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Transport Economics

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4.50 EUR

Part III: Transport supply and demand

10. Demand for transport

1. Introduction

What is transport modelling?

- Mathematical representation and simplification of reality; forecasts and estimations
- Focus on key relationships and available data
- Passenger transport
- Freight transport
- Combination of passenger and freight transport
- To make forecasts
- Policy guidance, input to cost-benefit analysis, results are input to business plan (if used and interpreted correctly)
- Instrument for making decisions

➔ *This chapter*: analysis and forecasts of transport demand, with a distinction between passenger and freight transport.
→ Purpose: to provide a scientific insight into the determinants of mobility growth
+ tool for making conditional forecasts of transport demand levels.
Such forecasts can help us evaluate the expected consequences of alternative transport scenarios and strategies.

➔ *Focus*: number of empirical studies in order to illustrate the level of mobility growth.

Research into transport demand: largely model-based (+ most empirical studies are concerned with passenger transport) → <u>three types of models</u>:

1) Classical four-stage models:
   - Often used in urban transport studies
   - Mostly uses **aggregate data**
2) Microeconomic approach of travel-choice behaviour:
   - Supported by the random utility theory
   - Traveller behaviour is explained mostly at **individual level**
3) Activity-based approach:
   - Travel is **day-to-day behaviour** (travel patterns) related to and derived from variations in lifestyle and the degree of active participation

Passenger demand models: assumption that individual travellers maximise their utility.
Freight demand models: transport firms strive to minimise costs.

➔ Producer aims for maximisation of production at a given cost level and minimisation of costs at a given production level.

2. Aggregate models

2.1 The Methodological Framework

Transport planning process → based on modelling. **Different components** of travel or transport behaviour (decisions you have to make):

- Decision of whether or not to travel or to have freight transported to a certain destination
- Choice of destination
- Choice of transport mode
- Choice of route

➔ Transport user will take these decisions simultaneously, in transport demand models they are usually considered **in sequence**. Output of each phase = input for the next phase.

➔ **Trip matrix**: a scheme consisting of four consecutive phases.

Table 10.1: The trip matrix

Destination / Origin	1	2	3	...	I	Total traffic departing
1	x_{11}	x_{12}	x_{13}	...	x_{1i}	R_1
2	x_{21}	x_{22}	x_{23}	...	x_{2i}	R_2
3	x_{31}	x_{32}	x_{33}	...	x_{3i}	R_3
...	...	...	...	...	...	...
I	x_{i1}	x_{i2}	x_{i3}	...	x_{ii}	R_I
Total traffic arriving	K_1	K_2	K_3	...	K_I	X

➔ x_{ij} : number of trips from zone *i* to zone *j*

R_i : total amount of traffic departing from zone *i* $R_i = \sum_{j=1}^{I} x_{ij}$

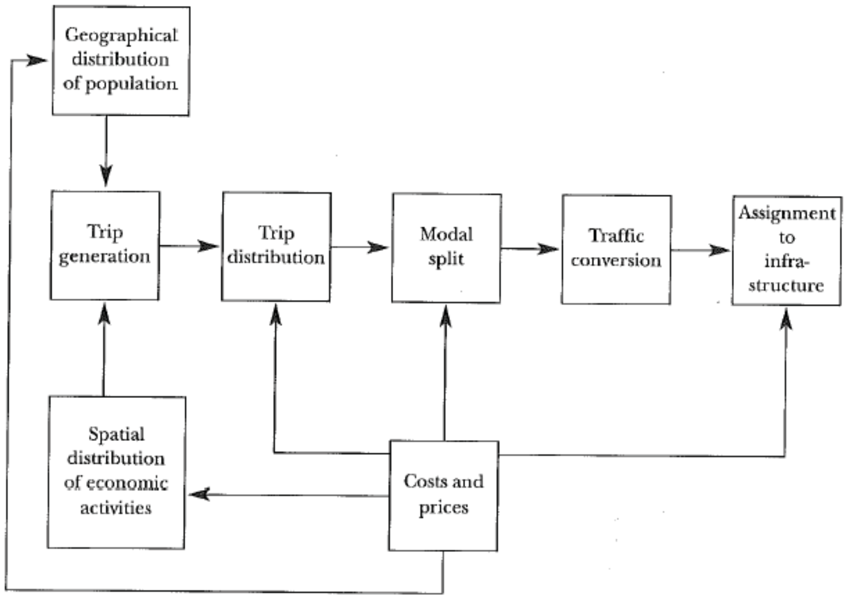
K_j : total amount of traffic arriving in zone *j* $K_j = \sum_{i=1}^{I} x_{ij}$

X: number of passengers transported in the area studied (sum of all row totals and sum of all column totals). $X = \sum_i R_i \sum_j K_j$

Four sequential **levels of demand determination**:

- **Trip generation**:
  - determination of the total transport quantity X as well as the row and column totals K_j and R_i, or the incoming and outgoing traffic per region
- **Trip distribution**:
  - Distribution of the row and column totals K_j and R_i over the separate flows x_{ij} between the zones
- **Modal split**:
  - Determination of the share of the modes in the traffic flows x_{ij}
- If required: **traffic conversion**
  - Translate the traffic flows into the corresponding number of trips.

