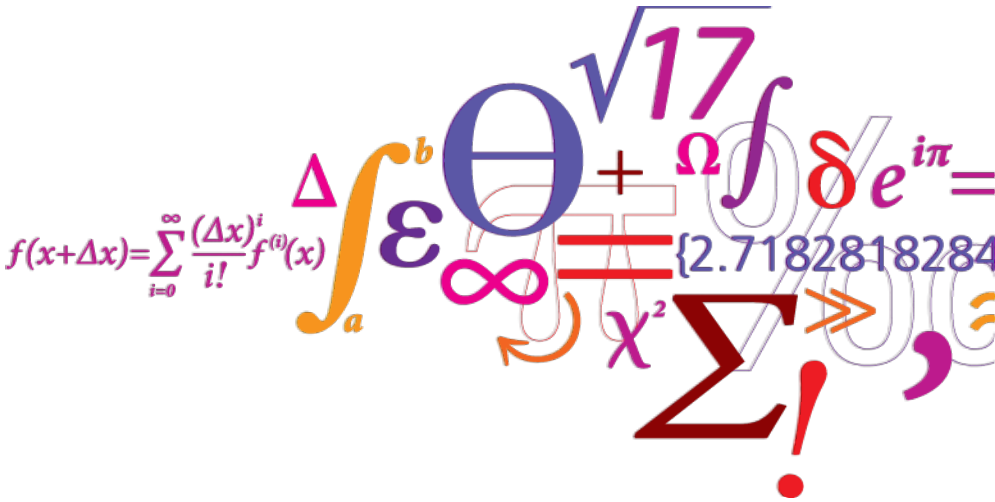
A model for freight transport chain choice in Europe

Anders Fjendbo Jensen, Mikkel Thorhauge, Gerard de Jong, Jeppe Rich, Thijs Dekker, Daniel Johnson, Manuel Ojeda Cabral, John Bates, Otto Anker Nielsen

