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Spatial Diffusion of Patents in Europe: Trends in Dispersion and Concentration In Central-Eastern European and Western European Countries, 1980–2022

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Has the East met the West?

Spatial Dynamics of Innovation in Europe (1980–2022)

DATA

- 3.2 million patents (Europe)
- 30 countries
- 1980–2022
- OECD Regions (TL2 & TL3) + de Rassenfosse et al. (2019)

A unique 42-year perspective combining two datasets

COHESION POLICY

- spread diffusion
- regional development

EXCELLENCE POLICY

- clusters top universities
- innovation hubs

Two competing forces shape the geography of innovation

METHODS

Regional data — Lorenz curve → GINI (inequality within country)

Point data — Voronoi cells → ETA (spatial concentration beyond borders)

Two complementary lenses for a deeper view of space

POLICY DILEMMA

COHESION POLICY (diffusion & convergence) ⟷ EXCELLENCE POLICY (agglomeration & divergence)

U-SHAPED OUTCOME

THE BIG PICTURE

Spatial concentration of innovation

1980 → 2022

U-SHAPED TRAJECTORY

Diffusion (1980s – early 2010s): Decreasing concentration: spillovers, cohesion, convergence, catching-up

Re-concentration (early 2010s – 2022): Increasing concentration: core-periphery dynamics, divergence

Innovation became more spatially dispersed until the early 2010s, then concentration increased again.

EAST vs WEST

WEST (WE)
- ✓ less concentrated
- ✓ mature innovation systems

EAST (CEE)
- ✓ stronger diffusion
- ✓ but still more concentrated

→ Partial convergence, but persistent structural asymmetries in innovation geography

EUROPEAN INNOVATION LANDSCAPE

- Regional rankings of patents show persistency and slow convergence.
- Top regions in 1980s remain on top in 2010s – same leaders, different order.

Concentration in few dominant regions → More regions contribute Dispersion & diffusion → Leading hubs strengthen again

MAIN DISCOVERY

"Spatial equalisation is temporary."

Innovation eventually re-agglomerates.

KEY TAKEAWAY

- Europe does not follow a linear path.
- The geography of innovation follows a U-shaped path driven by two competing policy forces.
- Understanding this dynamic is crucial for designing effective innovation and regional policies.

Source: Own calculations based on OECD Regions and Cities Atlas and de Rassenfosse et al. (2019) Kopczewska & Piotrowska (2024)

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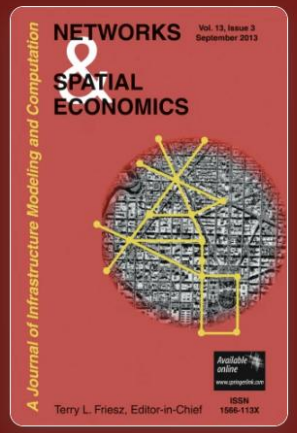

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Abstract

This paper examines long-term trajectories of the spatial concentration of innovation activity across regions in 30 European countries using patent data covering the period

Sections Figures References

Abstract

Highlights

Introduction

Literature Review

Methodology

Spatial organisation of innovative activity

- Let’s start with short survey – how do you think?
  - **Are patents distributed evenly within (inside) European countries?**
    - Does each region have the same level of patent intensity?
  - **What is the trajectory of the spatial concentration of patents?**
    - Are patents becoming more territorially dispersed or more concentrated?
  - **Are there differences between East and West?**
    - Is the degree of patent concentration the same in Western Europe and Central-Eastern Europe?

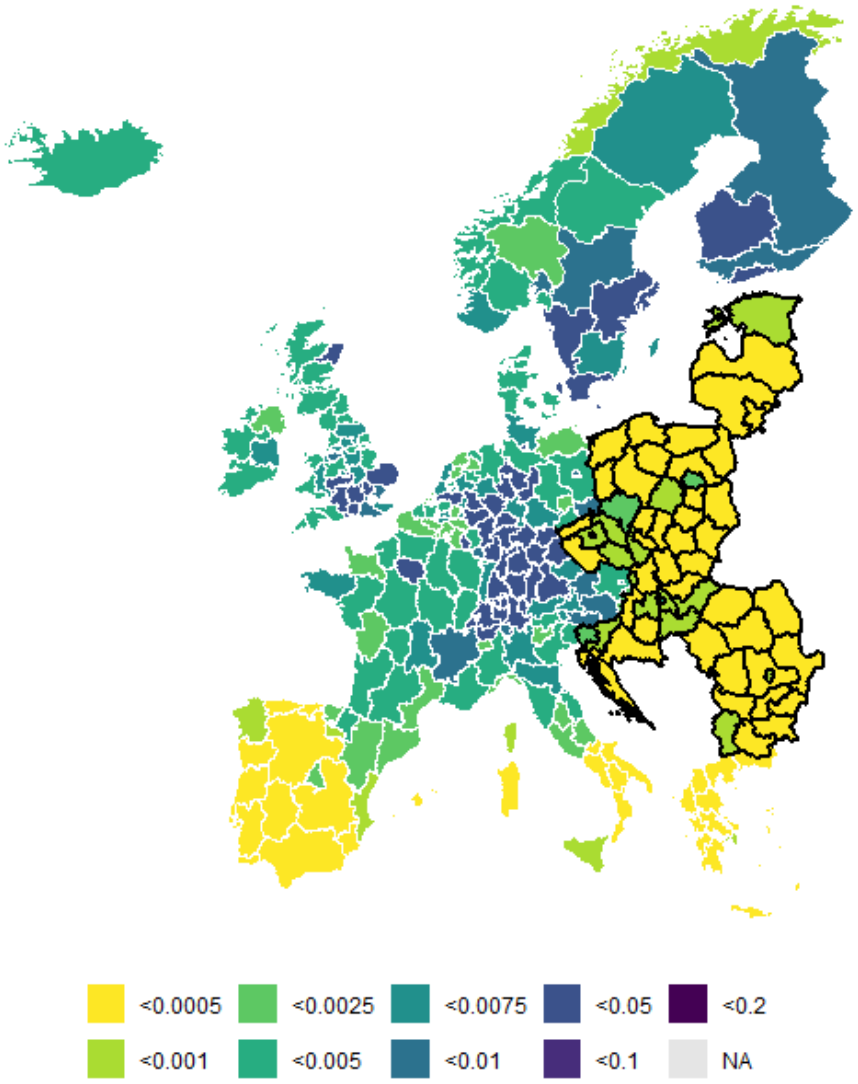
Why those questions are important?

