Preliminary Draft: Not for Quotation or Distribution

Airline Strategies, Competition and Network Evolution in Aviation: How Important are Slots?

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GARS Workshop: *How to Make Slots Work*
University of Applied Sciences, Bremen
November 8, 2003

Abstract

The focus of this paper is the evolution of business strategies and network structure decisions in the commercial passenger aviation industry and how the introduction of slots or auction allocation mechanism for airport capacity might play a role in the evolving business models. The paper reviews the growth of hub-and-spoke networks as the dominant business model following deregulation in the latter part of the 20th century, followed by the emergence of value-based airlines as a global phenomenon at the end of the century. The paper highlights the link between airline business strategies and network structures, and examines the resulting competition between divergent network structure business models. In this context we discuss issues of market structure stability and the role played by slots in affecting the relative importance of each business model and how the industry might evolve.

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1. INTRODUCTION

Taking a snapshot of the North American commercial passenger aviation industry in the fall of 2003, the signals on firm survivability and industry equilibrium are mixed; some firms are under severe stress while others are succeeding in spite of the current environment.[1] In the US, we find United Airlines still in Chapter 11 and US Airways having recentlyy emerged from Chapter 11 and altering strategic direction in joining the STAR alliance. We find American Airlines having just reported the largest financial loss in US airline history in the spring but improvements with fewer loses in the fall, while Delta and Northwest Airlines along with smaller carriers like Alaska, America West and several regional carriers are restructuring and employing cost reduction strategies. We also find Continental Airlines surviving after having been in and out of Chapter 11 in recent years, while Southwest Airlines, Jet Blue and AirTran all continue to be profitable. In Canada, we find Air Canada in CCAA bankruptcy protection (the Canadian version of chapter 11), after reporting losses of over $500 million for the year 2002 and in the fall of 2003 it reported continued losses amid its restructuring efforts.[2] Meanwhile WestJet, like Southwest continues to show profitability, while two new carriers, Jetsgo and CanJet (reborn), have successfully entered the market and seem to be profitable.

Looking at Europe, the picture is much the same, with large full-service airlines (FSAs hereafter) such as British Airways and Lufthansa sustaining losses and suffering financial difficulties, while value-based airlines (VBA's) like Ryanair and EasyJet continue to grow and prosper. There has also been growth in the low cost carrier segment with Germania and Hapag-Loyld Express entering in Germany. In the fall of 2003 KLM and Air France announced plans to merge. This still requires clearance from anti-trust authorities as well as approval in the Netherlands. It certainly, if it proceeds, will alter the membership in all strategic alliances and will create the 3rd large global alliances. KLM like Alitalia and Olympic Airways is in deep finance difficulties.

Asian air travel markets were performing somewhat better than in North America, however the SARS epidemic had a severe negative effect on many Asian airlines.[3] Asian as well as Australasian carriers were hard hit as well as North American carriers that had a significant presence in the Pacific markets.

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[1] This scenario is true in most other countries as well; Australia, New Zealand and the EU.
[2] CCAA refers to the Companies Creditors Arrangement Act .
[3] SARS (Severe Acute Respiratory Syndrome) began in China and quickly spread to Hong Kong, Vietnam, Singapore, and Canada. Cathay Pacific, based in Hong Kong had seen passenger traffic drop from 35,000 per day to less than 10,000.

However, traffic improved over the summer and airlines reported fewer loses and growing traffic. Asian and Australasian markets are also experiencing the urge to merge, with Qantas and Air New Zealand seeking authority to create an alliance and Qantas taking a 22.5% equity position in Air New Zealand and the growth of the VBA segment with Air Asia and others.[4]

Clearly, the current environment is linked to several independent negative demand shocks that hit the industry hard over the last 20 months.[5] A broad multi-country macroeconomic slowdown was already underway in 2001, prior to the 9-11 tragedy, which gave rise to the 'war on terrorism' followed by the military action in Iraq; this for an industry that was already suffering excess capacity. Finally, the SARS virus had not only severely diminished the demand for travel to areas where SARS has broken out and led to fatalities, but it has also helped to create yet another reason for travelers to avoid visiting airports or traveling on aircraft, based on a perceived risk of infection. All of these factors created an environment where limited demand and price competition has favoured the survival of airlines with a low-cost, low price focus.

The downturn in demand also relieved the pressure on airport and airway capacity where previously, up to 2000, the delays in the aviation system in Europe and North America were significant with calls to expand the system and to introduce more efficient allocation of scarce airport capacity. There are very few slot-controlled airports in the US. However, there was quite a bit undertaken on the control of gates and other facilities as a competitive tool. Much of this was done around the time of the DOT competition policy during the last years of the Clinton Administration. At present, US airports must file an annual competition plan saying how they will accommodate entry. Interestingly, Southwest have announced they are entering the PHL (Philadelphia) market, a US Airways hub. This airport is also

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[4] Both the Australian and New Zealand Competition authorities have rejected the alliance but the decision is under appeal in Australia. There has been no decision to appeal the New Zealand decision.

[5] People want to get from A to B for business, family and vacation purposes. The demand will therefore depend upon the overall health of the economy but it will also depend on the competitive environment for air services. The growth in air travel over the last few decades was not simply a matter of general economic growth but also due to changes in the rules governing trade, such as under the WTO (World Trade Organization) and the liberalization of markets, both domestic and internationally which led to falling airfares and broader service. The demand for air travel has also grown due to shifts in the structure of economies from manufacturing to service economies and service industries are more aviation intensive than manufacturing. Developed economies as in Europe and North America as well as Australia and New Zealand, have an increasing proportion of GDP provided by service industries particularly tourism. One sector that is highly aviation intensive is the high technology sector. It is footloose and therefore can locate just about anywhere; the primary input is human capital.

congested which runs counter to the typical Southwest airport.[6] The airway system did and continues to need an upgrading of capacity and the introduction of efficient allocation methods. Europe has more capacity constrained airports, Heathrow, Frankfurt for example, and its airways system places limits on numbers of flights between centers.

Finally, since 2000 in North America carriers and passengers have seen an unprecedented increase in airport fees, taxes and other charges that have added to overall ticket prices in an environment of 'soft' demand. These charges brought this component of costs closer to what European carriers have experienced for years; until recently airport fees and charges in North American have been 5-6 % of operating costs while in Europe they have been in excess of 15%. In addition, the new taxes and fees for security and airport improvement have been more a profits tax than a user fee.