- **Assignment to infrastructure**:
    - Choice of route for transportation by each of the modes, so that one can determine the traffic burden on the infrastructure network.



➔ May be translated into a table specifying the **required input and output**:

Model	Input	Output
1 Trip generation	- Geographical distribution of population - Location of economic activities - …	Outgoing traffic (R_i) Incoming traffic (K_j)
2 Trip distribution	- Output trip generation - Transport costs - …	Traffic flows x_{ij}
3 Modal split	- Output trip distribution - Costs and rates - Travel times - …	Modal shares
4 Assignment	- Output modal split - Time savings and distance savings - …	Assignment to infrastructure

➔ These four levels of demand determination correspond to four successive operational phases.

➔ For each phase there is a submodel that explains part of the demand process. These can be used to resolve specific transport issues.

2.2 Trip Generation

Purpose: to predict the number of trips with origin and destination in each of the zones. Starting from row totals, how these totals will evolve in the future.

2.2.1 Trip generation in passenger transport

Determining factors (of number of passengers travelling to and from a zone):

- Number of inhabitants and the related factors household size and composition
- Car ownership
- Employment
- Income
- Distance of various centres of activity

7 types of trip:

1) Home → work
2) Work → home
3) Home →shopping
4) Shopping → home
5) Home → other destinations
6) Other destinations →home
7) Home ≠ origin or destination

➔ For each of these types of trip, separate estimations are made on the basis of an appropriate methodology.

Travel behaviour of a passenger: function of his destination.

- Home-based work trips → made on a regular and daily basis, usually during the morning and/or evening rush-hour.
  ~ trips between home and school
- Shopping trips → not regular, other explanatory factors (location of large shopping centres, changing purchasing patterns)
  For social and recreational trips, a different approach is required.

The prediction method = function of the type of trip studied

- Fixed ratio between number of trips and explanatory variable
  - E.g. home-based work trips: fixed ratio between number of trips on the one hand and the size of the population and the employment rate on the other hand.
  - Sum of incoming traffic = sum of outgoing traffic, if not: correction (in this example they will usually correct the column totals as demographic evolution is easier to predict than employment trends).
  - ➔ Can only be used for home-based work traffic
- Other types of trips: other methods of forecasting
  - Regression analysis or category analysis

Regression analysis = row totals are estimated using this equation:

Example: outgoing trips

$$R_i = a + b_1 y_{1i} + b_2 y_{2i} + \dots + b_n y_{ni}$$

R_i = *the row total (outgoing trips) of zone i*

a = *a constant*

y_{ni} = *the value of factor n (e.g. population size, number of cars, average income, …) in zone i*

Row totals = f(employment, value added, production figures…)

Column totals = f(overall spending, consumption figures…)

- ➔ The coefficients a, b_1, b_2, … , b_n are estimated on the basis of observations. They represent the effect of the population size, the car fleet, income, … on the total number of trips leaving the zone.
- ➔ Calculated totals for each row and column are balanced by a correction coefficient.

Category analysis:

- ➔ Divides households into a number of categories on the basis of such characteristics as household income, car ownership, the number of employed individuals.
  The trips are assigned to each category on the basis of observations in the base year.
- ➔ The method is essentially based on the assumption that households with equal characteristics produce an equal number of trips.
- ➔ Prediction of the number of trips by multiplying the average number of trips by the number of households and by summating over the different categories.
- ➔ Zone-based approach: zonal characteristics will be employed as variables.

2.2.2 Trip generation in freight transport

Freight traffic generation → determined by the relationship between transport activity and economic activity.

- ➔ One tries to identify an indirect relation between the volume and the structure of freight transport, and the level and the structure of economic activities.

Demand for transport is derived: transport is only necessary when goods are produced and consumed in different locations.

Desired model output for freight:

- A representation of the total incoming and outgoing traffic for a number of zones
- A breakdown of these results over a number of goods categories
- ➔ Trip generation in a certain zone will depend upon the nature and level of economic activity in that zone (supply of goods)
- ➔ Traffic attraction will depend upon the same factors and more specific final demands factors (demand for commodities)

Same approach as in passenger transport:

- E.g. one can explain the row totals on the basis of employment or the value added in the zone, and the column totals on the basis of overall spending.

You obtain better results if you derive the row and column totals directly from production and consumption figures for the goods concerned. Eg: row total = proportional to the production of a good, whereas the column total = proportional to the consumption (by both households and firms) of that good. **Sum row totals = sum column totals!**

2.3 Trip distribution

Determination of the separate traffic flows from zone to zone. All transport-attracting zones are competing with each other for trips coming from zone *i* (trip-generating zone).

