PRODUCTION AND OPERATIONS MANAGEMENT
POMS
Vol. 13, No. 2, Summer 2004, pp. 123–134
ISSN 1059-1478 | 04 | 1302 | 123$1.25

Performance Improvement Paths in the U.S. Airline Industry: Linking Trade-offs to Asset Frontiers

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Several articles have been written during the past few years examining performance improvement paths and various forms of efficiency frontiers in operations strategy. These articles focus primarily on defining and describing these frontiers and raise questions concerning how to improve operations. In this paper, we provide one of the first empirical studies aimed at validating these earlier studies. Using a database on the 10 largest U.S. airlines for a period of 11 years, we test and validate some of the models presented in the operations literature. The 10 major airlines are separated into 2 groups for analysis: geographic specialists and geographic generalists. Our analysis shows that better performing airlines (in terms of cost-quality position) in both groups confirm the predictions of the sand cone model when operating further away from their asset frontiers, although trade-offs do occur when operating close to asset frontiers.

Key words: operations strategy; performance improvement paths; trade-offs; asset frontiers; logistic regression; services; strategy
Submissions and Acceptance: Received August 2002; revision received February 2003; accepted May 2003 by Robert Hayes.

1. Introduction

During the past 20 years, some of the fundamental thinking in the Operations Management field has changed dramatically. In the early 1980s, operations managers and operations management courses addressed trade-offs between operations priorities. In the late 1980s and early 1990s, the discussion turned to sequences of capabilities improvements and the possibility that trade-offs actually no longer existed in operations. In 1996, in a special issue of *Production and Operations Management* (see Skinner 1996a), Clark (1996) and Hayes and Pisano (1996) introduced the notion of performance improvement paths. This paper presents one of the first longitudinal empirical analyses of performance improvement paths, using quality and cost data from the U.S. airline industry.

We plot performance improvement paths for the 10 largest U.S. airlines over a period of 11 years. The 10 major airlines are separated into 2 subgroups: geographic specialists and geographic generalists. In both subgroups, we find that airlines operating close to their asset frontiers faced initial trade-offs, whereas airlines operating farther away from their asset frontiers were able to improve quality and cost simultaneously. Logistic regression estimates confirm our analysis of the performance improvement path plots. We also find that lasting quality improvements precede lasting cost improvements.

In this paper, we first discuss some of the evolution of the Operations Management community's view of trade-offs, mass customization, and improvement paths. Next, we describe our data and plan of analysis. Finally, we present and discuss results concerning how these data either support or refute some of the theories discussed below.

2. Trade-off Models

For many years, operations managers focused on four primary objectives: cost, quality, flexibility, and delivery. In the 1970s and early 1980s, the relationships between them were typically described as pure trade-offs. As one cartoonist put it, "I have low cost or high quality. Which do you want?" If one desired very high quality, then the expectation was that this could only be achieved at high cost (and vice versa). Models were developed to calculate the "optimal" number of defects desired in a process (e.g., Fine 1986).

If one desired rapid delivery, this could only be achieved through the maintenance of high levels of finished goods inventory. The existence of this inventory precluded any flexibility in the operations. If a customer desired something which was non-standard, requiring flexible operations, the penalty was typically delayed shipment. Of course, flexibility was a simpler concept at that point in time as well. In today's environment, we deal with numerous types of flexibility (see Gerwin 1993 or Upton 1994).

This fundamental view of trade-offs was challenged by Ferdows and De Meyer (1990) when they introduced the sand cone model, built on the concept of cumulative capabilities. Based on empirical evidence, this model postulated that there was a sequence in which operations objectives should be achieved. The sequence they presented began with quality and ended with cost, with flexibility and delivery in between. Their fundamental result was that operations should have a good base of high quality first and, from that, expand into improving the other operations objectives, with cost last. Since its introduction, this model has been examined in other settings to determine its validity (see, e.g., Roth 1996 and Noble 1995). While these researchers and many others found support for the sand cone model, others found evidence which was contrary to it. For a complete review of research on the sand cone model, see Scudder (2001).

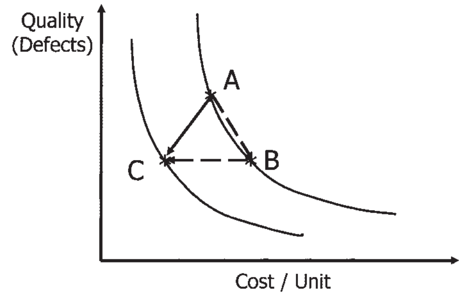
As operations technologies advanced, the concept of trade-offs was further challenged. Mass customization, where a customer could have flexibility, rapid delivery, good quality, and reasonable cost was proposed by Pine (1993). Distinctions were also made between short-term and long-term trade-offs (St. John and Young 1992). Operations management textbooks began eliminating discussions of trade-offs between the operations objectives. But, as we neared the latter half of the 1990s, more research emerged re-examining the need for trade-offs in operations (Skinner 1996b, 1996c). Most recently, Safizadeh, Ritzman, and Mallick (2000) found trade-offs between some of the operations capabilities, but not all of them. Boyer and Lewis (2002) examined how manufacturing firms that have recently implemented advanced manufacturing technologies view competitive priorities. Their results indicate that trade-offs still do exist, but some of the differences are more subtle than in earlier years.

In the midst of the trade-off discussion, Porter (1996) re-emerged on the strategy front describing productivity frontiers. He makes the point that firms farther from their productivity frontiers do not encounter trade-offs and are able to simultaneously improve on multiple performance measures. However, as firms improve their performance and move closer to the frontier, trade-offs are required. In his view, firms improve their productivity frontiers by investing in new technologies or processes.

