Market clustering and performance of U.S. OD markets

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ABSTRACT

We segment the U.S. OD markets into peer groups, using a statistical cluster analysis on OD city-pair data on the basis of market concentration, passenger volume and yield. The results show: 1) that high yield markets have, on average, consistently underperformed the industry in both passenger and revenue growth, whereas low yield markets have led the industry in both areas; and 2) mid-sized ODs have experienced higher average growth and lower volatility than the largest U.S. domestic ODs, which have accounted for the least revenue per passenger as compared to all other market types. Financial portfolio analysis indicates the prospect of long-term decision making based on OD market risk and return rather than the aggregated market share analysis used by airlines today.

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1. Introduction

Air transportation represents the most highly networked travel system in the world. This network is comprised of markets with varying levels of growth, performance, and volatility. Over the last decade, international air travel markets have experienced overall volatility resulting from increased competition and external shocks like the September 11th, 2001 terrorist attacks, the severe acute respiratory syndrome (SARS) in 2002 and 2003 and the financial market crisis in 2008 and 2009 (Franke and John, 2011). Volatility is expected to increase tremendously beyond 2025 (Linz and Rothkopf, 2010), necessitating the ability to delineate between "winners" and "losers" in airline planning. A considerable amount has been written on the U.S. industry's reaction to volatility resulting from competitive entry, singular shocks (Franke and John, 2011; Bhadra and Kee, 2008; Lai and Lu, 2005; Ito and Lee, 2004; Belobaba and Van Acker, 1994) and the transmission of these shocks throughout the airline industry (Gillen and Lall, 2003). Nevertheless, our understanding of the nature and dynamics of U.S. domestic air travel demand and the functioning of individual passenger markets remains limited, as suggested by Bhadra and Kee (2008). Furthermore, our ability to make long-term network planning decisions is similarly restricted by this lack of understanding.

Currently, airline planning groups rely primarily on macroscopic trends for fleet, labor, and strategic planning. Conversely, network planners and regional managers make incremental network, schedule, and fare modifications based on individual OD performance. In an attempt to model the markets, Belobaba and Van Acker (1994) classified OD markets according to their level of competition defined by market concentration. Bhadra and Kee (2008) focused their research on the implications of market size on fares and passenger demand elasticities, leading to broad market clusters. Airlines have yet to leverage market classification to create OD market "portfolios" from their networks, or vice versa. This paper introduces a financial portfolio approach to airline network planning to facilitate investments with a risk management approach rather than market share focus.

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1.1. Motivation

In the face of increased competition and profit cyclicality, a deeper understanding on U.S. OD markets and their structures is needed to enable airline executives to align strategic investments and asset trade-offs to long-term network performance, with consideration of market volatility. Improved understanding of U.S. OD markets can bridge the gap between macro-level strategic planning and micro-level network planning to support long-term optimization and stability. Aggregation at the macro-level leads to decision making that is calibrated by all of the U.S. OD markets. Our strategy is to analyze OD market peer groups, clustered by three intrinsic characteristics, to compare a market's risk and return relative to its peers. Today, airline planning is akin to

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a financial investor choosing to obligate additional assets to a given investment on the basis of that investment's prior performance (e.g., invest $100 in GOOG because it grew at 5% over the previous period) without consideration of the opportunity cost of investing that $100 (e.g., how is GOOG performing relative to other technology stocks, or the NASDAQ index).

The error with this type of thinking is that there is a loss of information fidelity across the investor's portfolio. If the investor were to compare his holdings in similar companies, the investor makes better-informed decisions about the risk and return of his holdings relative to its peers. Similarly, airline network planners can apply portfolio thinking to analyze the risk and return of it investments (resource allocation) in its various OD markets (e.g., short-haul, high volume, business markets or long-haul vacation/leisure markets) to determine an acceptable level of risk and expected return over the long-term. Our research leverages financial portfolio thinking and statistical cluster analysis to enable comparisons across and within network clusters, allowing for a richer context in assessments of market performance.

2. Methodology and analysis

In our research, we classified the largest 10,000 unique domestic U.S. OD markets according to three dimensions, passenger volume, yield, and market concentration, intending to increase the level of detail in understanding OD market structure as compared to Belobaba and Van Acker (1994) who employ only market concentration (HHI) and the number of competitors to classify markets. Passenger volume and yield describe the demographics of the OD market. A change in these characteristics occurs over a long time-frame and is not highly variable given an airline's decision to enter or exit the market. To perform this segmentation, we used statistical cluster analysis to classify OD markets into natural "peer groups" with the greatest intrinsic similarities. Subsequently, we model the year over year growth and volatility of OD markets within each peer group to estimate the risk and return properties of the OD markets. Lastly, we present two financial portfolio concepts and their application to airline network planning to illustrate that analysis of all the U.S. OD markets does not provide a one-size-fits-all solution for airline network planning.