In this paper I examine the evolution of air transport networks with evolving economic deregulation, and the connection between networks and business strategies, in an environment where regulatory changes continue to alter the rules of the game. I then examine how the evolving business models and networks will affect the need for slot allocation mechanisms. This introductory section continues with a descriptive account and analysis of developments in the aviation sector since deregulation in the US. Section 2 describes and contrasts distinguishing elements of the two dominant but divergent business models: the traditional FSA business model, which is tied to the use of hub-and-spoke networks and the VBA business model, which utilizes a point-to-point network structure. Section 3 examines the issue of how the differences in business models may lead to quite different outcomes for airport/airway resource allocation and in section 4 propose a modelling approach to assess the impact of slot allocation or pricing with the two different business models. Some concluding remarks are offered in section 5.

1.1 The story so far…

The deregulation of the US domestic airline industry in 1978 was the precursor of similar moves by most other developed economies in Europe (beginning 1992-1997), Canada (beginning in 1984),

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[6] Some of the explanation may lie with PHL having expanded its terminal facilities. It had four contiguous gates open with expansion possible. American Airlines released these gates when they moved into one of the new international terminals.

Australia (1990) and New Zealand (1986).[7] The argument was that the industry was mature and capable of surviving under open market conditions subject to the forces of competition rather than under economic regulation.[8]

Prior to deregulation in the US, some airlines had already organized themselves into hub-and-spoke networks. Delta Airlines, for example, had organized its network into a hub at Atlanta with multiple spokes. Other carriers had evolved more linear networks with generally full connectivity and were reluctant to shift to hub-and-spoke for two reasons. First, regulations required permission to exit markets and such exit requests would likely lead to another carrier entering to serve 'public need'. Secondly, under regulation it was not easy to achieve the demand side benefits associated with networks because of regulatory barriers to entry. In the era of economic regulation the choice of frequency and ancillary service competition were a direct result of being constrained in fare and market entry competition. With deregulation, airlines gained the freedom to adapt their strategies to meet market demand and to reorganize themselves spatially. Consequently, hub-and-spoke became the dominant choice of network structure.

The hub-and-spoke network structure was perceived to add value on both the demand and cost side. On the demand side, passengers gained access to broad geographic and service coverage, with the potential for frequent flights to a large number of destinations.[9] Large carriers provided lower search and transactions costs for passengers and reduced through lower time costs of connections. They also created travel products with high convenience and service levels – reduced likelihood of lost luggage, in-flight meals and bar service for example. The FSA business model thus favoured high service levels that helped to build the market at a time when air travel was an unusual or infrequent activity for many

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[7] Canada's deregulation was not formalised under the National Transportation Act until 1987. Australia and New Zealand signed an open skies agreement in 2000, which created a single Australia-New Zealand air market, including the right of cabotage. Canada and the US signed an open skies agreement well in 1996 but not nearly so liberal as the Australian-New Zealand one.

[8] In contrast to deregulation within domestic borders, international aviation has been slower to introduce unilateral liberalization. Consequently the degree of regulation varies across routes, fares, capacity, entry points (airports) and other aspects of airline operations depending upon the countries involved.. The US-UK, German, Netherlands and Korea bilaterals are quite liberal, for example. In some cases, however, most notably in Australasia and Europe, there have been regional air trade pacts, which have deregulated markets between and within countries. The open skies agreement between Canada and the US is similar to these regional agreements.

[9] Like telephone networks, adding a point to a hub and spoke system creates 2n connections.

individuals. Building the market not only meant encouraging more air travel but also expanding the size of the network, which increased connectivity and improved aircraft utilization.

On the cost side the industry was shown to have few if any economies of scale, but there were significant economies of density. Feeding spokes from smaller centres into a hub airport enabled full service carriers to operate large aircraft between major centres with passenger volumes that lowered costs per available seat.

An early exception to the hub-and-spoke network model was Southwest Airlines. In the US, Southwest Airlines was the original 'value-based airline' (VBA) representing a strategy designed to build the market for consumers whose main loyalty is to low price travel. This proved to be a sustainable business model and Southwest's success was to create a blueprint for the creation of other VBA's around the world. The evolution has also been assisted by the disappearance of charter airlines with deregulation as FSA's served a larger scope of the demand function through their yield management system. In Europe where Charter carriers have continued to represent a sizable portion of the market, new entrant VBAs are eroding their market and more charters are exiting the industry.

Meanwhile, the benefits of operating a large hub-and-spoke network in a growing market led to merger waves in the US (mid-1980s) and in Canada (late-1980s) and consolidation in other countries of the world. Large firms had advantages from the demand side, since they were favoured by many passengers and most importantly by high yield business passengers. They also had advantages from the supply side due to economies of density and economies of stage length.[10] In most countries other than the US there tended to be high industry concentration with one or at most two major carriers. It was also true that in most every country except the US there was a national (or most favoured) carrier that was privatized at the time of deregulation or soon thereafter.

In Canada in 1995 the Open Skies agreement with the US was brought in. Around this time we a new generation of VBA's emerged. In Europe, Ryanair and EasyJet experienced rapid and dramatic growth following deregulation within the EU. Some FSA's responded by creating their own VBAs: British Airways created GO, KLM created BUZZ and British Midland created BMiBaby for example. WestJet

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[10] Unit costs decrease as stage length increases but at a diminishing rate.

airlines' started service in western Canada in 1996 serving three destinations and has grown continuously since that time and currently has a market capitalization over 20 times that of Air Canada.

Canadian Airlines was merged with Air Canada in 2000, with Air Canada having assumed substantial debt and constraining service and labour agreements as a result of the merger. Canada now had one FSA and one dominant VBA in Westjet. It also has three or four smaller airlines, two of which were VBAs.

In the new millennium, some consolidation has begun to occur amongst VBA's in Europe with the merger of, EasyJet and GO in 2002, and the acquisition of BUZZ by Ryanair in 2003. More importantly perhaps, the VBA model has emerged as a global phenomenon with VBA carriers such as Virgin Blue in Australia, GOL in Brazil, Germania and Hapag-Lloyd in Germany and Air Asia in Malaysia.

