



Spatiotemporal Evolution of Patent Clusters: A Comprehensive Analysis from 1980 to 2010 in the UK

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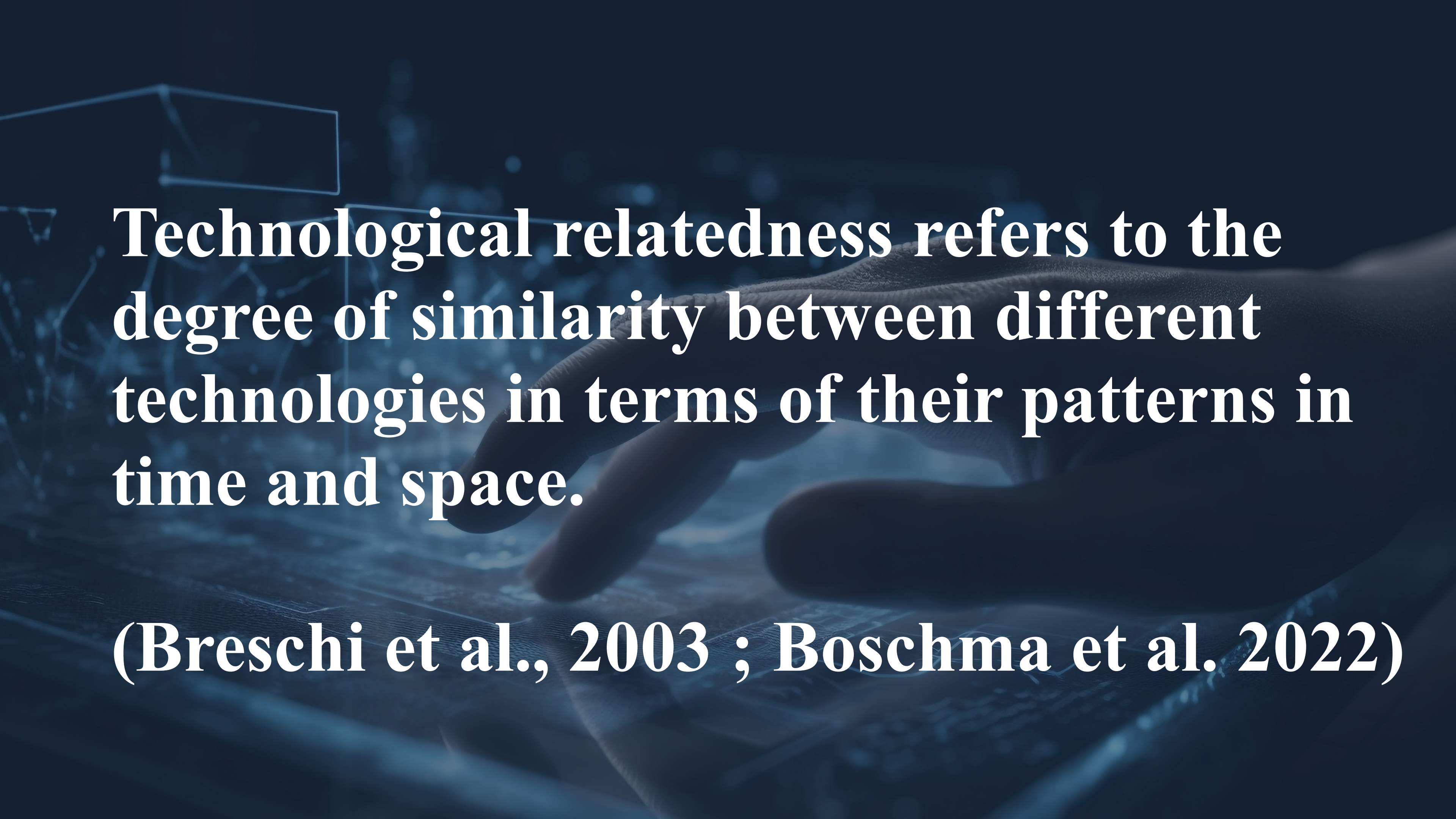
Relatedness

Diversity

How innovations change over time and within spatial clusters?

Spatial Clusters

Regional Specialization

The background image shows a hand with a finger touching a transparent, futuristic digital interface. The interface displays various data visualizations, including a 3D wireframe box in the upper left and a network of glowing blue lines. Below the hand, a circuit board is visible, suggesting a connection between human interaction and technology. The overall color scheme is dark blue with white text.

Technological relatedness refers to the degree of similarity between different technologies in terms of their patterns in time and space.

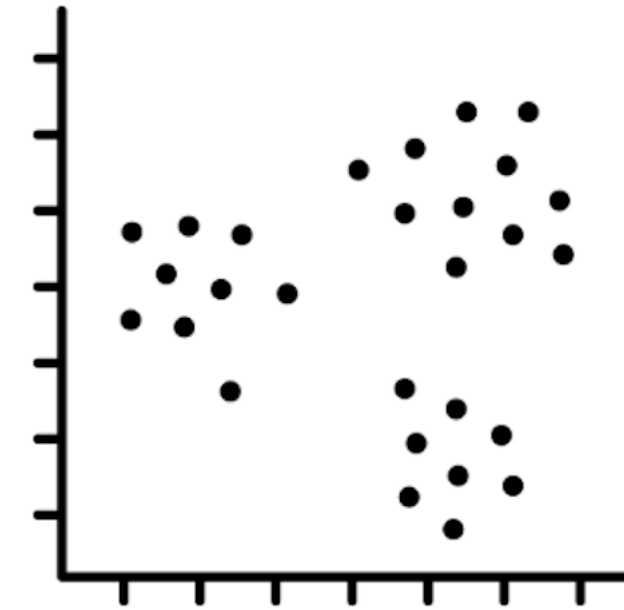
(Breschi et al., 2003 ; Boschma et al. 2022)

What we know ?



