TURKISH AVIATION ACADEMY

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Estimation of Demand and Market Share

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Lecture Outline

- **Air Travel Demand Models**
  - Time series vs. causal models for demand forecasting
  - Simple Market Demand Function
  - Demand Segmentation

- **Market Share Estimation**
  - Market Share vs. Frequency Share “S-Curve” Model
  - Quality of Service Index (QSI) Model
  - Logit Models of Passenger Choice

Air Travel 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 better 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

Demand Forecasting Methods

- **Time series methods extrapolate patterns in historical booking data to forecast demand**
  - Statistical methods to estimate recent growth/declines
  - Adjustment for known seasonality and cycles

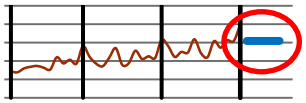
- **Causal methods include additional explanatory variables that can affect future demand**
  - Actual advance booking data for future dates
  - Additional “exogenous” variables such as economic growth, expected changes in price or frequency
  - Adjustment for changes to competitive conditions

Example: Combined Model for Estimating Total O-D Demand in a Market

History Model

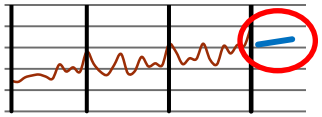
Step 1 Level

- Estimates the level of the industry using data* of the previous year



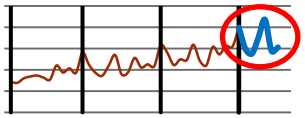
Step 2 Trend

- Estimates the trend of the industry using data of the two previous years



Step 3 Seasonality

- Estimates seasonality of the market using data of the three previous years



Booking Model

Step 1 Indirect Bookings

- Compares MIDT bookings for the following months with the ones that existed for the same months of the previous year

Step 2 Total bookings

- Adds the estimations of direct bookings (Non MIDT)

Step 3 Estimation

- Uses the difference between last year bookings and last year actual traffic to estimate how much will the bookings increase

By combining the results from the two models, the tool estimates the market size for the following 6 months

Source: LAN Airlines (2012)

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

	Business Air Travel Demand	Personal Air Travel Demand
First Class	D_{fb}	D_{fp}
Coach Class	D_{cb}	D_{cp}
Discount Class	D_{db}	D_{dp}

Demand Models by Segment

Demand Functions for Business Travel

$$D_{fb} = M_b \; I_f \; P_f^{a1} \; T_f^{b1} \; P_c^{c1}$$

$$D_{cb} = M_b \; I_c \; P_c^{a1} \; T_c^{b1} \; P_f^{c1}$$

Where M_b = the market sizing parameter for business travel demand (constant)

I_f , I_c = constant image factors for first and coach class services

P_f , P_c = prices of first and coach class services

T_f, T_c = total travel times for first and coach class services

a1 = price elasticity of demand for business travelers

b1 = time elasticity of demand for business travelers

c1 = cross-elasticity of business travel demand for first class service with respect to the price of coach class service, and vice versa

Demand Models by Segment

Demand Functions for Personal Travel

$$D_{cp} = M_p \; I_c \; P_c^{a2} \; T_c^{b2} \; P_d^{c2}$$

$$D_{dp} = M_p \; I_d \; P_d^{a2} \; T_d^{b2} \; P_c^{c2}$$

Where M_p = the market sizing parameter for personal travel demand (constant)
I_c , I_d = constant image factors for coach and discount class services
P_c , P_d = prices of coach and discount class services
T_c , T_d = total travel times for coach and discount class services
a2 = price elasticity of demand for personal travelers
b2 = time elasticity of demand for personal travelers
c2 = cross-elasticity of personal travel demand for coach class service with respect to the price of discount class service, and vice versa

Issues in Price Elasticity Estimation

- **Sources of data**
  - Airlines have detailed historical booking data by fare class
  - US DOT 10% ticket sample provides flown ticket data for US domestic markets -- passengers and average fare by airline
  - But, all available data reports traffic flown, *NOT* "demand"
- **Measurement issues**
  - Ideally, need a dataset with no change to schedules, competitors, economic conditions
  - Price and service attributes of travel substitutes (esp. short-haul)
  - Cross-sectional, time series, or panel data samples
  - Demand segmentation and revenue management impacts
  - Identification problem – supply affects demand
  - Focus on one airline (or airport) will exaggerate elasticity estimates