2.3.1 Distribution of passenger traffic

Distribution: concerns the estimation of transport volumes moving between all zones *i* and *j*, whereby *i* represents the trip-generating zone and *j* represents the trip-attracting zone.

Example: home-to-work traffic

$R_i{}^0$ = the observed row total for zone i

$K_j{}^0$ = the observed column total for zone j

$x_{ij}{}^0$ = the observed traffic flows from zone i to zone j

- → Assumption: change is predicted in overall employment and the size of the working population, but with zonal variation (new row and column totals R_i and K_j).
- → How large are the new separate flows x_{ij}?

Determine trip distribution → **various methods**:

- The growth factor method and synthetic approach

THE GROWTH FACTOR METHOD

- Growth factors are applied to the existing distribution pattern as represented in the trip matrix.
- Number of variations depending on the growth factors
    - o Detroit factor method
- New traffic flows are determined by:

$$x_{ij} = x_{ij}{}^0 \left(\frac{r_i * k_j}{r}\right)$$

    - o All traffic flows of row i are multiplied by a growth factor r_i
    - o All traffic flows of column j are multiplied by a growth factor k_j
    - o All traffic flows are divided by the general growth factor r.
- Factors r_i, k_j, and r are determined in such a way that the new traffic flows add up to the given row and column totals.

- How are growth factors determined?

$$r_i = \frac{R_i}{R_i^0} \qquad k_j = \frac{K_j}{K_j^0} \qquad r = \frac{X}{X^0}$$

- Calculation of flows:

$$x_{ij} = x_{ij}^0 \left(\frac{(R_i / R_i^0) \cdot (K_j / K_j^0)}{X / X^0} \right)$$

Critical remarks:

- No account is taken of changing transport costs
- The method cannot be applied if old traffic flows are unknown
- No new zones can be incorporated and no zone can be subdivided
- Unreliable if zone is small and rapidly expanding
- Forecasting of future traffic flows does not take account of changes in travel demand brought about by network changes.

THE SYNTHETIC METHOD

~ An analogue of Newton's law of gravitational attraction:

➔ The force of attraction between 2 zones (*i* and *j*) is assumed to be proportional to the mass of zone *i* and the mass of zone *j*, and to be inversely proportional to the distance squared. Mathematical:

$$x_{ij} = \frac{k \cdot O_i \cdot D_j}{c_{ij}^{\beta}}$$

x_{ij} – traffic flow from zone i to zone j
O_i – importance of zone i as an origin
D_j - importance of zone j as a destination
c_{ij} – transport cost from i to j (function of distance)
k – a constant that is determined in such a ways that the total number of trips equals the observed total
β – a parameter to be estimated

➔ O_i and D_j: measures of the generative and attractive characteristics of the origin and destination localities → divided into 2 categories:

➔ Proxy variables: a rough measure such as population size

➔ Exact variables: in the case of traffic between the home and the workplace; the working population and the number of jobs.

Gravity model can also be stated **more generally**:

$$x_{ij} = k \cdot O_i \cdot D_j \cdot f(c_{ij})$$

➔ The general functional form $f(C_{ij})$ remains to be specified empirically and does not need to adopt the form $1/C^{ß}_{ij}$.

$O_i = R_i$ and $D_j = K_j$

Probability that a trip corresponds to row *i* = R_i/X
Probability that a trip corresponds to column *j* = K_j/X
Probability that a trip falls on the connection within zones *i – j* = $(R_i/X) – (K_j/X)$

Expected number of trips within the interval i-j:

$$X * \frac{R_i}{X} * \frac{K_j}{X} = \frac{R_i * K_j}{X}$$

Taking into account transport costs:

$$x_{ij} = k * \frac{R_i * K_j}{X} * f(C_{ij})$$

- ➔ This specification is based on a statistical prediction.
- ➔ Assuming that the transport cost does not change and traffic flows only change through changes in the row and column totals, the above variant also allows one to interpret the Detroit growth factor model.

Another variant of the pool model employs correction coefficients determined in such a way that the calculated traffic flows add up to the given row and column totals.

$$x_{ij} = k * \frac{R_i * r_i * K_j * k_j}{X * r} * f(C_{ij})$$

- ➔ ! Strong resemblance with Detroit model, including the iterations!!

Another formulation: the number of trips between zones i and j is not only affected by the cost on the relationship concerned, also by the cost of travelling from i to another destination (v).

$$x_{ij} = k * \frac{R_i * K_j}{\sum_{v=i}^{I} K_v (C_{iv})^{\beta}} * f(C_{ij})$$

- ➔ Typical example of a **multiple gravity model**.

2.3.2 Distribution in freight transport

All methods applying to the distribution of passenger traffic may be applied in this case too.
Cost-minimizing distribution methods: methods that are specifically designed for freight transport.

