



# A DATA SCIENCE PERSPECTIVE ON EUROPEAN AVIATION: MEASURING SCHEDULING ASYMMETRY ACROSS CARRIER TYPES

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## Abstract:

Structured aviation datasets increasingly enable empirical analysis of airline behavior at the route level. While prior research on European aviation has addressed pricing, network topology, and connectivity, the temporal dimension of route operation, specifically how flights are distributed across the days of the week, remains underexplored as a measurable feature. This research presents a data science framework for quantifying scheduling asymmetry in European air routes, applied to a publicly available dataset of 18,111 routes, which was reduced to 16,094 after preprocessing. A normalized scheduling asymmetry score is determined for routes from binary weekly availability vectors and compared across low-cost carriers (LCC) and full-service carriers (FSC) using exploratory analysis, descriptive statistics, and non-parametric hypothesis testing. Only 39.2% of LCC routes operate on all seven days, compared to 55.4% of FSC routes, and the difference in scheduling asymmetry between the two groups is statistically significant under a Mann-Whitney U test. LCC routes exhibit higher scheduling asymmetry and more limited weekly coverage than FSC routes. A strong negative Spearman correlation between asymmetry and weekly frequency further confirms that routes served on fewer days tend to be much more uneven. The analysis also identifies a price paradox in which routes operating fewer days per week carry higher median fares, consistent with market concentration effects. These findings are especially useful for airlines, airport management, tourism boards, and regulators seeking to optimize route planning and regional connectivity.

## Keywords:

Data Science, European Aviation, Scheduling Asymmetry, Temporal Analysis, Statistical Inference.

## INTRODUCTION

Recent work at the intersection of data science and transportation research has produced comprehensive analyses of airline behavior, route structure, and pricing dynamics. Within this sector, European aviation is a particularly complex object of study, as the network encompasses a heterogeneous mix of legacy (full-service) carriers, budget operators, regional airlines, and hybrid models, operating across diverse markets with varying levels of competition and demand [1]. The temporal organization of these routes, whether a connection operates daily, on selected weekdays, or only on weekends, reflects strategic decisions about resource allocation, market targeting, and demand anticipation that are rarely captured in aggregate analyses [2].

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Seasonality and temporal variation in aviation have been reported at the aggregate level, with global studies identifying monthly and seasonal rhythms in passenger air services [3]. However, the weekly temporal structure of individual routes, specifically the weekday pattern of scheduled operations, has received considerably less direct attention as a primary analytical variable. Most studies of individual routes focus on pricing, network centrality, or connectivity metrics, treating temporal structure as a secondary attribute rather than a key property of the route itself. The present study addresses this gap by proposing a simple, interpretable framework grounded in empirical data for measuring weekly scheduling asymmetry in individual routes.

The central contribution is the scheduling asymmetry score  $A_i$ , a normalized metric derived from binary weekly availability vectors that reflects the weekly distribution of service across a route. This score is utilized to compare low-cost carriers (LCCs) and full-service carriers (FSCs), test for statistically significant differences, and explore how asymmetry relates to pricing and route frequency across a dataset of 18,111 European routes. The study addresses three research questions:

1. Do LCC and FSC routes differ significantly in their weekly scheduling asymmetry?
2. How do weekly service patterns differ between carrier types, and what do they reveal about business models?
3. How does scheduling asymmetry relate to ticket price and weekly flight frequency across individual routes?

The remainder of the paper is organized as follows: Section 2 reviews the relevant literature; Section 3 describes the dataset, metric design, and statistical approach; Section 4 presents and interprets the results; and Section 5 concludes the paper.

## 2. RELATED WORK

Research on airline operations spans multiple analytical topics, from carrier strategy and network topology to temporal structure and flight data analytics. This section reviews the literature most relevant to the present study, organized around three thematic areas.

### 2.1. CARRIER MODELS AND ROUTE STRATEGY

The distinction between low-cost and full-service carriers has been foundational to air transport research for decades, anchoring analyses of pricing behavior, route entry decisions, and network design. The commercial

success of the LCC model in Europe and beyond is extensively discussed, with research highlighting how cost minimization strategies such as uniform aircraft fleets, less complicated routing structures, secondary airports, and minimal service amenities translate into competitive fare advantages and growing market share [4]. Over the past few years, the boundaries between carrier models have shifted since network and legacy carriers undertook broad capacity adjustments, fleet rightsizing, and selective route suspension, reshaping what it means to operate as a full-service carrier in the European market [5]. The present study acknowledges this ongoing hybridization while maintaining the LCC and FSC distinction as an analytically useful way to capture underlying scheduling philosophies that continue to produce notable behavioral differences across individual routes.

