Capital stranding cascades: The impact of decarbonisation on productive asset utilisation

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Stranded assets and systemic risk

- Low-carbon transition might lead assets to lose their value
  - Fossil reserves (Ekins and McGlade, 2015)
  - Financial assets (Battiston et al., 2017)
  - Potential systemic impacts of transition (Carney, 2015)

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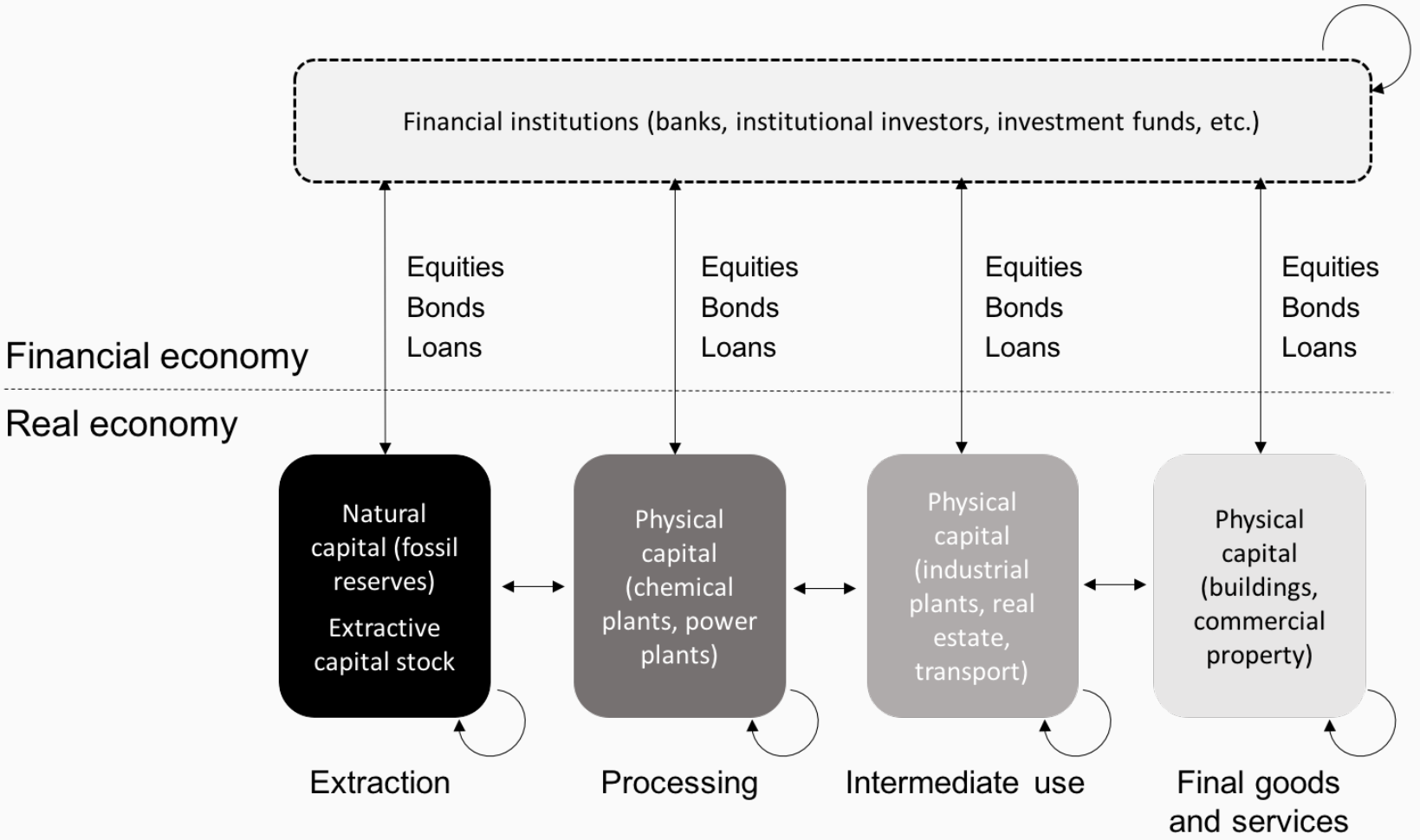
  - Potential systemic impacts of transition (Carney, 2015)
- Stranding of physical productive capital stocks
  - Built infrastructure, industrial plants, machinery, buildings
  - Asset stranding in the form of idle productive capacity
  - Starts in the fossil sector but propagates to the entire economic system following chains of intermediate exchange

Real-financial asset stranding



Related literature

- Limited work on physical capital stranding
  - Literature on "committed cumulative emissions" suggests premature decommissioning to reach 2°C (Davis et al. 2010; Smith et al. 2019)
  - Limited empirical analysis on relevance of capital asset stranding (Pfeiffer et al. 2018; IRENA 2017)
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  - Capital stranding almost never incorporated in climate economic modelling (Rozenberg et al. 2018)
- Methodological approach
  - Input-Output techniques (Ghosh 1958)
  - IO tables as directed weighted networks (Blochl et al. 2011; Acemoglu et al. 2012)

Our contribution

- We apply input-output and network theory techniques to:
  1. Identify sectors most likely to create asset stranding and most exposed to asset stranding risk
  2. Study how stranding would cascade down from the mining sector to the rest of the economy
  3. Provide an estimate of total capital at risk of stranding

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  3. Provide an estimate of total capital at risk of stranding
- Analysis for ten countries:
  - Austria, Belgium, Czech Republic, Germany, Greece, France, Italy, Sweden, Slovakia, United Kingdom
  - Eurostat data (2010)

Sectoral asset stranding multipliers

IO national accounting

Inter-Industry matrix (**Z**)		**Intermediate uses**		**Final uses (f)**			**Total use (TU)**
		Sector A	Sector B	Cons.	Inv.	Exp.	
Production	Sector A	Products of A used as inputs by A	Products of A used as inputs by B	Final use of products by A			Total use of products of A
	Sector B	Products of B used as inputs by A	Products of B used as inputs by B	Final use of products by B			Total use of products of B
Total		Total intermediate inputs		Total final uses			Total uses
Value added (v)	Comp. of employees	Total value added					
	Cons. of fixed capital						
	Operating surplus						
Output		Total domestic output					
Imports		Total imports					
Total supply (TS)		Total supply					

Figure 1: Stylised IO table

A supply-side view: the Ghosh matrix

- We define a matrix of *allocation* coefficients: $\mathbf{B} = \hat{\mathbf{x}}^{-1}\mathbf{Z}$
  - Elements $b_{i,j}$ represent the share of output produced in sector i allocated to sector j
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  - $\mathbf{G}$ takes into account both direct and indirect effects
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- Elements $g_{i,j}$ of $\mathbf{G}^T$ can be interpreted as the change in output taking place in sector i due to a unitary change in primary inputs flowing into sector j.
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  - Primary inputs: compensation of employees, other value added terms
- With IO, low-carbon transition more appropriately described as a quality change (from high- to low-carbon) of the same basket of goods than as a shift between demand categories