- ➔ The traffic flows are determined in such a way that they add up to the row and column totals and, under this restriction, result in the lowest possible transport costs.

$$Min \sum_{i=1}^{I} \sum_{j=1}^{J} C_{ij} \cdot x_{ij}$$

where:

$$\sum_{j=1}^{J} x_{1j} = R_1 \qquad \sum_{i=1}^{I} x_{i1} = K_1$$

$$\sum_{j=1}^{J} x_{2j} = R_2 \qquad \sum_{i=1}^{I} x_{i2} = K_2$$

$$\vdots \qquad\qquad \vdots$$

$$\sum_{j=1}^{J} x_{ij} = R_i \qquad \sum_{i=1}^{I} x_{ij} = K_j$$

- ➔ C_{ij} = transport costs per tonne of freight transported from zone *i* to zone *j*
  X_{ij} = tonnage transported from *i* to *j*
- ➔ Represents a linear programming problem, with a linear objective function and linear restrictions.

2.4 Modal split

The establishment of the share of each mode in the traffic flows. In the short term, it can result in an efficient use of existing capacity. In the long term, there will be implications for any replacement or expansion investments in the transport system.

2.4.1 The modal split in passenger traffic

The question arises of travellers' choice between various modes of transportation.

A modal choice model is concerned with the behaviour of travellers with regard to the selection of transport modes.

The modal choice of travellers is determined by **3 explanatory factors**:

1) The socioeconomic status of the traveller
   - *Car ownership*: people owning a car will tend to use it under all circumstances
   - *Income*: non-car owners on a high income will use taxis more often and those on a low income would rather travel by tram or by bus. ('white collar-blue collar')
   - *Age*: people under the age of 18 and above the age of 60 make less frequent use of the car.
   - *Household composition*
2) The nature of the trip
   - *Length of the trip*: long distances → negative impact on car-use and positive impact on the modal share of rail and air travel
   - *Motivation for travelling*: car is used less frequently for travelling between the home and work or school than it is for shopping.
3) The characteristics of alternative modes
   - *Difference in travel time*: the greater the difference, the more likely that a traveller will opt for the quickest mode.
     Total travel time consists of three components: in-vehicle time, walking time and waiting time (latter two = excess time).
   - *Difference in cost*: modal choice between the car and public transport is influenced by out-of-pockets expenses (= costs that you pay immediately or the costs that you regard as more or less proportional to the distance covered)

2.4.2 The modal split in freight transport

= goods flow per transport mode under various market conditions.

The factors that determine the modal split in freight transport may be divided into **three categories**:

1) Aspects regarding the distributor (goods)
   1) The category of the goods
   2) Rail transport and inland navigation are important modes for transportation of goods with a relatively low value per unit of weight. Road transport dominates in the other categories.
   3) Batch size, time, frequency, ownership of vehicles, network connections

2) Characteristics of the trip
    1) Distance
    2) Average distance covered per tonne is the highest in rail traffic
3) Characteristics of the transport supply
    1) Price and reliability of the competing modes
    2) Risk of damage and loss
    3) Competitive position = sum total of all elements determining the modal choice.

2.5 Traffic conversion

It gives an insight into the equivalent number of trips per mode.

Traffic conversion models → allows you to convert transport flows into loaded trips.
This poses 2 problems:

1) It does not suffice to calculate the number of trips per mode on each geographical relationship.
2) One needs to determine the number of empty trips (part of the total number of trips).

➔ Traffic conversion involves **2 operations**:
   ➔ conversion of traffic flows in terms of tonnes into loaded trips per capacity category
   ➔ the determination of the number of empty trips per capacity category

2.6 Assignment to infrastructure

Modal split offers insight into the traffic flows per mode from zone to zone.
Traffic conversion offers insight into the corresponding number of trips.

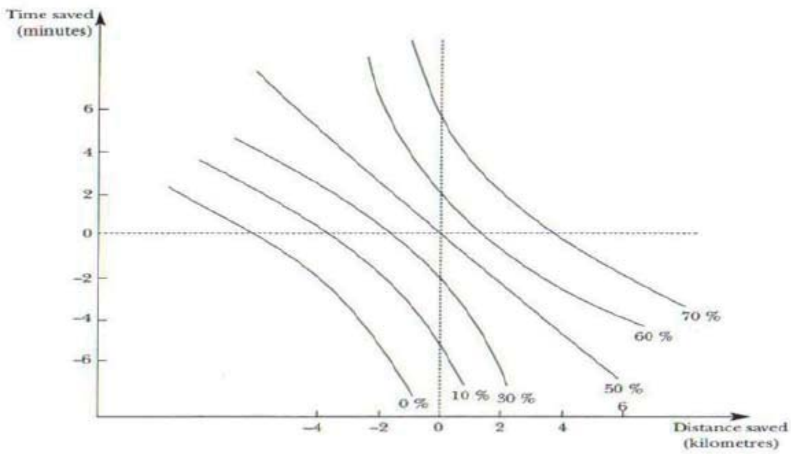
➔ How to assign these flows to existing infrastructure?