Looking at aviation markets since the turn of the century, casual observation would suggest that a combination of market circumstances created an opportunity for the propagation of the VBA business model – with a proven blueprint provided by Southwest Airlines. However a question remains as to whether something else more fundamental has been going on in the industry to cause the large airlines and potentially larger alliances to falter and fade. If the causal impetus of the current crisis was limited to cyclical macro factors combined with independent demand shocks, then one would expect the institutions that were previously dominant to re-emerge once demand rebounds. If this seems unlikely it is because the underlying market environment has evolved into a new market structure, one in which old business models and practices are no longer viable or desirable. The evolution of business strategies and markets, like biological evolution, is subject to the forces of selection. Airlines which cannot or do not adapt their business model to long-lasting changes in the environment will disappear, to be replaced by those companies whose strategies better fit the evolved market structure. But to understand the emerging strategic interactions and outcomes of airlines one must appreciate that in this industry, business strategies are necessarily tied to network choices.

2. NETWORK STRUCTURE AND BUSINESS STRATEGY

The organization of production spatially in air transportation networks confers both demand and supply side network economies and the choice of network structure by a carrier necessarily reflects aspects of its business model and will exhibit different revenue and cost drivers. This section outlines important characteristics of the business strategy and network structures of two competing business models: the full service strategy (utilizing a hub-and-spoke network) and the low cost strategy model that operates under a partial point-to-point network structure.

2.1 Hub-and-spoke networks and the full-service strategy

The full service business model is predicated on broad service in product and in geography bringing customers to an array of destinations with flexibility and available capacity to accommodate different routings, no-shows and flight changes. The broad array of destinations and multiple spokes requires a variety of aircraft with differing capacities and performance characteristics. The variety increases capital, labour and operating costs. This business model labours under cost penalties and lower productivity of hub-and-spoke operations including long aircraft turns, connection slack, congestion, and personnel and baggage online connections. These features take time, resources and labour, all of which are expensive and are not easily avoided. The hub-and-spoke system is also conditional on airport and airway infrastructure, information provision through computer reservation and highly sophisticated yield management systems.

The network effects that favoured hub and spoke over linear connected networks lie in the compatibility of flights and the internalization of pricing externalities between links in the network. A carrier offering flights from city A to city B through city H (a hub) is able to collect traffic from many origins and place them on a large aircraft flying from H to B, thereby achieving density economies. In contrast a carrier flying directly from A to B can achieve some direct density economies but more importantly gains aircraft utilization economies. In the period following deregulation, density economies were larger than aircraft utilization economies on many routes, owing to the limited size of many origin and destination markets.

On the demand side, FSA's could maximize the revenue of the entire network by internalizing the externalities created by complementarities between links in the network. In our simple example, of a flight from A to C via hub H the carrier has to consider how pricing of the AH link might affect the demand for service on the HB link. If the service were offered by separate companies, the company serving AH will take no consideration of how the fare it charged would influence the demand on the HB link since it has no right to the revenue on that link. The FSA business model thus creates complexity as the network grows, making the system work effectively requires additional features most notably, yield management and product distribution. In the period following deregulation, technological progress provided the means to manage this complexity, with large information systems and in particular computer reservation systems. Computer reservation systems make possible sophisticated flight revenue management, the development of loyalty programs, effective product distribution, revenue accounting and load dispatch. They also drive aircraft capacity, frequency and scheduling decisions. As a consequence, the FSA business model places relative importance on managing complex schedules and pricing systems with a focus on profitability of the network as a whole rather than individual links.

The FSA business model favours a high level of service and the creation of a large service bundle (in-flight entertainment, meals, drinks, large numbers of ticketing counters at the hub etc.), which serves to maximize the revenue yields from business and long-haul travel. An important part of the business service bundle is the convenience that is created through fully flexible tickets and high flight frequencies. High frequencies can be developed on spoke routes using smaller feed aircraft, and the use of a hub with feed traffic from spokes allows more flights for a given traffic density and cost level. More flights reduce total trip time, with increased flexibility. Thus, the hub-and-spoke system leads to the development of feed arrangements along spokes. Indeed these domestic feeds contributed to the development of international alliances in which one airline would feed another utilizing the capacity of both to increase service and pricing.

2.2 Point-to-point networks and the low-cost strategy

Like the FSA model, the VBA business plan creates a network structure that can promote connectivity but in contrast trades off lower levels of service, measured both in capacity, frequency and timing of flights, against lower fares. In all cases the structure of the network is a key factor in the success of VBAs even in the current economic and demand downturn. VBAs tend to exhibit common product and process design characteristics that enable them to operate at a much lower cost per unit of output.[11]

On the demand side, VBAs have created a unique value proposition through product and process design that enables them to eliminate, or “unbundle” certain service features in exchange for a lower fare. These service feature trade-offs are typically: less frequency, no meals, no free, or any, alcoholic beverages, more passengers per flight attendant, no lounge, no interlining or code-sharing, electronic

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[11] Product design refers to the “look and feel” of a product, and is the most visible difference between low-cost and full service carriers to the airline passenger.

tickets, no pre-assigned seating, and less leg room. Most importantly the VBA does not attempt to connect its network although there may be connecting nodes. It also has people use their own time to access or feed the airport.[12]

There are several key areas in process design (the way in which the product is delivered to the consumer) for a VBA that result in significant savings over a full service carrier. One of the primary forms of process design savings is in the planning of point-to-point city pair flights, focusing on the local origin and destination market rather than developing hub systems. In practice, this means that flights are scheduled without connections and stops in other cities.[13] Low-cost carriers also tend to focus on secondary airports that have excess capacity and are willing to forego some airside revenues in exchange for non-airside revenues that are developed as a result of the traffic stimulated from low cost airlines. In simpler terms, secondary airports charge less for landing and terminal fees and make up the difference with commercial activity created by the additional passengers. Further, secondary airports are less congested, allowing for faster turn times and more efficient use of staff and the aircraft.

Table 1 compares cost drivers for FSAs and VBAs in Europe to illustrate the differences in the business models. The table shows the key underlying cost drivers and where a VBA like Ryanair has an advantage over FSAs in crew and cabin personnel costs, airport charges and distribution costs. The first two are directly linked to network design. A hub-and-spoke network is service intensive and high cost. Even product distribution cost-savings are related indirectly to network design because VBAs have simple products and use passengers' time as an input to reduce airline connect costs.

To some degree, VBAs have positioned themselves as market builders by creating point-to-point service in markets where it could not be warranted previously due to lower traffic volumes at higher FSA fares. VBAs not only stimulate traffic in the direct market of an airport, but studies have shown that VBAs have a much larger potential passenger catchment area than FSAs. The catchment area is defined as the geographic region surrounding an airport from which passengers are derived. While a

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[12] Southwest Airlines claims passengers will travel up to 1-2 hours to access an airport with lower fares. In Canada, Westjet has observed the same phenomena.

