RFF-CMCC - EIEE Webinar

May 9, 2019 - h 12.00 pm CEST

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

Emanuele Campiglio, Presenter
Vienna University of Economics and Business (WU)

Francesco Lamperti, Moderator
Institute of Economics, Scuola Superiore Sant'Anna (Pisa) and RFF-CMCC European Institute on Economics and the Environment (EIEE), Centro Euro- Mediterraneo sui Cambiamenti Climatici, Italy

To attend the webinar, register at: http://bit.ly/WebMay9

www.cmcc.it

The RFF-CMCC European Institute on Economics and the Environment (EIEE)

RFF CMCC European Institute on Economics and the Environment

EIEE is an **transatlantic partnership** between two leading international research institutes **on economics**, **climate** and the **environment**

cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici

Euro-Mediterranean Center on Climate Change

RESOURCES for the FUTURE

Resources for the Future

RFF CMCC European Institute on Economics and the Environment

www.eiee.org

MISSION

To improve **environmental, energy and natural resource decisions** through **impartial economic research** and **policy engagement**

ECONOMICS
Our scholars have built some of the most powerful and insightful models for economic and environmental analysis at regional, national, and global scales.

ENVIRONMENT
From climate policy to a wider range of environmental, energy, natural resource and societal issues, we're addressing some of the most important challenges of our day.

EUROPE
We're a central focal point for research insights and policy solutions in Europe, with an international network of experts, policymakers, and stakeholders.

Q&A Session

To participate in the Q&A Session, please use the “Questions” menu provided by the Go-to-Webinar system

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

Louison Cahen-Fourot[1], **Emanuele Campiglio**[1], Elena Dawkins[2], Antoine Godin[3], Eric Kemp-Benedict[2],

May 9, 2019

RFF–CMCC–EIEE Webinar

[1]Vienna University of Economics and Business (WU)
[2]Stockholm Environment Institute
[3]Agence Française de Développement

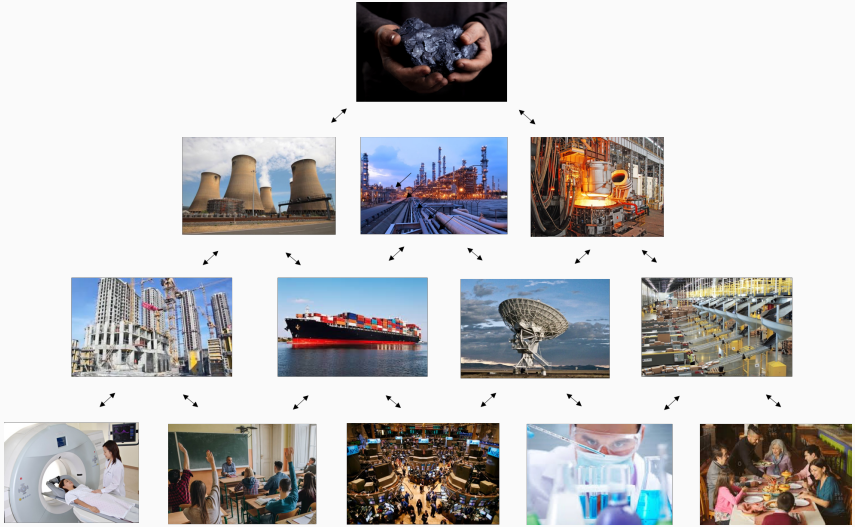
Stranded assets and systemic risk

- 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)

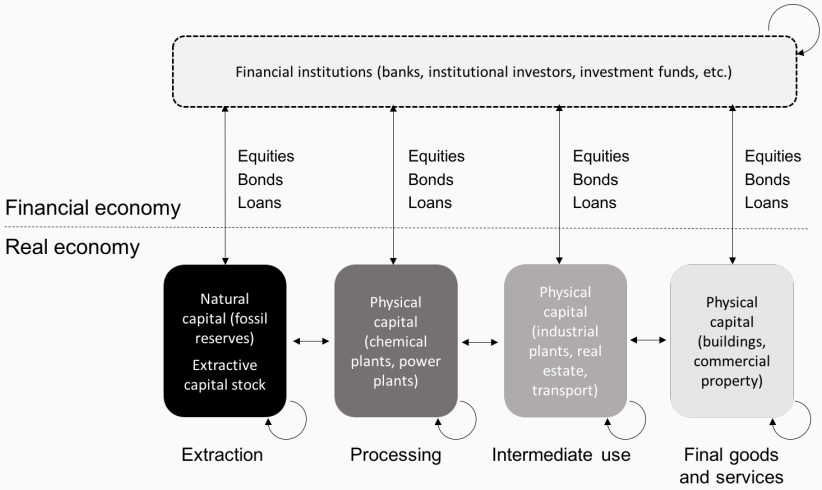
Stranded assets and systemic risk

- 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)
- 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

