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Industry Issue Paper: Airlines Entry and Exit and the Impact on Air Traffic Management: An Analytical Framework for Zero-Sum and Positive-Sum Outcomes

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Airlines Entry and Exit and the Impact on Air Traffic Management: An Analytical Framework for Zero-Sum and Positive-Sum Outcomes

Passenger airline service can have a significant impact on a metropolitan region's economy in terms of direct spending and employment, as well as on indirect spending related to industries such as tourism and the service sector. In the past decade passenger service levels have changed considerably in many markets because of a wide variety of events including increased competition, terrorism, and a downturn in the economy. Airlines have responded to these challenges in a variety of ways. Some of the traditional network carriers have been forced into bankruptcy in an attempt to reduce costs and compete more effectively with low cost carriers. In contrast, the low cost carriers have expanded service and entered new markets at a rapid pace.

This paper examines the economic evolutionary process whereby a dominant carrier competes intensely in one market against a similar airline and retreats in another where new, lower-cost entrant expands service. Literature is examined for evidence pertaining to the market's response to a network carrier's financial distress, its impact on airport service levels, and implications for local economies. A zero sum case is explained using a recent example. A positive sum case is explored, where the positive contributions of the entering carrier exceed those left behind by the resident carrier. In the process, depending on the types of gains and nature of the evolving airlines' network, the patterns of air traffic may also change. Using these experiences, an analytical framework is proposed that attempts to explain the emergent behavior of low cost carriers when they enter new markets. In addition, the impact of these changes on the air traffic management system is also examined.

by Tom Berry, Dipasis Bhadra, Jennifer Gentry, and Gregory Nelson¹

INTRODUCTION

Airline Industry House of Cards?

Bankruptcies (Chapter 11) and liquidations (Chapter 7) are not new to the U.S. airline industry. There were 83 cases of Chapter 11 in the decade following deregulation of the industry in 1978, and 6 resulted in Chapter 7. The economic growth of the 1990s, especially in the latter part of the decade, stabilized the economic environment of the airline industry. In the 1990-1999 era, there were 46 Chapter

11 cases, of which five evolved into Chapter 7. The decade of 2000, which began with an economic slowdown and the tragic events of Sept. 11, 2001, appears to have increased the bankruptcy and liquidation possibility. The industry had already witnessed 14 bankruptcies, of which two resulted in liquidation, through October, 2003 (ATA, 2003).

In addition to the direct impact on service to passengers, bankruptcies have profound economic impact. Air carriers are an integral part of local economies, large or small. Through their direct and indirect effects on

employment, tourism, and airport finance, air carriers can both stimulate and benefit from local economies. Bankruptcies and possible liquidation affects these local economies substantially. So much so, that the trends in bankruptcies following Sept. 11, 2001, have caused alarm among regulators and policy-makers. Since every bankrupt carrier is unique, both in terms of the role they play in their local economies and their role in the overall air transportation network, it would be impossible to draw generalized conclusions regarding the effects of these bankruptcies. Nonetheless, it is important to understand and quantify what impact these bankruptcies have on route networks and hence on air transportation and local economies.

This paper attempts to examine this economic evolutionary process whereby a dominant carrier retreats from markets as new entrant(s) exploit opportunities left behind. If the entering carrier(s) is truly a substitute for the resident carrier, in terms of number of passengers and operations,² the resulting outcome is zero-sum; positive if the contributions of the entrant(s) exceed those left behind by the resident carrier and *vice versa*. In the process, depending on the types of gains and nature of evolving airlines' networks, the patterns of air traffic may also change. The underlying fiscal relationships may undergo significant changes as well. In this paper we examine two carriers, US Airways and Southwest Airlines, in two markets, Baltimore-Washington International Airport (BWI) and Philadelphia International Airport (PHL). Using experience from the BWI market, an analytical framework was built that attempts to explain the emergent behavior of Southwest in PHL.

Review of Evidence: Your Loss is My Gain

Market Response to Bankruptcies. Bankruptcies at US Airways and United sent stocks of rival carriers surging around the time of those decisions, Aug. 11 and Dec. 9, 2002, respectively. This response was primarily guided by the anticipation, analysts argue, that rivals such as American, Delta, Northwest and

Continental – all network carriers – are likely to gain in two different ways from the bankrupt airlines' problems. First, other network carriers are expected to pick up capacity from the restructuring of United and US Airways, as these carriers are expected to leave markets that are unsustainable under bankruptcy requirements. Second, rivals may gain significant cost savings by gaining concessions from employees by posing the possibility of bankruptcy if concessions are not made (Reuters wire reports, 6/11/2004).

Impact of Bankruptcies on Airline Services.

The impact of bankruptcies on airline service levels (i.e., the operations and number of destinations they serve) has been empirically studied by Borenstein and Rose (2003a, b). By examining data from 1984-2001, they estimate the impact of major airline bankruptcies on the level of flights and destinations served at U.S. airports. These impacts depend on time-lagged effects of bankruptcies. Thus, the two quarters leading up to, and the two quarters after bankruptcy, and including the quarter at which bankruptcy took place were considered as independent variables in addition to local employment and personal income. Finally, by incorporating a set of airport-seasonal and time-effects to control for systematic changes in service levels, they estimate the number of flights at airports and number of destinations they serve. Furthermore, sub-sampling data by three hub sizes, (large, medium, and small), allows them to capture the hub-specific impact of airline bankruptcies. Large hubs, for the purpose of empirical estimation, were defined as those averaging more than 400 flight operations a day during the 18-year sample period. There were 26 airports in this category. Medium hubs (51 airports) were defined as those with 100-400 flight operations a day, while small hubs (118 airports) were those with 8-100 flight operations a day.

The empirical findings support the general belief that bankruptcies reduce both the number of flights airlines operate and the number of destinations they serve. In particular, the number of flights declines by about 20% in the quarter an airline files for

bankruptcy. The quarters leading up to a bankruptcy also have a negative impact; but the effect gradually declines over time. The cumulative impact of bankruptcies on flight operations, observed over 5 quarters, was estimated to be around -8.7%. Thus, if an airline operator has a 50% share of the market, bankruptcy would result in an overall decline of 4.35% in flight operations at the airport. A similar effect has been estimated for number of destinations. However, the cumulative impact is relatively lower, estimated at -5.4%.

The empirical work by Borenstein and Rose is an important contribution, especially when so many airlines are faced with bankruptcy and/or liquidation. Furthermore, industry, academia, and policy-makers alike lack full understanding of the impact of airline bankruptcies despite numerous occurrences over the last two decades.³ Thus, there are important financial implications arising from the findings of Borenstein and Rose (2003a, b) which need careful consideration by airport operators.⁴

However, the applications of these results for policy implications and airport finance, as the authors themselves point out, require further research. This is because the empirical study had several shortcomings: (i) The statistical significance of empirical point estimates does not appear to be consistent. For example, it is not clear why the bankruptcy during quarters prior to filing would have a positive impact for smaller airports, but negative for other airports. (ii) Many of the estimated coefficients, especially those for the number of destinations, were statistically insignificant. Bankruptcy appears to have a statistically significant effect only on the number of flights at the time (quarter) of filing, especially at medium and small airports. (iii) The speed at which airports adjust to the post-bankruptcy environment did not receive any attention in the study. While there is some evidence that the effect of bankruptcy decreases over time, the evidence is not definitive. The airlines industry is dynamic. It is expected that as bankrupt air carriers abandon markets, they may open up opportunities for rival carriers. The quicker those responses, the faster airports will adjust

to return to original levels of service.⁵ The Borenstein and Rose study does not consider these important aspects stemming from bankruptcy and adjustments; and, (iv) the impact of regional economies has not been given attention even though both local employment and personal income were in both estimating equations. Conversely, given the causality embedded in the estimating equations, the impact of airline operations (or lack thereof due to bankruptcies) on regional economies can not be understood either.