- **The European policy paradox**
  - Cohesion policy → spatial diffusion – patents everywhere
  - Excellence policy → spatial concentration – patents in hubs
  - Which force has dominated in the long run – over the last 40+ years?

- Patents and innovations are considered as an important engine of growth
- Innovative regions are considered as competitive, resilient, dynamic
- Regions with less patents risk being ‚lagging behind places'

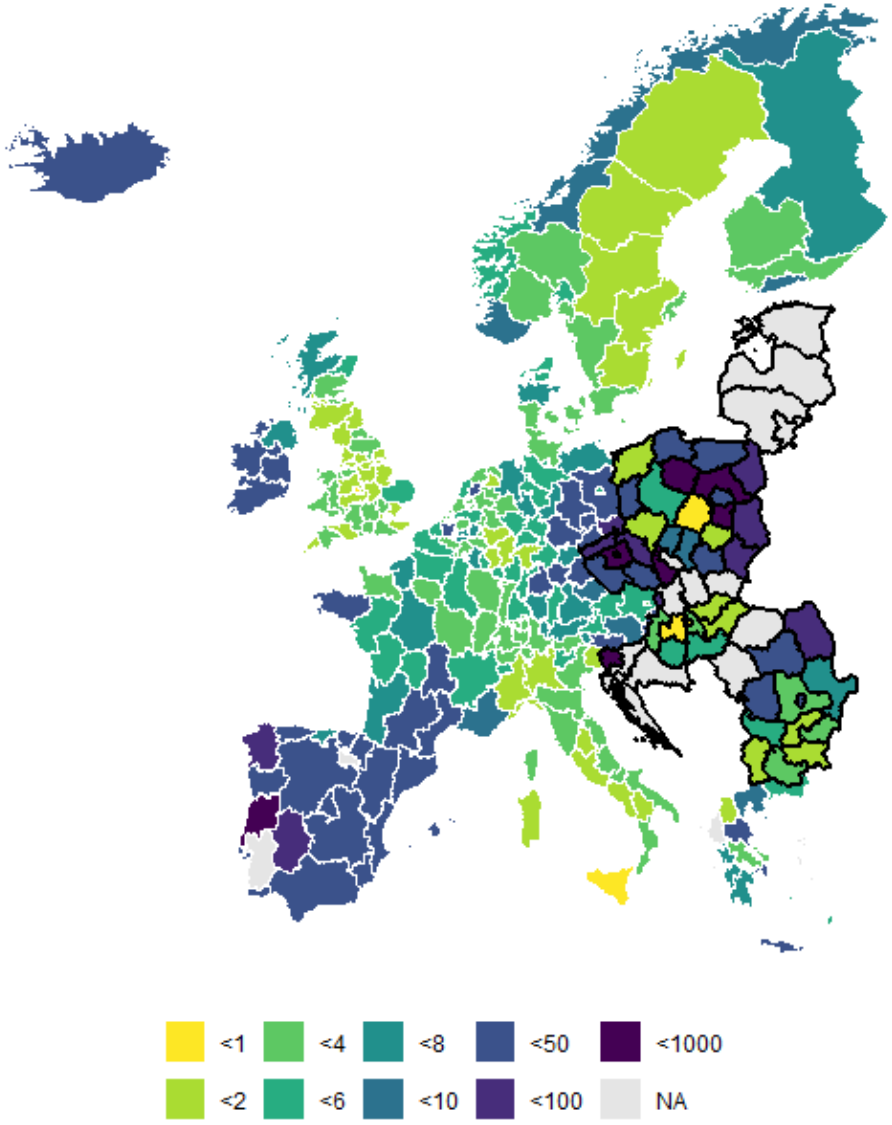
Total number of patents 1980-2014 per 1.000 inhabitants

Dark borders of regions are for Central-Eastern countries



Growth rate of number of patents between 1980-1984 and 2010-2014

Dark borders of regions are for Central-Eastern countries



Data – not an obvious part of the study

- Patents and innovations are one of the most important development factors – and therefore **essential economic data**
- Suprisingly, **EUROSTAT stopped collecting regional patent data 10+ years ago**
- European regional patent data, based on EPO (European Patent Office) data, are available from **OECD Regions and cities atlas** (for TL2 and TL3 units) – now for 1995-2022
- There is also a dataset by de **Rassenfosse et al. (2019) published in Scientific Data** journal – with **geo-located point data** for years 1980-2014 for the whole world (3.2 mln for Europe)
- This study makes a **42-years** analysis from those two datasets to understand trajectory of spatial concentration – for **30 European countries** and their regions
- Number of regions varies between datasets and years, from **227 in case of TL2** OECD dataset, **432 in case of de Rassenfosse et al.** (2019) dataset and **1012 in case of TL3 OECD** dataset.

Methods – for regional data

Gini Index for regions within the country:

$$G = \frac{n+1}{n-1} - \frac{2}{n(n-1)\mu}\sum (n+1-i)x_{[i]}$$

calculated in rolling-window of 5-years average (stabiliser for annual frictions)

Checking the temporal trend with quadratic regression:

$$Gini = \beta_0 + \beta_1 \cdot t + \beta_2 \cdot t^2 + \varepsilon$$

$$Gini = 0.72 - 0.007 \cdot t + 0.002 \cdot t^2 + \varepsilon$$

with all coefficient significant

Gini~0 is interpreted as regular distribution
Gini~1 is interpreted as extreme concentration