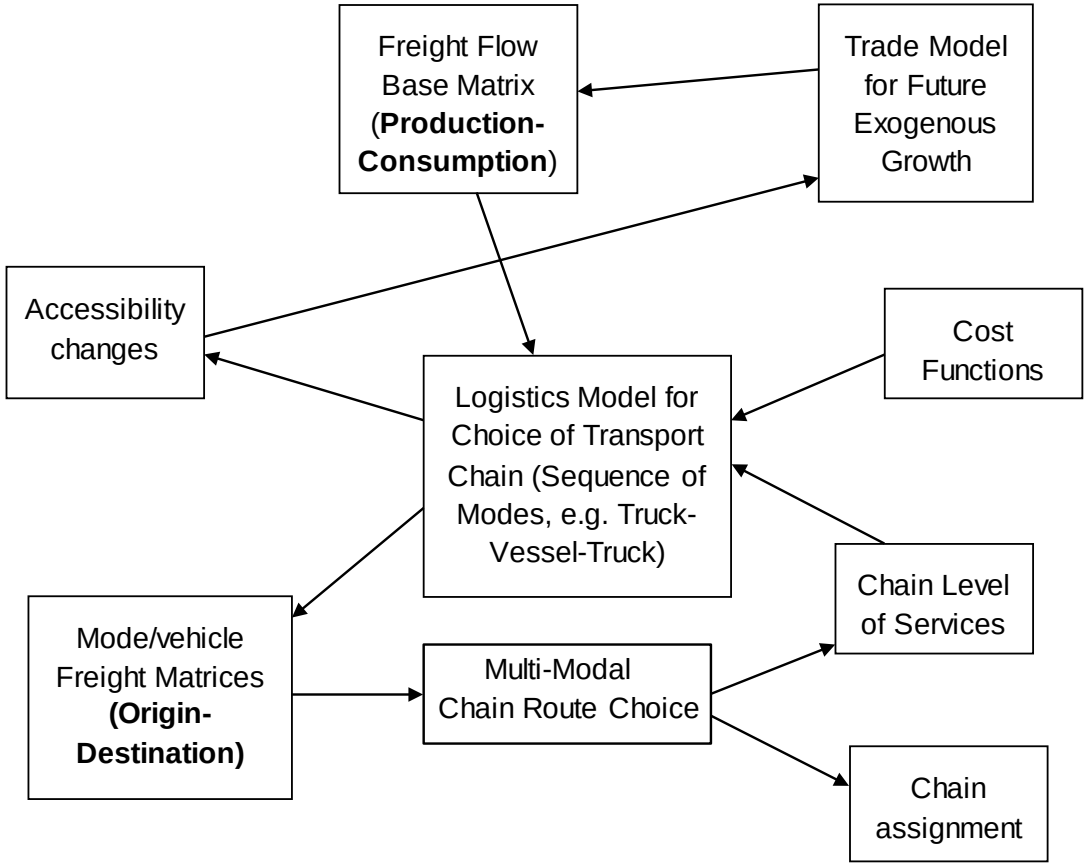


DTU Management Engineering
Department of Management Engineering

Position of the Transtools3 freight model

- 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.
- Commodity classification is NSTR-1

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



Position of the Transtools3 transport chain choice model

- Most modal split models in freight explain main mode choice
  - We explain choice of transport chain (sequence of modes), e.g. road and rail
- Most mode choice models concern origin-destination (OD) trips
  - We explain the chains for production-consumption (PC) flows
- Most modal split models in freight transport are based on aggregate data
  - We estimate the model on disaggregate (shipment level) data
- Most modal split models use a linear cost function
  - We test various linear and non-linear cost specifications.

Data source 1: Swedish commodity flow survey 2009

- Shippers in Sweden were interviewed by Statistics Sweden about their incoming and outgoing shipments (domestic and international)
- Records are individual shipments, with information on P and C location, mode sequence, commodity type, weight and value
- We only used outgoing shipments and removed OD flows (e.g. forest products) and air transport
- We recoded the P and C zones into Transtools3 zones (in several steps)
- We added time, distance and transport cost information from the networks for these zones (assignment determines transshipment locations and vehicle types)
- Final estimation sample has 1.6 mln shipments.

Data source 2: the French ECHO survey (2004)

- Almost 3,000 shippers in France were interviewed by IFSTTAR/ISL about their outgoing shipments (domestic and international)
- Then also 27,000 carriers and receivers were interviewed for these shipments, to reconstitute around 10,000 complete chains
- Records are individual shipments, with information on P and C location, mode sequence, commodity type, weight and value, transshipment locations, annual volume
- We recoded the P and C zones into Transtools3 zones (in several steps)
- We added time, distance and transport cost information from the networks for these zones (assignment determines transshipment locations and vehicle types)
- Final estimation sample has about 8,000 shipments.

Alternatives in transport chain choice model; freight load type is containers and general cargo

1. Road direct (includes road-ferry combinations) – container
2. Road direct (includes road-ferry combinations) – non-container
3. Road with roll on/roll off (RORO) – container
4. Road with RORO – non-container
5. Rail – container
6. Rail – non-container
7. Inland waterways (IWW)
8. Rail and IWW
9. Sea
10. Rail and sea
11. IWW and sea
12. Rail and IWW and sea.

- Road can be part of all chains
- RORO are re-classified road transport observations, where RORO is cheaper.

Alternatives in transport chain choice model; freight load type is dry bulk and liquid bulk

1. Road direct (includes road-ferry combinations) – container
2. Road direct (includes road-ferry combinations) – non-container
3. Road with roll on/roll off (RORO) – container
4. Road with RORO – non-container
5. Rail – container
6. Rail – non-container
7. Inland waterways (IWW)
8. Rail and IWW
9. Sea
10. Rail and sea
11. IWW and sea
12. Rail and IWW and sea.

