hence make them more viable. Examples include policies that would lower regulatory restrictions for smaller airports and small regional air transport movements, or new technologies such as GLS (GBAS) at the airport level.

We finally performed a simple demand estimation to get a first impression of the potential market size for new regional air services in Europe, which builds on existing demand volumes on indirect routings between Germany and Europe derived from Sabre's MI database. Based on a number of assumptions that should be relaxed in future research, we see a potential of 313 new routes from Germany, which could generate an additional 2,264,182 passengers per year, equaling an average 7,233 annual passengers per route or 18 passengers per flight.

References

Airline Business (2013) *Regional Airline Rankings*. October 2013, pp. 32-33.

ATR (2014) *600 Series*. http://www.atraircraft.com/products_app/media/pdf/Brochure-ATR-600-SeriesBD.pdf [retrieved 05 June, 2015].

Bieger, T., Wittmer, A. (2006) Air transport and tourism – Perspectives and challenges for destinations, airlines and governments. *Journal of Air Transport Management*, 12, pp. 40-46.

Brueckner, J., Pai, V. (2009) Technological innovation in the Airline Industry: the impact of regional jets. International Journal of Industrial Organization, 27, pp. 110-120.

Cleansky (2015) *GRA - Green Regional Aircraft*. http://www.cleansky.eu/content/page/gra-green-regional-aircraft [retrieved 05 June, 2015].

Dusseldorf Airport (2015) *Tariff Regulations 2015*. https://www.dus.com/~/media/fdg/dus_com/businesspartner/aviation/entgelte/tariff_regulations_2015_02-02-2015.pdf [retrieved 05 June, 2015].

Dresner, M., Windle, R., Zhou, M. (2002) Regional jet services: supply and demand. *Journal of Air Transport Management*, 8, pp. 267-273.

Ehmer, H., Berster, P., Bischoff, G., Grimme, W., Grunewald, E., Maertens, S. (2008) *Analyses of the European air transport market - Airline Business Models*. Study prepared on behalf of the European Commission, DG Energy and Transport, EC contract number: TREN/05/MD/S07.74176, Cologne, http://ec.europa.eu/transport/modes/air/doc/abm_report_2008.pdf [retrieved 14 August, 2016].

European Commission (2011) *Flightpath 2050, Europe's Vision for Aviation*. http://ec.europa.eu/research/transport/pdf/flightpath2050_final.pdf [retrieved 05 June, 2015].

Fageda, X., Flores-Fillol, R. (2012) Air services on thin routes: regional versus low cost carriers. *Regional Science and Urban Economics*, 42, pp. 702-714.

Flightglobal (2010) *Thales outlines thinking on single-crew cockpits*. 7 July 2010, http://www.flightglobal.com/news/articles/thales-outlines-thinking-on-single-crew-cockpits-344156/ [retrieved 05 June, 2015].

Gelhausen, M., Berster, P., Wilken, D. (2013) Do airport capacity constraints have a serious impact on the future development of air traffic? *Journal of Air Transport Management*, 28, pp. 3-13.

Gillen, D., Hazledine, T. (2015) The Economics and Geography of Regional Airline Services in Six Countries. *Journal of Transport Geography*, 46, pp. 129-136.

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

Graham, B. (1997) Regional airline services in the liberalized European Union single aviation market. *Journal of Air Transport Management*, 3, pp. 227-238.

Grubesic, T., Wei, F. (2013) Essential air service: a local, geographic market perspective. *Journal of Transport Geography*, 30, pp. 17-25.

Hanlon, J.P. (1992) Regional air services and airline competition. *Tourism Management*, 13, 181-195.

Malighetti, P., Paleari, S., Redondi, R. (2016) Base abandonments by low-cost carriers. *Journal of Air Transport Management*, 55, pp. 234-244.

Merkert, R., O'Fee, B. (2016), Managerial perceptions of incentives for and barriers to competing for regional PSO air service contracts. *Transport Policy*, 47, pp. 22-33.

Swan, W.M., Adler, N. (2006) Aircraft trip cost parameters: A function of stage length and seat capacity. *Transportation research Part E*, 42, pp. 105-115.