Technology Network Structure Conditions the Economic Resilience of Regions

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Motivation

Structural challenges and persistent disparities in economic performance across European regions.

- Stagnating and declining industrialised and peripheral regions, dynamic large urban agglomerations (Iammarino et al. 2019).
- Slow and uneven recovery in the aftermath of the 2008 crisis (OECD 2019):
    - 8+ years to reach pre-crisis levels of GPD/capita for many regions
    - Some capital regions creating more than 50% of new jobs since 2006 in their country.
- Regions are increasingly exposed to external shocks due to openness and interdepedencies in the global economy.
- Growing political discontent following diminishing economic opportunities for people in an increasing number of regions (Rodríguez-Pose 2018).

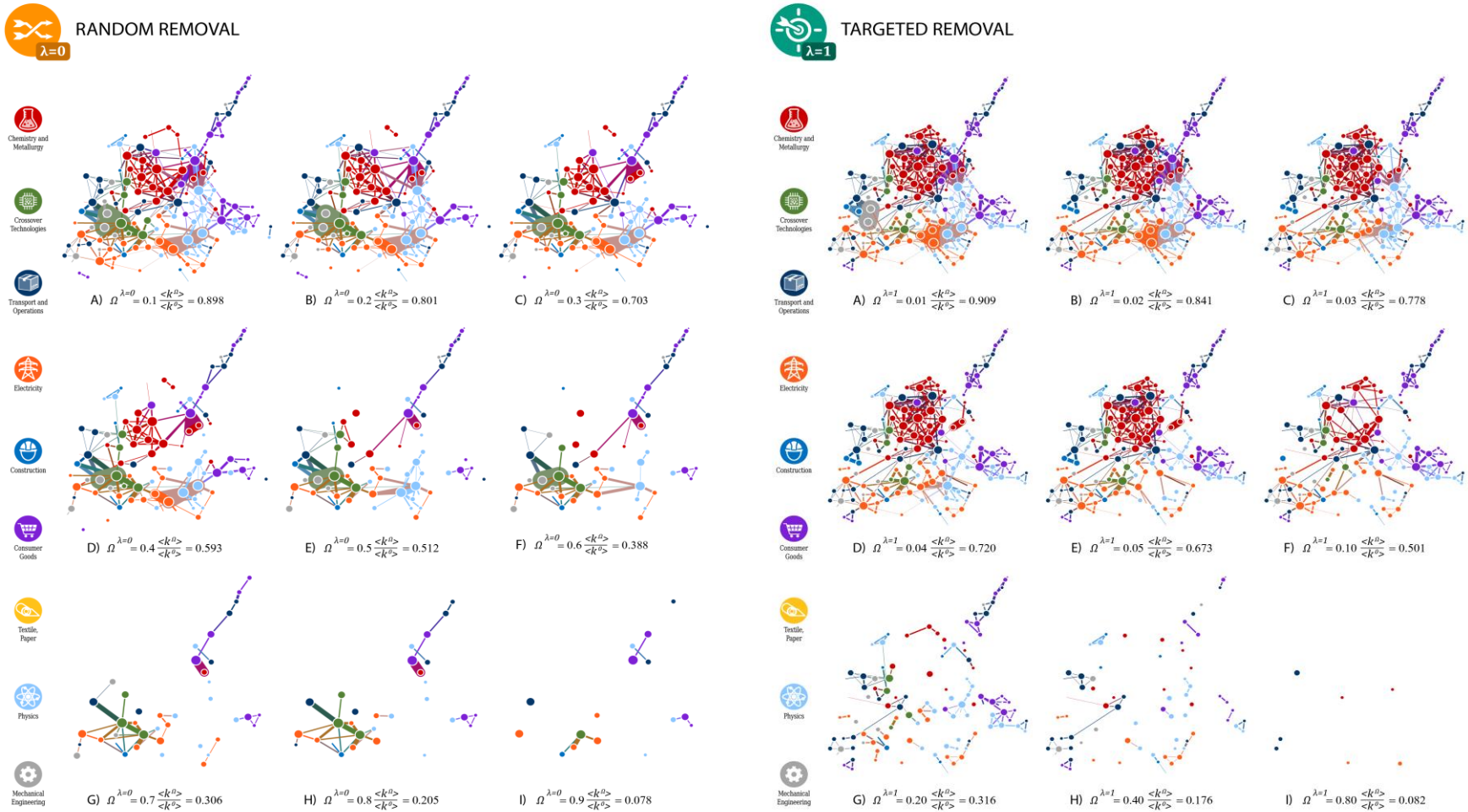
Motivation

General question: why are some regions more vulnerable to structural pressures than others?