- Road can be part of all chains
- RORO are re-classified road transport observations, where RORO is cheaper.

Data overview

Alternatives			CFS			Echo		
Chain	Alternative ID	Chain ID	Model 1 Dry Bulk	Model 2 Liquid Bulk	Model 3 Gen. Cargo and Cont.	Model 1 Dry Bulk	Model 2 Liquid Bulk	Model 3 Gen. Cargo and Cont.
Road – container	1	1	-	-	14,200	889	77	227
Road – non-container	2	1	16,440	74,636	1,237,099	889	77	5,819
RORO – container	3	5	-	-	966	-	-	-
RORO – non-container	4	5	225	136	31,422	10	1	-
Rail – container	5	2	-	-	425	-	-	10
Rail – non-container	6	2	166	106	26,823	100	58	176
IWW	7	3	-	-	-	25	4	-
Rail and IWW	8	6	-	-	-	-	-	-
Sea	9	4	220	174	201,043	35	4	350
Rail and sea	10	7	2	0	26	-	-	1
IWW and sea	11	8	-	-	-	4	-	22
Rail and IWW and sea	12	9	-	-	-	-	-	-
"Valid" observations			**17,053**	**75,052**	**1,512,004**	**1,063**	**144**	**6,605**

- ECHO data is reweighted so that CFS and ECHO have equal weight

Specification testing

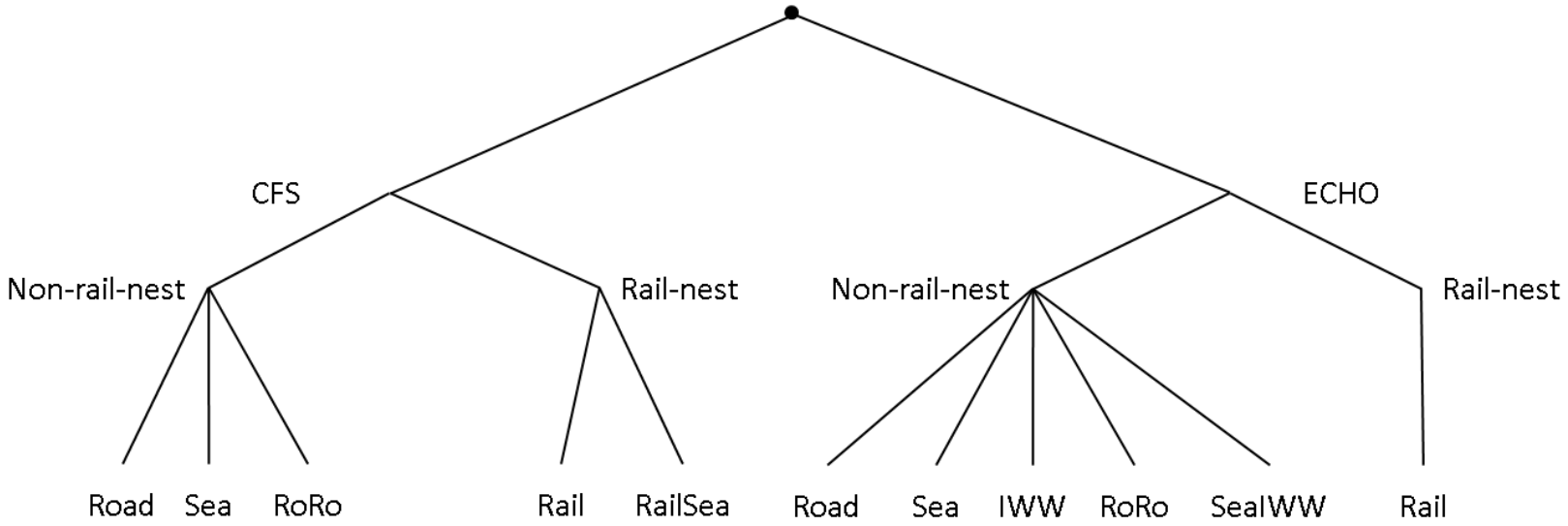
1. MNL models were estimated for each FLT and Data combination (3*2)
   - Dummies for commodity types (NSTR classification, 10 types)
   - Alternative-specific time parameters
   - Various non-linear cost specifications
     - Linear
     - Logarithmic
     - Linear + Logarithmic
     - Linear Spline (five intervals based on cost distribution)
     - Non-linear spline (Rich 2015)
   - Dummies for High Value goods based on value distribution for each FLT
   - Dummies for direct access to Sea and direct access to Rail