Assignment process: **two phases**

- Determination of the alternative routes
- Assignment of the movements to routes

2 methods to assign traffic to available infrastructure:

1) *All-or-nothing method* involves choosing one single route for the entire traffic flow. May be combined with feedback.
    - E.g. the shortest or cheapest route
2) *Diversion curve method*: share of various routes is influenced in a gradual, continuous manner by differences in terms of time, distance, cost, etc.



- → Function of travel time and distance saved compared to an alternative route.
- → All points on a 60%-curve are more favourable than those on a 50%-curve.
- → Feedback can be used to calculate the traffic density and ensuing speed, if needed: reassign until a stable equilibrium is reached.

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3. The microeconomic approach to transport-choice behaviour

Units of observation and analysis: individuals or households (rather than zones).

- → Takes account of who actually makes the transport decision. Therefore they can respond more efficiently to transport patterns.
- → Models based on individual choice, eg: discrete choice models
- → Models based on utility maximisation of each individual

Important data problem:

- Most observed characteristics of the decision-maker (car ownership, income, etc.) are available, while other data (social status, health, etc.) is unknown.
- Most characteristics of the alternatives (travel times, costs, etc.) will be known, while others (reliability, degree of comfort) may be unknown.

Basic model (utility model):

$U_{jsn} = V_{jsn} + \varepsilon_{jsn}$

with

U_{jsn} the total relative utility of person n when choosing option j in situation s

V_{jsn} the observable utility which is a function of one or more explanatory variables

ε_{jsn} the random utility component (unobservable uitility due to missing variables, coincidental events, measuring mistakes...)

Example: choice of car or public transport

Assumption: choice only depends on cost and time

$U_{car} = \beta_1 (time_{car}) + \beta_2 (cost_{car}) + \varepsilon_i$

$U_{PT} = \beta_1 (time_{PT}) + \beta_2 (cost_{PT}) + \varepsilon_i$

Choice of car in a certain situation if:

$U_{i1} (car) \geq U_{i2} (PT)$

$\Leftrightarrow \; V_{i1} + \varepsilon_{i1} \geq V_{i2} + \varepsilon_{i2}$

Assumption concerning the distribution of the error term (Ɛ):

- If the errors are distributed in accordance with the extreme value distribution, then one arrives at t**he multinomial logit model**.
- If the errors are distributed normally, one arrives at a **multinomial probit model.**

The multinomial logit model:
Allows easy computation and interpretation

- Choice probability:

$$P(j) = \frac{e^{V_j}}{\sum e^{V_i}}$$

➔ In our example:

$$P(car) = \frac{e^{\beta_1(time_{car})+\beta_2\,(cost_{car})}}{e^{\beta_1(time_{car})+\beta_2(cost_{car})} + e^{\beta_1(time_{PT})+\beta_2(time_{PT})}}$$

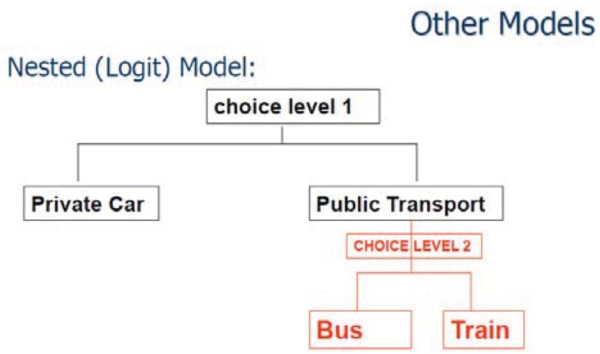
- How to estimate the ß's?
  - o Maximum Likelihood Estimator: estimator that calculates the parameters for which the observed choices is most likely to have occurred.
  - o Also called: Log-likelihood estimation as log-likelihood is maximized

$$maxLL(\beta) = \sum_{n=1}^{N}\sum_{s=1}^{S}\sum_{j=1}^{J} y_{nsj} log P_{nsj}$$

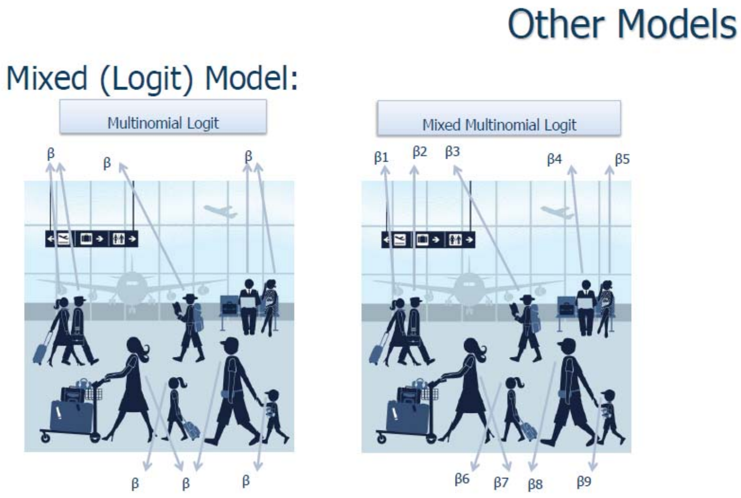
$$y_{nsj} = 1 \text{ if alternative j is chosen}$$
$$y_{nsj} = 0 \text{ if alternative j is not chosen}$$

Other models:

Best-known generalisation of a multinomial logit model:



Mixed multinomial logit model:



Joint-choice models (discrete-continuous models):
A discrete choice (destination) is combined with an additional discrete or continuous choice (the quantity shipped).