In the Operations Management literature, Schmenner and Swink (1998) introduce their "Theory of Performance Frontiers." They introduce the concept of an "asset frontier," which is formed by structural choices made by a company-investment in plant and equipment. They also describe the "operating frontier," which is defined by choices management makes in operating the plant, the infrastructural choices. They point out that firms whose operating frontiers are closer to the asset frontier are operating under the law of trade-offs, while firms further from the frontier operate under the laws of cumulative capabilities. They also introduce the concepts of "bettering" performance and "improving" performance, where the former refers to improved performance on a better operating frontier (higher performance, lower cost), while the latter refers to moving toward an existing operating frontier. Vastag (2000) extends their concepts to a "between-firm" analysis where a firm's operating frontier can be viewed as a unique resource of the firm with the potential to provide a sustainable competitive advantage.

While these authors discuss different approaches to understanding operations trade-offs and performance, they do not explicitly address how one makes these improvements. Clark (1996) and Hayes and Pisano (1996) raise the issue of performance improvement paths. Given an existing operating frontier and a "bettered" operating frontier, how *do* firms move from one to the other? How *should* they? If we think about cost and quality as our two primary objectives, how should a firm improve quality and lower costs? Should improvement first occur on the existing operating frontier, where improved quality generally results in increased costs (A to B in Figure 1), followed by an effort

Figure 1 **Performance Improvement Paths**



to lower costs, thus moving the firm to a "better" operating frontier (B to C in Figure 1)? Or could a firm put into place a program which allows improvement on both at the same time (A to C in Figure 1)? What determines which paths are available to choose from? These authors point out that there has been almost no empirical research on questions such as these.

This paper examines how airlines have improved performance based on longitudinal data collected by the U.S. Department of Transportation. Specifically, we develop measures of cost and quality from these data and will "test" whether airlines first improve cost or quality, or both at once. In addition, we also examine how performance improvements change when airlines are operating closer to their "asset frontiers." Based on ideas by Schmenner and Swink (1998) and Porter (1996) discussed above, we will test:

Hypothesis 1: Airlines operating closer to their asset frontiers will face initial trade-offs such that they will only be able to improve either cost or quality, but not both simultaneously.

Based on sand cone thinking (Ferdows and De Meyer 1990) discussed above, we will also test:

Hypothesis 2: Airlines that end up in a sustainable superior quality-cost position will make larger initial improvements on quality compared with cost.

3. Data and Method

3.1. Data

3.1.1. Quality. We use consumer complaints filed with the U.S. Department of Transportation (DOT) as an indicator of quality. From 1987 to 1998, passengers could file complaints with DOT in writing, by telephone, or in person. Complaint categories included flight problems, oversales, reservations/ticketing/boarding, fares, refunds, baggage, customer service, smoking, advertising, credit, tours, and other. Several factors led to a surge of complaints against airlines in 1987: in August 1987, complaints were up by almost 500% over January 1987.

First, in early 1987, airlines' performance as well as DOT's consumer phone number and address were given widespread publicity, which in turn led to increased consumer awareness concerning airline quality and the means to file complaints.

Second, in May 1987, the Secretary of Transportation, Elizabeth Dole, sent a letter to all major airlines concerning consumer dissatisfaction with the airline industry. She asked airlines to consider several steps, including re-education and training of employees, assessment of resources allocated to various sources of dissatisfaction, such as processing refunds and baggage claims, and review of complaint trends and processing times to resolve complaints.

Third, starting in October 1987, DOT required major airlines to report mishandled baggage, involuntary denied boarding, and on-time arrival statistics. DOT, subsequently, started to publish these statistics along with complaints per 100,000 passengers (the broadest measure of quality) in DOT Air Travel Consumer Reports. In 1999, DOT introduced an e-mail address as an additional channel for filing consumer complaints.

To measure quality, we use annual data on consumer complaints filed with DOT for the period 1988–1998 for the following reasons:

1. In services, every interaction between a consumer and a service provider is a "moment of truth." Consumers compare ex ante expectations about the service to be provided with ex post perceptions concerning the service delivered. Consumer (dis)satisfaction is a function of the difference between expected and perceived service. The more perceived service exceeds expected service, the higher consumer satisfaction will be. Conversely, the more perceived service falls short of expected service, the higher consumer dissatisfaction will be. Service quality is typically defined in terms of consumer (dis)satisfaction. Hence, service quality is inherently subjective in nature. Consumer (dis)satisfaction, in turn, drives repeat purchases (Fitzsimmons and Fitzsimmons 2001; Metters, King-Metters, and Pullman 2003; Heskett, Sasser, and Schlesinger 1997; Zeithaml, Parasuraman, and Berry 1990). Consumer complaints filed with DOT clearly capture customer dissatisfaction: these customers were so dissatisfied that they wanted to tell the government about their service interactions.
2. "Consumer complaints" is the broadest measure of quality available.
3. The impact of factors such as weather and holidays on quality can exhibit seasonal trends and potentially introduce noise. By using annual data as opposed to quarterly data, we control for any seasonal trends.
4. During the period 1988–1998, consumers could only file complaints with DOT in writing, by telephone, or in person. No other channels were added or deleted during this time frame. Restricting our dataset to 1988–1998 controls for ease of reporting complaints. By starting in 1988, as opposed to 1987, we also control for increased awareness of filing complaints with DOT.
5. We study consumer complaints filed directly with DOT. Airlines were not involved in collecting and reporting these complaints. So, our analysis is not confounded by any changes in reporting patterns by airlines.

3.1.2. Cost. The traditional measure for unit cost in the airline industry is cost per available seat mile, calculated as operating expenses divided by available seat miles. (One available seat mile is one seat flown over one mile available for revenue service.) Airlines report both operating expenses and available seat miles to DOT. As we are interested in real efficiency gains as opposed to inflation effects, we express all operating expenses in 1988 dollars using the Airline Composite Cost Index (Air Transportation Association 2001).