Relatedness based
on **regions**

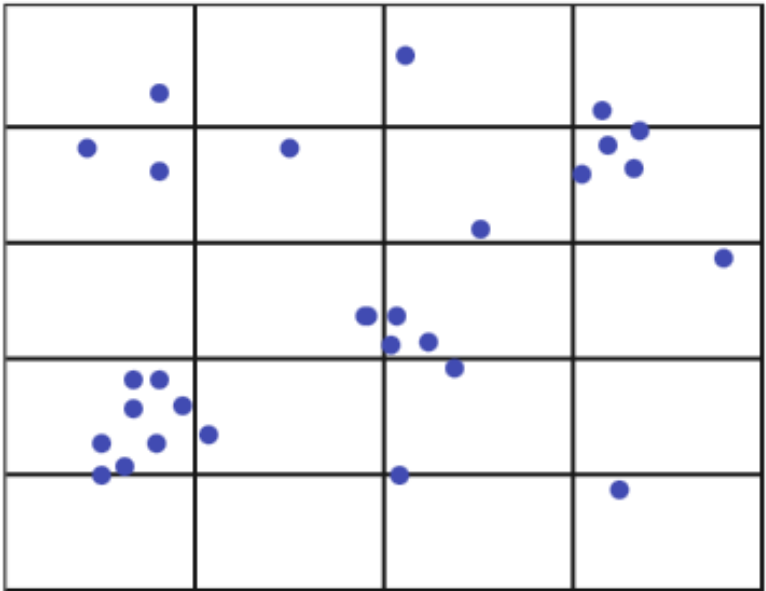
What we don't know ?



