Research paper

# The big three EU Low Cost Carriers before and during the Covid-19 pandemic: Network overlaps and airfare effects

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## ARTICLE INFO

## ABSTRACT

This study uses a large dataset to consider the network change of the three largest European Low Cost Carriers (LCCs) easyJet, Ryanair and Wizz Air during the pre-Covid-19 period and the Covid-19 pandemic period. Network changes are characterized in terms of airport pairs, city pairs, numbers of flights and network overlaps. The results show that European LCCs increasingly expanded their networks into markets that had already been served by incumbent LCCs, which indicates that LCCs increasingly compete head-to-head among themselves. Difference-in-differences regressions estimate that network overlaps among these LCCs lead to airfare reductions of approximately six Euros, ten percent.

## 1. Introduction

Europe accounted for more than one quarter of all flights worldwide and almost one quarter of all international flights in 2019 (IATA, 2019). A large share of those flights and the corresponding passengers are served by Low Cost Carriers (LCCs) which typically operate point-to-point networks with a homogeneous fleet. This is in contrast to Full Service Carriers (FSCs) which operate hub-and-spoke networks with a wide variety of different aircraft. LCCs provided 534 million seats reflecting more than 37 percent of the total capacity offered by airlines registered in Europe in the year of 2019 (OAG, 2020). The three biggest LCCs in terms of seats offered in Europe are easyJet, Ryanair and Wizz Air (Jimenez & Suau-Sanchez, 2020).

This study considers the flight network changes of the three biggest European LCCs before and during the Covid-19 period. The objective is to describe changes in the competitive environment and to quantify how these changes affect airfares. Competition is considered as most intense on origin-destination routes which are operated in parallel by airlines. Therefore, the analysis especially concentrates on the change of network overlaps by distinguishing between origin-destination routes described by airport pairs or city pairs. The latter distinction allows identifying the role of adjacent airports in multi-airport regions.

Many flights were originally scheduled for operation during the

Covid-19 pandemic but later canceled because of travel bans and demand reductions caused by compulsory quarantines among other regulations. To develop a valid dataset, this study uses flight information provided by Flightradar24. The virtue of this database is that it tracks actual flights in real time and, thus, does not include flights that are scheduled but not operated. This data source has been used by Bubalo and Gaggero (2015) and Sun et al. (2020) amongst others.

This study complements previous studies which considered airline networks in Europe and elsewhere. Dobruszkes (2006) found that LCCs were drawing new networks complementing those of FSCs. In a subsequent study, Dobruszkes (2013) found that LCCs increasingly moved in frontal competition with FSCs on pre-existing airport pairs. de Wit and Zuidberg (2016) found that the route networks of LCCs in Europe were not stable and route churn occurred frequently. Dobruszkes et al. (2017) highlighted that LCCs were increasing their operations from major airports. The importance of major airports for LCC networks has been further highlighted in a recent study by Jimenez and Suau-Sanchez (2020). Major airports are often prone to delays. Bubalo and Gaggero (2015) highlighted that the LCCs' fast aircraft turn-around times improve the delay performances of airports.

Several studies have considered the airfare impact of overlapping flight networks. Morrison (2001) found that LCC competition exerted dramatic downward pressure on airfares. He used an original set of

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competition variables to quantify the impact that Southwest Airlines had on airfares through actual, adjacent, and potential competition. Brueckner et al. (2013) discussed three types of markets and levels of competition: in-market airport pairs, adjacent city pairs for both legacy carriers and LCCs, and potential competition from LCCs. Their results indicated that the airline competition via the use of adjacent airports could effectively reduce airfares. Zou and Yu (2020) and Wang et al. (2020) considered network overlaps among LCCs in the US and New Zealand, respectively. They found that the LCCs' entry decisions on domestic airport pairs had become less sensitive or were not sensitive, respectively, to airline competition within the same market. Bilotkach (2011) considered airline competition in non-price product characteristics such as flight frequencies.

This study contributes to the above-mentioned studies by indicating that the three big European LCCs increasingly expanded their network and/or diverted flights into markets that had already been served by incumbent LCCs. These changes can be observed before and even during the Covid-19 pandemic period. This provides evidence for a trend that involves increasing overlaps among LCC networks in Europe. This study further contributes by quantifying the effect of network overlaps on airfares. Difference-in-differences estimations indicate that network overlaps reduce airfares by around six Euros or, approximately, ten percent of the airfares.

The paper is organized as follows. Section 2 introduces the data sources. Section 3 uses descriptive statistics to characterize the market position of the three big European LCCs before the Covid-19 period. Section 4 analyzes monthly data and describes the change of LCC networks in terms of airport pairs/city pairs in the pre-Covid-19 and during the Covid-19 pandemic periods. Section 5 develops and estimates various difference-in-differences regression models to quantify the effect of network overlaps on airfares. The final section summarizes our findings and develops avenues for future research.

## 2. Data sources

The panel data period starts January 1, 2018 and ends November 30, 2020. It involves around 3.3 million flights from three European LCC groups. The three groups involve the Wizz Air group, the easyJet group and the Ryanair group. The Wizz Air group includes Wizz Air (0.33 million observations) and Wizz Air UK (16 thousand observations). The easyJet group includes easyJet (1.1 million observations), easyJet Europe (5800 observations), and easyJet Switzerland (300 observations). The Ryanair group includes Ryanair (1.72 million observations), Laudamotion (62 thousand observations) and Ryanair Sun (7600 observations). The flight data is collected from Flightradar24, which records ADS-B messages transmitted by any aircraft operating IFR flights, as required by the European Union, from ground and satellite-based ADS-B receivers. Flighradar24 reports marketing carriers which is the relevant information for our study because it accurately captures the carriers' own passenger services.

Observations with a missing origin/destination airport, or observations with all five time stamps (duration, estimated time of departure, actual time of departure, estimated time of arrival, and actual time of arrival) missing were deleted. The corresponding share of missing data is around 0.15% of the total dataset. Airport pair observations are deleted for a specific LCC if this LCC serves the airport pair with fewer than 12 flights per year. This eliminates ferry flights which relocate aircraft from one airport to another. The corresponding share of these observations represents around 0.16% of the total dataset.

The dataset concentrates on airports located in the European Union before Brexit in January 2020 and on origin-destination routes connecting these airports. Therefore, the dataset keeps airports and origin-destination routes although they became and involved, respectively, non-European Union airports during the study period. The dataset includes 348 airports. The following considers non-directional airport pairs. This means that flights between airports A and B are considered to

occur on the same airport pair independent of whether airport A or airport B is the origin or destination airport. Alternatively, directional airport pairs could be used. The results presented in this study are, however, robust with respect to the consideration of directional or non-directional airport pairs. Other studies such as Roucolle et al. (2020) also referred to non-directional airport pairs in their analysis of airline networks.

Regional GDPs are used to measure the hinterland demands for flight services.[1] The GDP data is obtained from the statistical office of the European Union Eurostat (2020), which is also used in Fageda et al. (2015). The whole European Union territory is classified into NUTS 1, NUTS 2 and NUTS 3 regions. There are over 2000 regions classified as NUTS 3 regions which can be characterized as "city-level" information whereas NUTS 2 is "province/state-level" and NUTS 1 is "country-level." The hinterland identification is based on the IATA airport code and the corresponding airport locations as measured by their longitude and latitude obtained from OpenFlights Airport Database dated 2017. The airport location data was used to pinpoint the airport into its corresponding hinterland as classified by the NUTS 3 region to identify the relevant GDP information associated with each airport. The GDP information refers to the year 2017 (the 2017 information was unavailable for eight airports and the 2016 information was used instead in these cases).