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 among flight schedules, prices and product quality to minimize air travel disutility:**
  - 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 Estimation

- **Given estimate of total demand for air travel in an O-D market, what is each airline's market share?**

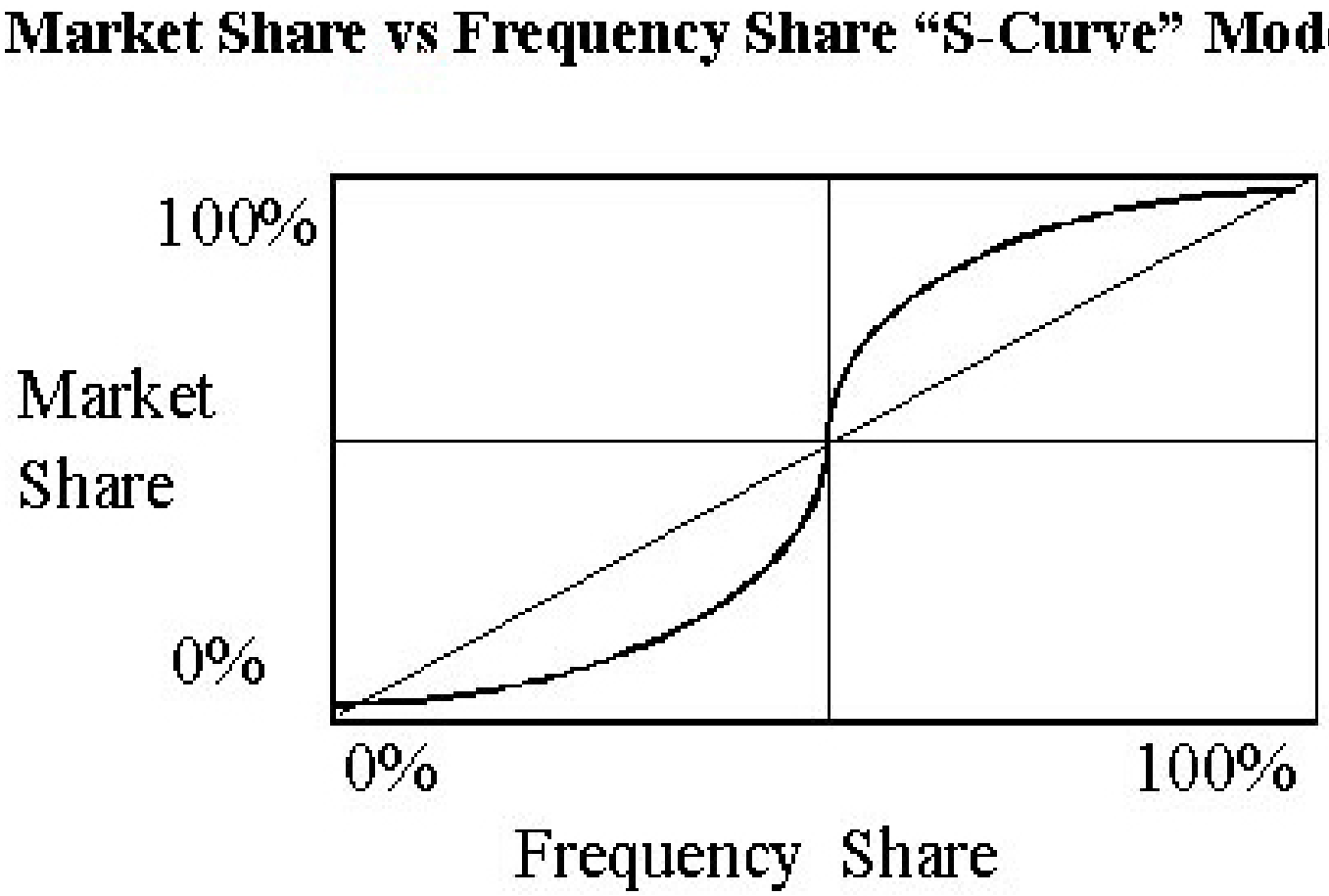
- **Several modeling approaches can be used to estimate airline market shares:**
  - "S-curve" model of market share/frequency share
  - Extensions to "Quality of Service Index" (QSI Model)
  - Logit Models used in profit estimation software systems

Market Share / Frequency Share

- **<u>Rule of Thumb</u>: 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
- α = exponent greater than 1.0, and generally between 1.3 and 1.7

Example: S-Curve Market Share Model

- **Single O-D market, short-haul non-stop route**
  - Two airlines, each offer 4 daily flights with 120 seat aircraft
  - Assume prices and service quality are equal
- **Total daily demand (PDEW) is a function of frequency**

$$PDEW = 10000 * [4 + 4 / TOT\ FREQ)^{-1.7}$$

- **S-curve model of MS vs. FS with alpha = 1.5**

		AIRLINE A	AIRLINE B
AIRCRAFT CAPACITY		120	120
TOTAL DAILY PAX	775		
FLIGHTS per day		4	4
FREQUENCY SHARE		50.0%	50.0%
MARKET SHARE		50.0%	50.0%
AIRLINE PAX PER DAY		387.7	387.7
AVE. LOAD FACTOR		80.77%	80.77%

Airline A Adds 1 New Flight

- **Airline A expands its schedule to gain market share**

		AIRLINE A	AIRLINE B
AIRCRAFT CAPACITY		120	120
TOTAL DAILY PAX	792		
FLIGHTS per day		5	4
FREQUENCY SHARE		55.6%	44.4%
MARKET SHARE		58.3%	41.7%
AIRLINE PAX PER DAY		461.6	330.3
AVE. LOAD FACTOR		76.94%	68.82%

- **Airline A gains passengers and market share**
  - But its load factor decreases
  - Note that load factor of Airline B decreases even more!
  - If we assume both airlines have a 75% Break-Even Load Factor, then Airline A's change causes Airline B to become unprofitable

Discussion: How Should Airline B Respond?

- **What should Airline B do to regain profitability?**
  - Without changes to price, image, service quality
  - Schedule and capacity changes only

		AIRLINE A	AIRLINE B
AIRCRAFT CAPACITY		120	120
TOTAL DAILY PAX	792		
FLIGHTS per day		5	4
FREQUENCY SHARE		55.6%	44.4%
MARKET SHARE		58.3%	41.7%
AIRLINE PAX PER DAY		461.6	330.3
AVE. LOAD FACTOR		76.94%	68.82%

QSI Market Share Models

- **Quality of Service Index (QSI)**
  - Values an airline's set of flights offered in an O-D market, relative to competitors
  - Extension of simple MS/FS model to include one-stop and connecting flight options
  - Used to estimate the markets share potential of new routes and incremental flights

- **Developed in the 1960s, widely used by airlines for planning and scheduling**

QSI Market Share Example

- **QSI for Buenos Aires (EZE) to Bogota (BOG)**

	Number	Weight	Index
Daily Nonstops	1	1.0	1.00
One-stop Flights	2	0.33	0.66
Connections	8	0.03	0.24
Market QSI			1.90

- **Current share of 1 non-stop flight = 1.0/1.9 = 53%**
- **Impact on QSI of additional non-stop flight = 1.0**
- **New Market QSI is 2.90**

Impacts of Adding a Second Non-stop Flight

- **Total demand EZE-BOG estimated as 250 PDEW**
  - (Assume new frequency stimulates demand by 10%)
- **QSI share for new non-stop flight**

