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US Feeder Airlines: Industry Structure, Networks and Performance

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Abstract

This paper examines the US airline industry in terms of the relationships between the three largest full service carriers, American Airlines, Delta Airlines and United Airlines, and the set of regional carriers that are contracted to provide feeder services to them. The evolution of the regional carriers and the full service carriers are compared and recorded and the current industry structure and size is described. The paper uses the full set of Official Airline Guide (OAG) schedules for 2017 to analyse the industry structure and scale, overlap and seasonality in service provision among the groups of carriers and to understand the network organisation and capacity deployment strategy of the largest network carriers in the US market. The analysis provides evidence to explain how the large airlines are improving their cost and financial performance as well as significantly improving their operational efficiency through the achievement of high overall load factors. The sophistication in each airline's schedule design and service delivery is highlighted.

Key words: regional airlines; feeder airlines; seasonality; airline network structures

Introduction

This paper examines feeder airlines that support the mainline operations of the largest US full service air carriers[1]. The feeder airlines are made up of both certificated carriers and commuter/regional carriers that operate 'small aircraft' (i.e. aircraft with an original design capacity of 60 or fewer seats) or small regional jets with seating capacity of up to 77 seats. These feeder carriers emerged after deregulation as a key sector providing air services that gave continuity to many small and medium sized communities when certificated carriers reoriented their networks towards larger centres and away from smaller centres. The feeder carriers have also facilitated higher frequency service on short-haul routes and filled service gaps in the mainline operations across the national airports system. The current structure of the industry and relationships between feeder and mainline carriers are the focus of this paper. Frederick & Hudson (1942) examine the characteristics of feeder airlines and suggest the following broad definition in the regulated period: "A feeder airline is (1) a common carrier (2) performing the dual function of concentrating and dispersing mail, passengers, and/or property (3) within a given marketing area (4) from widely scattered points (5) to a few terminal points".

While a number of studies have examined aspects of the feeder carrier impacts on mainline operations, no detailed examination of the feeder operations has been undertaken to date. The first section of this paper examines the US and North American airline industry in the context of global air traffic patterns and highlights a number of unusual features characterising the US domestic market. Section 2 traces the evolution of the feeder carriers and their relations with the largest US mainline carriers particularly in the last decade. The current industry structure and relationships are then

[1] The paper is not concerned with the South Sudan carrier *Feeder Airlines* founded in 2007 and rebranded as *South Supreme Airlines* in the 2010s (ICAO designator FDD) (see CAPA (Centre for Aviation) https://centreforaviation.com/data/profiles/airlines/feeder-airlines-fdd and https://www.ch-aviation.com/portal/airline/Fed).

described in detail and characteristics of the carriers operations in 2017 are set out in Section 3. The paper concludes by demonstrating how US carriers have deployed capacity of mainline and feeder carriers to deal with geographic and demographic characteristics to achieve high utilisation of mainline capacity and realise low levels of seasonal variability compared to other global regions.

1: US air transport operations in a global context: some key distinguishing characteristics

The US airline industry is the largest national air transport market in the world, although the North American share of global traffic has been declining steadily as Asian countries rapidly expand their air transport sectors. US air traffic has become less concentrated spatially in the 2010s compared to previous decades and this pattern has been driven by a significant expansion in the number of airports (and number of routes) receiving jet services following the great recession in 2007/8. Reynolds-Feighan (2017) shows that North American communities receiving regular scheduled jet services are generally smaller than communities receiving comparable levels of air services in other global regions, reflecting a higher propensity to travel by air and higher incomes than in other regions. Table 1 is reproduced from the study and shows average population for different hub classes[2] in each major global region in 2015. In addition, the average aircraft size is significantly smaller for North America in all hub classes than in other global regions, and as the hub size gets smaller, so does the average aircraft size (i.e. number of seats per movement).

Using the Official Airline Guide (OAG) daily airline schedules, the monthly air traffic capacity[4] distributions were examined for major global regions and are summarised in Figure 1 showing the temporal Gini index scores for 1996, 2006 and 2016. The temporal Gini is computed by measuring monthly traffic (measured as either departure movements or available seats) for each of the years indicated across the continental systems shown and adjusted to take account of the number of days per month (see Reynolds-Feighan (2018) for a more thorough discussion). If every month has an equal traffic share, the temporal Gini Index takes a value of 0. As the monthly traffic distribution varies, the Gini Index value increases. If all of the traffic takes place in just 1 month, then the Gini Index score will be 1. The Gini Index scores in Figure 1 range from 0.04 to 0.14, reflecting the fact that significant traffic volumes take place in every month of the year for the continental regions[5]. The North American temporal Gini scores are consistently lower than other regions, but have been increasing gradually since the 1990s. The European temporal Gini index scores are consistently higher than in other regions reflecting strong seasonality related to tourism traffic flows. Reynolds-Feighan (2018) reports that when carrier-specific temporal Gini index scores are computed, US carriers have very low scores compared to other large carriers operating in Europe, Asia and Latin America. Taken together, the continent-wide analysis points to significant differences in the way that the North American airline industry operates compared with other regions.

[2] The FAA hub classification system is adapted and applied to major global regions to classify global communities based on annual departure movements; these are linked to urban population data (see Reynolds-Feighan, 2017).

[4] Air traffic in this paper is measured as either non-stop departure movements (take-offs) or available seats on non-stop departure movements. The OAG schedules give the ex-post daily airline schedules and represent a 'supply-side' view of air traffic operations. Daily, weekly, monthly or yearly measures of traffic can be compiled by carrier, airport pair and aircraft. Detailed and consistent passenger numbers reflecting demand are not available.

[5] The Gini index summarises the pairwise variability between each month's traffic and every other month. Because there are just 12 month categories, temporal Gini Index scores will be relatively low if there are significant traffic volumes recorded in each month. The temporal Gini Index scores were compared with the ratio of the lowest:highest months' traffic for hundreds of airports and airlines and as the ratio decreased (showing greater disparity between the low traffic month and the high traffic month, the variability in the Gini Index increased reflecting the influence of traffic levels in the other months on the computed value.

There is a vast literature examining economic and operational aspects of the US airline industry. Most of the literature has focused on the largest carriers and most heavily trafficked routes. A number of recent studies have examined the provision of service to smaller communities and the role and operation of commuter and feeder carriers that support the larger US carriers' domestic operations.

Regional airlines are subcontracted by the mainline carriers to provide capacity in regional markets, using labour supplied by the regional carrier, but flying under the mainline carrier's code and livery[6]. The mainline carriers have faced significantly higher labour costs compared to the regionals (Hirsch, 2007) and even when the regional carriers are wholly owned subsidiaries, the regionals operate as separated companies with separate labour agreements. The regional carrier's labour market is generally considered to be more competitive and this has kept costs down (Forbes & Lederman (2009; 2007). More recent contracts between mainline and regional affiliates have taken the form of capacity purchase agreements (Forbes and Lederman (2013)). These agreements result in the mainline carrier retaining all revenues and paying a fixed fee for regional departure movements. The capacity purchase agreements are long term in nature. Alternatively, regional carriers may operate flights under a revenue proration agreement, where a fixed share of ticket revenue for connecting flights is agreed between the regional and mainline carrier partners. However scope clauses in labour agreements with mainline (legacy) carriers place limits on the extent to which services may be outsourced to regional carriers[7]. The scope clauses not only limit the size of aircraft that can be used by regional affiliates, but also the total number of aircraft operated on behalf of the mainline carrier. The employment of regional carriers gives mainline carriers operational flexibility and an ability to bypass in-house labour restrictions (Bitzan & Peoples, 2014).

Forbes and Lederman (2007) describe the development and evolution of the regional carriers up to the early 2000s in some detail. They show that vertically integrated regional carriers are more likely to be used by the mainline carrier on routes with more precipitation and snowfall, and from airports that are highly ranked in the mainline carrier's network hierarchy (major or regional hubs). The large carriers often use multiple feeder regionals from the same airport and it is suggested that the mainline carriers "do not choose a single regional or a single type of regional to serve all routes out of a given airport". The analysis is by airport rather than by route in the study.

Using the same dataset from 2000, Forbes and Lederman (2009, 2010) suggest that the mainline carrier's decision to use an 'owned regional feeder' (as opposed to an independent regional carrier) on a given route depends on the "returns to integration" on that route, on other routes in the mainline carrier's network and on system-wide effects. The sample consists of flights operated in the US in the second quarter of 2000 for the top 300 airports. While climate and congestion variables are matched to the flight data, seasonal identifiers are not included. In a subsequent study, the same authors report that operational performance (delays experienced) of a mainline carrier improves on a given day by using an owned regional carrier rather than an independent regional carrier, and the performance advantage increases on days with extreme rain and congestion (Forbes and Lederman (2013). The

[6] The mainline partner in many instances owns or leases regional aircraft and places them with a regional affiliate as part of a service contract. It has not been possible to establish exactly how many aircraft are owned by the mainline partner from annual reports and SEC filings.

[7] Pilot unions demanded 'scope clauses' in the 1990s and 2000s to regulate the use of subcontracted regional airline services by mainline carriers. The scope clauses set limits on the maximum size of aircraft permitted for the regional carriers to operate under mainline contracts: initially these were set at 50 seats, but expanded to 76 seats (2012 agreements) until 2019-2020 (United Airlines will be first to renegotiate in January 2019) (see FlightGlobal (20th March 2018) "*Are US airlines at their next scope crossroads?*", Edward Russell, accessed July 2018: www.flightglobal.com/news/articles/analysis-are-us-airlines-at-their-next-scope-crossr-446881/ .

2013 study uses a sample week in each quarter from 1997-2001. Mainline carriers had shifted from using revenue-sharing contracts with regional carriers to fixed price or capacity purchase contracts in the period from 1999 to 2001, and had deployed regional jets on many routes where no service was previously provided.

Tan (2017) finds that legacy carriers increase their use of independent regionals on routes where there is stronger competition particularly from low-cost carriers. The partnership between mainline and regional carriers is associated with lower fares leading to the conclusion that regional carrier growth has encouraged a pro-competitive response from legacy carriers. Data are drawn from the US BTS Airline Origin and Destination Survey for the period 1998-2015 and are quarterly and exclude wholly-owned regional carrier service. Brueckner and Pai (2009) looked at the introduction of regional jet technology and concluded that these aircraft had facilitated mainline carriers serving a larger number of smaller communities through contracting regional feeder services.

Fageda and Flores-Fillol (2012) examine the impact of regional jets and the low cost business model on thin routes in the US and Europe and conclude that very different patterns of service are observed in the two markets. Only in the US are the advantages of regional jets exploited on medium haul routes, where high frequency service may be deployed. In Europe by contrast, low cost carriers operate on thin routes and utilise larger single aisle jets. The authors note that this may also reflect the congested nature of many larger European airports. The air traffic data used in their empirical research comes from a UK consulting firm (RDC Aviation) and consists of annual data for 2009 for c. 2,800 US and c.2,800 European routes.

