Airline Economics
Chapter 3

SYST 461/660    OR 750
Spring 2010

Sources:
The Global Airline Industry
Peter Belobaba, Amedeo Odoni, Cynthia Barnhart, MIT, Library of Flight Series
Published by John Wiley & Sons, © 2009, 520 pages, Hardback

Outline

• Basic Terminology and Measures for Airline Economics
• Basic Airline Profit Equation and Airline Profit Maximizing Strategies
• Typical Passenger Trip Process
• Airline Markets
• Dichotomy of Supply and Demand
• O-D Demand
  – Factors affecting O-D Demand
  – Total Trip Time Model
  – Demand Models
  – O-D Market Demand Functions
• Airline Competition and Market Share
  – Market Share/ Frequency Share Model
• Price/ Time Elasticity of Demand
  – Air Travel Demand Segments
Four Types of Traffic

“Airline Traffic” – Amount of airline output that is actually consumed or sold

<table>
<thead>
<tr>
<th>4 Types of Traffic</th>
<th>Passenger Aircraft</th>
<th>Cargo “Freighter” Aircraft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passengers</td>
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<tr>
<td>Passenger Bags</td>
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<tr>
<td>Air Freight</td>
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<td>X</td>
</tr>
<tr>
<td>Mail</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

➢ Focus of this lesson is on Passenger Traffic
Airline System-Wide Measures

• Traffic – Enplaned Passengers
  – RPM = Revenue Passenger Mile
    • One paying passenger transported 1 mile
  – Yield = Revenue per RPM
    • Average fare paid by passengers, per mile flown
  – PDEW = Passenger trips per day each way
    • A common way to measure O-D market demand

• Airline Demand = Traffic + “Rejected Demand”
  – “Rejected Demand” or “Spill” = Passengers unable to find seats to fly

• Airline Supply
  – ASM = Available Seat Mile
    • One aircraft seat flown one mile
  – Unit Cost = Operating Expense per ASM (“CASM”)
    • Average operating cost per unit of output

• Airline Performance
  – Average Load Factor (LF)= RPM/ASM
    • Average Leg Load Factor (ALLF) = Σ LF/ # of Flights
    • Average Network or System Load Factor (ALF) = ΣRPM/ΣASM
  – Unit Revenue = Revenue/ASM (“RASM”)
  – Total Passenger Trip Time
US Domestic Traffic (Revenue Passenger Miles) Source: BTS

RPM = Revenue Passenger Mile
One paying passenger transported 1 mile

RPM is Seasonal
US Domestic Supply (Available Seat Miles) Source: BTS

ASM = Available Seat Mile
One aircraft seat flown one mile

ASM is Seasonal

Source: BTS 2005 2006 2007 2008 2009
ALF is Seasonal

Peaks in RPM, ASM, and ALF in summer months stress the system

Average Network or System Load Factor (ALF) = ΣRPM/ΣASM
Average Network Load Factors (ALF) Source: BTS

Average Network or System Load Factor (ALF) = ΣRPM/ΣASM
Yield versus Distance

Yield = Revenue per RPM
Average fare paid by passengers, per mile flown
Additional Airline Measures

• **Average Stage Length**
  – Average non-stop flight distance
  – Aircraft Miles Flown/ Aircraft Departures
  – Longer average stage lengths associated with lower yields and lower unit costs (in theory)

• **Average Passenger Trip Length**
  – Average distance flown from origin to destination
  – Revenue Passenger Miles (RPM)/ Passengers
  – Typically greater than average stage length, since some proportion of passengers will take more than one flight (connections)

• **Average Number of Seats per Flight Departure**
  – Available Seat Miles (ASM)/ Aircraft Miles Flown
  – Higher average seats per flight associated with lower unit costs (in theory)
Basic Airline Profit Equation

• Operating Profit =

\[ \text{RPM} \times \text{Yield} - \text{ASM} \times \text{Unit Cost} \]

(Revenue) – (Operating Expenses)

• Use of any of the individual terms as indicators of airline success can be misleading
  – High Yield is not desirable if ALF is too low
  – Low unit cost is of little value if Revenues are weak
  – High ALF can be the result of selling a large proportion of seats at low fares
## Airline Profit Maximizing Strategies