Stranding cascades in productive sectors



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)

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)
- 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

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
- Online material:
  - Working paper: http://epub.wu.ac.at/6854/
  - Code: https://github.com/capital-stranding-cascades

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

- The Ghosh ($\mathbf{G}$) matrix is defined as $\mathbf{G} = (\mathbf{I} - \mathbf{B})^{-1}$
  - $\mathbf{B} = \hat{\mathbf{x}}^{-1}\mathbf{Z}$ is the matrix of *allocation* coefficients
  - $\mathbf{G}$ takes into account both direct and indirect effects

A supply-side view: the Ghosh matrix

- The Ghosh ($\mathbf{G}$) matrix is defined as $\mathbf{G} = (\mathbf{I} - \mathbf{B})^{-1}$
  - $\mathbf{B} = \hat{\mathbf{x}}^{-1}\mathbf{Z}$ is the matrix of *allocation* coefficients
  - $\mathbf{G}$ takes into account both direct and indirect effects
- We create a matrix of "stranded asset multipliers" $\mathbf{S} = \hat{\kappa}\mathbf{G}^T$
  - κ_i is the capital intensity of sector i

A supply-side view: the Ghosh matrix

- The Ghosh ($\mathbf{G}$) matrix is defined as $\mathbf{G} = (\mathbf{I} - \mathbf{B})^{-1}$
  - $\mathbf{B} = \hat{\mathbf{x}}^{-1}\mathbf{Z}$ is the matrix of *allocation* coefficients
  - $\mathbf{G}$ takes into account both direct and indirect effects
- We create a matrix of "stranded asset multipliers" $\mathbf{S} = \hat{\kappa}\mathbf{G}^T$
  - κ_i is the capital intensity of sector i
- Every element $s_{i,j}$ of $\mathbf{S}$ can be interpreted as 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

- We apply the methodology to ten European countries for 2010:
  - Austria, Belgium, Czech Republic, Germany, Greece, France, Italy, Sweden, Slovakia and the United Kingdom.
  - Data availability constraints (switch to WIOD?)

Our data

- We apply the methodology to ten European countries for 2010:
  - Austria, Belgium, Czech Republic, Germany, Greece, France, Italy, Sweden, Slovakia and the United Kingdom.
  - Data availability constraints (switch to WIOD?)
- Source of data is the Eurostat statistical database:
  - symmetric input-output tables at basic prices (product by product, naio_10_cp1700)
  - cross-classification of fixed assets by industry and by asset (stocks, nama_10_nfa_st)

Our data

- We apply the methodology to ten European countries for 2010:
  - Austria, Belgium, Czech Republic, Germany, Greece, France, Italy, Sweden, Slovakia and the United Kingdom.
  - Data availability constraints (switch to WIOD?)
- Source of data is the Eurostat statistical database:
  - symmetric input-output tables at basic prices (product by product, naio_10_cp1700)
  - cross-classification of fixed assets by industry and by asset (stocks, nama_10_nfa_st)
- We consider both
  - Physical productive infrastructure (N112N) (dwellings are excluded)
  - Machinery and equipment (N11MN)

