Introduction to Transportation Planning

Demand Model, Four Step Demand Model

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Demand Model

Demand Model

Demand

Number of trips q that travellers demand to make between origin o and destination d.

$$q_{od} \tag{1}$$

Demand model

Estimate the demand

$$q_{od} = f(o, d, X_o, X_d, c_{od}, \dots) \tag{2}$$

to determine expected/mean/average demand expressed as a function of known variables X_o and parameters $\boldsymbol{\beta}$ estimated to match the observed demand.

Travel survey

Travel survey

Demand model input

Personal Travel diary

Chain of trips executed by an individual during the day

1. activity 1: type, location, start time
2. trip 1: type, location, start time, mode, route
3. activity 2: type, location, start time
4. trip 2: type, location, start time, mode, route
5. activity 3: type, location, start time

Travel survey

reason

Survey

We cannot know diaries of all individuals (cost, time, organization, privacy, ...).
We need to sample the population.

Sampling and extrapolation

The sample is representative if the key statistics of the population are the same as for the sample.

Travel survey

sample sizes

Małopolska 2013

12 000 individuals

Kraków 2014

18 000 individuals

Warszawa 2016

24 000 individuals

Wrocław 2018

300 000 individuals - GSM traces

Travel survey

methods

Paper

fill the form

Tablet

fill the form online

Census

officially fill the form

App based

install the tracing (GPS) App on your cell phone

BigData

record anonimized traces - GSM, bluetooth, instargam, etc.

Travel survey

results

Survey results

1. average number of trips (per purpose, per person group, per zone)
2. temporal distribution of trips
3. trip distance profile/ destination choices
4. mode shares/mode choices
5. route choices
6. vehicle occupancy

Four step demand model

FSM

Survey results

Reproduce (model) the behaviour read (understood) from survey.
Model shall be calibrated, i.e. modelled values shall match the observed (emprical ones)

Four step demand model

Four step demand model

Intro

- analitical
- built on and to reproduce the survey
- interpretable
- algorithmic
- probabilistic (expected demand)
- trip based (not chains)

Four step model

FSM

Four step demand model

1. Trip Generation
2. * Time Choice
3. Destination Choice
4. Mode Choice
5. Path/Route Choice

Four step model

FSM

1	**do?/how often?**	zone production /attraction	q_o, q_d	**Trip Generation**
2	**where?**	od matrix	q_{od}	**Destination Choice**
3	**how?**	mode shares	p_{od}	**Mode Choice**
4	**which way?**	network loads	q_a	**Route/Path Choice**

Trip Generation

Trip Generation

presented on the blackboard at the lecture

Trip Distribution - Gravity

Destination choice

Problem

We know where trips originate (production) and end (attraction)
We do not know where the originating trips finish

Choice

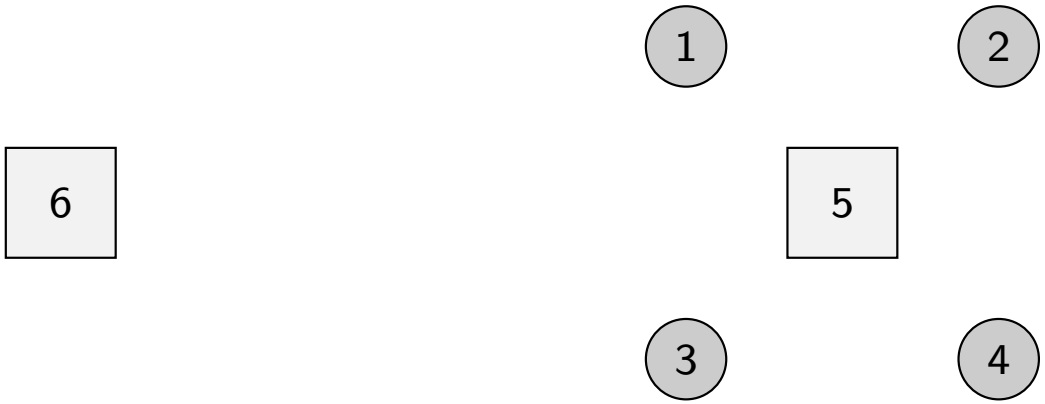
Traveller:

- located in a given place (origin) o
- has travel demand to be supplied at some destination
- selects (chooses) a place where he supplies his demand

Destination choice

Example 1

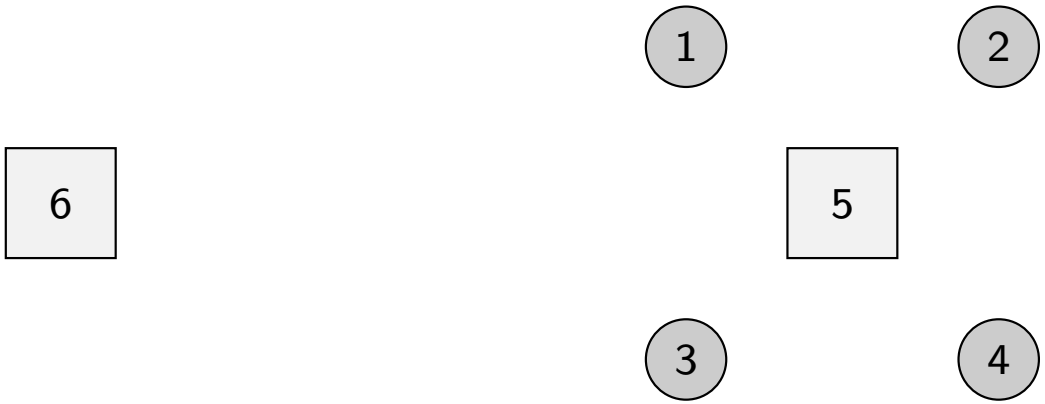
Four travel assignment zones (1-4) generate total of 1000 trips that may be supplied at two destinations: 5 (closer) and 6 (further).



o, d	P	A
1	100	-
2	200	-
3	300	-
4	400	-
5	-	200
6	-	800

Destination choice

Example 1



o, d	P	A
1	100	-
2	200	-
3	300	-
4	400	-
5	-	200
6	-	800

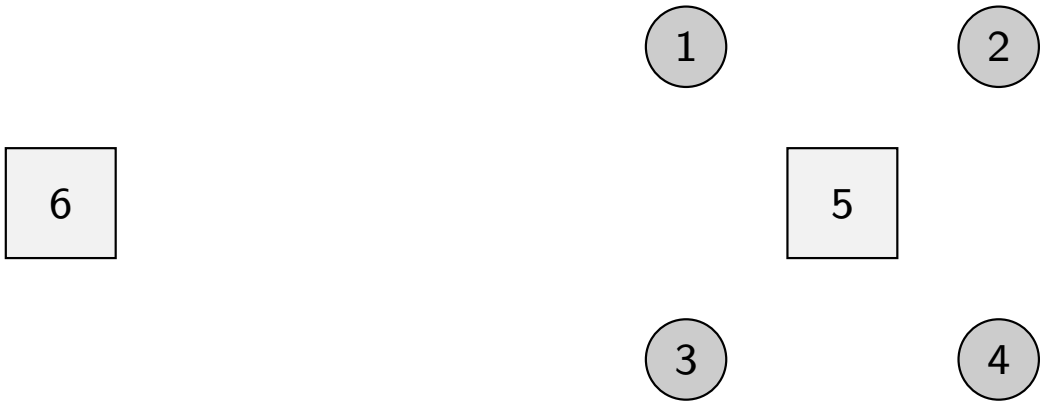
Non systematic (non-obligatory) trips with high trip cost impedance

e.g. shopping to the closest supermarket (Biedronka)