### 2.2. TEMPORAL STRUCTURE OF AIRLINE OPERATIONS

The organization of airline operations in time is as important as their organization in space. At major hub airports, operations are typically structured into wave systems, with closely grouped arrivals and departures designed to maximize indirect connection opportunities [6]. Beyond hub design, the European aviation market has experienced structural reconfigurations in route availability, carrier mix, and scheduling regularity [7]. Operational adaptations such as schedule condensation, frequency reductions, and new route introductions have been examined from an operations research perspective, yet the weekly structure of these shifts across individual routes remains less explored [8]. The present work builds on a recent dataset that captures both established routes and routes flagged as upcoming, providing a snapshot of a network in transition and enabling detailed analysis of the scheduling patterns behind each connection.

### 2.3. FLIGHT DATA ANALYTICS AND STUDY FOCUS

Airline scheduling is traditionally organized into fleet assignment, aircraft routing, and crew scheduling, which remain the three anchor problems reviewed by [9] and typically addressed through mathematical optimization of cost and profitability. Complementing this operations research practice, [10] shows that empirical flight data supports revenue management, demand forecasting, and passenger behavior patterns, while also expanding the role of computer science methods in aviation research. However, limits in data availability and scale still constrain how these sources can be fully exploited, highlighting the need for stronger preprocessing and analytical methods.



The paper also builds on prior work by the authors. An LSTM sequential behavior analysis framework for traffic data [11] demonstrated the analytical value of modeling temporal regularity and deviation in transport contexts, while an ensemble regression study of airfare variation from major European airports [12] established the importance of carrier and route features in explaining pricing outcomes. The preprocessing methodology adopted here draws on structured data preparation approaches developed in earlier work on textual review analytics [13]. The paper extends this line of research by targeting the temporal dimension of scheduling behavior and proposing an asymmetry metric that is deliberately transparent and reproducible.

### 3. METHODOLOGY

The methodology combines structured data preparation, a compact set of derived scheduling metrics, and non-parametric statistical testing. This section describes the dataset and preprocessing pipeline, defines the route representation and asymmetry metrics, and outlines the statistical approach used to compare carrier groups and examine relationships with continuous route attributes.

#### 3.1. DATASET AND PREPROCESSING FRAMEWORK

The dataset used in this study is a publicly available collection of European airport and air route data sourced from Kaggle [14], comprising 18,111 route records across 33 variables. Each record represents a directed route between two airports and includes fields covering origin and destination IATA and ICAO codes, geographic coordinates, indicative ticket price, daily and weekly frequency indicators, availability flags during the week (day1 through day7), first and last flight dates, and airline metadata embedded in a structured JSON field.

The dataset covers 46 departure and 177 arrival countries, with Italy, Spain, United Kingdom, Germany, and France accounting for more than 50% of departing routes.

Before the scheduling metrics were computed, the dataset was inspected for inconsistencies and anomalous entries. Records with ticket prices of zero, which often indicate missing or unreported fares rather than free travel, were reviewed separately, and extreme upper outliers above 2,000 EUR were flagged as potentially unreliable since they deviated sharply from the central range of fares. A small number of records with missing geographic coordinates or incomplete airline metadata were also excluded, as their absence prevented reliable classification and feature construction. After filtering, 16,094 records remained for further processing.

Carrier type classification was performed by extracting the primary carrier IATA code from the airline JSON field and mapping it against a list of known budget carriers operating in Europe, including Wizz Air, Ryanair, easyJet, Pegasus Airlines, Vueling, Transavia, Volotea, Jet2, Eurowings, and Sky Express. All remaining carriers with valid IATA codes were classified as FSC. Carrier extraction succeeded for all records, yielding a clean working sample of 8,568 LCC routes (53.2%) and 7,526 FSC routes (46.8%). Availability flags for days were originally encoded as three-valued strings: 'yes' (currently operating), 'no' (not operating), and 'upcoming' (scheduled but not yet active). Since upcoming flags reflect confirmed scheduling decisions about which days a route is intended to operate, they were treated as equivalent to 'yes'. Table 1 summarizes the main variables used in the analysis.