Relatedness based
on **point clusters**

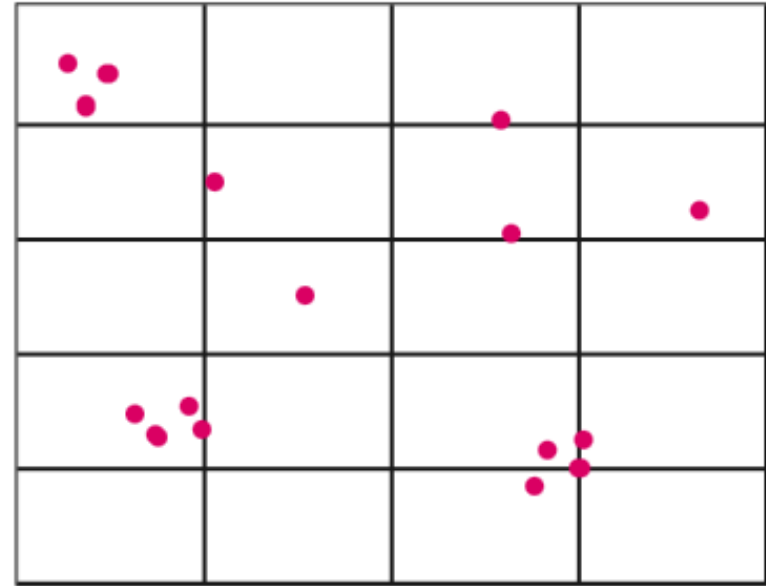
Current relatedness method

Patent Type A



1	0	1	1
2	1	1	4
0	1	3	1
7	1	1	0
1	0	1	1

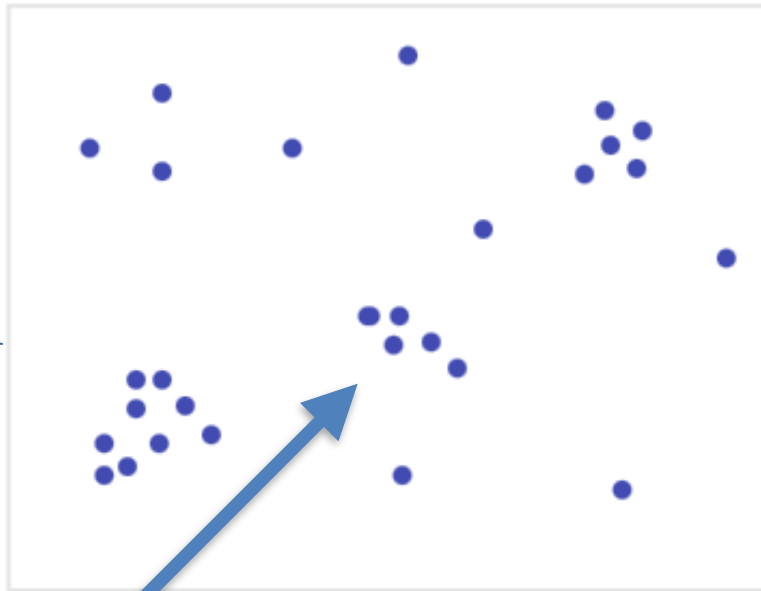
Patent Type B



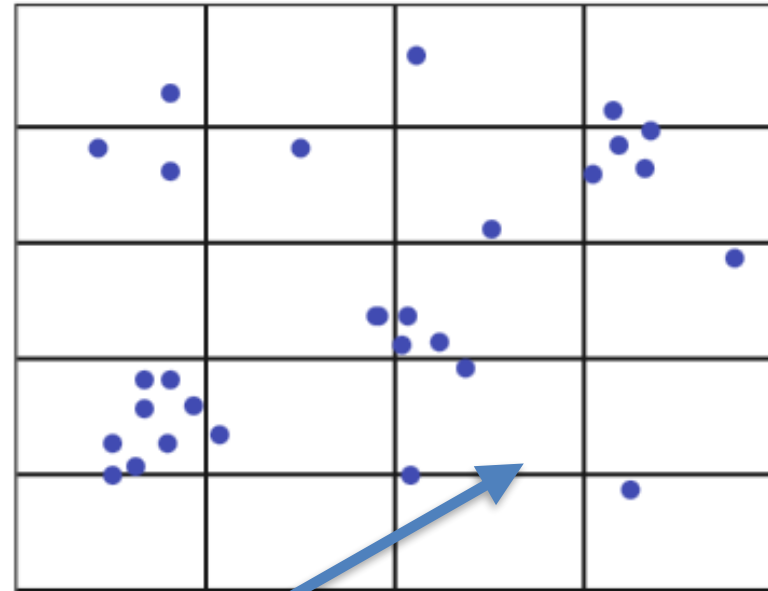
3	0	1	0
0	1	1	1
0	1	0	0
4	0	1	1
0	0	1	1

Current relatedness method

Patent Type A



Patent locations

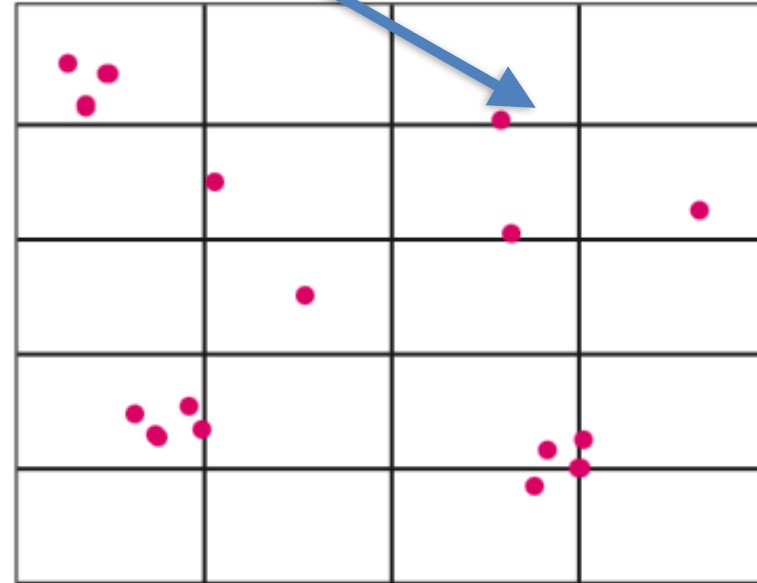
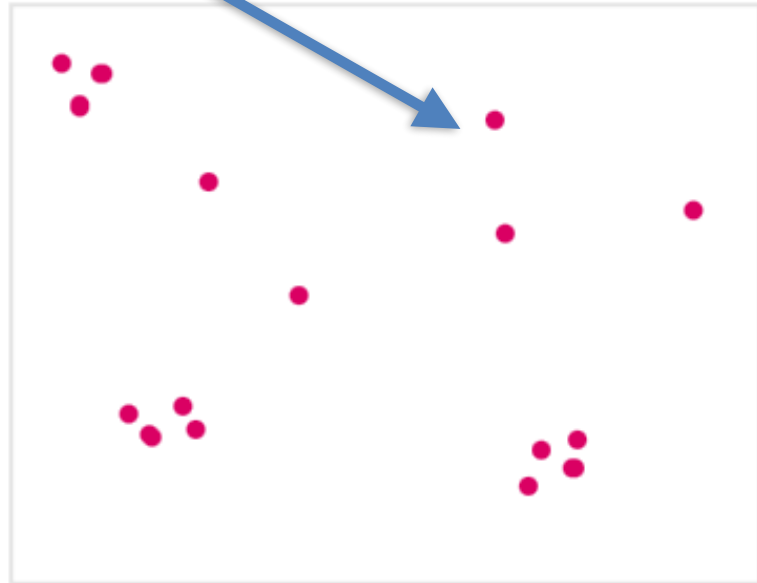