3.1.3. Fleet Utilization. We compare fleet utilization across airlines to assess how close airlines are to their asset frontiers. We calculate fleet utilization as Total Block Aircraft Hours/(24 hours/day × Total Aircraft Days). Block Aircraft Hours measure the elapsed time from the moment an aircraft first moves under its own power from the boarding ramp at one airport to the time it comes to rest at the ramp for the next point of landing. Total Block Aircraft Hours are the sum of Block Aircraft Hours over all aircraft for all flights. Total Aircraft Days are the sum over all aircraft owned or acquired through rental or lease of the number of days they are available for service. In sum, fleet utilization measures the portion of the day an airline uses aircraft for service with passengers on board taxiing, taking off, flying, landing, and taxiing. All major airlines also report Block Aircraft Hours and Aircraft Days to DOT.

3.2. Two Subgroups of Airlines

DOT classifies an airline as major if the airline has at least 1% of total U.S. domestic passenger revenues. Our dataset includes the 10 major airlines for the entire period 1988–1998: Alaska, America West, American, Continental, Delta, Northwest, Southwest, TWA, United, and U.S. Airways. The only other major airlines operating in part of 1988–1998 ceased operations well before 1998: Eastern in 1990 and Pan Am in 1991. Combined, the major airlines account for more than 93% of revenue passenger miles for all U.S. airlines. (One revenue passenger mile is transporting one passenger over one mile in revenue service.)

Three airlines (Alaska, America West, and Southwest) focus on routes in North America only. Simplified operations with a single plane type result in fast turnaround times—the time a plane spends at a gate between successive flights. These airlines cherry pick routes and less congested airports that fit their business model of fast turnaround times. As a result, these airlines provide frequent, less expensive service. We will refer to these three airlines as "geographic specialists" (cf. Ingram and Baum 1997).

The other seven majors (American, Continental, Delta, Northwest, TWA, United, and U.S. Airways) offer both continental and intercontinental services. For example, all seven operate transatlantic routes. Within the U.S., these airlines operate at least two major hubs. Hub-and-spoke systems aim to provide large domestic coverage as well as feed passengers into intercontinental routes. Different types of planes within a fleet, connecting passengers and longer flights with higher in-flight service requirements, make for complicated operations. Intercontinental operations impede fast turnaround times. We will refer to these seven airlines as "geographic generalists" (cf. Ingram and Baum 1997).

We will conduct our performance improvement path analysis for each subgroup of airlines.

3.3. Method

We construct a performance improvement path for each major airline by plotting the evolution of annual quality-cost positions. For each subgroup, we also plot fleet utilization over time. We use the fleet utilization plots as surrogates for asset frontiers: airlines with higher fleet utilization are closer to their asset frontiers. Since the ". . . asset frontier is altered by the kinds of investments that would typically show up on the fixed asset portion of the balance sheet" (Schmenner and Swink 1998, p.108), the number of aircraft represents the asset frontier. Utilization of these aircraft then is the surrogate for "closeness." For airlines closer to their asset frontiers, initial trade-offs are more appropriate (Hypothesis 1). So, initially, we do not expect to see simultaneous improvements on both cost and quality for airlines closer to their asset frontiers (i.e., operating at higher utilization levels). Combined with sand cone thinking (Hypothesis 2), we expect an initial improvement on quality at the expense of cost, before high performing airlines will reach a position superior on both quality and cost.

For airlines farther removed from their asset frontiers, the laws of cumulative capabilities are more appropriate (Schmenner and Swink 1998). Thus, for airlines farther away from their asset frontiers, simultaneous improvement on cost and quality is possible. However, the occurrence of simultaneous improvement on cost and quality is not guaranteed. It will depend on airlines' abilities to move forward. For airlines that are able to (i) improve quality and cost at the same time, and (ii) sustain a superior quality-cost position, we expect larger initial improvements on quality compared with cost, as the sand cone model would predict (Hypothesis 2).

In addition to the analysis of performance improvement path plots described above, we also conduct a multivariate analysis to test whether trade-offs are more likely to occur for airlines operating closer to their asset frontiers (Hypothesis 1).

Formally, let $C_{i,t}$ denote cost per available seat mile (cost per ASM) for airline i in year t. Let $Q_{i,t}$ denote consumer complaints per 100,000 passengers for airline i in year t. Cost and quality improvements are denoted by $\Delta C_{i,t} = C_{i,t} - C_{i,t\text{-}1}$ and $\Delta Q_{i,t} = Q_{i,t} - Q_{i,t\text{-}1}$, respectively. For every airline-year observation (i,t), we determine whether (i) both cost and quality improved ($\Delta C_{i,t} < 0$ and $\Delta Q_{i,t} < 0$), (ii) a trade-off occurred ($\Delta C_{i,t} \times \Delta Q_{i,t} < 0$), or (iii) both cost and quality worsened ($\Delta C_{i,t} > 0$ and $\Delta Q_{i,t} > 0$). As we are interested in simultaneous improvements vs. trade-offs, we omit all airline-year observations for which both cost and quality worsened. For the remaining observations, we define $TO_{it} = 1$ if a trade-off occurred, 0 if simultaneous improvement occurred for airline i from year $t - 1$ to t.