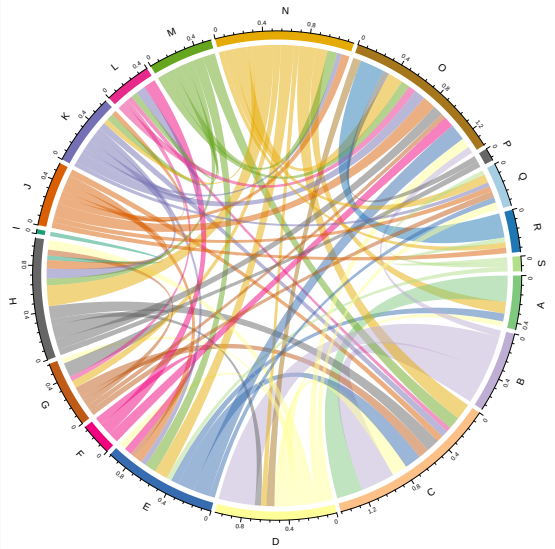
Our data

- We apply the methodology to ten European countries for 2010:
  - Austria, Belgium, Czech Republic, Germany, Greece, France, Italy, Sweden, Slovakia and the United Kingdom.
  - Data availability constraints (switch to WIOD?)
- Source of data is the Eurostat statistical database:
  - symmetric input-output tables at basic prices (product by product, naio_10_cp1700)
  - cross-classification of fixed assets by industry and by asset (stocks, nama_10_nfa_st)
- We consider both
  - Physical productive infrastructure (N112N) (dwellings are excluded)
  - Machinery and equipment (N11MN)
- 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

- We construct aggregate synthetic indicators of sectoral stranding multipliers and sectoral exposure to stranding risk
- Sectors with high stranding multipliers across countries
  - B: Mining and quarrying
  - C: Manufacturing
    - C33: Repair and installation services of machinery and equipment
  - M: Professional, scientific and technical activities
    - M74_75: Other professional, scientific and technical activities
  - N: Administrative and support service activities
    - N80-82: Security and investigation activities; buildings and landscape; office support
  - E: Water and waste management activities
    - Sweden, Austria
  - H: Transportation and storage
    - Czechia, Slovakia

Cascades of stranding originating in the mining sector

The effects of a low-carbon transition

- We select B to be at the origin of the cascade
  - We study the effects of a unitary drop of primary inputs used by sector B.

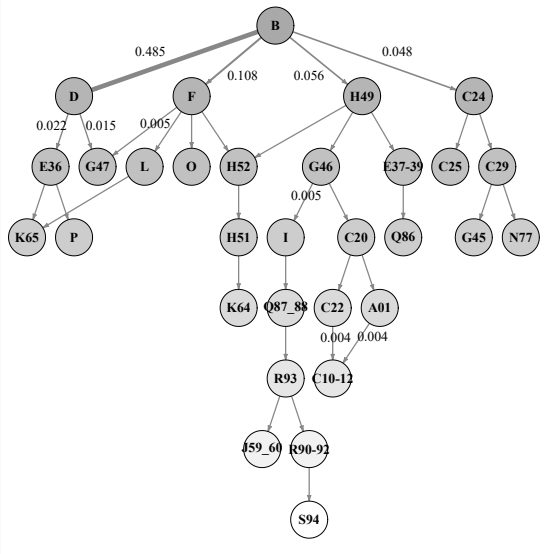
The effects of a low-carbon transition

- We select B to be at the origin of the cascade
  - We study the effects of a unitary drop of primary inputs used by sector B.
- We identify the sectors affected by the top q percentile of outward edges in terms of weight, and place them on the first layer of the network
  - We repeat the same procedure for the sectors in the first layer, and so on, until no new sectors are identified

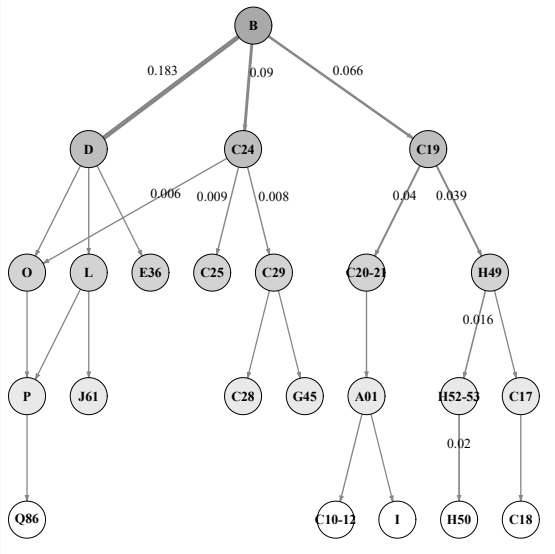
The effects of a low-carbon transition

- We select B to be at the origin of the cascade
  - We study the effects of a unitary drop of primary inputs used by sector B.
- We identify the sectors affected by the top q percentile of outward edges in terms of weight, and place them on the first layer of the network
  - We repeat the same procedure for the sectors in the first layer, and so on, until no new sectors are identified
- The weight of the edges is reduced by the weakening input loss of the sectors in the lower layers
  - Stranding is stronger the closer links are to the shock origin and get gradually weaker as they cascade downwards