The S matrix

- We create a **S** matrix of "stranded asset multipliers"
  - We define κ_i as the capital intensity of sector i, calculated as the ratio between productive capital stock of a sector and the sectoral domestic output
  - The matrix of stranded multipliers **S** is then defined as $\mathbf{S} = \hat{\kappa}\mathbf{G}^T$

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- Every element $s_{i,j}$ of **S** can be interpreted as the change in utilisation of capital stock taking place in sector i due to a unitary change in primary inputs flowing to sector j
  - For our purposes, $s_{i,j}$ tells the value of the capital stock becoming stranded in sector i due to a unitary drop of primary inputs flowing to sector j (e.g. fossil fuel extraction)

Our data

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  - Physical productive infrastructure (N112N) (dwellings are excluded)
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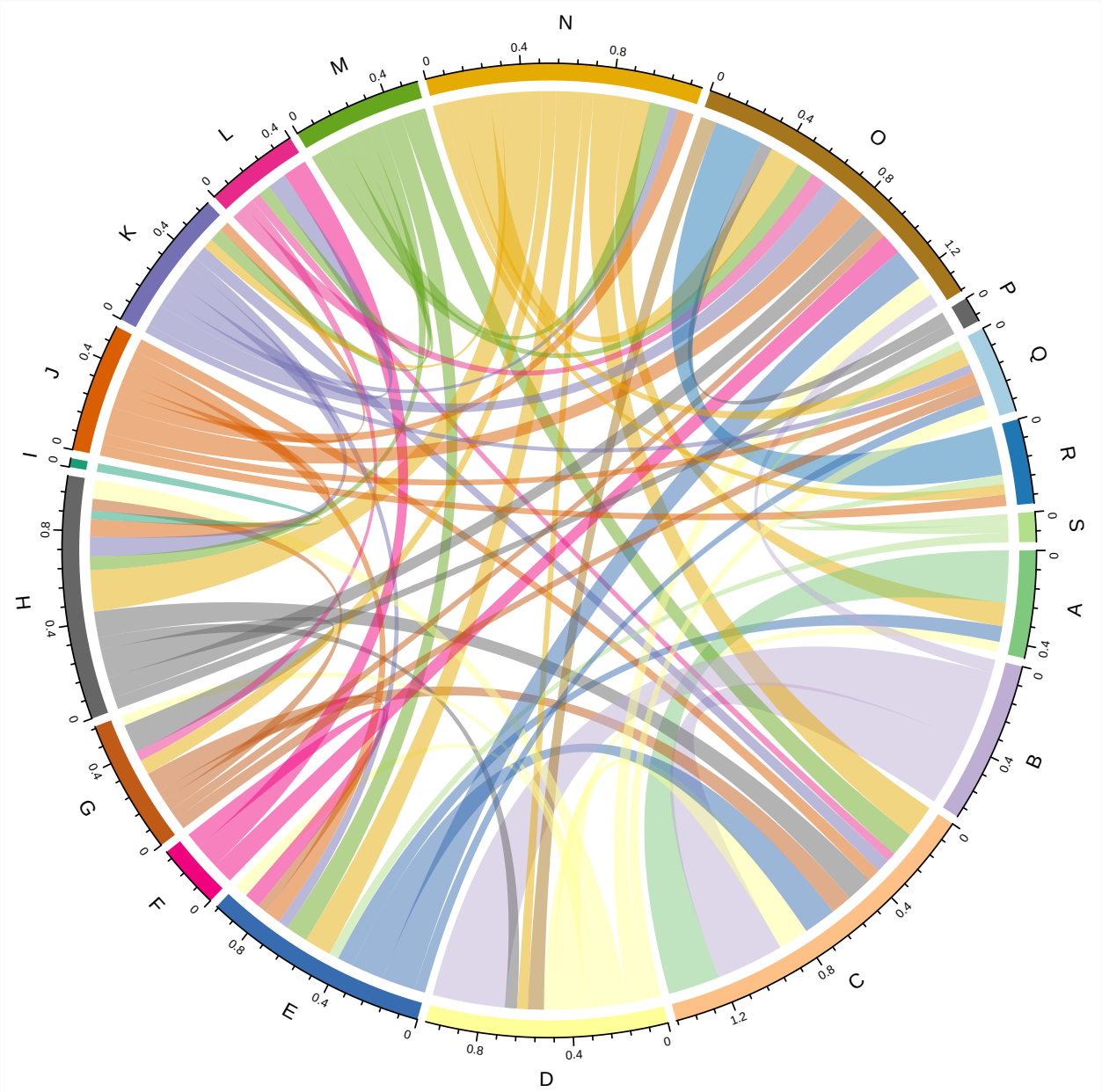
- Sectors are classified using the NACE classification system

NACE Level 1 categories

Sector code	Sector description
A	Agriculture, forestry and fishing
B	Mining and quarrying
C	Manufacturing
D	Electricity, gas, steam and air conditioning
E	Water supply; sewerage; waste management and remediation activities
F	Constructions and construction works
G	Wholesale and retail trade; repair of motor vehicles and motorcycles
H	Transportation and storage
I	Accommodation and food service activities
J	Information and communication
K	Financial and insurance activities
L	Real estate activities
M	Professional, scientific and technical activities
N	Administrative and support service activities
O	Public administration and defence; compulsory social security
P	Education
Q	Human health and social work activities
R	Arts, entertainment and recreation
S	Other services activities

Germany stranding network



Stranding multipliers and risk exposure

- Column sums of **S** represent the total stranding triggered by a unitary drop in sector j (total stranding multiplier)

$$s_j^{\mathrm{TOT}} = \sum_{i=1}^{n} s_{ij}$$

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- The row sums of **S** represent the stranding in sector i due to a unitary drop in all the sectors (exposure to stranding risk)

$$s_i^{\mathrm{EXP}} = \sum_{j=1}^{n} s_{ij}$$

Total asset stranding multipliers (top 5 sectors)

Austria	Belgium	Czech	Germany	Greece
E36 (11.32)	H (3.13)	E36 (13.66)	E (6.65)	N77 (5.89)
A03 (9.92)	E (2.52)	O (7.88)	R (3.7)	A02 (4.62)
A01 (8.48)	D (2.51)	H52 (6.74)	A (3.58)	E36 (4.08)
E37-39 (8.44)	N (1.65)	P (6.01)	O (3.21)	O (3.59)
H52 (8.06)	C16-18 (1.65)	H50 (5.86)	N (2.84)	D (3.46)