2. Best MNL specification for each data set is used in a joint FLT model
   - Joint model using logit scaling approach with re-weighting of ECHO data
   - Test of several Nest specifications

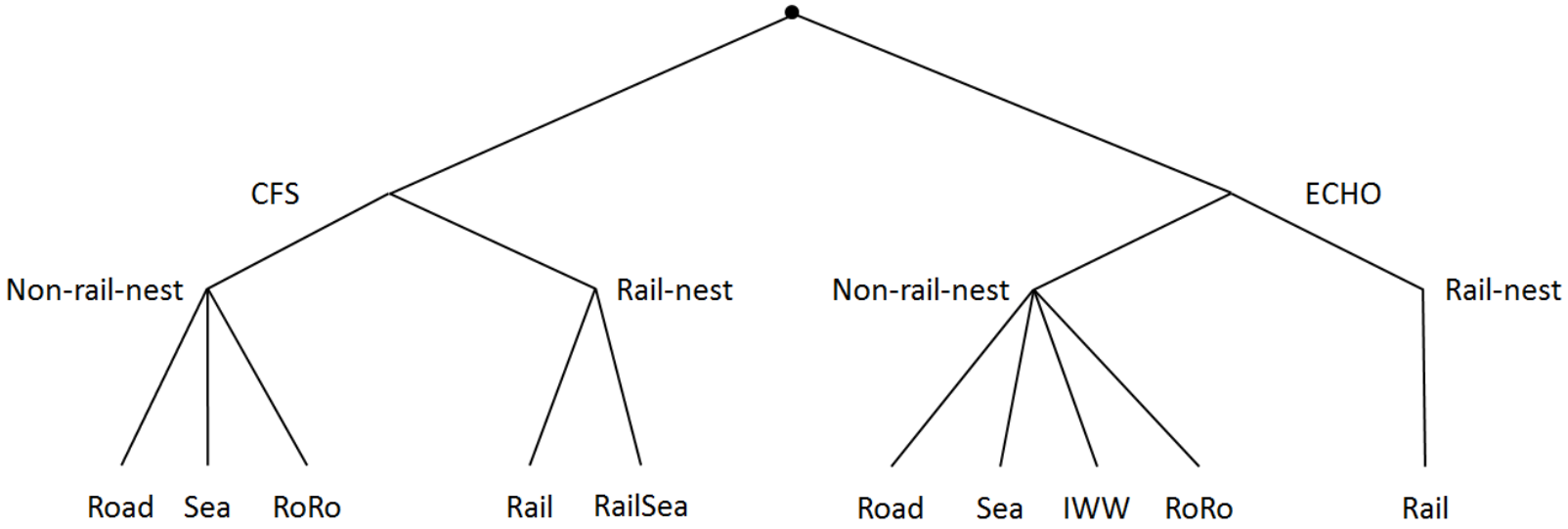
Specification testing

FLT	DATA	Base spec.	Time specificatio	Cost specification	Final Spec.	Joint Model
1	ECHO →	NSTR dummies →	Sea →	Lin + Ln →	Direct: Rail, IWW HVD: -	→ Rail nest
	CFS →	NSTR dummies →	Sea →	Lin + Ln →	Direct: - HVD: Road	
2	ECHO →	NSTR dummies →	Sea →	Spline →	Direct: Rail HVD: -	→ Rail nest
	CFS →	NSTR dummies →	Sea →	Spline →	Direct: - HVD: -	
3	ECHO →	NSTR dummies →	Sea + Gen. Cargo →	Ln →	Direct: Rail cont. Rail gen. Cargo HVD: Cont., Road, Sea	→ General cargo nest
	CFS →	NSTR dummies →	Sea + Gen. Cargo →	Ln →	Direct: - HVD: Cont., Road, Sea, Roro	

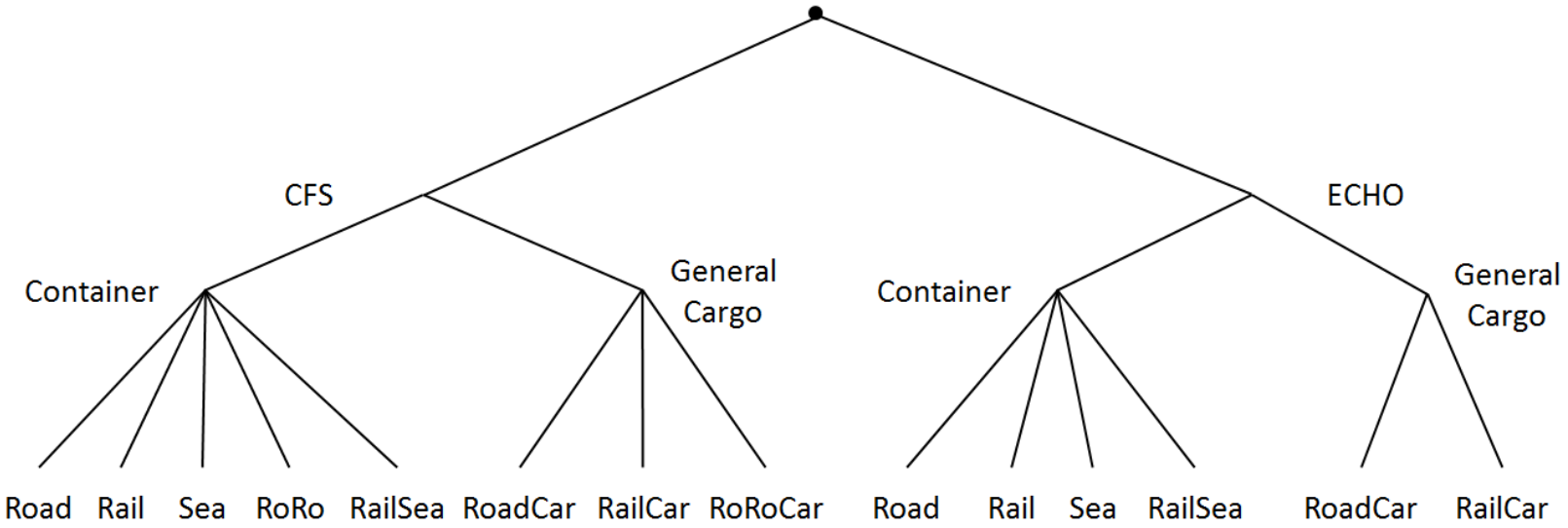
Joint Nested Logit Model
Model 1: Dry Bulk