Zero-Sum Game: A Case Study of Washington Dulles International Airport (IAD)

When carriers with similar business models compete, it tends to result in a zero-sum game. In the case of Washington Dulles International Airport (IAD), a network carrier, US Airways, attempted to establish itself at a secondary hub of another network carrier, United Airlines. The scenario is a very familiar one. A competing airline comes into another airlines' established "territory." The number of operations and passengers increase dramatically as both airlines lower fares and compete for market position. Ultimately the surviving carrier is the one willing to sustain losses the longest, since neither airline has a low enough cost structure to sustain their competitive position indefinitely. Typically the airline trying to move into the market is the casualty, because the existing airline has some advantages (e.g., a large base of frequent fliers and more flight offerings). Once the challenging airline retreats, the market characteristics at the airport revert to initial levels of activity. Thus, the competition yields a zero sum outcome in the long run.

In this scenario, neither carrier can afford to charge fares that do not cover their operating costs for extended periods of time. Network carriers tend to focus on market share and market dominance as desired goals as opposed to individual segment profitability, thus leading them to serve some unprofitable routes. This strategy cannot be sustained for all destinations from a hub airport.

Table 1: Aviation Activities at Washington Dulles (IAD)

Airport	All Carriers		United Airlines		US Airways	
	Departures	Passengers	Departures	Passengers	Departures	Passengers
Mar-97	4,511	376,344	32%	48%	12%	11%
Mar-00	6,881	555,075	43%	54%	27%	19%
Mar-02	4,775	401,260	40%	54%	5%	4%

Source: T100 segment data from Form 41; <http://www.transtats.bts.gov>.

Table 1 demonstrates the situation at IAD. In 1997, United accounted for close to half of the passengers departing Washington Dulles (48%). US Airways was among the other network carriers that had a presence at IAD in order to serve its hub and spoke network.

By March of 2000, US Airways and United were nearing the end of the market share battle at Dulles. Both passengers and departures had significantly increased from 1997 levels as United Airlines increased operations to match US Airways competition for the market. Eventually US Airways retreated, and by March of 2002, its presence at Dulles was minimal. By this time total operations and passengers had nearly reverted to their 1997 levels. In other words, intense competition had not yielded any differentiable and long-term sustaining benefit to either carrier, and perhaps not to the passengers either.

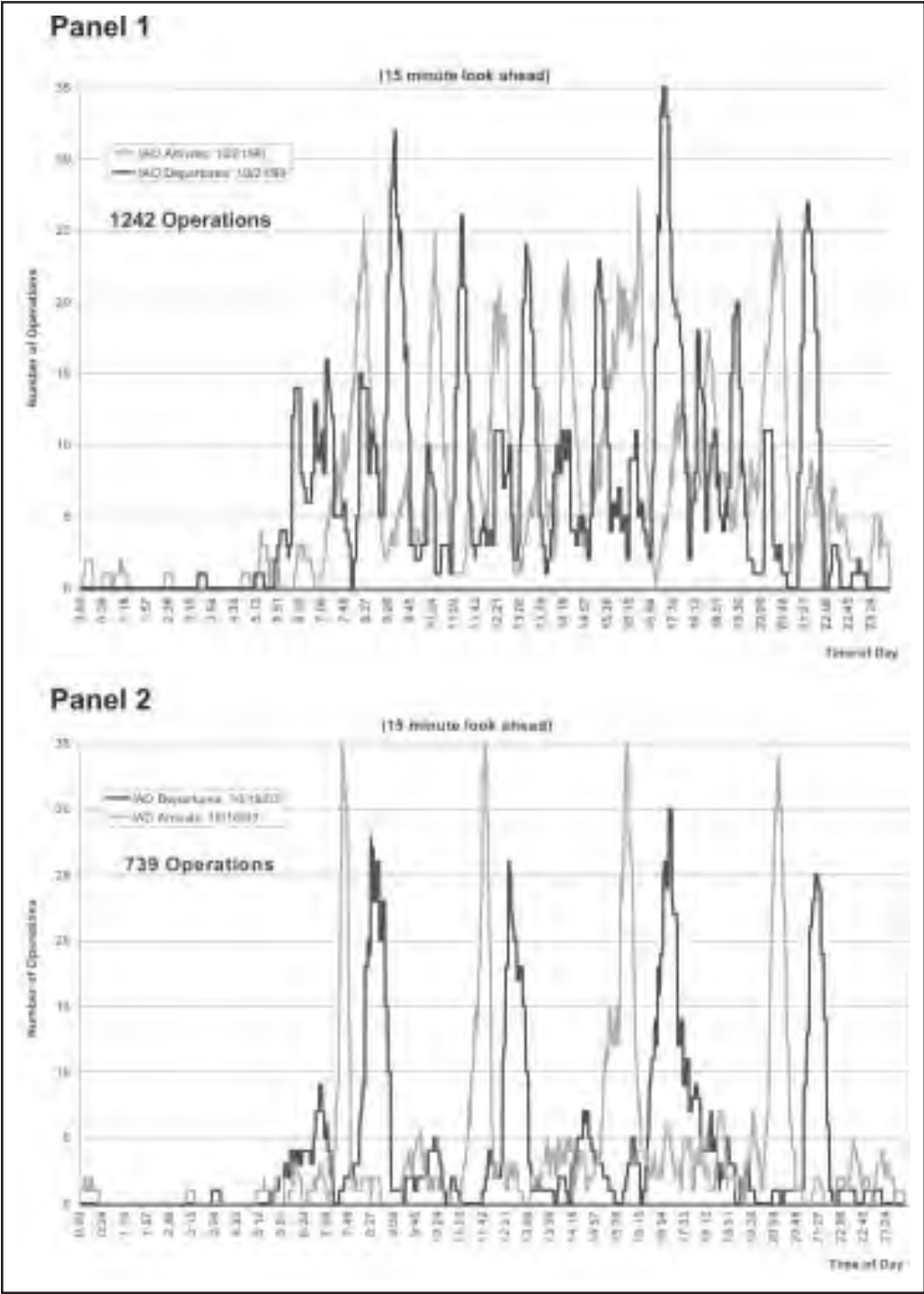
United's advantage can be seen in the percentages above. As United rose to meet the challenge by US Airways, a 9% increase in departure market share led to a 6% increase in passenger market share (a ratio of 2/3). However US Airways had to work a lot harder to get similar results. For US Airways a 15% increase in departure market share only led to an 8% increase in passenger market shares (a ratio of only 1/2).

