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Estimating the market potential for long-haul narrowbody aircraft using origin-destination demand and flight schedules data

Wolfgang Grimme[a]*, Sven Maertens[a], Stephan Bingemer[b], Marc C. Gelhausen[a]

[a]German Aerospace Center (DLR) – Institute of Air Transport and Airport Research, Linder Höhe, 51145 Cologne, Germany
[b]Hochschule Heilbronn, Max-Planck-Str. 39, 74081 Heilbronn, Germany

Abstract

Air transport has constantly evolved over the past decades. Main drivers affecting the shape of supply were new, e.g. low cost, business models, and new aircraft technologies, like the emergence of jet airliners in the 1950s/1960s. One of the most recent and potentially highly disrupting developments was the announcement by Airbus in 2015 and 2018 to launch new long-range (LR) and extra long-range (XLR) versions of its largest narrowbody aircraft, A321neo. With this step, Airbus is tapping into a market which is covered insufficiently by existing aircraft types. The new Airbus A321 versions will be used to replace the aging fleet of Boeing 757 aircraft, but will also offer airlines the opportunity to serve thin long-haul routes. Airlines may offer a higher number of frequencies than with today's widebody aircraft or introduce completely new non-stop services, where existing types are either limited in range or have too many seats. We estimate the market potential for long-haul narrowbody aircraft with a model using Sabre's Market Intelligence origin-destination demand and Innovata's flight schedules data. Furthermore, the implications of the new long-range narrowbody aircraft for airline business models will be discussed.

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Keywords: Connectivity; long-haul air transport; aircraft technology; air transport networks

1. Introduction

Air transport has strongly developed over the past decades. Main drivers affecting the shape of supply in the past include new business models, as, e.g. introduced by low cost carriers (LCC), and new aircraft technologies, like the emergence of jet airliners in the 1950s/1960s. One of the most recent and potentially highly disrupting developments

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* Corresponding author. Tel.: +49-2203-601-2459
E-mail address: wolfgang.grimme@dlr.de

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was the announcement by Airbus in 2015 to launch a new long-range (LR) version of its largest narrowbody aircraft, A321neo, followed by an even longer range version (XLR) in 2018 (Airbus, 2019).

In this paper, we analyze the prospects for the operation of narrowbody aircraft for long-haul routes of distances between 4,000 and 10,000 km. The paper is structured as follows: First, a literature review shows the existing work on “niche” long-haul markets, followed by a section on the theoretical capabilities and practical utilization of current and future narrowbody aircraft in the long-haul market. We then estimate the market potential of thin long-haul routes in the range segment between 4,000 and 10,000 km with a logistic regression model utilizing data sets provided by Innovata (flight schedules) and Sabre Market Intelligence (origin-destination passenger demand data). The paper concludes with a discussion on the impacts of narrowbody long-haul aircraft for airline business models.

2. Literature Review

Although many secondary airports have sufficient infrastructures, long-haul operations are typically concentrated at the major hubs (Maertens, 2010). With the growing LCC sector, it has been assessed whether this business model could also be transferred to long-haul markets. De Poret et al. (2015) argued that a key success factor for the LCC business model is the use of state of the art aircraft, while the transatlantic market due to its structure remains highly challenging. However, the (potential) use of secondary airports for long-hauls is not reserved to LCC. Also full-service carriers (FSC) used to fly into secondary airports from their hubs in an attempt to widen their network. From 2005, Continental operated to secondary airports in Europe using Boeing 757 jets with 150 seats (Dennis, 2005). In June 2019, American Airlines announced to replace its aging 757 fleet with new A321XLR (Diaz, 2019). American Airlines’ president Robert Isom pointed out that the aircraft can be flexibly utilized either on transcontinental domestic, transatlantic or South American routes (Diaz, 2019). In December 2019, United announced to replace its fleet of 73 Boeing 757 by 50 A321XLR with an expected entry into service in 2024 (Bellamy III, 2019). United EVP and CCO Andrew Nocella stated that the new model will be used for a direct replacement of older, less-efficient aircraft and for the development of new destinations (Bellamy III, 2019). For carriers already operating a fleet of Boeing 757 aircraft, the replacement is especially interesting because the A321XLR can service the same routes but without payload restrictions and without the risk of fuel stops in inclement meteorological conditions thus adding punctuality and reliability to the route network while providing an additional degree of freedom.