Bitzan and Peoples (2014) examine allocative efficiency in the US airline industry from 1993-2010 using annual USDOT Form 41 financial and T-100 traffic data. Earlier studies had suggested that US carriers had overutilised labour relative to other inputs because of restrictive labour practices. Bitzan and Peoples (2014) present evidence that the carriers in the more recent period underutilize labour in favour of capital and fuel. Technological improvements (including adoption of regional jets) and flexibility in the use of regional feeder carriers have facilitated the mainline carriers exploiting these cost-saving alternates to in-house capacities. In the slightly longer time frame in Bitzan and Peoples (2016), cost and productivity changes are examined for full service, regionals and low-cost carriers 1993-2014. Again, annual data is utilised and it is demonstrated that the FSCs experienced cost reductions of 10%, while regionals experienced a 22% reduction. LCCs saw cost increases of 8.5% over the same period, reducing the cost advantage traditionally enjoyed over FSCs. Increases in load factors and stage lengths are suggested as the sources of the productivity gains by FSCs.

While these studies provide valuable insights into the role and operation of feeder carriers, the structure of the industry and significance of the sector receives little attention. The network structures and coordination with mainline carriers is not explained nor is the evolution of service provision under the consolidation process that has characterised the US airline industry in the 2010s. This paper looks at the 2017 US domestic market and focuses on the impact of seasonality on airline provision of service by the mainline carriers in partnership with their regional feeder affiliates. The industry structure is described and this updates previous studies that have tracked the development and growth of regional carrier operations since the 1990s. The network structures of the regional carriers and their contribution to their mainline carrier domestic networks are examined in detail. Monthly data are generated for 2017 and all routes with jet service are included. It is argued that coordination of regional and mainline operations and management of capacity deployment across the network has contributed to the achievement of load factor improvements and productivity gains.

2. Regional carriers in the US market: industry structure and recent trends

A key issue for the US market has been the consolidation in the industry with four very large carriers now dominating the domestic market and this has been widely reported for the larger carriers (see for example GAO (2014)). Figure 2 summarises what has been happening among the regional carriers from 1996-2017 and shows consolidation among the regional carriers owned by the majors, as well as the largest independent regional carrier groups. The current surviving carrier brands (along with the IATA code) are highlighted in bold for each of the main airline groups.

Figure 2 demonstrates that there has been considerable consolidation among the regional carriers as well as the mainline carriers so that the surviving carriers are larger. American Airlines and Delta Air Lines have reduced the number of wholly-owned regional carriers to three and one respectively, while United Airlines no longer owns any regional carriers. The largest independent regional carriers provide feeder services to multiple large full-service carriers: service partners are shown in Table 2 for 2017, along with basic statistics capturing the significance of these contributions.

The US Bureau of Transportation Statistics (BTS) report passenger traffic statistics by the operating carrier and the 2017 distribution of domestic passengers by carrier are illustrated in Figure 3, along with the available capacity and summary load factors. The figure illustrates the significant difference in scale between the largest four carriers and other US airlines. For the three largest full-service carriers, (Delta, United and American), the statistics reported relate to the mainline operation only and the set of regional feeder services supporting these operations are recorded separately under the relevant regional carrier codes. SkyWest Airlines is the largest regional carrier in the US in 2017 (5th largest carrier overall) and it operates all of its services under three regional affiliate brands for Delta Air Lines (Delta Connection), American Eagle (American Airlines) and United Express (United Airlines). The BTS data do not break out the SkyWest services by the mainline brands. The regional carriers providing feeder services to the mainline carriers are identified in Figure 3 in shaded patterns. The regional feeder carriers generally have load factors in the range of 75-79%, while the mainline carriers have load factors of 81-85%. The Official Airline Guide (OAG) ex-post schedules *do* record the operating carrier as well as the mainline brand and these data are utilised to undertake a more detailed analysis of the regional affiliate and mainline relationships and traffic profiles.

Southwest Airlines is the largest carrier by passengers carried in 2017, with 140 million passenger enplanements. The airline operates point-to-point services, in many instances with multi-stop segments being offered under separate flight codes. Southwest Airlines does not contract regional carriers to supplement their services and utilises a single-model aircraft fleet (Boeing 737) in contrast to the other large carriers [8]. Southwest's network is smaller than the three largest full service carriers, but more routes per airport are operated reflecting the different network and operational strategy. Differences in the business model will be discussed further after the main results are presented.

Table 2 gives basic operating statistics for the 14 regional airlines providing feeder services under mainline flight codes in 2017. The data in this table relate to the full regional carrier operation in each case. The table shows the very large scale of many of these carriers and highlights the fact that all of the independent regionals provide service to multiple mainline carriers. Further analysis of Alaskan Airlines is not included in subsequent tables as the focus is particularly on the three largest full-service

[8] Southwest Airlines merged with AirTran Airways in 2011. AirTran operated capacity purchase agreements with SkyWest Airlines but these ceased once the merger with Southwest was completed (World Airline News, 09/07/2011). Southwest sold the AirTran fleet of B717 aircraft in order to maintain its single aircraft fleet of B737s. According to the 2018 Southwest Airlines' Annual Report, the airline had 706 Boeing 737 aircraft in operation on December 31st 2017; of these 512 were B737-700s, 181 were 737-800s and the remaining 18 were 737 Max8s

operators. Table 3 gives the breakdown of regional carrier service under each of these three brands in 2017, and also provides details on the types of communities served by each regional affiliate and mainline carrier using the FAA hub type classification in 2017. Southwest Airlines details are also included for comparative purposes. The number of airports served by each carrier in the busiest month and least busy month are recorded as is the average number of months of service operation. Most of the regional carriers serve a significant share of large and medium FAA hubs as well as significant numbers of small hubs and non-hubs. For the mainline carriers, Delta Air Lines serves all 30 of the FAA large hubs, while American and United airlines serve 29 of the 30. All three also serve almost all of the medium hubs and a significant share of the small hubs. The three mainline carriers serve only a small share of the non-hubs which handle less than 0.05% of annual enplanements. Southwest Airlines also serves most of the large and medium hubs as well as 32 out of the 72 small hubs. It only served 3 non-hub communities in 2017.

Temporal and spatial Gini index scores are recorded for each carrier's network in 2017. The temporal Gini Index scores are computed in two ways: firstly an overall temporal Gini score is computed using the total monthly traffic (available seats) performed by each carrier in 2017. The second temporal Gini index measures the weighted average temporal Gini index score across all routes served (i.e. each carrier's route temporal Gini index weighted by its share of traffic operated under the mainline brand). These scores are considerably higher and reflect the extent to which many routes are only served for a subset of months in the year. While the spatial Gini index scores were computed for traffic across the set of airports in the carrier's network in 2017 using both available seats and departure movements, only the scores for seats are recorded in the table as there were very small differences between the two traffic measures. Minor differences in the two spatial Gini index scores reflect utilisation of a mix of aircraft. The average number of seats per movement is also recorded in the table.

A number of patterns emerge from Table 3. The three mainline carriers have a substantial share of their domestic traffic performed by regional feeders, ranging from 25-30% of seating capacity to 46-53% of total departure movements. In each case, the two largest regional affiliates make up over half of this requirement. The temporal Gini index scores are very low for the mainline carrier capacity ranging from 0.013 for American Airlines, to 0.042 for United Airlines. For most of the regional affiliates, the temporal Gini scores are higher than their mainline partner, although this is not the case for United Airlines. The weighted temporal Gini index scores are considerably higher than the system scores and reflect the variability in the number of months of operations on routes served. Southwest Airlines has a low temporal Gini score for both measures, reflecting low seasonality generally across its route network and the high average number of months of operation (10.35 months on average across the domestic system) across all routes in the network.

Most of the routes operated by regional carriers have air services provided between 6 and 9 months of the year. A breakdown of the service continuity by carrier is illustrated in Figure 4, where the share of departures on routes with 1-4 months, 5-8 month, 9-11 month and 12-month service are shown. There is considerable variability within each group of carriers, but the three mainline carriers have over 90% of their movement capacity on routes with year-round service. The average number of months of operation recorded in Table 3 reflects the fact that the mainline carries will augment, supplement or substitute services where demand variability will support deployment of larger aircraft[9].

[9] If sales are higher/lower than expected on a particular flight, the airline can decide to change the aircraft from the scheduled equipment. This may result in passengers being bumped from the flight, or bumped from

The spatial Gini Index scores indicate highly concentrated overall traffic distributions across the carrier networks, although these have reduced in the last decade as service has been expanded to a larger number of communities. Many of these communities receive service from the mainline carriers for limited periods in the year. The mainline carriers serve the vast majority of the FAA large and medium hubs and then different mixes of small hubs and non-hubs. The regional carriers also serve a significant number of the large and medium hubs in most cases, suggesting that they play roles feeding mainline hubs from small communities, augmenting frequency or substituting for mainline service between hubs and larger centres, providing direct service between centres rather than connecting service via mainline hubs, and maintaining service on routes where peaked seasonal demand patterns might otherwise reduce or remove service for a number of months of the year. Southwest Airlines has the lowest spatial Gini Index score of any carrier, reflecting the fact that it has more routes (and therefore more seating capacity) on average operating from each airport in its domestic system.

The average stage length for each carrier is shown in Figure 5. Each mainline carrier has a significantly larger average stage length than their regional affiliates (between 1230 and 1440 miles for mainline carriers and 500-600 miles for the regional affiliates). Southwest Airlines average route stage length is 1495km/929 miles in between the average of the three large mainline carriers and regional affiliates.

In 2017, there were between 7,064 (May) and 7,361 (December) non-stop directed routes segments operated per month in the US, with between 56% and 58% of routes having just one carrier. A further 21-22% of routes had 2 carriers, while 20-22% had 3 or more carriers. In terms of traffic however, 27-29% of available seats and departure movements were offered on routes with just one carrier; 24-25% on 2-carrier routes and 47-49% with 3 or more carriers. There was remarkably little variation in the number of carriers operating on routes from month to month over the course of the year.

3: Network structures and deployment of capacity in the large US carrier groups

To explore these aspects further, tables were compiled to examine the traffic distribution and seasonal variability in operations in more detail for each carrier group. The number of other carriers operating on each carriers' set of routes were counted (distinguished by being the mainline partner, another regional affiliate in the same carrier group or other carriers outside the airline group). The share of traffic across routes with different numbers of competitors or partners were computed and these are reported in Tables 4, 5 and 6 for Delta Air Lines, United Airlines and American Airlines respectively. A diagrammatic representation of each carrier's network is included in Figures 6, 7 and 8 along with summary information regarding the main hubs served by each of the regional affiliates (number of routes served, average number of months of service on non-stop routes served and average temporal Gini index for non-stop routes from the hub). Note that Figures 6, 7 and 8 purely illustrate the set of connections between the nodes and have no geographic dimension, so distance is not scaled, and the relative location of hubs is randomly assigned.

