Service Triad Alignment and Profitability: An Empirical Study in the U.S. Airline Industry

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This research tests the importance of the alignment of service triad design elements and its effect on firm profitability. We focus specifically on the system design of the service delivery employed by the U.S. domestic airline industry. Key strategic design decisions are the spatial centrality of the airline flight network and the variety resulting from the choice of the aircraft fleet deployed. Afixed effects regression model analysis finds that network spatial centrality and aircraft fleet complexity jointly exhibit a significant relationship to service firm profitability. These findings augment prior research and demonstrate the interactive nature of service design variables in relation to firm profitability. Analysis of the relationship between service design and profitability provides an estimate of the optimum service design choices. The specific findings suggest that many U.S. airlines create flight networks that are too concentrated around hub airports and the aircraft fleet is too complex.

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I. INTRODUCTION

The goal of this research is to estimate an optimal alignment of specific structural service delivery choices and the impact these choices have on service operations profitability. While there has been significant research attention focused on service operational performance in relation to service profitability (i.e., Tsikriktsis, 2007), less attention has been given to empirical evidence establishing the impact of service structural design on firm profitability. Recently, some empirical evidence has been advanced to confirm this relationship (West and Dellana, 2016). However, there is a lack of empirical research that explores the design of an optimal service structure.

Roth and Menor's (2003) service triad concept is depicted in Fig. 1 for the U.S. domestic airline industry. The service triad consists of three elements that influence the service encounter.

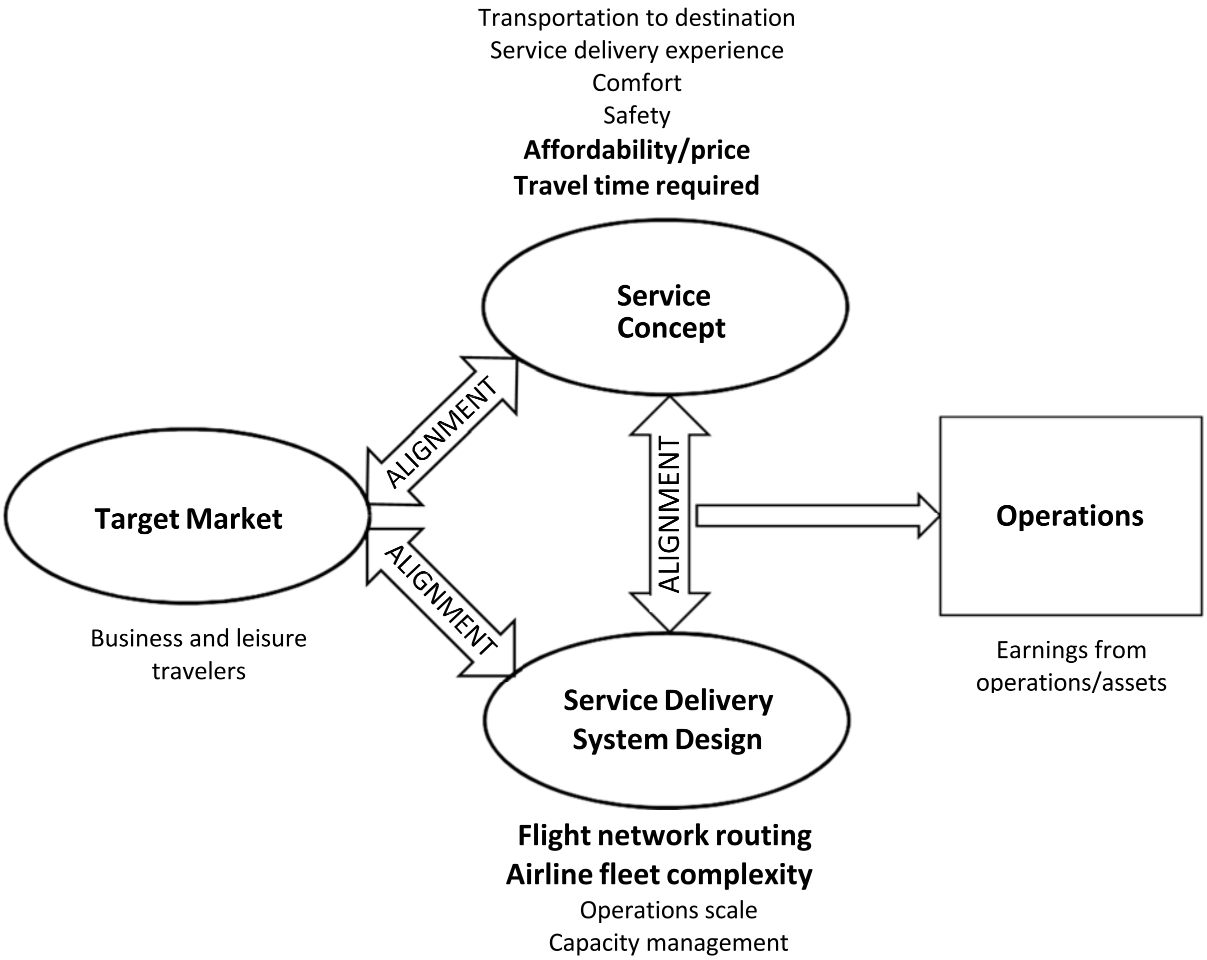

FIGURE 1. SERVICE TRIAD ALIGNMENT CONCEPTUAL MODEL.

These include the target market, the service concept and the service delivery system design choices. Roth and Menor (2003) make a clear distinction between the service concept and the service delivery system. They define the service concept as the portfolio of core and peripheral service elements, while the service delivery system involves strategic design choices that are structural, infrastructural, and integration.

We will argue that the target market of business and leisure travelers is the same for all nine domestic carriers investigated in this research. None of the carriers is attempting to cater exclusively to business or to leisure travelers. Loyalty programs and special amenities are used by all domestic airlines to retain the high frequency business traveler. United Airlines has defined its target market as follows:

> *Our target audience is men and women aged 35-54 who travel* ***for either work or leisure****. These people are married with or without children. They live in smaller metropolitan cities and suburban areas. Most are homeowners that have at least a college education and read more magazines and newspapers* (https://alexiaconley.files.wordpress.com/2013/04/united-media-plan-v5.pdf).

Similarly, Southwest's stated goal is to, *"To attract **more business and leisure travelers** with the powerful low-fare brand and outstanding Customer Service commitment."* (http://www.slideshare.net/primrose020/southwest-airlines-12654882)

We also argue that the service concepts of the nine carriers are very similar. The service concept defines the tangible and intangible elements of the service being offered. This includes the functional aspect of transportation from origin to destination, affordability, safety, comfort, convenient schedules, the service experience and the total time (or throughput time) for the customer. The aspects of the service concept most relevant to the purchase decision can be inferred from major search/booking sites like Google flights. This site highlights the top few flight alternatives and summarizes the price (affordability), the flight times, layover times and total time, and the comfort level. The comfort level is largely measured by two metrics of the seat design, the pitch and width of the seats. While there are different classes of comfort offered by the airlines, there is very little within-class difference in comfort offered between airlines. It is also evident that comfort and affordability represent economic tradeoffs. More comfort is achieved by configuring aircraft with fewer but larger seats which increases the costs per available seat mile and the ticket prices. To summarize the service concept, they are all in business to transport customers from origin to destination. They use the same aircraft, provide the same level of comfort (or discomfort) and have comparable safety levels. The lack of differentiation in the U.S. domestic airline industry was recognized by Michael Porter (2008). He concludes that price competition, as practiced by the domestic airline industry, is the most destructive basis for competition: it transfers profits directly from the industry to customers.