It should be noted that United may have been even more eager to curb the growth of US Airways at Dulles because of its experience at Chicago. United's main hub of operations, Chicago O'Hare International (ORD) was already shared with another

airline, American Airlines. In the past, the duopoly at Chicago has made it difficult for United to pursue favorable airport improvements and use airport capacity efficiently.⁶

When network carriers compete against each other, it also has implications for air traffic management (ATM). Because the network carriers tend to have similar operational characteristics, they make banking operations⁷ at the airport more complex when they compete with each other. Network carriers tend to operate banks of flights, where many incoming or outgoing operations occur in a short period of time. This operational characteristic reduces passenger connect times, but uses resources very intensely. As can be seen from Figure 1, when US Airways and United were competing in 1999, there were multiple bursts of activity throughout the day, with little time for operations to recover if the system was disrupted. In 2003, with United as the lone dominant carrier at Dulles, the schedule becomes even more intense. However there is now room for schedule recovery should operations become disrupted by weather or other causes because there are only four periods of peak operations. From an air-transportation-management perspective these short but intensive bursts of operations take a toll on the en-route environment, because adjacent traffic control sectors can only handle so many aircraft in a given period of time. In conclusion, airports and local economies obtain no net gain when one network carrier attempts to compete against another dominant network carrier in the latter's territory.

Figure 1: IAD Banking Operations in 1999 and 2003



Source: Official Airline Guide (2003)

Positive-Sum Game: A Case Study of Baltimore-Washington International (BWI) Airport

In 1992, US Airways had a strong presence at BWI. With more than 1,300 weekly departures to 63 domestic and international destinations, US Airways was serving more than 4.5 million annual passengers (UNISYS, 2002). Southwest Airlines entered the market in October, 1993. Although the major impact was felt the following year, with a staggering 42% annual growth, Southwest's expansion at BWI has been persistent over the years. On average, BWI has experienced an annual growth rate of 13.7% in total passengers. By 2000, the airport was serving almost 9 million passengers and Southwest was the dominant carrier.

While Southwest expanded its base and developed BWI as a major East Coast operations base, US Airways contracted gradually. As Figure 2 demonstrates, US Airways served about a million passengers in 2001, less than half of what it served in 1995. By 2001, the number of total destinations served by US Airways was 32. In contrast, Southwest expanded and served almost 4 million passengers and 50 destinations from BWI in 2001. This transition has come about gradually; as US Airways has become marginalized at BWI, Southwest has become an important player, not only at BWI but throughout the East Coast.

Has this process left the Baltimore-Washington metro economy better or worse off? To understand this, we should weigh the relative gain against relative losses. Because US Airways and Southwest are the two major airlines at BWI, this analysis includes these two carriers only. The overall magnitude of the net gain may change if we expanded our analysis to account for other carriers, but the overall conclusions would not change. Figure 3 demonstrates that, overall, Southwest's gains (represented by dark shade) far exceed US Airways's losses (lighter gray), both in terms of passengers (panel 1) and number of departures (panel 2). In particular, Southwest began to pull ahead in much larger passenger volumes than passenger losses of US Air-

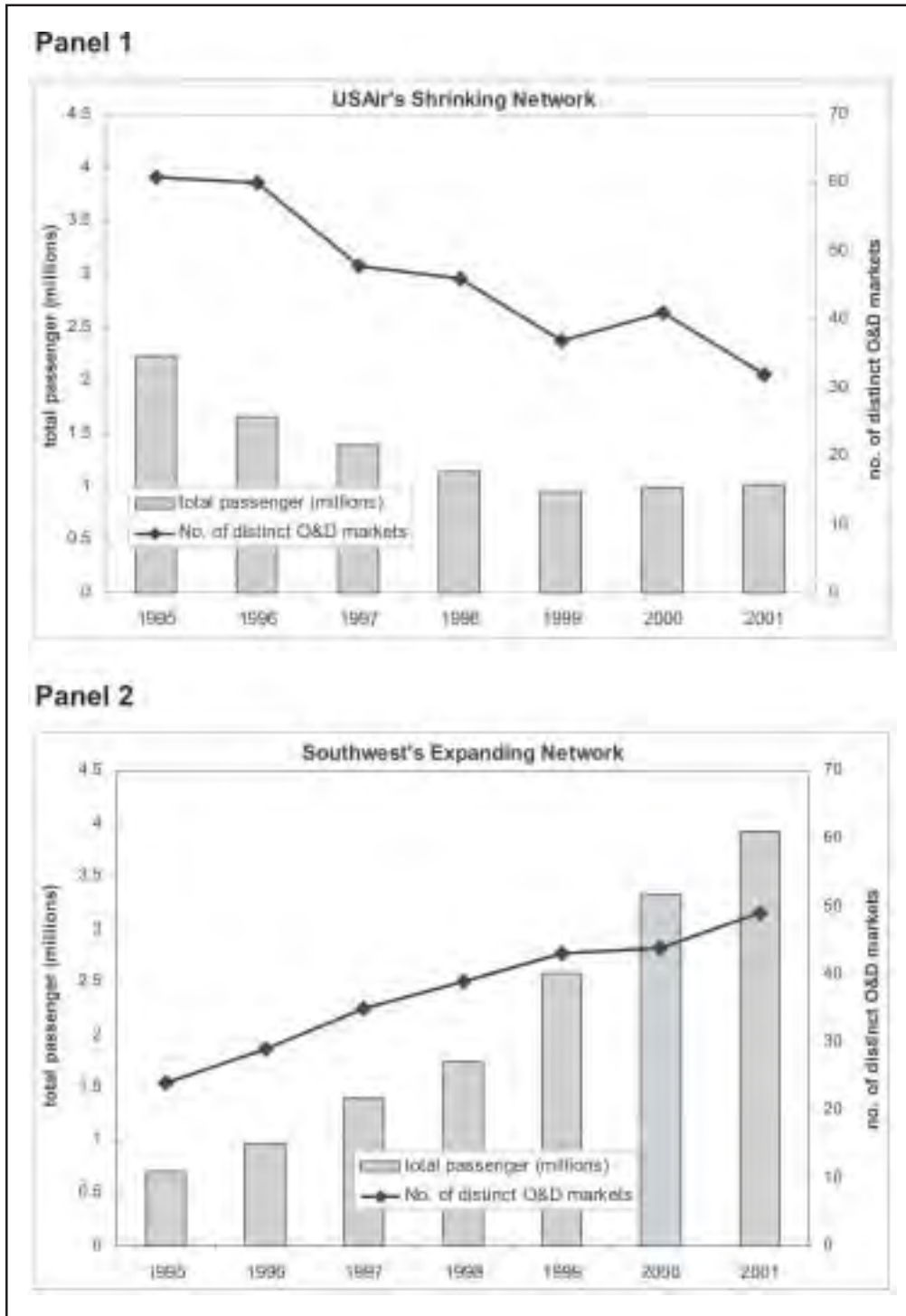
ways. While US Airways lost a little more than 1.24 million passengers during the period 1996-2000, Southwest gained almost 2.63 million passengers. In other words, more than 1.38 million new passengers were added to the system assuming that passengers (lost and gained) are perfect substitutes for each other. During the same period, while the number of US Airways departures declined by more than 17,000, Southwest added a little more than 29,000 departures.

Clearly, these findings have important implications for the Baltimore-Washington metro economy. Assuming that Brueckner's 10:1 ratio⁸ applies to this context and can be maintained over time in the Baltimore-Washington metro area, this would imply that Southwest's entrance has added 138,000 new jobs in the metro area. Furthermore, the 1.38 million net additional passengers have added more than \$7 million in revenue to BWI airport from passenger facility charges alone. Notice, however, that this net gain in employment has taken more than 5 years and the adjustment process may not have been smooth for many people involved, particularly those who lost employment with US Airways or were transferred elsewhere.