Delta Airlines merged with Northwest Airlines in 2009 and began a process of rationalisation and streamlining of the combined networks and regional partners. Several small regional carriers were merged over the period (for example, Pinnacle Airlines, Mesaba Airlines, Colgan Air and Comair were merged and rebranded as Endeavor Air between 2007 and 2012), with Delta retaining ownership of

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business/first class to economy. According to the DOT website, "*Bumped passengers are NOT eligible for compensation in the following situations: Aircraft Change - A smaller plane is substituted for the larger one the airline originally planned on using due to operational or safety reasons.*" https://www.transportation.gov/individuals/aviation-consumer-protection/bumping-oversales .

Endeavor Air. Delta's continued ownership of this regional airlines allows the mainline carrier to maintain a pipeline of pilots without having to incur mainline labour costs and long term contract commitments[10].

The Delta Air Lines domestic network in 2017 consisted of 6 regional affiliate partners supporting the mainline carrier operations, with Endeavor (9E) and SkyWest Airline (OO) being the two largest partners operating 780 and 736 routes respectively (Table 4). Just over one fifth of SkyWest's capacity is on routes where it was the only carrier operating; on 55% of its routes, the mainline carrier operates at some stages during the year and for over 40% of routes both the mainline carrier and at least one other Delta Connection affiliate operates. The SkyWest routes are particularly concentrated around Detroit (DTW), Minneapolis (MSP) and Salt Lake City (SLC), but there are significant operations at several other Delta bases including Atlanta. There is significant overlap in the networks operated by all of the Delta regional affiliates, but with clear subsets of routes and focus on three hubs each in the Delta domestic network. The different regional carriers operate different mixes of aircraft and give the mainline carrier choice and flexibility in the range of aircraft size available. Multiple regional carrier contracts allow the mainline carrier flexibility to add or vary capacity or frequency and still maintain a full schedule of service as demand varies.

There is a significantly higher degree of seasonality in the traffic capacity operated by SkyWest under the Delta and United brands than under the American Airlines brand reflecting the fact that greater capacity is operated on routes with less than 8-months service. The SkyWest-owned ExpressJet also operates for the three mainline carriers and it has a still higher seasonality score typically operating routes for just 6-months. While regional affiliates like SkyWest that serve several mainline carriers have flexibility in rostering staff between the different affiliate networks, they do not have the ability to redeploy aircraft in the short run[11].

Figure 6 shows overlap among the regional carrier networks operating under the Delta brand, although the smaller partners Compass (CP), GoJet (G7) and Republic Airlines (YX) networks are built around different subsets of hubs: Compass around Minneapolis (MSP), Salt Lake City (SLC) and Los Angeles (LAX); GoJet around Detroit (DTW), Minneapolis (MSP) and New York (JFK) and Republic Airlines around New York La Guardia (LGA), Detroit (DTW) and Boston (BOS). Over half of the routes

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[10] Delta Air Lines has an agreement to fill 35% of pilot vacancies from the regional affiliate pilot pool (see the 2014 document 'Endeavor-to-Delta Pilot Hiring Program & Commitment' at http://www.endeavorair.com/documents/EtD_Hiring_Program_Overview_61314.pdf). Delta Air Lines argue that their commitment to regional affiliate pilots is not a 'flow through' programme, as Endeavor pilots may not return to the regional carrier, nor may Delta pilots flow down to Endeavor Air as a right.
In light of the global pilot shortage in 2017/18, and the expected retirement of a significant share of Delta Air Lines pilots between 2018 and 2027, Delta is likely to retain ownership of its regional carrier (see for example Reuters (June 6th 2018) "*Airlines Struggle with global pilot shortage*", Jamie Freed, Chayut Setboonsarng, Allison Lampert, accessed July 2018: www.reuters.com/article/us-airlines-iata-pilots-analysis/airlines-struggle-with-global-pilot-shortage-idUSKCN1J20XK ; Financial Times (May 10th 2018) "*China buys up flying schools as pilot demand rises*", Jamie Smyth & Ben Bland, accessed July 2018: www.ft.com/content/448b059e-4ea4-11e8-9471-a083af05aea7). Delta Air Lines estimated that 10,000 current pilots would retire between 2015 and 2025 (see 2014 Delta Air Lines document referenced in footnote 8).

[11] Large regional carriers like SkyWest do operate several non-branded aircraft that can be taken into service on an ad hoc basis for any mainline partner in order to avoid cancellation or schedule disruption due to technical or maintenance issues. Generally however, the mainline contract will dictate that services are provided on branded aircraft with 'branded' crew. According to the 2018 SkyWest Annual Report, 87.8% of all passenger revenues were fixed-fee contract flights (where the mainline carrier compensates the regional carrier for the costs of owning or leasing aircraft on a monthly basis).

operated by all of affiliates also receive some service from the mainline Delta Air Lines, with 40-50% of affiliate routes having two or more Delta carriers operating at some stages during the year. The contracts with Compass Airlines and GoJet Airlines (both part of Trans State Holdings) and Republic Airlines are for smaller sets of routes and involve typically less than 6 months of service as seen in the table in Figure 6.

The United Airlines network is the largest in terms of airports served and has a higher degree of spatial concentration compared to other carriers. United expanded its domestic network from 125 airports in 2011 to 189 airports in 2017. The United Airlines group of carriers consisted of 9 independent regional affiliates supporting the mainline carrier domestic operations in 2017. The two SkyWest Group carriers, SkyWest (OO) and Expressjet (EV) provided 30% of United's domestic departure movements in 2017 (14% of available seats) and operated to 172 and 161 airports respectively. Table 5 shows the number of carriers operating on each regional affiliates routes under the United brand. For SkyWest, 36% of the available seating capacity was performed on routes where it was the only carrier. This is the highest recorded for any regional carrier. However for 83% of the routes that it operated, the mainline United Airlines performed some service during 2017.

Figure 7 shows the extensive networks operated by both regional carriers centred on multiple United hubs. The smaller regional partners have networks focused on just one or two hubs; Air Wisconsin began operating flights under the United Express brand in mid-September 2017 and operates 50-seater CRJ-200 aircraft. The mainline United Airlines carrier overlaps with the regional affiliates to a much greater extent than with the other groups and reflects the fact that United does not wholly own any regional partners and will deploy larger aircraft when the route characteristics support mainline service. This also explains the low average number of months of operation for the mainline carrier recorded in Table 3 and slightly higher temporal Gini index value.

The spatial concentration is significantly higher for the mainline United Airlines traffic distribution compared to other carriers and indicates a concentration of capacity around a relatively small set of heavily trafficked corridors. The regional affiliates have enabled United to rapidly expand its domestic network to smaller US cities without committing to acquisition of new fleets and labour resources. However the pilot shortage may be problematic for United Airlines in the next few years as it does not have the possibility of 'flow through' arrangements for sourcing regional carrier pilots transferring to the mainline operation. United Airlines has a maximum number of regional affiliate 76-seater aircraft specified as part of its 2012 scope clause and this limit was reached in December 2017. One possibility discussed in the industry journals is that United may purchase a regional carrier in order to facilitate further service expansion and boost the pipeline of pilots[12].

The mergers of Delta Air Lines with Northwest Airlines in 2009 and United Airlines with Continental Airlines in 2010 gave rise to streamlining of mainline and regional affiliate operations. Both carriers have reduced the number of partner regional affiliates during the 2010s through contract renewal processes and given the consolidation among regional carriers described earlier. The more recent

[12] Continental Airlines once owned ExpressJet which currently operates as a United regional partner and is part of the SkyWest group of carriers. American Airlines ended its contract with ExpressJet during 2018 as did Delta Air Lines, leaving United as the exclusive partner from 2019. Bloomberg reported in December 2017 that United was exploring the possibility of acquiring ExpressJet: (8 December 2018): "*United Express investing in Regional Airline ExpressJet*", Michael Sasso, accessed July 2018: www.bloomberg.com/news/articles/2017-12-08/united-is-said-to-mull-investing-in-regional-airline-expressjet .

merger of American Airlines with US Airways in 2013 will result in a reduction in the number of regional partners in the coming years.

The American Airlines group of carriers is the largest grouping in terms of number of affiliate partners with 10 regional affiliates supporting the mainline domestic operation in 2017, three of which were wholly-owned subsidiaries[13]. A relatively small proportion of routes operated by the affiliates are single carrier, with most routes having 2, 3 or 4 other carriers operating at some stage during the year. The mainline carrier operates the highest share of single carrier routes in the group at 18%.

Table 5 shows that for a large proportion of affiliate-operated routes, either the mainline carrier or another American Eagle partner operates at some stage during the year. On many of these category of routes, the mainline carrier may only deploy a very small number of flights in a given month or indeed over the course of the year. What emerges from detailed scrutiny of the routes data is that the mainline carrier may deploy larger aircraft on affiliate routes for particular or seasonal events (such as holidays or sports events) and leave the affiliate to provide service in other months when demand is lower[14]. Small adjustments to service levels can be made using other regional affiliates in the group; larger capacity adjustments are made using mainline aircraft capacity. The affiliates can be deployed on routes to supplement service (and increase frequency) as demand varies; these adjustments vary by route and day, presumably based on flight bookings. Yield management techniques have been lauded in the literature as a source for better management of pricing and allocation of seating capacity ahead of departures. Deployment of aircraft and execution of the schedule is as important in achieving optimum revenue and resource management and the regional affiliate contracts give the mainline carriers greater scope to do this.

For routes where the mainline carrier provides significant capacity all year round, the regional affiliates may be used to supplement these services and offer the possibility of fine tuning the extent to which additional capacity can be deployed across the network: the range of aircraft operated by the affiliates (reflected in the average number of seats per movement in the tables) shows that the airline has greater flexibility in matching capacity to variation in demand. The improvements in capacity allocation are evident from the significant improvements in load factors experienced by the larger carriers in the 2010s and this supports earlier research examining efficiency and productivity changes.