**Table 1.** Main variables used in the scheduling asymmetry analysis

Variable	Description	Type	Role in analysis
iata_from, iata_to	Departure and arrival IATA codes	Categorical	Route identification
price	Indicative ticket price (EUR)	Continuous	Link to asymmetry
day1 to day7	Weekly availability flags (yes, no, upcoming)	Binary (encoded)	Weekly vector, $A_i$ input
flights_per_week	Scheduled flights per week	Discrete	Link to asymmetry
carrier_iata	Primary carrier IATA code	Categorical	Carrier classification
carrier_type	Derived label (LCC or FSC)	Binary	Group comparison
ni	Active days per week (Eq. 1)	Discrete [0 to 7]	Input to $A_i$
$A_i$	Normalized asymmetry score (Eq. 2)	Continuous [0, 1+]	Primary outcome
$W_i$	Weekend concentration ratio (Eq. 3)	Continuous [0, 1]	Supplementary indicator



### 3.2. ROUTE REPRESENTATION AND ASYMMETRY METRIC DESIGN

Each route  $i$  is represented by a binary weekly availability vector with seven elements,  $d_i = (d_{i1}, d_{i2}, \dots, d_{i7})$ , where  $d_{ik} = 1$  if route  $i$  operates on day  $k$  of the week (Monday = 1 through Sunday = 7), and  $d_{ik} = 0$  otherwise. The binary vector captures the weekly scheduling pattern of each route. The three derived metrics that form the analytical core of this study are defined as follows:

- Active days per week

$$n_i = \sum_{k=1}^7 d_{ik} \quad (1)$$

- Normalized asymmetry score

$$A_i = \frac{7 - n_i}{6} \quad (2)$$

- Weekend concentration ratio

$$W_i = \frac{d_{i6} + d_{i7}}{n_i} \quad (3)$$

Equation (1) defines  $n_i$  as the number of active operating days for route  $i$ , obtained by summing the seven binary day flags. That means the result  $n_i$  ranges from 0 to 7, where 0 indicates no active day and 7 indicates daily operation. Equation (2) defines  $A_i$  as a normalized asymmetry score, where  $A_i = 0$  corresponds to a route operating on all seven days and larger values indicate increasingly limited weekly coverage. This representation aligns with airline planning frameworks that operate on structured schedules, where flight data informs routing and timing decisions [15]. Equation (3) defines  $W_i$  as the weekend concentration ratio for routes with  $n_i > 0$ , measuring the share of active days that fall on Saturday or Sunday. Here,  $W_i = 0$  denotes a purely weekday route, while  $W_i = 1$  denotes a route operating only on weekends. Figure 1 summarizes the analytical workflow, showing that raw flight data are converted into weekly vectors and then into interpretable metrics for statistical analysis.

### 3.3. STATISTICAL ANALYSIS

The statistical analysis addressed two questions. First, we tested whether LCC and FSC routes differ significantly in scheduling asymmetry, using  $A_i$  as the comparison variable. Second, we tested whether route asymmetry is associated with ticket price and weekly flight frequency.

Since the distribution of  $A_i$  was strongly right skewed in both carrier groups, a non-parametric test was used instead of a parametric alternative. The Mann-Whitney U test was applied to compare LCC and FSC routes with respect to  $A_i$ . The aim was to assess whether the two carrier groups differ in scheduling asymmetry and whether the observed difference is practically meaningful. The Mann-Whitney U statistic is given by

$$U = R_{LCC} - \frac{n_{LCC}(n_{LCC} + 1)}{2} \quad (4)$$

where  $R_{LCC}$  is the sum of ranks assigned to the LCC group and  $n_{LCC}$  is the number of LCC routes. A two-sided test was applied with significance assessed at  $p < 0.05$ . To complement the  $p$  value, effect size  $r$  was computed as

$$r = 1 - \frac{2U}{n_{LCC} \cdot n_{FSC}} \quad (5)$$

with  $|r| = 0.1, 0.3,$  and  $0.5$  interpreted as small, medium, and large effects, respectively.