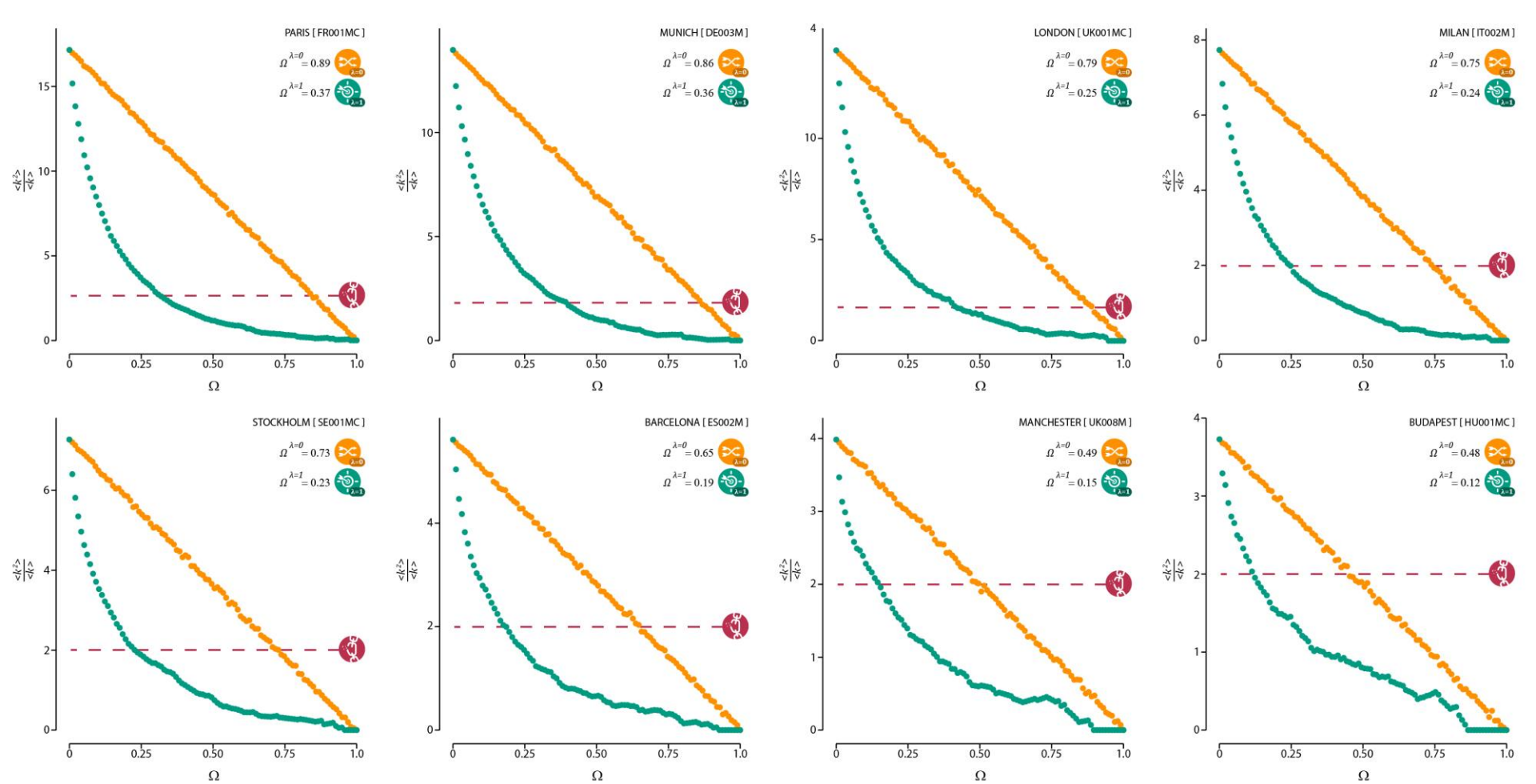
Regional economic resilience: the capacity of regional economies to withstand economic shocks and at the same time to retain the long-term ability to develop new growth paths (Christopherson et al. 2010, Martin 2012, Boschma 2015, Bristow & Healy 2020).