There have been many advances in model types during the last years due to the increasing power of computers.
Probit: in the past more difficult to calculate but now there are no problems anymore.

<u>Data collection</u>

Revealed preference data:

- Data from observed choices in the market
- Advantage: real choices
- Some disadvantages:
  - Sometimes not all possible alternatives are known
  - Hypothetical choices cannot be tested
  - How people “perceive” characteristics of choice cannot be included
  - Data collection (a lot of observations are needed; often only one choice per person is registered)

Stated preference data:

- Data from interviews/experiments
- Advantages:
  - New alternatives can be included
  - One person can make numerous choices
- Some disadvantages:
  - Hypothetical choice situations
  - Choices and characteristics of alternatives have to be defined in advance

4. The activity-based approach

- Analysis of transport behaviour in the context of consecutive activities of an individual during a certain period at varying locations
    - E.g. study of daily transport activities
- Emphasis on underlying derived nature of transport
- More realistic but also more complex
- Need to understand the relationship between exogenous socio-demographics & activity travel environment characteristics on the one hand and revealed activity-travel pattern on the other.
- Problem: data requirement
    - E.g. insights into travel and activity pattern

New generation of regional travel demand models is characterised by 3 features:

1) Activity-based approach: travel derived from daily activities and patterns by the individuals
2) Tour-based structure of travel
3) Micro-simulation modelling techniques: convert activity and travel-related choices into a series of discrete decisions

5. An empirical application: freight transport in Europe

An overview of the most significant empirical results of an econometric model of demand for freight transport in Europe:

➔ Purpose: to put forward a possible method and to show how empirical results can be interpreted economically and used for making transport prognoses.

11. Transport supply

1. Introduction

Supply = f (product price, prices of alternative goods, production factor prices, technology, etc.)
Two methods of **cost analysis**:

- **Statistical method**: uses time-series data as a basis for defining a function that corresponds maximally to reality.
- **Engineering method**: development of analytical models on the basis of production functions that are dissected into successive operations so that we can use accounting data to calculate a unit cost per operation.

The choice depends on the data available:
If the causal relationship is clear and it's possible to conduct experiments → **Engineering method**
If the database consists of historical observations → **Statistical method**

2. Output, inputs, heterogeneity and calculation

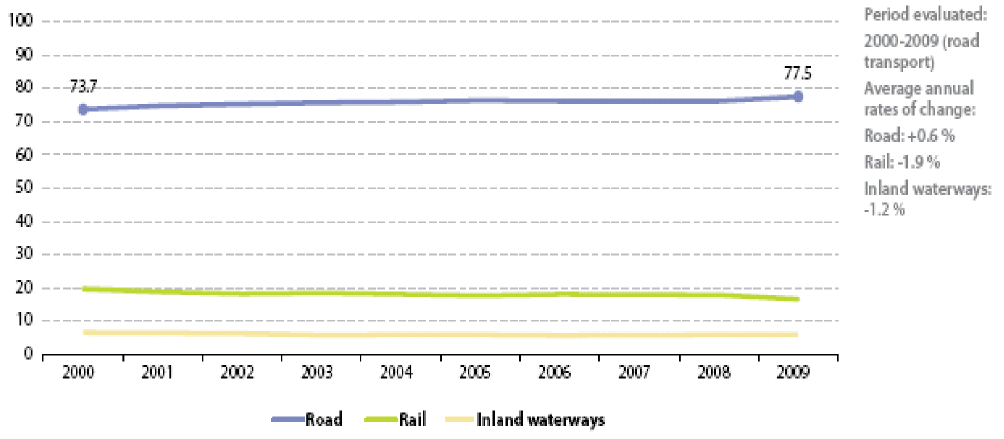
2.1. The output unit in transport

2 measurements of output:

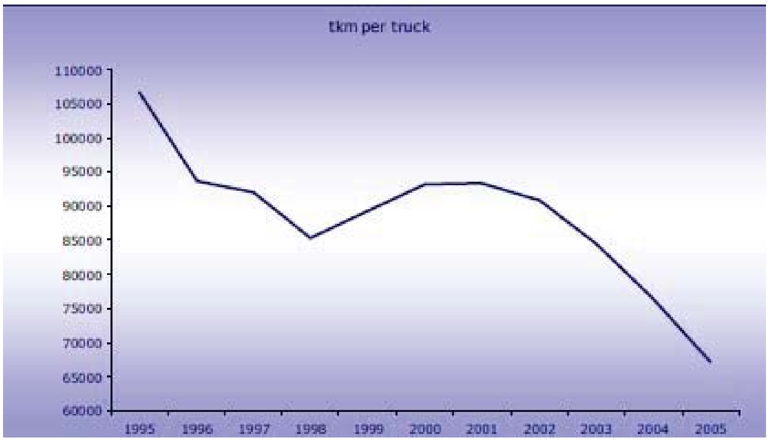
- In passenger transport:
  - Number of passengers
  - Passenger-kilometres
- In freight transport:
  - Tonnage
  - Number of tonne-kilometres

There is **own-account transport** which is freight transport for personal use. Eg: a big company that provides its own transport for produced goods ⇔ **Professional transport** = transport companies.