$o, d,$	5	6
1	90	10
2	200	0
3	270	30
4	400	0

Destination choice

Example 2



o, d	P	A
1	100	-
2	200	-
3	300	-
4	400	-
5	-	200
6	-	800

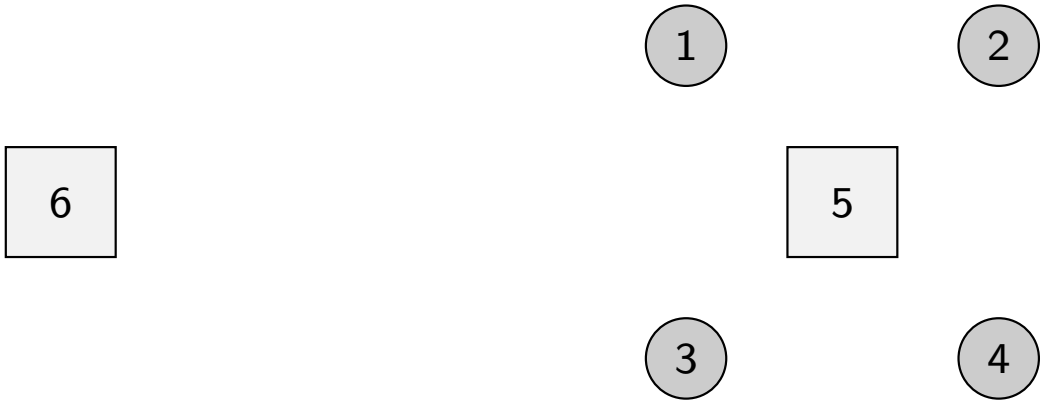
Non systematic (non-obligatory) trips with highly varying attractivenses

e.g. to a restaurant of various attractiveness (reflected in attraction)

$o, d,$	5	6
1	20	80
2	40	160
3	60	240
4	80	320

Destination choice

Example 3



o, d	P	A
1	100	-
2	200	-
3	300	-
4	400	-
5	-	200
6	-	800

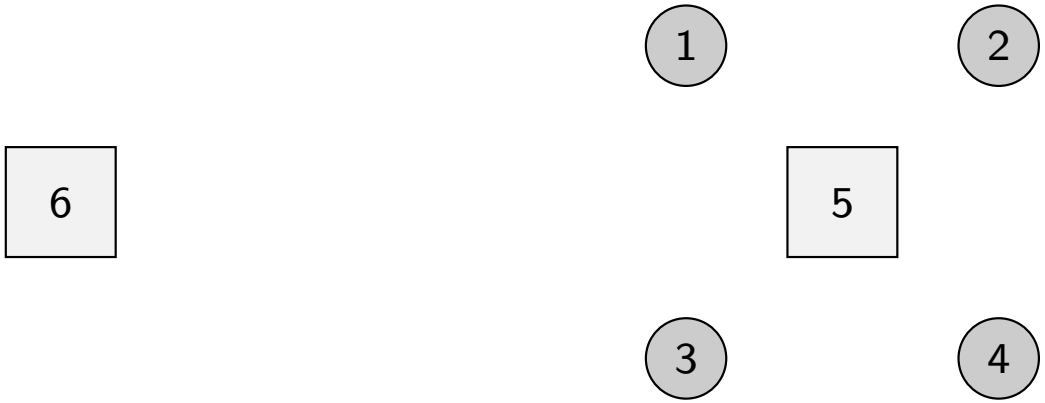
Systematic (obligatory) trips with limited attraction capacity

