Channel Coordination

Marketing Litterature
- Centralized Control

-Non-linear Pricing

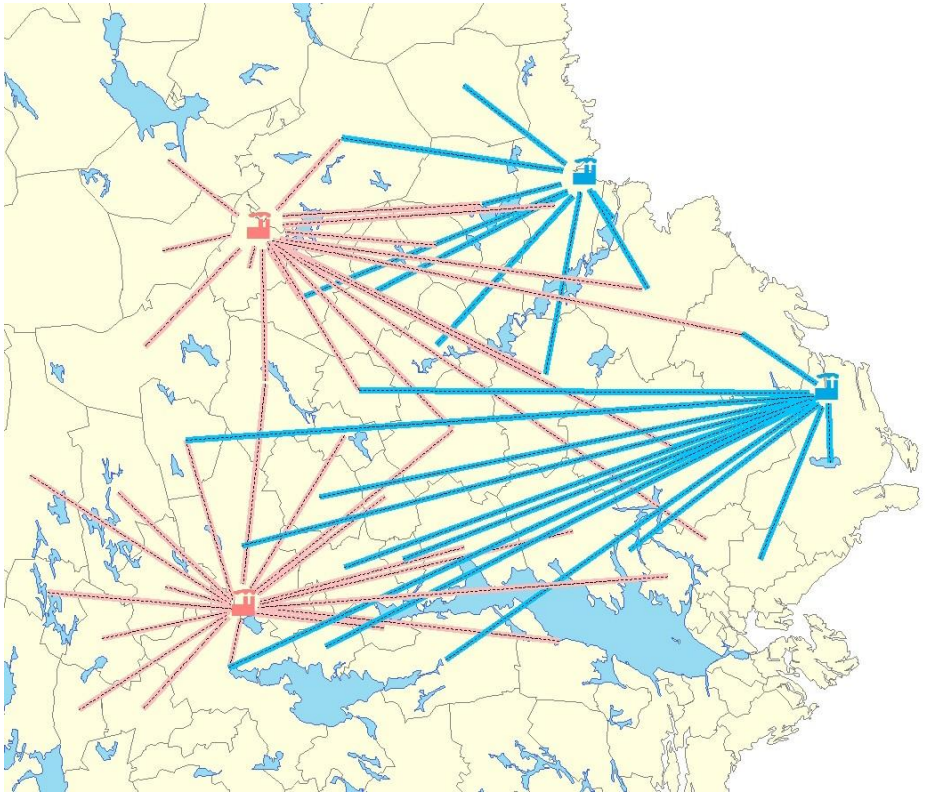
Two supply chain examples

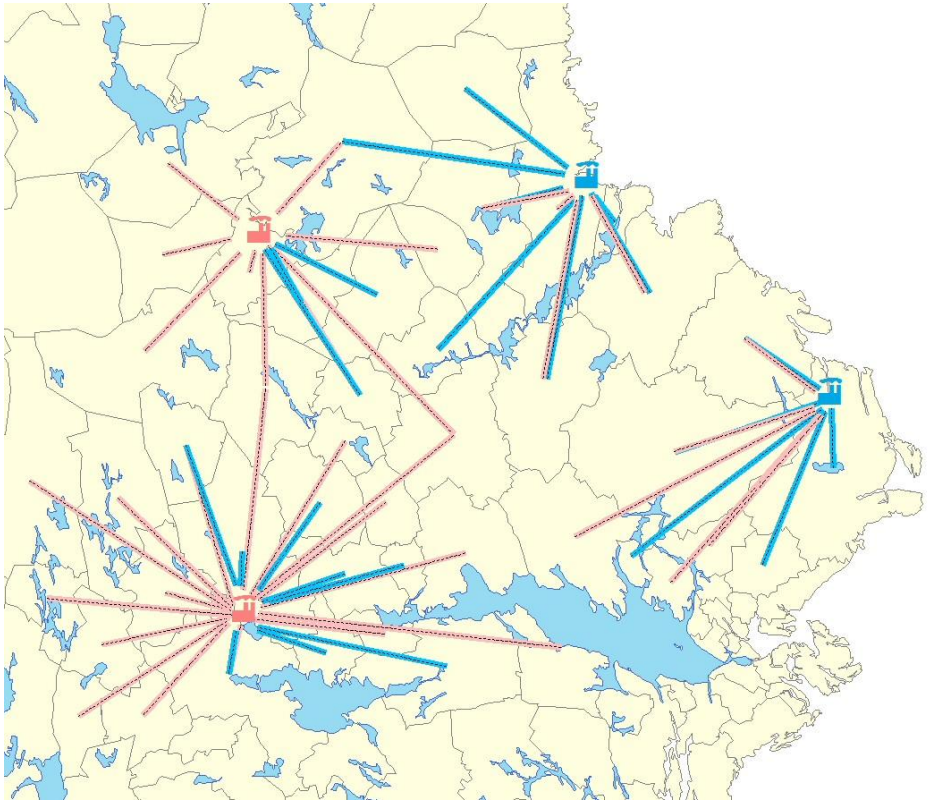
- Early day fish farming industry (1980s)
- Distribution of Industrial Gases

