Institute for Transport Studies
FACULTY OF ENVIRONMENT

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Modelling production-consumption flows of goods in Europe: the trade model within Transtools3

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Position of the Transtools3 freight model

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Transtools1 and 2 were EU-wide models for passenger and freight transport for the European Commission DG MOVE

A consortium led by DTU is now developing a new model for passenger and freight transport at the European scale for DG MOVE

These are all transport-network-based models (heavy; relatively detailed networks)

The Transtools3 freight transport model follows a different approach than before

Transtools3 zones are NUTS3 or subdivisions of those and the commodity classification is NST/R-1

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Structure of the overall Transtools3 freight transport model (follows ADA)

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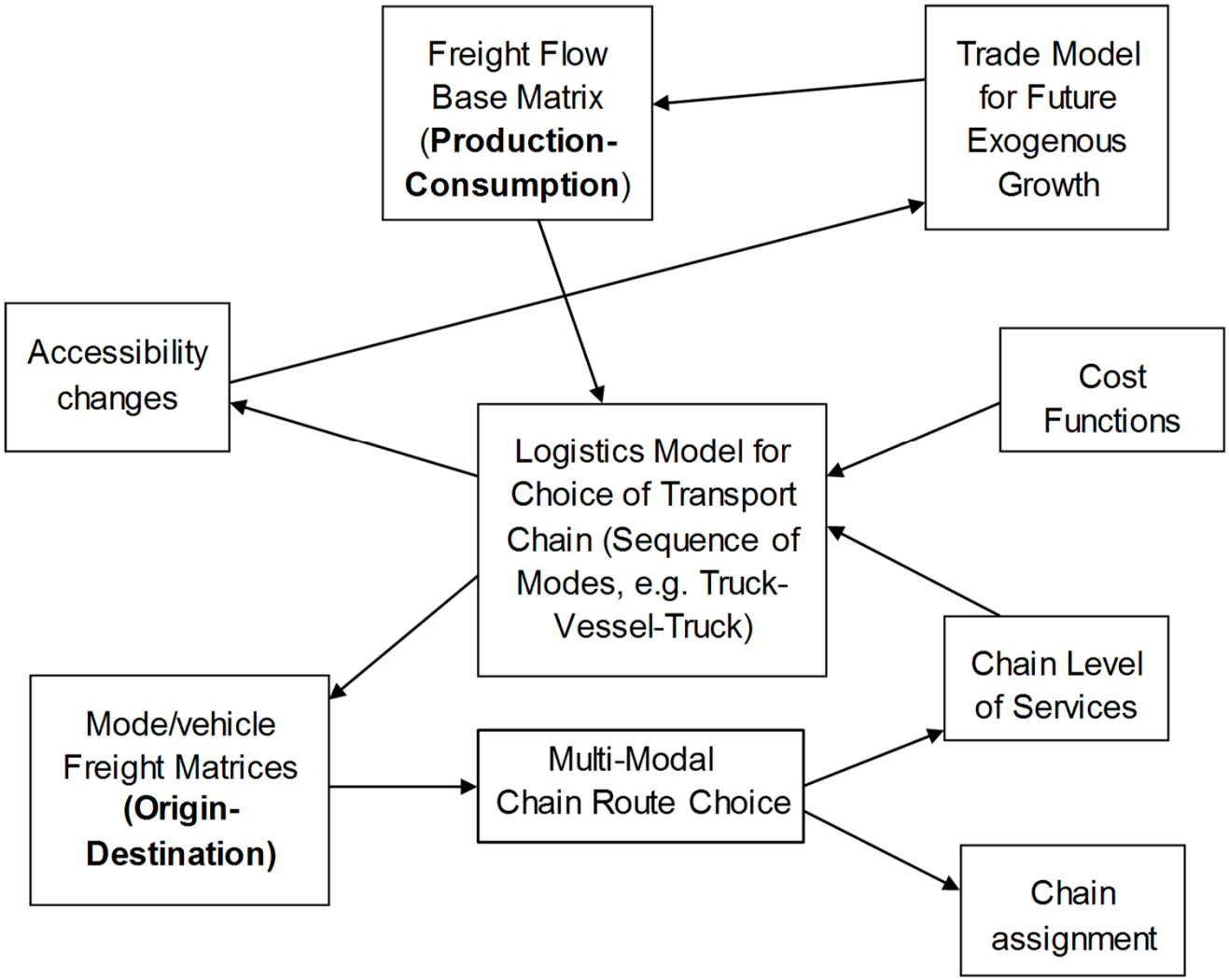