France	Italy	Sweden	Slovakia	UK
B (4.20)	D (5.52)	E36 (12.65)	E36 (29.83)	E36 (8.61)
O (3.79)	A (5.07)	D (5.04)	H52 (13.66)	H52 (4.79)
E (2.26)	O (4.07)	A01 (4.82)	H50 (9.81)	E37-39 (3.3)
D (2.07)	B (3.99)	O (4.81)	B (8.96)	A02 (3.21)
R (2.01)	H (3.38)	J61 (3.33)	D (7.54)	H49 (3.12)

- United Kingdom
  - E36: Natural water; water treatment and supply services
  - H52: Warehousing and support activities for transportation
  - E37-39: Sewerage services; waste collection and treatment
  - A02: Forestry and logging
  - H49: Land transport and transport via pipelines

External asset stranding multipliers (top 5 sectors)

Austria	Belgium	Czech	Germany	Greece
E36 (3.64)	M69-71 (0.91)	H50 (3.93)	N (1.12)	M74_75 (1.57)
E37-39 (2.44)	N (0.81)	H53 (3.08)	B (0.89)	N77 (1.5)
N78 (2.05)	M73-75 (0.71)	N80-82 (3.02)	M (0.73)	C18 (1.5)
N80-82 (1.89)	J62_63 (0.59)	M74_75 (2.85)	J (0.72)	N80-82 (1.48)
B (1.86)	K (0.56)	B (2.12)	D (0.68)	C33 (1.47)

France	Italy	Sweden	Slovakia	UK
B (1.02)	B (1.79)	S95 (1.68)	H50 (6.3)	C23 (1.45)
N (0.83)	C19 (1.29)	E36 (1.58)	B (4.03)	N77 (1.43)
M73-75 (0.77)	M69-71 (1.28)	C33 (1.45)	C33 (3.51)	N79 (1.42)
E (0.74)	N (1.19)	N80-82 (1.25)	M74_75 (3.4)	C33 (1.37)
K (0.67)	D (1.14)	E37-39 (1.23)	M71 (2.51)	C16 (1.34)

- United Kingdom
  - C23: Other non-metallic mineral products
  - N77: Rental and leasing activities
  - N79: Travel agency, tour operator and other reservation services
  - C33: Repair and installation services of machinery and equipment
  - C16: Wood and products of wood and cork, except furniture

Exposure to stranding risk (top 5 sectors)

Austria	Belgium	Czech	Germany	Greece
L (9.32)	H (2.18)	O (10.52)	C (1.56)	O (7.63)
O (3.19)	G (1.28)	H52 (7.58)	O (1.41)	H50 (4.8)
F (2.82)	F (0.96)	H49 (2.92)	H (0.83)	H49 (3.32)
A01 (2.81)	C10-12 (0.67)	L (2.6)	E (0.71)	I (1.76)
H52 (2.74)	D (0.55)	D (2.43)	D (0.69)	D (1.51)

France	Italy	Sweden	Slovakia	UK
O (2.62)	H (2.97)	O (5.71)	D (11.69)	F (6.36)
L (0.97)	D (2.3)	L (3.93)	O (11.19)	H49 (2.64)
D (0.94)	O (2.28)	D (3.09)	H52 (11.16)	O (1.97)
H (0.77)	G (1.61)	J61 (2.42)	E36 (2.61)	H52 (1.72)
A (0.73)	A (1.54)	E36 (1.58)	C29 (2.33)	G47 (1.68)

- United Kingdom
  - F: Constructions and construction works
  - H49: Land transport and transport via pipelines
  - O: Public administration and defence; compulsory social security
  - H52: Warehousing and support activities for transportation
  - G47: Retail trade services, except of motor vehicles and motorcycles