<table>
<thead>
<tr>
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<th>Intended Benefit</th>
<th>Strategy Pitfalls</th>
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<tbody>
<tr>
<td><strong>Cutting Fares/ Yields</strong></td>
<td>Stimulate Demand</td>
<td>The price cut must generate a disproportional increase in total demand, “elastic demand”</td>
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<tr>
<td><strong>Increasing Fares/ Yields</strong></td>
<td>Increase Revenue</td>
<td>The price increase can be revenue positive if demand is “inelastic”</td>
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<tr>
<td><strong>Increase Flights (ASM)</strong></td>
<td>Stimulate Demand</td>
<td>Increases Operational Costs</td>
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<tr>
<td><strong>Decrease Flights (ASM)</strong></td>
<td>Reduce Operational Costs</td>
<td>Lower Frequencies made lead to market share losses and lost demand</td>
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<tr>
<td><strong>Improve Passenger Service Quality</strong></td>
<td>Stimulate Demand</td>
<td>Increases Operational Costs</td>
</tr>
<tr>
<td><strong>Reduce Passenger Service Quality</strong></td>
<td>Reduce Operational Costs</td>
<td>Excessive cuts can reduce market share and demand</td>
</tr>
</tbody>
</table>
US Airline Historical Reported Profits/ Losses (source BTS)

Airline Profit /Losses ($M)

- $3,000
- $2,000
- $1,000
- $0
- $1,000
- $2,000
- $3,000

1QTR04 1QTR05 1QTR06 1QTR07 1QTR08 1QTR09

Regional
Low-Cost
Network
21-Carrier Total

US Airline Historical Reported Profits/ Losses (source BTS)
Typical Air Passenger Trip

Outbound Air Trip

Ground Access

Enplanement
Processing

Deplanement
Processing

Inbound Air Trip

Ground Egress

Enplanement
Processing

Deplanement
Processing

Destination

Ground Access

Ground Egress

Origin

Figure 3.1
Enplanement/ Deplanement

• Enplanement
  1. Purchasing Tickets
  2. Boarding Pass
  3. Checking Baggage
  4. Undergoing Security Inspections
  5. Boarding Airplane

• Deplanement
  1. Exiting Airplane
  2. Exiting Terminal
  3. Baggage Retrieval
  4. Immigration and Customs Inspections
Airline Supply Terminology

• Flight Leg (or “flight sector” or “flight segment”)
  – Non-stop operation of an aircraft between A and B, with associated departure and arrival times

• Flight
  – One or more flight legs operated consecutively by a single aircraft (usually) and labeled with a single flight number (usually)

• Route
  – Consecutive links in a network served by single flight numbers

• Passenger Paths or Itineraries
  – Combination of flight legs chosen by passengers in an O-D market to complete a journey
Airline Markets

• The purpose of each air trip is to move from the “true” origin to the “true” destination of the passenger.

• There is typically an outbound and inbound portion of passenger air trips.
  – In the Air Transportation System Typically Arrival = Departures

• Direct/ Connecting Flights
Distinct and Separate Origin – Destination Markets

- **Catchment Area** – an area which contains all the origin points of travelers
- An airport’s **catchment area** can extend for hundreds of kilometers and can vary with the destination and trip purpose of the traveler
- The market for air services from A to C is **distinct and separate** from the market from C to A
Air Travel Markets

- **Opposite Markets** – passengers who originate their trips from the destination airport region.
- **Parallel Markets** – the flight operations serving each parallel market can to some extent substitute for each other.
- **City-Pair Markets** – Demand for air travel between two cities.
- **Region-Pair Markets** – Demand for air travel between two regions or metropolitan areas.
- **Airport-Pair Markets** “Parallel” – City-Pair and Region-Pair Markets Demand can be disaggregated to different airports serving the cities or regions.

- With the existence of overlapping airport regions, parallel markets, and the sharing of scheduled airline supply on connecting flights, even “distinct” and “separate” origin-destination markets are interrelated.
Connecting versus Direct Traffic