Methods– for point data

ETA (Entropy-Tesselation-Agglomeration) index

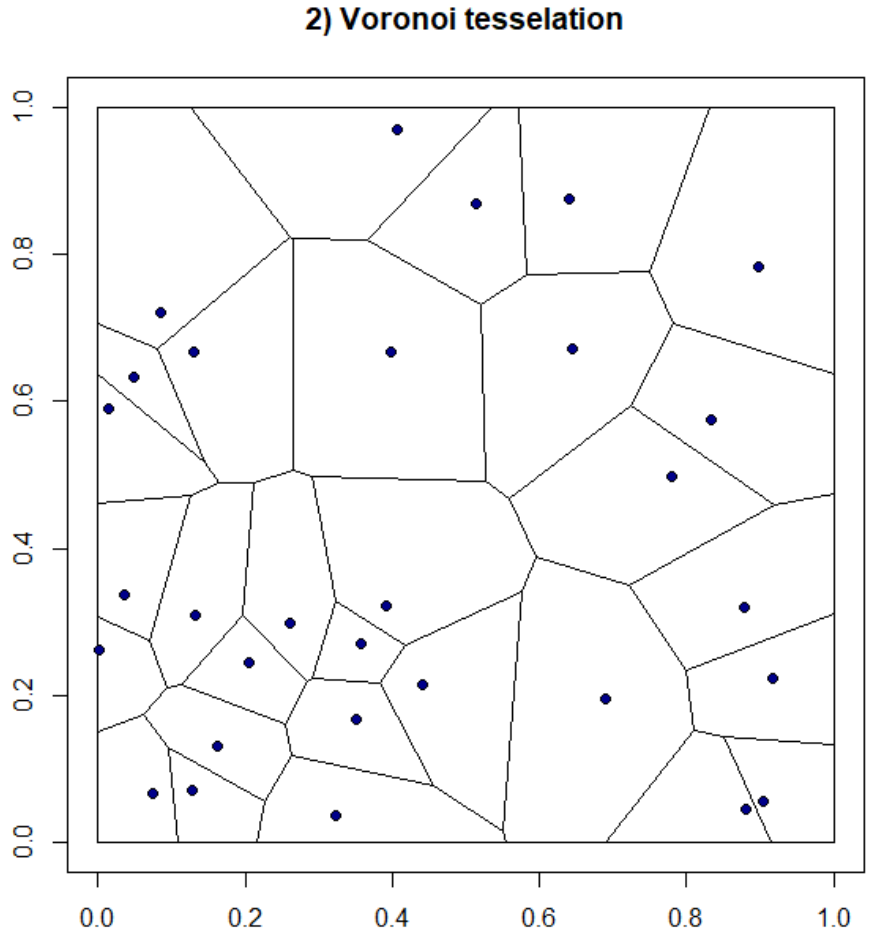
$$H_{empir} = -\sum_{i=1}^{n} p_i * \log(p_i)$$

$$H_{max} = -n \cdot p_i \cdot \log(p_i) = -n \cdot \frac{1}{n} \cdot \log\left(\frac{1}{n}\right) = -\log(\frac{1}{n})$$

$$H_{rel} = \frac{H_{empir}}{H_{max}}$$

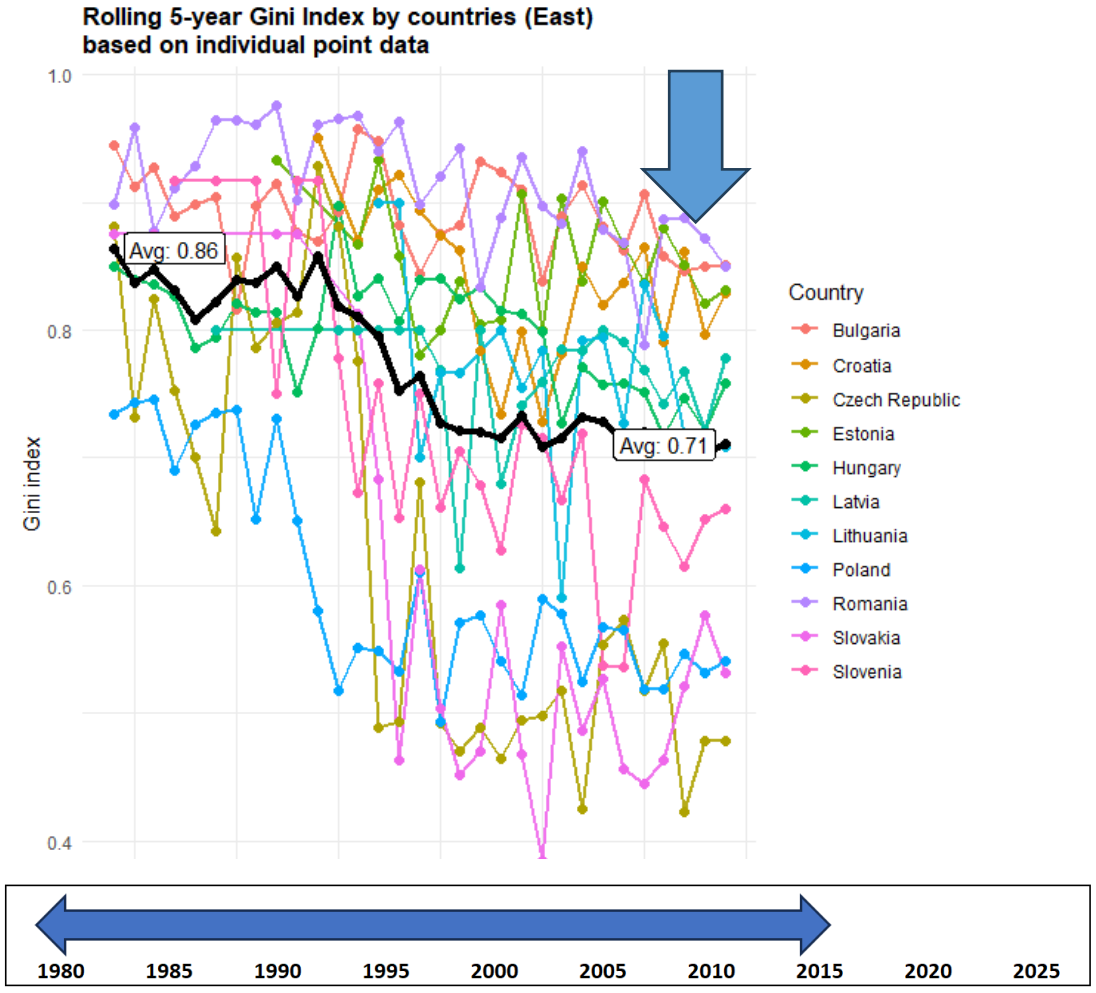
p(i) is the share of ith tile from the Voronoi tesselation