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The trade model within Transtools3

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- Focus in Transtools 3 was on estimating transport chain choice models on disaggregate data
- We tried to keep trade model relatively simple and to base it on the limited amount of available data
  - No SCGE or I/O model, but a gravity-based trade model
- But have to tackle a number of issues:
  - Relative costs
  - Many trade flows between countries are zero

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From my lecture notes: freight transport distribution models

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Type of model	Advantages	Disadvantages
Gravity	Limited data requirements Some policy effects through transport cost function	Limited scope for including explanatory factors and policy effects Limited number of calibration parameters (which rules out a good fit to the data)
Input-output	Link to the economy Can give land use Interactions Policy effects if elastic Coefficients	Need input-output table, preferably multi-regional Restrictive assumptions if fixed coefficients Need conversion from values to tonnes
SCGE	Link to the economy Based on economic theory Can give land use (and other) interactions Can give policy effects	Needs as least as much data as input-output Includes many assumptions (e.g. equilibrium, cost functions) Needs conversion from values to tonnes Still in (academic) development phase

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Gravity for trade: relative cost

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- Modern theoretical literature on gravity-based trade models:
  - trade between two countries is not simply determined by the absolute trade costs between the two countries, but by the relative trade cost (=the trade cost of country *i* from importer *j* relative to its overall trade cost for all the countries from which it imports).
- In an empirical gravity model, this can be taken into account by adding multilateral resistance terms.
- However a simpler method is to use importer or exporter fixed effects
  - But then GDP of country i or j has no impact anymore
- Or random effects model

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Fixed effects model

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Model with fixed effects at the level of destination countries *j* :

$$\ln\left(x_{ij}\right) = \gamma_j + \sum_{k=1}^{K_D} \alpha_k \cdot \ln\left(d_{ij(k)}\right) + \beta_1 \cdot \ln\left(gdp_i\right) + \beta_3 \cdot \ln\left(\frac{gdp_i}{pop_i}\right) + \ldots$$

$$\ldots + \beta_5 \cdot euefta_{ij} + \beta_6 \cdot euro_{ij} + \beta_7 \cdot neig_{ij} + \beta_8 \cdot lang_{ij} + \varepsilon_{ij}$$

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Random effects model

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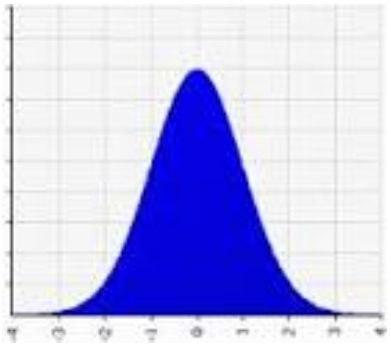
Model with random effects:

$$\ln\left(x_{ij}\right) = \sum_{k=1}^{K_D} \alpha_k \cdot \ln\left(d_{ij(k)}\right) + \beta_1 \cdot \ln\left(gdp_i\right) + \beta_2 \cdot \ln\left(gdp_j\right) + \beta_3 \cdot \ln\left(\frac{gdp_i}{pop_i}\right) + \beta_4 \cdot \ln\left(\frac{gdp_j}{pop_j}\right) + \ldots$$

$$\ldots + \beta_5 \cdot euefta_{ij} + \beta_6 \cdot euro_{ij} + \beta_7 \cdot neig_{ij} + \beta_8 \cdot lang_{ij} + \vartheta_j + \varepsilon_{ij}$$



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Countries with zero trade

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- In the data many country-country flows (by NST/R 1) are zero

- Actually two decisions:
  - Whether to export to a country at all
  - How much trade if trade