- Industrial structure is a key determinant of resilience (Doran & Fingleton 2018, Martin-Sunley 2020).
- Networks have been used to capture the local economic structure and to understand the diversification (e.g. Neffke et al. 2011, Boschma et al. 2013, Kogler et al. 2017), and the resilience of regions (Balland et al. 2015).

Aim: to assess the robustness of a region's network structure against the elimination of some of its nodes (technological capabilities), and to provide systematic evidence on how this network robustness conditions the economic resilience of regions.

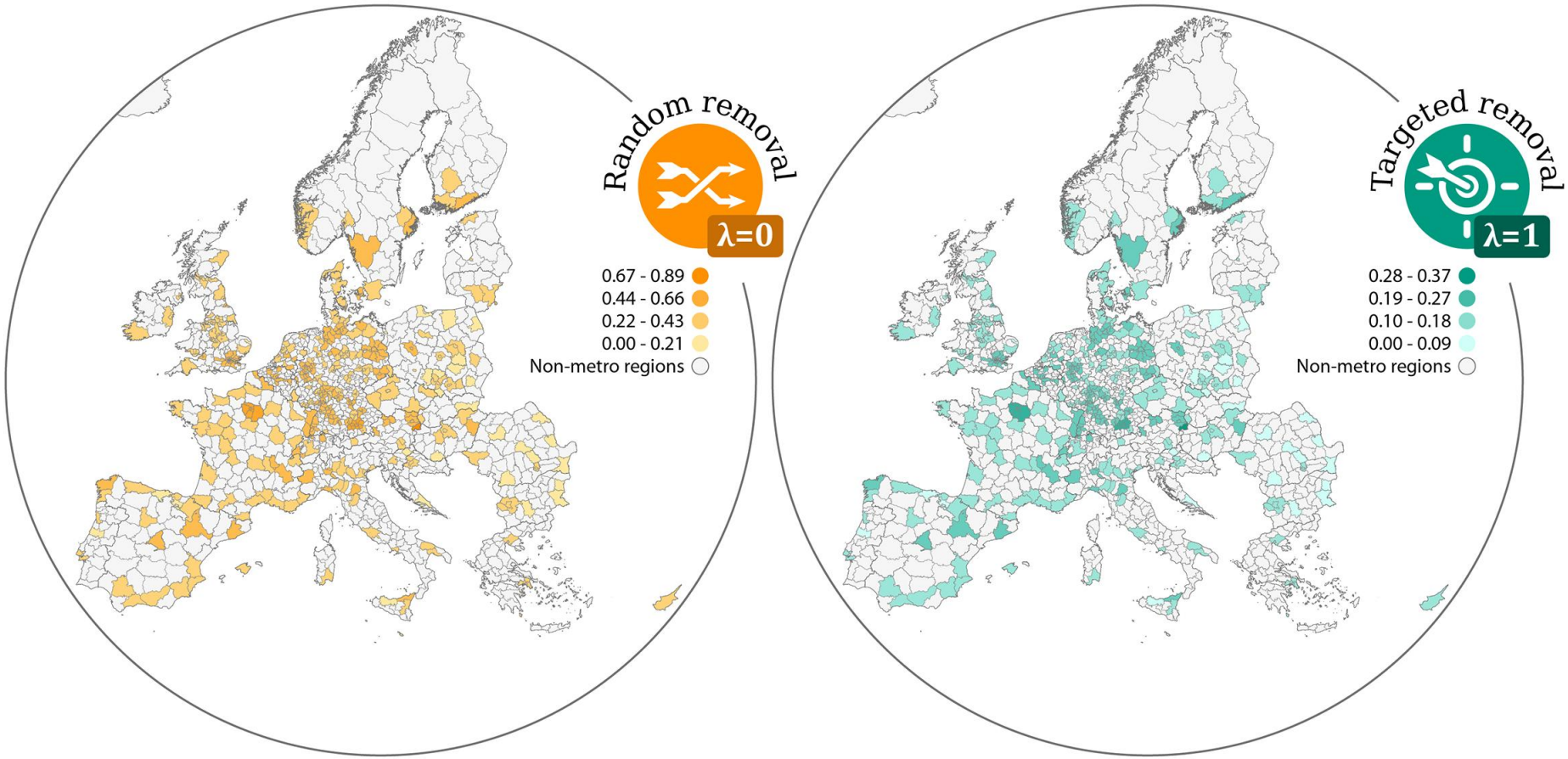


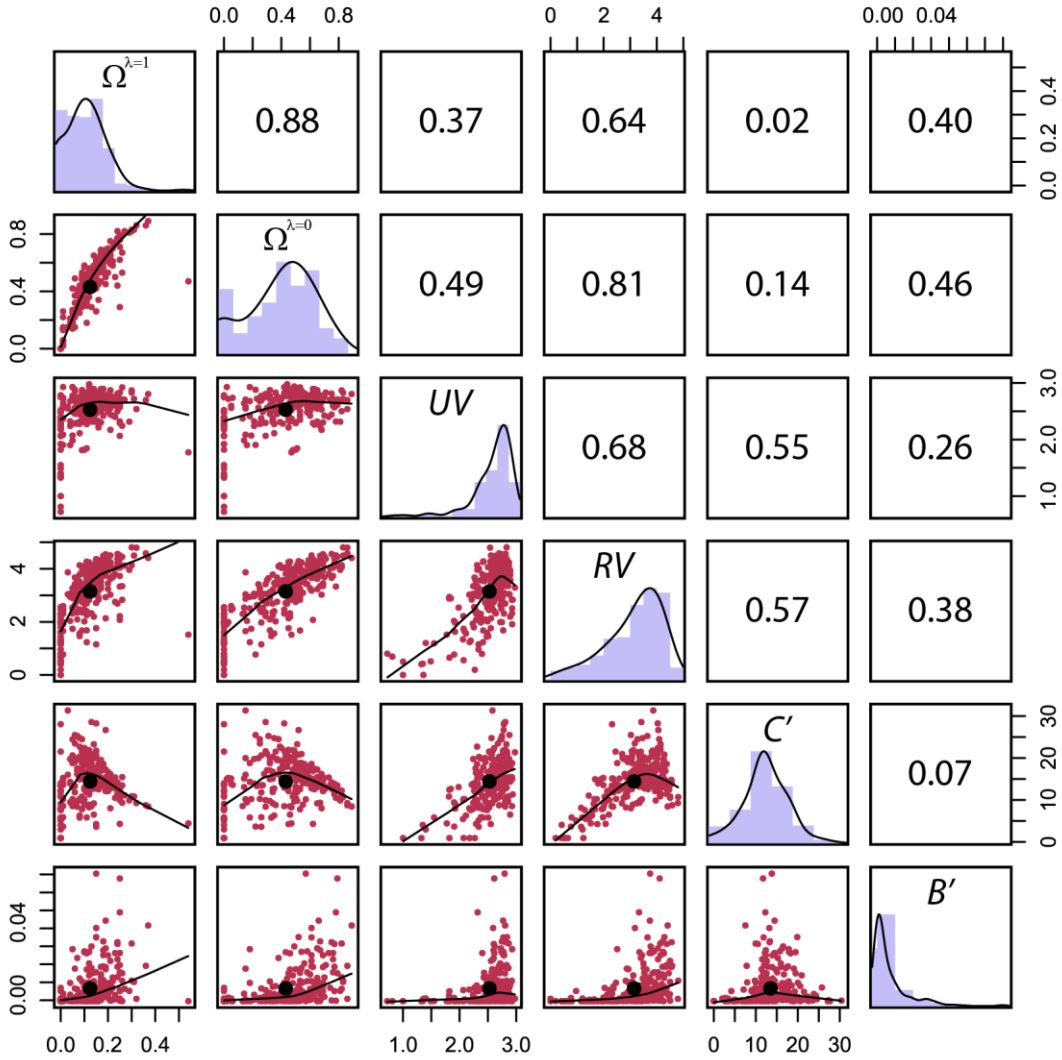
The colour of the node represents the broad economic sector that primarily utilizes that specific technology class, the size of the node corresponds to the number of patents belong to the given technology class, and the weight of the connection is equal to the co-occurrence of technology classes on patents. $\Omega^{\lambda=0}$ refers to the extent of the random failure and $\Omega^{\lambda=1}$ refers to the extent of the attack