From a methodological point of view, Wilken et al. (2016) developed an empirical model to analyze demand structures on intercontinental routes to and from Europe to identify potentials for new non-stop low-cost services. The authors showed that smaller, more cost efficient aircraft could make more connections viable. Less passengers needed to make a flight viable in turn means a potentially higher flight frequency which is particularly important in thin origin-destination (OD) markets. Gelhausen et al. (2020) estimated an econometric model to capture the effects of the introduction of a new non-stop service on non-stop and transfer passenger volumes at OD level. Besides variables like OD passenger volume, flight frequency and distance, they distinguished between several types of routes depending on the OD passenger share, like hub routes and point-to-point routes. Moving to a more detailed game-theoretic network approach like proposed by Evans and Schäfer (2011 & 2014) is certainly desirable; however, this is currently not feasible on a global level given the large number of airports and numerous global airlines unless strong assumptions were made. As Evans and Schäfer (2014) pointed out, the number of airlines and airports needs to be limited and assumptions be made to maintain model tractability. Nevertheless, their model provides valuable insights, and further research is needed to handle larger and more flexible models.

3. Capabilities and Utilization of Current and Future Aircraft

Air transport networks are largely determined by the structure of demand and the capabilities of aircraft. New aircraft generations have been capable of flying ever longer distances as non-stop services. However, the market for aircraft remained segregated in the segment for long-haul aircraft with twin aisles, a typical size of 250 seats or more and ranges of up to 15,000 km on the one hand and the segment for single aisle aircraft with typically less than 200 seats and a design range of around 4,000 km on the other hand. Nevertheless, airlines have been using various single aisle aircraft at an increasing scale for long-haul operations, as shown in Fig. 1. Over the period from the year 2000 to the year 2019, the number of scheduled passenger flights over 4,000 km with narrowbody aircraft types has increased almost six-fold from 67,000 to 389,000 flights per year.

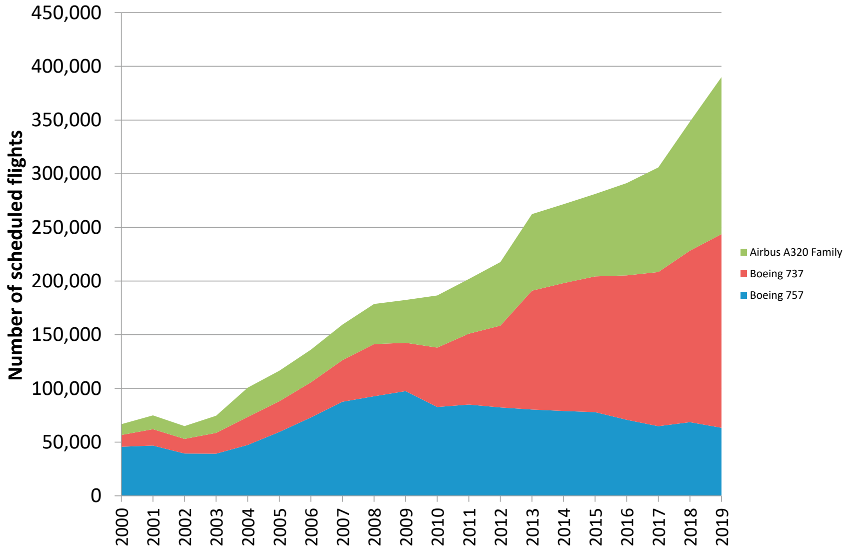

Fig. 1. Usage of Boeing 737, 757 and Airbus A320 Family aircraft on routes >4000 km (Source: Innovata)

Such operations are, however, commercially challenging, as the design range of these aircraft is exceeded. For instance, full payload ranges of the Airbus A321-231 (classic engine option) and Boeing 757-200 are 4,158 km and 3,986 km, respectively (Fig. 2). If these aircraft are utilized on longer routes, e.g. as shown on Fig. 2 for Berlin-New York (6,385 km), substantial reductions in payload have to be accepted. At a payload of less than 10,000 kg, the Airbus A321-231 is likely not be operated in a commercially sustainable way between Berlin and New York, while the Boeing 757-200 at about 15,000 kg could be operated on this route, as done by Continental Airlines and United Airlines between 2005 and 2015, although still being subject to operational restrictions, particularly when strong headwinds occur.