Cascades of stranding originating in the mining sector

The effects of a low-carbon transition

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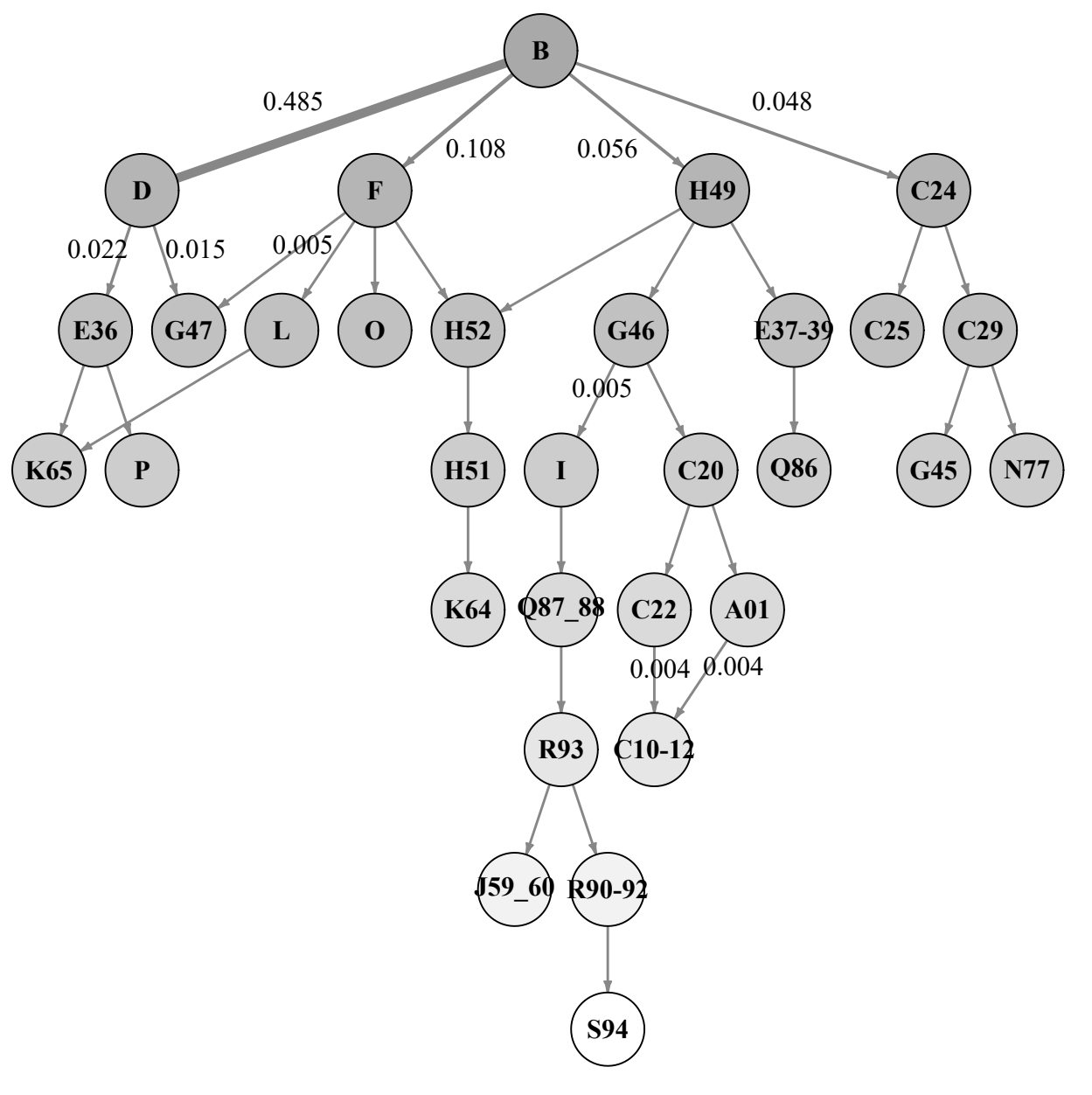
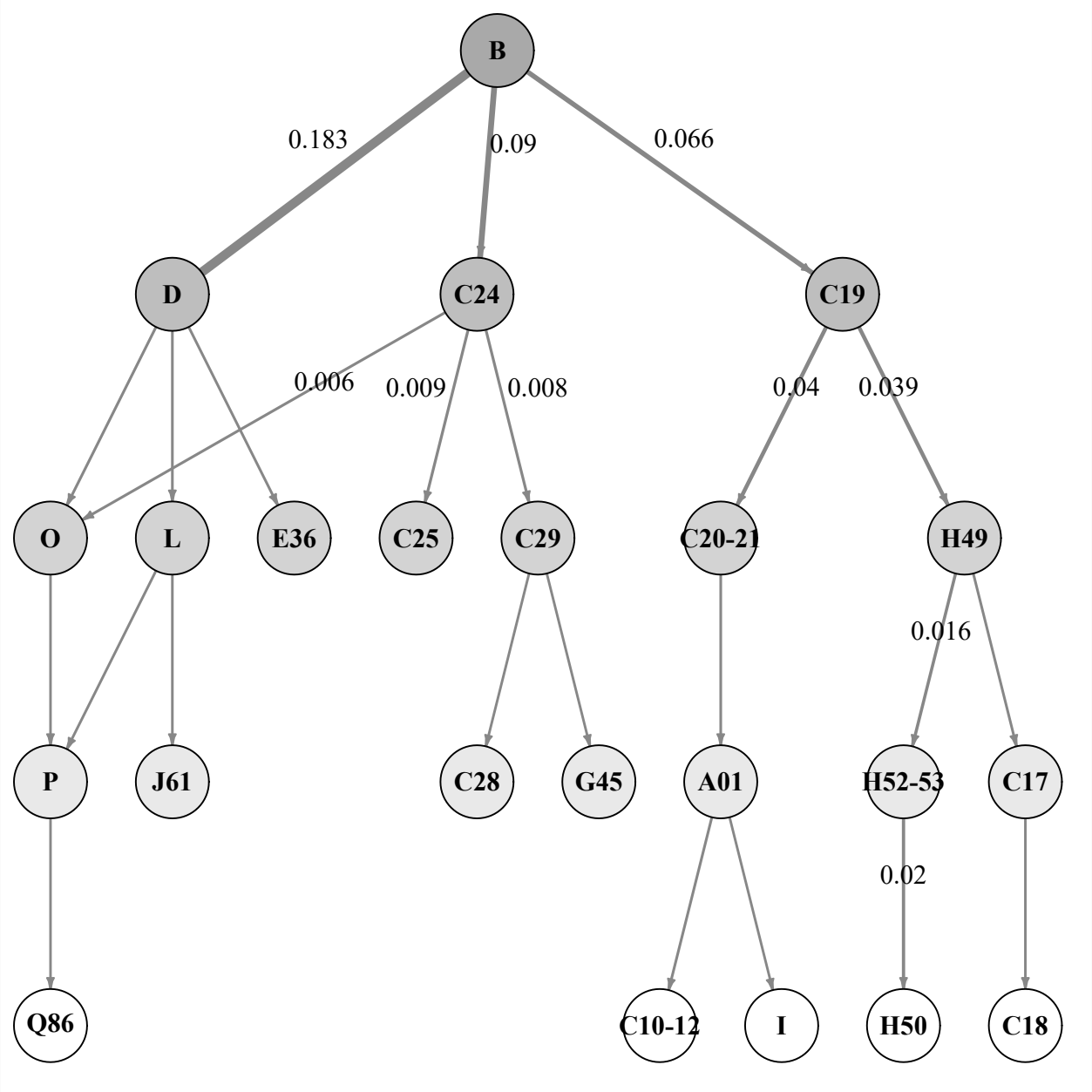
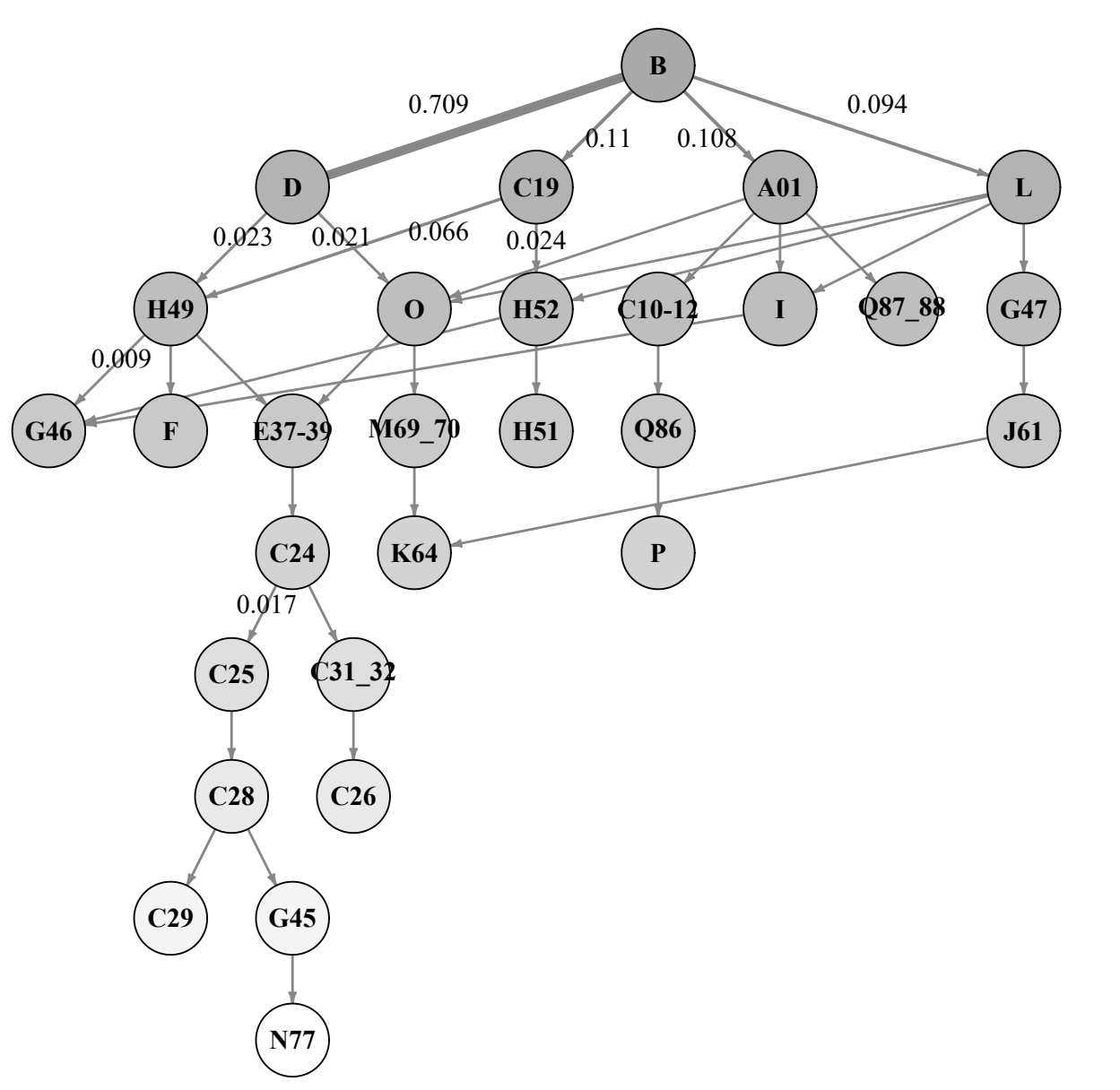
United Kingdom: stranding cascade (q=0.05)