Associations between  $A_i$  and ticket price, and between  $A_i$  and weekly flight frequency, were assessed using Spearman's rank correlation coefficient. This test was chosen because the variables were skewed and the expected relationships followed a consistent direction rather than a strictly linear relationship. The analysis was focused on the direction and strength of association, not only on linear fit. Spearman's coefficient is defined as

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)} \quad (6)$$

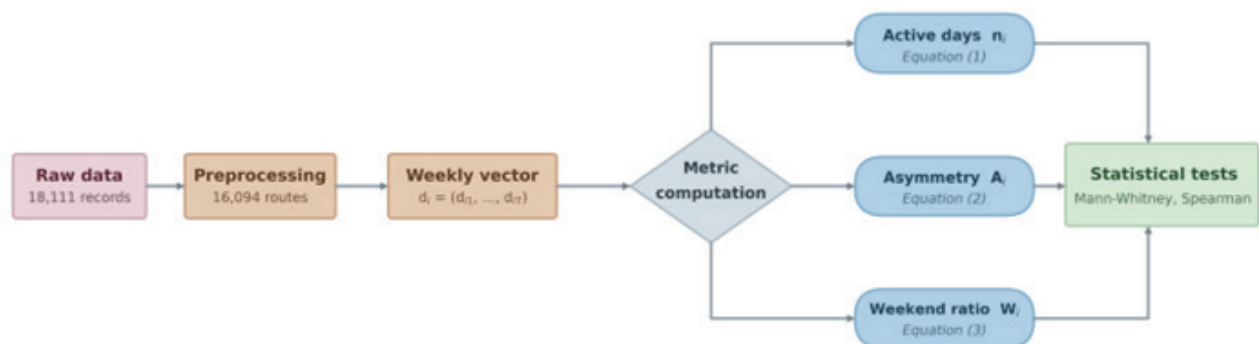


Figure 1. Workflow of the proposed scheduling asymmetry analysis



where  $d_i$  represents the difference between paired ranks and  $n$  is the number of observations. Correlations were reported with two-sided  $p$  values, but interpretation was guided by the sign and magnitude of  $\rho$ , as large samples can make even weak relationships statistically significant.

## 4. EXPERIMENTAL RESULTS

This section presents the empirical results of the scheduling asymmetry analysis. The results are organized into three parts, beginning with the overall distribution of asymmetry scores, followed by the comparison between low-cost and full-service carriers, and concluding with the associations between asymmetry, frequency, price, and geographic route characteristics.

### 4.1. DATASET PROFILE AND ASYMMETRY DISTRIBUTION

Operating day counts across routes range from 0 to 7 and show a clear bimodal pattern. As shown in Figure 2, 7,528 routes (46.8%) operate on all seven days and receive a score of  $A_i = 0$ , while 652 routes (4.1%) operate on only one day per week and reach  $A_i = 1.0$ . The overall mean asymmetry score is  $A_i = 0.317$  (SD = 0.360), indicating that the average European route deviates measurably from service across the whole week, while the distribution remains strongly right skewed with a long tail toward maximum asymmetry.

More than half of all routes (53.2%) operate on fewer than seven days per week, and nearly one in five (18.6%) operates on two days at most. In addition, 51.0% of routes contain at least one operating day flagged as upcoming, and these routes show a higher mean asymmetry of 0.395 compared to 0.236 for fully established routes. LCCs account for 64.7% of upcoming routes, suggesting that they are associated with new route introductions and tend to enter markets with schedules focused on fewer days of the week before scaling up to higher weekly coverage.

### 4.2. COMPARISON OF CARRIER TYPES

The comparison between LCC and FSC routes demonstrates that only 39.2% of LCC routes operate on all seven days of the week, compared to 55.4% of FSC routes. In contrast, 42.1% of LCC routes show high asymmetry ( $A_i \geq 0.5$ ), compared to 32.1% of FSC routes. The mean asymmetry score is 0.355 (SD = 0.356) for LCC routes and 0.275 (SD = 0.360) for FSC routes. The Mann-Whitney U test further confirms that this difference is statistically significant ( $U=36,898,406$ ;  $p = 4.93 \times 10^{-63}$ ), indicating that the observed contrast between LCC and FSC routes is highly unlikely to be random. The corresponding effect size ( $r = -0.144$ ) suggests a modest but still very informative difference between the two carrier groups. Table 2 presents summary statistics by carrier group.