Cost Allocation to Achieve Collaborative Transportation Solutions

Kurt Jörnsten, Mikael Rönnqvist
The Norwegian School of Economics and Business Administration, Bergen, Norway
Maud Göthe Lundgren VTI, Sweden

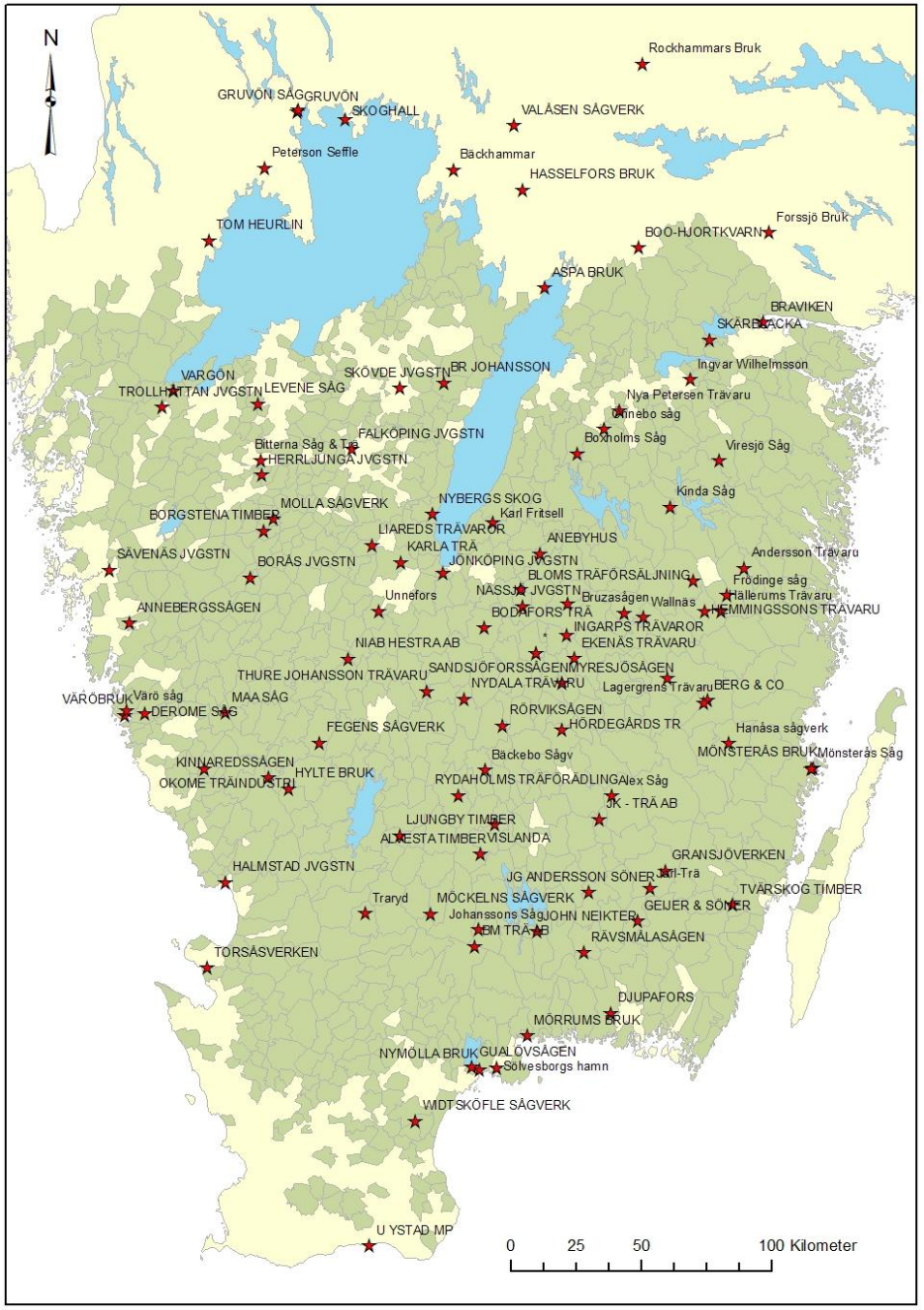
Co-operation two companies