Southwest has attracted passengers to BWI primarily by offering competitive fares. Southwest's relatively low fares forced US Airways into an uncompetitive position. In order to maintain its revenue at BWI, US Airways attempted to raise fares in some markets, short-hauls in particular, that led passengers to either choose Southwest or leave the market altogether (UNISYS, 2002). Also, Southwest's lower fares induced many motorists to choose Southwest over driving. Thus, substitutability between carriers, and the demand inducement through competitive fares (i.e., complementarity effect) caused BWI's rapid traffic growth in recent times.⁹

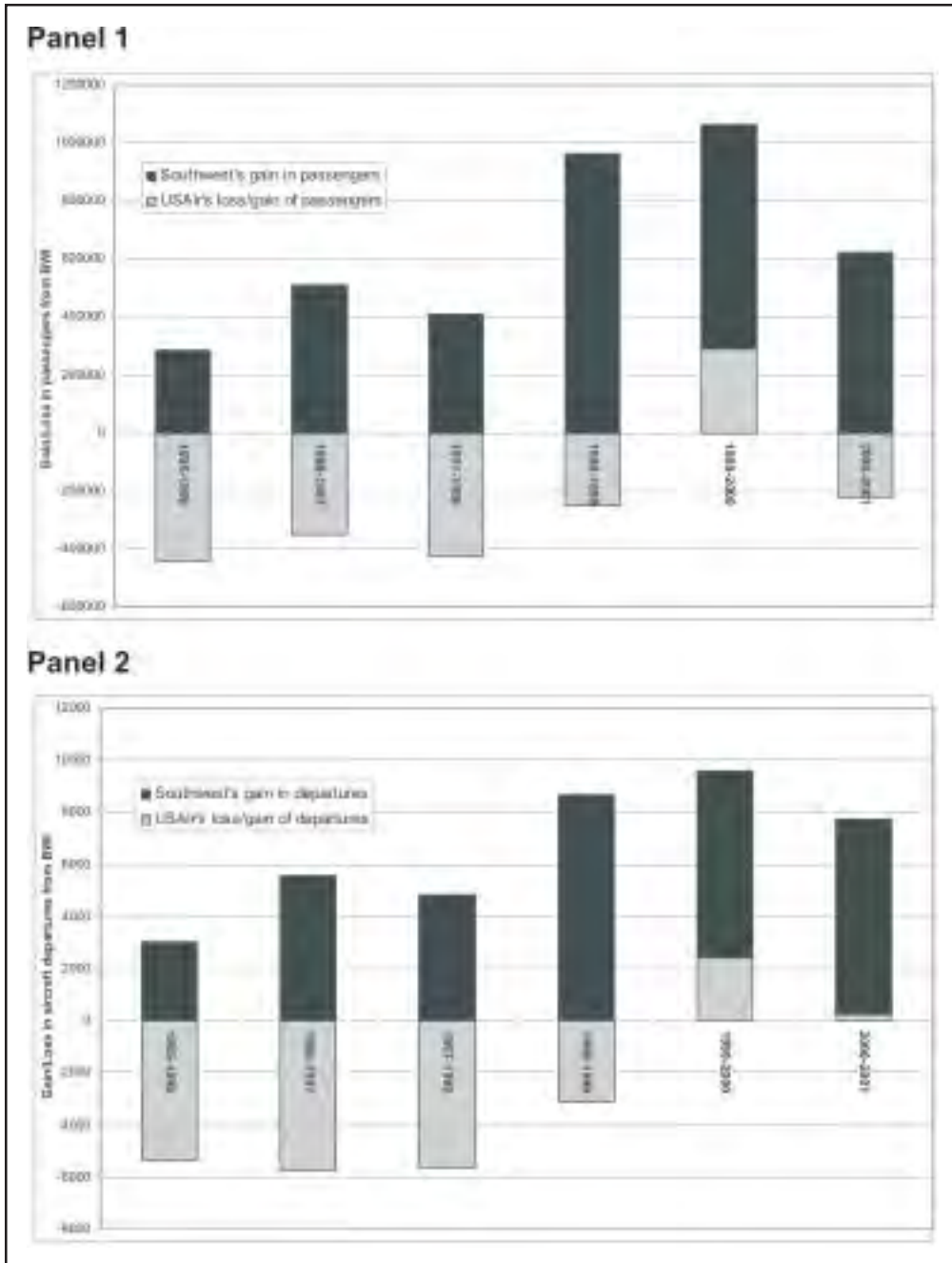
The dynamics underlying fare competition is also shown in Figure 4, drawn notionally based on estimated relationships. Using 10% sample data from the US Department of Transportation's (DOT) Bureau of Transportation Statistics (BTS) for the second quarter of 2003, we estimated a log-linear relationship between average fare and

Figure 2: USAir and Southwest Airlines at BWI Market

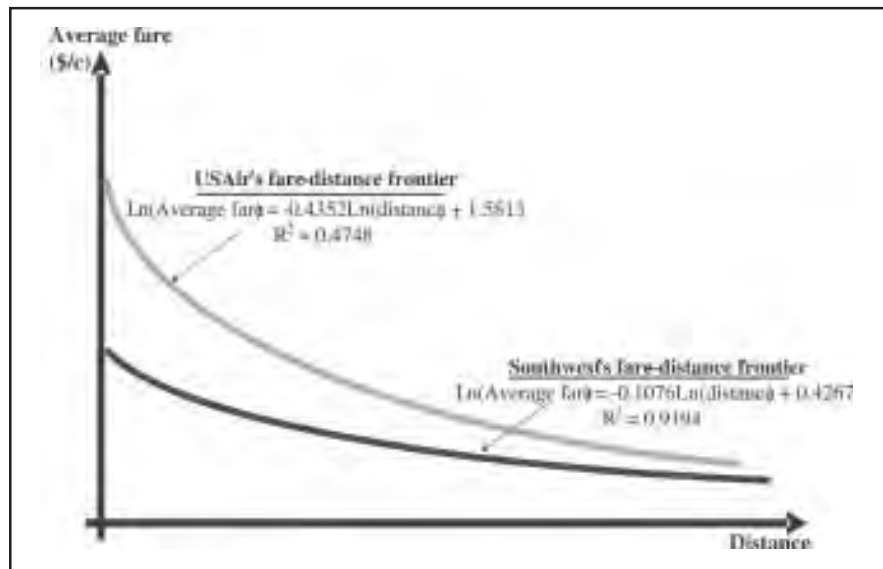


Source: T100 segment data from Form 41; <http://www.transtats.bts.gov>.

Figure 3: Gain and Losses in BWI Market



Source: T100 segment data from Form 41; <http://www.transtats.bts.gov>.

Figure 4: Fare Distance Frontier for Two Carriers at BWI Market

Source: Based on 10% Sample Data (DB1B) for second quarter, 2003;
<http://www.transtats.bts.gov>.