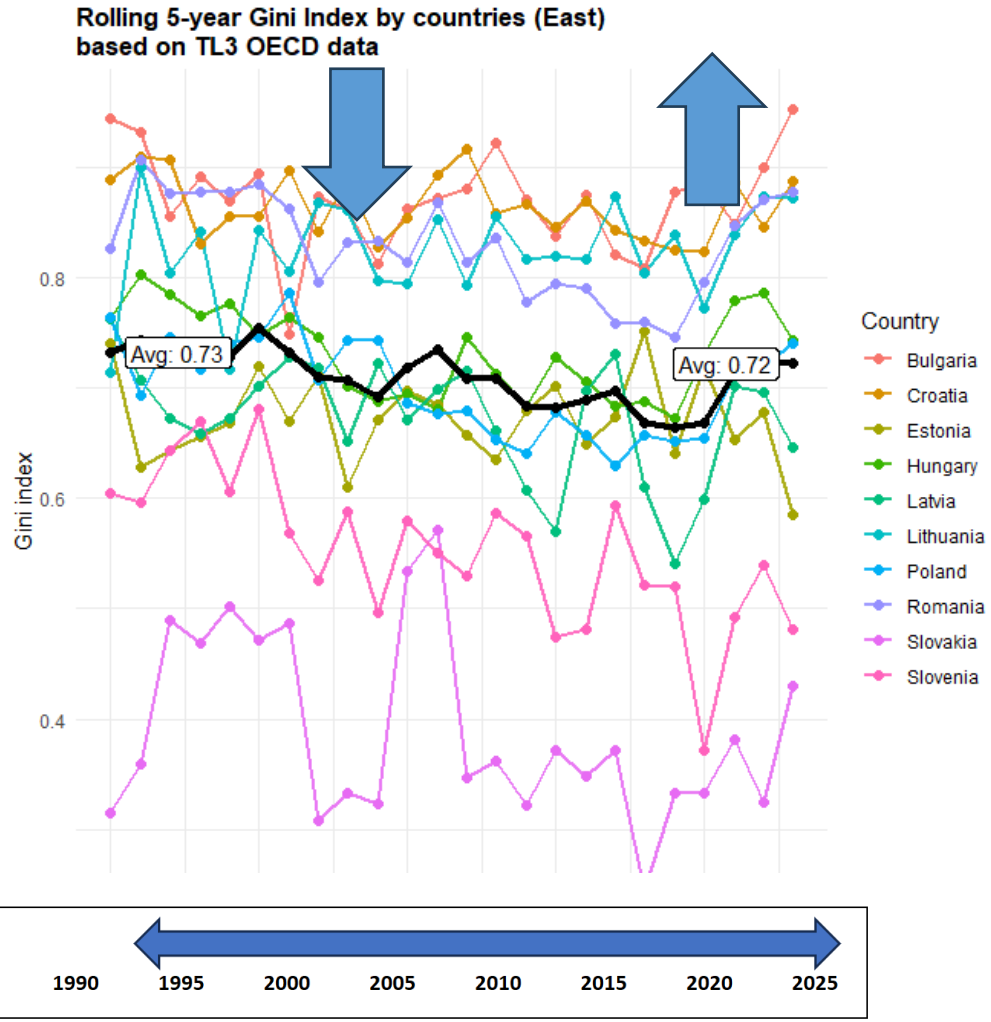
For 5-years data – geolocated patents within the country, ETA index was calculated



ETA~1 is interpreted as regular distribution
ETA~0 is interpreted as extreme concentration

Gini coefficient for a regional number of patents in Central-Eastern European countries – rolling window of 5-years average