Sometimes they **aggregate** the output indicators. However this only works for homogenous units and two movements are never identical so the aggregation is useless. For example, two shipments carried out by the same mode, on the same origin-destination relation may differ from one another because they occurred at different times during the day, so weather conditions may be different. Therefore the **mode split** is very important.

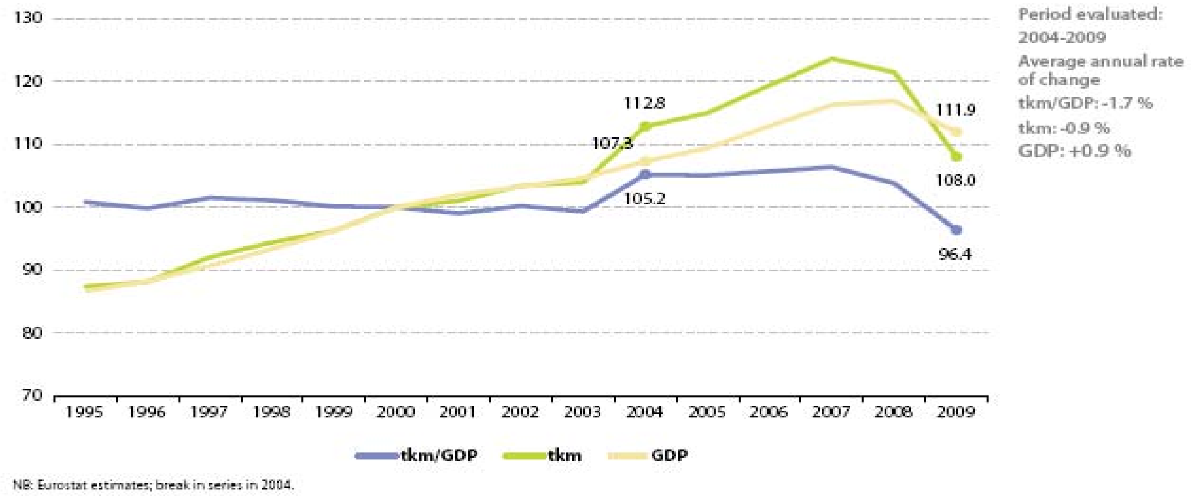


Output per vehicle: It's decreasing. How can we increase the ton per car? Pricing measures are the most efficient and have almost no negative impact. If you want more, you will pay more.

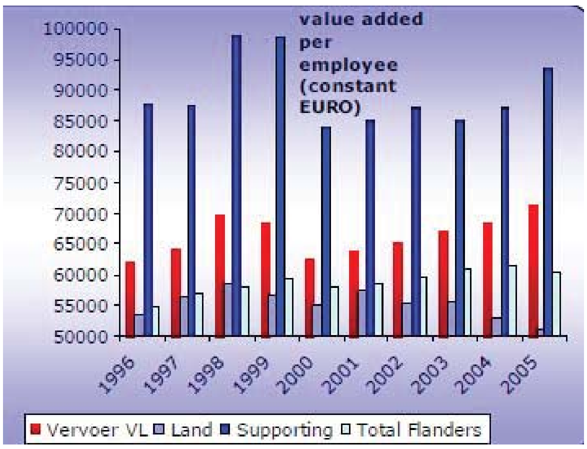


Link with the GDP (graph)

Time line: Strong relation between the economy and transport. Free time is the least affected by the crisis because the people still go on holidays, whereas business men may travel less during the crisis. However there is not always a strong correlation between economy and transport.



Value added: The evolution of value added of transport in different domains. It contains all the activities that are included in the process of transportation (logistic, packaging, etc.).



2.2 Inputs in the production of transport

No output, without input

2 inputs: labour and capital

1. **Labour**; number of staff and number of hours worked. The physical units of labour that one aggregates must be as homogenous as possible. For example, a simple measure that is based on the number of employees does not take into account the number of hours worked or the quality of the work performed.

2. **Capital**; number of vehicles, infrastructure (differs from one mode of transport to another; inland navigation and road transport do not own their infrastructure, whereas railway and pipeline transport do), leasing and buying.
   - ➔ The factor capital gives us measurement problems at aggregate level: the capital service provided is important, not capital stock! Capital services are hard to measure because they are only partly hired, most items are purchased. Therefore they take capital stock as a proxy variable, since changes in the level of stock will mostly reflect changes in the level of services employed.