In order to address the needs of airlines, Airbus announced in 2015 the launch of a new long-range (LR) version of its largest narrowbody aircraft, A321neo. The A321neo LR has a maximum range of 5,600 km with a payload of 24 metric tons and of 7,400 km with a payload of 18 metric tons (Airbus, 2020). Following the initial success of the LR version, in 2018 an even longer-range variant (XLR), with an expected design range of 8,700 km with a payload of 18 metric tons, was announced. These versions have typical capacities between 164 seats in three-class to 244 seats in high-density, single economy-class layout, which is relatively small compared to previous long-haul aircraft types. The green area in Fig. 2 shows the additional commercially relevant payload-range capabilities coming up with the A321XLR, bounded by 66% of maximum payload (as assumed to be a lower limit of commercially relevant payload, still permitting ~150 passengers), the capabilities of existing aircraft (A321-231 and Boeing 757-200) and the payload-range limitations of the A321XLR.

The new Airbus A321 versions will be used to replace the aging fleet of Boeing 757 aircraft, where a reduction of 30% in fuel burn is expected, but will also offer airlines the opportunity to serve thin long-haul routes with a higher number of frequencies than with today's widebody aircraft, or to introduce completely new non-stop services, where existing types are either limited in range or have too many seats. As Airbus received more than 600 orders and options for the A321LR and XLR during the first years on offer, airlines seem to perceive a strong need for aircraft with the offered payload/range capacity. This observation is consistent with the study of Oliveira (2008) that links route choice to airline profitability.

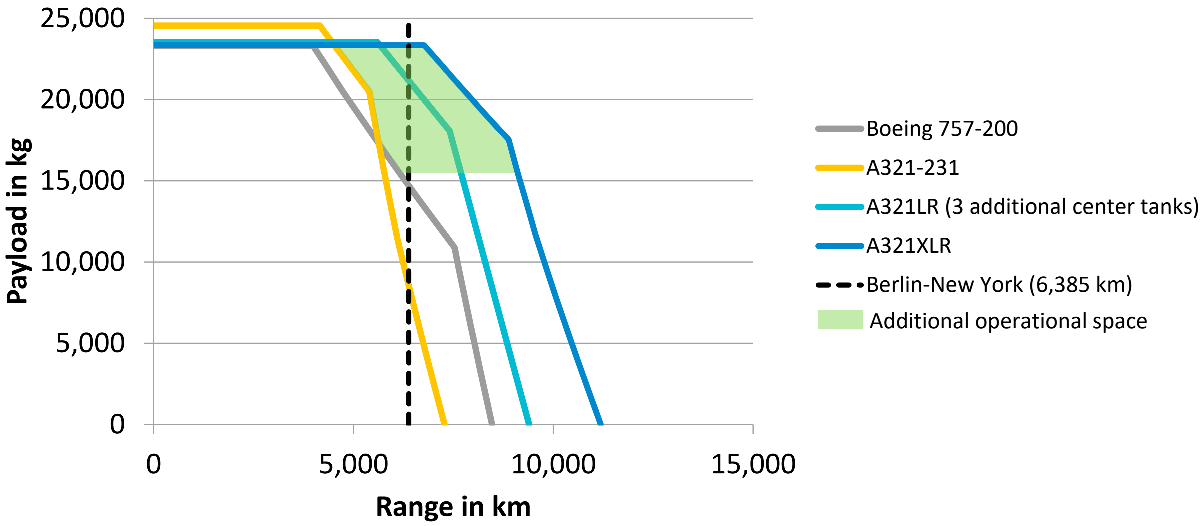

Fig. 2. Payload-Range Diagram for Airbus A321 and Boeing 757-200 (Source: Piano-X and Airbus, 2020)

4. Input Data & Modelling Approach

For the analysis of the market potential of narrowbody long-haul aircraft, we combine two data sources: OD and leg passenger data set from Sabre Market Intelligence for 2019, in order to identify OD and segment demand volumes between airport pairs; and Innovata flight schedules for 2019, in order to retrieve the number of non-stop frequencies.

Table 1 displays the model estimation results of the logistic regression. The dependent variable "Non-stop" refers to the probability of a non-stop flight between two airports. Independent variables are a constant, the natural logarithm-transformed OD passengers (OD Passengers), flight distance (Distance), and the route type (Gelhausen et al., 2020) reflecting the level of transfer passenger volume. The key variable for route classification is the ratio of OD demand, i.e. passenger demand between trip origin and trip destination airport regardless of any stop-overs, and leg passenger volume, i.e. passengers actually flying on that particular airport pair non-stop, regardless of their trip origin and destination airport. The central point is to compare a particular airport pair in terms of leg passengers and OD demand. If the ratio is well below 100%, i.e. more leg passengers than OD demand, we typically have a route with a high share of transfer passengers. On the other hand, if it is well above 100%, a substantial share of the OD demand favors a stop-over instead of a non-stop flight, e.g. because of a low service frequency. Finally, if the ratio is around 100%, OD passengers predominately take a direct service with only few taking a transfer connection. Furthermore, there are only few "behind", "beyond" and "bridge" transfer passengers on that airport pair. As a result, routes are technically defined as:

- "Hub routes" (Hub), defined as routes where the proportion of OD passengers in relation to segment passengers (all passengers flying on the airport pair, irrespective of their OD) is less than 50%. Hence, the total number of passengers flying on the airport pair contains more than 50% transfer passengers with a different OD (i.e. "behind", "beyond" or "bridge" connections).
- "Point-to-point routes" (P2P), defined as routes where the proportion of OD passengers in relation to segment passengers (all passengers flying on the airport pair, irrespective of their OD) is between 95% and 105%. These are routes where the majority of OD passengers are typically travelling non-stop.
- "Low frequency routes" (LF), defined as routes where the proportion of OD passengers in relation to segment passengers (all passengers flying on the airport pair, irrespective of their OD) exceeds 150%.

These are routes where the majority of OD passengers take a stop-over flight, because direct services are e.g. operated with insufficient capacity, frequency or at inconvenient times for the OD demand.
- Some routes do not belong to any of the aforementioned categories, as they have an OD share of 50% to <95% and >105% to 150%, respectively.

Table 1. Model estimation results

Dependent variable: Non-stop		
ln(OD passengers)	2.031***	(0.078)
Distance	-0.0002***	(0.00003)
Hub	3.256***	(0.745)
P2P	-1.845***	(0.325)
LF	-6.527***	(0.244)
Constant	-13.371***	(0.756)
Observations	10,601	
Log Likelihood	-1,473.279	
Akaike Inf. Crit.	2,958.558	
McFadden's pseudo-R^2	79.95%	
McFadden's pseudo-R^2 adj.	79.86%	
Nagelkerke's pseudo-R^2	89.32%	
McKelvey-Zavoina pseudo-R^2	89.77%	

Note: *p<0.1; **p<0.05; ***p<0.01

The "Hub" variable is mainly for avoiding biased coefficients, most of the potential new non-stop routes will be of the "LF" or maybe "P2P" category. However, while we try to capture transfer passenger effects, we do not consider OD demand generation effects due to a new non-stop service, which makes the model results a bit conservative. All coefficient estimates have the expected sign and are highly significant (p<0.01). The mathematical expression of the model is:

$$Non-stop = 1/(1+\exp(-(-13.371+2.031*\ln(\text{OD passengers})-0.0002*\text{Distance}+3.256*\text{Hub}-1.845*\text{P2P}-6.527*\text{LF})))$$

Table 1 shows various goodness-of-fit measures, of which McKelvey-Zavoina pseudo-R^2, which reaches a value of 89.77%, comes closest to ordinary least square R^2 (Veall and Zimmermann, 1992). Thus, we conclude, model fit is sufficiently good. Table 2 displays a contingency table to compare the model forecast with the actual data. Of the 10,601 observations only 478, i.e. 4.5%, are misclassified (discrimination probability: 50%).

Table 2. Contingency table for comparison of model results with actual data

Actual/Forecast	**Non-stop**	**Stop-over**	**Sum**
Non-stop	4,997	387	5,384
Stop-over	91	5,126	5,217
Sum	5,088	5,513	10,601

5. Results

Table 3 shows the model forecast results for the top 20 airport pairs in terms of OD passenger demand in 2019 that were not served by a non-stop connection. For 2019, we have calculated a probability of a non-stop flight between two airports based upon the actual data ("Probability of a Non-stop Connection with Reference Aircraft"). For the scenario with new narrowbody long-haul aircraft we have assumed the following:

- 136 passengers per flight (e.g. A321 with 170 seats and 80% load factor)
- P2P or LF route, i.e. there is mainly OD traffic
- We have created a so-called reference aircraft in terms of passengers per flight. For this, we have regressed the number of passengers per flight on flight distance to obtain a functional relationship and assign a hypothetical passenger per flight value to each route based upon current aircraft technology.
- To simulate the new aircraft, which is not part of the model estimation process, we have adjusted the “OD passengers” coefficient proportionally to the relation of “Passengers per Flight of Reference Aircraft” and “Passengers per Flight of new Aircraft”. For example, for the HKT-CDG connection the “OD passengers“ coefficient is multiplied by 322/136=2.37, i.e. the new coefficient for this route is 2.031*2.37=4.813. Hereby, we consider the reduced need of passenger demand to make a non-stop flight viable.

Table 3. Top 20 airport pairs in terms of OD passenger demand without a direct service in 2019

Rank	**Origin Airport**	**Departure Airport**	**OD Demand**	**Distance (km)**	**Passengers per Flight of Reference Aircraft**	**Passengers per Flight of new Aircraft**	**Probability of a Non-stop Connection with Reference Aircraft**	**Weekly Flight Frequency with Reference Aircraft**	**Probability of a Non-stop Connection with new Aircraft**	**Weekly Flight Frequency with New Aircraft**
1	HKT	CDG	91,739	9,745	322	136	71%	5.5	100%	13.0
2	CDG	HKT	80,956	9,745	322	136	66%	4.8	100%	11.4
3	GOI	LHR	72,827	7,593	292	136	73%	4.8	100%	10.3
4	CDG	CMB	71,378	8,483	304	136	67%	4.5	100%	10.1
5	LHR	GOI	64,308	7,593	292	136	67%	4.2	100%	9.1
6	IKA	YYZ	63,779	9,911	324	136	53%	3.8	100%	9.0
7	WNZ	MXP	63,547	9,357	317	136	57%	3.9	100%	9.0
8	CMB	CDG	62,832	8,483	304	136	61%	4.0	100%	8.9
9	SCL	HAV	61,212	6,389	276	136	72%	4.3	100%	8.7
10	YYZ	IKA	60,440	9,911	324	136	51%	3.6	100%	8.5
11	HAV	SCL	59,816	6,389	276	136	71%	4.2	100%	8.5
12	WNZ	FCO	59,592	9,357	317	136	53%	3.6	100%	8.4
13	MXP	WNZ	59,589	9,357	317	136	53%	3.6	100%	8.4
14	ZYL	LHR	59,289	8,018	298	136	61%	3.8	100%	8.4
15	WNZ	CDG	57,284	9,507	319	136	51%	3.5	100%	8.1
16	CUN	GRU	56,544	6,603	279	136	67%	3.9	100%	8.0
17	TLV	ORD	56,402	9,923	324	136	47%	3.3	100%	8.0
18	GRU	CUN	55,849	6,603	279	136	66%	3.9	100%	7.9
19	FCO	WNZ	54,851	9,357	317	136	49%	3.3	100%	7.8
20	CDG	WNZ	54,150	9,507	319	136	48%	3.3	100%	7.7

The probabilities of non-stop connections with new aircraft in Table 3 are estimated by the model shown in Table 1. Weekly flight frequency with new aircraft is calculated as follows: OD demand divided by passengers per flight with new aircraft divided by 52 weeks per year. For almost all airport pairs, the probabilities are larger than 50%, however, in some cases not by much. On first sight this seems counterintuitive, but we have to consider that this is a probabilistic model. In case of a 50% probability one out of two connections have a non-stop service, in case of a 66% two out of three, and so on. That means, while for the individual airport pair a non-stop connection is more likely than not, if the probability is slightly larger than 50% (and this is how the contingency table works), on the sample level there will be only about half of the airport pairs with a direct service, if the probabilities are only slightly larger than 50% (this is the probabilistic view). This share increases, if the probabilities increase, but the results of the contingency table remain the same. Therefore, the figures of Table 1 are more relevant for the model performance than the classification results of Table 2. Nevertheless, a contingency table is easily interpretable. Furthermore, the analysis of Table 3 is limited to the top 20 airport pairs in terms of OD demand, but without a direct service. These 20 airport pairs are the most critical ones in terms of misclassification of Table 2: they are the top 20 out of the 91 data points, where the model wrongly predicts a non-stop connection for 2019 because of strong OD demand, if we use the standard discrimination probability of 50% for a contingency table. Therefore, there is some potential for additional non-stop routes already in 2019, but given the reference aircraft only with less than one connection per day. This is rather unattractive from the passengers' view. However, with the new narrowbody long-haul aircraft, the probability of a non-stop connection rises to 100% for almost all airport pairs with a service frequency of one to two flights per day. The quintessence of this analysis is that by introducing the new aircraft, the probability of a non-stop service rises substantially to 100% for almost all the top 20 airport pairs.

6. Impacts on airline business models

The data analysis in the preceding section concentrated on the identification of demand potentials on airport pairs not yet regularly served with non-stop scheduled passenger flights. However, beyond this obvious commercial strategy, new narrowbody aircraft types with long range capabilities have the potential to re-shape the global aviation network also in other areas. The new aircraft versions offer long-haul market entry opportunities with lower financial risk for LCCs, which so far have widely refrained from long-haul operations due to high costs associated with operating widebody aircraft, even when they are as efficient as the Boeing 787 (De Poret et al., 2015). LCCs could be tempted to offer services bypassing the existing hubs and connecting secondary cities, e.g. on routes between Europe and North America. Norwegian can serve as a first example of such services, as it briefly operated transatlantic flights with Boeing 737 MAX between the United Kingdom and Ireland and the US in 2017/2018, although with limited commercial success. Moreover, concepts of self-hubbing (Malighetti et al., 2008) could further support passenger demand and contribute to the financial viability of LCC long-haul services. This can be a further contribution to the competitive landscape, which in long-haul markets is increasingly dominated by joint ventures of the legacy network carriers leading to a narrow oligopoly on many region pairs.

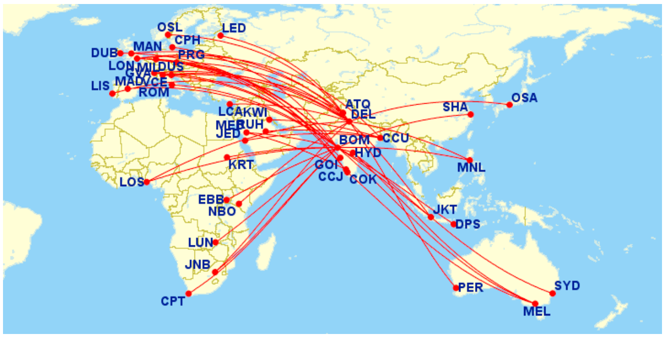

Fig. 3. Unserved routes from India with more than 20,000 OD passengers (Source: www.gcmap.com, based on Sabre MI data)

The existing order book of the Airbus A321LR/XLR supports this argumentation, as LCC Frontier Airlines (36 aircraft), Norwegian, Air Asia X and Indigo (30 aircraft each), as well as JetBlue (26), Pegasus (24), Air Arabia (22) and Wizzair (20) are among the customers with the largest number of orders for the aircraft type. JetBlue has announced the plan to operate transatlantic flights from Boston and New York (Bloomberg, 2019), while our data analysis shows a high potential for Indigo for flights originating in India, as more than 50 unserved city pairs feature a demand of more than 20,000 origin-destination passengers, as shown in Fig. 4. The geographic location of India could be used for a low cost hub, connecting e.g. Africa and Europe with Southeast Asia and even Australia. Besides the development of new markets by LCCs, also network carriers can defend their business model by employing long-range narrowbody aircraft. With direct services from their hubs to secondary and tertiary destinations, more city pairs than today could be offered, increasing network scope. By-passing the major hubs en-route to more long-haul destinations could further weaken the global strategic alliance system, as European network carriers would be less dependent on feeder services of their North American partners and vice versa. Further key beneficiaries of these new developments could be secondary and tertiary airports, which so far had only very few long-haul flights (Maertens, 2010).

7. Conclusions

The analysis presented in this paper shows the versatile operational and commercial capabilities of long-haul narrowbody aircraft. These aircraft types are capable of serving city pairs with lower demand, where existing aircraft could not be operated in a commercially sustainable way. Moreover, existing routes could be served at higher frequencies. The estimation of the demand potential for thin routes which are currently not served are rather conservative, as we do not model traffic stimulation effects due to the introduction of new non-stop services. Particularly network carriers could be inclined to serve also routes even with a lower direct origin-destination demand, as additional demand could be generated out of the network. This would follow the current business strategy, as for instance Lufthansa's long-haul flights out of Frankfurt typically accommodate 85-95% transfer passengers. We also have not considered the potential on airport pairs without historical demand figures. Such routes are typically selected by LCC, and we perceive that it is highly likely that narrowbody long-haul aircraft will be used for entering such markets. This would follow the example of Norwegian with B737Max services between the United Kingdom/Ireland and secondary/tertiary destinations in the US between 2017 and 2018. Finally, in the light of the Covid-19 crisis, smaller long-range aircraft are likely to be preferred by airlines in future, as operational flexibility and low operating costs will meet a more reluctant travel demand. Smaller long-range aircraft will then enable airlines to uphold direct connectivity. Further research should concentrate on the network impacts the new aircraft versions may have – besides traffic stimulation of new routes, it is very likely that a shift from existing to new routes will occur, reducing the demand on existing flights connecting major hubs.

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