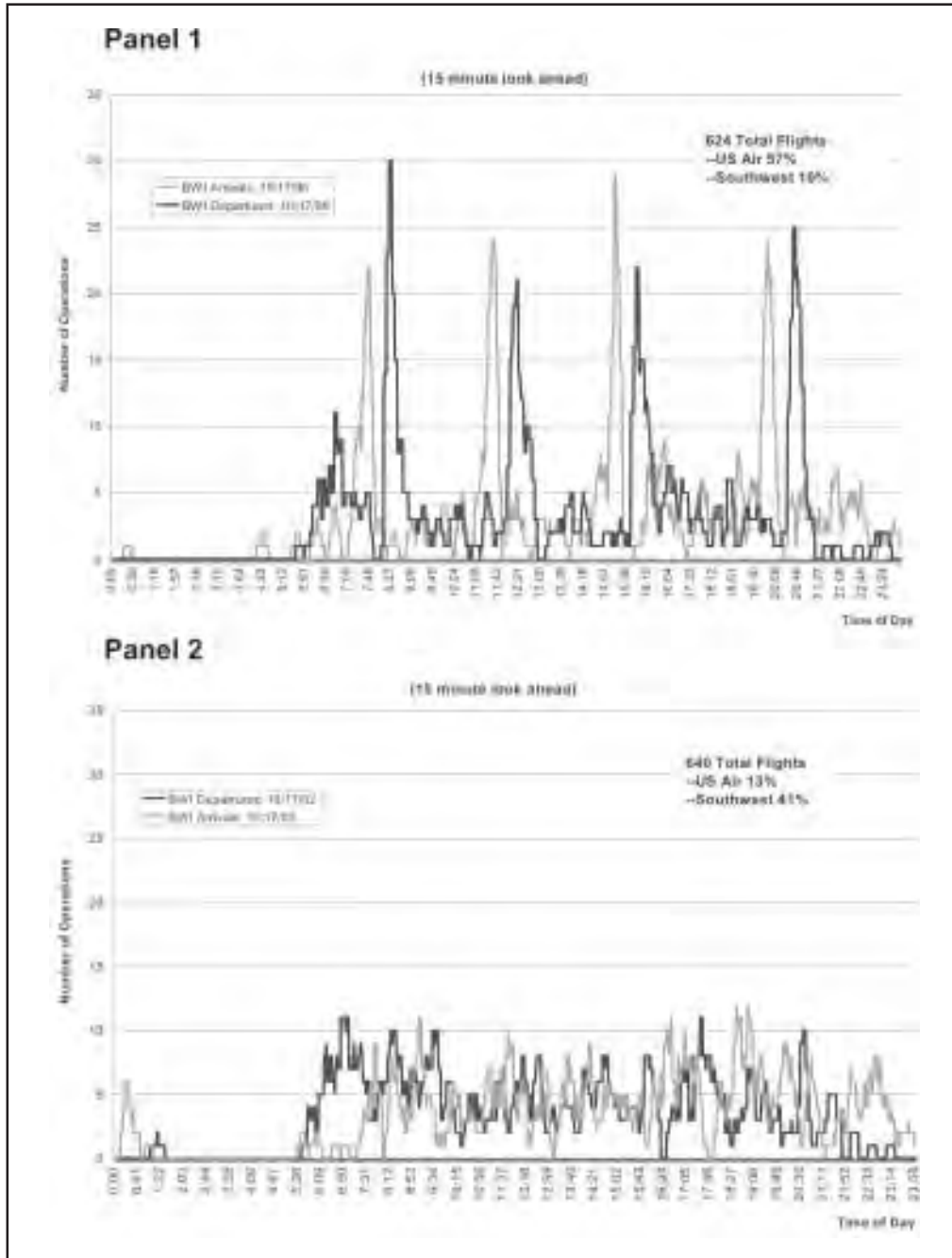
distance. We have plotted the results of these estimated relationships in notional form. As the figure shows, average fare tends to decline for both carriers with distance, although relatively faster for US Airways than Southwest. Second, US Airways still tends to have a relatively higher entry or reservation fare, as measured by the higher vertical intercept. Finally, US Airways tends to charge higher variants (i.e., difference between base price and walk-up fares) than does Southwest. These three characteristics together also form the foundation of Southwest's fare policy. Competitive fares (as reflected by lower intercepts) across many destinations (as measured by distances) with lower base prices (i.e., maximum walk-in fares of \$299/one-way) have led Southwest to attract new passengers and retain them over time [UNISYS (2002) for market-to-market competition between the two carriers]. Pursuing a policy counter to this has led US Airways to retreat from the BWI market.

The changes in airline market share and increases in activity levels also have implications for air traffic management at BWI and the surrounding airspace.¹⁰ Complexities in air traffic management will likely increase, *ceteris paribus*, as the operational intensity

(time clustering of flights) increases. However, the complexity arising from higher operations can be offset by airline scheduling practices. In other words, airlines can dampen the intensity of air traffic complexities by distributing their operations evenly throughout the day, resulting in a less "peaky" banking structure.¹¹ Figure 5 demonstrates this effect.

Panel 1 of Figure 5 shows the number of operations at BWI in 15-minute increments in 1996. US Airways was still the dominant carrier, and accounted for 57% of all operations at the airport. The four traditional hub-and-spoke connecting banks US Airways operated at BWI are clearly evident, with a peak of 30 departures during the 8:30 am bank. In contrast, Panel 2 shows BWI operations on a typical day in 2002, when Southwest had become the dominant carrier with 41% of the market, and US Airways had declined to 13%. Even though the total number of flights increased (640 versus 624), the peak period activity had declined by nearly a third, with a peak of only 12 flights. This flattening of the curve reflects the rolling hub technique employed by Southwest. Rather than offering a limited number of connecting opportunities to a wide number of destinations (as shown in the left hand panel), Southwest

Figure 5: BWI Banking Operations in 1996 and 2002



Source: Official Airline Guide (2003)

provides very frequent service to a limited number of destinations. This greatly increases their operating efficiencies by ensuring that Southwest gate, ramp staff, and ground equipment are fully utilized throughout the day. From an air traffic management perspective, the rolling hub allows for more aircraft to operate at an airport per day compared to a traditional connecting bank structure. Smoothing out the peaks allows for a more efficient operation thus facilitating the air traffic control (ATC) system to recover more easily from adverse weather and other events which may limit the capacity of an airport or surrounding airspace.

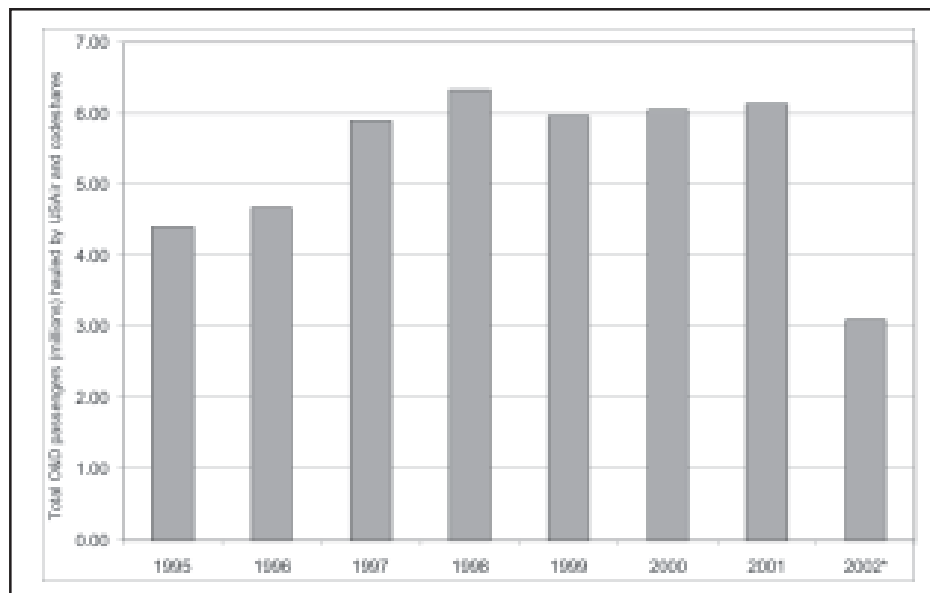
Southwest Airlines in Philadelphia International (PHL) Market: Taking the Cue from BWI