The figure shows the tolerance of metropolitan regions against targeted and random elimination based on their technological network (2006 – 2008). The green series of dots refers to targeted, the yellow series of dots refers to random elimination of technologies, while the red dashed line indicates the threshold for the collapse of the giant component. Using the Molloy-Reed criterion, a giant component exists if $\langle k^2 \rangle / \langle k \rangle$ is higher than 2. $\Omega^{\lambda=0}$ and $\Omega^{\lambda=1}$ denotes the amount of eliminations the city can tolerate with a functioning network.

Geography of technology network robustness in Europe



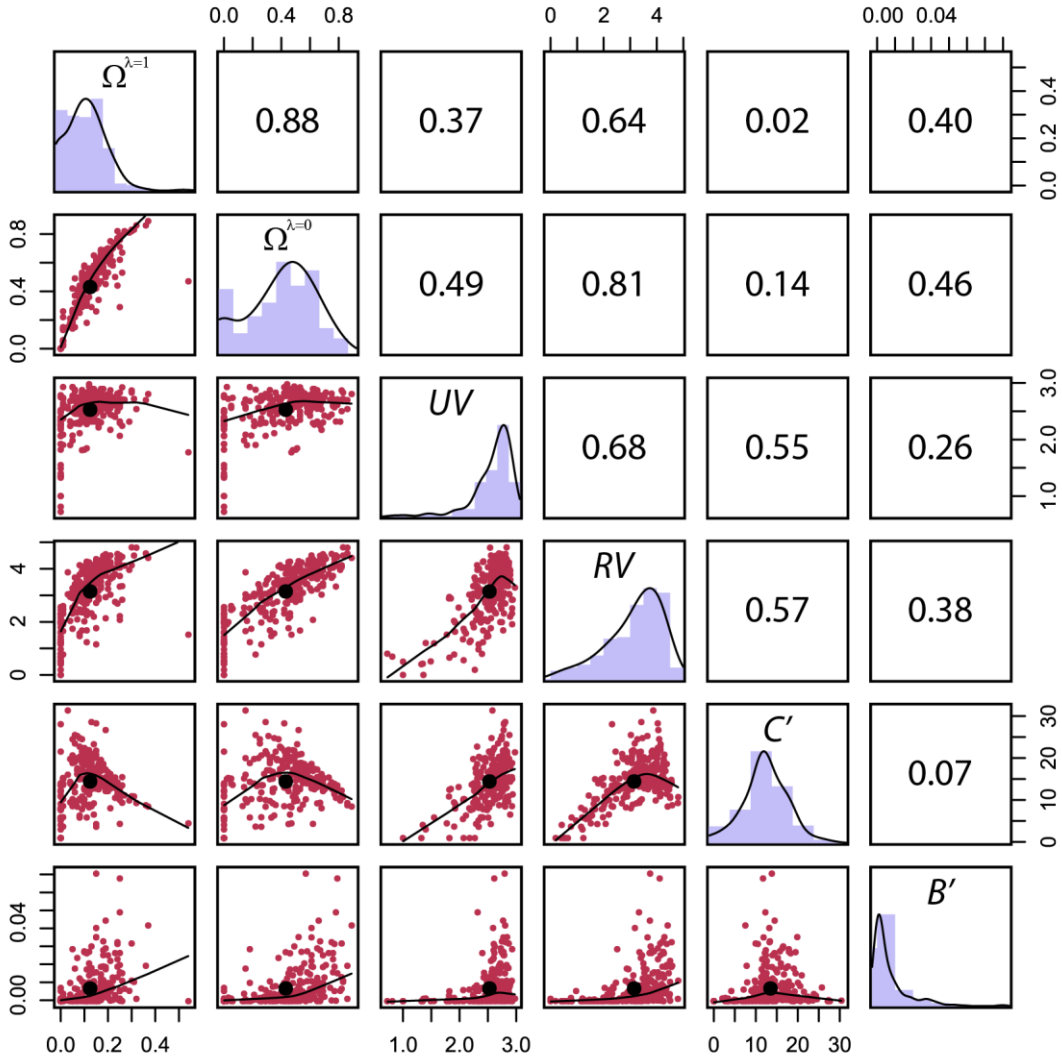


Following Frenken (2007), unrelated variety (UV) captures the variety of technology codes between higher-order groups (1-digit level),