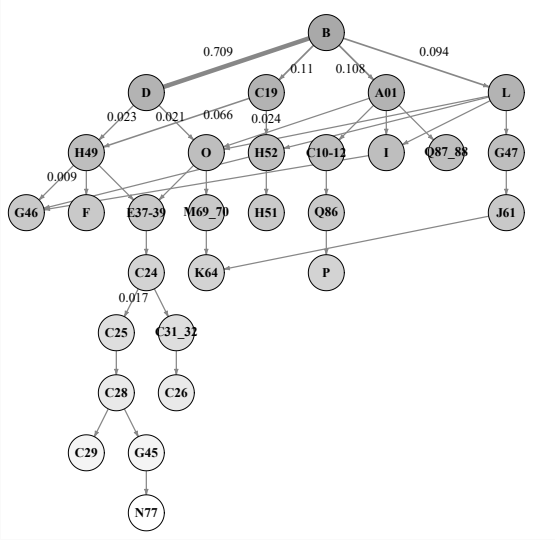
United Kingdom: stranding cascade (q=0.05)



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

- From D the stranding cascade often continues affecting:
  - Public administration (O)
  - Water services (E36)

Main conclusions

- From D the stranding cascade often continues affecting:
  - Public administration (O)
  - Water services (E36)
- From C19 the stranding cascade often continues affecting:
  - Chemicals (C20)
  - Land transport and pipelines (H49)

Main conclusions

- From D the stranding cascade often continues affecting:
  - Public administration (O)
  - Water services (E36)
- From C19 the stranding cascade often continues affecting:
  - Chemicals (C20)
  - Land transport and pipelines (H49)
- From C24 the stranding cascade often continues affecting:
  - Fabricated metal products (C25)
  - Motor vehicles (C29)
    - And from C29 further to trade of motor vehicles (G45)

Main conclusions

- From D the stranding cascade often continues affecting:
  - Public administration (O)
  - Water services (E36)
- From C19 the stranding cascade often continues affecting:
  - Chemicals (C20)
  - Land transport and pipelines (H49)
- From C24 the stranding cascade often continues affecting:
  - Fabricated metal products (C25)
  - Motor vehicles (C29)
    - 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

The capital stock at risk of stranding

- Two factors:
  - Loss of use of fossil fuels by other sectors
  - Loss of production for the fossil industry

The capital stock at risk of stranding

- Two factors:
  - Loss of use of fossil fuels by other sectors
  - Loss of production for the fossil industry
- No disaggregation of data available in Eurostat
  - We complement the analysis with Exiobase, a multi-regional IO database

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%)

Conclusions and future research

- Main conclusions
  - Mining is among the productive sectors with highest stranding multipliers
  - We can identify particularly relevant cascade patterns
  - Transition-driven physical capital stranding is likely to be significant and systemic

Conclusions and future research

- Main conclusions
  - Mining is among the productive sectors with highest stranding multipliers
  - We can identify particularly relevant cascade patterns
  - Transition-driven physical capital stranding is likely to be significant and systemic
- Future research directions:
  - Expand country sample
  - Decompose the effect of asset stranding (e.g. capital intensity, imports, ..)
  - Study employment effects
  - Link to financial stranding analysis
  - Include dynamic effects (macro modelling)

Thank you!

emanuele.campiglio@wu.ac.at

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

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

Additional slides

Stranding multipliers and risk exposure

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

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

- Subtracting the j-th diagonal element gives stranding effect on the rest of economic system (external stranding multiplier):

$$s_j^{\mathrm{EXT}} = s_j^{\mathrm{TOT}} - s_j^{diag}$$

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

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

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)

- Italy
  - B: Mining and quarrying
  - C19: Coke and refined petroleum products
  - M69-71: Legal; accounting; management consulting; architectural/engineering services
  - N: Administrative and support service activities
  - D: Electricity and gas