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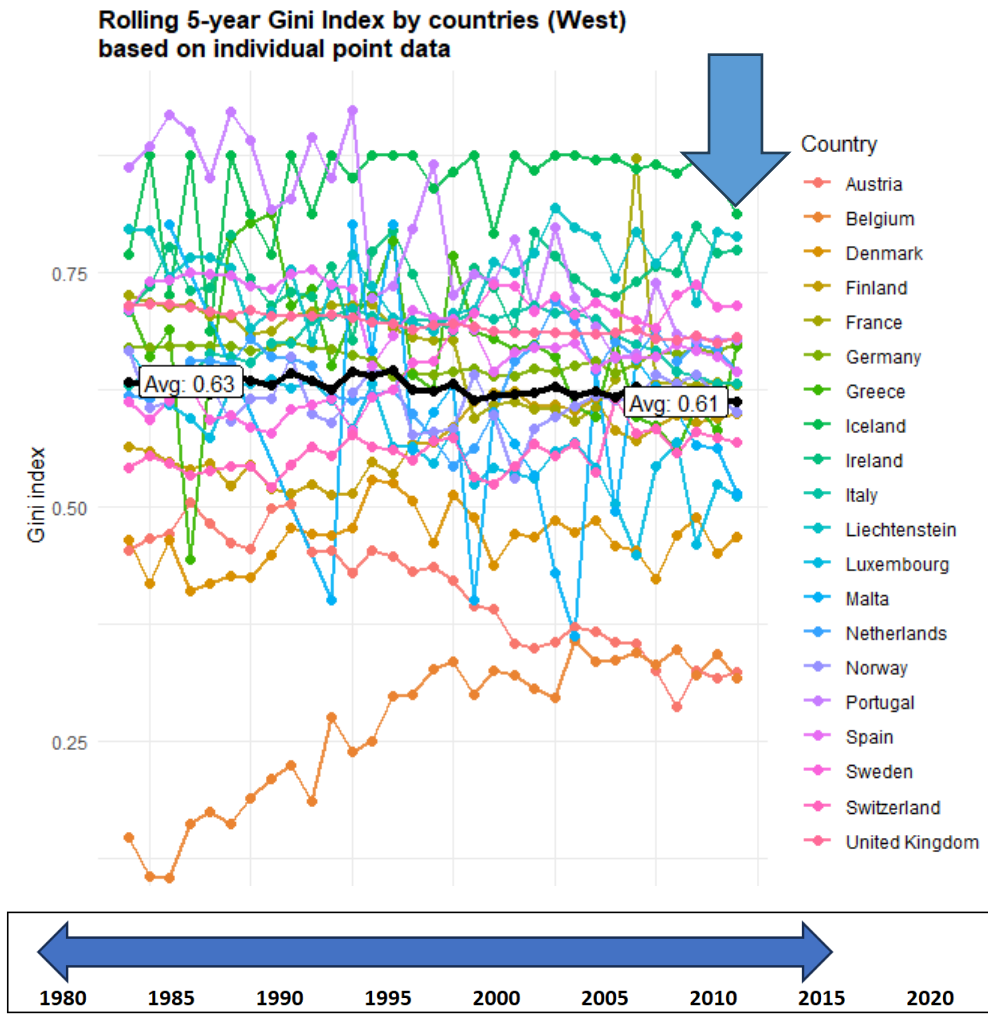
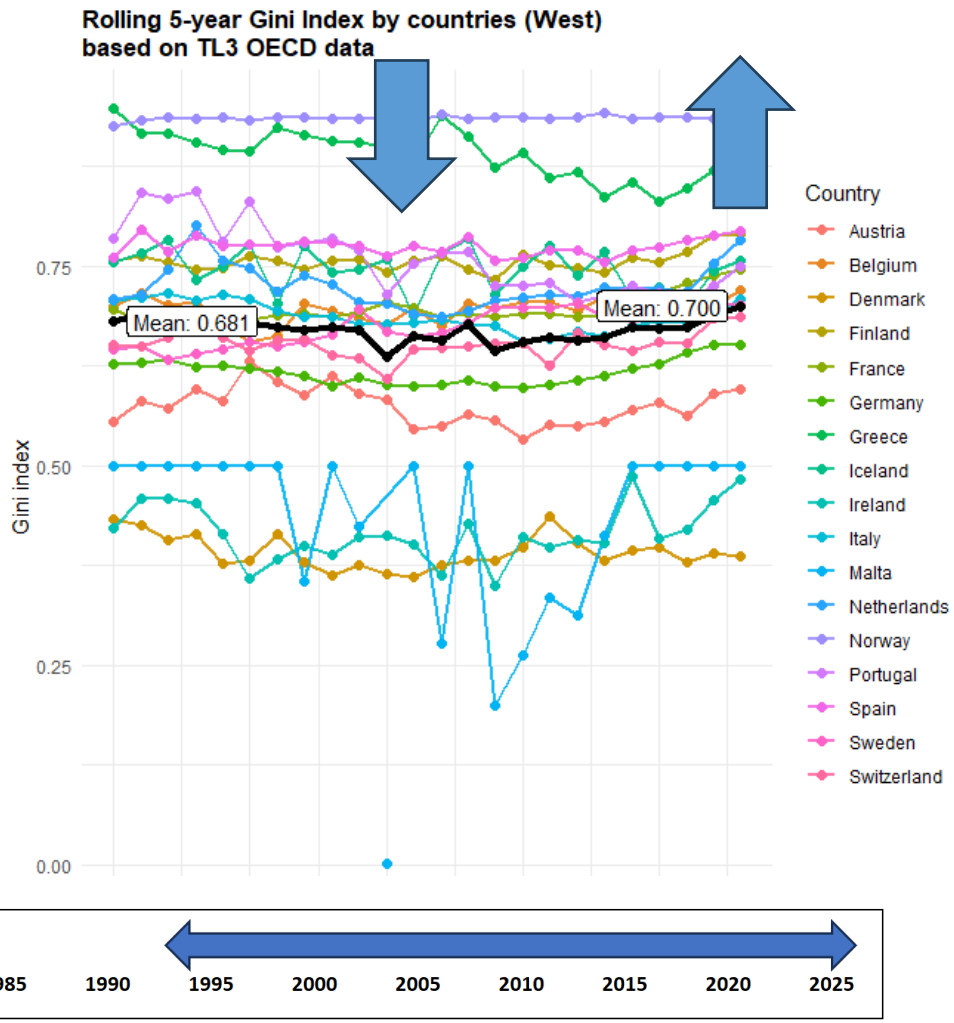
a) for years 1980-2014 based on de Rassenfosse et al. (2019) data
b) for years 1995-2022 based on TL3 OECD data

Gini coefficient for a regional number of patents in Western European countries – rolling window of 5-years average





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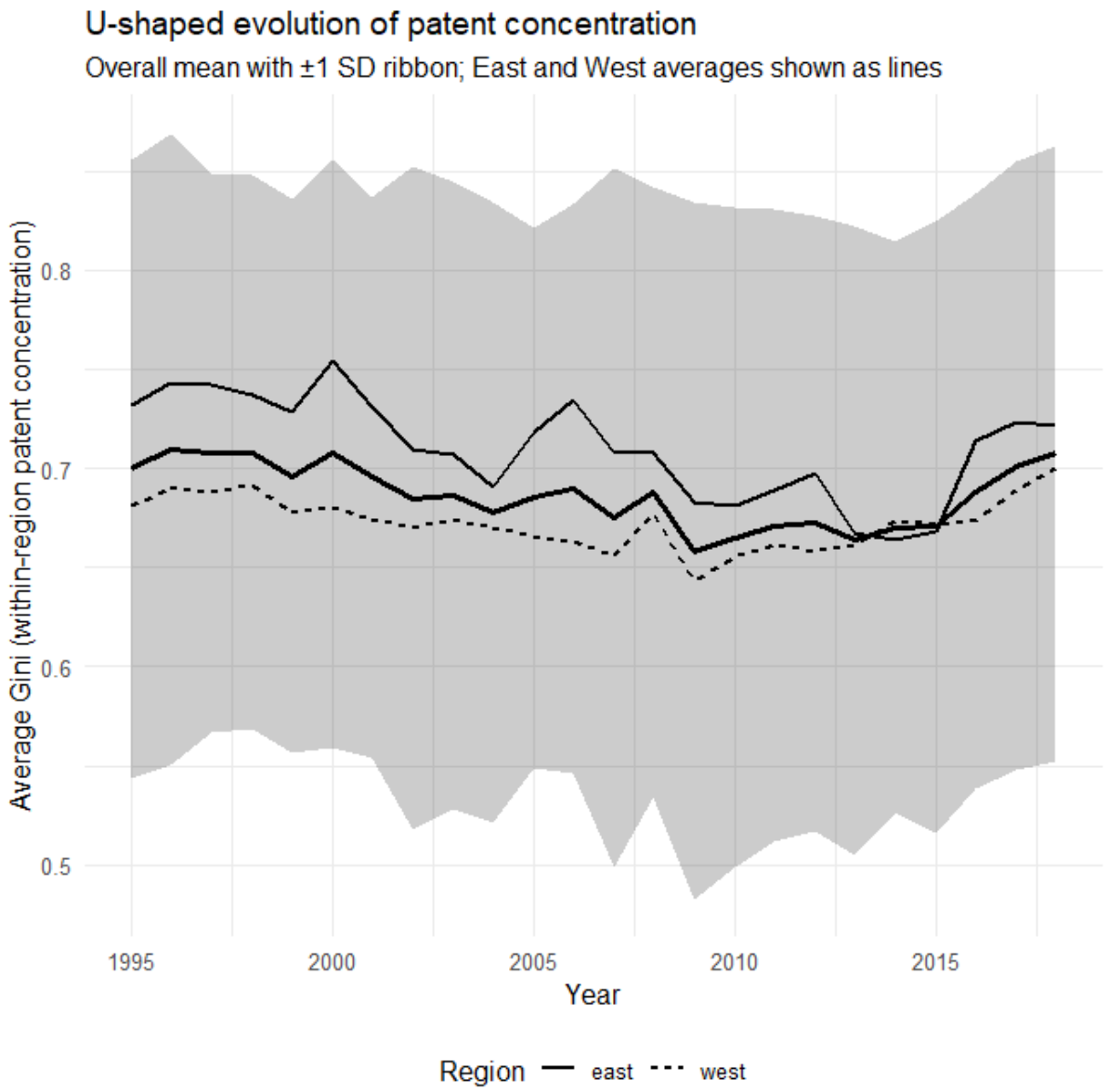
Trends of spatial concentration

