Air Transport Demand

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Air Transport Demand

- Demand for air transport between two cities or two regions depends on
  - Socio-economic characteristics of the regions
  - The characteristics of the transportation system that links them
Air Transport Demand

- Models to evaluate air transportation demand most often evaluate
  - The number of potential passengers
  - The number of passenger kilometers that can be achieved
  - The expected number of operations (take offs and landings)
  - A percentage share of the number of air passengers out of the total number of passengers
Air Transport Demand Estimation

- The process of forecasting transportation demand most often comprises the following steps:
  - Trip generation
  - Trip distribution
  - Modal split
  - Trip assignment
Classification: Competitive Mode

- Whether or not the model includes competitive modes of transportation
  - Models that are independent of the characteristics of alternative modes of transportation
  - Multimode models
Independent of Other Modes

- The airplane is the predominant mode of transportation on many long-distance traffic routes. Therefore, demand for air transportation on long-haul routes should be estimated independently of other modes of transportation.
Multimode

- Multimode models are primarily used to estimate demand for air transportation on short-haul routes.

- Air transportation demand on shorter routes is usually estimated simultaneously with the estimation of demand on other modes of transportation.
Classification: Macro vs. Micro

- Classification of air transportation demand model
  - Macroscopic models
  - Microscopic models
Classification: Macro vs. Micro

- Macroscopic models are used to estimate the development level of air transportation in a certain country or region
  - Estimate
    - The number of passengers
    - The number of airplane operations
    - The number of passenger kilometers
Classification: Macro vs. Micro

- Microscopic models estimate
  - Demand between two cities
  - The passenger traffic at an airport
  - The number of passengers along a specific route
  - The number of passengers in each class
Macroscopic Models

- Macroscopic Models: Demand is a function of time
  - Factors that affect the number of passengers are not taken into consideration
Macroscopic Models

$t : \text{time}$

$y : \text{the number of air passengers that changes over time}$

- **Model 1**
  
  $k, m, : \text{parameters}$

  $y = kt + m$

  - Model calibration : can be the least squares method
Macroscopic Models

- Model 2

\[ y = a \cdot b^t \]

- logarithmic form

\[ \log y = \log a + t \cdot \log b \]

- Advantage: \( a, b \) can be estimated using the least square method
Macroscopic Models

○ Model 3: modified exponential curve

\[ y = k + a \cdot b^t \]

- When \( a < 0, b < 1 \)

- \( k \): fixed saturation level
Macroscopic Models

- Model 4: Gompertz curve

\[ y = k \cdot a^{b^t} \]

- Logarithmic form

\[ \log y = \log k + b^t \cdot \log a \]
Macroscopic Models

- When $\log a < 0, b < 1$

- $k$: saturation level
Macroscopic Models

- **Model 5: Logistic curve**
  - Logistic curve, or called Pearl-Reed curve
    \[
    y = \frac{k}{1 + b \cdot e^{-at}}
    \]
  - Has a shape similar to the Gompertz curve
Macroscopic Models

- The least squares method cannot be applied to estimate the parameters of:
  - Modified exponential curves
  - Pearl-Reed curve
  - Gompertz curve

- The three-point methods have proven very successful in estimation the parameters of these curves
Macroscopic Models

- Macroscopic models: Demand is a function of socio-economic characteristics
  - Dependent variables
    - The number of passengers
    - The number of operations
    - The number of passenger kilometers
  - Independent variables
    - Chosen from socio-economic characteristics and characteristics of the transportation system
Macroscopic Models

- Most often socio-economic
  - Population
  - National income
  - Personal consumption
  - Volume of trade
  - Number of tourist

- Most often transportation system
  - The cost of transportation
  - Speed / travel time
Macroscopic Models

Model:

\[ m : \text{the total number of socio-economic characteristics} \]
\[ n : \text{the total number of transportation system characteristics} \]
\[ y_t : \text{the number of air passengers in time } t \]
\[ S_{it} : \text{the value of the i-th socio-economic characteristics in time } t \]
\[ T_{jt} : \text{the value of the j-th transportation system characteristics in time } t \]
\[ a, b_i, c_j : \text{parameter} \]

\[ y_t = a \prod_{i=1}^{m} S_{it}^{b_i} \prod_{j=1}^{n} T_{jt}^{c_j} \]
Macroscopic Models

- Logarithmic form

\[
\log y_i = \log a + \sum_{i=1}^{m} b_i \cdot \log S_{it} + \sum_{j=1}^{n} C_j \cdot \log T_{jt}
\]

- \(a, b_i, C_j\) parameters estimation:
  - Multiple regression technique
  - Maximum likelihood function
Trip Distribution

- Trip distribution models
  - When the total number of trips that a region can generate has been established, the trips are then distributed.
  - Trip distribution: establishes the number of trips between individual zones.

- Commonly used models
  - Entropy model
  - Gravity model
Trip Distribution

○ The Gravity model
  
  - an analogy to Newton’s Law of Gravity

\[ f_{ij} = k \frac{A_i \cdot B_j}{d_{ij}^2} \]

- \( f_{ij} \): the number of trips between city \( i \) and city \( j \)
- \( k \): constant
- \( A_i \): the “size” of city \( i \)
- \( B_j \): the “size” of city \( j \)
- \( d_{ij} \): the distance between city \( i \) and city \( j \)
Trip Distribution

- $A_i, B_j$ is most often taken as the number of emitted or attracted trips, i.e. $A_i = a_i, B_j = b_j$

- Problems in the original gravity model: not satisfied by the following flow conservation equations

$$\sum_{j=1}^{n} f_{ij} = a_i, \sum_{i=1}^{m} f_{ij} = b_j$$
Trip Distribution

- Modified Gravity model

\[ f_{ij} = k_i \cdot a_i \cdot k_j \cdot b_j \cdot f(d_{ij}) \]

- \( k_i, k_j \): coefficients associated with the number of trips emitted or attracted by the cities
- \( f(d_{ij}) \): distance function, can be distance, travel time…etc., or a combination of different variables
Trip Distribution

Since \[ \sum_{j=1}^{n} f_{ij} = a_i \]

\[ \sum_{j=1}^{n} k_i \cdot a_i \cdot k_j \cdot b_j \cdot f(d_{ij}) = a_i \]

\[ k_i = \frac{1}{\sum_{j=1}^{n} k_j \cdot b_j \cdot f(d_{ij})} \]

Similarly \[ \sum_{i=1}^{m} f_{ij} = b_j \]

\[ k_j = \frac{1}{\sum_{i=1}^{m} k_i \cdot a_i \cdot f(d_{ij})} \]
Multimode Models

- Multimode models
  - Aggregated models
    - Aggregated models take certain socio-economic characteristics into consideration.
  - Disaggregated models
    - Disaggregated models start with the individual as the one making the decision to travel and therefore operate with certain socio-economic characteristics related to the individual, obtained by surveying passengers.
    - Disaggregated models can also quantify the effect of comfort or the feeling of safety.
Multimode Models

- Aggregated models: abstract mode model
- Disaggregated models: choice models