- Heckman model (two steps):
  - Discrete participation (selection) equation
  - Continuous demand equation

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Heckman model

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The demand equation is:

$$\ln\left(x_{ij}\right)=\alpha_1\cdot\ln\left(d_{ij}\right)+\beta_1\cdot\ln\left(gdp_i\right)+\beta_2\cdot\ln\left(gdp_j\right)+\beta_3\cdot\ln\left(\frac{gdp_i}{pop_i}\right)+\beta_4\cdot\ln\left(\frac{gdp_j}{pop_j}\right)+\varepsilon_{ij}$$

The selection equation is:

$$s_{ij}=\gamma_1\cdot\ln\left(d_{ij}\right)+\delta_1\cdot\ln\left(gdp_i\right)+\delta_2\cdot\ln\left(gdp_j\right)+\delta_3\cdot\ln\left(\frac{gdp_i}{pop_i}\right)+\delta_4\cdot\ln\left(\frac{gdp_j}{pop_j}\right)+\delta_5\cdot lang_{ij}+\xi_{ij}$$

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Data for estimation

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Dependent variable:

- PC matrices in tonnes by NUTS3 zones for 2010 from ETISplus project ('synthetic' or 'modelled')
- Aggregation to country level ('observed')
  - We tried both in estimation, but prefer latter, since this is based on observed data, not a synthetic split.

Independent variables:

- GDP and population from World Bank -> GDP and GDP/capita
- Crow-fly distance (will be replaced by generalised costs) -> distance splines
- Dummy variables on barriers to trade, trade blocks, etc.:
  - EU or EFTA member
  - Euro as currency
  - Neighbours
  - Same language

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Estimations

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- By NST/R-1 commodity: 10 submodels
- For NUTS3 zones and for countries
- Linear and double logarithmic
- Standard absolute costs, fixed effects (2x), random effects
- With and without participation equation (Heckman)

We prefer:

Random effects model estimated on country data:

- Observed data
- Account for relative costs
- Full effect of GDP changes
- Deleting zero flows is acceptable (Linders and de Groot, 2006; and our data)

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Random effects model estimation results for agricultural products (n=6388)

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variable	coefficient	t-ratio
Distance 100-300 km	1.327	0.76
Distance 300-500 km	-2.881	-2.59
Distance 500-1000 km	-2.025	-4.62
Distance 1000-2000 km	-2.200	-8.90
Distance >2000 km	-0.339	-4.64
Ln(origin GDP)	0.824	39.12
Ln(destination GDP)	0.598	12.43
Ln(origin GDP/cap)	-0.274	-8.37
Ln(destination GDP/cap)	-0.111	-1.64
Both member EU/EFTA	0.743	5.07
Both Euro	0.596	3.36
Neighbours	1.743	7.03
Same language	0.742	5.64
Constant	-9.103	-4.88

GDP elasticities of trade flows in tonnes from random effects model

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Product type	
0 Agricultural prod. & live animals	1.04
1 Foodstuffs and animal fodder	1.21
2 Solid mineral fuels	0.28
3 Petroleum products	1.13
4 Ores and metal waste	0.73
5 Metal products	1.22
6 Crude and manufactured minerals	0.96
7 Fertilisers	-0.42
8 Chemicals	2.04
9 Machinery	1.87

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Implementation of trade model within Transtools3

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- In the application of the trade model, we only use the GDP and GDP per capita elasticities
  - We assume that distances and the dummies do not change
  - The model however can also be used however to calculate the trade effects of changes in the composition of the European Union, such as Brexit, or the EURO zone
- The trade model then reads in the 2010 base PC matrix (from ETIS+) and income and population changes per zone.

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Conclusions and further work

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- In Transtools3, future year PC matrices from the trade model are combined with the disaggregate transport chain choice model.
- We estimated fixed effects, random effects and Heckman models on zonal and on country data
- We prefer the random effects model on country data
- This uses distance between countries
- We are working on replacing distance by a logsum variable from the transport chain choice model
  - so that there will also be an influence of transport costs on the pattern of PC flows

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