Description of PHL Market. Philadelphia is an underserved market (UNISYS, 2003). The size of the origin-destination (O&D) market is relatively low compared with similar-sized cities and airports. For example, while O&D passengers per capita is around 1

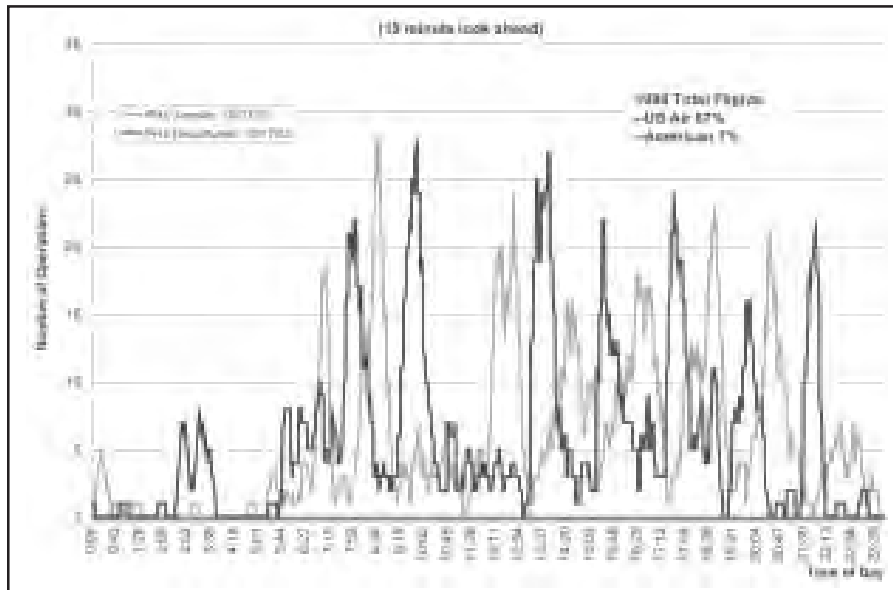
for the Philadelphia economic area, it is 2.42 for San Francisco, 2.2 for the Baltimore-Washington metro, 1.9 for Chicago, 1.85 for Boston, 1.6 for Houston, and 1.24 for New York.¹¹ This has been primarily due to US Airways' failure to grow the market to its full potential as Figure 6 demonstrates. With US Airways as its dominant air carrier, PHL's total O&D traffic was about 6 million between 1997 and 2002.

One of the ways that air carriers grow market, as we have seen from the BWI case study, is through offering competitive fares. In almost all the markets that Southwest serves through BWI, lower air fares have induced powerful responses from travelers. This has been possible as Southwest exploited its comparative cost advantage over US Airways at BWI. In comparison, US Airways had little or no opportunity to offer competitive fares, either at BWI or PHL, since it was faced with increasing per unit cost (i.e., cost per available seat miles) throughout the 1990s. Consequently, the markets originating and ending at PHL did not grow, especially between 1997-2002.¹²

Figure 6: USAir in PHL O&D Market



Source: T100 segment data from Form 41; <http://www.transtats.bts.gov>. **: Estimated 2002 based on data for 6 months.

Figure 7: PHL Banking Operations in 2002

Source: Official Airline Guide (2003)

As at BWI under US Airways dominance, PHL too has a very peaky banking structure at present (see Figure 7). The peaky banking structure, together with relatively higher volumes in operations, also increases the likelihood of delays at PHL.

Choice of Markets. A simple framework is presented below to analyze Southwest's choice of markets as it enters PHL. Much of the choice rationale is based on Southwest's demonstrated behavior at BWI, and what is likely given the uniqueness of PHL. There are two primary reasons why predicting the right markets for Southwest at PHL may have important implications, especially for air traffic management. First, market choices by Southwest will have a tremendous impact, as demonstrated at BWI and elsewhere, on airline traffic and the entire metro economy. This, in turn, will have implications for infrastructure development at the airport and in the metro economy. If Southwest induces air transportation demand of half of the magnitude it has generated at BWI, there will be tremendous pressure on all aspects of aviation infrastructure in the very near future.¹⁴

Second, increased operations resulting from higher demand will also increase the problems of air traffic management. The major difference between BWI and PHL is that the airspace above PHL is already crowded due to high volumes of enroute traffic destined for or departing from New York City metro area airports. Hence, any increase in operations at PHL will further complicate the airspace congestion problems in the Northeast. For reasons discussed earlier, it is expected that traffic at the terminals, in immediate airspace (i.e. TRACON) and en route will increase gradually even if US Airways departs the PHL market quickly.

The optimal choice of markets for Southwest results from identifying the best metro markets that US Airways is presently serving, and then constraining them by factors that are unique to Southwest. Given that established US Airways markets¹⁵ are already proven and tested destinations, they are the most likely candidates for selection (also known as cherrypicking).¹⁶ However, these choices are constrained by some Southwest-specific factors. For example, Southwest's network is very different than US Airways.¹⁷ In choosing new markets, Southwest will likely try to

optimize its own network's capacity. Thus, the Boston metro area (i.e., Providence, R.I., and Manchester, N.H., because Southwest does not fly to Boston Logan International Airport) is expected to receive special consideration since a Philadelphia-Boston operation would consolidate Southwest's eastern seaboard operations. Similarly, flying to West Coast destinations directly and/or via some other markets, distributed across different locations, strengthens Southwest's national network.

Also, Southwest possess only one broad type of aircraft; short (737 300/500) and long-haul narrowbodies (737 700/800). Optimal use of these aircraft imposes constraints on short-distance hauls. Hence, it is likely that Southwest will choose markets that are medium- to longer-haul distance in order to optimize the efficient use of its aircraft inventory. Third, Southwest does not code-share.¹⁸ Lack of code-sharing partnerships also restricts Southwest's market choices in medium- to long-haul markets. Choice of medium- to longer-haul distance markets is further enhanced by Southwest's stringent turn-around requirements.

Finally, Southwest has been very careful in selecting its markets. In choosing all previous 58 markets, PHL being the 59th, Southwest has carefully avoided markets and airports that already have a dominant carrier. In many instances, these airports are already crowded. Furthermore, Southwest's entrance has triggered a fare war on numerous occasions. Although, the carrier has a tremendous cost advantage over all its competitors, Southwest has used this advantage in developing markets at secondary airports by offering lower fares,¹⁹ rather than plunging into direct competition at the primary airport. Hence, we postulate that Southwest would, most likely, avoid those airports where a dominant carrier already operates a hub.²⁰

The market choice framework for Southwest in PHL, therefore, can be posed as follows. It is likely that Southwest will choose the best markets that are presently served by US Airways (i.e., Cherrypick US Airways' markets). This can be done by undertaking a gradient search method subject to the constraints described below. In order to find

the solutions, we first define the objective function as follows: US Air's cherry markets are those which have $\geq 1\%$ share of total O&D passengers from PHL. In order for these markets to qualify as possible selections, we also look at the stability of these market shares over the years, 1999-2002. Thus, we restrict Southwest's choice set as those USAir O&D markets which have had $\geq 1\%$ share of total PHL passengers over 1999-2002 period. For each of the first two quarters of 2002, USAir served 56 O&D markets, out of which 40 had a $\geq 1\%$ market share. Second, noticing that Southwest does not fly to many of the primary airports, we identify locations around these cherry markets where Southwest may fly. Once those unconstrained choice sets have been identified, we then impose three restrictions, i.e., distance, network capacity maximization, and no primary hub of an established carrier. Thus, the selection process can be summarized as follows.