Figure 8 shows that there is a certain degree of regional specialisation in the affiliate carrier networks, though the larger partners have extensive networks focused around multiple hubs and centres. In Figure 8, the smaller American partners have more focused networks concentrated around particular hubs: Compass Airlines at Los Angeles (LAX), ExpressJet (EV) at Dallas-Fort Worth (DFW) and Trans State Airlines (AX) at La Guardia (LGA) and Washington Dulles (DCA). The American Airlines contract with Compass Airlines came about because of a dispute with the pilots at Envoy Air in 2014 relating to the number of regional aircraft purchased and operated by the wholly-owned affiliate. During 2018, American Airlines cut back on the number of regional affiliates ending its contract with Air Wisconsin, migrating its service arrangement with ExpressJet to SkyWest and shifting service provided by Trans

[13] Piedmont Airlines and PSA Airlines were USAir wholly-owned carriers; American Eagle was the regional affiliate of American Airlines before the 2013 merger and became Envoy Air from 2014. Extensive contracts, agreements and programmes were in place governing relationships between the mainline carriers and regional partners prior to the merger. As these expire or come up for renewal, the mainline carrier is expected to gradually streamline and reorganise service provision across its domestic network.

[14] The weekly schedules for a number of routes were compared over several months to understand why multiple carriers from the same airline group were providing service.

State Airlines to Envoy Air[15]. When compared with Delta and United, American Airlines is at an earlier stage of reorganisation of the sets of airlines that came together in the 2013 merger.

Conclusions

Regional carriers have experienced strong traffic growth during the last decade and emerged as an increasingly important group of airlines serving the US domestic market, with c45% of departures by the three largest full service carrier domestic operations being provided by regional carrier affiliates. The utilisation of regional jets has extended the range and scope of regional carrier operations and via partnership arrangements, regional jet service is increasingly being deployed as an efficient means to enable new services or supplement, augment or substitute for larger jet service when demand conditions vary. The partnership arrangements in place between the three largest US full service carriers and their regional affiliates allows for service a greatly increased hierarchy of air transport communities. Passenger feed at mainline hubs is important in sustaining frequent long haul North American and global routes. The regional affiliates facilitate the mainline brands maintaining a 12-month presence in small and medium-sized communities throughout the year and contribute to passenger feed at the main hubs, despite seasonal fluctuations in demand.

There is a high degree of sophistication in the co-ordination of mainline and regional partner service schedules, with adjustments being made to daily route flight operations in some cases to better match demand profiles. The result has been more efficient use of the mainline carrier capacity, with higher load factors and low levels of seasonal variation in overall traffic patterns compared to other global regions. The cost advantages for the mainline carriers have been examined in other studies: this study has focused on the network characteristics and seasonal variations in service provision to present supporting evidence of the sources of the improved efficiency and productivity in recent years in the airline industry. There is also an important environmental impact when capacity is more efficiently utilised by scheduling more appropriately-sized aircraft to cater for the variability in air transport demand.

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Table 1 Average population of air transport communities for major regions and hub types[1] in 2015

IATA/ICAO Region	Large Hub	Medium Hub	Small Hub	Non-hub 'A'	Non-hub 'B'	Non-hub 'C'	Average for region
Africa (AF)	2,576,220	1,011,142	372,920		209,307	70,433	587,116
Asia (AS)	7,749,732	2,681,584	850,734	439,460	314,056	124,408	962,677
Europe (EU)	2,358,831	813,727	382,665	219,958	136,902	105,486	389,538
Latin America (LA)	3,921,544	849,151	427,915	183,557	194,455	64,580	598,274
Middle East (ME)	1,904,106	828,383	325,665	161,303	234,413	173,228	632,931
North America (NA)	1,333,028	461,868	158,670	68,781	48,144	90,624	199,773
Southwest (SW)	1,150,177	75,945	24,220		29,864	23,335	198,467
Average per hub type	3,104,298	1,131,526	456,197	267,258	187,128	92,019	566,948

Reproduced from Reynolds-Feighan (2017) and based on OAG global air transport schedules in 2015

[1] Hub Classification Scheme used to categorise air transport communities (Reynolds-Feighan, 2017)

Traffic criterion	*Hub Type*
1% or more of annual departure movements	Large
At least 0.25%, but less than 1% of annual departure movements	Medium
At least 0.05%, but less than 0.25% of annual departure movements	Small
More than 500 but less than 0.05% of annual departure movements	Non-Hub - Type A
Between 10 and 499 annual departure movements	Non-Hub - Type B
Less than 10 annual departure movements	Non-Hub - Type C

Table 2: Summary operating statistics for regional airlines providing feeder services to mainline carriers in 2017

Regional Carrier	Carrier Code[2]	Number of Airports Served	Available Seats (Non-stop Segment)	Departure Movements (Non-stop)	Routes (Non-stop airport pairs)	Mainline Affiliations
SkyWest Airlines Inc.	OO	251	34,599,613	587,059	903	AA DL UA AS
ExpressJet Airlines Inc.	EV	203	19,964,743	358,266	726	AA DL UA
Republic Airlines	YX	102	18,798,768	254,708	544	AA DL UA
Endeavor Air Inc.	9E	152	15,060,465	232,673	390	DL
Envoy Air	MQ	151	15,035,229	256,175	256	AA
Mesa Airlines Inc.	YV	120	10,896,960	146,442	154	AA UA
Compass Airlines	CP	72	7,401,723	97,558	151	AA DL
GoJet Airlines	G7	99	6,690,780	95,013	253	DL UA
Air Wisconsin Airlines Corp	ZW	100	4,636,200	92,724	230	AA UA
Trans States Airlines	AX	99	4,397,550	87,951	210	AA UA
Piedmont Airlines	PDT	54	2,065,050	41,301	69	AA
CommutAir[3]	C5	33	1,239,650	24,793	53	UA
Horizon Air	QX	29	593,104	7,804	42	AS
Shuttle America[1]	S5	44	303,811	4,209	102	DL UA

Source: OAG Schedules, 2017

Mainline codes: American Airlines (AA); Delta Air Lines (DL); United Airlines (UA); Alaskan Airlines (AS)

1/ Merged with Republic in Jan 2017; Shuttle America brand and code were discontinued from February 2017.

2/ Carrier codes used by OAG are generally the IATA carrier code, though in some cases (such as Piedmont Airlines) the ICAO codes are used.

3/ United Continental Airlines Holdings owned 40% of CommutAir in 2017

Table 3: Regional feeder characteristics for each of the three largest mainline carriers and Southwest Airlines in 2017

Carrier (wholly owned subsidiaries italicised)	**OAG Carrier Code**	FAA Hubs Served by Type				Total Number of **US** Airports Served	**Number of Airports Served**		**Share of Group Total Domestic Available Seats**	**Share of Group Total Domestic Departure Movements**	**Temporal Gini[3] For Domestic Network in 2017**		**Average No. Months Ops[4]**	**Average Seats Per Movement**	**Spatial Gini – 2017: Available Seats**
		L (30)	**M** (31)	**S** (72)	**N 249**		Least Busy Month	Busiest Month			**Available Seats**	**Weighted average across all routes**			
American Airlines	**AA**	**29**	**27**	**36**	**11**	**106**	**92**	**100**	**69%**	**47%**	**0.013**	**0.096**	**10.2**	**160**	**0.78**
PSA Airlines, Inc	JIA	12	18	37	33	101	86	94	7%	12%	0.016	0.133	8.8	66	0.68
Envoy Air	MQ	15	18	47	66	151	114	134	7%	13%	0.025	0.154	8.3	59	0.73
Republic Airline	YX	16	18	23	6	65	48	54	5%	7%	0.014	0.169	7.5	76	0.70
Mesa Airlines	YV	6	17	33	35	94	59	74	4%	5%	0.021	0.153	7.5	76	0.75
SkyWest Airlines	OO	12	16	34	40	107	59	90	3%	5%	0.088	0.149	8.0	61	0.69
Air Wisconsin	ZW	11	12	29	20	78	39	72	2%	4%	0.117	0.253	6.1	50	0.72
Compass Airlines	CP	8	6	6	2	23	18	21	1%	2%	0.027	0.097	10.3	76	0.66
Piedmont Airlines	PDT	6	10	23	12	54	25	48	1%	2%	0.173	0.230	6.1	50	0.70
ExpressJet	EV	3	2	12	35	54	17	46	1%	1%	0.077	0.213	5.5	59	0.77
Trans State Airlines	AX	4	11	19	5	41	17	34	1%	1%	0.060	0.138	5.6	50	0.73
Delta Air Lines	**DL**	**30**	**29**	**56**	**39**	**162**	**145**	**148**	**76%**	**56%**	**0.031**	**0.120**	**9.1**	**159**	**0.79**
SkyWest Airlines	OO	26	24	48	87	198	143	171	8%	15%	0.038	0.215	7.9	59	0.68
Endeavor Air	9E	21	20	43	57	152	97	125	7%	13%	0.021	0.249	7.5	65	0.75
ExpressJet	EV	16	20	39	46	125	71	109	4%	7%	0.121	0.263	6.2	65	0.73
Compass Airlines	CP	20	12	15	10	65	23	45	2%	3%	0.020	0.244	5.2	76	0.76
GoJet Airlines	G7	20	16	24	10	72	37	52	2%	3%	0.038	0.304	5.5	71	0.76
Republic Airline	YX	16	16	15	3	50	18	37	2%	2%	0.134	0.259	4.8	72	0.82
Shuttle America	S5	13	11	6		30	30	30	0%	0%	1/		1.0	73	0.72
United Airlines	**UA**	**29**	**29**	**46**	**35**	**189**	**84**	**115**	**76%**	**51%**	**0.042**	**0.154**	**5.8**	**168**	**0.88**
ExpressJet	EV	22	20	49	53	161	92	114	7%	16%	0.056	0.229	6.3	49	0.78
SkyWest Airlines	OO	19	25	45	67	172	104	112	7%	14%	0.015	0.287	7.7	54	0.75
Republic Airline	YX	18	20	34	8	86	52	61	3%	5%	0.041	0.379	7.5	70	0.73
GoJet Airlines	G7	10	14	29	12	67	42	49	2%	3%	0.027	0.349	8.5	70	0.71
Trans State Airlines	AX	8	15	37	28	92	54	68	2%	5%	0.020	0.320	7.9	50	0.72
Mesa Airlines	YV	8	13	15		39	29	33	2%	3%	0.032	0.260	11.2	70	0.67
CommutAir[5]	C5	3	7	19	4	33	17	28	1%	2%	0.116	0.347	8.7	50	0.64
Air Wisconsin	ZW	2	4	27	19	52	10	44	0%	1%	0.749 2/		2.3	50	0.70
Shuttle America	S5	9	11	11		32	30	30	0%	0%	1/		1.0	70	0.67
Southwest Airlines	**WN**	**24**	**29**	**32**	**3**	**88**	**87**	**88**	**100%**	**100%**	**0.019**	**0.072**	**10.35**	**149**	**0.59**

1 S5 (Shuttle America) merged with Republic Airlines (YX) on January 31st 2017. Shuttle America brand and code were discontinued from February 2017