Regions

1	0	1	1
2	1	1	4
0	1	3	1
7	1	1	0
1	0	1	1

Counts of patents in each region

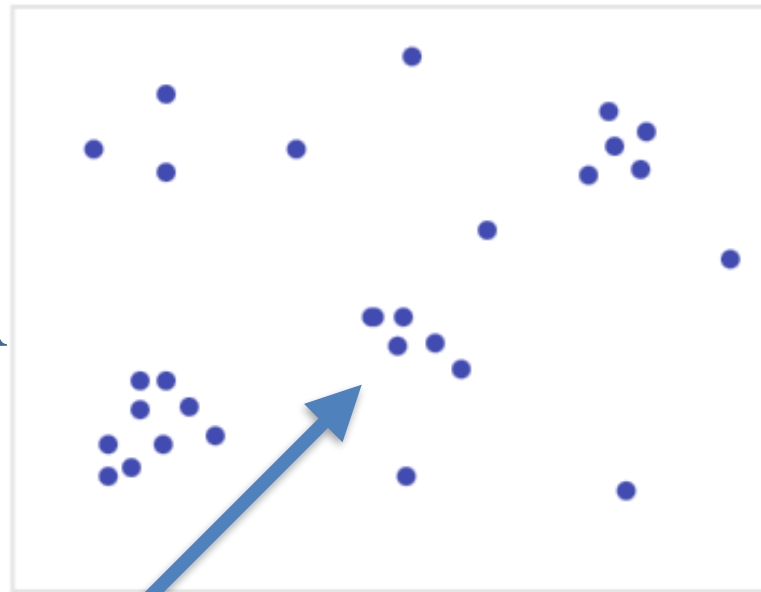
Patent Type B



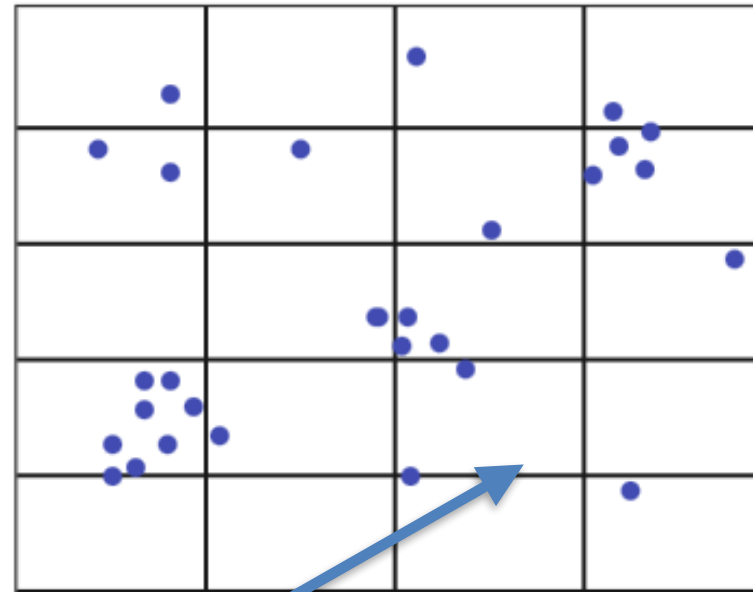
3	0	1	0
0	1	1	1
0	1	0	0
4	0	1	1
0	0	1	1

Current relatedness method

Patent Type A



Patent locations

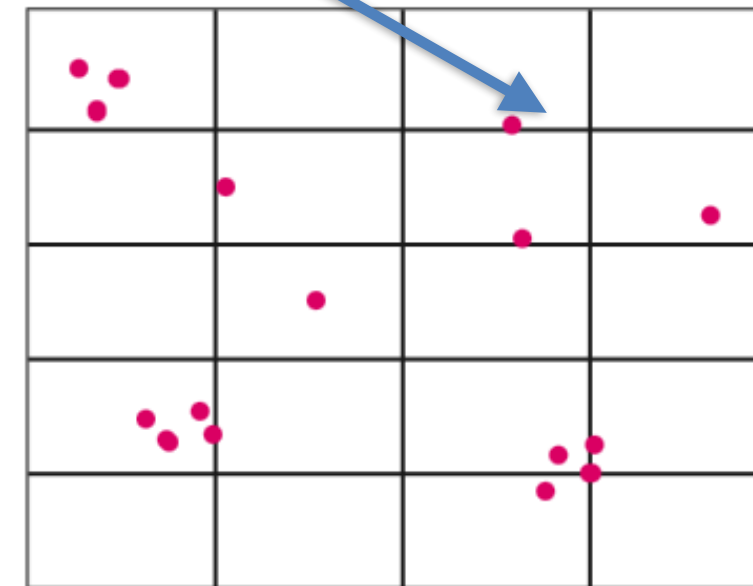


Regions

1	0	1	1
2	1	1	4
0	1	3	1
7	1	1	0
1	0	1	1

Counts of patents in each region

Patent Type B



3	0	1	0
0	1	1	1
0	1	0	0
4	0	1	1
0	0	1	1

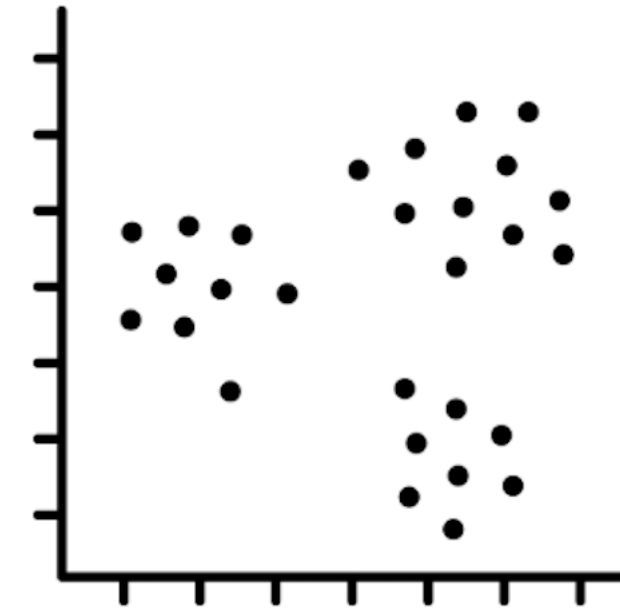
Are these patents related ? In other words, are they co-exist together in regions ?

Why new methods are needed?



**Modifiable
Areal Unit
Problem**

Relatedness based
on **regions**



**We let data
decide the
regions with
clustering**

Relatedness based
on **point clusters**

Breschi et al., (2003)

Rigby (2015)

Boschma et al. (2022)

Mascarini et al. (2023)

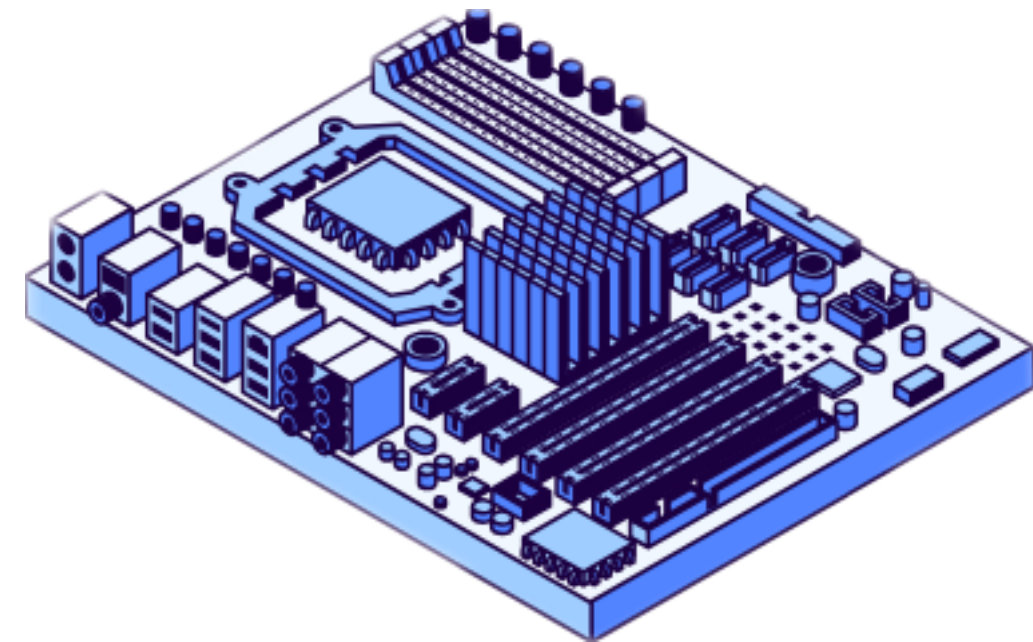
Why new methods are needed?