City information from Flightradar24 can be used to identify 16 multi-airport regions (see Table A in the Appendix). This seems, however, only a small share of the airport regions because, for instance, Sun et al. (2017) identified 88 multi-airport regions in Europe using a more sophisticated geographical approach.[2] Anyway, despite this issue of accurately treating airport catchment areas in multi-airport regions, the approach produces results that are consistent with the results obtained by previous studies as will be highlighted later.

To shed light on how airfares were affected by the entry of other LCCs, Wizz Air's airfares have been collected from RDC aviation intelligence. RDC scrapes airfares from airline online booking platforms six-month, three-month, one-month, and one-week prior to the travel date. In total, 65,837 round-trip airfares have been included in our dataset.

## 3. Two-year pre-covid-19 period

The two-year period between January 1, 2018 and December 31, 2019 is called the pre-Covid-19 period. This section considers pooled data for the two-year pre-Covid-19 period to develop an overall understanding of the differences among the three biggest European LCCs. The statistics are summarized in Table 1. This table is divided in three parts. The first part considers total flight numbers, the second part airport pairs, and the third part city pairs.

### 3.1. Number of flights

The number of flights is a common measure for the size of airline networks. The table shows that Ryanair ranked number one among the three LCCs with almost 1.5 million flights for the whole two years during the pre-Covid-19 period. Ryanair was followed by easyJet with almost 1 million flights and Wizz Air with (only) slightly more than 0.26 million flights.

In Table 1 and elsewhere the term "share of total" is used. The share

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[1] GDP is used although it may not properly capture the demand for short getaways and migration flows. The positive relationship between economic activity and flight demand is well-established (for example, Lim, 1997, and Morphet & Bottini, 2020). GDP also serves as a proxy for tourism demand as empirically demonstrated by Martins et al. (2017) and Massidda and Etzo (2012).

[2] Evangelinos, C., Staub, N., Marcucci, E. and Gatta, V. (2021) propose a theoretically justified, utility-based identification of catchment areas.

**Table 1**
Pre-Covid-19 pooled two-year data.

| | easyJet | Ryanair | Wizz Air |
|---|---|---|---|
| | Total | | |
| Total number of flights | 981,092 | 1,477,755 | 266,828 |
| Share of total (in percent) | 36 | 54 | 10 |
| Average GDPˆ per flight (in billion Euros) | 33.3 | 33.3 | 21.2 |
| | Airport pairs served | | |
| Number of airport pairs | 993 | 2154 | 483 |
| Share of total (in percent) | 27 | 60 | 13 |
| Average flight number | 988 | 686 | 552 |
| Coefficient of variation | 1.4 | 1.3 | 1.2 |
| Average GDPˆ per airport pair (in billion Euros) | 26.7 | 25.3 | 19.9 |
| | City pairs served | | |
| Number of city pairs | 878 | 2054 | 478 |
| Share of total (in percent) | 26 | 60 | 14 |
| Average flight number | 1117 | 720 | 558 |
| Coefficient of variation | 1.7 | 1.5 | 1.2 |

ˆGDP presents Average Geometric Mean in billion Euros and hereinafter for all Tables.

of total refers to the relative importance of one of the biggest three LCCs among themselves. In terms of share of total as measured by number of flights this translated into a share of 54 percent for Ryanair, 36 percent for easyJet and 10 percent for Wizz Air. Ryanair operated more than half of all the flights operated by the biggest three LCCs and, therefore, was the clear market leader, whereas Wizz Air was small relative to both Ryanair and easyJet.

Table 1, part 1 contains information about the "Average Geometric GDP Mean." The geometric GDP mean associated with a specific airport pair was calculated by using the GDP information of the two NUTS 3 regions associated with the origin and destination airports. easyJet and Ryanair were both flying to high demand markets with Average Geometric GDP Mean of slightly more than 33 billion Euros relative to Wizz Air whose corresponding Average Geometric GDP Mean was only slightly higher than 21 billion Euros. This is consistent with the findings of Dobruszkes et al. (2017) and Jimenez and Suau-Sanchez (2020). One explanation is related to the geographical distribution of flights: Wizz Air flights largely covered the Eastern European area with low GDP relative to the Western European area which were largely covered by Ryanair and easyJet flights. Observe that easyJet and Ryanair had almost the same average geometric GDP mean although Ryanair operated many more flights. This indicates that these two LCCs were more likely to compete in and for markets with relatively high demand.

### 3.2. Airport pairs

A given number of flights can be used to integrate many airport pairs with low flight numbers per airport pair or few airport pairs with high flight numbers per airport pair. Table 1 considers non-directional airport pairs. In terms of the number of airport pairs, Ryanair operated the largest flight network involving more than 2000 airport pairs, easyJet operated almost 1000 and Wizz Air operated slightly less than 500 airport pairs. Ryanair's and Wizz Air's shares of total in terms of airport pair numbers were slightly higher than the shares of total based on the number of flights. Correspondingly, easyJet's share of total in terms of airport pair numbers was lower than its share of total in terms of the number of flights. This indicates that easyJet's average number of flights per airport pair was high relative to the other two LCCs. easyJet indeed operated the highest average number of flights per airport pair, Ryanair took the intermediate position and Wizz Air operated the lowest number of flights per airport pair. This is consistent with the findings of Dobruszkes (2006).

One may wonder whether easyJet operated high flight numbers across all airport pairs or whether easyJet boosted the average flight numbers by offering (very) high flight numbers at some airport pairs

only. The coefficient of variation of flight numbers across airport pairs provides this information. If the coefficient of variation is high, then the distribution of flight numbers is uneven across the airport pairs whereas a low coefficient of variation value indicates that flight numbers are more evenly distributed across the LCC network. The coefficient of variation value was the highest for easyJet, Ryanair took the intermediate position, and that of Wizz Air was associated with the lowest coefficient of variation value. In this sense, easyJet operated the most heterogenous airport pair network relative to the other two LCCs.

The Average Geometric GDP Mean associated with easyJet's and Ryanair's networks in terms of airport pairs (Average GDP per airport pair) were lower than the corresponding values associated with flight numbers (Average GDP per flight). This indicates they operated relatively high flight numbers in markets with Geometric GDP Mean values higher than around 25 billion Euros. That was not true for Wizz Air because the Average Geometric GDP Mean associated with its flight and airport pair networks were almost equal.

### 3.3. City pairs

Some cities are served by multiple airports. The London, Paris and Rome regions may serve as European examples. The distinction between LCC networks in terms of airport pairs and city pairs in Table 1 is used to illustrate the implications of the existence of multi-airport regions. The difference, between the network sizes associated with airport pairs and city pairs, indicates to which extent LCCs served the same city pairs by using various adjacent airports.

The difference between network sizes as measured by the number of airport pairs and the number of city pairs was the highest for easyJet (993 minus 878) and the lowest for Wizz Air (483 minus 478). This indicates that easyJet made most use of adjacent airports in their network. As a consequence, the shares of total of Ryanair and Wizz Air in terms of city pairs were slightly increased compared to the first and second parts of the table, which considered flight and airport pair numbers, respectively. Another consequence is that easyJet's average flight number per city pair was high relative to the other two LCCs.