Next, we develop a measure for distance to the asset frontier. Let FU_{it} be the Fleet Utilization for airline i in year t. For each subgroup of airlines, we define the highest fleet utilization observed up to year t as $MaxFU_t = \max_{j,s \le t} \{FU_{js}\}$, and the lowest fleet utilization observed up to year t as $MinFU_t = \min_{j,s \le t} \{FU_{js}\}$. We define Distance to the Asset Frontier as

$$DAF_{it} = \frac{MaxFU_t - FU_{it}}{MaxFU_t - MinFU_t}.$$

Since our dependent variable (TO_{it}) is a binary variable, we cannot use ordinary least squares regression. Logistic regression, however, is designed for binary-dependent variables (Hair, Anderson, Tatham, and Black 1998). We estimate the following logistic regression:

$$p_{it} = \Pr[TO_{it} = 1] = \frac{\exp(\alpha + \beta DAF_{i,t-1})}{1 + \exp(\alpha + \beta DAF_{i,t-1})},$$

or equivalently

$$\ln \frac{p_{it}}{1 - p_{it}} = \alpha + \beta DAF_{i,t-1}. \quad (1)$$

One advantage of using logistic regression to estimate (1) is that coefficients can still be interpreted in the same way as for multiple regression (Hair, Anderson, Tatham, and Black 1998). A negative estimate for β in (1) would imply that the probability of a trade-off is higher for a lower distance to the asset frontier. In other words, closer to the asset frontier, trade-offs would be more likely to occur.

4. Results

Figure 2a shows the performance improvement paths for the 10 major airlines, arranged in alphabetical order by subgroup. Note that the scales differ for each airline. Among the geographic specialists, for example, Alaska's cost per ASM was 9.68 cents in 1988, whereas Southwest's cost per ASM was 5.77 cents. Among the geographic generalists, U.S. Airways' unit cost was 10.45 cents per ASM in 1998, whereas Delta's was 7.09 cents per ASM. While Continental started with 11.9 complaints per 100,000 passengers in 1988, Delta was at 1.4 complaints per 100,000 passengers. The different scales allow us to study different types of performance improvement paths. In addition, the different scales make it easier to see whether an airline ended up in a 1998 cost-quality position superior to its 1988 starting position. Figure 2b shows the same performance improvement paths using common scales for all airlines. Thus, Figure 2b depicts the absolute magnitude of improvements achieved by each airline, relative to the others.

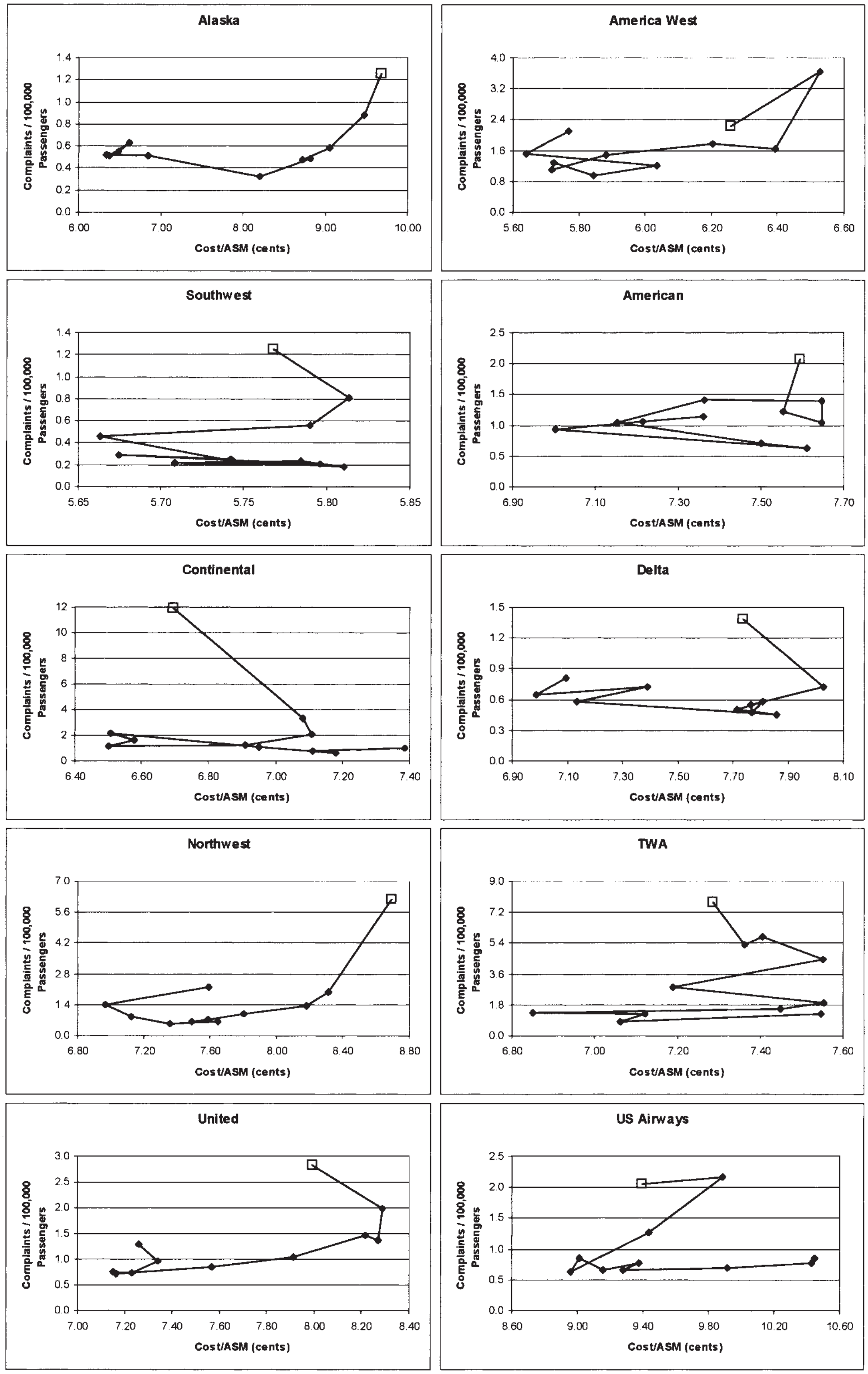
Figure 3 shows the fleet utilization evolutions. It is important to note that small differences in fleet utilization have a big impact. For example, for Southwest, the difference between 0.44 and 0.46 translates roughly into squeezing one additional flight out of every other plane. In an industry with high fixed costs and slim profit margins, such additional revenue-generating opportunities are very significant. In 1992, DOT released a study describing the Southwest effect on the airline industry. While the benefits of fast turnaround times are obvious (keep planes in the air where they earn money), Figure 3 shows that only the geographic specialists were able to perfect the practice of turning around planes quickly during 1994–1998 (e.g., see Hallowell and Hampton 2000). Fleet utilizations for all geographic specialists outperform fleet utilizations for all geographic generalists. Consequently, it makes sense to analyze each subgroup separately. Figure 4 shows evolutions of our measure for distance to the asset frontier measure, $DAF_{i,t}$.