$$UV = \sum_{i \in S_j}^{J} P_j log_2 \left(\frac{1}{P_j} \right)$$

and related variety (RV) captures the degree of variety within the group (3-digit level)

$$RV = \sum_{j=1}^{J} p_j \sum_{i \in S_j} \frac{p_i}{P_j} log_2 \left(\frac{1}{\frac{p_i}{P_j}} \right)$$

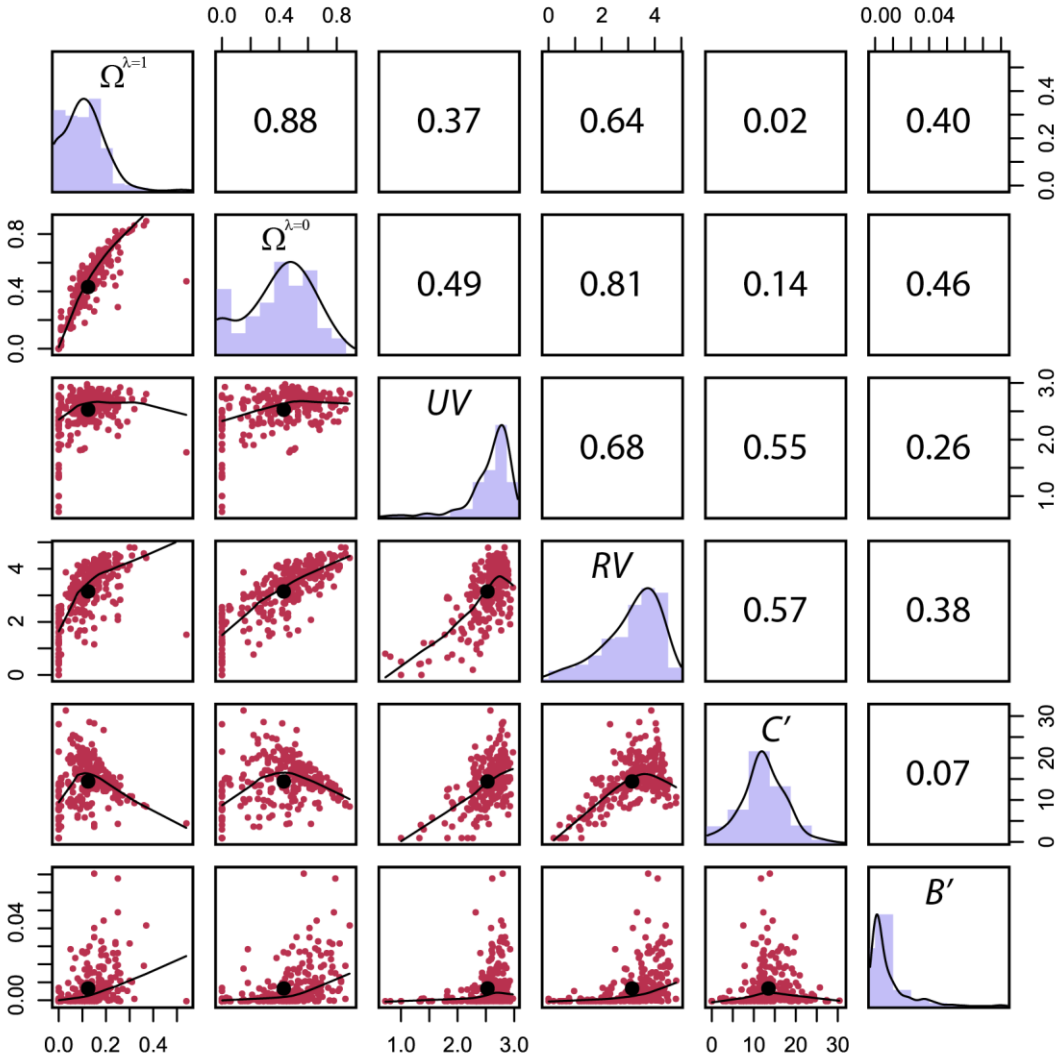


We control for average clustering, which is the probability that two neighbours of a randomly selected node link to each other.