- From year 1995 (1980) spatial concentration was decreasing (spillover, cohesion, convergence, catching-up)
- From year 2015 spatial concentration started to increase (core-periphery, divergence)



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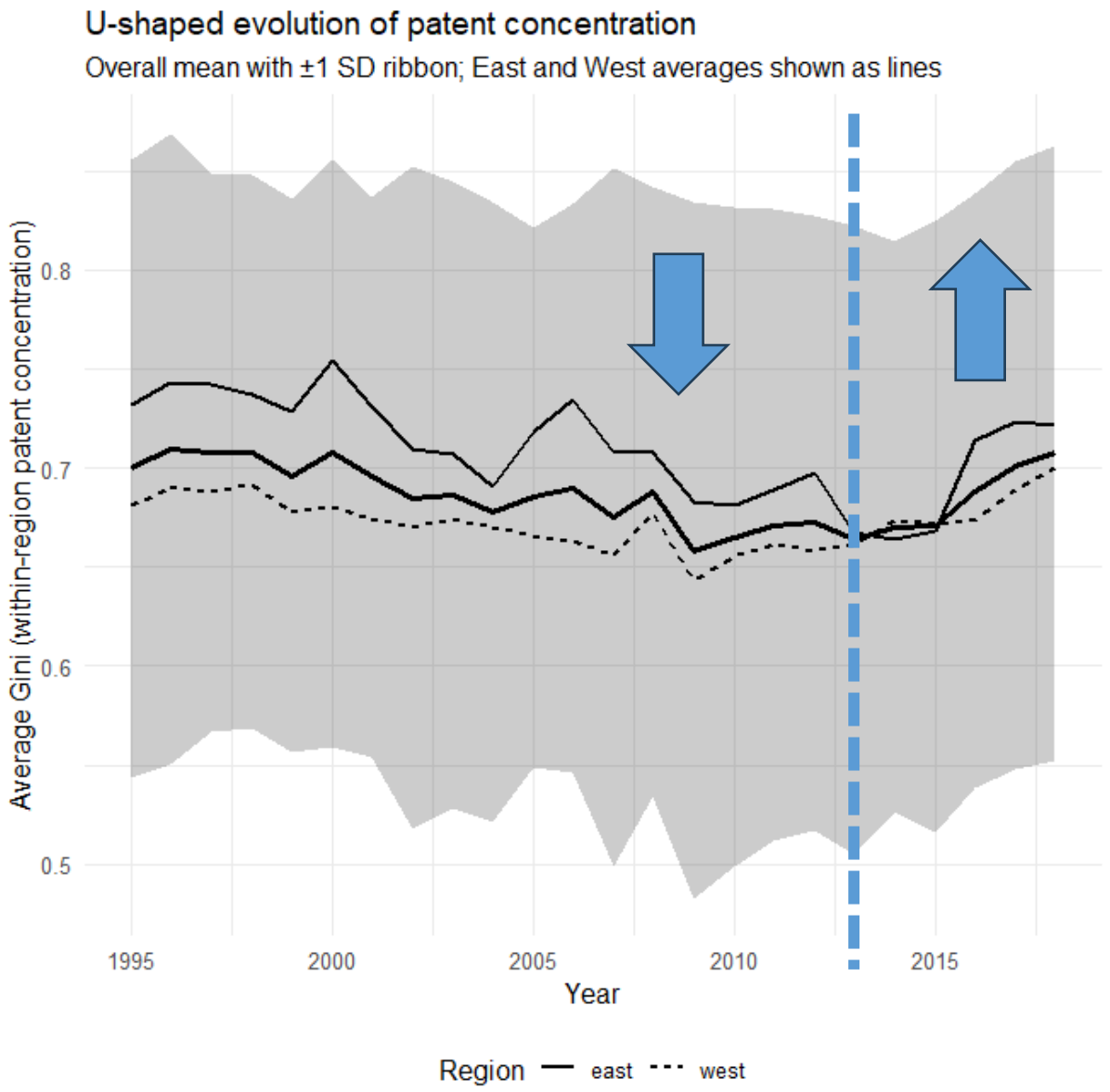
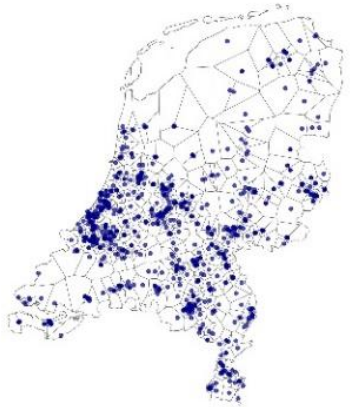


Netherlands

RelH=0.85

1980



RelH=0.86

1990

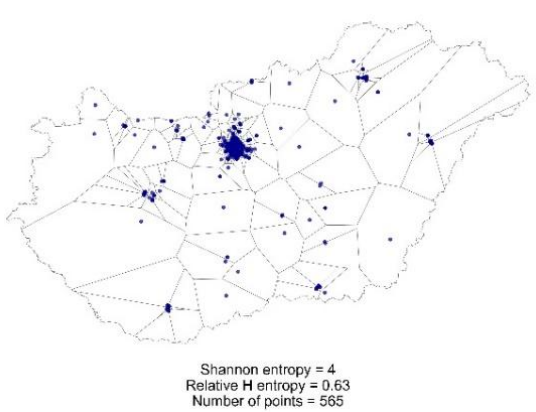
RelH=0.86

2000

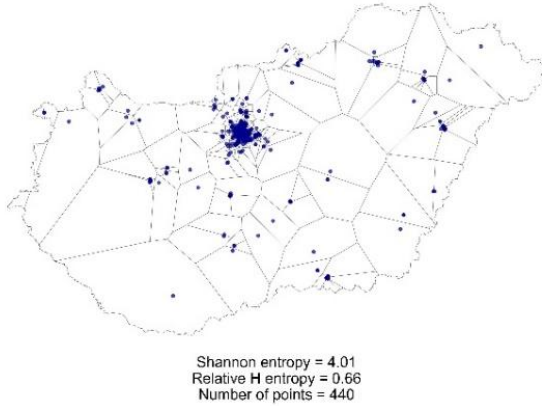
RelH=0.87

2010

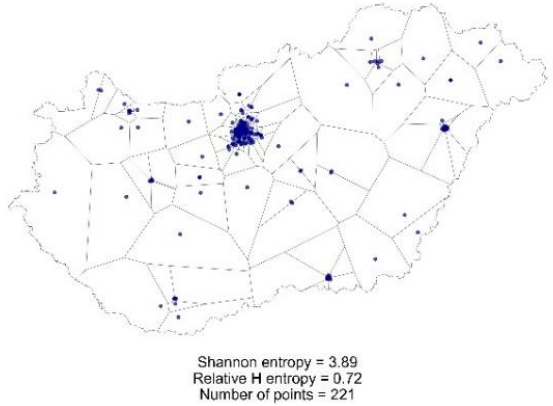
Hungary



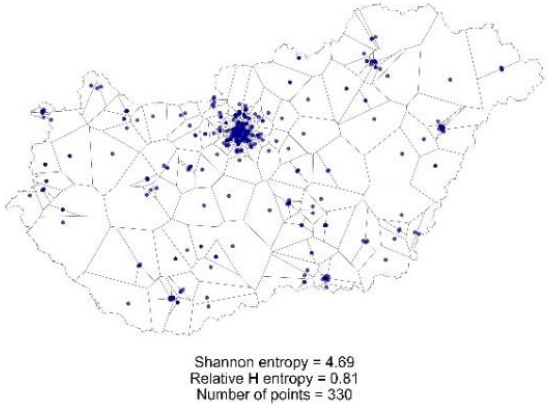
RelH=0.63



RelH=0.66



RelH=0.72



RelH=0.81

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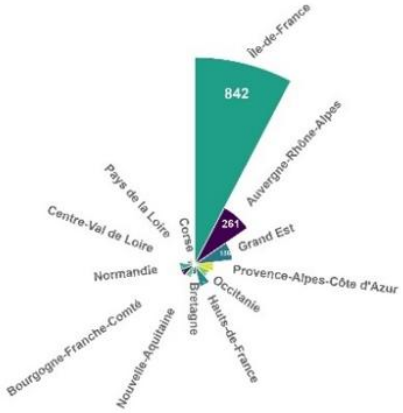
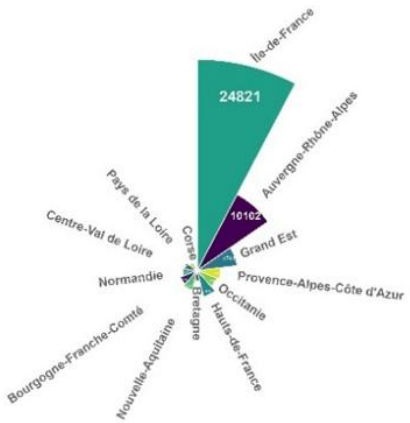
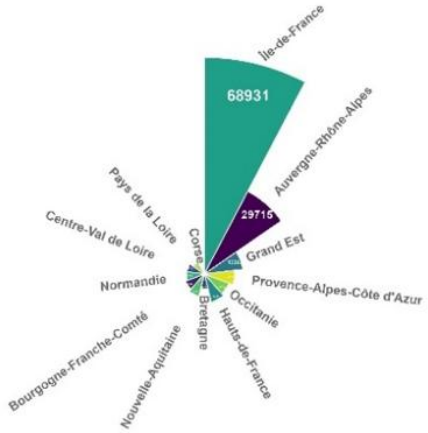
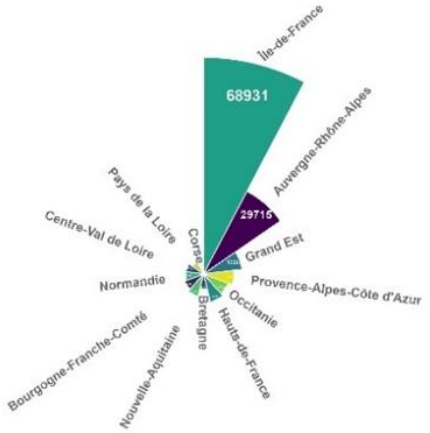
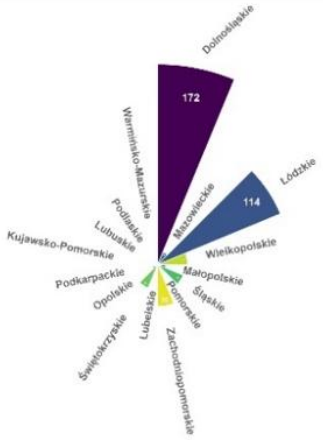
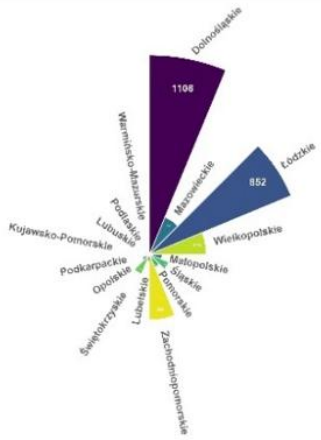
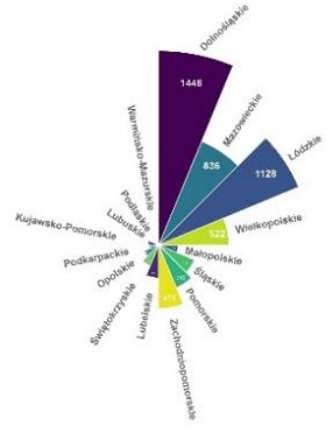
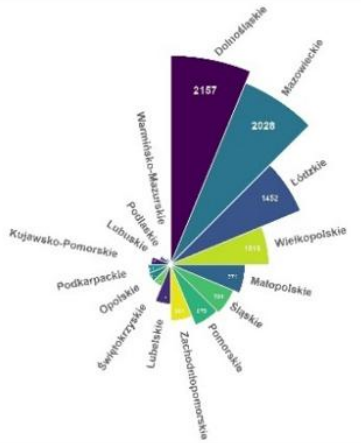
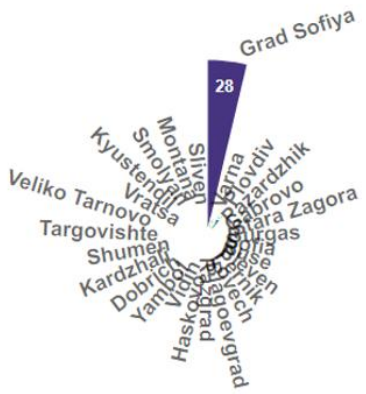
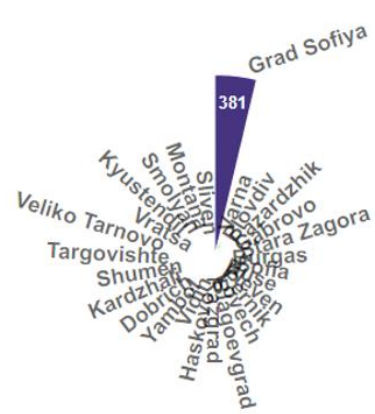
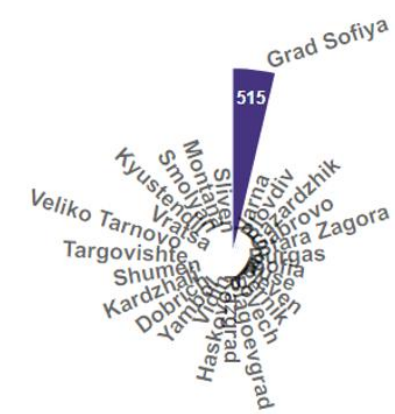
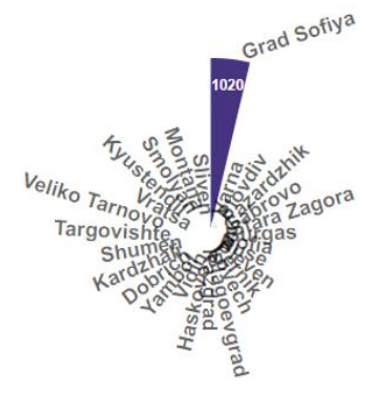
ETA index is not sensitive to number of patents and captures well the patterns of spatial concentration