The consideration of city pairs for Ryanair and Wizz Air reveals no major qualitative change with respect to the coefficient of variation relative to the consideration of airport pair numbers. easyJet continues to have the most heterogenous city pair network. NUTS 3 and city areas collected by Flightradar24 can be equal or different, which makes it difficult to derive the city GDP from the NUTS 3 database. Therefore, the discussion of GDP values is omitted in this part of the table.

## 4. Network changes

This section distinguishes between the two-year pre-Covid-19 period between January 1, 2018 and December 31, 2019 and the 11-month Covid-19 pandemic period between January 1, 2020 and November 30, 2020. It consists of three parts. The first part considers the LCCs' networks in isolation. The second part considers the change of network overlaps. The last part compares the top ten overlapping airport pairs from the end of the pre-Covid-19 period with top ten overlapping airport pairs from the peak Covid-19 month, August 2020 for each LCC pair. The top 10 overlapping airport pairs are used to illustrate the geographical coverage of network overlaps.

### 4.1. Monthly network adjustments

The left diagram in Fig. 1 shows the change of the number of airport pairs operated by each LCC across time. This figure uses monthly data, which is different from Table 1 which presents pooled two-year summaries. The number of Wizz Air's routes increased substantially during the sample period. For instance, the peak number of routes in terms of airport pairs served by Wizz Air increased from 364 to 407 to 452 in 2018, 2019 and 2020, respectively (see table C in the appendix). The
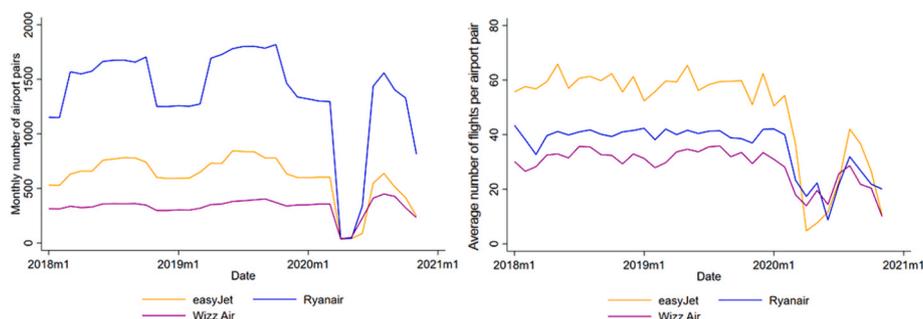
**Fig. 1.** Monthly number of airport pairs served by easyJet, Ryanair and Wizz Air and the corresponding average number of flights per airport pair.

corresponding network expansions of Ryanair and easyJet were more modest considering the size of their networks.

The pre-Covid-19 period is characterized by substantial seasonal variations involving up to 30% of Ryanair's network and even 50% of easyJet's network whereas such variations were almost absent for Wizz Air. This reveals that some airlines are able to flexibly adjust substantial parts of their networks, which could affect airport competition as has been discussed by de Wit and Zuidberg (2016), Wiltshire (2018) and Thelle and la Cour Sonne (2018).

During the Covid-19 pandemic period, the number of flights operated by the LCCs were down to almost zero in April and May 2020. For Ryanair, the corresponding drop was most substantial in absolute terms because Ryanair operated the largest network in the pre-Covid 19 period. More specifically, the numbers of airport pairs operated by the three LCCs in April and May 2020 were approximately 57, 46 and 46 per month for easyJet, Ryanair and Wizz Air, respectively. The drop was caused by the spread of the Covid-19 virus and the corresponding severe restrictions on air transport markets including quarantine for arriving passengers, partial travel bans and border closures (Pearce, 2020). With relatively few Covid-19 cases in summer, the numbers of airport pairs largely recovered until August 2020 in Europe and fell again in the subsequent months given the second wave of the Covid-19 pandemic.

The lines in the right diagram in Fig. 1 show the LCCs' monthly average flight numbers per airport pair. The ranking of the three LCCs in terms of these average flight numbers had also been stable during the pre-Covid-19 period in which easyJet ranked number one, Ryanair number two, and Wizz Air number three. The Covid-19 pandemic changed these rankings in the months of April, May and June, and the rankings returned to the pre-Covid-19 values after June 2020 until October 2020. Altogether, this demonstrates that easyJet consistently operated few airport pairs but with high average flight numbers relative to Ryanair.

### 4.2. Network overlaps

The previous subsection considered and compared each of the LCC networks in isolation. This subsection discusses the overlapping parts of the LCC networks pre-Covid-19 and during the Covid-19 pandemic period. Those overlapping parts are of interest because they can be considered as a measure for the level of competition between the LCCs. A difference-in-differences analysis will be applied in Section 5 producing estimated airfare reductions by the incumbent airline of approximately six Euros or ten percent in response to the entry of a rival LCC.

This subsection develops around three figures. The first figure, Fig. 2, shows the change of network overlaps in absolute numbers in terms of airport pairs and city pairs. The second figure, Fig. 3, concentrates on the overlap between the networks of Ryanair and Wizz Air with and without considering the number of flights. The third figure, Fig. 4, illustrates the magnitude of network overlaps relative to each LCCs' network.

#### 4.2.1. Airport pairs versus city pairs

In London and other city regions, several airports exist. In such city regions, airlines may use one or several airports in parallel. Airport choices may depend on slot availability, airport charges and the presence of airline competitors. This subsection distinguishes between overlaps in terms of airport pairs and overlaps in terms of city pairs. This distinction is used to capture that the presence of multiple LCCs in the same airport pair should have a stronger competitive effect than the presence of multiple LCCs in the same city pair.

There were very few airport pairs and city pairs in which all three LCCs are present. Therefore, the following concentrates on the network overlaps of the three LCC pairs easyJet and Wizz Air (orange color), Ryanair and easyJet (blue color) as well as Wizz Air and Ryanair (purple color).

The two diagrams in Fig. 2 depict the change of network overlaps as measured by the monthly number of overlapping airport pairs (left) and monthly number of overlapping city pairs (right). City pairs operated by different airlines count as overlapping even if airlines use different airports in the same city pair. For this reason, overlaps in terms of airport pairs are always lower than overlaps in terms of city pairs, which can be spotted by comparing the lines with the same color in the left and right diagrams. Ryanair and easyJet had much larger networks relative to Wizz Air, it is therefore unsurprising that the network overlaps based on the numbers of airport pairs and city pairs were higher for them than for the other two LCC pairs involving Wizz Air.

The changes in time can be described as follows. During the whole pre-Covid-19 period, the overlap between the networks of easyJet and Wizz Air stayed constantly low, whereas the overlap between the networks of Ryanair and easyJet slightly increased. The overlap between networks of Wizz Air and Ryanair increased substantially in October 2019 because *Ryanair* started serving 19 new airport pairs in which Wizz Air was the incumbent. The difference-in-differences analysis in Section 5 will concentrate on these changes.

During the Covid-19 period, the difference in the order of magnitude in the overlaps for Ryanair-easyJet and Wizz Air-Ryanair narrowed down in the peak month August 2020. This is because the overlap for Ryanair-easyJet decreased whereas the overlap for Wizz Air-Ryanair increased. The overlap for easyJet-Wizz Air also increased. The involvement of Wizz Air in these changes indicates that Wizz Air tended to expand their networks before and during the Covid-19 pandemic period even though the expansion was associated with increased network overlaps with other major LCCs.