[13] This could also be considered product design, as the passenger notices the benefit of traveling directly to their desired destination rather than through a hub. Rather than having a bank of flights arrive at airports at the same time, low-cost carriers spread out the staffing, ground handling, maintenance, food services, bridge and gate requirements at each airport to achieve savings.

FSA relies on a hub-and-spoke network to *create* catchment, low-cost carriers create the incentive for each customer to create their own spoke to the point of departure.

Table 1

Comparison of Cost Drivers for VBAS and FSAs

Unit Costs in US$ ASK adjusted for 800 km Stagelength (2001)			
	3Major EU Flag Carriers	Ryanair	easyjet
Aircraft Ownership	1.2	0.7	1.0
Airport/ATC	3.8	1.2	1.0
Distribution	1.9	0.5	0.2
Crew	1.4	0.9	0.8
Total	8.3	3.3	3.0

Source: Hyped for Hopes: Europe's Low Cost Airlines (McKinsey Quarterly, No. 4, 2002)

2.3 Survival of the fittest?

The trend worldwide thus far indicates two quite divergent business strategies. The entrenched FSA carriers' focuses on developing hub and spoke networks while new entrants seem intent on creating low-cost, point-to-point structures. The hub and spoke system places a very high value on the feed traffic brought to the hub by the spokes, especially the business traffic therein, thereby creating a complex, marketing intense business where revenue is the key and where production costs are high. Inventory (of seats) is also kept high in order to meet the service demands of business travellers. The FSA strategy is a high cost strategy because the hub-and-spoke network structure means both reduced productivity for capital (aircraft) and labour (pilots, cabin crew, airport personnel) and increased costs due to self-induced congestion.[14]

The hub and spoke system creates congestion due to closely spaced banks of aircraft arriving at a hub in a short space of time. This congestion contributes to overall congestion in the system as well as at the airport. Recent work by Brueckner (2002) and Mayer and Sinai (2002) has questioned the need for any congestion pricing at airports since a monopoly airline at its hub airport would schedule flights to

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[14] Airlines were able to reduce their costs to some degree by purchasing ground services from third parties. Unfortunately they could not do this with other processes of the business.

optimize the delay in their flights and hence internalize the externality. There are no monopoly airports in the US but since deregulation there has been an increase in concentration at airports; in 2000 25% of domestic flights in the US originated or terminated at a dominant airport (an airport for which one carrier accounts for 60 % and two carriers account for 85% of operations). However a recent paper by Morrison and Winston (2003) challenges the findings that air carriers internalize congestion as airport concentration increases and provide empirical support for their position from estimates of a model of delay of air traffic operations.

The FSA business strategy is sustainable as long as no subgroup of passengers can defect from the coalition of all passenger groups, and recognizing this, competition between FSAs included loyalty programs designed to protect each airline's coalition of passenger groups – frequent travelers in particular. The resulting market structure of competition between FSAs was thus a cozy oligopoly in which airlines competed on prices for some economy fares, but practiced complex price discrimination that allowed high yields on business travel. However, the vulnerability of the FSA business model was eventually revealed through the VBA strategy which (a) picked and chose only those origin-destination links that were profitable and (b) targeted price sensitive consumers.[15] The potential therefore was not for business travelers to defect from FSAs (loyalty programs helped to maintain this segment of demand) but for leisure travelers and other infrequent flyers to be lured away by lower fares.

Figures 1 and 2 present a schemata that help to summarize the contributory factors that propagated the FSA hub-and-spoke system and made it dominant, followed by the growth of the VBA strategy along with the events and factors that now threaten the FSA model.

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[15] VBAs will also not hesitate to exit a market if it is not profitable (e.g. WestJet's recent decision to leave Sault St. Marie and Sudbury) while FSAs are reluctant to exit for fear of missing feed traffic and beyond revenue.