Current relatedness methods can't provide asymmetric rules

(Boschma, 2016)



Software



Hardware

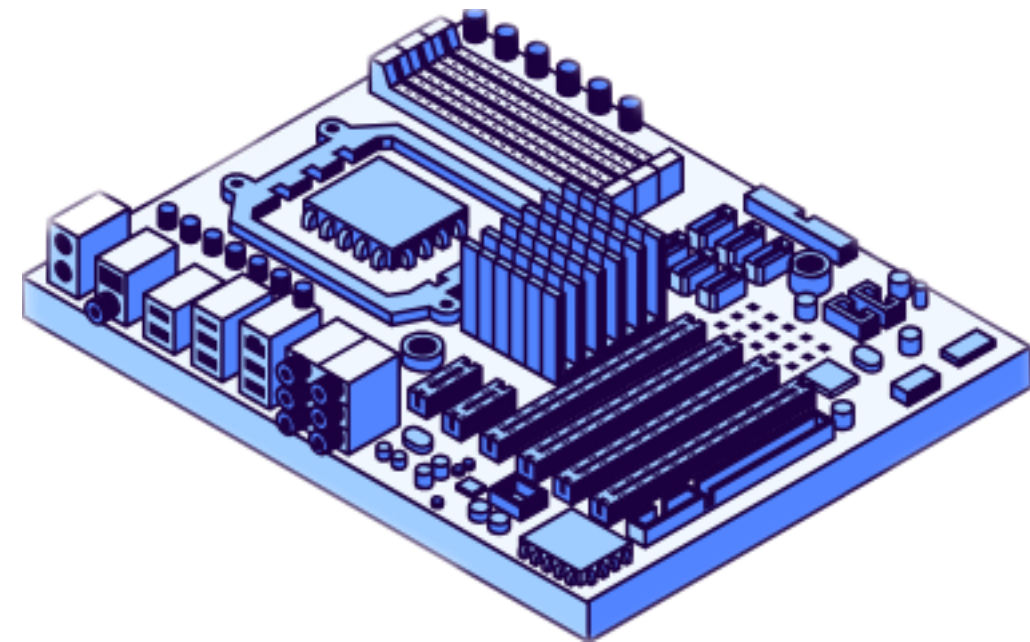
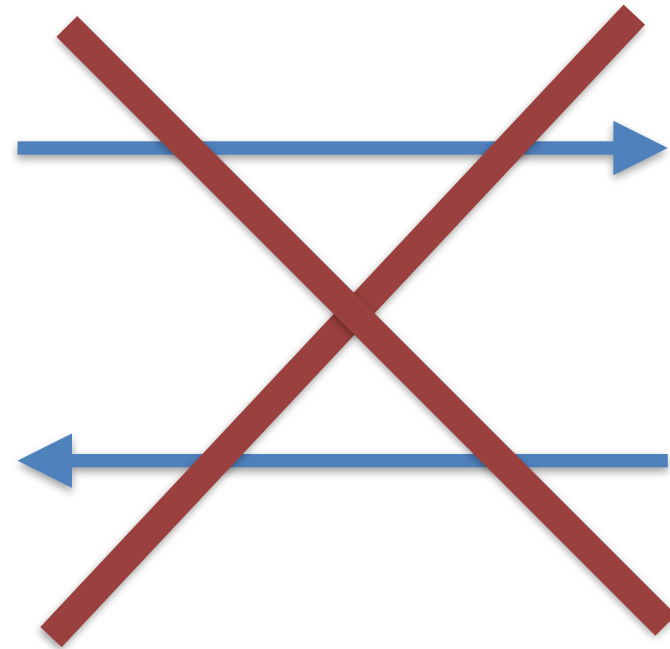
Why new methods are needed?

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(Boschma, 2016)



Software



Hardware

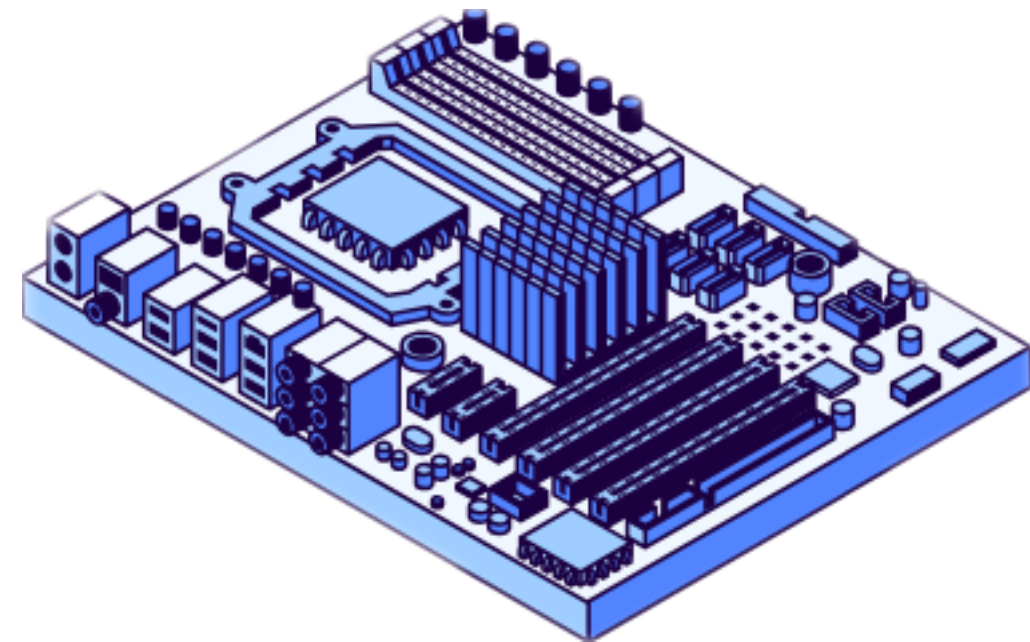
Why new methods are needed?

In reality relatedness is asymmetric most of the time

(Boschma, 2016)



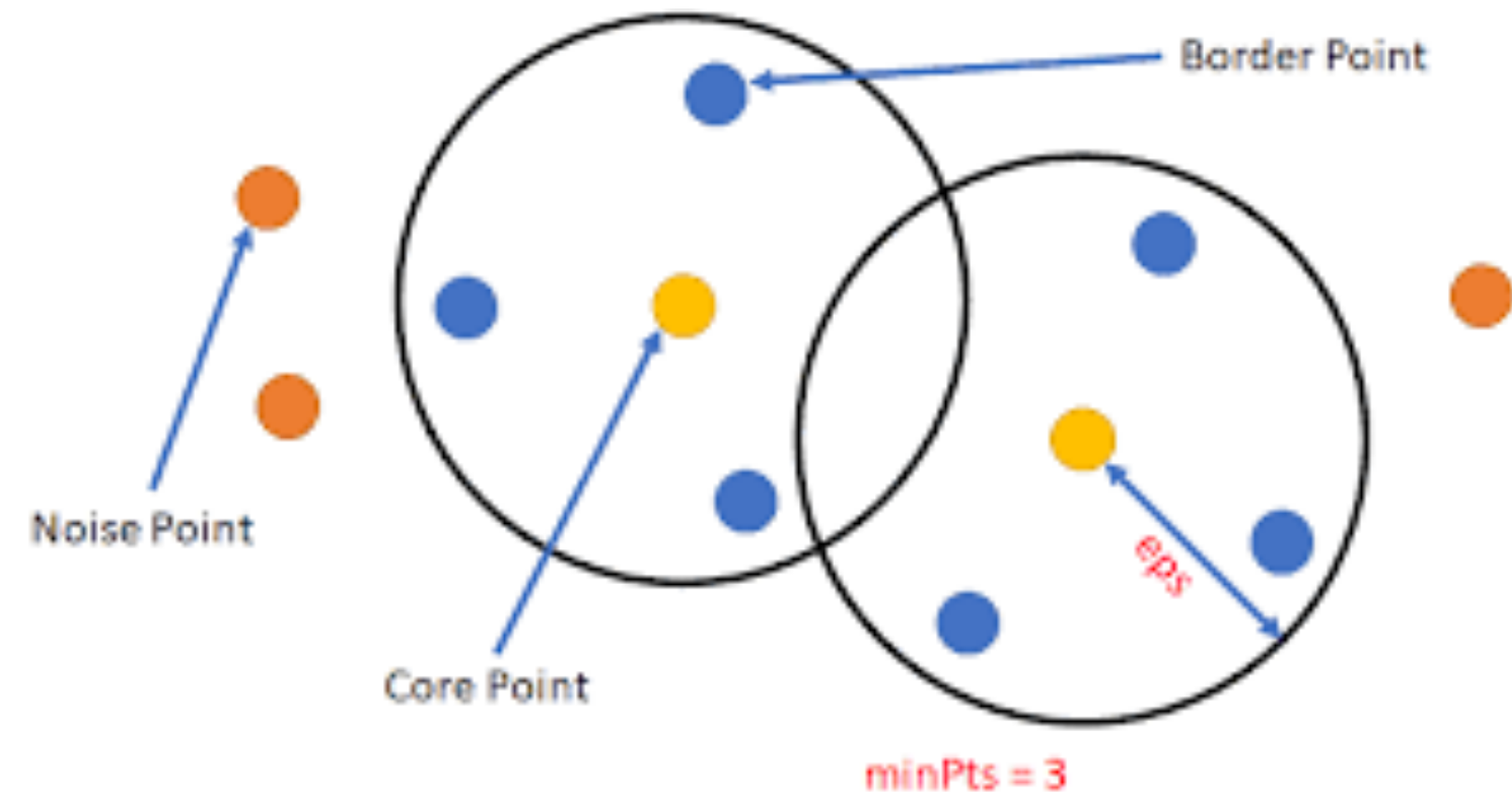
Software



Hardware

Data and Methods

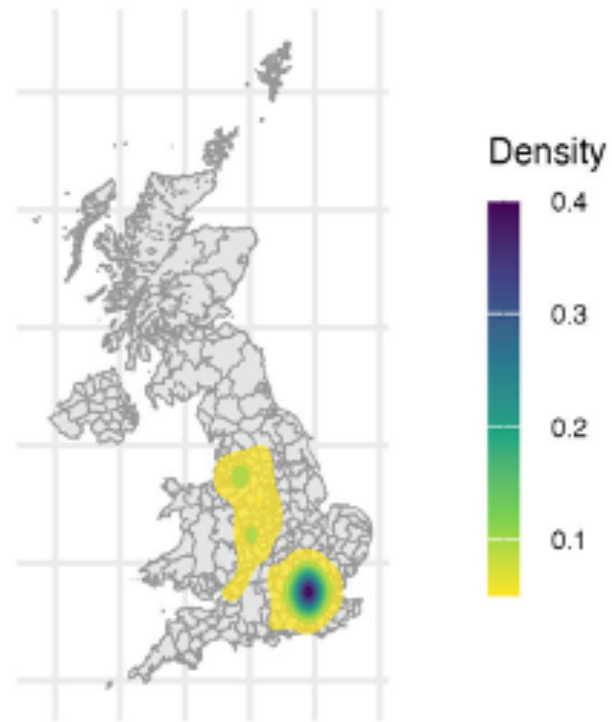
- Exact location of 26,976 patents in UK
- Unsupervised Machine Learning
- DBSCAN Clustering
- Association Rule Mining
- Kernel Density Estimation
- Shannon Entropy



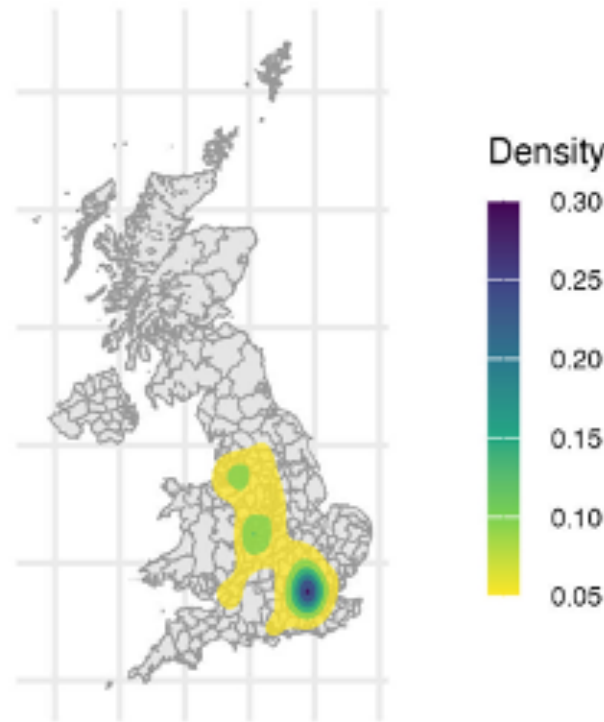
$$\begin{aligned} \text{Rule: } X \Rightarrow Y & \begin{cases} \text{Support} = \frac{\text{freq}(X, Y)}{N} \\ \text{Confidence} = \frac{\text{freq}(X, Y)}{\text{freq}(X)} \\ \text{Lift} = \frac{\text{Support}}{\text{Supp}(X) \times \text{Supp}(Y)} \end{cases} \end{aligned}$$