#### 4.2.2. Ryanair versus Wizz Air

The two diagrams in Fig. 3 provide more details about the change of the Wizz Air-Ryanair network overlap. These can be used to illustrate the growing importance of adjacent airports for the new overlapping airport/city pairs and sacrifices in terms of flight frequencies measured by the average number of flights.

It uses indices to describe the change of network overlaps in terms of airport pairs (left) and city pairs (right) with base month January 2018.
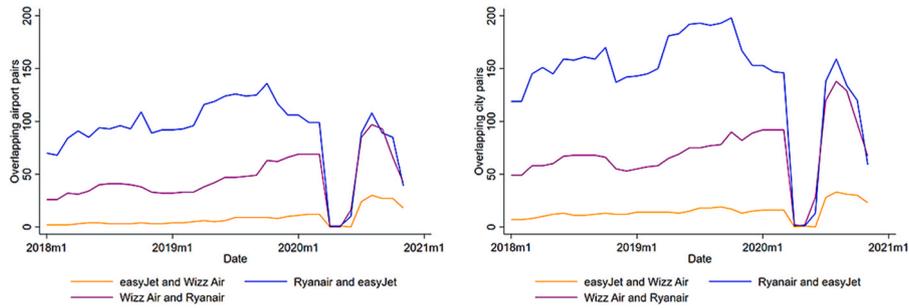
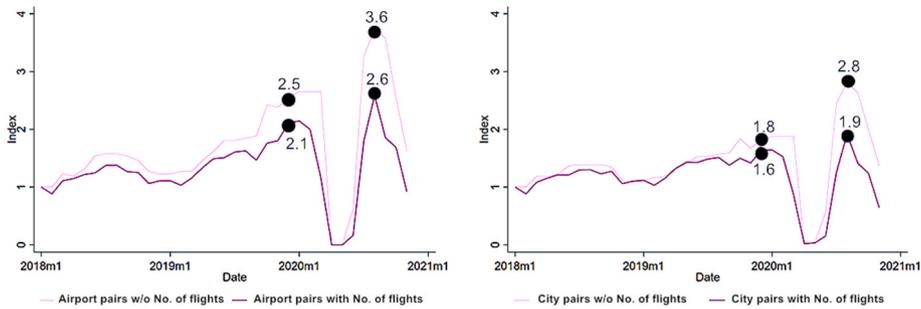**Fig. 2.** Monthly number of overlapping airport pairs (left), and city pairs (right) among the three LCCs.



**Fig. 3.** Indices of the monthly overlapping airport pairs (left) and city pairs (right) between Wizz Air and Ryanair.
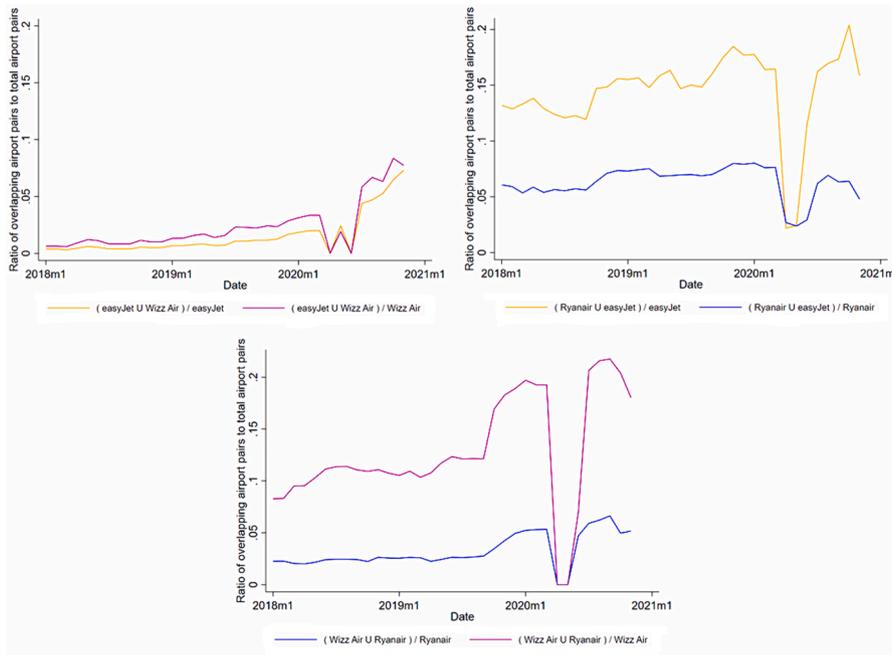


**Fig. 4.** Shares of overlapping as measured by the number of overlapping airport pairs to total airport pairs per month.

The diagrams distinguish between (i) the change of the monthly total number of overlaps (light purple) and (ii) the change of the monthly total number of flights operated on the overlapping airport/city pairs (dark purple).

The light purple line in the left figure shows a sharp increase in the number of airport pairs reaching an index value of 2.5 at the end of the pre-Covid-19 period. Compared to the base month, the number of overlaps in terms of airport pair more than doubled until the end of the pre-Covid-19 period. The overlap between networks of Wizz Air and

Ryanair increased substantially in October 2019 because Ryanair started serving 19 new airport pairs in which Wizz Air was the incumbent. The light purple line in the right figure shows a sharp increase also in the number of city pairs reaching an index value of 1.8 at the end of the pre-Covid-19 period, which is lower than 2.5 indicating the use of adjacent airports. Therefore, compared to the base month, the number of overlaps in terms of city pairs almost doubled until the end of the pre-Covid-19 period. In the peak Covid-19 pandemic month, August 2020, these indices reached even higher values of 3.6 and 2.8, respectively, showing

a further sharp increase in network overlaps compared to the end of the pre-Covid-19 period. Altogether, this indicates that Wizz Air/Ryanair expanded their network and/or diverted flights into markets that have already been served by the other LCC and that the use of adjacent airports had been a substantial part of this change in the pre-Covid-19 period and during the Covid-19 pandemic period.

The dark purple lines show network changes by calculating the monthly total number of flights operated on the overlapping airport/city pairs. For the changes in time, similar patterns can be observed for the dark and the light purple lines indicating that adjacent airports had been a substantial part of the change no matter whether flight numbers are considered or not considered. Observe that the dark purple lines are always below the light purple lines both during the pre-Covid-19 and the Covid-19 pandemic periods. Therefore, the increase in the overlap of Ryanair's and Wizz Air's networks was associated with relatively low average flight numbers compared to the base month. The Covid-19 pandemic period could have supported this change in the sense that removing flights from routes with low demands freed up capacity to extend operations to other routes and test the competitor's behavior.[3]

### 4.2.3. Overlaps versus total network

Fig. 4 shows the shares (ratios) of the number of the overlapping airport pairs between two LCCs to the total airport pairs of each of the two LCCs. This figure can be used to illustrate the increases in network overlaps relative to each LCCs' network indicating that LCC markets become more competitive.

The color code indicates the LCC in the denominator. Take the top-left diagram of Fig. 3 as an example. The orange line considers easyJet's network as the reference network, (easyJet U Wizz Air)/easyJet, whereas the purple line considers Wizz Air's network as the reference network, (easyJet U Wizz Air)/Wizz Air.