2 Air Wisconsin began operating services for United Airlines in September 2017

3 Temporal Gini Index is calculated in 2 ways: (i) monthly available seats across all of the routes in the regional affiliate network (ii) weighted average of individual route temporal Gini Index scores for affiliate routes under the mainline brand

4 Simple average number of months of operation across all routes in carrier network in 2017

5 United Continental Airlines Holdings owned 40% of CommutAir in 2017

Table 4: Delta Air Lines Domestic System : share of available seats on regional affiliate routes and number of routes by number of competitors, and number of carriers *within the Delta Air Lines Group* operating on routes also operated by regional affiliate indicated, 2017

Delta Air Lines, 2017																	
Operating Carrier[1]	**Number of Carriers Per Route (% of total Seats Available)[2]**						**Number of Carriers Per Route[2]**						**Total Routes**	**Routes where mainline DL also serves at some stage during year (%)**	**Routes with one other DL Carrier (including mainline)**	**Routes with 2 other DL Carriers (including mainline)**	**Routes with 3 other DL Carriers (including mainline)**
	1	**2**	**3**	**4**	**5**	**6 +**	**1**	**2**	**3**	**4**	**5**	**6+**					
9E[4]	1%	14%	21%	23%	16%	25%	**12**	**146**	**215**	**165**	**105**	**137**	**780**	**58%**	**24%**	**29%**	**23%**
CP	0%	4%	17%	13%	13%	53%	1	34	51	30	42	98	256	78%	29%	35%	7%
EV	2%	11%	32%	28%	8%	18%	15	80	134	101	83	114	527	64%	16%	27%	23%
G7	0%	2%	14%	15%	21%	48%	3	14	52	67	67	103	306	65%	8%	18%	24%
OO	22%	21%	20%	10%	10%	17%	121	145	144	105	83	138	736	55%	38%	24%	17%
S5[3]	0%	3%	3%	26%	14%	55%		8	17	17	24	55	121	69%	12%	10%	19%
YX	0%	3%	8%	26%	11%	52%	1	17	41	45	42	83	229	57%	15%	26%	20%
DL mainline	11%	20%	23%	20%	12%	15%	**233**	**289**	**262**	**195**	**133**	**179**	**1291**				

1 Operating carrier is the carrier operating the flight service under a DL flight code in 2017
2 Number of Competitors indicates the number of other carriers operating at any stage during 2017 on routes operated by the regional affiliate indicated
3 S5 (Shuttle America) merged with Republic Airlines (YX) on January 31st 2017
4 Wholly-owned DL subsidiary

Table 5: United Airlines Domestic System: share of available seats on regional affiliate routes and number of routes by number of competitors, and number of carriers *within the United Airlines Group* operating on routes also operated by regional affiliate indicated, 2017

United Airlines, 2017																	
Operating Carrier[1]	**Number of Carriers Per Route (% of total Seats Available)[2]**						**Number of Carriers Per Route[2]**						Total Routes	**Routes where mainline UA also serves at some stage during year (%)**	**Routes with one other UA Carrier (including mainline)**	**Routes with 2 other UA Carriers (including mainline)**	**Routes with 3 other UA Carriers (including mainline)**
	1	**2**	**3**	**4**	**5**	**6 +**	**1**	**2**	**3**	**4**	**5**	**6+**					
AX	7%	15%	23%	11%	21%	23%	9	38	66	44	59	96	312	83%	3%	17%	15%
C5[4]	4%	10%	35%	39%	12%	0%	4	12	33	42	15		106	100%	0%	2%	48%
EV	16%	19%	25%	19%	11%	9%	356	101	107	85	62	104	815	84%	29%	12%	32%
G7	0%	0%	20%	6%	14%	60%	2	3	28	12	46	108	199	89%	4%	6%	27%
OO	36%	15%	15%	10%	8%	16%	151	91	114	84	73	162	675	83%	33%	10%	28%
S5[3]	0%	1%	16%	13%	10%	62%		3	7	19	9	45	83	97%	3%	8%	32%
YV	0%	11%	41%	27%	15%	6%		8	29	23	14	2	76	97%	21%	46%	5%
YX	1%	4%	24%	20%	10%	41%	9	34	103	89	60	148	443	94%	9%	12%	41%
ZW	0%	9%	19%	29%	20%	22%	2	13	25	32	28	39	139	59%	15%	4%	16%
UA mainline	10%	19%	18%	23%	11%	18%	788	334	260	200	123	208	1913				

1 Operating carrier is the carrier operating the flight service under a UA flight code in 2017

2 Number of Competitors indicates the number of other carriers operating at any stage during 2017 on routes operated by the regional affiliate indicated

3 S5 (Shuttle America) merged with Republic Airlines (YX) on January 31st 2017

4 United Continental Airlines Holdings owned 40% of CommutAir in 2017

Table 6: American Airlines Domestic System : share of available seats on regional affiliate routes and number of routes by number of competitors, and number of carriers *within the American Airlines Group* operating on routes also operated by regional affiliate indicated, 2017

American Airlines, 2017																	
Operating Carrier[1]	**Number of Carriers Per Route (% of total Seats Available)[2]**						**Number of Carriers Per Route[2]**						**Total Routes**	**Routes where mainline AA also serves at some stage during year (%)**	**Routes with one other AA Carrier (including mainline)**	**Routes with 2 other AA Carriers (including mainline)**	**Routes with 3 other AA Carriers (including mainline)**
	1	**2**	**3**	**4**	**5**	**6 +**	**1**	**2**	**3**	**4**	**5**	**6+**					
AX	4%	3%	23%	15%	28%	28%	2	5	24	26	17	33	107	13%	11%	27%	41%
CP	0%	7%	5%	17%	5%	67%		7	7	7	2	22	45	31%	93%	7%	0%
EV	1%	63%	28%	7%	0%	1%	2	58	28	18		4	110	18%	42%	38%	18%
JIA[3]	**15%**	**30%**	**28%**	**12%**	**7%**	**7%**	**59**	**86**	**97**	**76**	**34**	**45**	**397**	34%	34%	29%	26%
MQ[3]	**11%**	**24%**	**13%**	**9%**	**8%**	**34%**	**40**	**149**	**99**	**63**	**41**	**120**	**512**	28%	58%	26%	11%
OO	11%	18%	12%	6%	10%	42%	30	48	37	23	28	84	250	23%	75%	16%	8%
PDT[3]	**14%**	**24%**	**19%**	**33%**	**4%**	**6%**	**16**	**37**	**31**	**31**	**13**	**10**	**138**	27%	32%	20%	27%
YV	3%	37%	41%	18%	0%	1%	15	100	74	36		6	231	48%	50%	40%	9%
YX	4%	14%	16%	34%	13%	19%	23	72	93	101	46	81	416	47%	38%	23%	28%
ZW	2%	28%	27%	28%	8%	6%	8	77	79	79	35	43	321	24%	26%	27%	32%
AA mainline	**18%**	**20%**	**22%**	**16%**	**8%**	**15%**	**238**	**222**	**213**	**154**	**75**	**122**	**1024**				

1 Operating carrier is the carrier operating the flight service under an AA flight code in 2017
2 Number of Competitors indicates the number of other carriers operating at any stage during 2017 on routes operated by the regional affiliate indicated
3 Wholly owned AA subsidiary