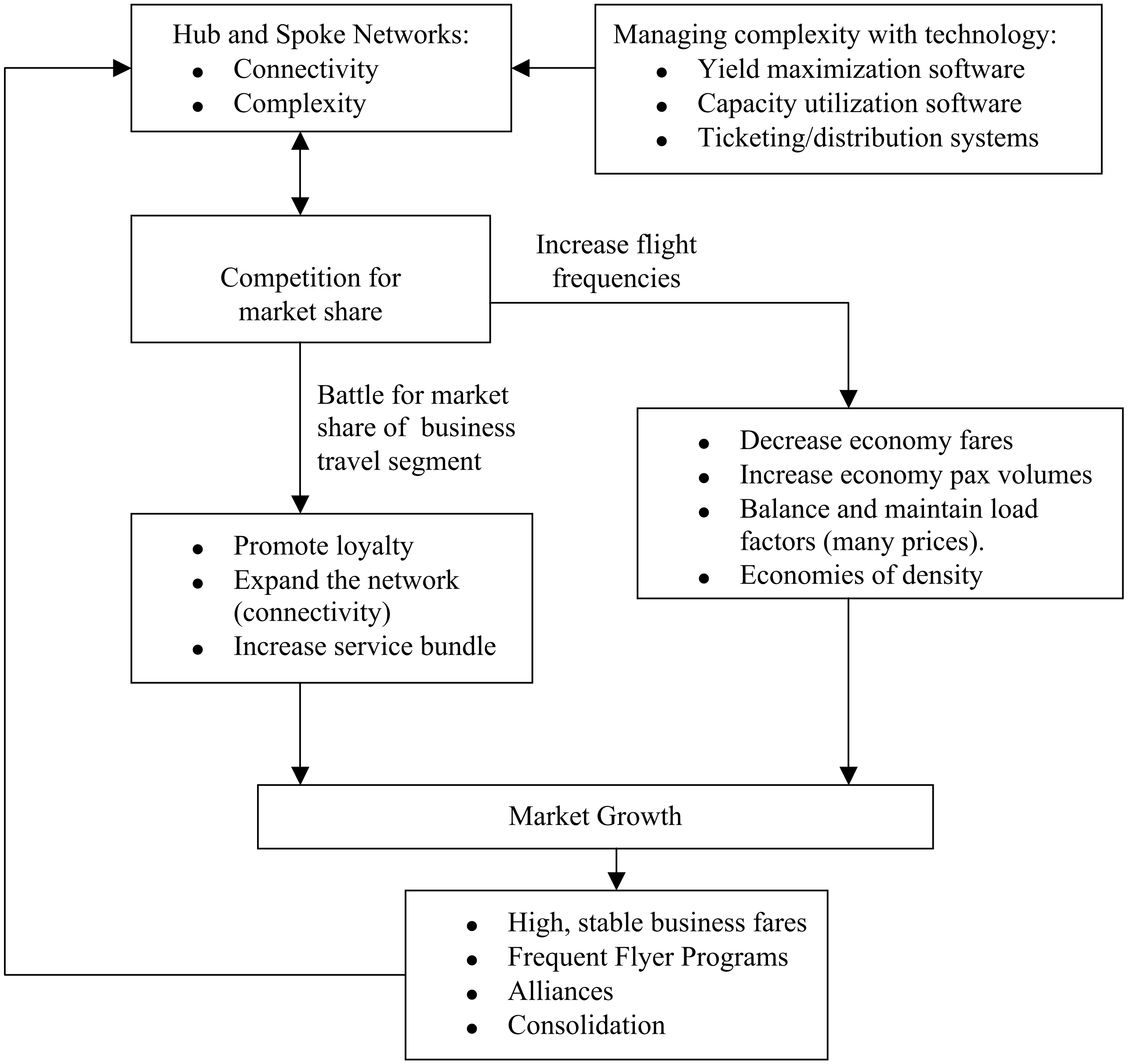

Figure 1
The rise of the FSA hub-and-spoke system

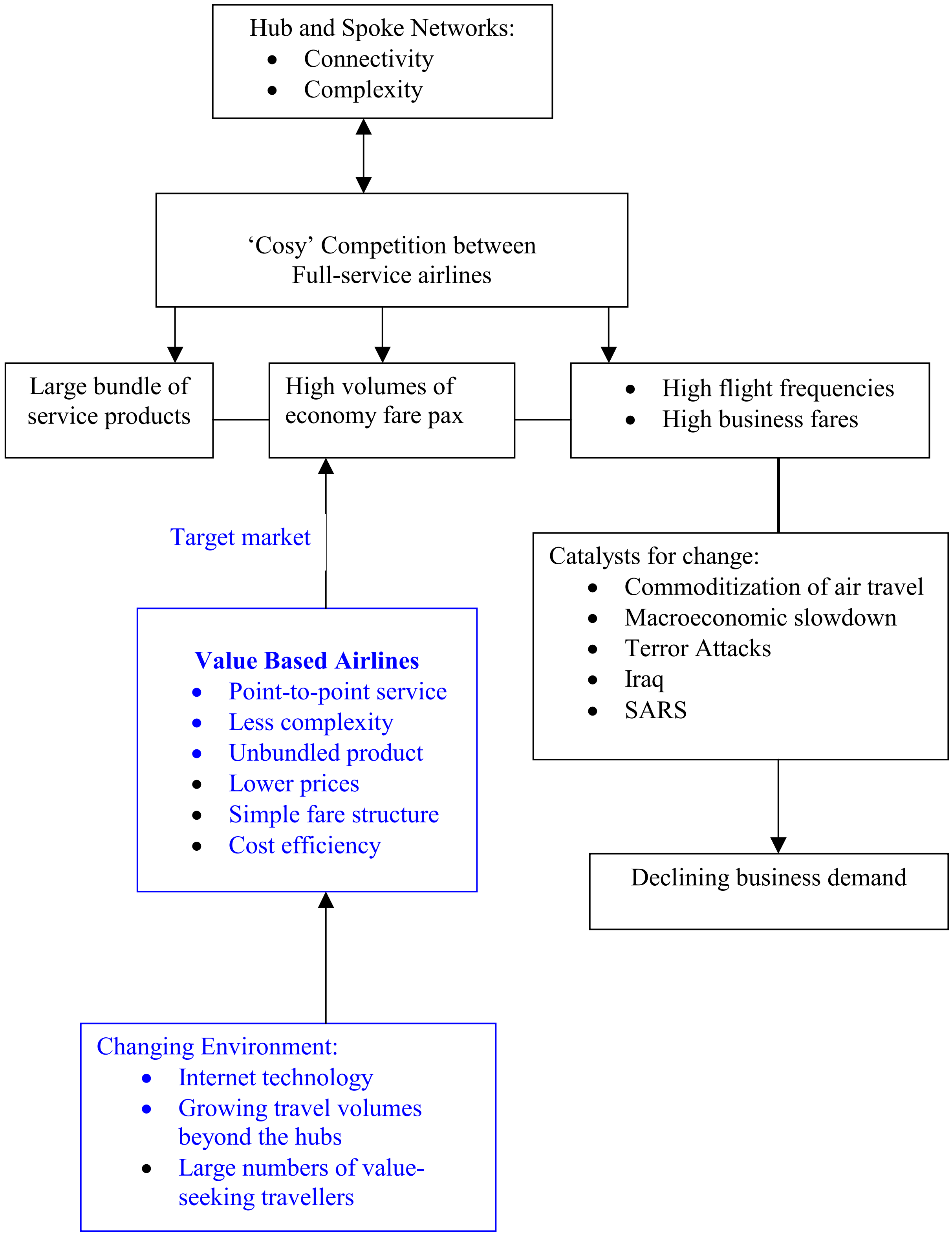
Hub and Spoke Networks:
• Connectivity
• Complexity
'Cosy' Competition between Full-service airlines
Large bundle of service products
High volumes of economy fare pax
• High flight frequencies
• High business fares
Target market
Catalysts for change:
• Commoditization of air travel
• Macroeconomic slowdown
• Terror Attacks
• Iraq
• SARS
Value Based Airlines
• Point-to-point service
• Less complexity
• Unbundled product
• Lower prices
• Simple fare structure
• Cost efficiency
Declining business demand
Changing Environment:
• Internet technology
• Growing travel volumes beyond the hubs
• Large numbers of value-seeking travellers

Figure2

3. THE ECONOMICS OF NETWORKS AND AIRLINE COMPETITION

In this section a simple framework to explain the evolution of network equilibrium is set out and the tie to the business model is illustrated. The linkage will depend on how the business models differ with respect to the integration of demand conditions, fixed and variable cost and network organization.

Let three nodes $\{\theta_1, \theta_2, \theta_3; (0,0), (0,1), (1,0)\}$, form the corner coordinates of an isosceles right triangle. The nodes and the sides of the triangle may thus represent a simple linear travel network that defines two 'short-haul' travel links $[(\theta_1, \theta_2)\ (\theta_1, \theta_3)]$ and one 'long-haul' link (θ_2, θ_3).