e.g. Home-Work with a fixed number of work-places at destination

$o, d,$	5	6
1	20	80
2	40	160
3	60	240
4	80	320

Destination choice

Example 3



o, d	P	A
1	100	-
2	200	-
3	300	-
4	400	-
5	-	200 -> 800
6	-	800 -> 200

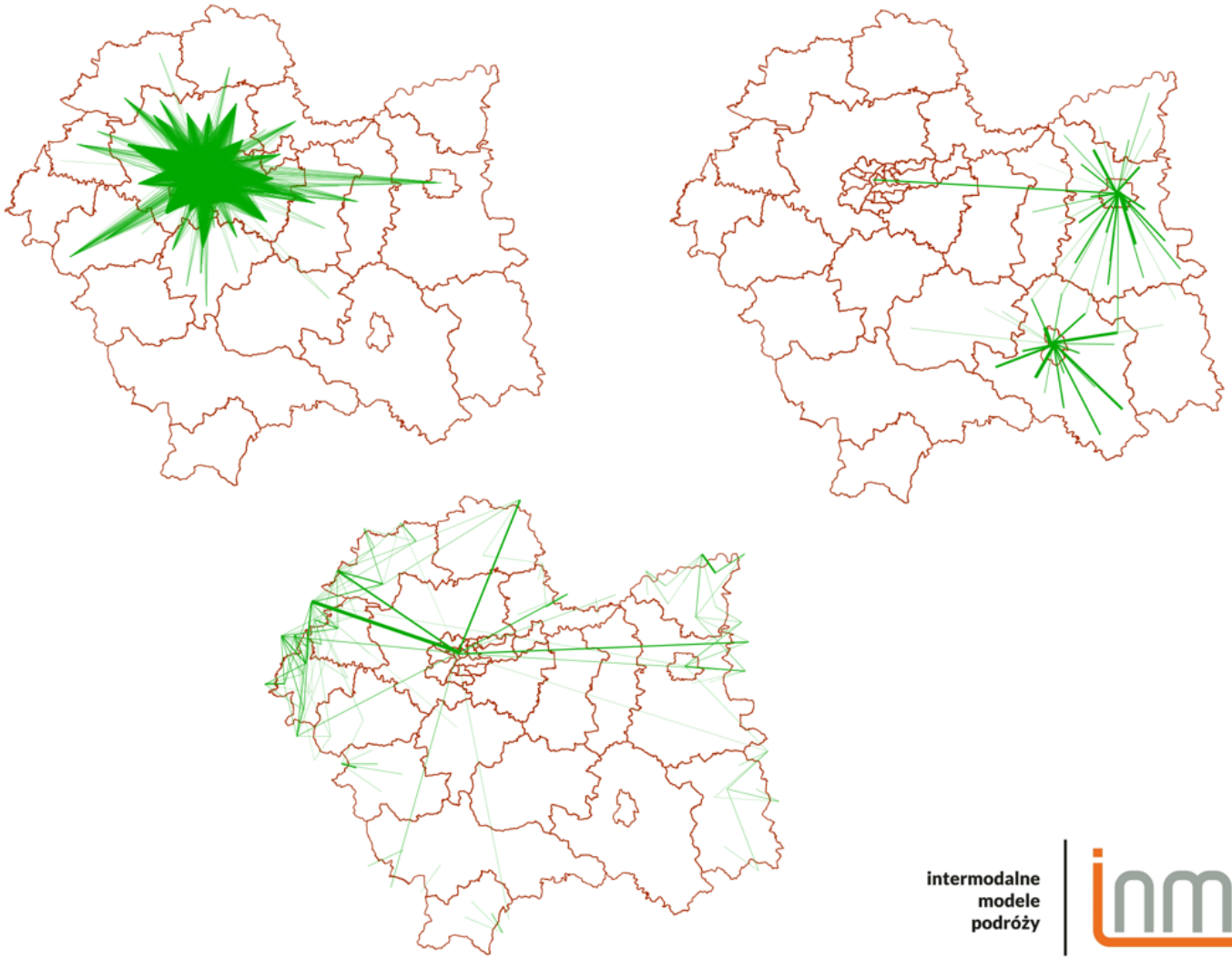
Systematic (obligatory) trips where supply eventually matched the demand

e.g. preschool locations moving closer to children

$o, d,$	5	6
1	80	20
2	1600	40
3	240	60
4	320	80

Actual trip distribtuion structure

Reflected in the GSM traces



intermodalne modele podróży

Gravity model

Formalization

Proportional model

If we assume that the only factor in trip choices is attractivity, we get:

$$Q_{od} = f(P_o, A_d) = \frac{P_o}{\sum_{o \in Z} P} A_d = P_o \frac{A_d}{\sum_{d \in Z} A}$$

we may read it as:
1. distribute production proportionally to attraction

$$Q_{od} = P_o \frac{A_d}{\sum_{d \in Z} A}$$

2. distribute attraction proportionally to production

$$Q_{od} = A_d \frac{P_o}{\sum_{o \in Z} P}$$

one of production/attraction needs to be in absolute values (trips) second one may be just proportionality factor