	1980	1980 - 1990	1980 - 2000	1980 -2010
France				
Poland				
Bulgaria				

European innovation landscape

- Regional rankings of number of patents show some persistency and slow convergence
- Comparing total number of patents in **1980-1984** and 30 years later in **2010-2014** the ranking of **top 5 regions is the same** (the order of top5 is different): Baden-Württemberg, Bayern and Nordrhein-Westfalen (Germany), England (United Kingdom) and Île-de-France (France) – in 1980's they noted ca. 10-45K patents and in 2010's it was 50-100K patents.
- **In 1980's in top 100 regions were only three from Central-Eastern countries**: Budapest (Hungary) in top20, Dolnoslaskie (Poland) in top50 and Sofiya (Bulgaria) in top90.
- **In 2010's top100 included 6 east regions**: Mazowieckie (Poland) in top65, Budapest (Hungary) in top80, Dolnoslaskie and Małopolskie (Poland) in top90 and Prague (Czech Republic) and Slaskie (Poland) in top100. Sofiya (Bulgaria) was in top130 (previously top90). Later statistics are quite similar.
- This ranking in absolute numbers shows that **over three decades only 4 new eastern regions managed to get to top100**.

Results

- Long-term trajectories of the spatial concentration of innovation activity across regions in 30 European countries over the period 1980–2022 show previously underexplored empirical regularity: a **U-shaped trajectory** – stronger **spatial dispersion** from the 1980s until the early–mid 2010s and **spatial re-concentration** in the most recent decade till 2022.

- **Central–Eastern European** (CEE) countries experienced a **stronger decline in spatial concentration** during the diffusion phase, they **remain more spatially concentrated** than Western European (WE) countries throughout the entire period ➔ partial convergence in spatial patterns but persistent structural asymmetries in the spatial organisation of innovation systems

Policy implications (1)

There is the trade-off between territorial cohesion and global competitiveness:

- **Cohesion policy** - the decline in spatial concentration → results from knowledge diffusion, institutional upgrading, and policy-supported capacity building, particularly in catching-up economies → for regions in phases of diffusion and absorption
- **Excellence policy** - the spatial re-concentration → underscores the cumulative, network-driven nature of frontier innovation, which favours regions with dense knowledge networks, specialised labour markets and strong global connectivity → for mature innovation systems

Policy implications (2)

- **The U-shaped trajectory**
  → spatial innovation dynamics is non-linear and stage-dependent
  → spatial de-concentration can be achieved, but it is unlikely to be permanent
- The re-emergence of spatial concentration should not be interpreted as a failure of cohesion policy ➔ **it shows the limits of policy-induced spatial equalisation in innovation-driven economies**, particularly once regions approach the technological frontier
- **The EU's pro-quality policy—which appears to be spatially neutral—has highly varied regional effects**
- As the spatial inequalities are dangerous it opens the floor for discussion of policy design

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- The geography of innovation follows a U-shaped path driven by two competing policy forces.
- Understanding this dynamic is crucial for designing effective innovation and regional policies.

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