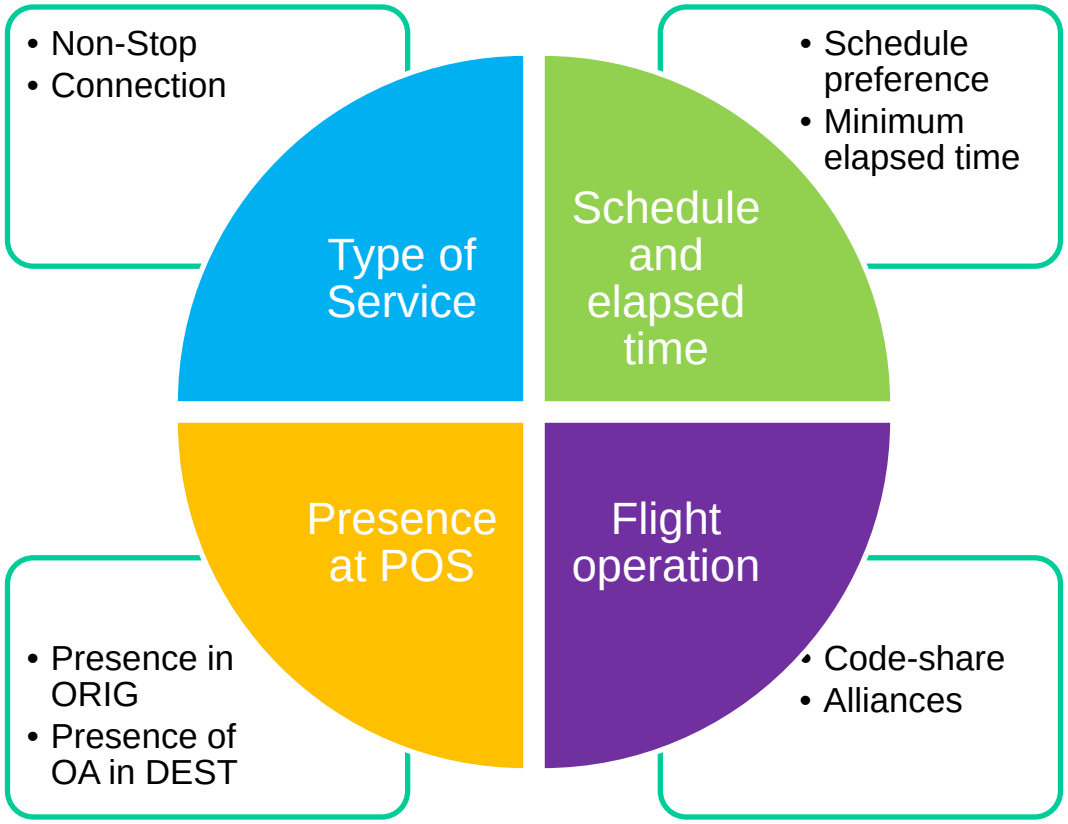
  = 250 x (1/2.90) = 250 x 0.345 = 86 passengers/day
- **Impacts on existing non-stop flight**
  - Previous share 227 x (1/1.90) = 227 X 0.53 = 120 pax
  - New share 250 x (1/2.90) = 86 pax/day
- **Overall effect of adding a 2nd non-stop flight**
  - Increase in total pax from 120 to 2 x 86 =172/day
  - Decrease in loads per flight from 120 to 86 = - 34

Logit Models for Market Share Estimation

- **"Discrete choice" models use logit formulation to further extend QSI approach**
  - Probability of passenger choice based on relative utilities of different flights/airlines in an O-D market
- **Utilities of flight alternatives can include:**
  - Path quality index (non-stop, 1-stop, connection) and/or actual elapsed trip times
  - Airline service quality and passenger preferences
  - Possible fare differences, frequent flyer programs, etc.
- **Historical input data needed to calibrate choice parameters**

Logit Model Market Share Estimation

Most important factors for passenger preference



Mathematical Expression

$$MS\ (i) = \sum_{t=0}^{167} p(t) \frac{e^{\sum_J \beta_J x^i_J}}{\sum_{k=1}^{m} e^{\sum_J \beta_J x^k_J}}$$

MS(i) is the market share of the itinerary i under consideration

p(t) is the probability of a passenger requesting a departure hour t (TOW)

$\beta_J = \beta_1, \beta_2 \ldots \beta_n$ are the logit coefficients for each attribute

$X_j^i = X_j^1, X_j^2 \ldots X_j^n$ are the attribute variables for itinerary i as described in the previous section

k = 1, 2 … m are all the itineraries in the market

Source: LAN Airlines (2012)

Logit Passenger Choice Model: New IST-BOS Non-stop Flight

- *Estimate the probability of passenger choice for all flight paths in an OD city-pair*
- *Relative utility of different flights and paths based on trip duration and number of stops*