Gravity model

Formalization

Problem with proportional model: no distance included

Gravity model

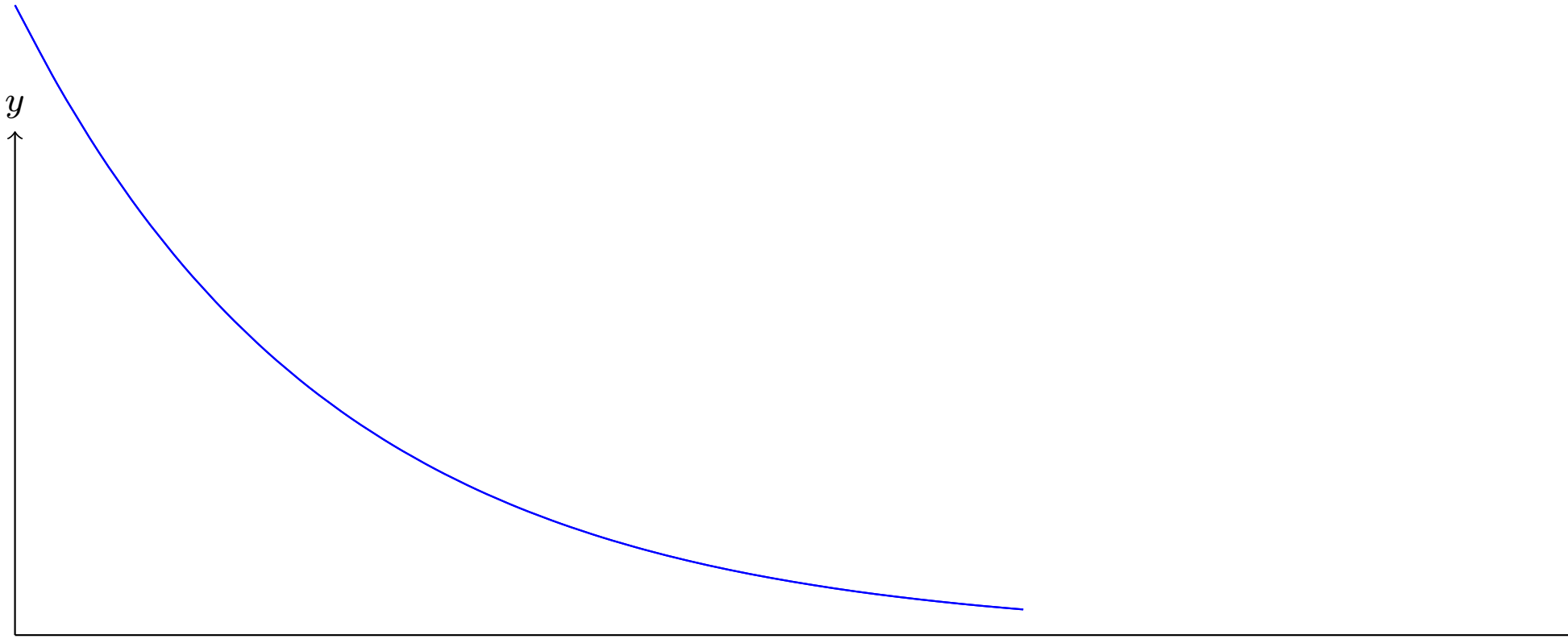
If in proportional model we include distance function (cost $c_o d$), we get:

$$Q_{od} = f(P_o, A_d, c_{od}) = f(c_o d) \frac{P_o}{\sum_{o \in Z} P} A_d$$

with two specific functions to apply:

Gravity model

Cost functions



Summary

Thanks for attention

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