1st Leg

Enplanement Processing

2nd Leg

Deplanement Processing

Ground Access

Enplanement Processing

Deplanement Processing

Ground Egress

Ground Access

Ground Egress
### Airline Markets Example

<table>
<thead>
<tr>
<th>Market</th>
<th>Itinerary</th>
<th>Segment / Leg</th>
<th>Airline</th>
<th>Seats</th>
<th>PAX</th>
<th>Connecting PAX</th>
<th>O-D Traffic</th>
<th>% Connecting</th>
<th>Load Factor</th>
<th>Daily Freq</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAD-BOS</td>
<td>IAD-BOS</td>
<td>IAD-BOS</td>
<td>Airline 1</td>
<td>100</td>
<td>50</td>
<td>N/A</td>
<td>50</td>
<td>N/A</td>
<td>.5</td>
<td>2</td>
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<tr>
<td>IAD-BOS</td>
<td>IAD-PHL-BOS</td>
<td>IAD-PHL</td>
<td>Airline 1</td>
<td>150</td>
<td>100</td>
<td>75</td>
<td>25</td>
<td>75%</td>
<td>.67</td>
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<tr>
<td>IAD-BOS</td>
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<td>IAD-JFK</td>
<td>Airline 2</td>
<td>200</td>
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- For this example no additional passengers are boarding at the connection
- Frequency Share for IAD-BOS —
  - Airline 1 = 2/6 = 33%, Airline 2 = 4/6 = 67%
- Market Share for IAD-BOS —
  - Airline 1 = ((2x50)+(4x75))/((2x50)+(4x75)+(2x50)+(3x75)+(1x75)) = 50%
- "Market" O-D Traffic for IAD-BOS =
  - ((2x50)+(4x75)+(2x50)+(3x75)+(1x25)) = 750
- "Segment" or "Leg" O-D Supply for IAD-BOS =
  - ((2x100)+(3x100)+(1x200)) = 700
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</table>

- For this example no additional passengers are boarding at the connection
  - **RPM** = \((2\times50\times1)+(4\times100\times1)+(4\times75\times1)+(2\times150\times1)+(2\times50\times1)+(3\times75\times1)+(1\times100\times1)+(1\times75\times1) = 1600
  - **ASM** = \((2\times100\times1)+(4\times150\times1)+(4\times100\times1)+(2\times200\times1)+(2\times100\times1)+(3\times100\times1)+(1\times200\times1)+(1\times150\times1) = 2450
  - **ALLF for IAD-BOS** = \((2\times.5)+(3\times.75)+(1\times.5)/6 = .625
  - **ALF for this network** – for this example all flight legs are 1 unit of distance
    = RPM/ASM = 1600/2450 = .653
Illustration of Direct versus Connecting Passengers

Top O-D Markets by Volume
Origin-Destination Market Demand

• Air travel demand is defined for an origin-destination market, not a flight leg in an airline network
  – Number of persons wishing to travel from origin A to destination B during a given time period
  – Includes both passengers starting their trip at A and those completing their travel by returning home (opposite markets)
  – Typically, volume of travel measured in one-way passenger trips between A and B, perhaps summed over both directions

• Airline networks create complications for analysis of market demand and supply
  – Not all A-B passengers will fly on non-stop flights from A to B, as some will choose one-stop or connecting paths
  – Any single non-stop flight leg A-B can also serve many other O-D markets, as part of connecting or multiple-stop paths
Dichotomy of Demand and Supply

- Inherent inability to directly compare demand and supply at the “market” level
- Demand is generated by O-D market, while supply is provided as a set of flight leg departures over a network of operations
- One flight leg provides joint supply of seats to many O-D markets
  - Number of seats on the flight is not the “supply” to a single market
  - Not possible (or realistic) to determine supply of seats to each O-D
- Single O-D market served by many competing airline paths
  - Tabulation of total O-D market traffic requires detailed ticket coupon analysis
Implications for Analysis

• Dichotomy of airline demand and supply complicates many facets of airline economic analysis

• Difficult, in theory, to answer seemingly “simple” economic questions, for example:
  – Because we cannot quantify “supply” to an individual O-D market, we cannot determine if the market is in “equilibrium”
  – Cannot determine if the airline’s service to that O-D market is “profitable”, or whether fares are “too high” or “too low”
  – Serious difficulties in proving predatory pricing against low-fare new entrants, given joint supply of seats to multiple O-D markets and inability to isolate costs of serving each O-D market

• In practice, assumptions about cost and revenue allocation are required:
  – Estimates of flight and/or route profitability are open to question
Demand Models

• Demand models are mathematical representations of the relationship between demand and explanatory variables:
  – Based on our assumptions of what affects air travel demand
  – Can be linear (additive) models or non-linear (multiplicative)
  – Model specification reflects expectations of demand behavior (e.g., when prices rise, demand should decrease)

• A properly estimated demand model allows airlines to more accurately forecast demand in an O-D market:
  – As a function of changes in average fares
  – Given recent or planned changes to frequency of service
  – To account for changes in market or economic conditions
Airline Demand

• Demand for carrier flight f of carrier i in OD market j is a function of:
  – Characteristics of flight f
    • Departure time, travel time, expected delay, aircraft type, in-flight service, etc.
    • Price
  – Characteristics of carrier i
    • Flight schedule in market j (frequency, timetable), airport amenities of carrier, frequent flyer plan attractiveness, etc.
  – Market characteristics
    • Distance, business travel between two cities, tourism appeal
  – Characteristics (including price) of all rival products:
    • Other flights on carrier i
    • Flights on other carriers in market j (carrier and flight characteristics)
    • Competing markets’ products (other airports serving city-pair in j, other transport modes, etc.)
Total Trip Time from Point A to B

- Next to price of air travel, most important factor affecting demand for airline services:
  - Access and egress times to/from airports at origin and destination
  - Pre-departure and post-arrival processing times at each airport
  - Actual flight times plus connecting times between flights
  - Schedule displacement or wait times due to inadequate frequency
- Total trip time captures impacts of flight frequency, path quality relative to other carriers, other modes.
  - Reduction in total trip time should lead to increase in total air travel demand in O-D market
  - Increased frequency and non-stop flights reduce total trip time
  - Increases in total trip time will lead to reduced demand for air travel, either to alternative modes or the “no travel” option
Total Trip Time and Frequency

- \( T = t(\text{fixed}) + t(\text{flight}) + t(\text{schedule displacement}) \)
  - Fixed time elements include access and egress, airport processing
  - Flight time includes aircraft “block” times plus connecting times
  - Schedule displacement = \((K \text{ hours} / \text{frequency})\), meaning it decreases with increases in frequency of departures

- This model is useful in explaining why:
  - Non-stop flights are preferred to connections (lower flight times)
  - More frequent service increases travel demand (lower schedule displacement times)
  - Frequency is more important in short-haul markets (schedule displacement is a much larger proportion of total \( T \))
  - Many connecting departures through a hub might be better than 1 non-stop per day (lower total \( T \) for the average passenger)
Total Trip Time Example

- With Uniform Passenger Demand
- Flight times highlighted in Yellow

<table>
<thead>
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<th>wait times</th>
<th>0600</th>
<th>0700</th>
<th>0800</th>
<th>0900</th>
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<th>1900</th>
<th>2000</th>
<th>2100</th>
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<td>7</td>
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<td>1</td>
<td>2</td>
<td>1.06</td>
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</table>

Increased Frequency reduces Passenger Total Trip Time and Increases Demand
Simple Market Demand Function

• Multiplicative model of demand for travel O-D per period:

\[ D = M \times P^a \times T^b \]

where: \( M \) = market sizing parameter (constant) that represents underlying population and interaction between cities
\( P \) = average price of air travel
\( T \) = total trip time, reflecting changes in frequency
\( a, b \) = price and time elasticities of demand

• We can estimate values of \( M, a, \) and \( b \) from historical data sample of \( D, P, \) and \( T \) for same market:
  – Previous observations of demand levels (\( D \)) under different combinations of price (\( P \)) and total travel time (\( T \))
## Multiple Demand Segments

<table>
<thead>
<tr>
<th></th>
<th>Business Air Travel Demand</th>
<th>Personal Air Travel Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First Class</strong></td>
<td>$D_{fb}$</td>
<td>$D_{fp}$</td>
</tr>
<tr>
<td><strong>Coach Class</strong></td>
<td>$D_{cb}$</td>
<td>$D_{cp}$</td>
</tr>
<tr>
<td><strong>Discount Class</strong></td>
<td>$D_{db}$</td>
<td>$D_{dp}$</td>
</tr>
</tbody>
</table>
Airline Competition

• Airlines compete for passengers and market share based on:
  – Frequency of service and departure schedule on each route served
  – Price charged, relative to other airlines, to the extent that regulation allows for price competition
  – Quality of service and products offered --airport and in-flight service amenities and/or restrictions on discount fare products

• Passengers choose combination of flight schedules, prices and product quality that minimizes disutility of air travel:
  – Each passenger would like to have the best service on a flight that departs at the most convenient time, for the lowest price
Market Share / Frequency Share