2.3 The heterogeneity of transportation supply

The heterogeneity is reflected in the:

- Number of available modes (transportation techniques)
- Various types of transport within a single mode
- Companies that supply transport vehicles

Heterogeneity is related to the organisation of the transport market, which varies from mode to mode, the capital that is required and the different submarkets. Various factors of heterogeneity:

- Transport costs = cost of the actual transport + additional costs such as loading, packaging, insurance, etc. → Principle of minimisation of the costs.
- Goods package: Transport requirements are different, eg: sand and gravel (low value) will be transported in bulk whereas other products such as food and flowers have to be shipped fast so they require road and air transportation.

General **quality requirements** crucial to the supply structure: size of the vehicle, speed, accessibility, variability in capacity, flexibility and special characteristics regarding packaging and risk of damage. Each mode offers a different combination of these quality requirements and competes in terms of quality and price. Consequently, the supply within a single method will become much more specialised.

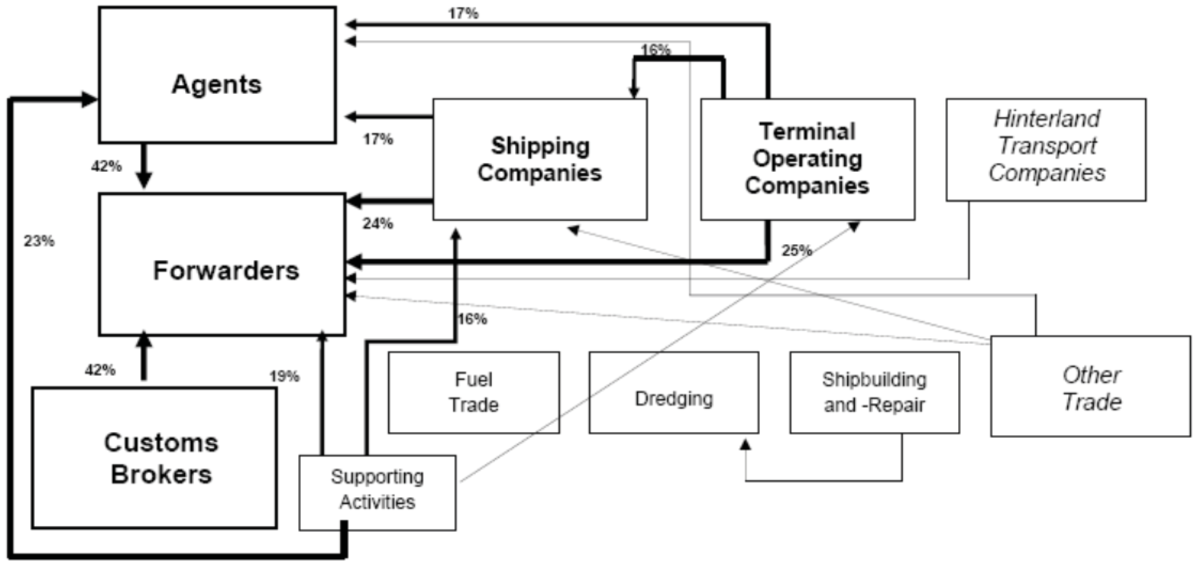
Heterogeneity is also evident in the **organisation and structure** of the supply side:

- **Irregular** transport services: an operator keeps a fleet of vehicles in reserve so that it could be deployed when there is demand. There is no operating schedule as orders are obtained on an irregular basis, eg: private hauliers.
- **Regular** transport services: they keep their fleet of vehicles on the move according to a fixed schedule. Orders are accepted if they can be fitted into this schedule, eg: public transport.

Also:

- Globalisation of the production process (longer distances)
- Growing competition in international trade (impact on value added)
- Logistic chains: increasing complexity
- Interplay of many actors

➔ Are an issue for the heterogeneity of the supply



Supporting activities = logistic activities = very important!

"The big parts can sometimes not be changed, so the modest parts are also important, especially for changes."
E.g. staff of an airport is a very important factor
→ The overall performance is determined by the weak link of the chain.

Trends:

- Hub concentration: increasing vessel size (hub = a switch/part in a chain) eg: an increase in capacity from 4.000 to 15.000 containers leads to bigger ports, better infrastructure, etc.
- Dedicated terminals (special terminals) = a personal terminal for ships, to load and loss faster.
- Stress on port productivity
- Government budget restrictions = lots of investments are needed but there is not enough money so private operators are needed.
- Privatisation = due to budget restrictions of the government.

2.4 Cost allocation in joint production processes.

Which costs of the combined production process need to be allocated to separate products? The differentiation concerns time and place.

Temporal and spatial heterogeneity = **economic heterogeneity**: implies that the elasticity of substitution between technically homogeneous transport services sometimes approximates to zero.