Estimation of Demand and Market Share

Dr. Peter Belobaba

Istanbul Technical University

Air Transportation Management

M.Sc. Program

Network, Fleet and Schedule

Strategic Planning

Module 7: 11 March 2014

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

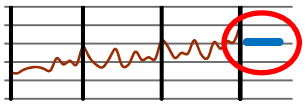
- **Causal methods include additional explanatory variables that can affect future demand**
  - Actual advance booking data for future dates
  - Additional “exogenous” variables such as economic growth, expected changes in price or frequency
  - Adjustment for changes to competitive conditions

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

History Model

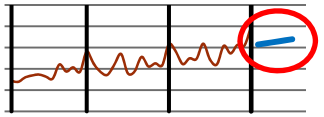
Step 1 Level

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



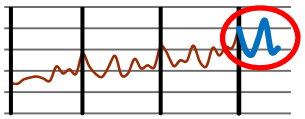
Step 2 Trend

- *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?**

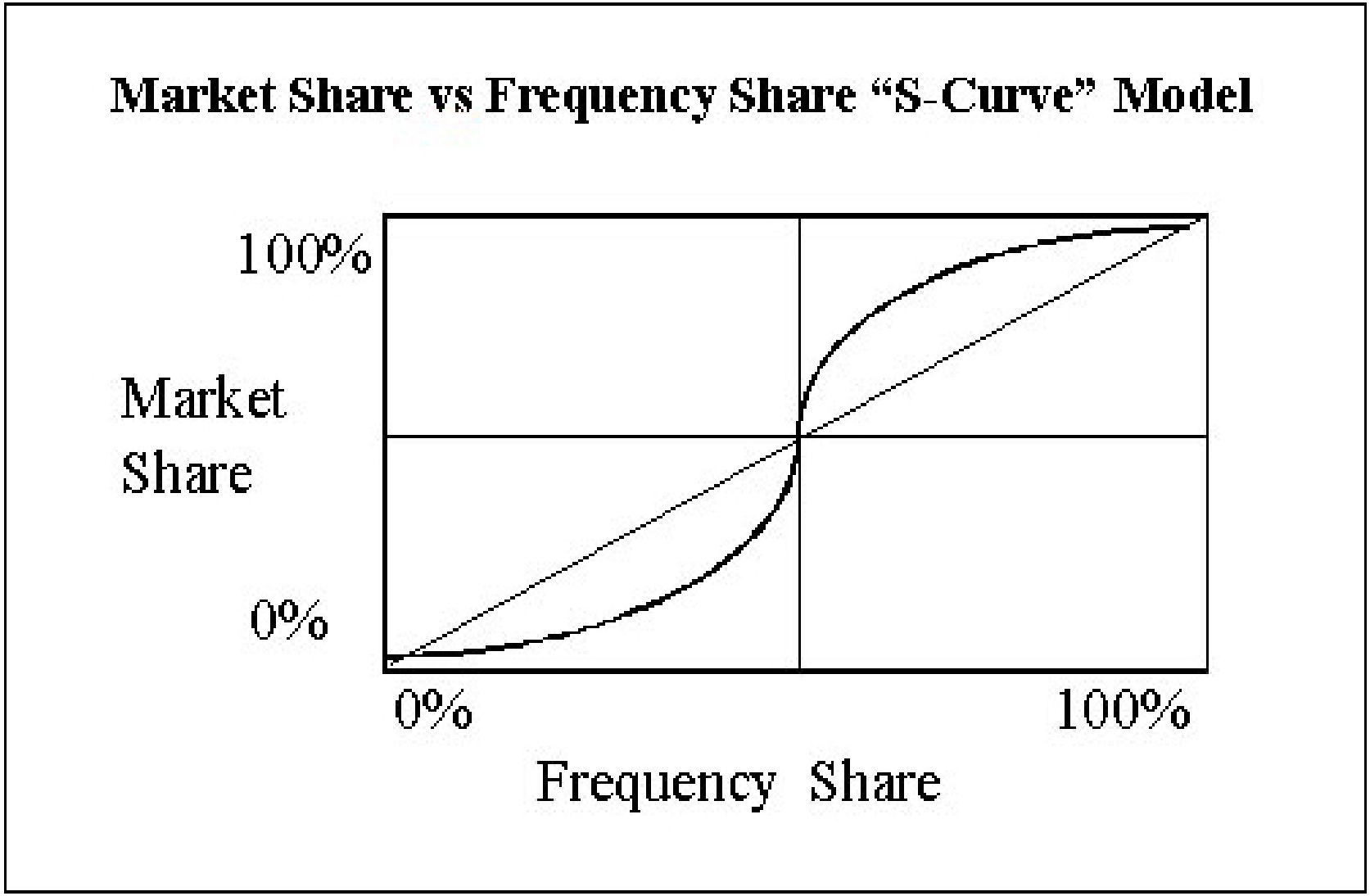
- **Several modeling approaches can be used to estimate airline market shares:**
  - "S-curve" model of market share/frequency share
  - Extensions to "Quality of Service Index" (QSI Model)
  - Logit Models used in profit estimation software systems