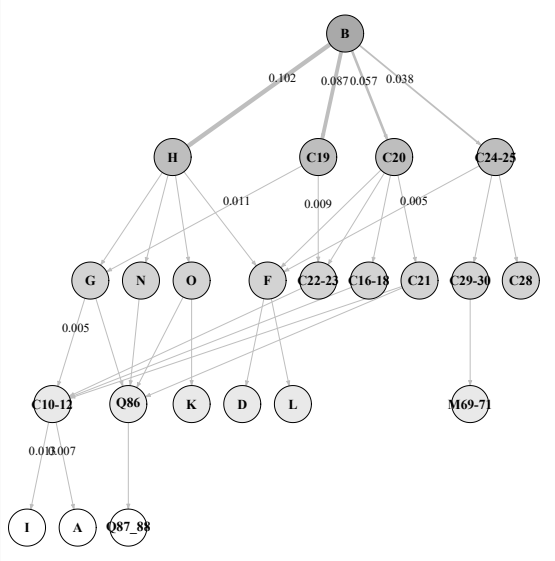
Exposure to stranding risk (top 5 sectors)

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)

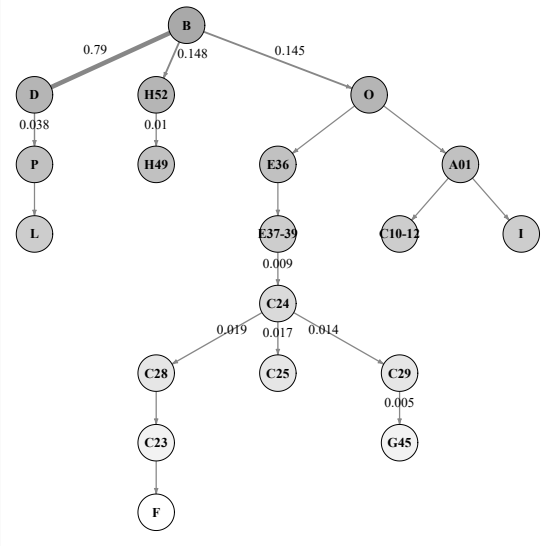
France	Italy	Sweden	Slovakia	UK
O (2.62)	H (2.97)	O (5.71)	D (11.69)	F (6.36)
L (0.97)	D (2.3)	L (3.93)	O (11.19)	H49 (2.64)
D (0.94)	O (2.28)	D (3.09)	H52 (11.16)	O (1.97)
H (0.77)	G (1.61)	J61 (2.42)	E36 (2.61)	H52 (1.72)
A (0.73)	A (1.54)	E36 (1.58)	C29 (2.33)	G47 (1.68)

- Italy
  - H: Transportation and storage
  - D: Electricity and gas
  - O: Public administration and defence; compulsory social security
  - G: Wholesale and retail trade; repair of motor vehicles and motorcycles
  - A: Agriculture, forestry and fishing

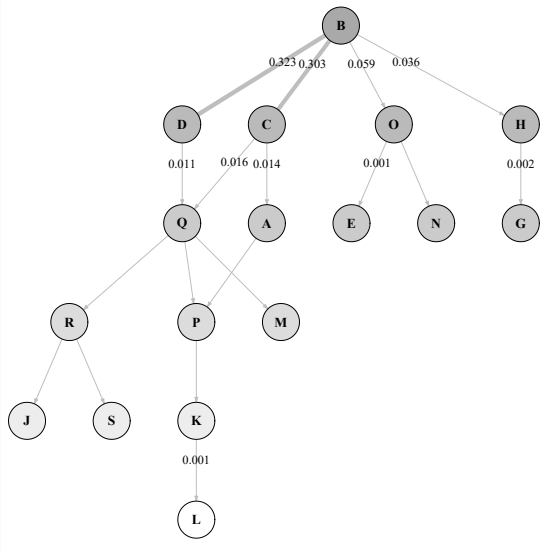
Belgium: stranding cascade (q=0.1)



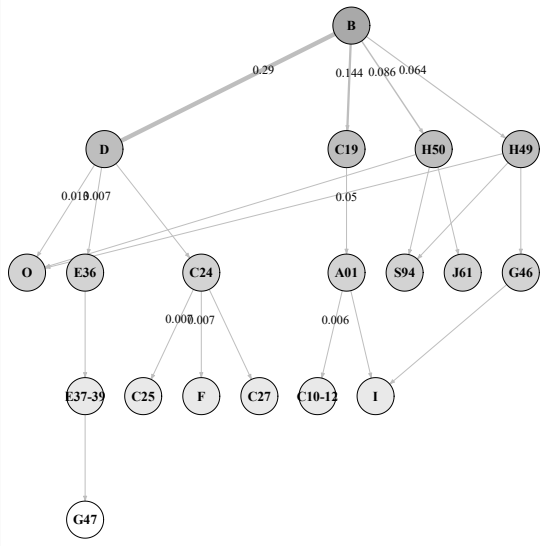
Czechia: stranding cascade (q=0.05)