$$C_j = \frac{2L}{k_j(k_j-1)}$$

However, the concept of clustering is sensitive to the size of the network, thus our final variable can be expressed as:

$$C' = \frac{\frac{1}{N}\sum_{j=1}^{N} C_j}{C_{ER}(N_j, L_j)}$$



Finally, following Balland et al. (2015), bridging is measured as the normalized betweenness centrality score for each region based on their position in inter-regional collaboration network:

$$B'_r = \sum_{j \neq j \neq r} \frac{p_{ij}(r)}{p_{ij}}$$

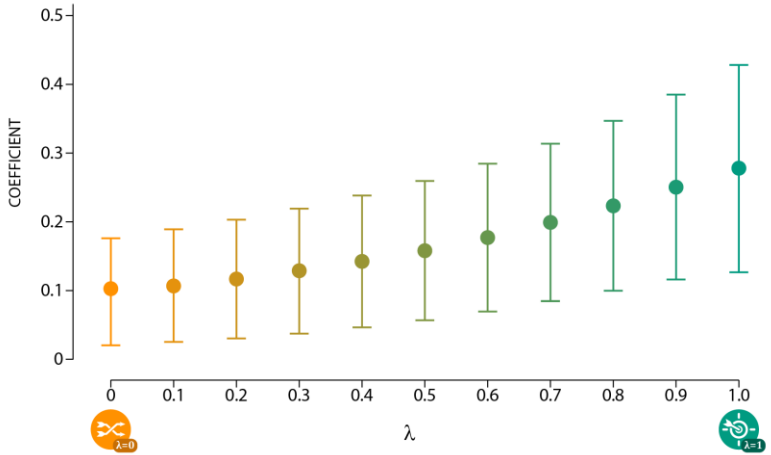
$$\frac{Emp_{i,t+1}}{Emp_{i,t}} = \alpha + \gamma_1 \Omega^{\lambda} + \beta_1 \left[\Phi_{i,t}\right] + \beta_2 X'_{i,t} + e_{i,t} \quad \text{where} \quad \Phi_{i,t} = (UV, RV, C', B')$$

