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Impacts of correlated supplier disruptions in supply networks (topic presentation)

Petteri Koskiahde

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Instructor: *Joaquín de la Barra*

Supervisor: *Ahti Salo*

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Background - Supply networks

- Strategically important
- Concept has evolved from supply chains to supply networks (Kim & Choi & Yan & Dooley, 2011)
- ”Supply networks have become more complex…” (Käki & Salo & Talluri, 2015)

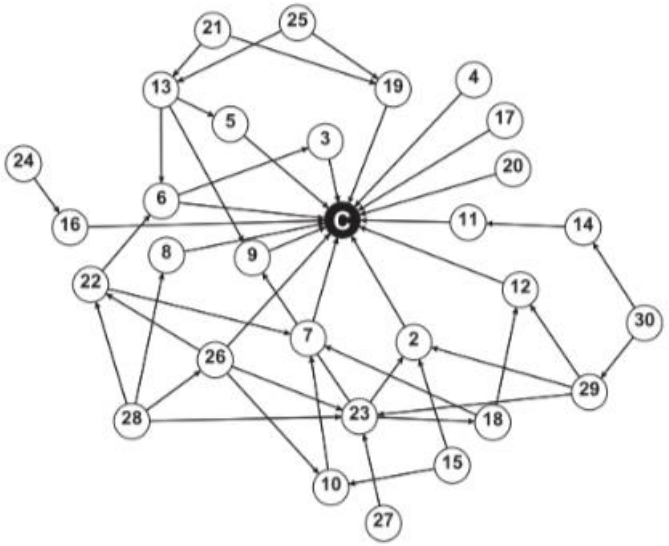


Figure 1: Example of a random network from Käki & Salo, &Talluri (2015)

Disruptions in supply networks

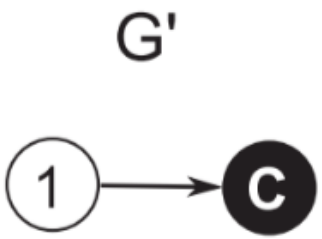
- There are many approaches to model risks in a supply network
- We use probabilistic risk assessment (PRA)
  - Adapted from Käki & Salo & Talluri (2015)
- Disruptions in the supply network may be correlated
  - This is not covered in Käki & Salo & Talluri (2015)

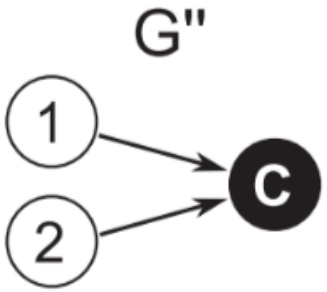
Objectives of the thesis

- Model the supply network as a Bayesian network
- Assess risk via simulations
  - With and without correlation
- Calculate relevant metrics from the simulations
  - Relate results to the approach in Käki & Salo & Talluri (2015)

Bayesian network

- Supply network as a Bayesian network
- Examples:





$$F'_C = \alpha'_C + (1 - \alpha'_C) F'_1 \beta'_{C|1} \quad (3)$$

$$F''_C = \alpha''_C + (1 - \alpha''_C)[\beta''_{C|1} F''_1 (1 - F''_2) + \beta''_{C|2} F''_2 (1 - F''_1) + (\beta''_{c|1} + \beta''_{C|2} - \beta''_{C|1} \beta''_{C|2}) F''_1 F''_2] \quad (4)$$

Figure 2: Simple networks and suppliers' disruption probabilities in Käki & Salo & Talluri (2015)

Methods and tools - Metrics

- Supplier Fortification Impact

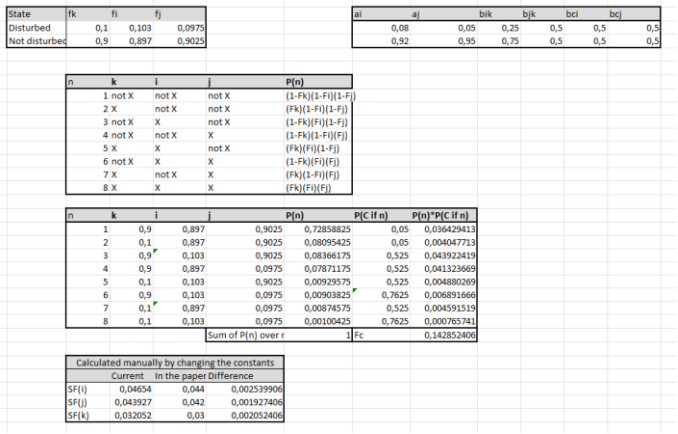
$$SF_I(n) = \{F_c - F_c(\sim n):\ F_c(\sim n) = The\ total\ risk\ with\ \alpha_n = \beta_{n|i} = 0 \forall i\ parent\ of\ n\}$$

- Supplier Disruption Impact

$$SD_I(n) = \{F_c(n) - F_c:\ F_c(n) = The\ total\ risk\ with\ \alpha_n = 1\}$$

Methods and tools

- Excel
  - Construct the Bayesian model
- Matlab
  - Solve the model by simulation approach
  - Perform Monte Carlo simulations



State	fk	fi	fj
Disturbed	0,1	0,103	0,0975
Not disturbed	0,9	0,897	0,9025

ai	aj	bik	bjk	bci	bcj
0,08	0,05	0,25	0,5	0,5	0,5
0,92	0,95	0,75	0,5	0,5	0,5

n	k	i	j	P(n)
1	not X	not X	not X	(1-Fk)(1-Fi)(1-Fj)
2	X	not X	not X	(Fk)(1-Fi)(1-Fj)
3	not X	X	not X	(1-Fk)(Fi)(1-Fj)
4	not X	not X	X	(1-Fk)(1-Fi)(Fj)
5	X	X	not X	(Fk)(Fi)(1-Fj)
6	not X	X	X	(1-Fk)(Fi)(Fj)
7	X	not X	X	(Fk)(1-Fi)(Fj)
8	X	X	X	(Fk)(Fi)(Fj)

n	k	i	j	P(n)	P(C if n)	P(n)*P(C if n)
1	0,9	0,897	0,9025	0,72858825	0,05	0,036429413
2	0,1	0,897	0,9025	0,08095425	0,05	0,004047713
3	0,9	0,103	0,9025	0,08366175	0,525	0,043922419
4	0,9	0,897	0,0975	0,07871175	0,525	0,041323669
5	0,1	0,103	0,9025	0,00929575	0,525	0,004880269
6	0,9	0,103	0,0975	0,00903825	0,7625	0,006891666
7	0,1	0,897	0,0975	0,00874575	0,525	0,004591519
8	0,1	0,103	0,0975	0,00100425	0,7625	0,000765741
			Sum of P(n) over r	1	Fc	0,142852406

Calculated manually by changing the constants			
	Current	In the paper	Difference
SF(i)	0,04654	0,044	0,002539906
SF(j)	0,043927	0,042	0,001927406
SF(k)	0,032052	0,03	0,002052406

Figure 3: Screenshot from Excel model for Bayesian network

Assumptions

- Each node has two possible states: disturbed or operational
  - Simplifies the model
- Distuptions can propagate only downstream
- Small networks
  - Supports the generation of insights

Schedule

- Literature review 09/2023
- Presentation 1.11.2023
- Performing simulations and writing the thesis 10/2023-12/2023
- Thesis ready 12/2023

References

- Anssi Käki, Ahti Salo, Srinivas Talluri, ”Disruptions in Supply Networks: A Probabilistic Risk Assessment Approach”, Journal of Business Logistics, 2015, 36(3):273-287
- Yusoon Kima, Thomas Y.Choi, Tingting Yan, Kevin Dooley, ”Structural investigation of supply networks: A social network analysis approach”, Journal of Operations Management 29, 2011,194–211