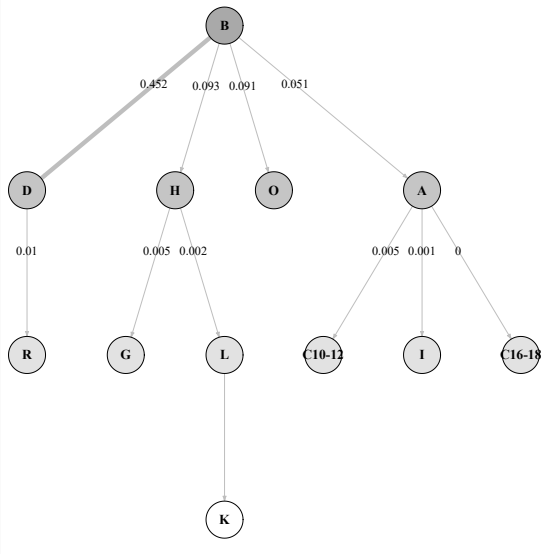
Germany: stranding cascade (q=0.2)



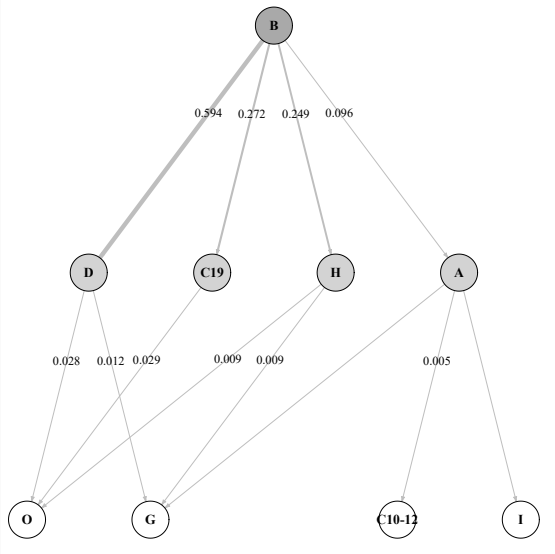
Greece: stranding cascade (q=0.05)



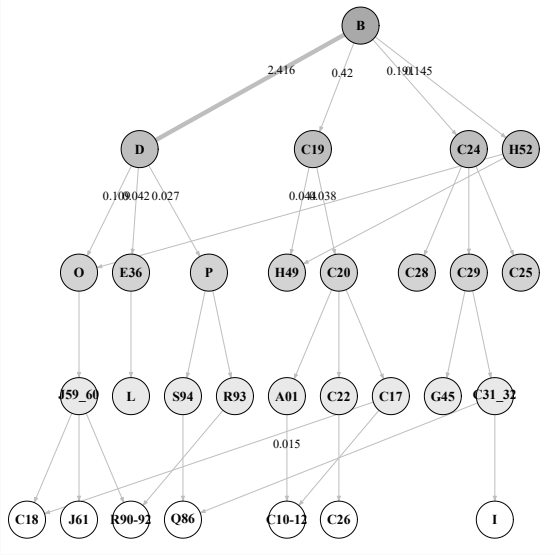
France: stranding cascade (q=0.1)



Italy: stranding cascade (q=0.1)



Slovakia: stranding cascade (q=0.05)



Q&A Session

To participate in the Q&A Session, please use the “Questions” menu provided by the Go-to-Webinar system

Thank you for attending this CMCC webinar.

This webinar was recorded and will be uploaded on CMCC Youtube Channel: https://www.youtube.com/CMCCvideo and to the CMCC website: www.cmcc.it

If you have any further question about the webinar, please email: webinar@cmcc.it

RFF CMCC European Institute on Economics and the Environment

cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici

Forthcoming CMCC Webinar

“Il servizio climatico CLIME: una piattaforma web per l’analisi e utilizzo multi utente dei dati climatici”

May 14, 2019 – h. 12:30 pm CEST

Presenter: Giuliana Barbato, Fondazione Centro Euro- Mediterraneo sui Cambiamenti Climatici, Italy
Moderator: **Sergio Noce**, Fondazione Centro Euro- Mediterraneo sui Cambiamenti Climatici, Italy

RFF CMCC European Institute on Economics and the Environment

cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici