



TECHNOLOGY TRANSFER AND INNOVATION DYNAMICS THROUGH CLUSTERING ANALYSIS OF EUROPEAN UNION COUNTRIES

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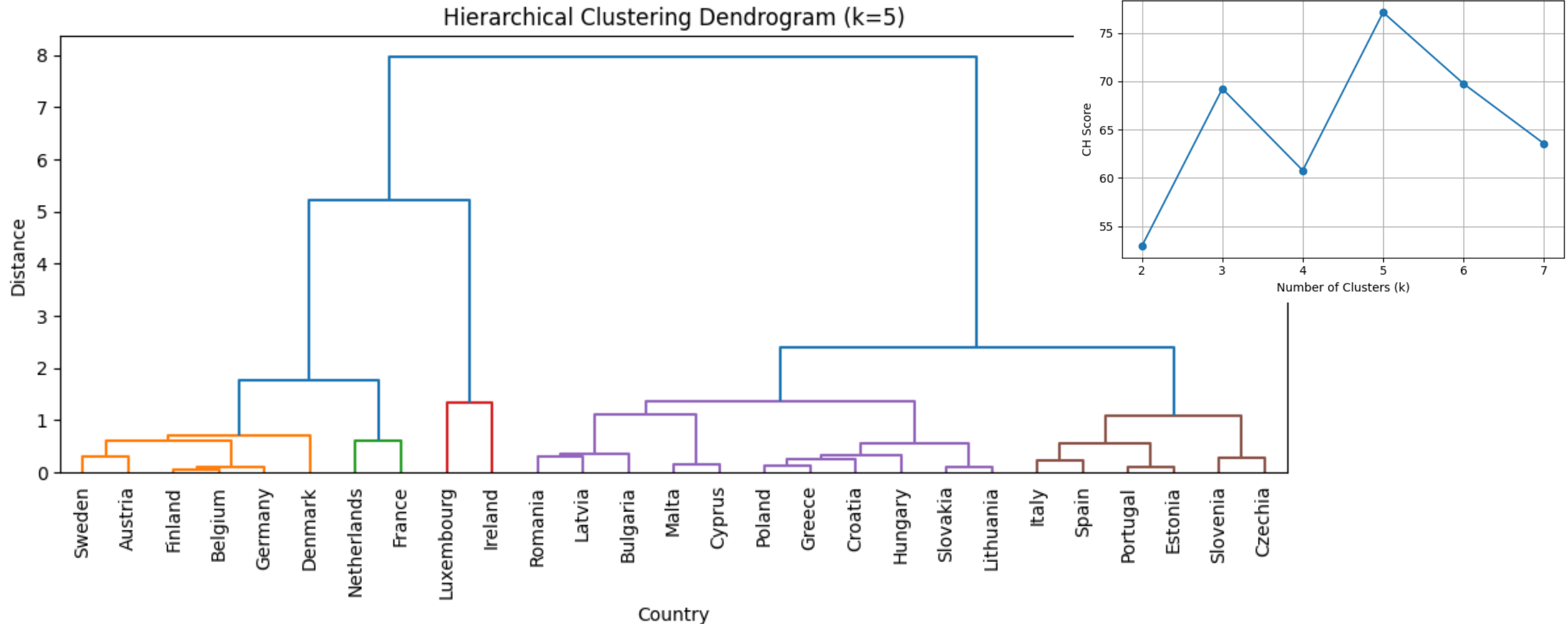
Technology Transfer Challenges in the EU

- SMEs are the engines of the market economy, innovation, and employment, including in the European Union (EU)
- Bulgaria's R&D intensity of GDP (0.8%) vs EU average (2.2%)
- Fragmented policy, weak academia-business links
- Goal: explore stratification using clustering
 - Data: Eurostat (2014–2024)
 - Indicators: GDP per capita, GERD €/inhabitant, GERD % of GDP
 - Tools: Python, Scikit-learn, Ward's method, K-means
 - Validation: Elbow method, Calinski-Harabasz index