Sweden: stranding cascade (q=0.05)



Austria: stranding cascade (q=0.05)



Common patterns across countries

- The strongest immediate stranding links are the ones affecting
  - Electricity and gas (D) (the single strongest link for all countries except Belgium).
  - Manufacturing activities, especially coke and refined petroleum products (C19) and basic metals (C24)
  - Transportation and storage sectors (H)

Main conclusions

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    - And from C29 further to trade of motor vehicles (G45)
- When disaggregation among H subsectors is available, there is a stranding clustering among them, especially amongst:
  - Land transport and pipelines (H49)
  - Warehousing and support to transportation (H52)

The capital stock at risk of stranding due to decarbonisation

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- For B, we assume fossil capital stock to be entirely at risk, and the remainder to be at risk from use like the other sectors.

Results

Proportion of capital stock at risk of stranding in B, C and D sectors due to a complete decarbonization:

	Total capital		Mining (B)		Manufacturing (C)		Electricity/gas (D)	
Austria	5,689	(0.8%)	431	(16.0%)	1,706	(2.4%)	3,315	(12.5%)
Belgium	3,181	(0.6%)	1	(0.1%)	2,692	(3.0%)	285	(1.2%)
Czechia	17,536	(3.7%)	4,075	(60.9%)	2,772	(3.3%)	6,718	(25.7%)
Germany	40,752	(1.0%)	3,629	(29.6%)	12,702	(2.8%)	21,627	(12.2%)
Greece	8,774	(2.7%)	1,313	(48.7%)	1,800	(8.1%)	2,683	(17.1%)
France	35,514	(1.4%)	3,644	(21.4%)	3,877	(2.1%)	21,913	(23.3%)
Italy	58,589	(2.1%)	2,252	(10.7%)	19,776	(4.9%)	30,565	(14.0%)
Sweden	3,970	(0.8%)	55	(1.4%)	1,762	(2.2%)	1,856	(3.1%)
Slovakia	18,749	(8.2%)	473	(15.1%)	3,220	(7.7%)	13,458	(35.1%)
UK	84,678	(3.6%)	45,900	(69.3%)	7,385	(2.9%)	28,384	(35.7%)

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Thank you!

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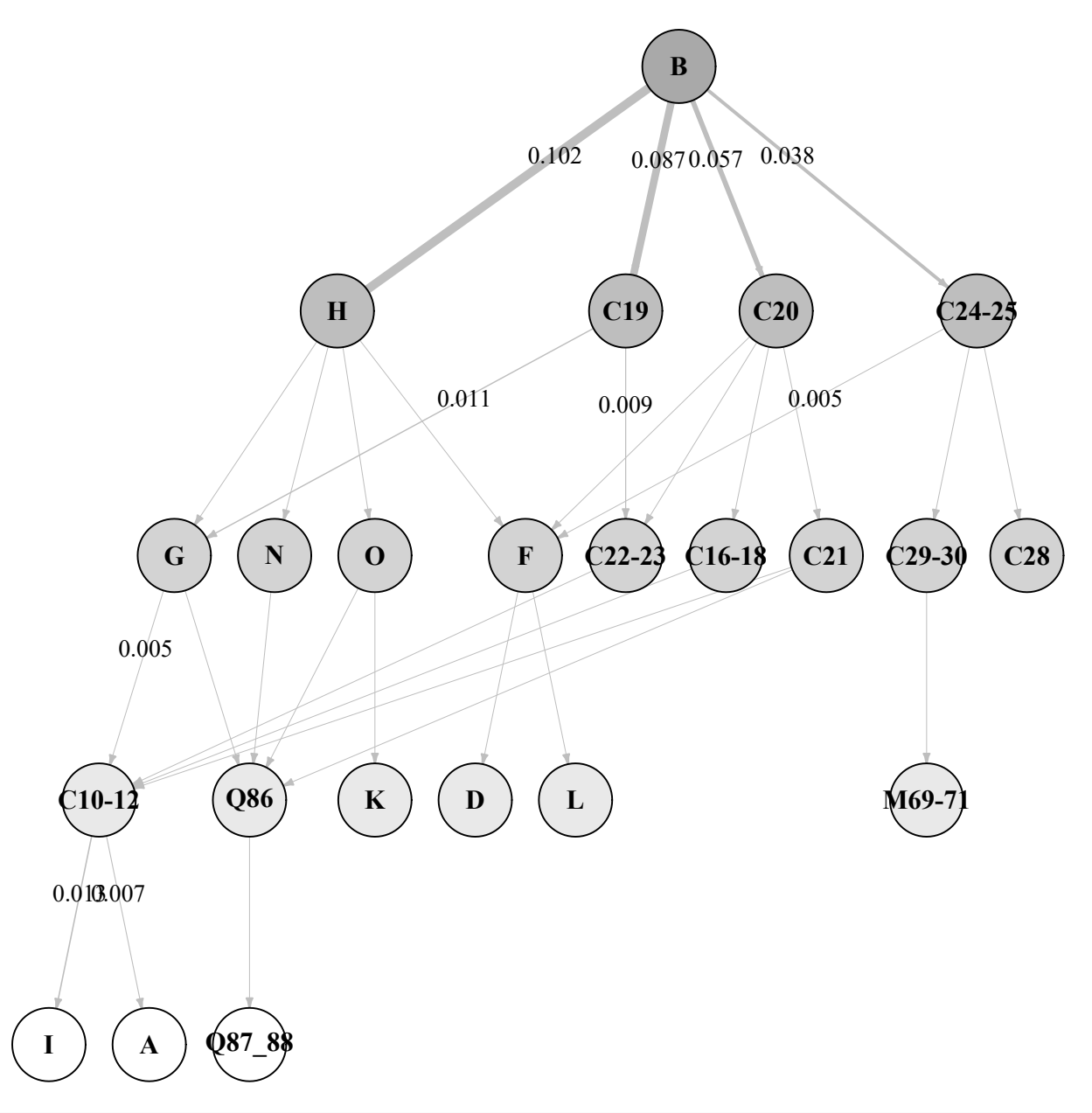
http://epub.wu.ac.at/6854/