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**

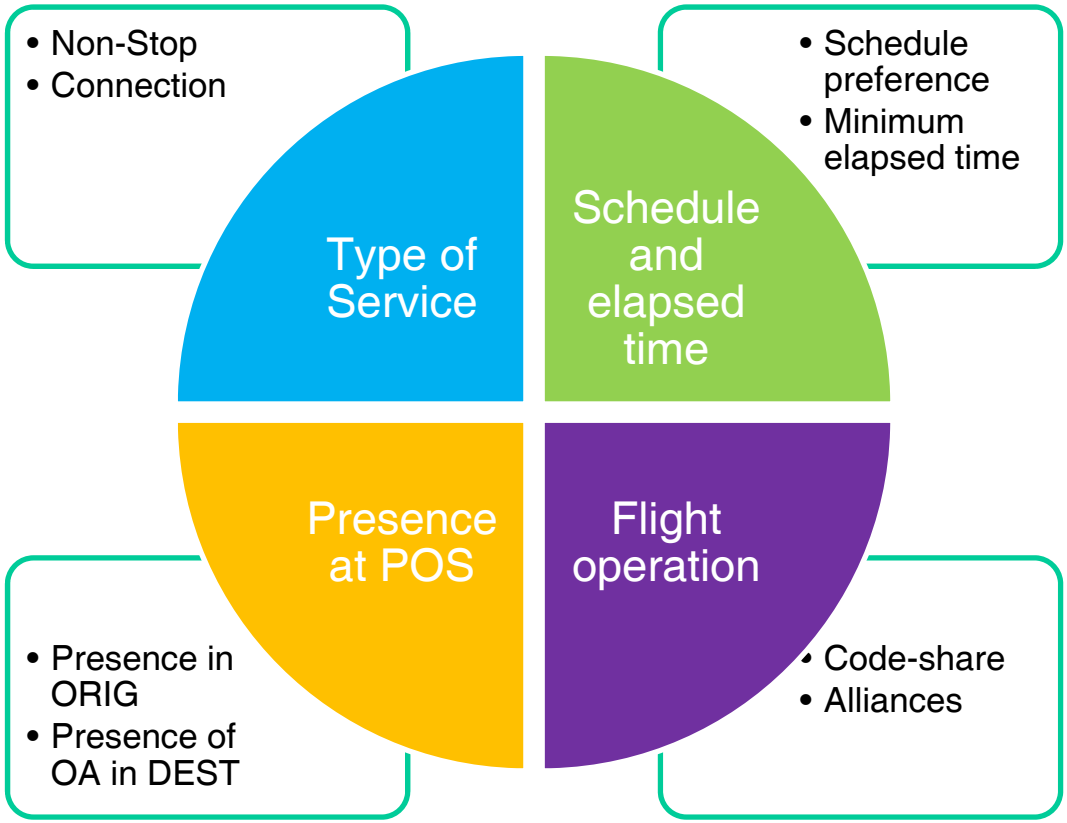
  = 250 x (1/2.90) = 250 x 0.345 = 86 passengers/day
- **Impacts on existing non-stop flight**
  - Previous share 227 x (1/1.90) = 227 X 0.53 = 120 pax
  - New share 250 x (1/2.90) = 86 pax/day
- **Overall effect of adding a 2nd non-stop flight**
  - Increase in total pax from 120 to 2 x 86 =172/day
 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