4.1. Geographic Specialist Airlines

In 1988, Southwest had the highest fleet utilization, followed by America West and Alaska (Figure 3). So, Southwest was closer to its asset frontier (Figure 4). Supporting Hypotheses 1 and 2, Southwest faced an initial trade-off, improving first on quality at the expense of cost (Figure 2a), before ending up in a superior quality-cost position. Southwest initially increased flying operations expenses, which presumably helped reduce complaints related to flight problems. Later, the airline reduced flying operations expenses somewhat. Southwest did not have to reduce flying operations expenses to its initial level, as it reduced expenses in promotion and sales, general and administrative, and depreciation and amortization.

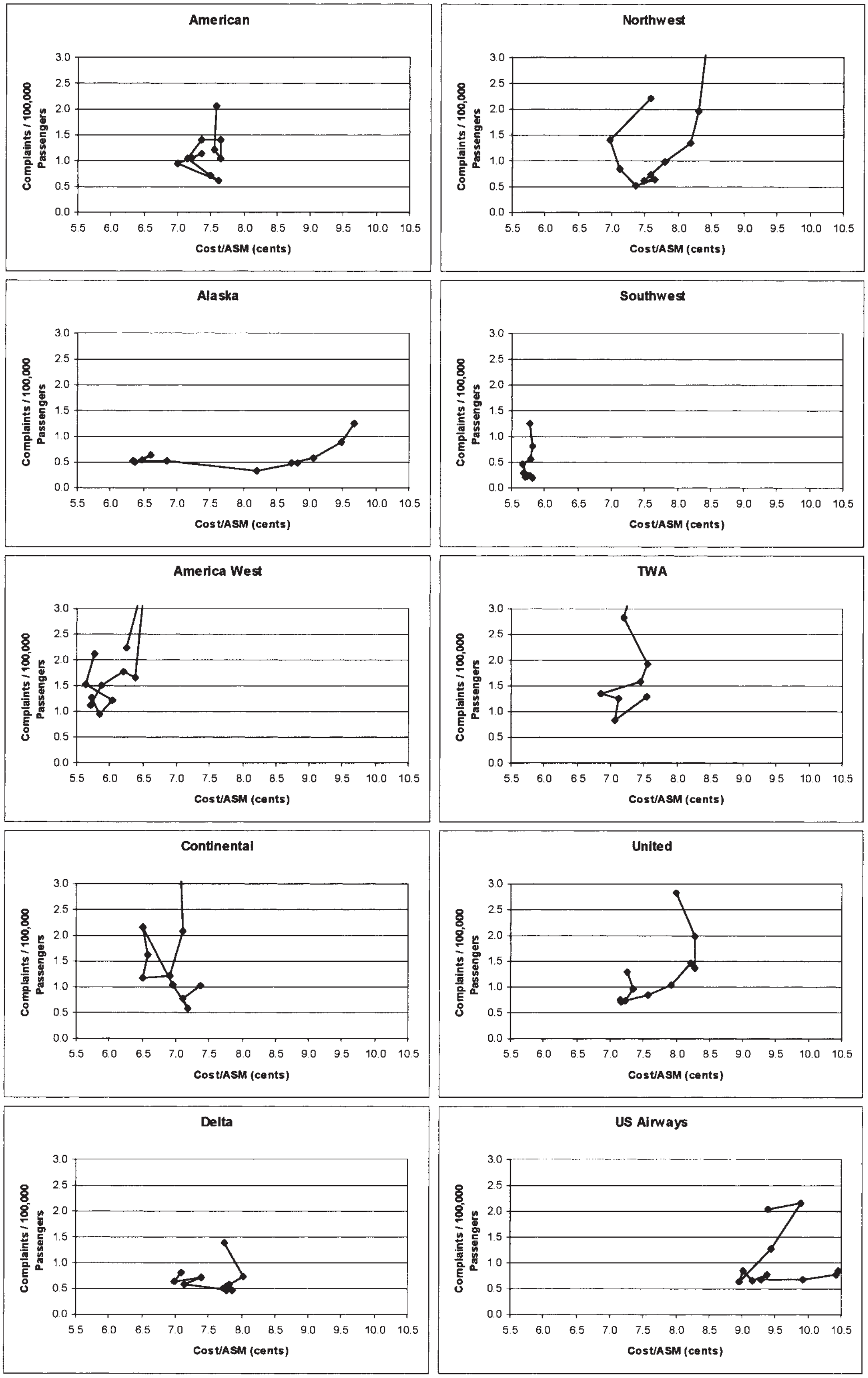
Alaska, on the other hand, started with the lowest fleet utilization in 1988 (Figure 3), thus it was farther from its asset frontier (Figure 4). Supporting Hypothesis 1, the airline was able to avoid any initial trade-offs by improving quality and cost simultaneously (Figure 2a). As Hypothesis 2 would predict, Alaska's quality improvements were initially larger than its cost improvements. Alaska was the first airline to use a "heads-up guidance system" during flight to reduce disruptions caused by fog. Investments in quality were offset by savings in other areas where the airline