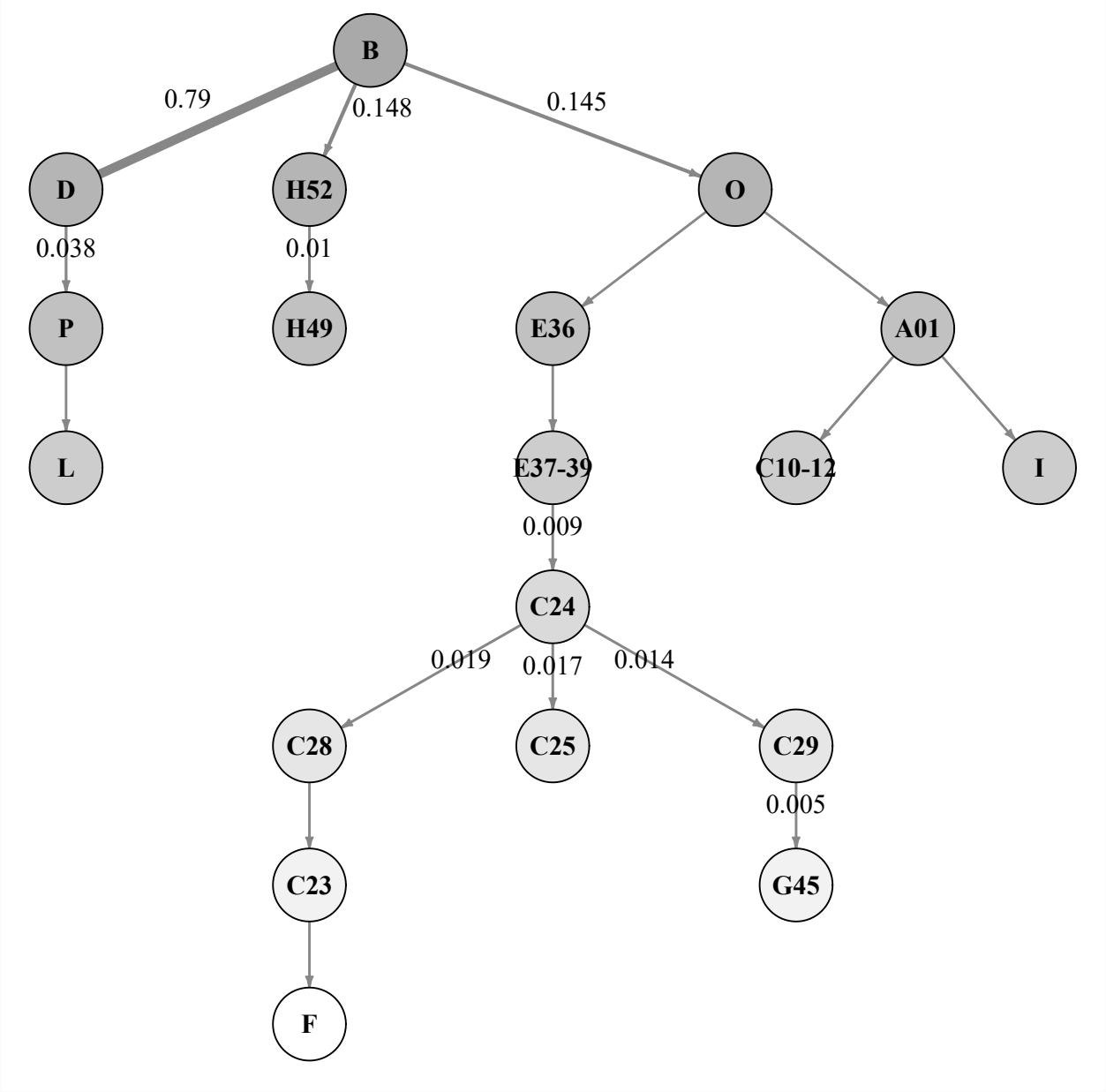
https://github.com/capital-stranding-cascades

Additional slides

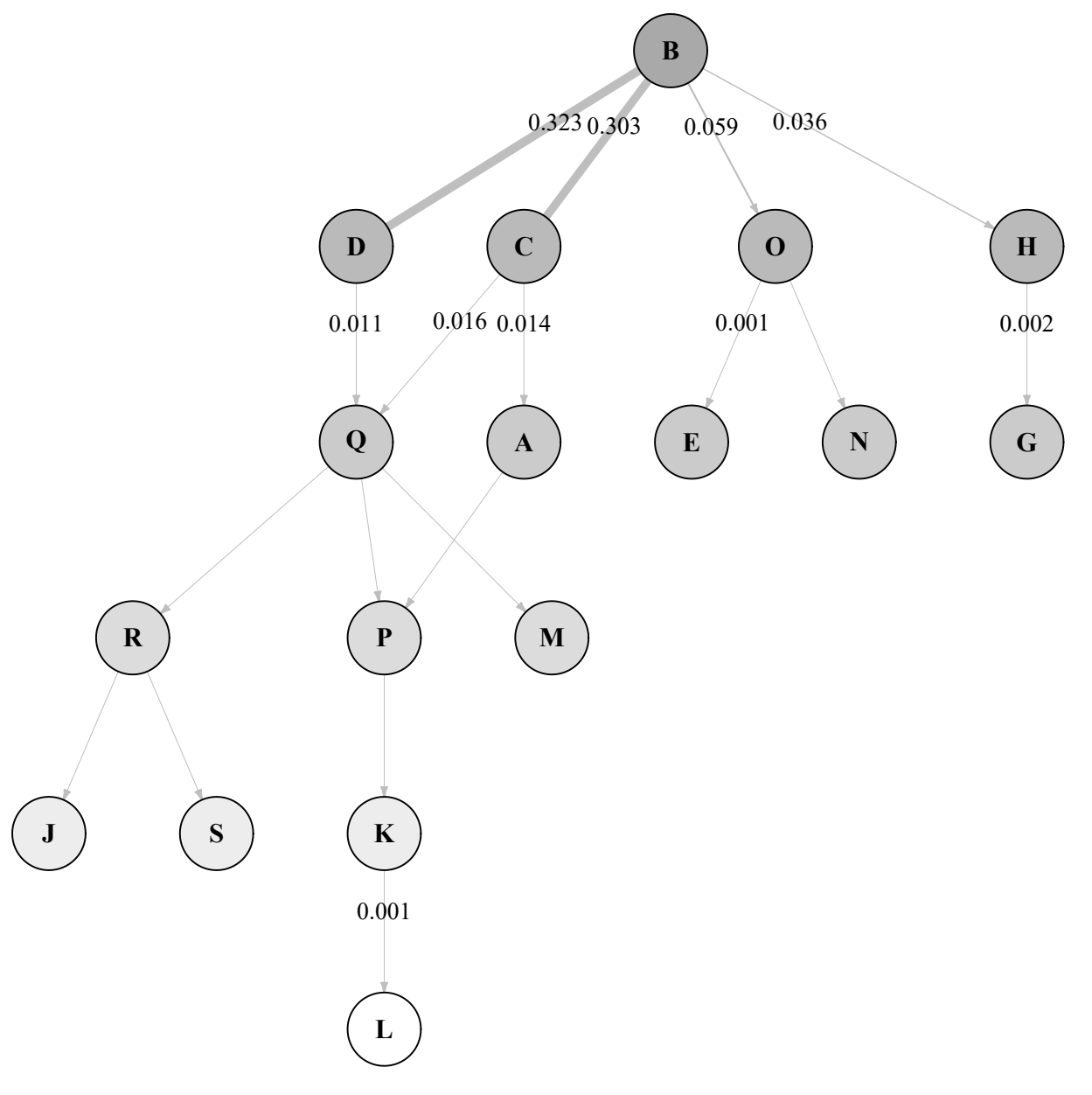
Belgium: stranding cascade (q=0.1)