Joint Nested Logit Model
Model 2: Liquid Bulk



Joint Nested Logit Model
Model 3: General Cargo and Containers



	Description	Model 1			Model 2			Model 3		
		Value	T-Test		Value	T-Test		Value	T-Test	
Parameters estimated jointly across data										
Alternative specific parameters										
	ASC, Road (non-container)							5.382	211.93	(***)
	ASC, RORO (non-container)				-1.16	-11.93	(***)			
	ASC, Rail (container)							-2.827	-64.46	(***)
	ASC, Rail (non-container)	-3.956	-14.75	(***)	-2.779	-14.19	(***)	8.732	185.1	(***)
	ASC, Sea	-5.041	-45.42	(***)	0.102	1.478		-0.844	-79.17	(***)
Time and cost parameters										
	Log(Cost)	-2.076	-24.6	(***)				-1.199	-155	(***)
	Cost	-0.055	-20.16	(***)						
	Linear spline for Cost 0-25 Euro				-0.114	-55.34	(***)			
	Linear spline for Cost 25-50 Euro				-0.087	-31.22	(***)			
	Linear spline for Cost 50-75 Euro				-0.041	-16.63	(***)			
	Linear spline for Cost 75-100 Euro				-0.195	-35.53	(***)			
	Linear spline for Cost >100 Euro				-0.078	-21.63	(***)			
	Time	-0.491	-7.133	(***)	-1.481	-20.12	(***)	-1.172	-79.82	(***)
	Time, general cargo							-3.166	-263.5	(***)
	Time, sea/IWW/RORO	-0.209	-14.71	(***)	-1.148	-48.9	(***)	-0.157	-114.1	(***)
NSTR commodity type parameters										

•
•
•

Other chain specific parameters										
	HvD-dummy, Container							-1.772	-108	(***)
	HvD-dummy, Road							1.16	109.74	(***)
	HvD-dummy, Sea							2.54	128.4	(***)
	HvD-dummy, RORO							0.845	55.517	(***)

Parameters estimated on ECHO dataset										
Alternative specific parameters										
	ASC, IWW	-4.335	-33.72	(***)	0.352	5.814	(***)			
	ASC, IWW and sea	-10.55	-29.08	(***)				-2.826	-159.1	(***)
NSTR commodity type parameters										

•
•
•

Other chain specific parameters										
	Direct access, Rail (container)							2.528	52.489	(***)
	Direct access, Rail (non-container)	2.847	17.628	(***)	6.023	32.227	(***)	1.049	110.26	(***)
	Direct access, IWW	3.195	24.213	(***)						

Parameters estimated on CFS dataset										
Alternative specific parameters										
	ASC, RORO (container)							-3.286	-21.72	(***)
	ASC, RORO (non-container)	-0.62	-6.438	(***)				1.225	33.907	(***)
	ASC, Rail and sea	-8.896	-7.961	(***)				-1.04	-5.651	(***)
NSTR commodity type parameters										

•
•
•

Nesting and scale parameters										
	Scale parameter, CFS	1.142	46.465	(***)	2.102	64.305	(***)	1.238	500.58	(***)
	Scale parameter, ECHO	1	-		1	-		1	-	
	Nesting parameter	0.72	21.914	(***)	0.517	36.062	(***)	0.815	235.62	(***)

Model Summary									
Final value of Likelihood	-648,365.7754			-2,122.6394			-1,172,635.78		
Likelihood with Constants only	-960,701.3636			-3,073.4343			-1,689,192.51		
Likelihood with Zero Coefficients	-2,942,090.4345			-10,582.5590			-5,450,457.19		
"Rho-Squared" w.r.t. Constants	.3251			.3094			0.306		
"Rho-Squared" w.r.t. Zero	.7796			.7994			0.785		
#parameters	35			25			47		
#observations Total	18,116			75,196			1,518,609		
#observations CFS	17,053			75,052			1,512,004		
#observations ECHO	1,063			144			6,605		

Elasticities
Model 1: Dry Bulk

	Elasticities: Change in market shares		
	Travel Cost Chain Specific	Travel Time Chain Specific	Travel Time Mode Specific
Road on Road	-0.21	-0.01	-0.01
Rail on Rail	-1.9	-0.49	-0.02
Rail on RailSea			-0.01
IWW on IWW	-2.12	-0.8	-0.56
Sea on Sea	-1.15	-0.67	-0.35
Sea on RailSea			-0.67
Sea on IWWSea			-0.15
RORO on RORO	-3.59	-0.37	-0.27
RailSea on RailSea	-2.48	-2.65	
IWWSea on IWWSea	-1.23	-2.5	
IWW on IWWSea			-0.14