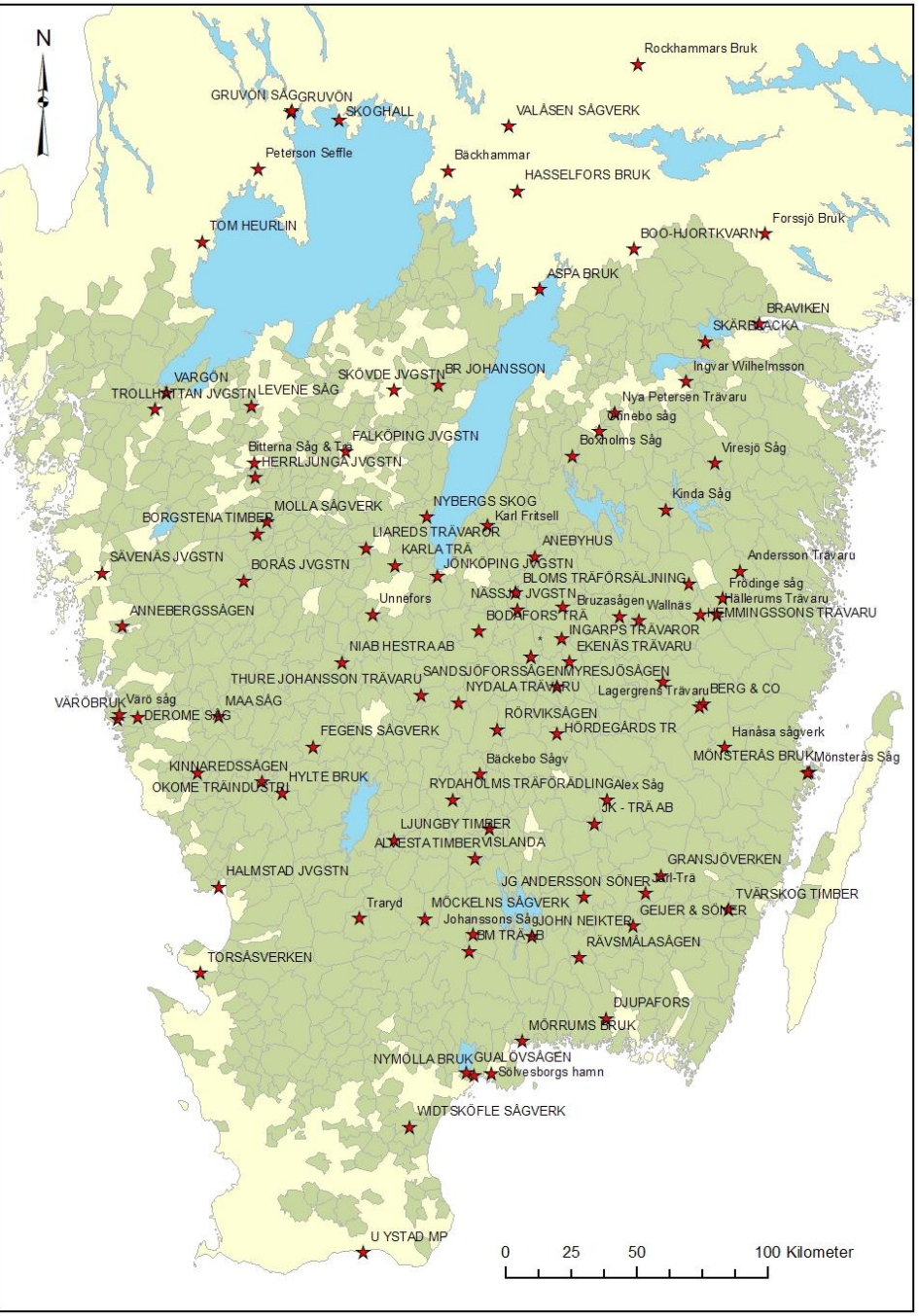




Case study

- 8 participating companies in southern Sweden (monthly volumes)
- Analysis done by Skogforsk (The Forest Research Institute of Sweden)
- 898 supply points
- 101 demand points
- 39 assortments, 12 assortment groups