Pick stable cherry markets, subject to:

- ▶ Optimize efficient use of 737 fleet inventory and turn-around time requirements, i.e., *fleet and operational constraint*.
- ▶ Optimize the maximum capacity gain for the entire network, i.e., *network constraint*. This would imply choosing airports that have relatively high O&D potentials and can also be used, as needed, as transfer points for distributing O&D passengers between the farthest points on the network; and finally,
- ▶ Minimize the possible competitive responses, i.e., *competition constraint*. Simply put, stay away from a competitor's large hub market, e.g., Atlanta Hartsfield Jackson International Airport (ATL).²¹

The result of this exercise is presented in Figure 8.

Given the data we have, we could choose any number of markets and sort them in terms of optimal choices. However, it is believed that these market choices are the result of a sequential process. As Southwest carves out

Figure 8: Optimal Markets for Southwest Airlines from PHL

market niches gradually and as more and more gates become available at PHL,²² it is likely that Southwest will add new markets. Therefore, six market areas are chosen initially: Boston, Raleigh/Durham/Charlotte, Florida, Chicago, Las Vegas, and Los Angeles. Using the selection process described above, our choices were narrowed to eight airports representing six markets: Manchester or Providence, Raleigh-Durham, Orlando, Tampa, Palm Beach, and Miami; Chicago Midway, Las Vegas McCarran, and Burbank Glendale Pasadena.

On December 11, 2003, Southwest announced its first selections for scheduled operations from PHL. These are: Providence, Orlando, Tampa, Chicago Midway, Phoenix Sky Harbor, and Las Vegas McCarran Airport. Our selections using the above criteria, made prior to Southwest's announcement, came fairly close. The analysis correctly predicted five of the destinations. On March 25, 2004, Southwest announced its second round of selections: one daily flight to Ft. Lauderdale/

Hollywood, Houston Hobby, Los Angeles, New Orleans and West Palm Beach, starting on July 6, 2004. In addition, Southwest will begin four daily flights from Philadelphia to Manchester and Raleigh/Durham and will launch a second daily flight on the Philadelphia-Tampa route, beginning July 6, 2004, as well. With the second round of selections now complete, our initial choices perform even better.

CONCLUSIONS

In this paper the economic evolutionary process in aviation was examined using three markets as the focus of discussion. It was demonstrated that when network carriers compete among themselves, the outcome is likely to be a zero-sum game. In the BWI market, on the other hand, it was demonstrated that the dominant carrier retreated from markets as new, lower-cost entrants expanded service. This has resulted in a positive-sum game for the BWI market. The review of

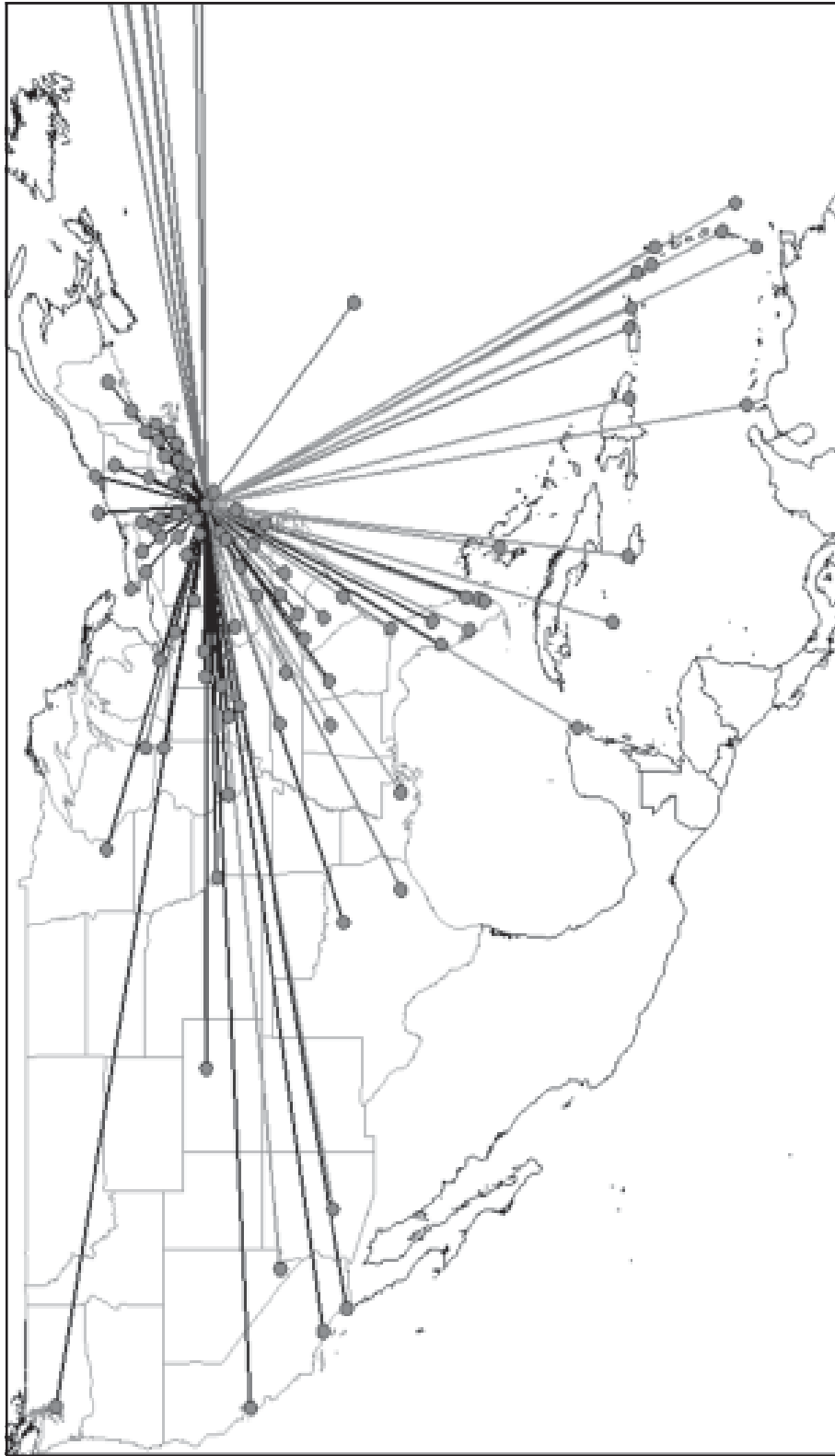
relevant literature pertaining to the market's response to a network carrier's financial distress, its impact on airport service levels, and implications for local economies provides the framework within which we study the evolutionary process.

Using the BWI experience as the guidepost and recognizing the comparative fare advantage of Southwest Airlines, a similar evolution may await the Philadelphia market as well. A positive sum case was explored, where the positive contributions of the entering carrier exceed those left behind by the resident carrier. In the process, depending on the types of gains and the nature of the evolving airline's network, the patterns of air traffic may also change. Using these experiences, an analytical framework was proposed that attempts to explain the emergent

behavior of low cost carriers when they enter new markets. In addition, the impact of these changes on the air traffic management system was also examined.