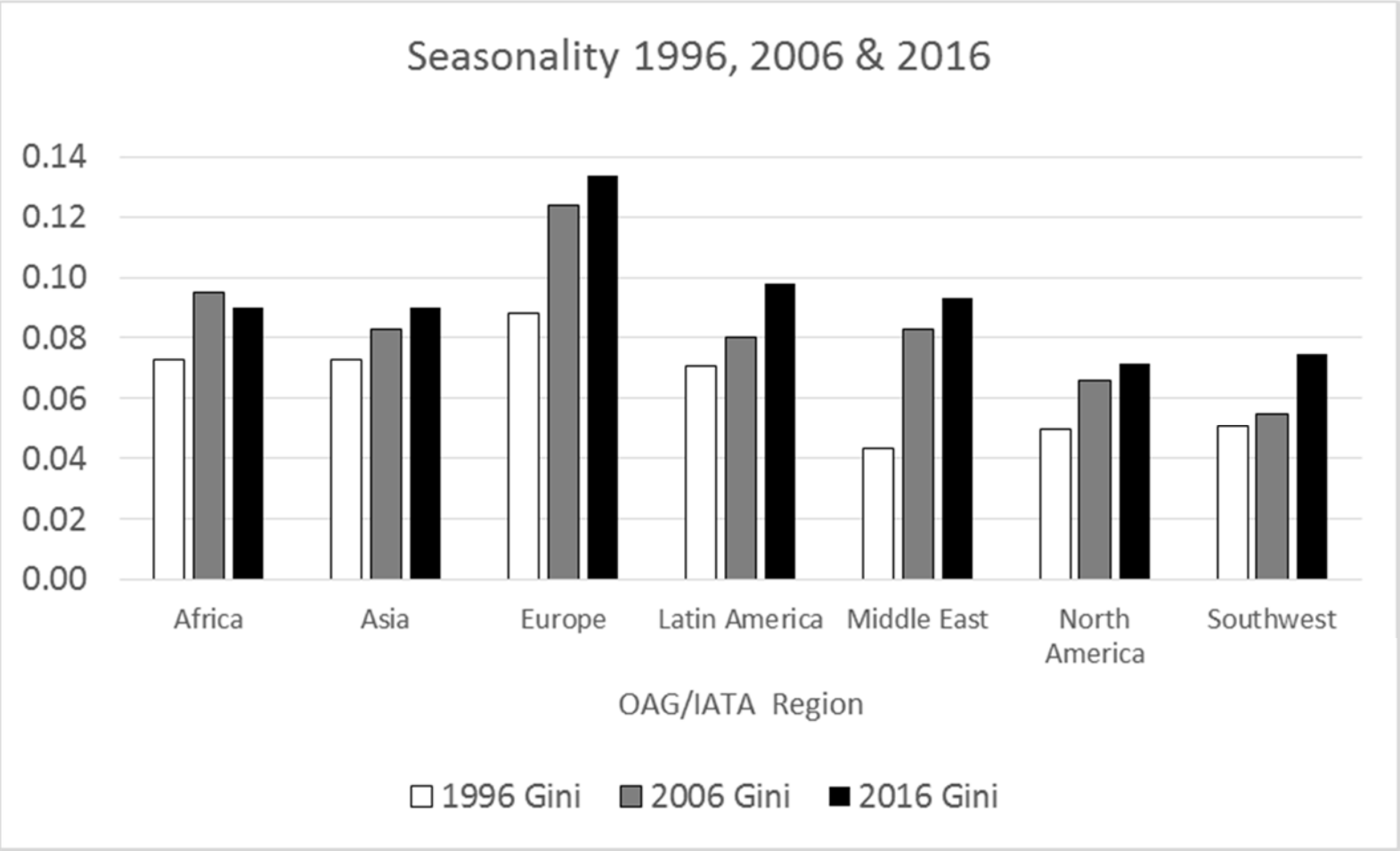
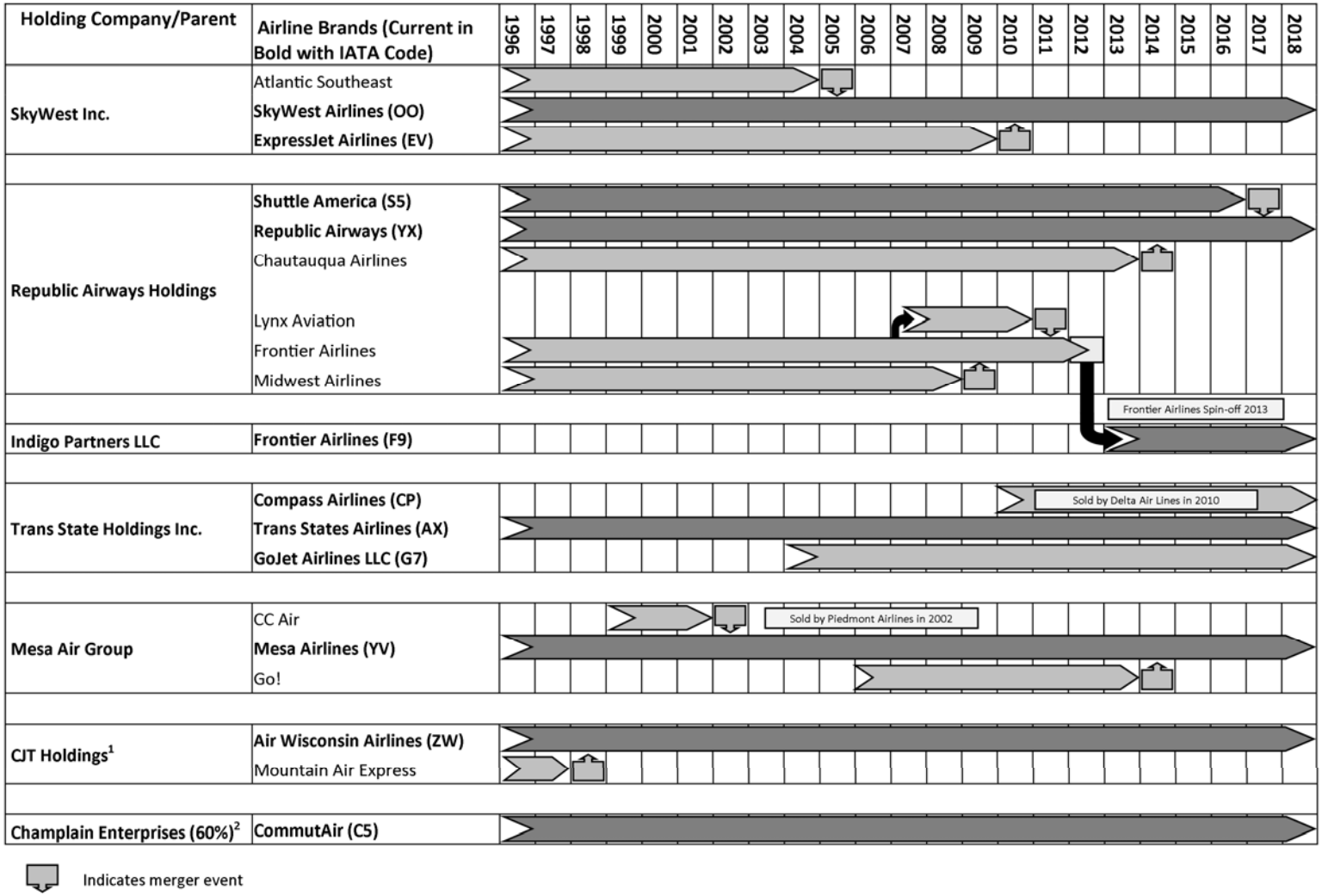


Figure 1: Comparison of seasonality in air traffic flows for major continental regions for selected years as measured by temporal Gini index scores



1/ Air Wisconsin Airlines Corporation (ZW) is the regional airline owned by CJT Holdings. Air Wis Services Inc. and Air Wisconsin Inc. are wholly owned subsidiaries of United Continental Holdings Inc. United Airlines owned Air Wisconsin between 1990 and 1993 and retained the company name after it was sold to CJT Holdings (United Continental Holdings Inc. Annual Report, 2018).
2/ Champlain Enterprises owns 60% of CommutAir with United Airlines owning the other 40% (CommutAir website).

Figure 2: Mergers among largest regional carrier brands, 1996-2017

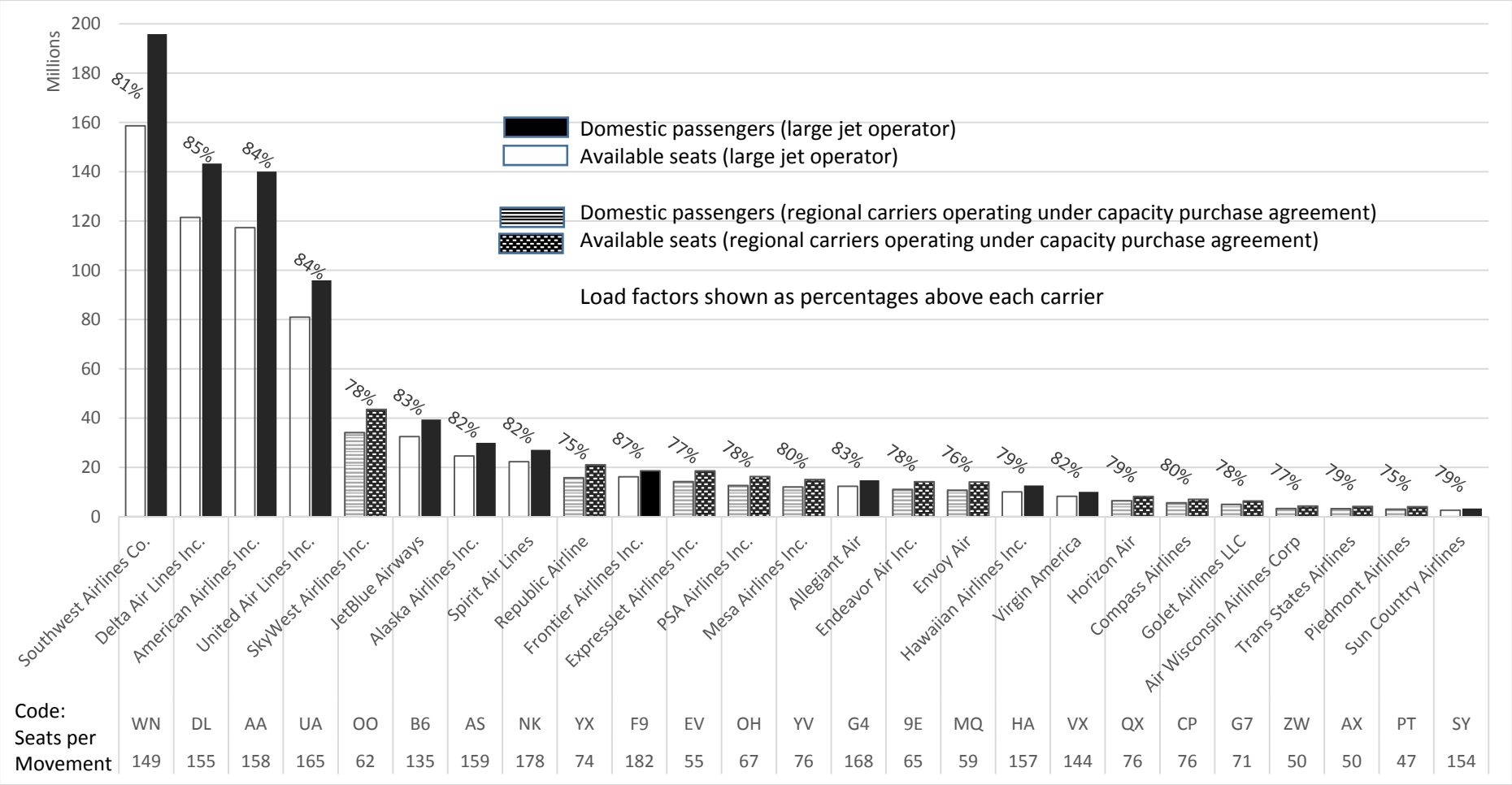


Figure 3: US Bureau of Transportation Statistics (BTS) ranking of the top 24 US carriers operating in 2017 (regional carriers operating under mainline flight codes are shown in shaded patterns)

Note: ranking is based on total number of passengers carried on non-stop domestic segments. Available seats and load factor are shown for each carrier, along with average number of seats per movement.

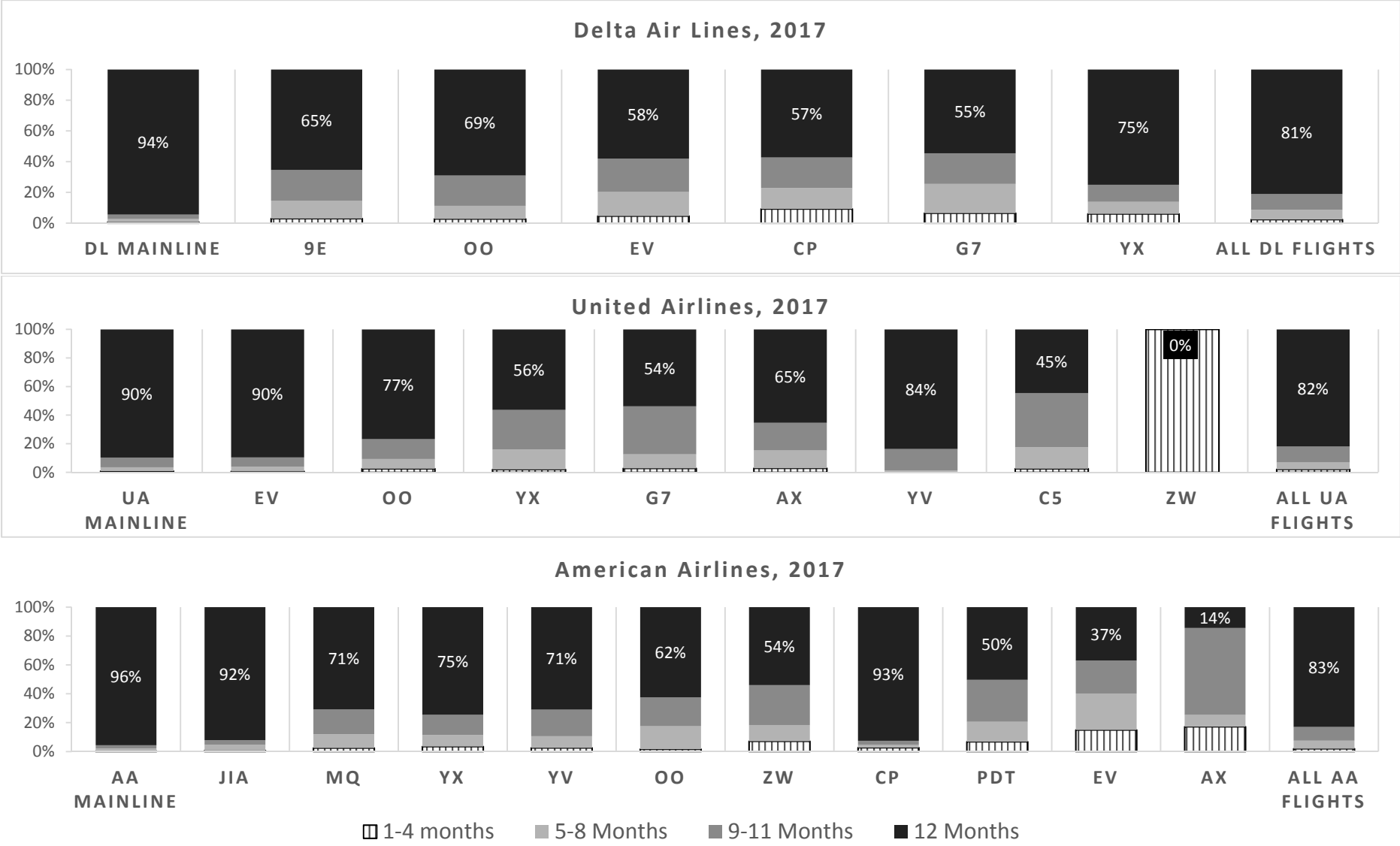


Figure 4: Service Continuity: share of departures for mainline and regional affiliates by number of months of service in 2017
Source: Compiled from OAG Schedules, 2017

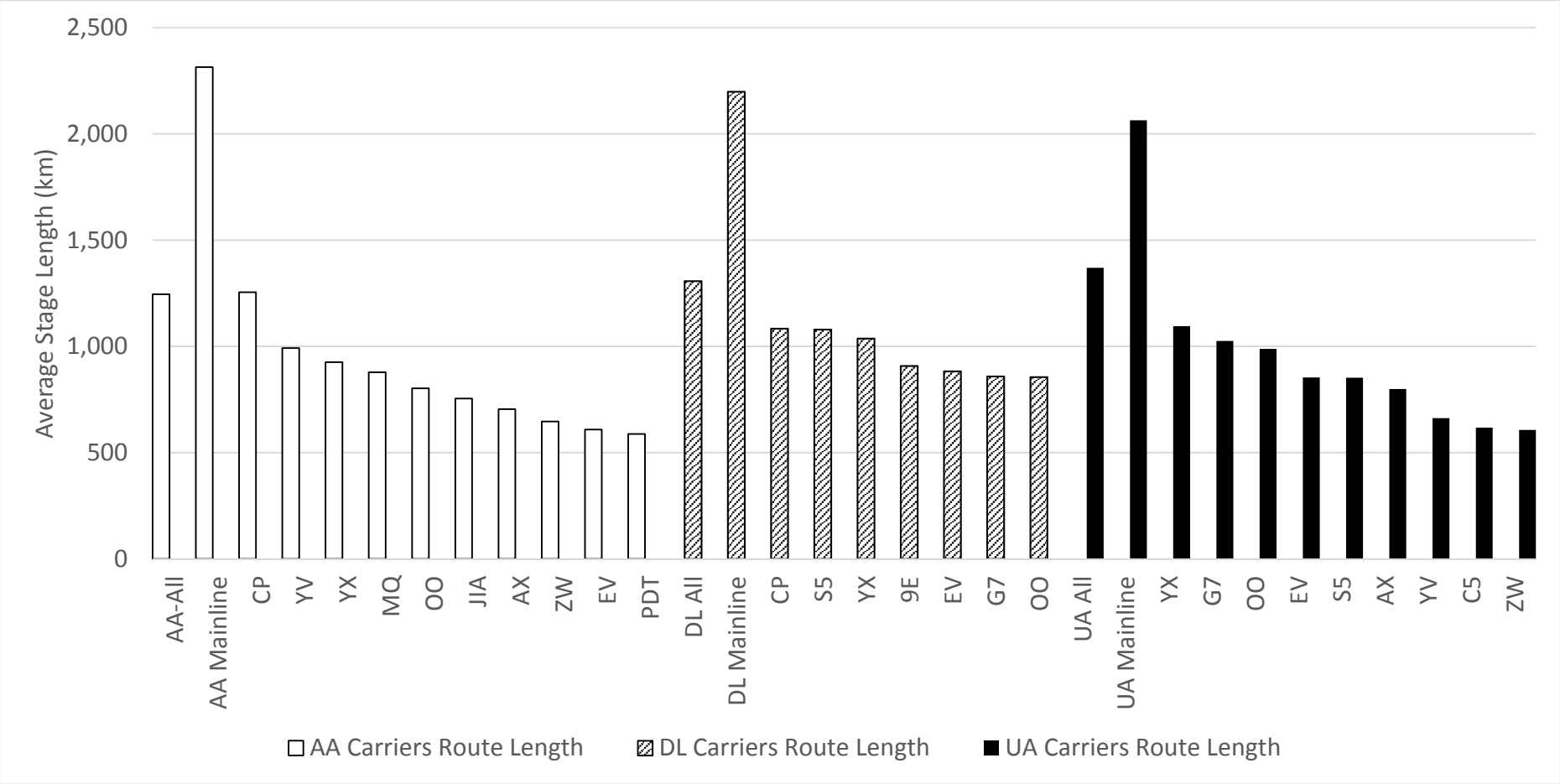
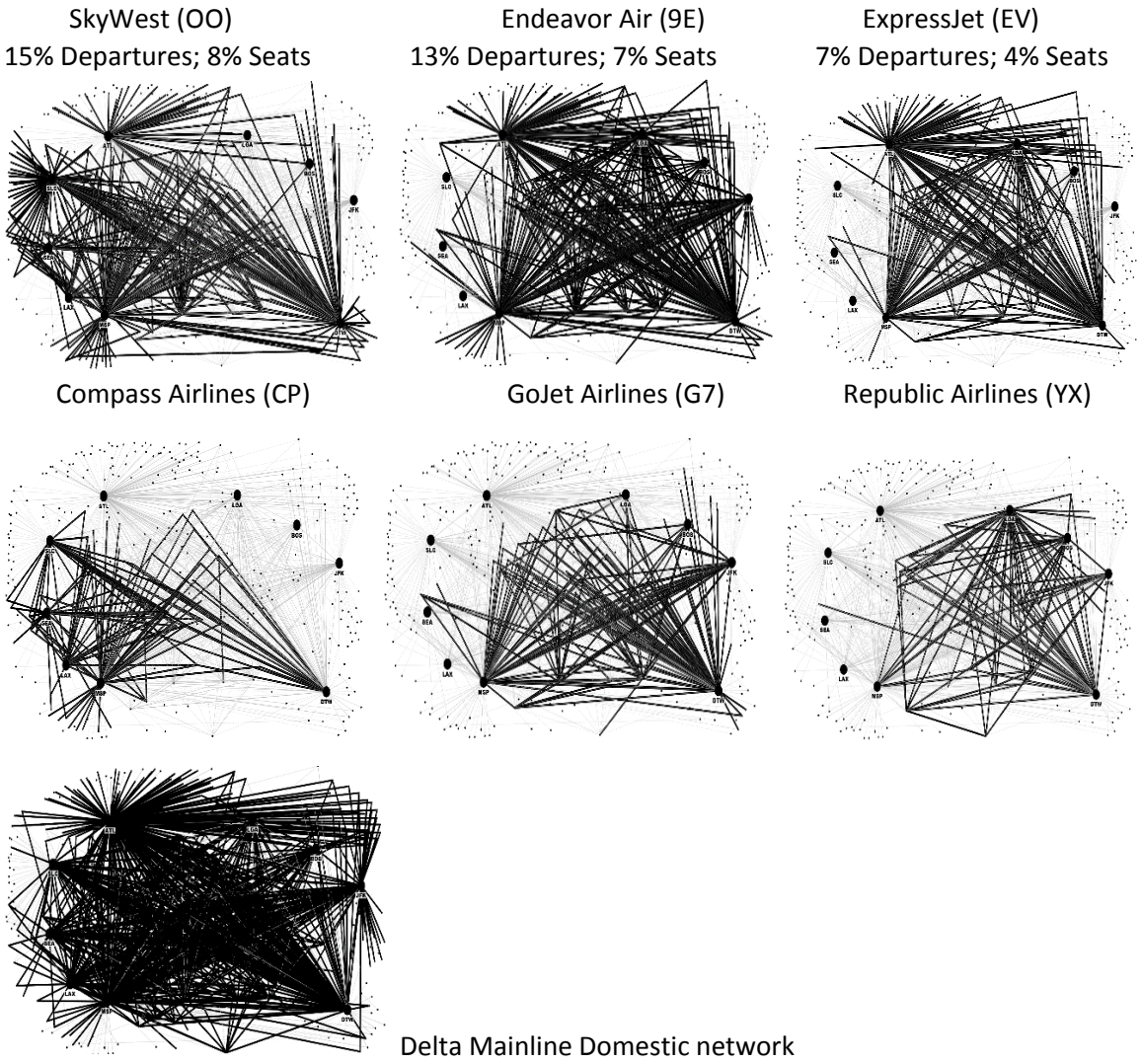