All lines in Fig. 4 have in common that they show a positive trend in the relative importance of network overlaps. The share of overlapping airport pairs between easyJet and Wizz Air (top-left) nearly tripled for Wizz Air and more than tripled for easyJet relative to the corresponding shares at the end of the pre-Covid-19 period. The relative importance of the overlaps between the networks of Ryanair and easyJet (top-right) is substantially higher for easyJet than for Ryanair; it reaches around 20 percent for easyJet whereas the share does not exceed 9 percent for Ryanair.

A similar situation can be seen for Wizz Air and Ryanair (bottom). For Wizz Air, the share of the overlapping part had approximately doubled from around 10 percent at the beginning of the pre-Covid-19 period to almost 20 percent until the end of the pre-Covid-19 period. As mentioned before, a big increase in the overlap between networks of Wizz Air and Ryanair happened in October 2019 because Ryanair started serving 19 new airport pairs in which Wizz Air was the incumbent. During the Covid-19 pandemic period, the magnitude of network overlap between Wizz Air and Ryanair even slightly exceeded 20 percent and exceeded the corresponding value for the network overlap between easyJet and Ryanair. This could not be observed in the pre-Covid-19 period.

The number of airport pairs operated by all three LCCs at the same time is almost zero (in average fewer than one pair per month). The increase in network overlaps is particularly high for Wizz Air. The shares of network overlaps displayed in Fig. 4 can be used to illustrate this point. Summing Wizz Air's shares of overlapping airport pairs with easyJet and Ryanair for the beginning of the sample period (2 plus 8 percent) and for August 2020 (10 plus 20 percent) yields an increase in the total share of network overlaps from 10 to 30 percent. This illustrates that the share of Wizz Air's network overlaps tripled within the sample period. It further illustrates that at times as much as one third of Wizz Air's whole flight network overlapped with the networks of the other

two major European LCCs. In this sense, Wizz Air operated in an increasingly competitive market environment.

### 4.3. Top ten overlapping airport pairs

This subsection illustrates the network overlaps during the pre-Covid-19 and Covid-19 pandemic periods geographically by considering the top ten overlapping airport pairs for each LCC pair.

Table 2 lists the top ten overlapping airport pairs as measured by their average daily flight numbers in December 2019. Average daily flight numbers are calculated by summing the number of flights of the two LCCs associated with the overlapping airport pair and dividing it by the corresponding number of days. The table also lists the average daily flight numbers across *all* overlapping airport pairs for the three LCC pairs for comparison (third row), and the share of the top ten overlapping airport pairs in terms of their number of flights relative to the total number of flights associated with the whole overlapping networks (last row). The third and the last rows can be used to illustrate the differences between the top ten overlapping airport pairs and the rest of the overlapping airport pairs.

The top ten overlapping airport pairs show that network overlaps involve the London airport region where easyJet's base is located, and Budapest where Wizz Air's base is located. They do not, however, involve Dublin airport where Ryanair's base is located.

The top ten overlapping airport pairs are in average served with high daily average flight numbers relative to the average daily flight numbers of the LCCs during the two-year pre-Covid-19 period. To see this, divide the average flight number in the second-last row of Table 2 by two because the average flight numbers in Table 2 refer to the sum of daily flights of the two involved LCCs. This yields numbers 1.6, 4.3 and 2.5 for easyJet-Wizz Air, Ryanair-easyJet, and Wizz Air-Ryanair, respectively. To obtain the benchmark value for the two-year pre-Covid-19 period, use the average flight numbers associated with airport pairs in Table 1 and divide this number by 730 representing the total number of days during the two years. This yields average daily flight numbers of 1.4, 0.9 and 0.8 for easyJet, Ryanair and Wizz Air, respectively. Comparing these average flight numbers reveals that the overlapping airport pairs are relatively important with respect to the LCCs' own flight networks.

Table 3 lists the average daily number of flights across all overlapping airport pairs for the three LCC pairs during the peak-pandemic month in August 2020 (third row). Comparing those numbers with the corresponding pre-Covid-19 average numbers in Table 2 (third row, too) reveals that the average flight numbers associated with the overlap easyJet-Wizz Air substantially increased, the average flight numbers on the overlap Ryanair-easyJet remained unchanged, and the average flight numbers on the overlap Wizz Air-Ryanair decreased.

Recall the strong increase in the overlap in terms of airport pair numbers associated with easyJet-Wizz Air in the peak-pandemic month (illustrated by Fig. 2). This increase reduced the relative importance of the top ten overlapping airport pairs in the sense that their share (last row) was reduced by more than one third from 100 percent (Table 2) to 57 percent (Table 3). Similar effects although less pronounced can be observed for the other two overlaps as well.

An overlapping airport pair is considered as newly operated in the peak month of the Covid-19 pandemic period if it had never been operated in the pre-Covid 19 period. The following Table 4 lists new entrant and incumbent LCCs in each LCC pair in August 2020:

The network overlap Wizz Air-Ryanair had only one of the new top ten overlapping airport pairs, VIE-MXP, entered by Ryanair in August 2020. All others of the new top ten overlapping airport pairs had been, however, entered by Wizz Air and with relatively low number of flights, which are shown in Table 3. This explains the decrease in the associated average number of flights. Wizz Air opened its Austrian base at Vienna International Airport in June 2018 and after only one and a half years of operations, the airline allocated its seventh aircraft to the Austrian capital. This explains why all the airport pairs shown in the third and

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[3] We thank the anonymous reviewer for highlighting this intuition to us.

**Table 2**
Average flight numbers on overlapping airport pairs in December 2, 019.[a]

| easyJet-Wizz Air | | | Ryanair-easyJet | | | Wizz Air-Ryanair | | |
|---|---|---|---|---|---|---|---|---|
| Average daily flight numbers on all overlapping airport pairs | | | | | | | | |
| 3.2 | | | 3.0 | | | 2.4 | | |
| Top 10 overlapping airport pairs in terms of average (av.) daily flight numbers | | | | | | | | |
| Airport pair | Av.. | GDP | Airport pair | Av. | GDP | Airport pair | Av. | GDP |
| BUD-LGW | 5.8 | 26.6 | MXP-CTA | 16.4 | 22.9 | DTM-KTW | 7.2 | 6.8 |
| LTN-LIS | 5.3 | 22.9 | MXP-PMO | 10.2 | 24.8 | CIA-OTP | 6.1 | 29.4 |
| LTN-KRK | 5.1 | 7.1 | STN-BFS | 9.9 | 6.5 | GDN-NYO | 5.4 | 11.6 |
| BUD-BSL | 3.9 | 31.0 | MXP-SUF | 9.4 | 13.8 | LTN-KRK | 4.8 | 7.1 |
| LTN-PRG | 3.8 | 13.0 | BCN-LTN | 7.8 | 34.9 | BGY-OTP | 4.8 | 13.9 |
| LTN-OPO | 2.3 | 15.2 | BCN-SXF | 7.4 | 30.0 | VIE-FCO | 4.8 | 52.1 |
| VIE-NAP | 2.1 | 31.6 | STN-PRG | 7.1 | 15.5 | BUD-CRL | 4.7 | 23.2 |
| LTN-TFS | 1.5 | 12.1 | ALC-LGW | 6.3 | 23.2 | BUD-BCN | 4.5 | 86.7 |
| BSL-WAW | 1.4 | 36.3 | MXP-BRI | 6.2 | 26.4 | CRL-OTP | 4.5 | 7.9 |
| LTN-GNB | 0.7 | 17.2 | ALC-MAN | 5.5 | 25.1 | BUD-SXF | 4.3 | 15.8 |
| Averages | 3.2 | 21.3 | Averages | 8.6 | 22.3 | Averages | 5.1 | 25.5 |
| % to total^ | 100 | N/A | % to total^ | 26.8 | N/A | % to total^ | 31.8 | N/A |

^The share of the total number of flights of the top 10 overlapping airport pairs relative to the total number of flights of all corresponding overlapping airport pairs. For instance, if this number is equal to 100, this means that there are no more than ten corresponding overlapping airport pairs.

[a] The majority of the airports listed on this table also ranked atop in December 2018, except for VIE which became a new base for Wizz Air. And easyJet-Wizz Air had only 4 overlapping airport pairs in December 2018.

**Table 3**
Average flight numbers on overlapping airport pairs for the peak-pandemic month, August 2020.

| easyJet-Wizz Air | | | Ryanair-easyJet | | | Wizz Air-Ryanair | | |
|---|---|---|---|---|---|---|---|---|
| Average daily flight numbers on all overlapping airport pairs | | | | | | | | |
| 3.6 | | | 3.0 | | | 2.0 | | |
| Top 10 overlapping airport pairs in terms of average (av.) flight numbers | | | | | | | | |
| Airport pair | Av. | GDP | Airport pair | Av. | GDP | Airport pair | Av. | GDP |
| LTN-AGP | 8.0 | 14.9 | MXP-CTA | 12.5 | 22.9 | VIE-FCO | 5.9 | 52.1 |
| LTN-PMI | 7.7 | 13.8 | MXP-PMO | 9.2 | 24.8 | VIE-MXP | 5.7 | 21.0 |
| LTN-FAO | 7.0 | 8.3 | LTN-AGP | 7.9 | 14.9 | VIE-CRL | 5.0 | 13.9 |
| LTN-MXP | 6.7 | 13.9 | MXP-SUF | 7.2 | 13.8 | CIA-OTP | 4.8 | 29.4 |
| LTN-LIS | 6.7 | 22.9 | LTN-FAO | 7.2 | 8.3 | VIE-ATH | 4.6 | 13.4 |
| MXP-IBZ | 6.4 | 10.3 | MAN-ALC | 6.9 | 25.1 | DTM-KTW | 4.5 | 6.8 |
| MXP-MAH | 5.9 | 7.2 | MAN-PMI | 6.5 | 21.4 | VIE-PMI | 4.5 | 20.5 |
| LTN-SPU | 5.3 | 5.5 | CTA-VCE | 6.3 | 23.2 | LTN-KRK | 4.2 | 7.1 |
| LTN-KRK | 3.9 | 7.1 | MAN-AGP | 5.9 | 23.2 | LTN-AGP | 4.1 | 14.9 |
| MXP-LIS | 3.9 | 43.0 | PMI-TXL | 5.9 | 59.3 | VIE-CGN | 4.0 | 32.5 |
| Averages | 6.2 | 14.7 | Averages | 7.6 | 23.7 | Averages | 4.7 | 21.2 |
| % to total | 57.0 | N/A | % to total | 23.0 | N/A | % to total | 24.0 | N/A |

**Table 4**
New entrant and incumbent LCCs in August 2020.

| Incumbent | easyJet | Ryanair | Wizz Air |
|---|---|---|---|
| New entrant | Wizz Air | Wizz Air | Ryanair |
| Airport pairs | LTN-AGP | VIE-CRL | VIE-MXP |
| | LTN-PMI | VIE-PMI | |
| | LTN-FAO | VIE-CGN | |
| | LTN-MXP | | |
| | MXP-IBZ | | |
| | MXP-MAH | | |
| | MXP-LIS | | |

fourth columns of Table 4 involved Vienna airport.

The network overlap easyJet-Wizz Air had seven of the top ten airport pairs entered by Wizz Air whereas none entered by easyJet. Most of the newly operated airport pairs involved leisure destinations in Spain and Portugal as August 2020 was the holiday season. All top ten peak-pandemic month airport pairs associated with the network overlap Ryanair-easyJet were already operated pre-Covid-19. Altogether, this clearly indicates that Wizz Air was the driving force for the increase in network overlaps and head-to-head competition among the three LCCs *during* the Covid-19 pandemic period.

Many FSCs received direct stated aids whereas this is not the case for the three LCCs discussed during the study period. Therefore, Wizz Air's network strategy was unlikely related to direct state aid payments.

## 5. Airfare impact of network overlaps

This section uses a difference-in-differences analysis in its "canonical format" with two periods and one treatment, which separates control and treatment groups to estimate how incumbents respond to the entry of new rivals in terms of their posted airfares.[4] The posted airfares have been collected from RDC aviation intelligence.[5] RDC scrapes airfares from the airlines' online booking platforms six months, three months,

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[4] Relatively recent studies found that deviating from the canonical format by considering more than two periods and treatments can cause many complications (for example, Chaisemartin & D'Haultfœuille, 2020; and Callaway & Sant'Anna, 2021. Those complications are not a concern for us because we use the canonical format.

[5] RDC collects airfares based on scheduled flights independent of whether they have been operated as scheduled or canceled whereas Flightradar24 only contains operated flights. The use of RDC data implies that, in the treatment group, observations are included although they might involve canceled flights.

one month, and one week prior to the travel date.

### 5.1. Data selection and descriptive statistics

An airline is considered a new entrant if it starts continuously operating an airport/city pair which it had not operated before. In October 2019, Ryanair started operating 19 OD airport pairs in which Wizz Air was the incumbent. Table B in the Appendix lists the 19 airport pairs. The associated increase in network overlaps is visible in Figs. 2–4 as was highlighted before. According to our dataset, other months with entries exist but with much fewer instances of only four or fewer entries. Concentrating on October 2019, a difference-in-differences analysis is conducted with 19 OD airport pairs in the treatment group and 572 OD airport pairs in the control group in which the control group that were operated by Wizz Air and not by Ryanair during the whole sample period.

For each airport pair and month, there are four categories of posted airfares. RDC provides the information about airfares which were posted six months, three months, one month, and one week prior to the travel date. Table 5 displays the numbers of posted airfare observations in the control and treatment groups. The 19 OD airport pairs in the treatment group involved 1257 airfare observations for the period before the entry of Ryanair and 949 airfare observations for the period after the entry of Ryanair. The 572 OD airport pairs in the control group involved 35,833 observations for the period before the entry of Ryanair and 27,798 observations for the subsequent period. The total number of posted airfare observations included in the difference-in-differences analyses is given by 65,837.[6]

Fig. 5 displays the Wizz Air airfare changes in terms of the four airfare categories in the control (blue lines) and treatment (red lines) groups during the sample period. The entry period October 2019 is indicated by dashed vertical lines. The parallel trend assumption is required for the difference-in-differences analysis to reach valid results. Fig. 5 indicates that the control and treatment groups exhibit similar trends both before and after the entry period of October 2019. The parallel trend assumption will be further discussed in the conclusions section.