Using this analytical framework, Southwest is likely to offer initial services to six markets from Philadelphia. Comparison of Southwest's recent announcement of initial markets, the choices selected using the framework appears to have matched fairly well. These choices and Southwest's expected dominance at PHL may have an impact on air traffic management. While increasing volumes of air traffic are expected, peakiness of the schedule, resulting in severe stress in the infrastructure, may be limited by Southwest's distributed schedules.

Appendix A: US Airways' Network from PHL in January 2003



Source: Official Airline Guide (2003). Note: The bolder the lines, the heavier the traffic (i.e., enplanement and number of departures).

Endnotes

1. An earlier version of this paper was presented at the 83rd Annual Transportation Research Board (TRB) meeting Jan. 11-15, 2004, in Washington, D.C. Authors would like to thank the attendees of that conference, Katherine Harback of the University of Delaware and Richard Golaszewski of the GRA Incorporated for their valuable comments and suggestions. We would also like to thank an anonymous referee and the general editor of the Journal of the Transportation Research Forum for extensive comments and suggestions that led to substantial improvement. Views expressed in this paper including all remaining errors are attributable to the authors only. Authors are with the Center for Advanced Aviation System Development (CAASD) of the MITRE Corporation [www.mitre-caasd.org]: 7515 Colshire Avenue, McLean, VA 22102; Correspondence can be made to: dbhadra@mitre.org.
2. One can also use the number of markets served. However, the number of markets is somewhat secondary, primarily built to serve total number of passengers given the fleet structure and hence aircraft operations.
3. This is demonstrated in the notice issued by the FAA/DOT in Federal Register, June 26, 2003.
4. Based on the empirical findings discussed in Borenstein and Rose, market share of the airline, and a few other assumptions such as load factors, and airport share of revenues can be easily calculated.
5. It is not obvious though that the airport will return to its original service levels; nor it is necessary. Given the severe financial distress facing the resident carrier, it is likely that pre-bankruptcy service levels were perhaps inefficiently high, as acknowledged by Borenstein and Rose. If, on the other hand, entering carriers cannot replace otherwise socially-efficient markets rapidly, due to costly entry and/or preference and cost structure, the resultant outcomes may very well be economically inefficient.
6. When new runway placement plans are discussed, neither airline, American nor United, wants the runway to be placed near the other's terminal, thus giving them an advantage. This has led to a substantial amount of gridlock in terms of airport planning.
7. Banking operations are created by flows of arrivals and departures that result from airline scheduling of incoming and outgoing traffic. Banking operations are the primary factor in intensifying air traffic management complexities at an airport. In order to visually capture the intensity of banking, a rolling count of operations, in 15 minute time intervals, is constructed. That is, for any given moment in time, say for example 8:30, the total number of aircraft operations occurring in the following 15 minutes (8:30-8:45) is plotted. This rolling total of 15 minute operations is referred to as *15-minute look ahead*.
8. Despite the importance of the issue, the empirical link between airline service levels and urban economic development had not been studied [see Brueckner (2003a) for a discussion of the existing empirical literature] until 2003 when Brueckner (2003a) offered an empirical framework to fill this void. Using a well-specified econometric framework, Brueckner specifies metro area employment as a function of airline traffic, measured as total enplanements, and a host of metro-specific exogenous factors. Using well-chosen instruments from a list of exogenous variables to determine airline traffic at the first stage, and metro employment at the second stage in a two-stage least squares framework, Brueckner finds that airline traffic exerts a significantly positive effect on total employment in a metro area. The point estimate demonstrates that a 10% increase in airline traffic, i.e., enplanements, raises metro area service employment by 0.9%. In other words, there is a 10:1 ratio in enplanements to total service employment in metro areas [see Brueckner (2003a, b) for more details].
9. These two effects together form the basis for what has become known as *Southwest effect*. Morrison (2001) estimates that Southwest's low fares were directly responsible for \$3.4 billion of savings to air passengers in 1998. In addition, \$9.5 billion was saved due to the effect that actual, adjacent, and potential competition from Southwest had on other carriers' fares. The author finds that these savings (\$12.9 billion) amount to 20% of the domestic scheduled passengers' revenue in 1998.

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10. For the sake of simplicity, issues relating to management of air traffic pertain to those managed by terminal towers, terminal radar approach control facilities (or, TRACONS), and en route traffic control centers (ARTCCs or, en route centers). Towers are located at airports and direct airport traffic on the ground and within approximately five nautical miles of the airport to altitudes of about 3000 feet. TRACON facilities sequence and separate aircraft as they approach and leave airports beginning approximately 5 nautical miles from the airport and ending approximately 50 nautical miles from the airport and at altitudes up to about 10,000 feet. En route centers control aircraft in transit and during approaches to TRACONS. The airspace that most en route centers control extends above 18,000 feet for commercial aircraft.

11. This is a rather simplified approach to a more complex problem. Here, we are assuming that flows of arrivals and departures, forming what is commonly known as airport bank structure, is the primary factor in intensifying air traffic management complexities. Weather, types of aircraft, runway conditions, and a host of other factors also influence the intensity of air traffic management that are held constant for the present discussion.

12. Furthermore, Brueckner (2003a) has found that a 1% increase in metro area population raises metro area enplanement by 1%, i.e., unitary elastic relationship. Hence, the observed relationship between population and O&D travel is expected to be maintained over time as metro areas experience differential population growth rates.

13. Following on our discussion of the relationship between population and O&D passengers, PHL may have a potential of as much as 16 million O&D passengers a year. We arrive at this number by multiplying O&D per capita quotient for Baltimore-Washington metro (2.2) by Philadelphia's population (7.32 million) in 2000 [see UNISYS (2003) for data].

14. The State of Maryland had to undertake investment amounting to \$1.8 billion in order to accommodate the increased demand arising from Southwest's increasing operations at BWI.

15. Market and airport choice needs some clarification. In metro areas where there is a unique airport, market and airport choice is identical. Phoenix (PHX) and Las Vegas (LAS) are examples of this type of situation. However, markets where there is more than one airport (Boston metro market is an example), market and airport choices would be different.

16. Appendix A provides the map of the entire network for US Airways from PHL. In line with our discussion here, we identify and rank markets according to frequencies and passengers served. Therefore, more bolder lines represent greater traffic and hence can be identified as candidates for cherrypicking.

17. While US Airways' is a typical example of a hub-and-spoke network, Southwest's represents what is commonly known as a distributed network. Distributed network optimizes the network capacity by efficiently using sets of equal-sized airports rather than intensely utilizing economies of scale in a hub-and-spoke network [see Berry (2004)].

18. Codeshare is an arrangement where network carriers contract with regional carriers in transporting feeder passengers. Under this arrangement, regional carriers feed passengers from spoke cities into major hubs where network carriers run their major hub operations.

19. Southwest's entrance has reduced the average fare by almost one-third in the BWI market.

20. However, there is one exception. We anticipate that Southwest would enter markets if it anticipates that the dominant market carrier is financially weakening (US Airways in PHL is an example), O&D market potential is large, and it optimizes Southwest's total network capacity.

21. Threat of a broad-scale fare war has always proved to be a strong deterrent for entry into established markets. Recently, Jet Blue found that out by entering the ATL market. This entry caused far stronger and wider responses than Jet Blue originally anticipated. By bringing leased aircraft quickly into the system

and offering competitive fares, Air Tran, another low-cost carrier from Atlanta (ATL), matched Jet Blue's service and fare offerings. This happened, interestingly enough, without bringing Delta intensely into competition. Jet Blue retreated and left ATL for Delta and Air Tran.

22. To begin with, the carrier will have four gates in May, 2004.

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