Figure 2a. **Performance Improvement Paths for major airlines 1988–1998. Key: 1988 starting points in open squares (□). Individual Scales**



had a lot of slack. On a typical flight, Alaska reduced the number of flight attendants from five to three (required FAA minimum), cut meal service from flights under 1 hour and 20 minutes, replaced Boeing 727s with Boeing 737–400s, which were 40% more fuel efficient and required one fewer pilot, added seats to

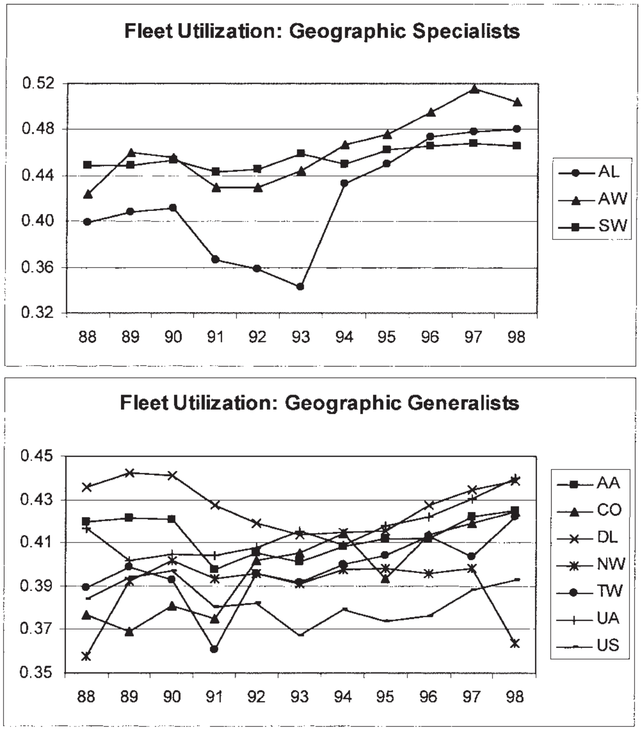
Figure 2b. Performance Improvement Paths for major airlines 1988–1998. Common Scales



aircraft by adjusting closets and galleys, and reduced turnaround times from 1 hour to 30 minutes (Hallowell and Hampton 2000).

So, for the two high performing geographic specialists (America West was never able to match the quality levels of Southwest and Alaska), we observe that

Figure 3 Fleet Utilization for Subgroups of Airlines. Key: Alaska (AL), America West (AW), Southwest (SW), American (AA), Continental (CO), Delta (DL), Northwest (NW), TWA (TW), United (UA), U.S. Airways (U.S.).



Southwest, with higher initial fleet utilization (closer to its asset frontier), faced an initial trade-off, whereas Alaska, with lower initial fleet utilization (farther away from its asset frontier), did not.

4.2. Geographic Generalist Airlines

In 1988, Delta, American, and United had the highest fleet utilizations among the generalist airlines, whereas TWA, U.S. Airways, Continental, and Northwest had lower fleet utilizations (Figure 3). So, we assume that the former airlines operated closer to their asset frontiers than the latter ones (Figure 4). Just like Southwest among the specialists, Delta and United faced an initial trade-off, improving quality in 1989 at the expense of cost, before reaching better quality-cost positions (Figure 2a). Delta, for example, initially reduced complaints while increasing expenses for flying operations, promotion and sales, and general and administrative. Within 2 years, Delta reduced spending on flying operations, aircraft and traffic servicing, promotion and sales, and general and administrative, without adversely affecting customer dissatisfaction. Although American did not face an initial trade-off in 1989, it could not maintain its 1989 cost position in 1990 and 1991. So, one could say that American faced an initial trade-off in the first 4 years of our study period before reaching and sustaining a quality-cost position superior to 1988. So, the performance improvement paths for Delta, United, and American lend further support to Hypotheses 1 and 2.

Northwest, starting with the lowest fleet utilization in 1988 (Figure 3), was farther removed from its asset frontier (Figure 4). Just like Alaska among the specialists, Northwest improved both quality and cost simultaneously with initially larger quality improvements than cost improvements (Figure 2a), supporting Hypotheses 1 and 2. In 1989, a new management team found that customers did not perceive Northwest employees as friendly. "That proved to be easy to fix, because one of the reasons employees were not friendly was that management had not been friendly to them. Nobody had told them to be friendly" (Dyer and Schlesinger 1997, p. 7). The new team undertook numerous initiatives to shed the airline's "Northworst" image, such as increasing the spare airplane to airplanes in service ratio at hubs to the industry norm, implementing a corporate program to empower local employees to resolve customer problems on the spot, using automated baggage tags to reduce the chance of misrouted luggage, and many others. While some of these investments in quality raised flying operations expenses, the team was able to reduce other expenses: maintenance, passenger service, aircraft and traffic servicing, promotion and sales, and depreciation and amortization. Northwest, for example, opted to retro-

Figure 4 Distance to Asset Frontier for Subgroups of Airlines. Key: Alaska (AL), America West (AW), Southwest (SW), American (AA), Continental (CO), Delta (DL), Northwest (NW), TWA (TW), United (UA), U.S. Airways (U.S.).

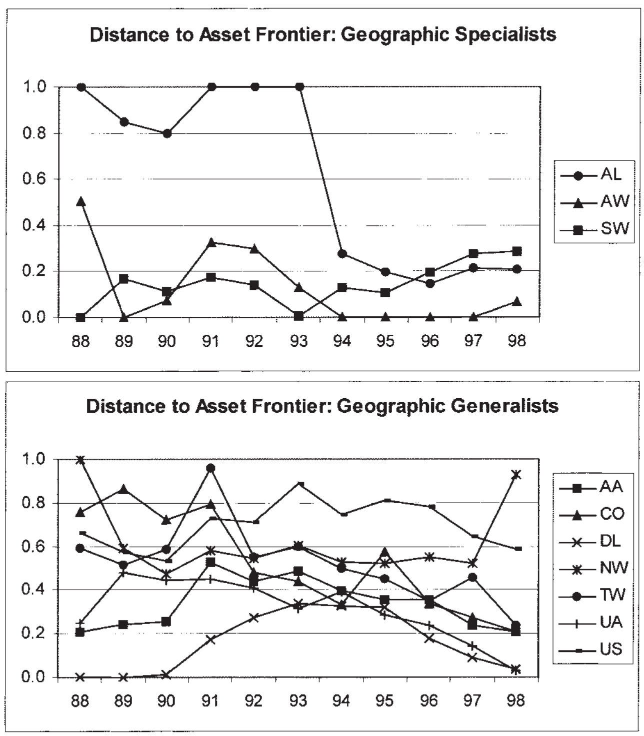


Table 1 Logistic Regression Estimates for Trade-off Occurrences

Constant (α)	1.022*
	(0.453)
$DAF_{i,t-1}$ (β)	−2.085*
	(0.928)
Model χ^2 (1)	5.52*
Log likelihood	−49.683
Number of observations	76

Standard errors in parentheses. * $p < 0.05$.

fit aging planes with "hushkits" to make them compliant with federal standards for noise control as well as more efficient. Retrofitting extended useful plane lives by as much as 15 years, saving significantly on buying new planes.

Again, we find that airlines closer to their asset frontiers faced initial trade-offs before ending up in superior quality-cost positions, whereas Northwest, farther away from its asset frontier, reached better quality and cost simultaneously. Unlike the other geographic generalists, TWA, Continental, and U.S. Airways did not reach complaint rates below 2 complaints per 100,000 passengers by 1989. In Section 5, we describe some of their circumstances.

4.3. Logistic Regression

Our sample contains 41 airline-year observations (i,t) for which a trade-off occurred for airline i from year t – 1 to t ($TO_{it} = 1$). The average distance to the asset frontier ($DAF_{i,t–1}$) in year t – 1 for these 41 trade-off observations was 0.345. Our sample contains 35 airline-year observations (i,t) for which simultaneous improvement occurred for airline i from year t – 1 to t ($TO_{it} = 0$). The average distance to the asset frontier ($DAF_{i,t–1}$) in year t – 1 for these 35 simultaneous improvement observations was 0.489. So, the average distance to the asset frontier for trade-off observations was lower.

Table 1 reports the logistic regression estimates of (1). The estimate for β, the coefficient for distance to the asset frontier ($DAF_{i,t–1}$), is negative and significant at 0.05. So, the closer an airline i is to the asset frontier in its subgroup in year t – 1, the higher the probability of a trade-off going from year t – 1 to t. The logistic regression estimates, therefore, lend further support to Hypothesis 1: firms closer to their asset frontiers are more likely to face trade-offs.

5. Discussion

Whereas cost per available seat mile is a good cost measure encompassing all operating expenses, the rate of consumer complaints only measures consumer dissatisfaction. The rate of consumer complaints is the only available measure that captures all facets of airline quality, yet the most common consumer response after a service encounter is to do nothing (Oliver 1997). Consequently, it is worthwhile exploring how well consumer complaints relate to airline performance.

As mentioned in Section 3, 1987 was a "ramp-up year" in terms of increasing both consumer and airline awareness about consumer dissatisfaction with airlines, as well as providing passengers with an easy method (phone number) to file complaints with DOT. The next year, 1988, was the first full calendar year for which the complaint rates were not confounded by awareness issues. In other words, 1988 provided a real starting statistic for airlines to work on. The year after that, 1989, provided the first evidence of airlines' abilities to reduce consumer dissatisfaction. Table 2 reports 1989 complaint rates for the (then) 12 major airlines, comments regarding some significant events following 1989, and cost positions at the end of our

Table 2 Customer Dissatisfaction with Major Airlines in 1989 and Subsequent Observations

	Complaints per 100,000 passengers	Cessation, bankruptcy, mergers and acquisitions during 1988–1998	Cost: 1998 vs. 1988	Close to asset frontier	Faced initial trade-off
Airlines with highest complaint rates					
Eastern	6.50	Ceased operations 1990	n/a		
Pan Am	6.14	Cased operations 1991	n/a		
TWA	5.33	1991: Under Chapter 11	Higher		
America West	3.64	1991: Under Chapter 11	Lower		
Continental	3.29	1991: Under Chapter 11	Higher		
US Airways	2.16	Acquired Pacific Southwest (1988) and Piedmont (1989)	Higher		
Airlines with lowest complaint rates					
United	1.97	n/a	Lower	Yes	Yes
Northwest	1.96	n/a	Lower	No	No
American	1.22	n/a	Lower	Yes	Yes
Alaska	0.88	n/a	Lower	No	No
Southwest	0.81	n/a	Lower	Yes	Yes
Delta	0.72	n/a	Lower	Yes	Yes

study period (1998). For airlines with the lowest complaint rates in 1989, Table 2 also reports closeness to asset frontiers and whether they faced initial trade-offs.

The two airlines with the highest complaint rates, Eastern and Pan Am, ceased operations within 2 years. The three airlines with the next highest complaint rates, TWA, America West, and Continental, all operated under Chapter 11 bankruptcy protection in 1991 (Kou and McGahan 1995). Of these, America West was the only airline to reach a better cost position in 1998 compared with 1988. The airline with the next highest complaint rate, U.S. Airways, did not reach a better cost position in 1998 compared with 1988.

In contrast, the six airlines with the lowest complaint rates in 1989 all ended up in quality-cost positions superior to their 1988 starting points. All six airlines followed patterns we expected for high performing airlines: initial trade-offs for airlines close to their asset frontiers, simultaneous improvements for airlines farther away from their asset frontiers, and larger quality improvements precede larger cost improvements.