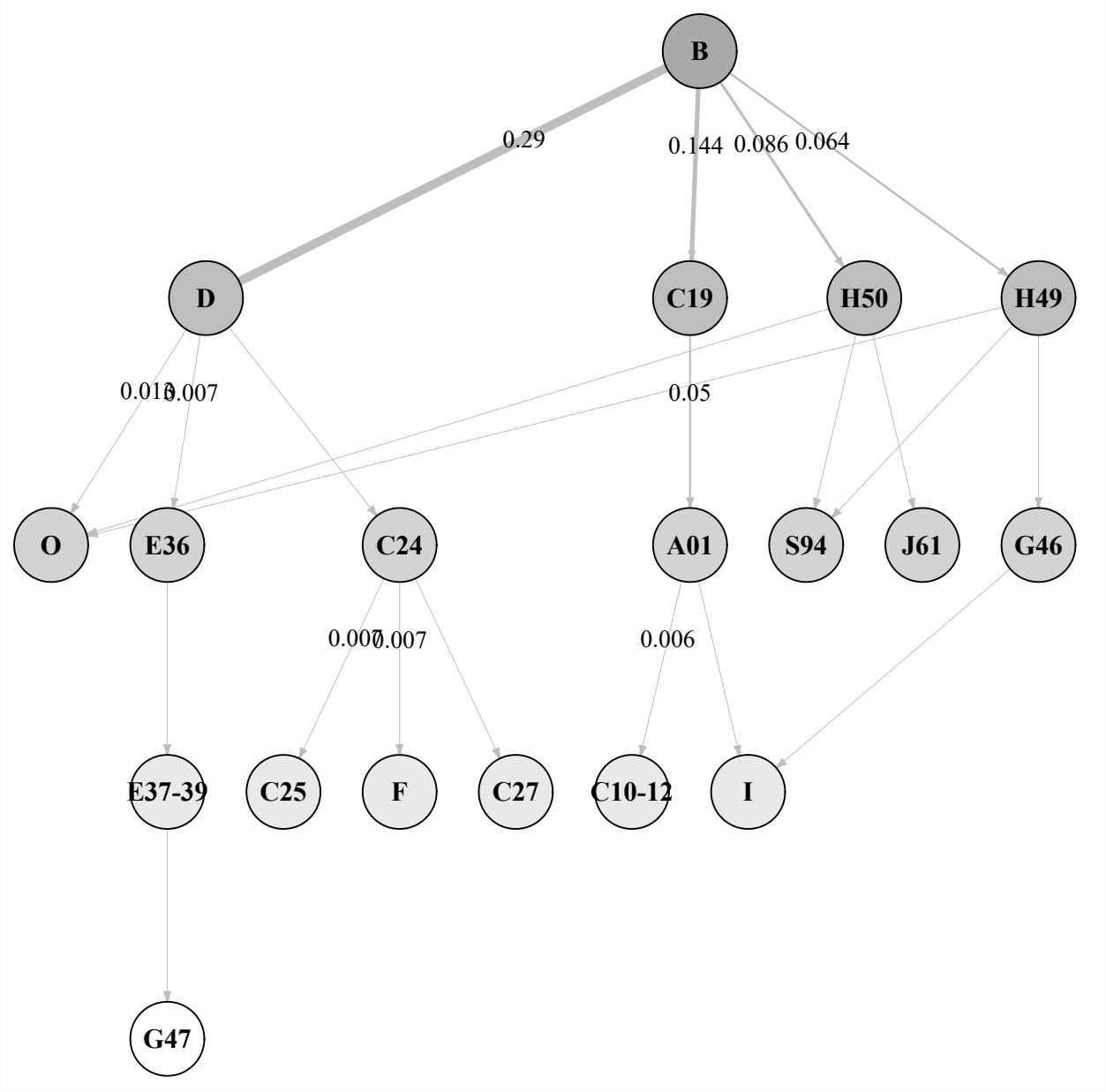
Czechia: stranding cascade (q=0.05)