• Rule of Thumb: With all else equal, airline market shares will approximately equal their frequency shares.
• But there is much empirical evidence of an “S-curve” relationship as shown on the following slide:
  – Higher frequency shares are associated with disproportionately higher market shares
  – An airline with more frequency captures all passengers wishing to fly during periods when only it offers a flight, and shares the demand wishing to depart at times when both airlines offer flights
  – Thus, there is a tendency for competing airlines to match flight frequencies in many non-stop markets, to retain market share
MS vs. FS “S-Curve” Model
S-Curve Model Formulation

\[ MS(A) = \frac{FS(A)^\alpha}{FS(A)^\alpha + FS(B)^\alpha + FS(C)^\alpha + \ldots} \]

where

- \( MS(i) \) = market share of airline \( i \)
- \( FS(i) \) = non-stop frequency share of airline \( i \)
- \( \alpha \) = exponent greater than 1.0, and generally between 1.3 and 1.7
Airline Prices and O-D Markets

• Like air travel demand, airline fares are defined for an O-D market, not for an airline flight leg:
  – Airline prices for travel A-B depend on O-D market demand, supply and competitive characteristics in that market
  – No economic theoretical reason for prices in market A-B to be related to prices A-C, based strictly on distance traveled
  – Could be that price A-C is actually lower than price A-B
  – These are different markets with different demand characteristics, which might just happen to share joint supply on a flight leg

• Dichotomy of airline demand and supply makes finding an equilibrium between prices and distances more difficult.
Price Elasticity of Demand

• Definition: Percent change in total demand that occurs with a 1% increase in average price charged.

• Price elasticity of demand is always negative:
  – A 10% price increase will cause an X% demand decrease, all else being equal (e.g., no change to frequency or market variables)
  – Business air travel demand is slightly “inelastic” (0 > Ep > -1.0)
  – Leisure demand for air travel is much more “elastic” (Ep < -1.0)
  – Empirical studies have shown typical range of airline market price elasticities from -0.8 to -2.0 (air travel demand tends to be elastic)
  – Elasticity of demand in specific O-D markets will depend on mix of business and leisure travel
Implications for Airline Pricing

• Inelastic (-0.8) business demand for air travel means less sensitivity to price changes:
  – 10% price increase leads to only 8% demand reduction
  – Total airline revenues increase, despite price increase

• Elastic (-1.6) leisure demand for air travel means greater sensitivity to price changes
  – 10% price increase causes a 16% demand decrease
  – Total revenues decrease given price increase, and vice versa

• Recent airline pricing practices are explained by price elasticities:
  – Increase fares for inelastic business travelers to increase revenues
  – Decrease fares for elastic leisure travelers to increase revenues
Time Elasticity of Demand

• Definition: Percent change in total O-D demand that occurs with a 1% increase in total trip time.
• Time elasticity of demand is also negative:
  – A 10% increase in total trip time will cause an X% demand decrease, all else being equal (e.g., no change in prices)
  – Business air travel demand is more time elastic (Et < -1.0), as demand can be stimulated by improving travel convenience
  – Leisure demand is time inelastic (Et > -1.0), as price sensitive vacationers are willing to endure less convenient flight times
  – Empirical studies show narrower range of airline market time elasticities from -0.8 to -1.6, affected by existing frequency
Implications of Time Elasticity

• Business demand responds more than leisure demand to reductions in total travel time:
  – Increased frequency of departures is most important way for an airline to reduce total travel time in the short run
  – Reduced flight times can also have an impact (e.g., using jet vs. propeller aircraft)
  – More non-stop vs. connecting flights will also reduce T

• Leisure demand not nearly as time sensitive:
  – Frequency and path quality not as important as price

• But there exists a "saturation frequency" in each market:
  – Point at which additional frequency does not increase demand
Examples of Price Elasticity

EWR-ORD (BTS 2008 2QTR)

EWR-PIT (BTS 2008 2QTR)

EWR-BOS (BTS 2008 2QTR)

EWR-SFO (BTS 2008 2QTR)

Source: BTS
Air Travel Demand Segments

- Low Price Sensitivity
- High Price Sensitivity

- Low Time Sensitivity
- High Time Sensitivity

- Type 1
- Type 2
- Type 3
- Type 4
Different Types of Passengers

• Type 1 – Time sensitive and insensitive to Price
  – Business Travelers, who might be willing to pay premium price for extra amenities
  – Travel flexibility and last minute seat availability extremely important

• Type 2 – Time sensitive and Price sensitive
  – Some Business Travelers, must make trip, but are flexible to secure reduced fare
  – Cannot book far enough in advance for lowest fares

• Type 3 – Price sensitive and insensitive to Time
  – Classic Leisure or vacation travelers, willing to change time and day of travel and airport to find seat at lowest possible fare
  – Willing to make connections

• Type 4 – Insensitive to both Time and Price
  – Few passengers who are willing to pay for high levels of service.
  – Can be combined with Type 1