Company	Volume	Proportion (%)
Company 1	77,361	8,76
Company 2	301,660	34,16
Company 3	94,769	10,73
Company 4	44,509	5,04
Company 5	232,103	26,29
Company 6	89,318	10,12
Company 7	36,786	4,17
Company 8	6,446	0,73
Total	882,952	

opt1: direct flows (individual)
opt2: backhaul flows (individual)
opt3: direct flows (collaboration)
opt4: backhaul flows (collaboration)

Company	Real	opt 1	opt 2	opt 3	opt 4
Company 1	3,894	3,778	3,640		
Company 2	15,757	14,859	14,684		
Company 3	4,828	4,742	4,703		
Company 4	2,103	2,067	2,043		
Company 5	10,704	10,340	10,153		
Company 6	5,084	4,959	4,826		
Company 7	1,934	1,884	1,877		
Company 8	0,333	0,333	0,332		
All				39,253	38,315
Total	44,637	42,963	42,257	39,253	38,315
Saving (%)	0,00	3,75	5,33	12,06	14,16

Optimization model

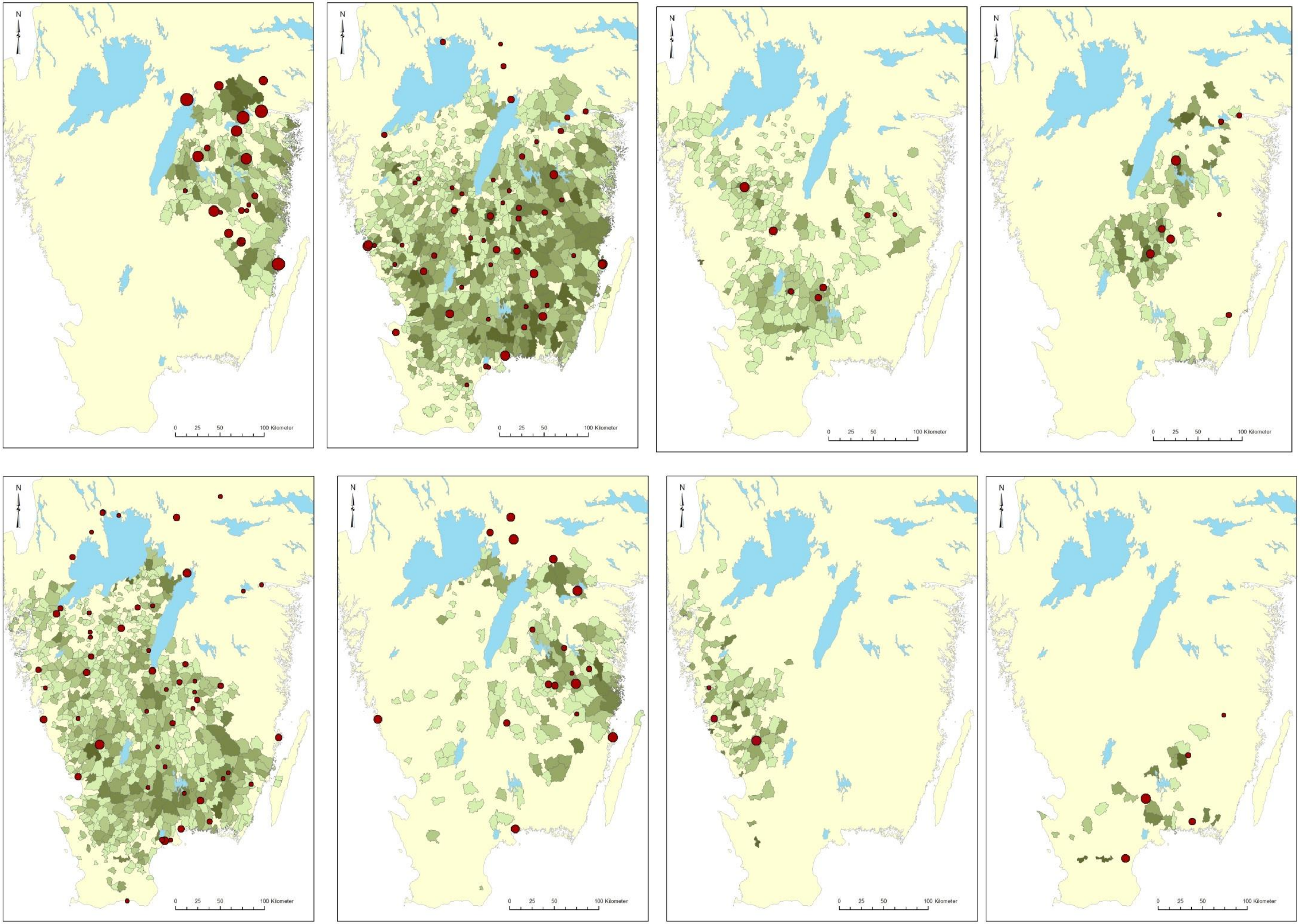
- # supply points: 4842
- # demand points: 310
- # constraints: 5,053
- # variables (direct flows): 240,000
- # variables (backhaul flows): > 100 million
- # used variables:
  240,000 + 125,000 through column generation