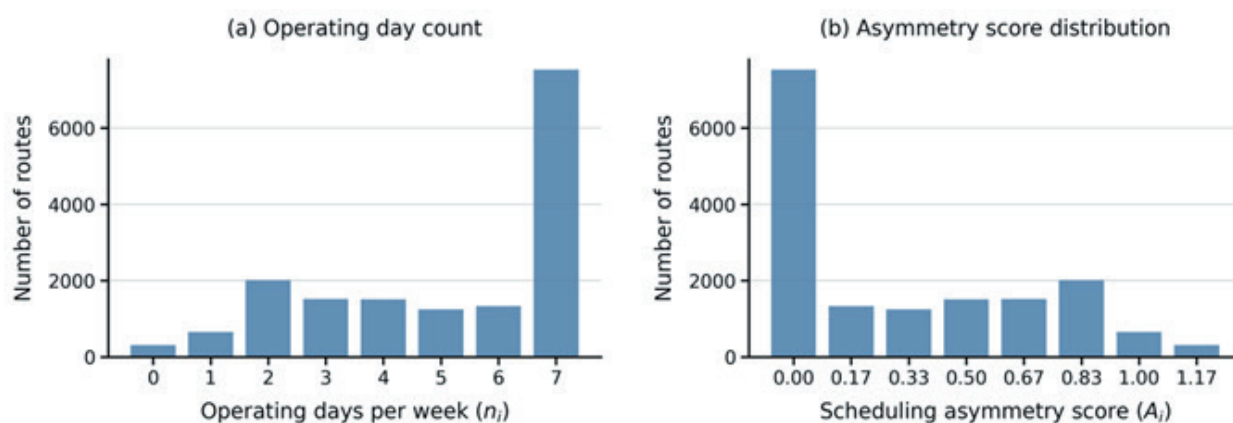


Figure 2. (a) Distribution of operating day counts, (b) scheduling asymmetry scores across all routes

Table 2. Summary statistics by carrier group

Carrier	N routes	Mean $A_i$	Median $A_i$	Daily routes	Median price	Median frequency per week
LCC	8,568	0.355	0.333	39.2%	EUR 50	3.0
FSC	7,526	0.275	0.000	55.4%	EUR 140	6.0
All routes	16,094	0.317	0.167	46.8%	EUR 80	4.0



#### 4.3. FREQUENCY, PRICE, AND GEOGRAPHIC INTERPRETATION

As weekly frequency increases, mean scheduling asymmetry drops sharply, from 0.668 in the 0 to 2 scheduled flights per week to just 0.002 in the 15+ flights per week, while the LCC share declines from 62.8% to 29.7%. The Spearman correlation across all routes is  $\rho = -0.805$  ( $p < 0.001$ ), confirming that routes operating fewer days per week tend to operate with lower overall frequency. Table 3 presents mean asymmetry scores and LCC shares across four weekly frequency bands, showing that asymmetry falls rapidly from sparse routes dominated by LCCs to very frequent routes led by FSCs. The lowest frequency band includes 29 routes with zero currently scheduled weekly flights that were retained because their day flags were marked as upcoming.

The pattern follows a tiered structure rather than a smooth progression. Routes with 15 or more weekly flights are effectively symmetric ( $A_i = 0.002$ ), while routes with at most 2 weekly flights cluster near the opposite extreme ( $A_i = 0.668$ ). The LCC share falls from 62.8% in the sparsest tier to 29.7% in the densest, confirming that FSCs dominate services with higher frequency, while LCCs are concentrated on routes with lower frequency. The sharpest transition appears between the 3 to 5 and 6 to 14 flights per week bands, where mean asymmetry drops from 0.309 to 0.029, indicating that service becomes nearly fully balanced above this threshold.

The relationship between asymmetry and ticket price is also positive ( $\rho = +0.200$ ,  $p < 0.001$ ), and stronger within carrier types (LCC:  $\rho = +0.322$ ; FSC:  $\rho = +0.269$ ). Figure 3 shows that the two groups occupy clearly distinct price ranges, which helps explain the joint pattern.

Daily routes ( $A_i = 0$ ) have a median fare of EUR 70, while routes with at most two operating days reach EUR 130, about 86% higher. This gap is consistent with market concentration effects, since reduced scheduling lowers effective competition and allows higher fares on the remaining departures. The direction of the effect is notable as it runs against the common intuition that less frequent routes should be cheaper due to weaker demand, instead suggesting that the limited number of departures places a stronger upward pressure on fares.