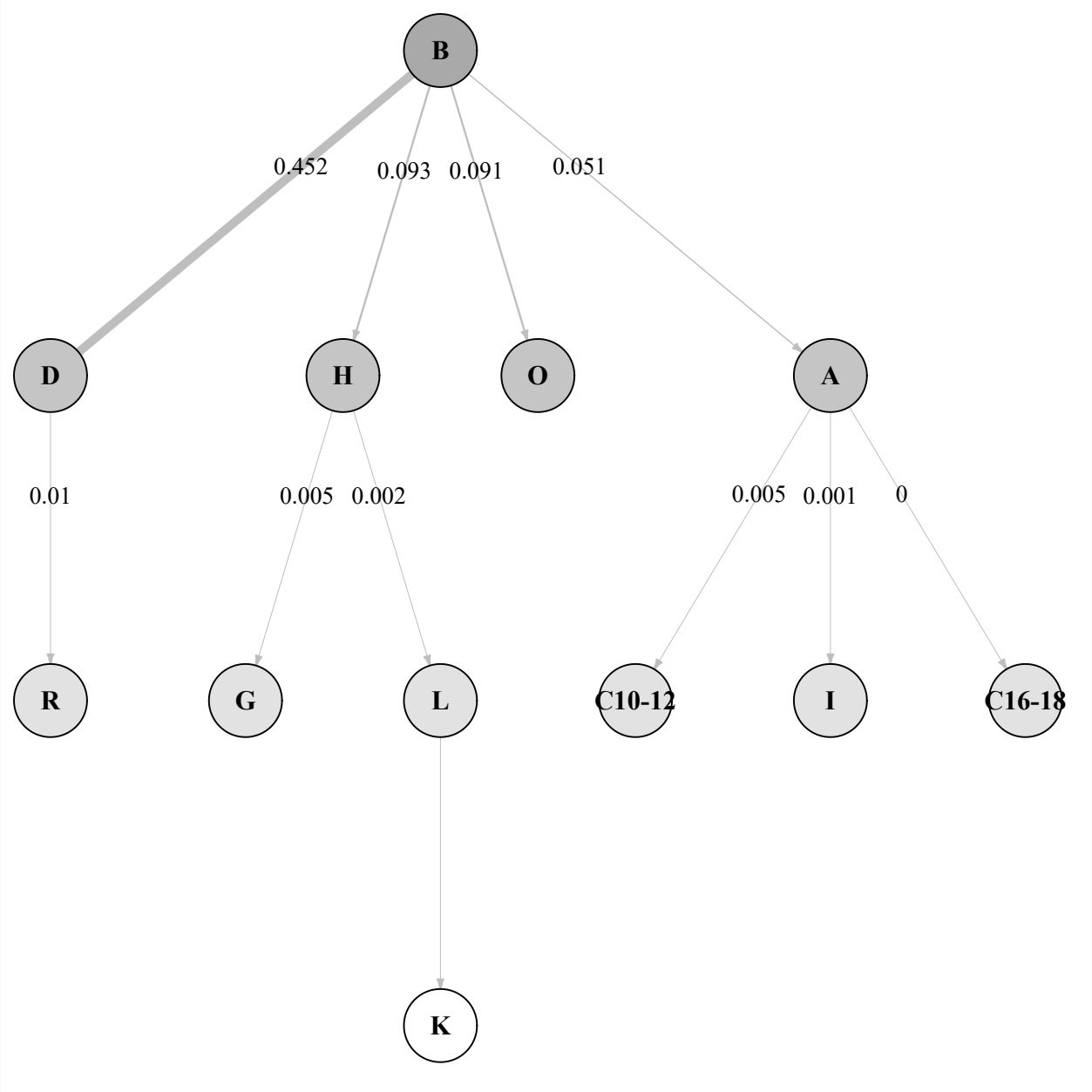
Germany: stranding cascade (q=0.2)



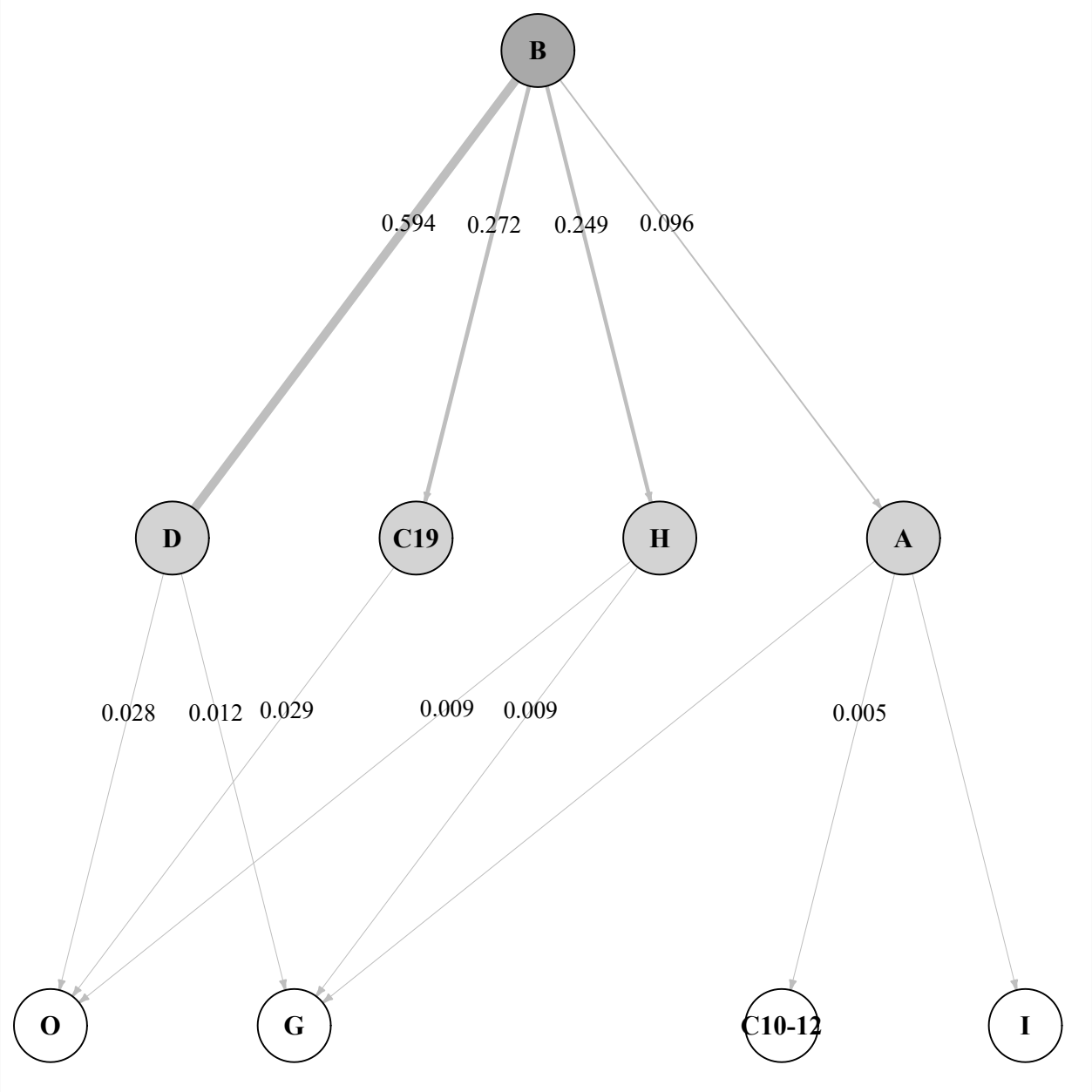
Greece: stranding cascade (q=0.05)



France: stranding cascade (q=0.1)



Italy: stranding cascade (q=0.1)



Slovakia: stranding cascade (q=0.05)