Elasticities
Model 2: Liquid Bulk

	Elasticities: Change in market shares		
	Travel Cost Chain Specific	Travel Time Chain Specific	Travel Time Mode Specific
Road on Road	-0.23	-0.05	-0.01
Rail on Rail	-0.94	-0.59	-0.03
Rail on RailSea			-0.08
IWW on IWW	-1.43	-2.32	-0.91
Sea on Sea	-1.34	-3.25	-1.66
Sea on RailSea			-2.06
RORO on RORO	-2.20	-0.99	-0.72
RailSea on RailSea	-1.98	-5.07	

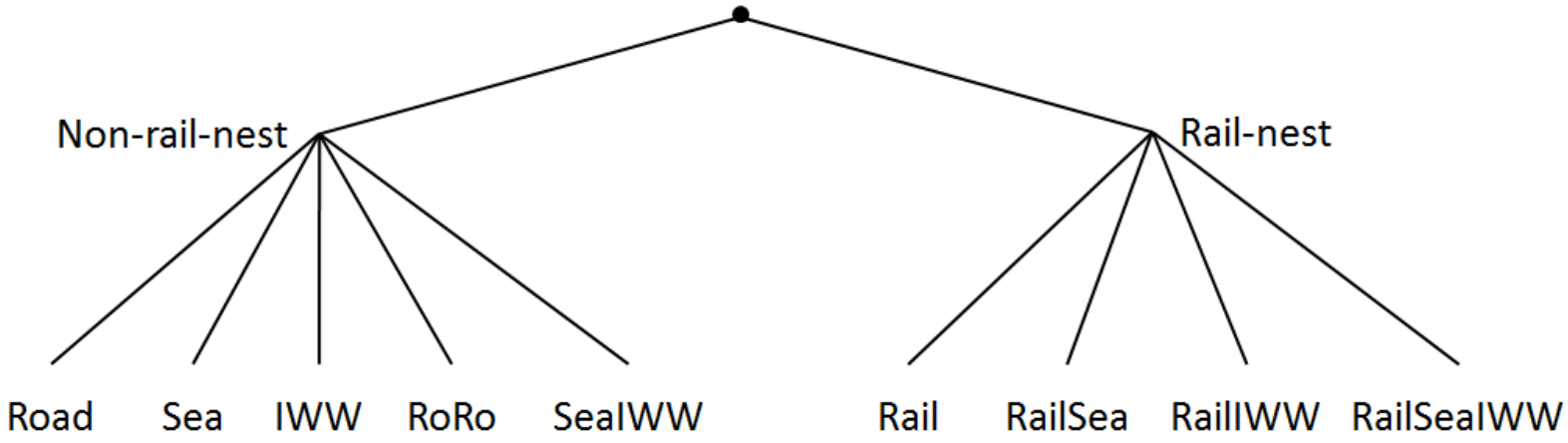
Elasticities
Model 3: General Cargo and Containers

	Elasticities: Change in market shares		
	Travel Cost Chain Specific	Travel Time Chain Specific	Travel Time Mode Specific
Road Container on Road Container	-0.43	-0.98	
Road General Cargo on Road General Cargo	-0.17	-0.11	
Road on Road Container			0.45
Road on Road General Cargo			-0.13
Rail Container on Rail Container	-1.36	-1.04	
Rail General Cargo on Rail General Cargo	-5.68	-1.10	
Rail on Rail Container			-0.09
Rail on Rail General Cargo			-0.38
Rail on RailSea			-0.02
RORO Container on RORO Container	-0.38	-1.31	
RORO General Cargo on RORO General Cargo	-0.40	-1.11	
RORO on RORO Container			-0.22
RORO on RORO General Cargo			-0.29
Sea on Sea	-0.46	-0.59	-0.23
Sea on RailSea			-0.08
Sea on IWWSea			0.02
RailSea on RailSea	-1.22	-0.48	
IWWSea on IWWSea	-3.14	-0.99	
IWW on IWWSea			-0.29