Inspection of the most asymmetric country-pair corridors, such as Romania to Greece ( $A_i = 0.700$ ), Austria to Greece (0.647), Germany to Tunisia (0.633), Spain to Norway (0.626), and Italy to Norway (0.604), further supports the usefulness of the proposed metrics. These corridors are mainly linked to seasonal tourism or travel related to family, migration, and community ties, each associated with uneven weekly service. Although the metric uses only binary day of week flags, it captures these patterns effectively, suggesting that the asymmetry score can serve as an unsupervised indicator of route function, distinguishing tourism and diaspora corridors from commercial connections without any direct demand insights, tourism flows, or population data.

Table 3. Mean scheduling asymmetry score and LCC share by weekly frequency band

Frequency band	N routes	Mean $A_i$	LCC share	Interpretation
0 to 2 scheduled flights/week	5,665	0.668	62.8%	Thin, LCC-dominated, highly asymmetric
3 to 5 scheduled flights/week	3,916	0.309	61.2%	Moderate frequency, mixed carriers
6 to 14 scheduled flights/week	3,692	0.029	48.1%	Near-daily, balanced carrier mix
15+ scheduled flights/week	2,821	0.002	29.7%	Ultra-high frequency, FSC-dominated

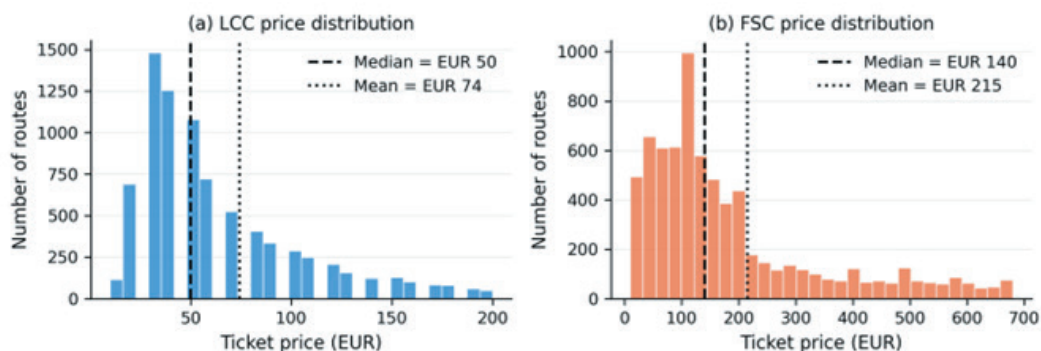


Figure 3. Ticket price distributions for LCC (a) and FSC (b), truncated at the 95<sup>th</sup> percentile for readability. Dashed lines indicate medians (EUR 50 and EUR 140), dotted lines show means (EUR 74 and EUR 215)



This also provides a useful foundation for future machine learning models aimed at route classification and market segmentation.

## 5. CONCLUSION

This study introduced a data science framework for quantifying weekly scheduling asymmetry in European air routes, applied to a cleaned sample of 16,094 directed connections across 46 departure countries. The proposed asymmetry score  $A_p$ , derived from binary weekly availability vectors, is transparent and reproducible, but powerful enough to denote important structural differences. The analysis showed a significant difference between LCC and FSC routes, with LCC services exhibiting higher asymmetry and more limited weekly coverage overall. A strong negative association between asymmetry and weekly frequency was also confirmed, alongside a price paradox in which sparser routes carry higher fares. Furthermore, the metric separates tourism and diaspora corridors from commercial connections without relying on any external demand or population data.

From a business and managerial perspective, these findings are useful for several stakeholders. Airlines can use the asymmetry score to identify underperforming weekday slots or overlooked demand during the weekend, airport authorities can align slot allocation with the temporal character of incoming routes, managers in tourism can identify seasonal connections to target promotion efforts, and regulators can monitor regional connectivity imbalances that aggregate indicators typically conceal.

Several limitations should be acknowledged. The carrier classification relies on a manually curated budget carrier list that may not fully capture smaller or hybrid operators, and the dataset reflects only one point in time, which prevents longitudinal analysis of how scheduling patterns change across seasons or years. The ticket price used is also an indicative market fare instead of a booked transactional price. These constraints motivate potential extensions based on dynamically scraped datasets, live fare feeds, and repeated scheduling snapshots.

Future work should extend the framework with machine learning methods, such as unsupervised clustering on weekly availability vectors to discover scheduling archetypes, supervised classification to predict carrier type or route purpose from temporal signatures, and sequence models applied to longitudinal panel data to capture scheduling evolution. Integrating the asym-

metry score into explainable ensemble regressors for airfare prediction is another promising direction, along with graph neural networks that can model scheduling asymmetry and airport network topology to capture how temporal and structural factors interact in the European aviation system.

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## REFERENCES

- [1] S.-H. Chung, H.-L. Ma, M. Hansen, and T.-M. Choi, "Data science and analytics in aviation," *Transportation Research Part E: Logistics and Transportation Review*, vol. 134, art. no. 101837, 2020, doi: 10.1016/j.tre.2020.101837.
- [2] M. Milazzo, F. Musciotto, S. Micciche, and R. N. Mantegna, "Analysis of the Structure and Dynamics of European Flight Networks," *Entropy*, vol. 24, no. 2, art. no. 248, 2022, doi: 10.3390/e24020248.
- [3] F. Dobruszkes, J.-M. Decroly, and P. Suaubert-Sanchez, "The monthly rhythms of aviation: A global analysis of passenger air service seasonality," *Transportation Research Interdisciplinary Perspectives*, vol. 14, art. no. 100582, 2022, doi: 10.1016/j.trip.2022.100582.
- [4] V. Majerova and M. Jirasek, "Flying high on low cost: Success in the low-cost airline industry," *PLOS ONE*, vol. 18, no. 12, art. no. e0294638, 2023, doi: 10.1371/journal.pone.0294638.
- [5] A. Hoszman and P. Zagrajek, "Network-Legacy Airline Business Model Developments in Post-COVID European Market," *Journal of Management and Financial Sciences*, no. 58, pp. 41–54, 2025, doi: 10.33119/JMFS.2025.58.3.
- [6] Z. Xiang, R. Han, X. Zhang, and X. Du, "Indirect Connection Analysis Based on Wave-system Structures of Airlines Architecture in Hub Airport," *Journal of Aerospace Technology and Management*, vol. 15, art. no. e1623, 2023, doi: 10.1590/jatm.v15.1306.
- [7] J. Su, H. Wu, K. W. H. Tsui, X. Fu, and Z. Lei, "Aviation resilience during the COVID-19 pandemic: A case study of the European aviation market," *Transportation Research Part A: Policy and Practice*, vol. 177, art. no. 103835, 2023, doi: 10.1016/j.tra.2023.103835.



- [8] L. A. Garrow, V. Lurkin, and L. Marla, "Airline OR Innovations Soar During COVID-19 Recovery," *SN Operations Research Forum*, vol. 3, no. 1, pp. 1–20, 2022, doi: 10.1007/s43069-022-00131-1.
- [9] L. Zhou, Z. Liang, C.-A. Chou, and W. A. Chaovaitwongse, "Airline planning and scheduling: Models and solution methodologies," *Frontiers of Engineering Management*, vol. 7, no. 1, pp. 1–26, 2020, doi: 10.1007/s42524-020-0093-5.
- [10] H. Tian et al., "Data Analytics for Air Travel Data: A Survey and New Perspectives," *ACM Computing Surveys*, vol. 54, no. 8, art. no. 167, pp. 1–35, 2022, doi: 10.1145/3469028.
- [11] M. Stojanović, M. Nikolić, and M. Marjanović, "Early Detection of Aggressive Driving Using LSTMs for Sequential Behavior Analysis," in *Proc. ICEST 2025 – International Scientific Conference on Information, Communication and Energy Systems and Technologies*, 2025, doi: 10.1109/ICEST66328.2025.11098181.
- [12] M. Stojanović and M. Nikolić, "Modeling Airfare Variation from Major European Airports Using Explainable Ensemble Regression," in *Proc. 25<sup>th</sup> Int. Symp. INFOTEH-JAHORINA*, Bosnia and Herzegovina, 2026, to appear.
- [13] M. Nikolić, M. Stojanović, and M. Marjanović, "Anomaly Detection in Hotel Reviews: Applying Data Science for Enhanced Review Integrity," in *Proc. TELFOR 2024 – Telecommunications Forum*, 2024, doi: 10.1109/TELFOR63250.2024.10819036.
- [14] Lunthu, "European Airports and Air Routes," Kaggle dataset, Nov. 8, 2025. Accessed: Apr. 16, 2026.
- [15] A. Abdelghany, K. Abdelghany, and V. S. Guzhva, "Schedule-level optimization of flight block times for improved airline schedule planning: A data-driven approach," *Journal of Air Transport Management*, vol. 115, art. no. 102535, 2024, doi: 10.1016/j.jairtraman.2023.102535.