Linear Production Game

- In fact: A Hitchcock-Koopmans transportation Game

Cost allocation based on volume

Company	Individual	Volume	%
Company 1	3,778	3,439	**9,0**
Company 2	14,859	13,411	**9,7**
Company 3	4,742	4,213	**11,2**
Company 4	2,067	1,979	**4,3**
Company 5	10,340	10,318	**0,2**
Company 6	4,959	3,971	**19,9**
Company 7	1,884	1,635	**13,2**
Company 8	0,333	0,287	**14,0**
Sum	**42,963**	**39,253**	


N
0 25 50 100 Kilometer
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Game theory approach – Basics

coalition S : a subset of participants N (or players)

grand coalition $S = N$: all participants

$c(S)$: cost for the transportation for S

Efficient allocation : $\sum_{j \in N} y_j = c(N)$

Individual rationality : $y_j \leq c(\{j\})$

Core : $\sum_{j \in S} y_j \leq c(S), \quad S \subset N$

$\sum_{j \in N} y_j = c(N)$ (efficiency)

Models

Volume based allocation : $y_j = w_j c(N)$

w_j is equal to participant j's share of the total volume

Shapley value : $y_j = \sum_{S \subset N : j \in S} \frac{(|S|-1)!(|N|-|S|)!}{|N|!}[c(S) - c(S - j)]$

The Nucleolus : minimize the maximum dissatisfaction

If the core is non-empty, the nucleoulus is in the core, i.e. it is stable.

Shadow prices : $c(N) = \sum_{i \in I} u_i s_i + \sum_{k \in K} v_k d_k$

shadow prices : u_i, v_k supply, demand : s_i, d_k

Volume vs Shapley value

Company	Volume	%	Shapley	%
Company 1	3,439	**9,0**	3,586	**5,1**
Company 2	13,411	**9,7**	13,528	**9,0**
Company 3	4,213	**11,2**	4,102	**13,5**
Company 4	1,979	**4,3**	1,889	**8,6**
Company 5	10,318	**0,2**	9,747	**5,7**
Company 6	3,971	**19,9**	4,503	**9,2**
Company 7	1,635	**13,2**	1,587	**15,8**
Company 8	0,287	**14,0**	0,310	**6,9**
Sum	**39,253**		**39,253**	
Stable	**No**		**Yes**	

Nucleoulus

Company	Volume	Shapley	Shadow	Nucleolus
Company 1	9,0	5,1	4,1	**3,4**
Company 2	9,7	9,0	12,7	**11,1**
Company 3	11,2	13,5	14,2	**14,0**
Company 4	4,3	8,6	13,3	**6,4**
Company 5	0,2	5,7	-1,8	**4,8**
Company 6	19,9	9,2	11,7	**8,3**
Company 7	13,2	15,8	15,6	**11,5**
Company 8	14,0	6,9	9,1	**4,6**

Model – Equal Profit Method

Relative saving: $\frac{c(i) - y_i}{c(i)} = 1 - \frac{y_i}{c(i)}$ Stable allocation $c(i) \geq y_i$.