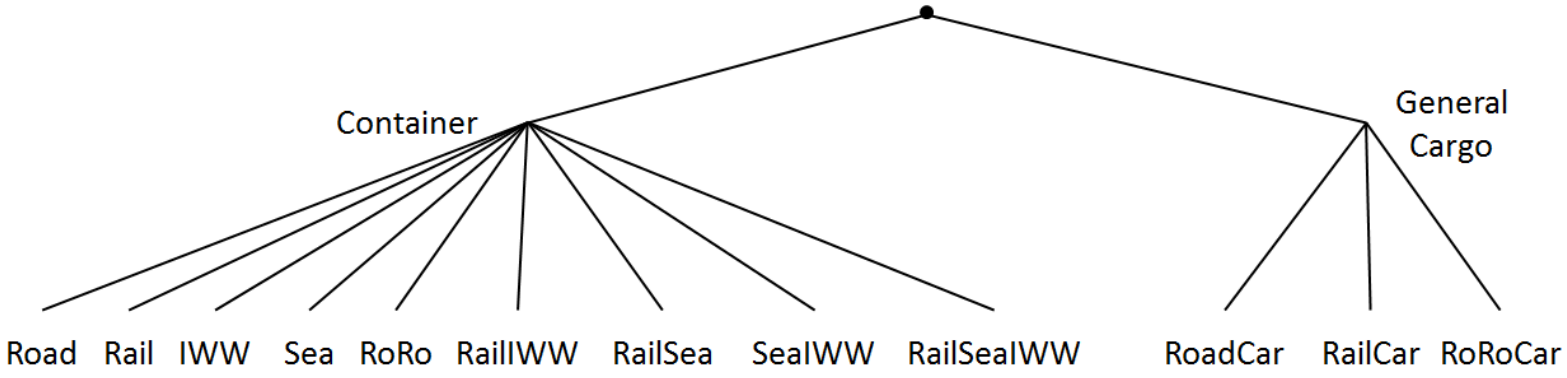
Application

- When specifying the utility functions to be implemented in TransTools3 the following guidelines are used:
  - Use specification for all alternatives estimated with ECHO data.
  - If an alternative is missing in ECHO but is present in CFS, the CFS specification is used (including potential dummies for NSTR and HVD)
  - If an alternative is specified in both CFS and ECHO data, the parameters estimated solely on CFS data will not be used.
  - For alternatives which are not specified in either CFS nor ECHO, generic parameters for time and cost are used.
  - Finally, estimated alternative specific constants are replaced with mode specific constants, which are calibrated to reproduce the actual market shares in TransTools3 (The mode specific constants are to be calibrated).

Simulation model 1 and 2: Dry Bulk and Liquid Bulk



Simulation model 3: General Cargo and Containers



Conclusion / Summary

- We have estimated a model for freight transport chain choice in Europe
  - Dry Bulk
  - Liquid Bulk
  - Containers and General Cargo
- We considered and tested:
  - Several non-linear cost specifications
  - Interaction between chain alternatives and high value freight
  - Interaction between chain alternatives and direct access to Rail, Sea and Water chain alternatives
- Models are estimated jointly on two datasets, each with their strengths
  - ECHO has a great level of detail and more variables (but small)
  - CFS is large but less detailed
- Several nesting structures were tested
  - A Rail chain nest was preferred for Dry Bulk and Liquid Bulk
  - A nest with General Cargo was preferred for Containers and Gen. Cargo (But Rail was also working very well here)

Thank you for your attention.
Questions?