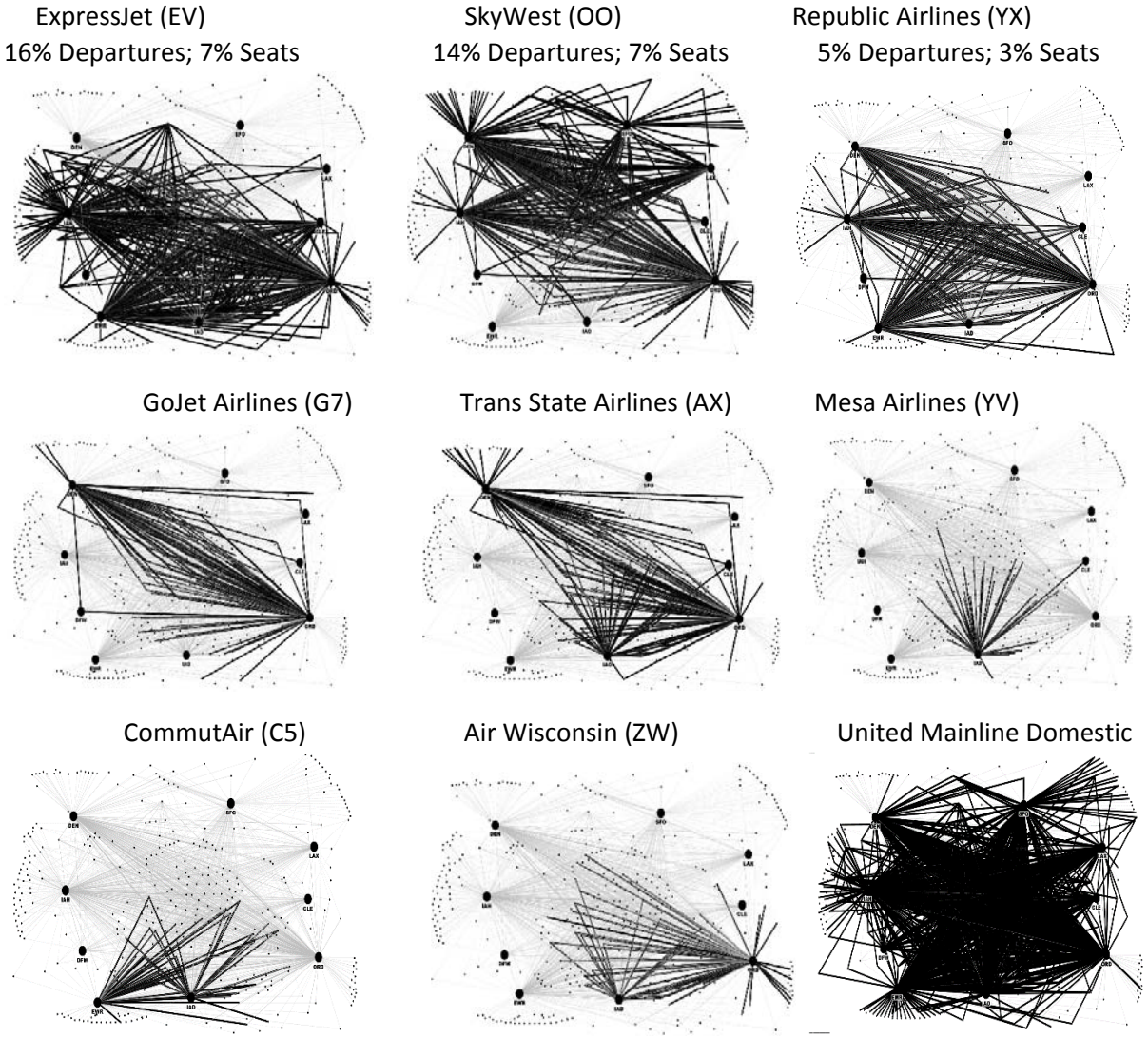
Figure 5: Average domestic segment stage length (km) for American Airlines, Delta Air Lines and United Airlines and regional affiliates, 2017



Affiliate Code	Main Hubs Served	Average Temporal Gini for all non-stop routes operated by the affiliate to the hub	Average Number of Months of Operations for Hub Routes	Number of Routes per Hub
9E	DTW	0.304	8.3	84
9E	MSP	0.275	7.5	79
9E	ATL	0.229	4.7	78
CP	MSP	0.240	4.0	39
CP	SLC	0.210	3.3	26
CP	LAX	0.189	8.4	23
EV	ATL	0.240	8.5	94
EV	DTW	0.307	5.1	67
EV	MSP	0.231	3.4	49
G7	DTW	0.271	6.7	61
G7	MSP	0.234	4.2	35
G7	JFK	0.224	4.8	21
OO	MSP	0.239	9.0	93
OO	DTW	0.241	9.1	81
OO	SLC	0.149	9.4	73
YX	LGA	0.224	5.5	44
YX	DTW	0.284	4.6	30
YX	BOS	0.167	4.8	17

Source: Compiled from OAG data using NodeXL

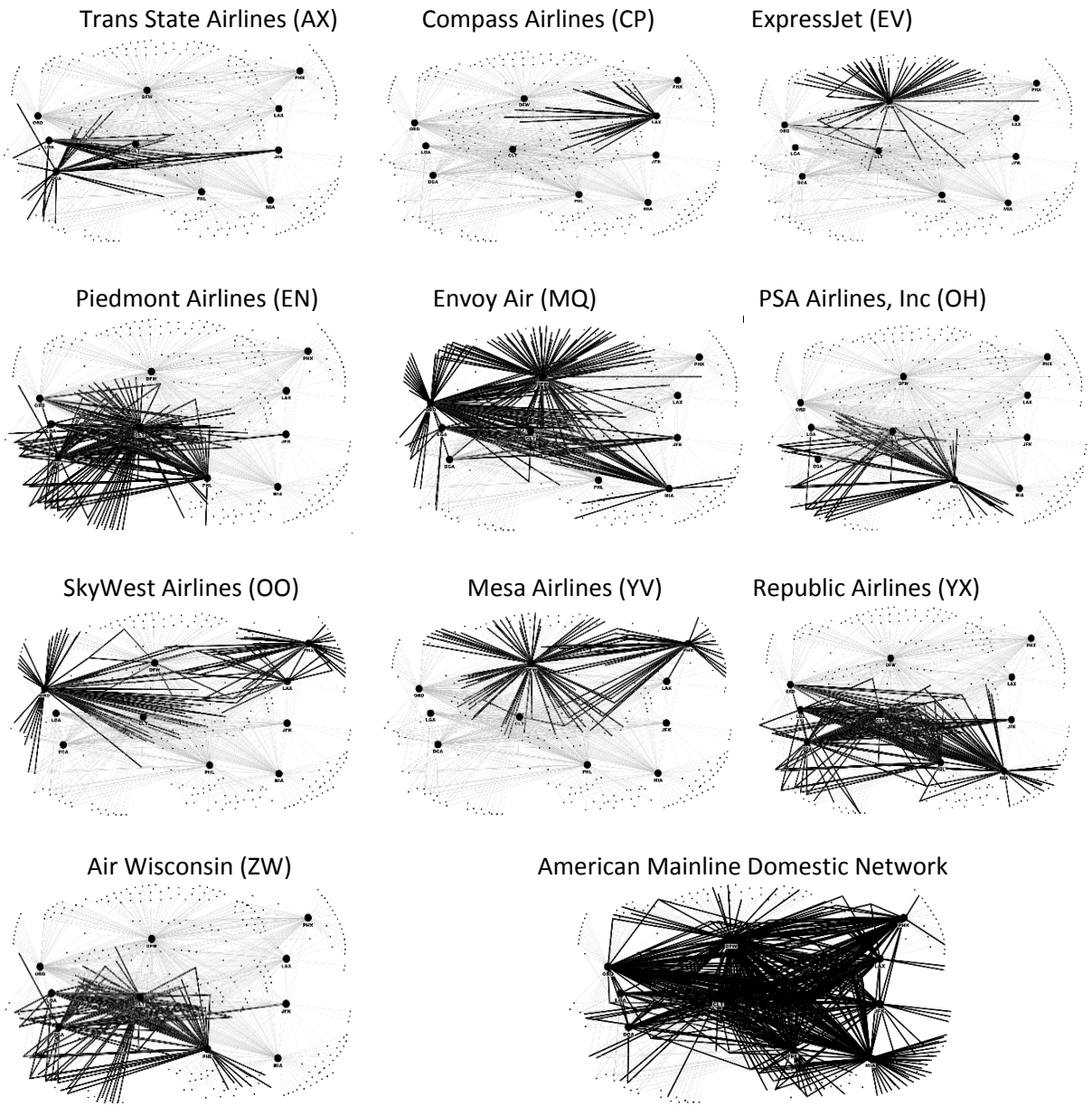
Figure 6: Diagrammatic representation of Delta Air Lines regional affiliates' networks in 2017



Source: Compiled from OAG data using NodeXL

Figure 7: Diagrammatic representation of United Airlines and regional affiliates' networks in 2017

Affiliate Code	Main Hubs Served	Average Temporal Gini for all non-stop routes operated by the affiliate to the hub	Average Number of Months of Operations for Hub Routes	Number of Routes per Hub
AX	ORD	0.297	7.7	63
AX	DEN	0.248	8.5	52
AX	IAD	0.360	7.4	41
C5	EWR	0.302	8.6	28
C5	IAD	0.352	8.8	26
EV	IAH	0.146	9.4	97
EV	ORD	0.270	9.1	93
EV	EWR	0.183	8.1	77
G7	ORD	0.335	8.1	60
G7	DEN	0.329	9.0	40
OO	DEN	0.274	8.8	97
OO	ORD	0.285	8.2	90
OO	IAH	0.360	5.9	58
YV	IAD	0.262	11.2	38
YX	ORD	0.330	7.1	60
YX	EWR	0.331	8.2	57
YX	IAH	0.334	8.7	53
ZW	ORD	0.160	2.2	47
ZW	IAD	0.200	2.6	22



Affiliate Code	Main Hubs Served	Average Temporal Gini for all non-stop routes operated by the affiliate to the hub	Average Number of Months of Operations for Hub Routes	Number of Routes per Hub
AX	DCA	0.166	7.0	31
AX	LGA	0.255	2.8	17
AX	JFK	0.244	6.8	5
CP	LAX	0.102	10.3	23
EV	DFW	0.235	5.5	50
EN	CLT	0.140	10.5	93
EN	DCA	0.158	9.0	55
EN	PHL	0.182	5.3	38
MQ	DFW	0.184	7.7	110
MQ	ORD	0.190	9.0	86
MQ	LGA	0.132	8.9	24
OO	ORD	0.180	8.2	71
OO	PHX	0.108	7.2	35
OO	LAX	0.143	9.1	15
OH	PHL	0.225	7.4	51
OH	CLT	0.079	2.3	12
YV	DFW	0.165	7.7	81
YV	PHX	0.150	7.7	39
YX	MIA	0.149	8.7	49
YX	DCA	0.188	8.7	48
YX	PHL	0.215	8.4	43
ZW	PHL	0.242	7.6	55
ZW	DCA	0.304	6.4	41
ZW	CLT	0.249	5.3	40

Source: Compiled from OAG data using NodeXL

Figure 8: Diagrammatic representation of American Airlines and regional affiliates' networks in 2017 and characteristics of main hubs served