Lastly, we need to address an alternative explanation regarding our measure of quality improvement—complaint reduction. Could complaints have decreased because of a decline in consumer expectations in response to poorer quality? Or did quality actually increase due to the airlines improving either the delivery of service or the management of consumer expectations? While we do not have perfect information to reject this alternative explanation, it seems unlikely in view of the following observations.

Airline performance improved on two out of three technical quality measures monitored by DOT. (Note that these are direct measures and not the result of customer complaints.) Involuntary denied boarding as a result of overbooking (bumping) for the 10 major airlines in our study combined dropped from 2.75 to 0.89 involuntary denied boardings per 10,000 passengers (from 1988 to 1998). Complaints related to oversales (overbooking) against airlines went down by two-thirds from 1988 to 1998. Similarly, significant reductions in mishandled baggage are accompanied by significant reductions in complaints related to baggage. So, service improvements in denied boarding and mishandled baggage are mirrored by reductions in complaints. Furthermore, Januszewski (2003, Chapter 3) shows with DOT quality data that the more actual performance falls short of expected performance, the more consumers file complaints with DOT.

In sum, consumer complaints filed with DOT do capture the gap between expectations and perceptions that determines consumer dissatisfaction. Coupled with observed improvements in two aspects of service quality (denied boarding and mishandled baggage) and corresponding reductions in complaints, it would seem unlikely that consumers merely reduced expectations without any increased skill on the part of airlines in service delivery or managing expectations.

6. Conclusion

Hayes and Pisano (1996) and Clark (1996) raised some fundamental and thought-provoking questions regarding performance improvement paths. They provide an early identification of the concept of performance improvement paths and identify these as an important area requiring empirical research in operations management. The key question: Should improvement be attempted on one dimension at a time (e.g., quality OR cost OR speed), or should a company attempt to improve on multiple dimensions simultaneously? Our analysis of the airline industry provides some preliminary answers to this question, as well as directions for future research.

Which dimension should firms improve first? Second? All airlines that ended up in 1998 quality-cost positions superior to their initial 1988 quality-cost positions improved more on quality first. The airline paths confirm one aspect of the sand cone model (Ferdows and De Meyer 1990): lasting quality improvements clearly precede lasting cost improvements. The sand cone sequence is quality at the base, followed by dependability, speed, and finally cost efficiency. There are no airline measures available to effectively measure dependability and speed. (DOT collects data on mishandled baggage and on-time performance. While both mishandled baggage and on-time performance measure dependability to some degree, both also capture conformance quality. Moreover, faced with increased congestion in the airline industry in the late 1990s, airlines created slack by increasing scheduled flying times for routes that did not change in length.) Future empirical research on performance improvement paths in other industries should include dependability and speed as well.

Can multiple dimensions be improved simultaneously (from A to C in Figure 1)? Or should improvement first occur along an existing operating frontier, followed by an effort to move the firm to a better operating frontier (from A to B to C in Figure 1)? What determines the paths available to choose from? We found that these questions are all related to how close an airline is to its asset frontier. Airlines close to their asset frontiers faced initial trade-offs, improving quality at the expense of cost, after which they were able to reach superior quality-cost positions. On the other hand, airlines farther removed from their asset frontiers were able to improve quality and cost simultaneously. For example, Alaska initially operated with a lot of slack, far removed from its asset frontier (Figure

4). But operating decisions, such as cutting turnaround times and adding seats to aircraft by adjusting closets and galleys (without reducing legroom), allowed Alaska to reduce cost without impairing quality. In fact, faster turnaround times led to more frequent flights, giving consumers more choice. Thus, our findings empirically corroborate Schmenner and Swink's (1998) conceptual notion that operations closer to their asset frontiers will have to make tradeoffs. We used fleet utilization compared with competitors in the same subgroup (geographic specialists or generalists) to assess closeness to asset frontiers. It should be fruitful to develop further measures for asset frontiers. It should also be interesting to investigate whether our airline findings generalize to other industries.

This paper only represents a beginning in the operations management literature for studying performance improvement paths. Much more research is needed in other industries. The challenge is the lack of readily available, reliable data in most industries. Airlines, due to government regulations, have to make enormous amounts of data available. For other industries, it may be necessary to plot and analyze performance improvement paths with empirical, longitudinal data collected on-site. If this hurdle can be overcome, these studies would further our understanding of the fundamentally dynamic nature of operations strategy.

Can our findings be generalized beyond airlines? Yes, in that this study has provided support for models proposed in the operations management literature which one should be able to apply to other industries. This study has focused on a service industry—airlines. Much of the theory that has been developed was intended more for manufacturing settings. One of the problems in service environments is describing and measuring the asset frontier. However, Schmenner (1986), in his service process matrix, defines four different service settings based on labor intensity and interaction and customization. Airlines fall in the quadrant with low labor intensity and low interaction and customization labeled "service factories." We believe our results are generalizable to many services which could be defined as "service factories" in Schmenner's framework. In these settings, it is conceptually easier to describe and measure the asset frontier. However, it is unclear whether the results are generalizable to the other quadrants of this matrix. Those quadrants should be the subject of a future research study. In conclusion, we believe this study further confirms the validity of Schmenner and Swink's (and Porter's) theory that firms closer to their asset frontiers are more subject to trade-offs than firms with a large amount of operational slack.

Acknowledgments

The area editor, three anonymous reviewers, Charles Corbett, Robin Lapré, and participants at the MSOM 2002 conference at Cornell University and the POMS 2003 annual meeting in Savannah, GA provided very thoughtful comments. The authors gratefully acknowledge a summer research grant from the Dean's Fund for Faculty Research at the Owen School at Vanderbilt. The FAA library staff at the U.S. Department of Transportation provided invaluable assistance in the data collection process.

Editor's note: This paper won the 2003 Wickham Skinner Best Paper Award.

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