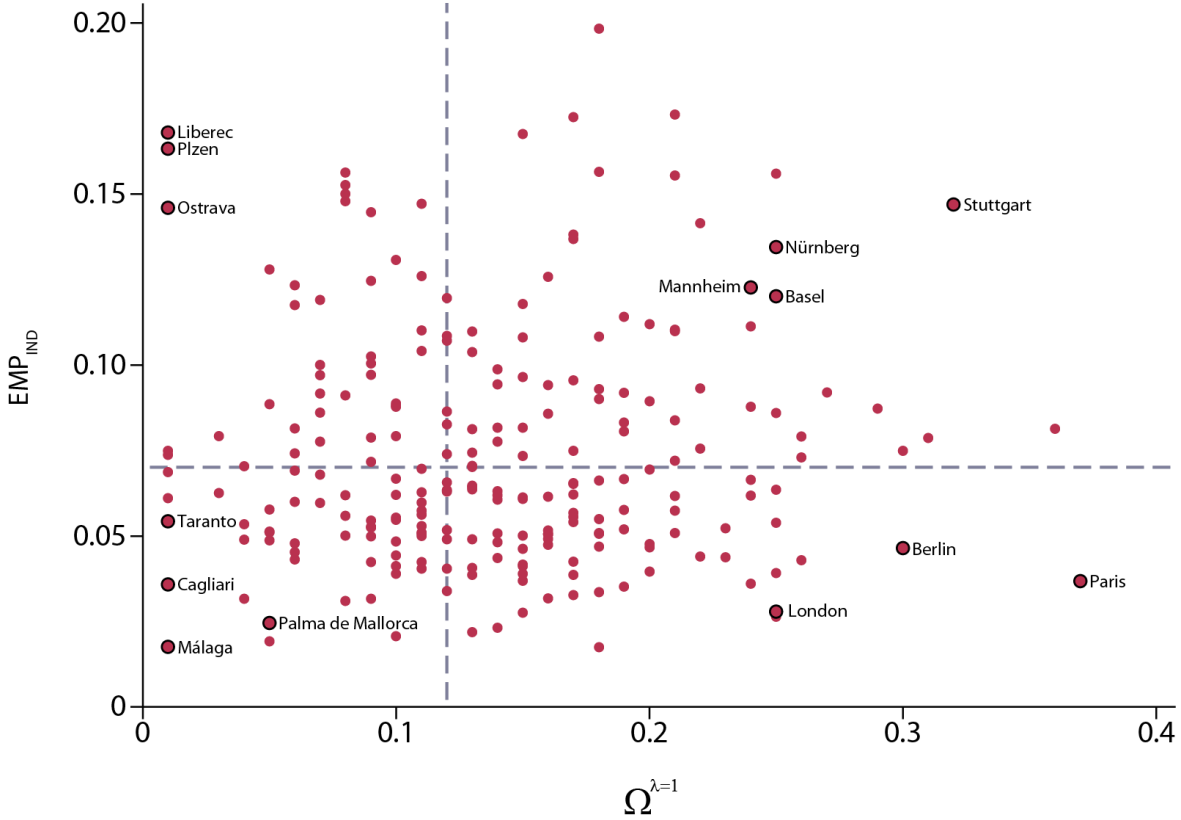
	(1)	(2)	(3)	(4)	(5)	(6)
	All sectors	Industry	All sectors	Industry	All sectors	Industry
$\Omega^{\lambda=0}$			**0.0594**	**0.1046*** **		
			(0.038)	**(0.036)**		
$\Omega^{\lambda=1}$					**0.1618** **	**0.2487*** **
					(0.076)	**(0.079)**
UV	0.0216	0.0023	0.0403*	0.0161	0.0436**	0.0212
	(0.02)	(0.023)	(0.021)	(0.026)	(0.02)	(0.025)
RV	0.0545***	0.0758**	0.0208	0.0372	0.0205	0.0388
	(0.018)	(0.03)	(0.015)	(0.027)	(0.015)	(0.027)
C'	-0.0035***	-0.0035*	-0.0755**	-0.0385	-0.0855**	-0.0561
	(0.001)	(0.002)	(0.034)	(0.048)	(0.034)	(0.052)
B'	0.6184	0.2647	0.5024	0.069	0.4798	0.0583
	(0.444)	(0.537)	(0.480)	(0.620)	(0.467)	(0.633)
	(0.038)	(0.016)	(0.046)	(0.017)	(0.043)	(0.017)
Constant	1.2406***	1.4044***	1.2078***	1.4034***	1.1993***	1.3947***
	(0.122)	(0.160)	(0.140)	(0.174)	(0.139)	(0.176)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.214	0.196	0.209	0.191	0.216	0.195
Adj. R^2	0.193	0.174	0.184	0.166	0.192	0.17
Observations	269	269	269	269	269	269

* p<0.1; ** p<0.05; *** p<0.01

We find a positive association between network robustness and predicted employment growth in industry for a range of λ parameter values

The coefficient of network robustness increases with increasing the λ parametermeaning, meaning that this network structure is more consequential for resilience the more a shock is affecting the core capabilities of the region.





Technology network robustness and employment in industry across European metropolitan areas.

Based on this classification, the most disconcerting regions would be those metropolitan areas with a high share of industrial employment but a vulnerable technological capability base, such as Liberec, Plzen or Ostrawa.

These, typically traditional industrial regions likely require attention from policy in case of a shock to core technological capabilities.

Conclusion

We propose a novel measure of resilient regions, connecting more tightly the literatures of network robustness and regional economic resilience.

We show that the network robustness of the local technological capability base predicts employment growth in the context of 269 metropolitan regions across Europe during the 2008 economic crisis.

First step...

- Technology space is a crude proxy for underlying capabilities.
- Static network, analysis limited to resistance to crisis.
- Random and targeted elimination measures capacity, not shock propagation.

Thank you for your attention!

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