That leaves differences in the service delivery system design as a major determinant of operational profitability. The service delivery design choices investigated in this study are: (1) the spatial concentration (i.e., centrality) of the airline's flight network (i.e., structure); and (2) the nature of the aircraft fleet used by the airline (i.e., degree of aircraft standardization). Certainly, anecdotal examples of minor differences exist in the target market and service concepts. These differences are neutralized using a fixed effects regression model (explained in Section 3).

In summary, the lack of differentiation in the domestic U.S. airline industry for the time window studied results in nine competitors with the same target market and very similar service concepts. The empirical model is designed to estimate the alignment between the service delivery structural design choices.

H1. The service delivery network routing structure is aligned with the service concept.

H2. The structural choice of fleet complexity is aligned with the service concept.

For each hypothesis, H_a represents the service design choice being aligned with the service concept, while H_0 is evidence of no relationship or a lack of alignment.

This study contributes to the service operations literature by providing empirical support of the value of properly aligning service design elements. Given the scale of the service industry considered and the amount of operational data, the empirical analysis underscores the potential for using "big data" and business analytics to better understand links between strategic design choices and business performance.

II. LITERATURE REVIEW

In the literature review that follows

we review studies on the alignment of service triad decisions. This includes a focus on studies that are pertinent to the alignment of service delivery options for the airline industry in the United States. This is followed by a description of the study methodology, data, measures, and model development. The final sections provide a discussion of the results relating to our hypotheses, along with conclusions and study limitations.

2.1. Research on the Service Triad and Service Performance

The Service System Triad (Heskett, 1987; Roth and Menor, 2003) consists of three constructs: (1) the target market defining who is to be served; (2) the service concept specifying the tangible and intangible services to be offered and; (3) the service delivery system defining how the service is to be delivered. The service delivery system design choices can be decomposed into structural choices, infrastructural choices, and integration choices. Structural choices identify key aspects of the physical delivery system including facilities, locations, layouts, technology, equipment, and network configurations for delivering service. The infrastructural design relates to people, leadership, and performance management. They define the necessary characteristics of employees and the organization's policies, practices, and processes. Integration choices define mechanisms for coordination, learning and adaptation, and the nature of service supply chains. This collection of strategic design choices defines the realized service delivery system (Roth and Menor, 2003).

There is consensus in the service theoretical literature on the necessity of aligning elements of the target market, the service concept, and the service delivery design (Ponsignon, Smart and Maull, 2011) and, in particular, to ensure that the service delivery system should support the realization of the service concept. Studies by Karwan and Markland (2006) and Silvestro (1999) emphasize the need for alignment but they did not investigate specific service delivery design decisions, nor did they consider different service concepts. Ponsignon, Smart, and Maull (2011) reported a case study of a business-to-business service in the power industry. They identified four different target markets and four different service concepts which are linked to corresponding service design characteristics. They found that service delivery design decisions are contingent on the degree of customization (i.e., differentiation) of the service concept.

Giloni, Seshadri and Kamesam (2003) investigated service system triad issues in the property and casualty insurance industry. The authors developed a framework for the design of distribution systems for property and casualty insurance and tested for consistency on empirical data. A case study of the South Carolina Department of Motor Vehicles investigated service design principles and efficiency for a public service organization (Karwan and Markland, 2006). The authors determined that strategic alignment of service triad elements, effective information technology deployment, and clear separation of front and back office tasks are vital for increasing public sector service efficiency. The alignment between the structural service delivery design and the service concept of the San Francisco Public Library was cited as the cause of service performance deficiencies by Apte and Mason (2006). The structural design of this service was a hub-and-spoke network configuration with the Main Library serving as the hub. The recommendations for changes to the service delivery system by Apte and Mason (2006) enabled the library to significantly lower both cycle times and costs and increase system capacity. Silvestro and Silvestro (2003) described the service delivery system design for the National Health Service Direct, a call center for patients in the United Kingdom. With data from the first three years of operations, the authors evaluated the strategic alignment of its service concept, operational objectives, and the design of its service delivery system. They identified a major deficiency in the process: the lack of an explicit service specification for the design of each call center. Li, Benton and Leong (2002) investigated the alignment between strategic design choices and performance for community hospitals. The model demonstrates a causal relationship between structural and infrastructural choices on quality, cost, and financial performance outcomes for 151 community hospitals. Maredza (2015) explored the relationship of expanded banking access, a strategic design decision, with firm profitability in a group of African nations. The goal of the study was to assess service delivery to other target markets. The study, using panel data and a fixed effects model across ten countries, reported mixed results. In cases where expanding access had a detrimental effect on profitability, they postulate that banking sectors in those countries have expanded service availability beyond the optimal point of profitability. However, they did not seek to define the point of optimality.

Citing the triad model as a potential framework for the study, West and Dellana (2016) explored the link between service design choices and profitability in the US airline industry. The study examined profitability in relation to four structural service elements. The researchers report that profitability may be enhanced by increasing operations scale and by reducing network centrality (i.e., the number of hubs) and fleet complexity (i.e., the number of different aircraft types). Network centrality and fleet complexity were considered the most significant elements. These accounted for 75% of airline profitability in the model. However, the study did not provide an optimal network and fleet configuration or alignment based on the established causal relationship to profitability. This study extends the work on airline service design and profitability by identifying an optimal service strategy alignment for the airline structure variables of network centrality and fleet complexity. The methodology and data are described in greater detail in section 3.2 of this paper.

2.2. Airline Service Design Choices

A critical component of the service design in the U.S. domestic airline industry is configuring a flight network of origins and destinations. The flight network scope and configuration involve a substantial portion of airline cost. Flight networks differ in the “degree of directness” (or spatial centralization) of the network paths. Many airlines use a hub-and-spoke network strategy that consolidates passengers arriving at the hub from many different locations into flights targeted to specific destinations. This allows airlines to take advantage of economies of scope, scale and density (Chen, 2007; Ryerson and Kim, 2013).

There is extensive support for spatial centralization (or hub strategies) in a thread of operations research utilizing game theory. For some recent examples see Wang (2016), Flores-Fillol (2009), and Kawasaki (2012). These studies analyze small networks consisting of three or four nodes, assume a high returns-to-density effect, frequently analyze monopoly or duopoly markets, and focus primarily on the cost and demand conditions of an airline to make an estimate of a Nash equilibrium (Wang, 2016). Airport congestion and passenger value/inconvenience is largely ignored in this thread of research.

With the consolidation of passengers,

the hub-and-spoke network affords greater frequency of flights and better load factors (Ball et al., 2007; Brueckner and Zhang, 2001; Rubin and Joy, 2005). Ball et al. (2007) report that a network with centralized hubs appears to have financial advantages, but primarily on relatively long flight segments.

Operating inefficiencies, which have not been universally recognized in prior research, are inherent in a centralized hub strategy. These include longer travel times for passengers and the delivery of flight service across several flight segments where the distance traveled is more than the point-to-point distance. Over time, many hub airports have experienced increased congestion as airlines seek to schedule flights that are more convenient for consumers (Rietveld and Brons, 2001; Wang, 2016; Flores-Fillol, 2010). This introduces added variability into the system which can cause reduced reliability and productivity. For example, a flight delayed on the taxiway due to its assigned gate being occupied creates a ripple effect of disruptions to flight schedules. The advantages of a centralized hub concept need to surpass the costs incurred by increased distances traveled, inefficiencies from potential disruptions, and an increase in the number of times a traveler must wait between flight segments. Martin and Voltes-Dorta (2008) discuss customer perceptions/value of indirect connection in airline service delivery routing. They emphasize that the attractiveness of an indirect connection depends on a number of other important factors including: (1) the waiting time at the hub; (2) the routing factor, which is the in-flight time for an indirect flight compared to the direct flight time; and (3) the perception of passengers that transfer time is longer than in-flight time. They argue lower fares may be necessary to compensate for longer transfer and in-flight times, thus impacting the service concept. The design of the service delivery network has not only a cost impact but also a direct value and revenue effect on profitability. Sasser, Olsen and Wychoff (1978) first defined this as the "service concept," which includes choices of service delivery methods and the customer's direct experience of both the service and the value of the service. The service delivery design decision directly influences value from the customers' perspective in the following way. Airline service delivery systems with a high degree of directness will, on average, provide shorter, more direct paths, while networks with low directness resulting from a hub design will have longer, slower paths. Service networks with a centralized hub design create more indirect routing for passengers, thereby increasing the wastes of waiting and longer flight times (Womack and Jones, 2005). While airline passengers are generally segmented into time-sensitive business passengers and cost-sensitive leisure travelers, we argue that both segments value shorter and more direct routing. Ball et al. (2007) report that if consumers care about flight time, then a point-to-point (decentralized) flight network is faster and preferred for short haul flights.

A point-to-point flight network structure decentralizes from a hub concept, routing flights more directly from origin to destination, resulting in fewer average flight segments (Bania, Bauer and Zlatoper, 1998). This type of system results in shorter travel distances, faster passenger throughput times and higher delivery reliability. There is no need to wait for the transfer of baggage and for passengers from delayed connecting flights. Aircraft utilization (i.e., the proportion of day spent flying) is typically increased (Flouris and Walker, 2005). A point-to-point airline service network tends to result in higher customer satisfaction than a hub system because it doesn't waste the customer's time, provides exactly what the customer wants, with minimum hassle (Womack and Jones, 2005). A point-to-point route structure also results in a more standardized fleet, which can result in lower unit costs for point-to-point airlines compared to hub airlines (Daraban, 2012). The drawback of this network type is the potential for flight segments with low demand.

For the time period considered in this study, there were two potential suppliers for larger scale aircraft (i.e., Boeing and Airbus) and several manufacturers of smaller regional jets. Aircraft model choices differed in capacity, operating costs, and turnaround times. In airline industry studies, the choice of aircraft types is often modeled as an assignment optimization problem that accounts for the many factors and constraints created by the route structure (Gao, Johnson and Smith, 2009; Ahmed and Poojari, 2008).

Kilpi (2007) has noted that the fleet composition of an airline is an important determinant of an airline's cost and operational performance, which impacts the service concept in relation to flight time and price. Kilpi's (2007) analysis of aircraft fleets from 1952 to 2005 reveals that the uniformity of airliner fleets has been steadily decreasing while scale has been steadily increasing. A challenge of airline management is to balance the benefits of a uniform fleet and the choice of suitable aircraft for different missions (Kilpi, 2007). The drivers of aircraft fleet complexity cost are identified in the Fleet Standardization Index (Pan and Santo, 2004). This consists of: (1) the aircraft manufacturer; (2) the aircraft family; and (3) aircraft and engine model. Large fleet variety (i.e., complexity) allows an airline to more closely match aircraft choices to the differing market demands than a standardized fleet characterized by limited aircraft choice (Lohatepanont and Barnhart, 2004). More complex fleets come with added costs. These include costs associated with the variation in maintenance requirements across different aircraft families and training of airline personnel (e.g., pilots, mechanics, etc.) on a larger number of different aircraft families and types (Flouris and Walker, 2005).

III. EXPERIMENTAL METHODOLOGY

3.1 Data Description

The data used in this study is publicly available from The Office of Airline Information of the Bureau of Transportation Statistics, which includes a substantial amount of airline operational financial data for domestic service. Several prior published empirical studies have used this secondary data set, so its integrity and value are well-established (Tsikriktsis, 2007; Deshpande, 2012; West and Dellana, 2016). The distinction of domestic and international service began in 2004. The data contains information on departures and arrival times, flight numbers, airports, air time, non-stop distance, etc. (www.transtats.bts.gov). The data from airline operations was matched to quarterly financial data, which includes operating income and assets for domestic operations. The specific databases used in this research are given in Table 1.

TABLE 1. DESCRIPTION OF DATA SCHEDULES USED.

Schedule P-7	This table contains quarterly operating expense statements, by functional grouping, for large certificated U.S. air carriers, and includes such items as aircraft operating expenses, passenger service expenses, advertising and publicity expenses, total operating expense, and other expense items
Schedule P-5.2	The table contains detailed quarterly aircraft operating expenses for large certificated U.S. air carriers. It includes information such as flying expenses (including payroll expenses and fuel costs), direct expenses for maintenance of flight equipment, equipment depreciation costs, and total operating expenses.
Schedule P-12(a)	This table contains monthly reported fuel costs, and gallons of fuel consumed, by air carrier and category of fuel use, including scheduled and non-scheduled service for domestic and international traffic regions.
Schedule P-1.2	This table provides quarterly profit and loss statements for carriers with annual operating revenues of $20 million or more. The data include operating revenues, operating expenses, depreciation and amortization, operating profit, income tax, and net income.
Schedule B-1	This table contains quarterly operating balance sheet statements for large certificated U.S. air carriers with annual operating revenues of $20 million or more, and includes on the balance sheet items as cash, short-term investments, accounts receivable, long-term debt, accounts payable, and salaries and wages.
T-100 Domestic Segment (U.S. Carriers)	This table contains domestic non-stop segment data reported by U.S. air carriers, including carrier, origin, destination, aircraft type and service class for transported passengers, freight and mail, available capacity, scheduled departures, departures performed, aircraft hours, and load factor when both origin and destination airports are located within the boundaries of the United States and its territories.

This study uses quarterly operational data of all domestic flights on nine major U.S. carriers in the period 2004-2007, which totaled over 12 million flights. This time frame was selected for several reasons. First, it constituted a period of relative stability in the economy and the domestic airline industry represented by a substantial number of larger mainline competitive domestic carriers. The industry experienced substantial chaos from 2001 to 2004. Second, before 2004 the data were not separated to allow analysis of the domestic industry. Third, the great recession of 2007-2009 created instability in the U.S. and global markets that lasted for years thereafter, which makes an analysis involving profitability much more challenging. Fourth, during the time period following the great recession there was a consolidation of domestic mainline carriers in the industry. During the time of this study there were 16 mainline domestic carriers, with nine of these representing over 90% of passenger demand. Therefore, the nine major U.S. airlines included in this study are American, Jet Blue, Continental, Delta, AirTran, Northwest, United, US Airways, and Southwest. Other carriers were excluded due to their small share of the market at that time. The consolidation of mainline carriers started around 2008 with the merger of Delta and Northwest and continued into 2014 with the merger of American and US Airways. Only five of the original major domestic carriers in the U.S. airline industry remained, which included American, Delta, Southwest, United and JetBlue. There was not a sufficient number of carriers to conduct a rigorous competitive analysis. Having more units of analysis (i.e., airlines) is more important than having fewer airlines with a longer time series of observations. We attempted model estimation for periods beyond 2007 but did not get credible models because of the reduction in units of analysis. Therefore, the period of 2004-2007 was the best and most recent time frame for analysis at the time this study was conducted.

3.2 Choice of Empirical Model

The data in this research is observational and more specifically panel data consisting of nine airlines observed for 16 quarterly time periods. The inability to create a randomized controlled experiment with observational data makes it difficult to establish causal relationships. One can identify many potentially confounding variables that would be controlled by the random assignment of a controlled experiment. For example, we would expect significant differences between airlines in: the aircraft fleet age and efficiency; jet fuel costs; salaries for operating personnel; the average flight network stage length; expenditures for food/amenity costs; economies of scale; decisions to buy or lease aircraft, and depreciation costs.

The solution to this dilemma is to structure the empirical analysis with a fixed effects regression model that replaces the traditional Ordinary Least Squares (OLS) regression. The fixed effects model controls for time invariant differences between airlines and supports drawing causality conclusions from the data. In this research, causality is the potential for network centrality and fleet complexity to exhibit a causal relationship with higher or lower profitability.

The basic structure of the linear fixed effects model is given in equation 1 (Allison, 2009) where y_{it} is the operational profitability of airline i at time period t and x_{it} is a set of predictor variables (network centrality and fleet standardization). The intercept μ_t, may vary for each time period. Another set of predictor variables z_i models the effect of all unobserved variables that do not vary over time. This would be reasonable for differences in stage length or leasing decisions but not for jet fuel differences which vary significantly. There are two error terms in the model, ε_{it} is the conventional residual for each airline at each time period. Errors across airlines (but not across time) are modeled by α_i.

$$y_{it} = \mu_t + \beta x_{it} + \gamma z_i + \alpha_i + \varepsilon_{it} \qquad (1)$$

Essentially the fixed effects model is estimating the effects of predictor variables by considering only differences within airlines and ignoring time invariant differences between airlines. It is loosely akin to doing a separate regression estimate for each airline and then averaging the effects of the predictor variables. Adjustments were made to the data for unobserved variables known to violate the assumption of time invariant. These included differences in jet fuel costs, operational salaries, and food/amenities costs. Details of these adjustments are given in section 3.3.

3.3 Data Modifications to Control for Time Varying Unobserved Variables

Analysis of the airlines' cost structures for the 16 time periods identified the following as significant time varying costs: differences among airlines fuel costs, salaries for airline operational personnel, costs for in-flight food and drinks, and marketing. These cost drivers represent about two-thirds of an airline's operating cost structure. Marketing costs were simply reversed and removed from the operating profit. Modifications for the other cost drivers were more involved and described in the following paragraphs.

Aircraft fuel accounts for a substantial portion of airline's expenses. During the period investigated in this study, fuel costs approximately doubled. There was also a substantial difference in the price paid for fuel among airlines. In 2007, Delta Airlines paid 43% more for aircraft fuel on average than Southwest airlines. We modified the fuel cost data to reflect the average aircraft fuel price per gallon for all airlines in the study. For each quarter the total quantity of fuel consumption (in gallons) for all nine airlines was calculated. In similar fashion the total cost of the gallons consumed was calculated and a cost per gallon determined. The fuel costs for each airline for each quarter were then restated as the gallons consumed times the average cost per gallon.

Salaries paid for comparable operational positions also differed across airlines during the time period of the study. Typically, the newer "low cost" airlines had lower salaries for management, pilots, and maintenance, while the older "legacy carriers" had significantly higher salary structures. For example, in 2004 pilots flying for Northwest airlines had an average quarterly salary almost double the salary of pilots flying for AirTran Airlines. We modified the salaries to reflect the averages for management, pilots, and maintenance personnel for all nine airlines on a quarterly basis. For each category of employee (and for each quarter) we totaled all nine airlines expenditure on salaries and divided by the total number of employees for all nine airlines to derive an average cost per employee. Each airline's salary costs were then restated for each quarter as the number of employees multiplied by the average cost per employee.

Food and drink expenditures were observed to vary with the airline's average flight length. Longer flights required higher food/drink expenditures. For this study, we applied a regression model to the food/drink cost per airline per quarter on the average flight length by airline. This is consistent with how this has been done in prior studies with this data (ref. West and Dellana, 2016).

3.4 The Definition of Metrics for Service Structural Design Choices

The profitability metric for the service system is measured by return on assets for each airline for each quarter between 2004 and 2007. This was calculated as the operating income earned divided by assets. The adjustments to the domestic operating income were made for costs as previously described in section 3.3.

The degree of network centrality can be measured with a hub index (Bania, Bauer and Zlatoper, 1998). A hub index quantifies the degree of centralization in an airline's network. The hub index is calculated in this study as the percentage of a carrier's flights originating from its four busiest airports. This is the same metric employed in the airline profitability study of West and Dellana (2016). This index is calculated for all nine airlines each quarter from 2004 through 2007. Airlines that structure the network with multiple hubs will exhibit a high hub index while airlines that favor direct flights with low hub use will have a lower hub index.

A fleet standardization index is used in this research to estimate the degree of aircraft fleet uniformity (Pan and Santo, 2004; Kilpi, 2007). For each airline, for each quarter between 2004 and 2007, we measure the number of distinct manufacturers of aircraft and secondly the number of distinct aircraft families in the aircraft fleet. Within-family differences in aircraft are limited to fuselage length, payload capacity and engines (Kilpi, 2007). The fleet standardization index is constructed by weighting the number of manufacturers by 0.6 and the number of aircraft families by 0.4 (Kilpi, 2007). This metric differs from that employed in the airline profitability study of West and Dellana (2016). In that study, the number of distinct aircraft models was used as the metric for fleet complexity. The standardization index of Kilpi (2007), which is used in the current study, is a more appropriate measure of fleet complexity.

The choices of aircraft fleet standardization vary significantly among airlines. For example, during the study period Southwest Airlines had a very low fleet complexity that consisted of just one aircraft family from one supplier (i.e., the Boeing 737). By comparison, US Air had very high fleet complexity with eight different aircraft models. These included: Boeing 737, Boeing 757, Boeing 767, Embraer 170, Airbus 320, Airbus 330, Airbus 319, and Airbus 321. The metric for fleet complexity is calculated by counting the number of distinct aircraft families, not models, for each airline for each quarter of the study. An aircraft family is a different configuration of the same model. For example, the Boeing 737-300 and 737-400 models are counted as part of one family in the fleet standardization measure.

3.5 Model Selection and Estimation

The model implemented in this research is the method by Parks (1967) using fixed effects terms (Allison, 2009). This model was selected because of the observational nature of the data. The dependent variable used in this study is the airline's return on assets (i.e., operating profit divided by assets) for each of the airlines. The primary explanatory variables for each airline are the hub centralization index, which measures network centrality, and the fleet standardization index, based on quarterly calculations.

Because there may exist unobserved variables that could impact the statistical inferences, panel data lack the control and random assignment required for experimental designs. Another issue is that OLS estimates of cross-sectional data often deviate from the normality assumptions of the model errors. The Parks method has been used in prior study involving research with this data (Tsikriktsis, 2007; West and Dellana, 2016). A brief summary is provided here. The reader is referred to West and Dellana (2016) for a detailed explanation of the method in relation to airline data research and to Parks (1967) and Allison (2009) for general information on the method.

The Parks fixed effects model was implemented in SAS software. This modeling approach can estimate autocorrelation of variables over time in the measurements of independent variables, contemporaneous correlation of cross-sectional variables between airlines, and heteroscedasticity that may result from differing scales of airline operations (Parks, 1967). The Parks algorithm has been shown to be the best estimator for efficiency when the ratio of number of time periods studied (T) to the number of cross-sectional units (N) is greater than 1.5 (Reed and Haichun, 2011). For this study there are 16 time periods (T) and nine airlines (N), which yields a ratio of T/N = 1.78.

In addition, the model data was transformed to a standard normal distribution to facilitate comparisons. An example of the original data is included in Table 2 for Southwest Airlines. The transformation process is explained for the first data point listed in the table, the ROA of 7.728 for Southwest Airlines in Quarter 1 of 2004. The mean for 144 observations of all nine airlines for 16 quarters is calculated as -0.2458. This quantity was subtracted from all 144 ROA data points to give a new distribution with mean of zero. The sample standard deviation is then calculated for the same set of 144

ROA observations resulting in 5.204. The final step is to divide each data point in the distribution with mean of zero by the sample standard deviation. Thus, the calculation of the transformed ROA is given by (7.728 - (-0.2458))/5.204. This results in a transformed ROA value of 1.53 for Southwest Airlines in Quarter 1 of 2004. The transformed data now has mean of zero and standard deviation of one.

TABLE 2. SOUTHWEST ARILINES EXAMPLE DATA.

Airline	Year	Quarter	Return on Assets	Fleet Complexity	Network Centrality
WN	2004	1	7.728	1.000	0.238
WN	2004	2	10.701	1.000	0.247
WN	2004	3	11.740	1.000	0.248
WN	2004	4	5.640	1.000	0.239
WN	2005	1	9.382	1.000	0.235
WN	2005	2	11.176	1.000	0.251
WN	2005	3	15.108	1.000	0.259
WN	2005	4	15.318	1.000	0.255

IV. DISCUSSION OF EXPERIMENTAL RESULTS

We first present results for individual variable fixed effects regression models and then a joint simultaneous model including both explanatory variables and an interaction term between flight network centrality and fleet complexity. The reader is reminded that the explanatory variables are transformed to a standard normal distribution to improve modeling and facilitate comparisons. This transformation results in negative values for both network centrality and fleet complexity. In the following discussion negative values can be interpreted as choices that are less than the industry mean, while positive values are choices greater than the industry mean.

The following regression symbols represent the variables that help define the model equations developed in this section on Experimental Results: **P** is Operational Profitability, (i.e., Adjusted Operating Profit/Assets); **Net4** represents Flight Network Centrality; and, **S** represents Aircraft Fleet Standardization.

4.1. Single Variable Fixed Effects Model

The parameter estimates for the flight network centrality (Net4) are summarized in Table 3. The dummy variable estimates (not shown) control for the effect of other service design variables (including fleet complexity) as well as unobserved influences. The R^2 of the fitted model is 0.72; the parameter estimate for the flight network centrality is -0.233 ($p = 0.0074$) and the estimate for the squared network centrality is -0.314 ($p < 0.0001$).

TABLE 3. STATISTICS AND PARAMETERS OF ESTIMATED MODEL FOR NETWORK CENTRALITY.

Estimation Method	Parks
Number of Cross Sections	9
Time Series Length	16

Fit statistics

SSE	49.61	DFE	134
MSE	0.37	Root MSE	0.61
R-Square	0.72		

Standardized parameter estimates

Structural Design Variable	Parameter Estimate	Error	t Value	Pr. > |t|
Flight Network Centrality	-0.233	0.0.08	-2.72	0.0074
Flight Network Centrality^2	-0.314	0.057	5.47	<0.0001

The estimated causal relationship between operational profitability (P) and the flight network centrality (Net4) is given by equation 2.

$$\boldsymbol{P = -0.233 * Net4 - 0.314 * Net4^2} \tag{2}$$

The first derivative of equation 2 (i.e., equation 3) can be solved to estimate the degree of flight network centrality that maximizes operational profitability. This occurs at a standardized value of network centrality of -0.37; the mean value of the industry's actual network centrality is zero.

$$\boldsymbol{\frac{dP}{dNet4} = -0.233 - 0.628 * Net4 = 0} \tag{3}$$

This suggests that, for the U.S. domestic airline industry, the service delivery choices of flight network centrality are not optimal. Hypothesis 1 that states, "the service delivery network routing structure is aligned with the service concept" is generally not supported for the airline industry during the timeframe investigated in this study. The negative standardized value implies a shift to less centralized flight networks would increase industry profits. This is supported by a map, presented in Fig. 2, of the position of the service design choice for flight network centrality for each airline. There are three different curves plotted in Fig. 2. These are displacements for different fixed effects estimates and have no influence over the optimal alignment of the variable.

American (AA), AirTran (FL), Delta (DL), and US Air (US) are close to the -0.37 optimal value for flight network centrality. Jet Blue (B6), Continental (CO), United (UA) and Northwest (NW) have positive standardized values, whereas Southwest (WN) has a highly negative standardized value. These locations reflect a significant lack of alignment and the opportunity to increase profitability. In the cases of Jet Blue, Continental, United, and Northwest this would be accomplished by designing less centralized route structures.

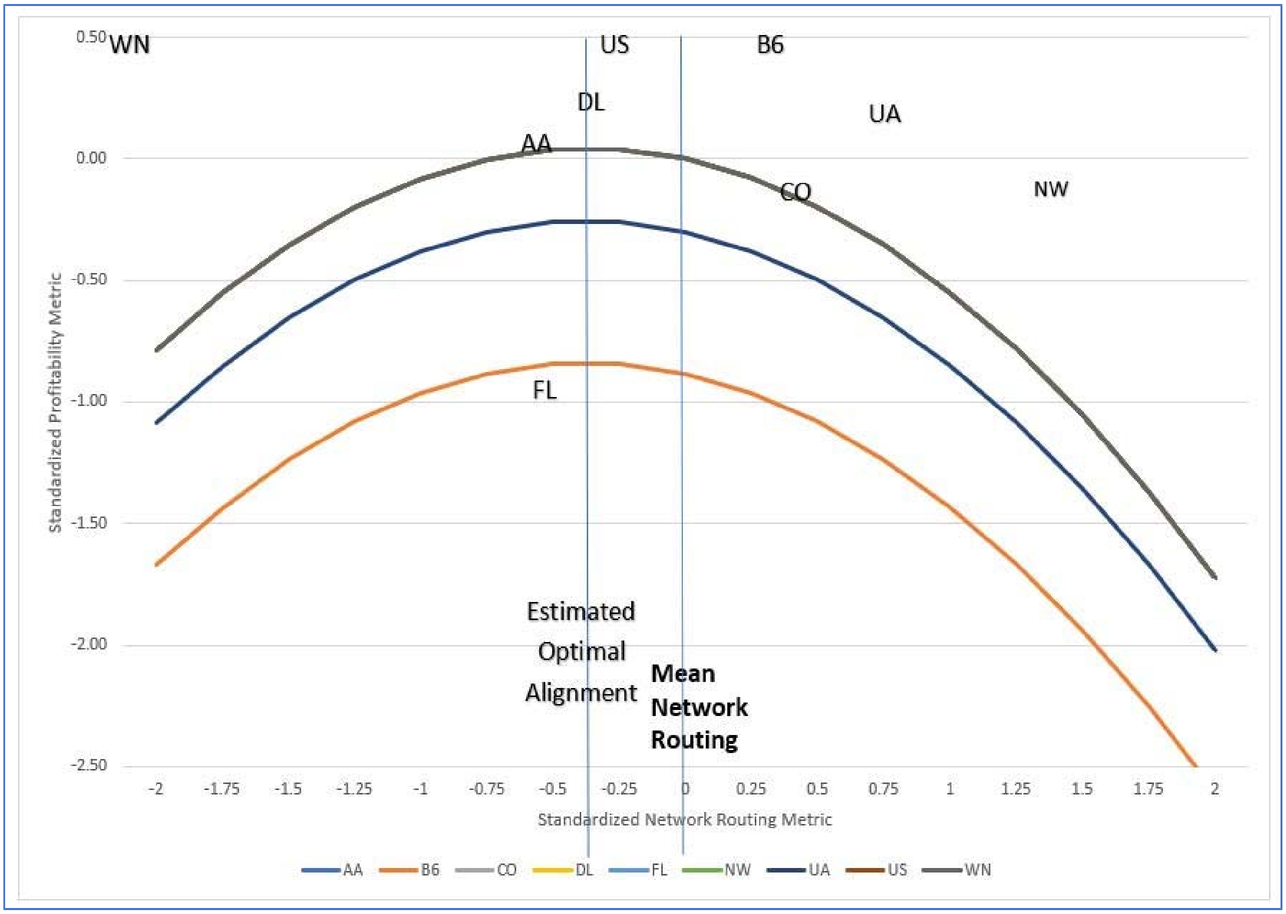

FIGURE 2. ALIGNMENT OF NETWORK ROUTING BY AIRLINE.

The single variable model of Parks fixed effects regression estimates for service delivery choices of fleet complexity are given in Table 4. The R^2 for this model is 0.88 with a fleet complexity parameter estimate of -0.718 ($p < 0.0001$) and the squared fleet complexity estimate of -0.428 ($p < 0.0001$). Equation 4 expresses the estimated impact of fleet standardization (S) on operational profitability (P).

$$\boldsymbol{P} = -.\mathbf{0718} * \boldsymbol{S} - \mathbf{0.428} * \boldsymbol{S}^{\mathbf{2}} \tag{4}$$

TABLE 4. STATISTICS AND PARAMETERS OF ESTIMATED MODEL FOR FLEET COMPLEXITY.

Estimation Method	Parks
Number of Cross Sections	9
Time Series Length	16

Fit statistics

SSE	53.46	DFE	134
MSE	0.40	Root MSE	0.63
R-Square	0.88		

Standardized parameter estimates

Structural Design Variable	**Parameter Estimate**	**Error**	**t Value**	**Pr. > |t|**
Fleet Complexity	-0.718	0.08	-8.98	<0.0001
Fleet Complexity^2	-0.428	0.052	8.30	<0.0001

The first derivative of equation 4 (i.e., equation 5) can then be solved to estimate the empirical level of fleet complexity that maximizes operational profitability.

$$\frac{dP}{dS} = -0.718 - 0.856 * S = 0 \tag{5}$$

The empirical estimate of the optimal value of fleet complexity is -0.84. Hypothesis 2 that states, "the structural choice of fleet complexity is aligned with the service concept" is generally not supported for the U.S. domestic airline industry during the timeframe investigated in this study. The alignment gap for fleet complexity is significantly larger than the gap reported previously for flight network centrality. The difference between the industry's actual fleet complexity and the estimated optimal is almost a full standard deviation. The negative standardized value implies that a shift to lower fleet complexity would increase industry profits.

This is supported by a map, presented in Fig. 3, that locates the relative positions of the airlines for the strategic choice of fleet complexity. Southwest (WN), AirTran (FL), Jet Blue (B6), and Continental (CO) have fleets that are less complex than the industry mean and are reasonably aligned to the estimated optimal alignment. The other five airlines have fleet complexity between one and two standard deviations greater than the estimated optimal point of alignment.

4.2. Multi-Variable Fixed Effects Model

In spirit, the single variable fixed effects models presented in section 4.1 control for other omitted design elements and external unobserved variables by analyzing only differences within airlines. In practice, airlines with higher levels of flight centrality tend to have more complex aircraft fleets. In this subsection we jointly estimate flight network centrality and fleet complexity and include an interaction term between the two. Table 5 has the parameter estimates from this model. The R^2 for the joint model is 0.79. The parameter estimate for fleet complexity is -0.333 (p = 0.020) and the square of fleet complexity is estimated at -0.244 (p = 0.0005). The linear term for flight network centrality was not significantly different from zero and does not appear in the model. The squared term for flight network centrality is estimated at -0.147 (p = 0.030). The estimate of the interaction between fleet complexity and flight network centrality is 0.130 (p = 0.008). The three-dimensional surface estimated for the joint model is defined by equation 6 and the two partial derivatives by equations 7 and 8.

$$\boldsymbol{P} = -\mathbf{0.333} * \boldsymbol{S} - \mathbf{0.244} * \boldsymbol{S}^{\mathbf{2}} - \mathbf{0.147} * \boldsymbol{Net4}^{\mathbf{2}} + \mathbf{0.13} * \boldsymbol{Net4} * \boldsymbol{S} \quad (6)$$

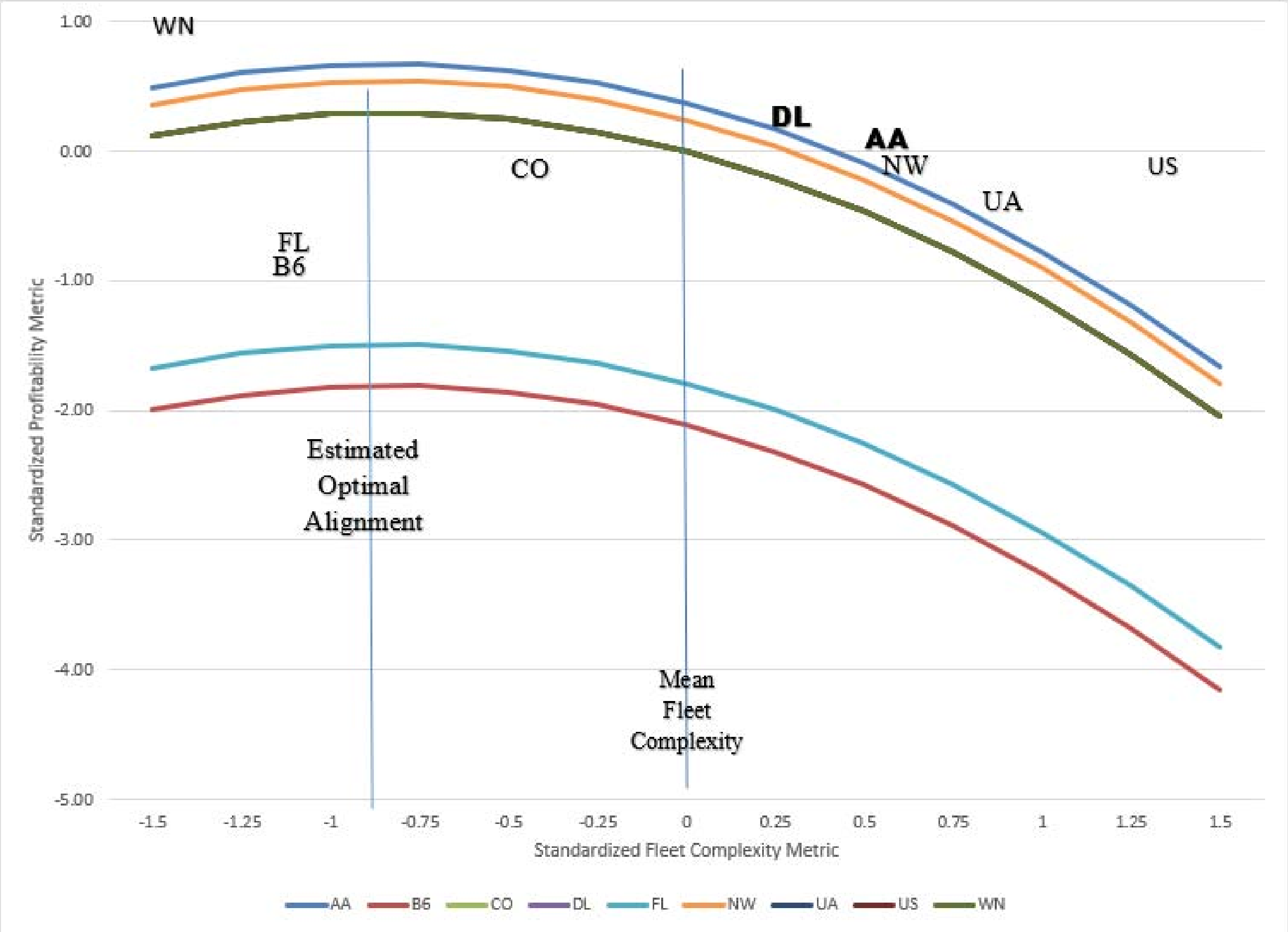

FIGURE 3. ALIGNMENT OF AIRCRAFT FLEET COMPLEXITY CHOICE BY AIRLINE.

The following partial derivatives are calculated.

$$\frac{\partial \boldsymbol{P}}{\partial \boldsymbol{S}} = -\mathbf{0.333} - \mathbf{0.488} * \boldsymbol{S} + \mathbf{0.13} * \boldsymbol{Net4} = \mathbf{0} \quad (7)$$

$$\frac{\partial \boldsymbol{P}}{\partial \boldsymbol{Net4}} = -\mathbf{0.294} * \boldsymbol{Net4} + \mathbf{0.13} * \boldsymbol{S} = \mathbf{0} \quad (8)$$

The solution to the two partial derivatives identifies an empirical optimal value for profitability at value of fleet complexity of -0.77 (vs. -0.84 for single variable model) and flight network centrality of -0.34 (vs. -0.37 single variable model). These estimates do not substantially differ from the values estimated for the single explanatory variable models. Fig. 4 depicts the variation of operational profitability with the jointly estimated values of fleet standardization and flight network centrality. It is evident that the variation is greatest along the fleet complexity axis.

TABLE 5. STATISTICS AND PARAMETERS OF ESTIMATED MULTI-VARIABLE MODEL.

Estimation Method	Parks
Number of Cross Sections	9
Time Series Length	16

Fit statistics

SSE	32.93	DFE	132
MSE	0.25	Root MSE	0.50
R-Square	0.79		

Standardized parameter estimates

Structural Design Variable	**Parameter Estimate**	**Error**	**t Value**	**Pr. > |t|**
Fleet Complexity	-0.333	0.142	-2.35	0.0203
Fleet Complexity^2	-0.244	0.069	3.55	0.0005
Flight network Centrality^2	-0.147	0.067	2.19	0.0303
Fleet*Flight Interaction	0.130	0.048	2.69	0.0080

The surface map of Fig. 4 is collapsed to a two-dimensional plot in Fig. 5. We see that Continental (CO), Jet Blue (B6), AirTran (FL), and Southwest (WN) have strategic choices for fleet complexity and flight network centrality that are reasonably well aligned with the optimal profitability estimated by the multi-variable model. The other airlines are far from the optimum point, in particular, Delta (DL), Northwest (NW), United (UA) and US Air (US).

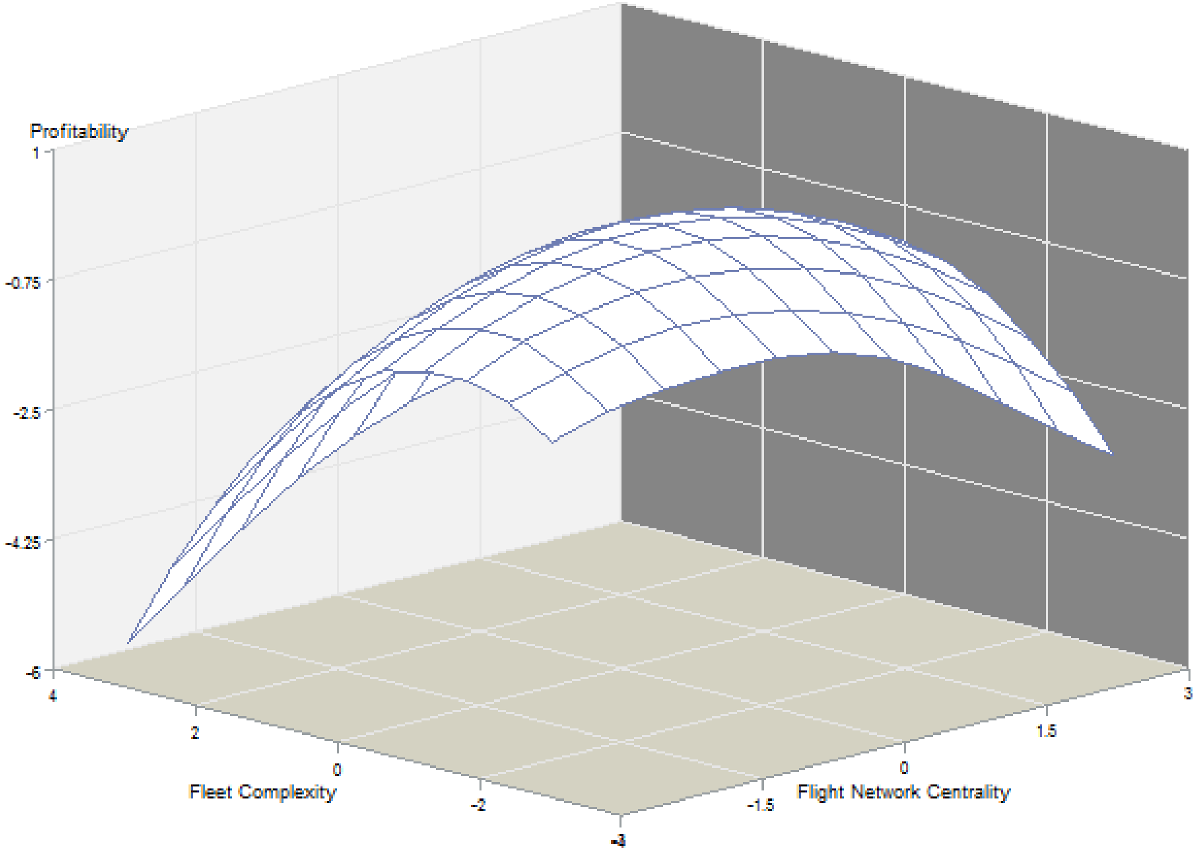

FIGURE 4. RESPONSE SURFACE OF JOINT MODEL.

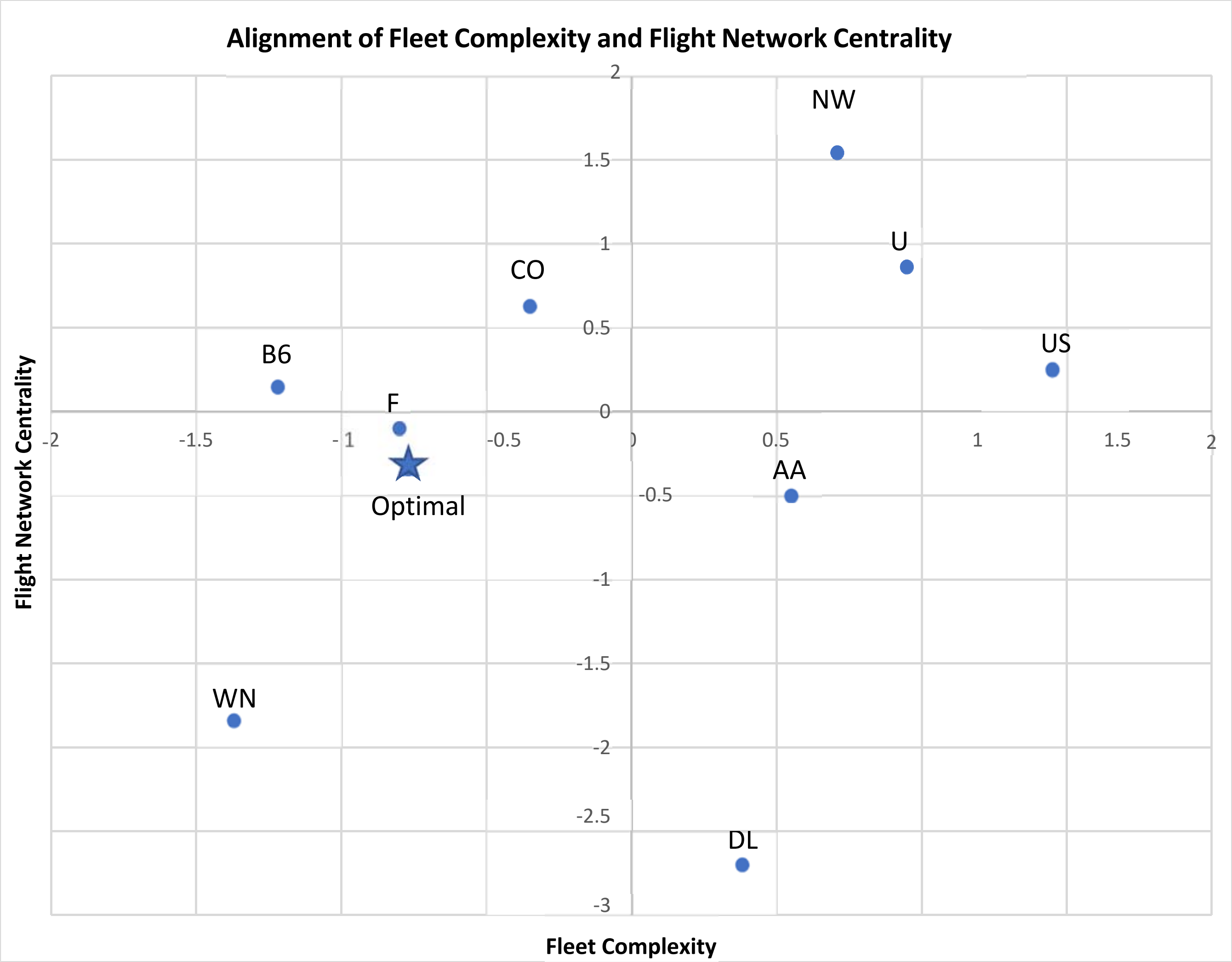

FIGURE 5. MAP OF MULTI-VARIABLE MODEL.

V. CONCLUSIONS AND IMPLICATIONS

To our knowledge, this is the first research to empirically test the alignment of the service triad elements in relation to service operations profitability. Our conceptual model measures and contrasts the empirical alignment of fundamental service delivery of strategic design choices to an estimated optimal alignment. These strategic design choices involve key managerial choices for the service structure and can be implemented at the managerial level.

This research is also unique in its examination of the service triad alignment, specifically in relation to the airline industry and potential impacts on the structural design decisions in that industry. The decisions entail the key structural variables related to the degree of centralization of the flight network and the resolution of the cost and benefit tradeoffs of aircraft fleet complexity. Our research demonstrates the use and value of big data to study and prioritize service improvements. It is also worth noting that using a spatial centrality metric as a continuous variable allows the analysis of other forms of flight networks. A long stream of research studies has involved only discrete alternatives for flight networks, namely single hub, multi-hub or point-to-point design.

The results of this study indicate that the competitors in the airline industry have varying degrees of misalignment to the optimum for their structural design variables involving flight network centrality and fleet complexity. The misalignment is moderate for network centrality but is large for fleet complexity.

The average results for network centrality indicate an industry over-emphasis on routing through hub airports. Greater use of direct flights has the potential to improve profitability. Customer value and satisfaction with the airline service concept may be judged to some extent by our hub measure of flight network centrality. This is because hub-and-spoke networks are characterized by longer, indirect flights, which likely impacts negatively on customer satisfaction. The reasons for this are difficult to judge but could involve customer inconveniences and discomforts associated with being confined on a long flight. In either case, the reasons are somewhat speculative since the data do not allow direct determination of customer value components from the network structure.

The standardization of the aircraft fleet is a strategic theme highlighted by our findings. The degree of misalignment of the fleet complexity structural design choice is rather large, with the industry average indicating a substantial over-commitment to fleet diversity. Delta, American, Northwest and US Airlines are all one to two standard deviations to the right of the estimated optimal alignment. The use of fewer aircraft types could improve profitability for these airlines. Across service domains, the proper balance of standardization and customization has become an important consideration (Joha and Marijn Janssen, 2014; Black, Childers, and Vincent, 2014; Wang, et al., 2010). Commercial airline fleet standardization is of particular interest given the large volume of passenger transport that occurs annually, and the substantial costs and revenues involved (Parast and Fini, 2010; West and Bradley, 2008; Tsikriktsis, 2007). As with any type of customization, there is a tension between different types of cost. Diverse fleets increase operating, maintenance and training costs associated with the many different types of aircraft (Flouris and Walker, 2005). However, fleet variety allows tailoring to better match aircraft capacity to the demand patterns along route segments (Lohatepanont and Barnhart, 2004). Clearly the proper balance of this type of customization and standardization will have an impact on potential profitability and also be related to the structure of the network.

Earlier studies on airline performance have emphasized the importance of scale and capacity management, but this research demonstrates how fleet complexity and flight network routing centralization play key roles in airline service strategy and performance. It has been evident that the domestic airlines have not been able to differentiate their service offerings and that price and convenience are the basis for customer purchase decisions. Therefore, airlines must be keenly aware of the number of competitors on each segment of their flight network and of the competitive behavior of these rivals.

If history is any indication of how well the typical service design has served the airline industry, one can reflect on the many recent consolidations of major air carriers reported in various media outlets. Between 2009 and 2014, many of the major airlines in this study merged. Delta (DL) acquired

Northwest (NW) airlines in 2009. In 2011, United Airlines (UA) acquired Continental (CO), and Southwest (WN) acquired AirTran (FL). Most recently American Airlines (AA) acquired US Air (US) in 2014. Jet Blue (B6) has managed on its own without being involved in a merger. It is also very close to the optimal point in Fig. 5, which depicts the joint relationship of network centrality and fleet complexity to the optimum. As previously noted, mergers have the effect of increasing an air carrier's scale, which tends to have a positive impact on profitability (West and Dellana, 2016). Also, the merger brings with it the network structure of the newly acquired rival, which allows rapid changes to the network structure that would otherwise take substantial time. In general, these mergers appear to have moved the parent organization closer to the optimum for network centrality. Fleet complexity is harder to judge, but it is more easily managed and changed than network structure. American Airlines recently announced it has changed its order plans to simplify its aircraft fleet, noting that a more standardized fleet has many benefits, including less friction in operations when planes are swapped, reduced inventory needs, and more consistent customer service (CAPA, 2018). Southwest's fleet complexity increased after the acquisition of AirTran and the addition of the Boeing 717 to their fleet. It is noteworthy that post-merger they subleased all of the Boeing 717 models to Delta maintaining their focus on a fleet of Boeing 737's. Aviation Weekly stated: "*Southwest says it will spend about $100 million to convert AirTran Airways' Boeing 717s to Delta Air Lines' livery and specifications before subleasing them to the legacy carrier, but Chairman, President and CEO Gary Kelly insists the expense is justified to eliminate all 88 of the 100-seat aircraft from Southwest's fleet.*" (https://aviationweek.com/awin/southwest-boeing-spending-140m-717-conversion). Southwest also inherited a highly centralized hub structure in Atlanta from AirTran. The strategic choice to reduce centrality is chronicled in The Fort Worth Star-Telegram: "*AirTran operated a connecting hub at Hartsfield-Jackson with more than 200 daily departures before the merger. But Southwest has "de-hubbed" that operation, focusing less on drawing passengers to connecting flights and more toward travelers starting or ending their trips in Atlanta. The result: a drop to about 160 daily departures for AirTran and Southwest combined.*" (https://www.star-telegram.com/news/business/article3848896.html). Such changes underscore the need for active alignment of the service system elements to maintain maximum profitability and performance.

There are several limitations to this study that should be mentioned. The study is confined to a short interval of time (2004 to 2007) when economic conditions were stable, and the industry consisted of nine major competitors. We were not able to extend the time horizon to include more recent data because mergers reduced the number of competitors to five. The US domestic airline industry is a complex system to model with the many potential economic factors that could confound the results. Some of these factors (e,g., differences in jet fuel prices between airlines) we could identify and make appropriate adjustments to the data. The impact of the remaining confounding effects is minimized by the use of a fixed effects regression model over a stable four-year period. Differences between airlines, such as aircraft financing decisions, are neutralized by the fixed effects regression model. We also note that OLS estimates of panel data usually deviate from the normality assumptions of model errors. The Parks (1967) regression method used minimizes the impact of these problems. The assumptions of this research may also be questioned. We make arguments that the target market is the same for all nine airlines and that the service concepts are the same or very similar. Deviations from these assumptions would justify differences between airlines in service delivery design.

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