### 5.2. DiD estimations

Let $i$ denote an airport pair in month $t$. The DiD regression model can be written as

**Table 5**
Numbers of posted airfare observations in the control and treatment groups.

|  | Before | After | Total |
|---|---|---|---|
| Control: | 35,833 | 27,798 | 63,631 |
| Treatment: | 1257 | 949 | 2206 |
| Total: | 37,090 | 28,747 | 65,837 |

[6] Multiplying the total number of routes in terms of OD airport pairs involved in the difference-in-differences analyses by 4 and then by 35 which captures the number of posted airfare observations per month and the number of months across the sample period, respectively, yields a total number of 82,740 posted airfare observations. The total number of observations mentioned in Table 5 is 65,873, which is a lower value. There are two explanations for this. The first is related to changes in the number of routes operated by Wizz Air. October 2019 is typically a peak month. The lower number of routes operated by Wizz Air during other months than the peak month reduces the actual number of observations by 11,932. The second reason is related to missing values in the RDC database which amounts to 4935 observations. The distribution of missing values seems random and they do not seem to affect the estimation results.

$$Airfare_{it} = \beta_0 + \delta_0\, Entry_i + \delta_1\, Period_t + \delta_2\, Entry_i \times Period_t + ODpair_i + Month_t + \varepsilon_{it} \quad (1)$$

The explained variable, $Airfare_{it}$, is the (Wizz Air's) airfare on the OD airport pair $i$ in month $t$. $Entry_i$ is a binary treatment variable which indicates whether one OD airport pair has been entered by another LCC or not. $Period_t$ is a binary period variable. In our case, it is 0 before October 2019, and 1 after October 2019. $Entry_i \times Period_t$ is the DiD term which is used to capture the difference between group (control and treatment) differences before and after the treatment to derive pure treatment effect. $ODpair_i$ captures the OD airport pair fixed effect and $Month_t$ captures the month fixed effect. Both terms are in brackets because the regression has been implemented with and without fixed effects. And $\varepsilon_{it}$ is the random error.

The following analysis[7] proceeds in two steps. The first part concentrates on the pooled airfare data whereas the second part considers each airfare category separately. Pooling the airfare data produces significant estimation results for the pre-Covid-19 period and the entire sample period. This allows identifying the effect of the Covid-19 period by comparing the estimation results.

The estimation results based on the pooled airfare data are displayed in Table 6. The estimation results are derived without and with route and month fixed effects. The top panel displays the results for the period before Covid-19. Without fixed effects the differences between the airfares in the control and treatment groups are significantly different from each other only in the period after entry whereas these differences are insignificant before and after entry when fixed effects are used. The coefficient estimate associated with the difference-in-differences term, DiD, is equal to −4.2 and significant when fixed effects are used. The coefficient estimate is of similar magnitude but not significant when fixed effects are not used.

The bottom panel displays the results for the periods before and during Covid-19. Without fixed effects the differences between the airfares in the control and treatment groups are significantly different from each other only in the period after entry whereas the differences are significant and positive before and after entry when fixed effects are used. This indicates that Ryanair entered the routes associated with relatively high airfares across the sample period. This is consistent with the average geometric means of airport pairs in the treatment and control groups given by 25.7 billion Euros and 20.4 billion Euros, respectively; thus, the treatment group is associated with relatively high demand in terms of GDP relative to the control group. The coefficient estimates associated with the DiD terms are equal to −6.2 and −5.5 and significant without and with fixed effects, respectively.

These estimations reveal that the coefficient estimates associated with the DiD terms are lower for the top panel than for the bottom panel (in absolute values). This indicates that network overlaps had a stronger effect on airfares during than before the Covid-19 period. This seems reasonable considering the overcapacity available during the Covid-19 period.

Table 7 displays the estimation results for each airfare category. These estimations are based on the observations from the entire sample period meaning that the analysis does not distinguish between the pre-Covid-19 and the Covid-19 pandemic periods. The estimation results are again derived without and with route and month fixed effects. The top panel displays the results without fixed effects and the bottom panel displays the results with fixed effects.

The results with respect to the differences between the airfares in the control and treatment groups as well as the DiD terms are largely consistent with the results in Table 6 which are associated with the pooled airfare regressions. The analysis of individual airfare categories, however, reveals that airfare pressure by market entry is stronger for airfares posted three and six months in advance relative to airfares

[7] All estimations were implemented in STATA with "didregress" or "diff" commands.
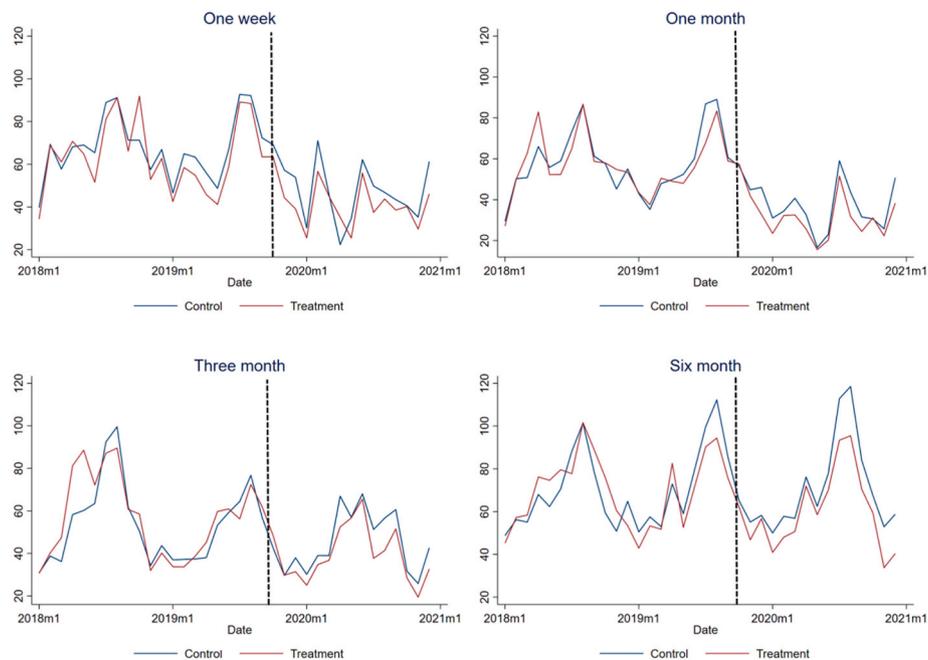
**Fig. 5.** Wizz air's airfares before and after the entry of Ryanair.