In this travel network, the nodes represent points of entry and exit to/from the network, thus if the network is assumed to be an air travel market, the nodes represent airports rather than cities. This can be important when considering congestion or other factors affecting passenger throughput at airports.

This simple network structure allows us to compare three possible structures for the supply of travel services: a complete (fully connected) point-to-point network (all travel constitutes a direct link between two nodes); a hub-and-spoke network (travel between θ_1 and θ_2 requires a connection through θ_2) and limited (or partial) point-to-point network (Selective direct links between nodes). These are illustrated in figure 3 below.

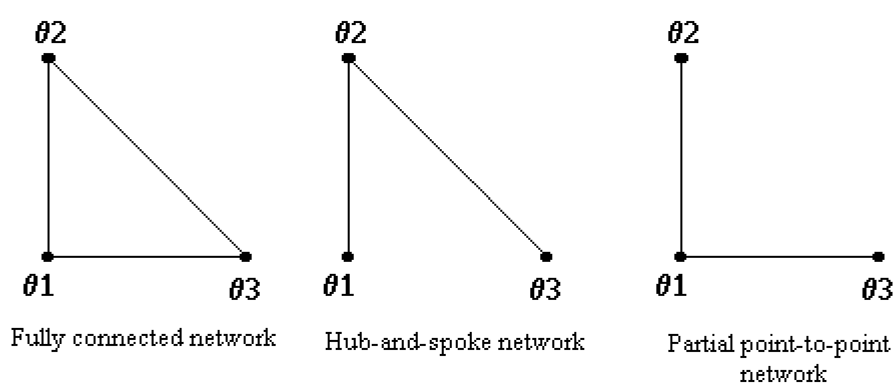

Figure 3: Alternative network structures

In the network structures featuring point-to-point travel, the utility of consumers who travel depends only on a single measure of the time duration of travel and a single measure of convenience. However in the hub-and spoke network, travel between θ_1 and θ_3 requires a connection at θ_2, consequently the time duration of travel depends upon the summed distance $d_{1c3} = d_{12} + d_{23} = 1+\sqrt{2}$. Furthermore, in a hub-and spoke network, there is interdependence between the levels of convenience experienced by travellers. If there are frequent flights between θ_1 and θ_2 but infrequent flights between θ_2 and θ_3, then travellers will experience delays at θ_2.

There has been an evolving literature on the economics of networks or more properly the economics of network configuration. Hendricks et al. (1995) show that economies of density can explain the hub-and-spoke system as the optimal system in the airline networks. The key to the explanation lies in the level of density economies. However, when comparing a point-to-point network they find the hub-and-spoke network is preferred when marginal costs are high and demand is low but given some fixed costs and intermediate values of variable costs a point-to-point network may be preferred. Shy (2001) shows that profit levels on a fully connected (FC) network are higher than on a hub-and-spoke network when variable flight costs are relatively low and passenger disutility with connections at hubs is high. What had not been explained well, until Pels (2000) is the relative value of market size to achieve lower costs per ASM versus economies of density.[16]

Pels et al. (2000) explore the optimality of airline networks using linear marginal cost functions and linear, symmetric demand functions; $MC=1-\beta Q$ and $P=\alpha-Q/2$ where β is a returns to density parameter and α is a measure of market size. The Pels model demonstrates the importance of fixed costs in determining the dominance of one network structure over another in terms of optimal profitability. In particular, the robustness of the hub-and-spoke network configuration claimed by earlier authors (e.g. Hendricks et al., 1995) comes into question.

In our three-node network, the Pels model generates two direct markets and one transfer market in the hub-and-spoke network, compared with three direct markets in the fully connected network. Defining aggregate demand as $Q = Q_D + Q_T$, the profits from a hub-and-spoke network, are:

[16] ASM – available seat mile.

$$\Pi_{HS} = 2\left(P_D Q_D + \frac{1}{2} P_T Q_T\right) - 2\left(Q_D + Q_T - \frac{\beta}{2}(Q_D + Q_T)^2 + f\right) \tag{1}$$

while the profits of a FC network are:

$$\Pi_{FC} = 3\left(P_{FC} Q_{FC} - \left(Q_{FC} - \frac{\beta}{2} Q_{FC}^2 + f\right)\right) \tag{2}$$

More generally, for a network of size n , hub-and-spoke optimal profits are:

$$\Pi_{HS} = (n-1)\left(P_D Q_D + \frac{(n-2)}{2} P_T Q_T\right) - (n-1)\left(Q_D + (n-2)Q_T - \frac{\beta}{2}(Q_D + (n-2)Q_T)^2 + f\right) \tag{3}$$

and FC profits are:

$$\Pi_{FC} = \frac{n(n-1)}{2}\left(P_{FC} Q_{FC} - \left(Q_{FC} - \frac{\beta}{2} Q_{FC}^2 + f\right)\right) \tag{4}$$

Under what conditions would an airline be indifferent between network structures? The market size at which profit maximizing prices and quantities equate the profits in each network structure is:

$$\alpha^* = \frac{\beta(2n-1) + 1 \pm \sqrt{X}}{\beta(2n-1+\beta)} \tag{5}$$

where, $X = [1 - \beta(2n-3)](\beta - 1)[2f\beta(2n-1+\beta) + \beta - 1]$ (6)

The two possible values of α* implied by (5) represent upper and lower boundaries on the market size for which the hub-and-spoke network and the fully connected network generate the same level of optimal profits. These boundary values are of course conditional on given values of the density economies parameter (θ) fixed costs (f), and the size of the network (n). These parameters can provide a partial explanation for the transition from FC to hub-and-spoke network structures after deregulation.

With relatively low returns to density, and low fixed costs per link, even in a growing market, the hub-and-spoke structure generates inferior profits compared with the FC network, except when the market size (α) is extremely high. However with high fixed costs per network link, the hub-and-spoke structure begins to dominate at a relatively small market size and this advantage is amplified as the size of the network grows. Importantly in this model, dominance does not mean that the inferior network structure is unprofitable. In (α,β) space, the feasible area (defining profitability) of the FC structure encompasses that of the hub-and-spoke structure. This accommodates the observation that not all airlines adopted the hub-and-spoke network model following deregulation.