2.1. Cluster identification

Our statistical cluster analysis of U.S. OD city-pair data was performed using Bureau of Transportation Statistics (2011) DB1B Coupon data (accessed 2011) for data from 2000 to 2010 by quarter. The cluster analysis was performed using three metrics: OD passenger volume, average annual yield (revenue per passenger mile), and market concentration (Herfindahl-Hirschman Index) at the origin and destination airports. These metrics were selected as intrinsic OD attributes which define comparable "peer groups" with similar expectations of performance — for example, the fundamental drivers of revenue performance for large, high-yield ODs versus small, low-yield ODs are likely distinct (Belobaba, 2009). As such, this research includes passenger volume and average annual yield to quantify the demographics of the OD market in addition to a market concentration measure used by Belobaba and Van Acker (1994).

As the three metrics are continuous and virtually unbounded, we discretize the metrics to resolve skew in distribution and to allow for meaningful comparisons, i.e., low, medium, or high values. The values in these categories (Table 1) also approximate industry standard metrics. The U.S. Department of Justice considers a market with an HHI >2500 as exhibiting low competition/monopolistic. Yield is distinguished along the 10th and 90th percentile, as these are amongst the most common measures of

Table 1
OD variable categorization for cluster analysis.

	Low	Medium	High
OD passenger volume	≤2500	2501−1,000,000	>1,000,000
Average annual yield	≤$.10	$.11−$.40	>$.40
Market concentration − HHI	≤2500	−	>2500

performance dispersion and reflect the significant annual variation that occurs in the middle-tier yield markets (Evans and Kessides, 1993). Passenger volume is distinguished along the 50th percentile and 95th percentile, reflecting previous research of demand elasticities (Gillen et al., 2003).

The OD market clusters are defined using a two-step clustering process, which first assigns cases to pre-clusters, and subsequently groups pre-clusters using a hierarchical clustering algorithm. The two-step process ensures that the OD markets are statistically similar and that each cluster has a unique interpretation. The pre-clustering algorithm assigns cases so as to minimize the average log-likelihood distance between cluster sets. The Schwarz Bayesian Information Criterion (SBIC), which measures the changes to log-likelihood distance as pre-clusters are grouped together, is then used to inform the optimal number of hierarchical cluster sets. The results of the clustering are shown in Table 2, with chi-square tests confirming that the clustering values fall within a 95% confidence interval for significance.

The cluster analysis resulted in the solution of 7 distinct clusters that each has at least one intrinsic characteristic that defines the peer group (e.g., Cluster 1 represents OD markets with high market concentration and low passenger volume, Cluster 7 represents OD markets with large passenger volume, etc.). In terms of portfolio analysis, clustering defines the peer group against which the performance of an OD market within that cluster is measured.

2.2. OD portfolio analysis: across clusters

Since market peer groups are defined based on intrinsic characteristics that are stable over long periods of time, we assess performance relative to passenger and revenue growth on a quarterly basis. Using quarterly data of the passengers and revenue for OD markets by peer group gives an indication of the peer group's volatility. Evaluating year-over-year growth rate (rather than actual values) allows for better comparisons of differentiated market types, and subsequently the identification of peer groups of OD markets that consistently outperform or underperform the industry, relative to the industry average.

Inspection of the top 10,000 U.S. domestic OD markets separated by cluster reveals that, over the last ten years, only the largest ODs (cluster 7) accounted for less revenue share than their respective passenger share. In other words, the largest U.S. domestic markets have generated less revenue per passenger as compared to other market peer groups. Classification of ODs into natural peer groups enables the *learning* of these insights, beyond what can otherwise be done through univariate querying.

The peer group data indicate some emerging trends across the clusters (Figs. 1 and 2). Since 2000, high yield markets (i.e., Cluster 6) have consistently underperformed the industry in both passenger and revenue growth and stability. Cluster 6 comprises the markets most often lagging in both passenger and revenue growth and stability. Conversely, low yield markets (i.e., Cluster 5) have led passenger and revenue growth for most quarters since 2000 and frequently outperformed the industry averages for passenger volume and revenue volatility. By inspection, mid-sized markets (i.e., Clusters 3 and 4) also show higher than average growth and lower volatility than the largest U.S. domestic ODs (i.e., Cluster 7) which,