Relative difference between two participants: $\frac{y_i}{c(i)} - \frac{y_j}{c(j)}$

Minimize difference i.e.

$$\min f$$

$$\text{s.t.} \quad f \geq \frac{y_i}{c(i)} - \frac{y_j}{c(j)}$$

$$\sum_{j \in S} y_j \leq c(S), \quad S \subset N$$

$$\sum_{j \in N} y_j = c(N)$$

EPM

Company	Volume	Shapley	Shadow	Nucleo.	EPM
Company 1	9,0	5,1	4,1	3,4	**6,7**
Company 2	9,7	9,0	12,7	11,1	**8,8**
Company 3	11,2	13,5	14,2	14,0	**8,8**
Company 4	4,3	8,6	13,3	6,4	**8,8**
Company 5	0,2	5,7	-1,8	4,8	**8,8**
Company 6	19,9	9,2	11,7	8,3	**8,8**
Company 7	13,2	15,8	15,6	11,5	**8,8**
Company 8	14,0	6,9	9,1	4,6	**8,8**

Coalition Formation

- Insinking: A Methodology to Synergy in Transportation

Cruijsen, Borm and Fleuren Tilburg University

Does there exist a monotone Shapley path?

Answer: Depends on the sequence

Monotonic Paths,
Rational Monotonic Paths,
Monotonic Incomplete Paths

Combinations	.AR	.RR	.AN	.RN
S..	-	**18**	**18**	**18**
E..	-	**2428**	**2428**	**2428**
N..	-	170	133	170

Savings Requirement when adding a new player to the sequence

$$\frac{(y_j^p - y_j)}{c(\{j\})} \geq \delta \qquad , j \in \{j_1, j_2, \ldots, j_p\}, \qquad (**)$$

No. of paths as a function of delta

δ	$5.0\ 10^{-4}$	$7.0\ 10^{-4}$	$9.0\ 10^{-4}$	$9.5\ 10^{-4}$	$9.7\ 10^{-4}$	$9.714611\ 10^{-4}$	$9.714612\ 10^{-4}$
No of MPs	900	256	10	4	3	3	0

The three last remaining sequences

- (8,6,2,7,4,1,5,3)
- (8,2,7,6,4,1,5,3)
- (8,2,6,7,4,1,5,3)

Filtering process

- Phase 1:
  - Solve full collaboration
  - Solve problem for each individual company
  - Remove all flows that are the same, fixed part
  - Remaining data, filtered part
- Phase 2
  - Solve full collaboration for filtered part
  - Add fixed cost to cost allocation go get final allocation

Filtering and EPM

Comp	Ind	Fixed	Filt	EPM	E+fix	%	tot
1	3,778	2,472	1,305	1,074	3,546	**17,8**	**6,1**
2	14,859	7,072	7,788	6,405	13,477	**17,8**	**9,3**
3	4,742	2,217	2,526	2,077	4,294	**17,8**	**9,5**
4	2,067	0,824	1,243	1,022	1,846	**17,8**	**10,7**
5	10,340	6,508	3,832	3,152	9,659	**17,8**	**6,6**
6	4,959	2,290	2,670	2,196	4,485	**17,8**	**9,6**
7	1,884	0,452	1,432	1,178	1,630	**17,8**	**13,5**
8	0,333	0,233	0,100	0,082	0,315	**17,8**	**5,3**
Sum	42,963	22,067	20,895	39,253			

Practical results

- The overall potential savings are 15%.
- Co-ordination savings are about 8%.
- Average transportation distance is decreased by 18%.
- Transportation work can be reduced with 18%.
- Energy consumption can be reduced by 18% resulting in 950 tons of less CO_2.
- Five companies are making plans for coordination

Strategic Implications from Filtering

- What should each company report as their input to the cooperation?

- Fernandez, Fiestras-Janeiro, Garcia-Jurado, Puerto: Competiton and Coordination in Non-Centralised Linear Production Games Annals of Operation Research 2005
- Does a Nash Equilibrium exist when players report strategically?

Concluding remarks

- Unusual to have 8 companies to collaborate
- 14.2% savings correspond annually to more than 8 million Euros
- The Shapley value and the EPM provides stable and reasonable cost allocations
- EPM easy to understand and acceptable for planners/managers
- Two phase approach with filtered data takes geographic location into account.
- Future:
  - Find out more about strategic behaviour and how it can affect the potential for collaboration
  - Implement DSS for companies
  - Which solution concept if any imposes thruth telling?