Where the model runs into difficulties is in explaining the emergence of limited point-to-point networks and the VBA model. It is the symmetric structure of the model that renders it unable to capture some important elements of the environment in which VBAs have been able to thrive. In particular, three important elements of asymmetry are missing. *First*, the model does not allow for asymmetric demand growth between nodes in the network. With market growth, returns to density can increase on a subset of links that would have been feeder spokes in the hub-and-spoke system when the market was less developed. These links may still be infeasible for FSAs but become feasible and profitable as independent point-to-point operations, providing an airline has low enough costs. *Second*, the model does not distinguish between market demand segments and therefore cannot capture the gradual commoditization of air travel, as more consumers become frequent flyers. To many consumers today, air travel is no longer an exotic product with an air of mystery and an association with wealth and luxury. There has been an evolution of preferences that reflects the perception that air travel is just another means of getting from A to B. As the perceived nature of the product becomes more commodity-like, consumers become more price sensitive and are willing to trade off elements of service for lower prices.[17] VBAs use their low fares to grow the market by competing with other activities. Their low cost structure permits such a strategy. FSAs cannot do this to any degree because of their choice of bundled product and higher costs.

Third, the model does not capture important asymmetries in the costs of FSAs and VBAs, such that VBAs have significantly lower marginal and fixed costs. Notice that the dominance of the hub-and-

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[17] To model a such a demand system we need a consumer utility function of the form:
$U = U(Y, T, V) = \gamma V(Y - P)$; where Y represents dollar income per period and $T \in [0,1]$ represents travel trips per period. V is an index of travel convenience, related to flight frequency and P is the delivered price of travel. This reduces each consumer's choice problem to consumption of a composite commodity priced at $1, and the possibility of taking at most one trip per period. Utility is increasing in V and decreasing in P, thus travellers are willing to trade-off convenience for a lower delivered price. Diversity in the willingness to trade off convenience for would be represented by distribution for Y, γ, and V over some range of parameter values. Thus the growth of value-based demand for air travel would be represented by an increase in the density of consumers with relatively low value of these parameters.

spoke structure over the FC network relies in part on the cost disadvantage of a fixed cost per link, which becomes prohibitive in the FC network as the number of nodes (n) gets large. Furthermore, the model specifically excludes congestion costs that would be higher in a HS network. VBAs do not suffer from this disadvantage because they can pick and choose only those nodes that are profitable. Furthermore, FSAs variable costs are higher (due to lower factor productivity) because of the higher fixed costs associated with their choice of hub-and-spoke network.

3. COMPETITION ISSUES, AIRPORT CONGESTION, SLOTS AND CAPACITY ALLOCATION

Two distinct business models in the industry have evolved. Although some have said the FSA is a dinosaur, announcement of its demise is premature. The market has shifted significantly to the VBA model and this will likely continue, up to 50 percent some argue. However, the need for FSA service will continue to exist, particularly in long haul international markets. To avoid extinction, the network carriers have to adapt to compete in revenue and costs. On the revenue side, the carriers are developing lower-fare airlines, tapping into new markets with regional jets and linking with other carriers. On the cost side, the network carriers have to deal with wage and overcapacity issues, along with shrinking hubs and reducing flight schedules. Most importantly there needs to be consolidation of large carriers and this requires cross–border consolidation such as we are seeing in Europe with KLM and Air France. Air Canada's dismal financial position could potentially be solved if allowed to merge with an American carrier.

What of the role of slots, and/or capacity pricing in this evolving competitive structure? Morrison and Winston (2003) argue, as others have in the past, that congestion pricing can still provide positive benefits. Brueckner (2001) supports a system of peak load pricing but also argues network carriers have internalized the congestion externality at their hubs. Presumably pricing would be for airways and at non-hub congested airports. Daniel (2003) uses evidence from Minneapolis-St. Paul airport to simulate the effects of congestion pricing on welfare. He found welfare increasing for three different patterns of demand elasticities; the sources of the welfare gains were reduced layover time, reduced queuing delays and lowering the probability of losing connecting flights at hub airports.

The usefulness and application of slot controls would seem to differ between FSA and VBA business models. For VBA carriers one might argue that slot allocation is essentially a non-issue. These carriers fly into non-congested airports or into somewhat congested airports but at off-peak times. Thus capacity is not scarce, nor does the airline create its own congestion. However, this may not be the case in the future as any airport that does engage in slot allocation changes the relative costs of one product (a FSA flight) relative to another (a VBA flight). Slot allocation may result in sufficient demand shifting that VBA are impinged.

A second issue, and one which seems to have been ignored in the airport slot auction literature, is slots for a FSA must be network based while for a VBA they would be airport based. A hub and spoke carrier such as Lufthansa would not bid for a slot at an airport but would bid for a number of slots at a network of airports since the value of one slot is contingent on the network. The slot allocation would affect schedules, fleet configuration and product offering. A network carrier would face higher costs under slot allocation due to the nature of its business model. The VBA with a homogeneous fleet and route independence would if necessary consider only the value of the route with no consideration for network contribution.

Third, as seen in the factors determining the source of welfare gains from more efficient allocation methods none would seem to apply to VBAs in their connected network. They also do not emerge from the business model of a VBA in their choice of airport or their choice of flight times. As the proportion of the market served by VBAs grows, as many claim, can we expect this will change? Since a uniform aircraft fleet is common in this business model one might argue that congestion may become an issue if frequency increases. This may be the case with Southwest at their Phoenix connect point, for example. Where the issue of slot allocation will become an issue for the VBA is when their business model evolves to take on more domestic business passengers.[18] Easyjet in the UK and Virgin Blue in Australia both have business models that take them into more primary, hence congested, airports and focus more on business passengers.

4. MODELLING SLOT ALLOCATION OR CAPACITY PRICING WITH DIFFERING BUSINESS MODELS

One approach to modelling the different business models is to consider an oligopoly with vertically differentiated products as in Barbot (2003). The vertical differentiation portrays the FSA product, peak period travel, being superior to the VBA off-peak product. In its simplest form we have two firms, an

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[18] Southwest in its latest quarterly report stated that 36 percent of traffic was walk-up, implying a sizable proportion of business passengers.

incumbent FSA (I) and an entrant VBA (E) both offering flights at an airport (A). There is a two-stage game to be played in which the airport sets the prices for airport use based on flight demand by the carriers and in stage 2 the carriers select their fares contingent on the quality (timing of flight) and the payment to the airport for use of its facilities.

Potential passengers are assumed to have preferences spread over the unit interval with preferences running from willingness to pay (WTP) for low quality and high quality flights, represented by v. The lowest quality can be set =1 and higher quality set equal to z-1; z>1. Therefore, the demands facing FSA (I) and VBA (E) are: [19]

$$Q_E=(p_I-zp_E)/(z-1) \qquad (7)$$

and

$$Q_I=(z-1+p_E-p_I)/(z-1) \qquad (8)$$

The airport, which has fixed costs, C with zero marginal costs sets a price per passenger, P. This may be a single price or might vary by time of day, P_P and P_{OP} for peak an doff-peak respectively.. The profit functions for the incumbent and entrant airline would be:

$$\Pi_E = (P_E-P)\bullet(P_I-zP_E)/(z-1) \qquad (9)$$

$$\Pi_I = (P_I-P)(z-1+P_E-P_I)/(z-1) \qquad (10)$$

From these standard reaction functions can be derived which can be solved for values of Π_E, Π_I, P_E, P_I, Q_E and Q_I.

$$P_E = (P_I+zP)/2z \quad \text{and} \qquad P_I = (z-1+P_E+P)/2 \qquad (11)$$

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[19] Note if one were modelling horizontal differentiation the specification would be as:
write the price-dependent demand curves for incumbents (I) and entrant (E):

$$P_I = a - bQ + eq_E$$
$$P_E = \alpha - \beta Q + \varepsilon Q_I$$

where: $Q = Q_I + q_E$

Note the airport is charging a single use fee. The airport maximizes profits outright if there is no regulation or subject to some regulatory barrier if airport profits are constrained. The airport obtains revenue from aviation and non-aviation activity; P for a passenger charge and R of non-aviation product purchased, where R is some per unit passenger revenue. Note as P increases R will decreases since fewer passengers will fly.

The airport profit is:

$$\Pi_A = P(Q_E+Q_I) + R(Q_E+Q_I) - C. \qquad (12)$$

In stage 1 the airport sets usage prices, P and in stage 2 the airlines take the airport price and maximize their profits. Setting R=1, the airport price is P = (z-1)/2(2z+1). This value is substituted back into the airline profit function to obtain values described earlier. The judgement of the optimal set of prices are those that maximize welfare defined as consumer surplus+ airline profit + airport profit.

If the airport charges different prices to peak and off peak carriers, this will change profits, output and welfare. If marginal cost is zero it might charge 0 in the off-peak. This is sensible if there is excess capacity and if there are complementarities between aviation pricing and non-aviation revenues. The other interesting result is if the FSA raises prices to reflect higher costs from peak pricing, the VBA has an incentive to also raise price since their product, although inferior is a strategic substitute for the FSA. Thus welfare may be lower under such an outcome.

5. CONCLUSION

It would seem that with each new economic cycle, the evolution of the airline industry brings about an industry reconfiguration. We know that a structural shift in the composition (i.e., more low-cost airlines) of the industry is occurring and travel substitutes are pushing down fares and traffic. We also observe that heightened security has increased the time and transacting costs of trips and these are driving away business, particularly short haul business trips. As legacy airlines shrink and die away, new airlines emerge and take up the employment and market slack. This might be characterized as market instability where too few competitors generate supra-normal profits for incumbents, which then attracts

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The e and ε coefficients measure the extent of horizontal product differentiation. If, say, e = b, then E's product is completely independent of I's in the marketplace -- they are not at all substitutes, because changes in q_E have no impact at all on P_I. If, at the other extreme, e = 0, then the products are perfect substitutes.

entry. However entry creates frenzied competition in a war-of-attrition game environment: the additional competition induced by entry results in market and revenue shares that produce losses for all the market participants. Consequently entry and competition leads to exit and a solidification of market shares by the remaining competitors who then earn supra-normal profits that once again will attract entry.

In evolution, the notion of selection dynamics lead us to expect that unsuccessful strategies will be abandoned and successful strategies will be copied or imitated. We have already observed FSAs attempts to replicate the VBA business model through the creation of fighting brands. Air Canada created Tango, Zip, Jazz, and Jetz. Few other carriers worldwide have followed such an extensive re-branding although two of the better ones have, Lufthansa and Qantas. In Europe, British Airways created GO and KLM created BUZZ, both of which have since been sold and swallowed up by other VBAs. Qantas has created a low cost long haul carrier - Australian Airlines. Meanwhile, Air New Zealand, Lufthansa, Delta and United are moving in the direction of a low price-low cost brand.

The evolution of networks in today's environment will be based on the choice of business model that airlines make. This is tied to evolving demand conditions, the developing technologies of aircraft and infrastructure and the strategic choices of airlines. As we have seen, the hub-and-spoke system is an endogenous choice for FSA while the linear FC network provides the same scope for VBAs. The threat to the hub-and-spoke network is the threat to bundled product of FSAs. The hub-and-spoke network will only disappear if the FSA cannot implement a lower cost structure business model and at the same time provide the service and coverage that higher yield passengers demand. The higher yield passengers have not disappeared the market has only become somewhat smaller and certainly more fare sensitive, on average.

FSAs have responded to VBAs by trying to copy elements of their business strategy including reduced in-flight service, low cost [fighting] brands, and more point-to-point service. However, the ability of FSA to co-exist with VBA and hence hub-and-spoke networks with linear networks is to redesign their products and provide incentives for passengers to allow a reduction in product, process and organizational complexity. This is a difficult challenge since they face complex demands, resulting in the design of a complex product and delivered in a complex network, which is a characteristic of the product. For example, no-shows are a large cost for FSA and they have to design their systems in such a way as to accommodate the no-shows. This includes over-booking and the introduction of demand variability. This uncertain demand arises because airlines have induced it with service to their high yield passengers. Putting in place a set of incentives to reduce no-shows would lower costs because the complexity would be reduced or eliminated. One should have complexity only when it adds value. Another costly feature of serving business travel is to maintain sufficient inventory of seats in markets to meet the time sensitive demands of business travellers.

The importance of slot allocation or capacity pricing cannot be underestimated. Airports as modern businesses will have an active role in shaping airline networks in the future. The large differences in network organization may change the role and implementation of slots. VBAs due to their business model attempt to avoid congestion while FSAs create it. Thus if as some claim the VBAs will increase their proportion of the domestic market the importance of slot allocation will diminish at most airports. This is as a result of both timing of flights at primary airports and the use of regional or secondary airports. However, the role of FSA in international travel will likely grow, therefore slot allocation and pricing will be of more importance at gateways and large connecting hubs for international passengers. These complex international networks will require more coordination across airports for slot allocation since the slot has network value. The difficulty is investment and pricing decisions by airports tends to ignore the network impact.

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