**Table 6**
Pooled airfare difference-in-differences regressions.

| | Baseline (Before entry) | | | Follow-up (After entry) | | | | |
|---|---|---|---|---|---|---|---|---|
| FE | Control | Treat. | Diff | Control | Treat. | Diff | DiD | $R^2$ |
| Before Covid-19 | | | | | | | | |
| Without | 62.6 | 61.7 | −0.9 | 51.2 | 46.2 | −5.0** | −4.1 | 0.01 |
| With[a] | 46.6 | 24.5 | −22.0 | 50.0 | 23.8 | −26.3 | −4.2** | 0.56 |
| Before and during Covid-19 | | | | | | | | |
| Without | 62.6 | 61.7 | −0.9 | 50.7 | 43.6 | −7.1*** | −6.2*** | 0.03 |
| With[a] | 29.3 | 77.9 | 48.6*** | 32.1 | 75.3 | 43.1*** | −5.5*** | 0.48 |

***p < 0.01; **p < 0.05; *p < 0.1.
[a] Route and month fixed effects are included.

**Table 7**
Difference-in-differences regressions for all airfare categories (Before and during Covid-19).

| | Baseline (Before Entry) | | | Follow-up (After Entry) | | | | |
|---|---|---|---|---|---|---|---|---|
| Airfare | Control | Treat. | Diff | Control | Treat. | Diff | DiD | $R^2$ |
| Without fixed effects | | | | | | | | |
| Six M. | 72.3 | 71.0 | −1.3 | 71.0 | 61.0 | −10.0*** | −8.7** | 0.00 |
| Three M. | 54.4 | 56.8 | 2.4 | 45.7 | 40.1 | −5.6*** | −8.1*** | 0.02 |
| One M. | 58.6 | 57.3 | −1.3 | 37.9 | 32.4 | −5.5*** | −4.2* | 0.11 |
| One W. | 67.9 | 63.9 | −4.0** | 50.0 | 42.5 | −7.5*** | −3.5 | 0.08 |
| With fixed effects[a] | | | | | | | | |
| Six M. | 24.1 | 30.3 | 6.2 | 39.0 | 39.6 | 0.6 | −5.6*** | 0.70 |
| Three M. | 29.3 | 66.2 | 36.9 | 25.4 | 55.2 | 29.9 | −7.0*** | 0.64 |
| One M. | 48.8 | 65.5 | 16.7 | 24.0 | 36.6 | 12.6 | −4.1** | 0.62 |
| One W. | 33.8 | 81.5 | 47.7*** | 29.4 | 72.8 | 43.4*** | −4.3** | 0.60 |

***p < 0.01; **p < 0.05; *p < 0.1.
[a] Route and month fixed effects are included.

posted closer to the actual departure times. This could be related to the available seat capacity which tends to be high long before departure time leading to relatively strong competition but tends to get lower closer to departure time potentially softening competition.

An analogue analysis based on city pair entries rather than airport pair entries revealed no statistically significant impact of network overlaps on posted airfares. One reason could be that the competitive effects of network overlaps is weaker if entry does not occur on the same airport pair but involves the use of adjacent airports. The treatment group involving city pairs and not airport pairs, that is, adjacent airports contained four or fewer city pairs. The small size of the treatment group could be another reason for the insignificant estimation results. For the overlaps between easyJet and Wizz Air, most of them were temporary and discontinued after some months.

## 6. Conclusion

This study used a large and detailed dataset involving information at the individual flight level. The objective was to analyze the change in the networks of the big three European LCCs Ryanair, easyJet and Wizz Air before and during the Covid-19 pandemic period. The results indicate that LCCs increasingly expanded their networks into markets that had already been served by incumbent LCCs and that the use of adjacent airports had been a substantial part of this change. The example of Ryanair and Wizz Air illustrated that overlap increases were associated with relatively low flight numbers. The example of Wizz Air showed that network overlaps reached up to 30 percent of the total LCC's network. Altogether, this indicates that European LCCs increasingly compete head-to-head among themselves.

A difference-in-differences analysis based on posted airfare information was used to estimate the airfare effect of head-to-head LCC competition on overlapping network parts. The posted airfares have been collected from RDC aviation intelligence. RDC provides the information about airfares which were posted six months, three months, one month, and one week prior to the travel date. Ryanair started operating 19 OD airport pairs in which Wizz Air was the incumbent in October 2019. The estimation results indicate that airfares posted by the incumbent are reduced by approximately six Euros, or ten percent of the average airfares, after the entry of a rival LCC. This indicates that the head-to-head LCC competition leads to substantive airfare reductions.

There are several avenues for future research which can be followed to test whether the airfare effects estimated in this study are generalizable to other competition scenarios. LCCs compete among each other but also with FSCs and their LCC subsidiaries. It would be useful to develop a more complete dataset involving a broader set of airlines to study the change in network overlaps for different types of airlines. The dataset could further be extended to include US airline markets. Such an extended dataset would allow for various difference-in-difference-in-difference (triple difference) regressions of type discussed in, for example, Gruber (1994) and Olden and Møen (2020). The advantage of triple difference regressions is that they can be used to handle issues associated with the parallel-trend assumption.

### CRediT authorship contribution statement

**Hanxiang Zhang:** Conceptualization, Methodology, Formal analysis, Investigation, Writing- Original draft and review & editing, Visualization, Project administration. **Achim I. Czerny:** Conceptualization, Methodology, Formal analysis, Investigation, Writing- Original draft and review & editing, Visualization, Supervision, Project administration. **Wolfgang Grimme:** Conceptualization, Methodology, Investigation. **Hans-Martin Niemeier:** Conceptualization, Methodology, Investigation.

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## Appendix

The following Table A lists 16 multi-airport regions located in the European Union (including the UK airports). The selection is based on the origin/destination cities information provided by Flightradar24. Cities with more than one airport are considered multi-airport regions.

**Table A**
Multi-airport regions[1]

| Regions | Airports | Regions | Airports |
| --- | --- | --- | --- |
| Belfast | BFS | Madrid | MAD |
|  | BHD |  | TOJ |
| Berlin | BER | Milan | BGY |
|  | SXF |  | LIN |
|  | TXL |  | MXP |
| Brussels | BRU | Murcia | MJV |
|  | CRL |  | RMU |
| Bucharest | BBU | Paris | BVA |
|  | OTP |  | CDG |
| Frankfurt | FRA |  | LBG |
|  | HHN |  | ORY |
|  | QEF |  | XCR |
| Hamburg | HAM | Rome | CIA |
|  | XFW |  | FCO |
| London[2] | BQH | Stockholm | ARN |
|  | LGW |  | NYO |
|  | LHR |  | VST |
|  | LTN | Tenerife | TFN |
|  | STN |  | TFS |
| Lyon | LYN | Warsaw | WAW |
|  | LYS |  | WMI |

[1]Some airports, for example, Biggin Hill Airport, Torrejon Air Base and Le Bourget Airport, have been deleted from the dataset during the data cleanse process because none of the three LCCs considered in this study operated more than 12 flights per year at these airports.

[2]Flightradar24 associates SEN airport with Southend and not London (even though SEN is called London Southend Airport). Adding SEN airport to the London multi-airport region would slightly increase the overlap between Ryanair and easyJet by one or two city pairs per month whereas the overlap in terms of airport pairs would not be affected by this change in classification. The network overlaps involving Wizz Air would also not be affected by this reclassification.

**Table B**
19 airport pairs entered by Ryanair in October 2019

| BCN-RIX | BUD-OPO | DTM-KTW | NYO-VIE |
|---------|---------|---------|---------|
| BOD-BUD | BVA-POZ | EIN-VIE | OTP-PSA |
| BUD-CTA | BVA-SOF | GDN-GOT | SKG-VIE |
| BUD-GOT | CGN-KTW | GDN-HAM | TFS-VIE |
| BUD-LIS | CTA-KTW | KRK-LTN | |

**Table C**
Peak numbers of airport pairs served by easyJet, Ryanair and Wizz Air in 2018, 2019 and 2020

| | easyJet | Ryanair | Wizz Air |
|------|---------|---------|----------|
| 2018 | 804 | 1768 | 364 |
| 2019 | 878 | 1828 | 407 |
| 2020 | 657 | 1590 | 452 |

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