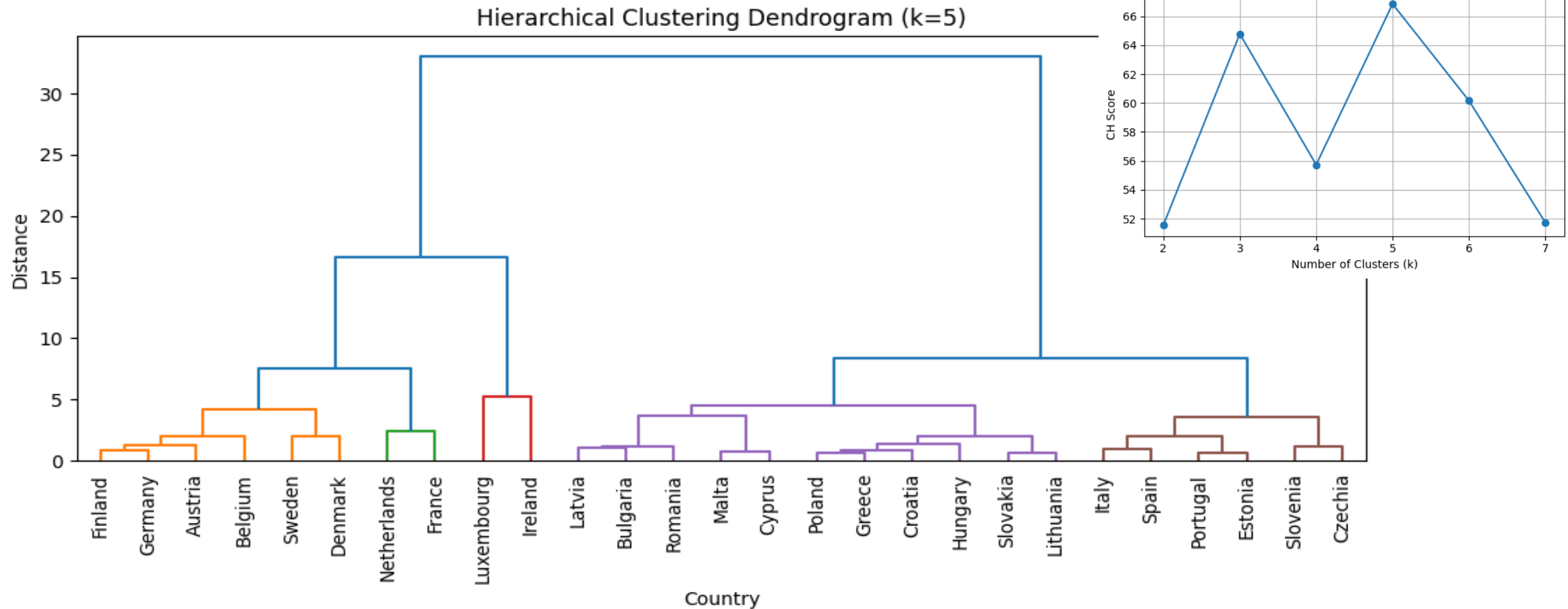
Strengths and weaknesses in the innovation activity of enterprises in Bulgaria

- Relative strengths:
 - High compared to the EU average index Design applications (147.6 at an average of 100);
 - High compared to the EU average index Trademark applications (118.9) at an average of 100);
 - Close to the average index for environment-related technologies (88.5);
- Relative weaknesses:
 - Extremely low index for direct and indirect government support of business R&D (index 2.2);
 - Extremely low index for population involved in lifelong learning (3.5);
 - Low index for resource productivity (14.0);
- Significant progress compared to 2017 in the following areas:
 - Employment in innovative enterprises – 37.4% increase
 - Foreign doctorate students as % of all doctorate students – 33.4% increase;
 - Broadband penetration – 29.7% increase.

The hierarchical clustering dendrogram for the 27 EU countries based on the average levels of GDP per capita and R&D expenditure



The hierarchical clustering dendrogram for the 27 EU countries based on GDP per capita and R&D expenditure growth dynamics



Clusters' characteristics based on average indicators and their dynamics

Clusters	GDP per capita (avg., EUR)	GERD per inh. (avg., EUR)	GERD as % of GDP (avg.)	GDP per capita (average $\Delta\%$)	GERD per inh. (average $\Delta\%$)	GERD as % of GDP (average $\Delta\%$)
1	24557,83	373,61	1,61	5,17%	6,23%	0,87%
2	17867,18	150,98	0,91	6,97%	9,87%	2,98%
3	92548,00	1006,61	1,16	4,48%	2,78%	-2,16%
4	43193,00	907,35	2,18	4,02%	3,44%	-0,24%
5	46673,00	1394,07	3,06	3,11%	4,13%	1,15%

Stratification of the EU countries

- Cluster 1 – Moderate economies with mid-level R&D – includes Italy, Spain, Portugal, Czechia, Slovenia, and Estonia. These countries have mid-range GDP per capita and moderate R&D intensities around 1.5–2.0%.
- Cluster 2 – Below average economies and R&D expenditures. The cluster includes many countries, encompassing Bulgaria, Romania, Hungary, Poland, Croatia, Latvia, Lithuania, Slovakia, Greece, Cyprus, and Malta. These eleven countries generally have the EU's relatively low GDP per capita and GERD per inhabitant, along with R&D intensities mainly under 1.2% of GDP.
- Cluster 3 – High GDP but moderate R&D. The cluster consists of only Luxembourg and Ireland, two outlier economies with exceptionally high GDP per capita but comparatively moderate R&D investment relative to their economic size.
- Cluster 4 – High GDP with high R&D expenditures – contains France and the Netherlands, two wealthy economies with high GDP per capita and above-average R&D investment
- Cluster 5 – Innovation leaders. This group comprises the economies with the highest GDP per capita and R&D investment levels. Countries in this cluster include Sweden, Denmark, Finland, Germany, Austria, and Belgium.

Conclusions & Policy Priorities

- Clusters reflect EU innovation inequality
- Bulgaria: improving GERD, needs structural reform
- EU policy: balance frontier tech with catch-up support
- Future work: add patent/digital indicators

Scientific Entrepreneur Hub in Bulgaria

- **SciEntBG Hub** at UNWE supports Bulgaria's innovation ecosystem.
- Aligned with **ERA Talent** and **EURAXESS Startup Hub** initiatives.
 - Training & webinars on digital innovation
 - Support for early-stage researchers & refugee scientists
 - Mentoring program
- Direct response to Cluster 2 gaps: knowledge transfer, SME collaboration, and R&D funding bottlenecks.
- Bridging EU policy and local impact via academic entrepreneurship.