Kernel Density Estimation of Patents 1980 - 2010

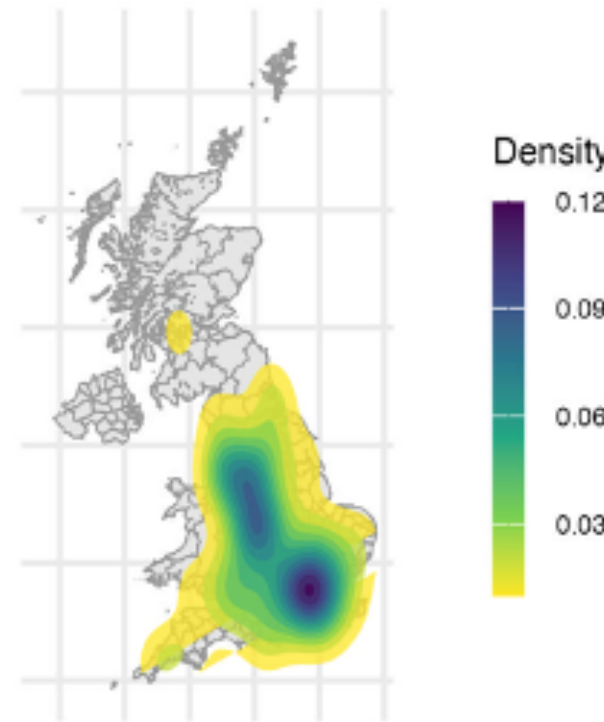
A. Human Necessities



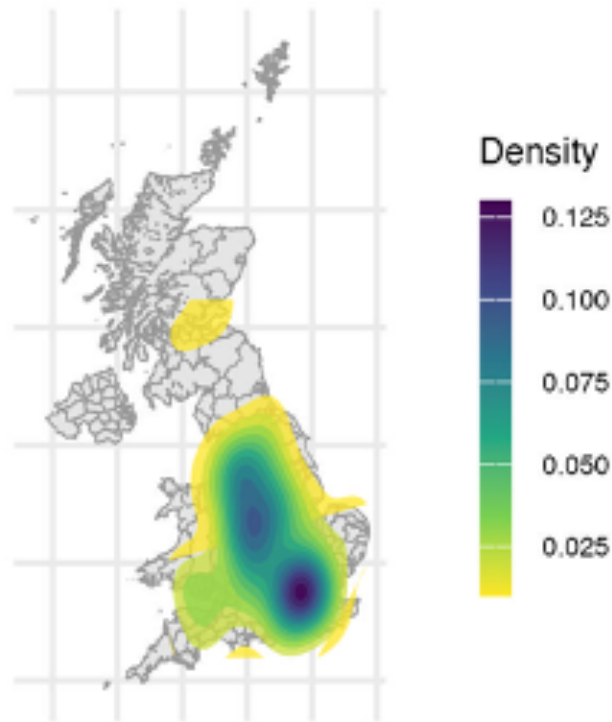
B. Transporting



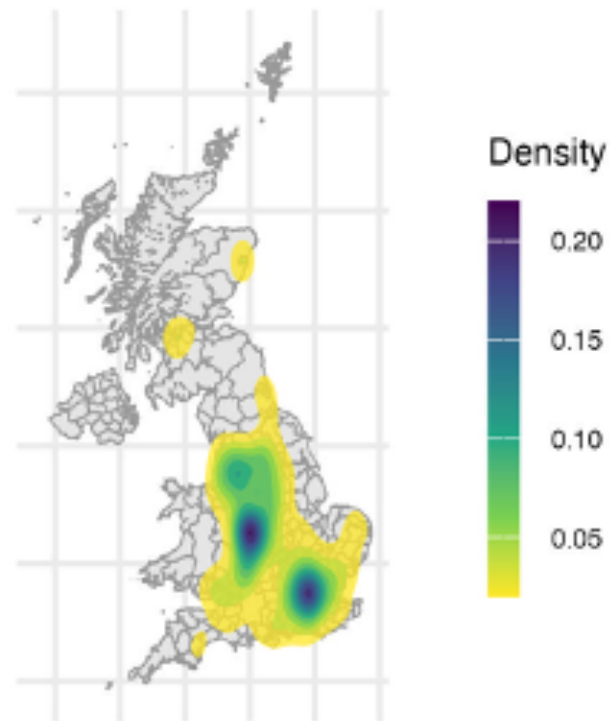
C. Chemistry; Metallurgy



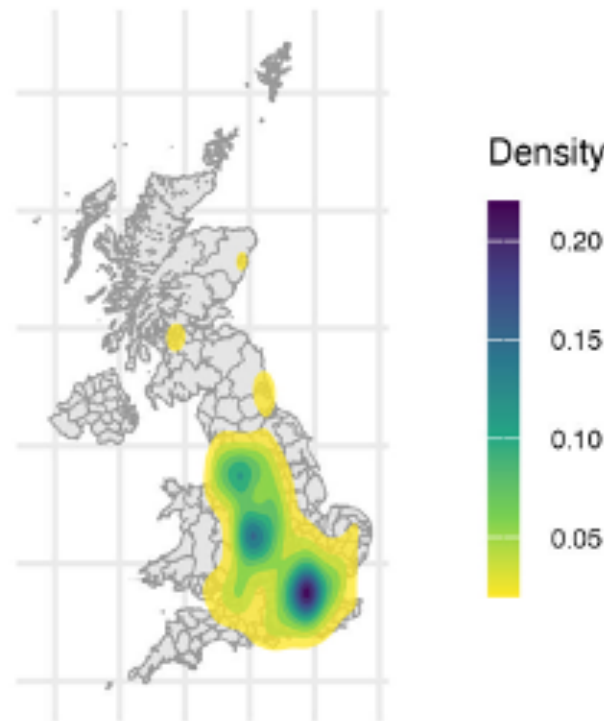
D. Textiles; Paper



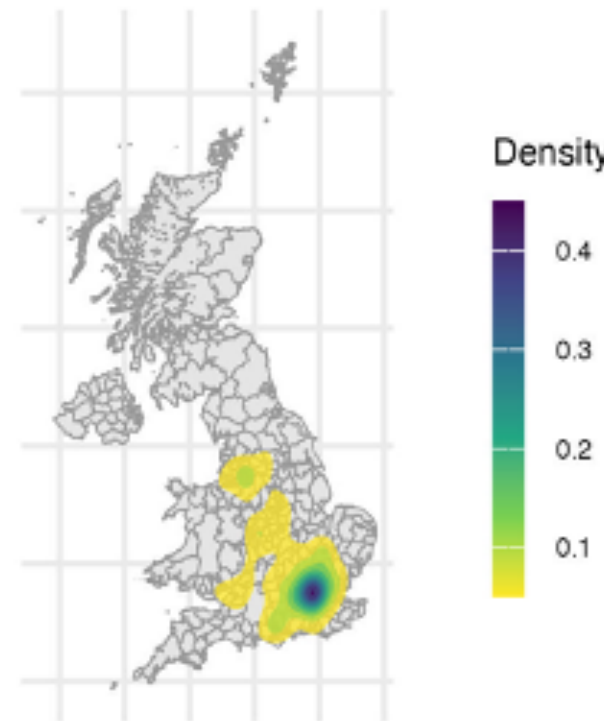
E. Fixed Constructions



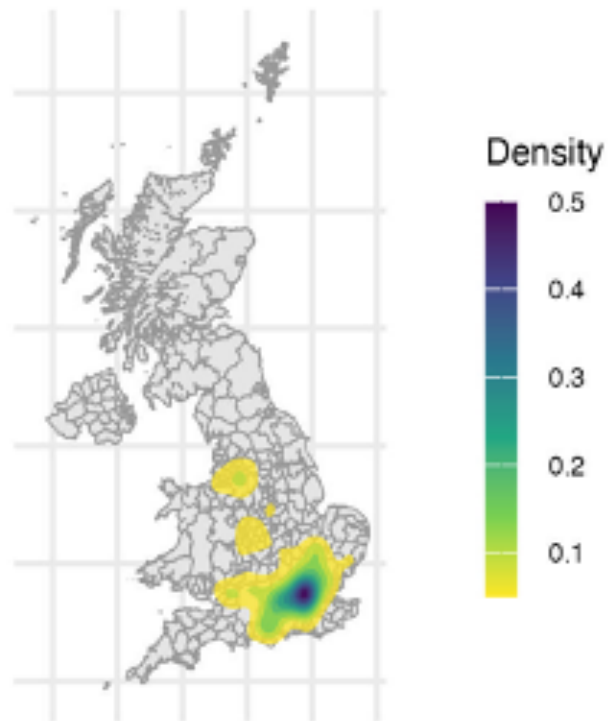
F. Mechanical Engineering



G. Physics

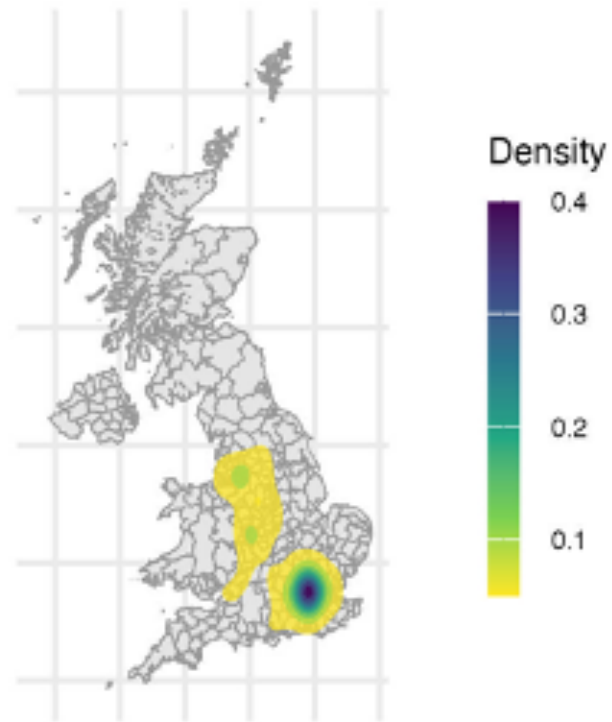


H. Electricity

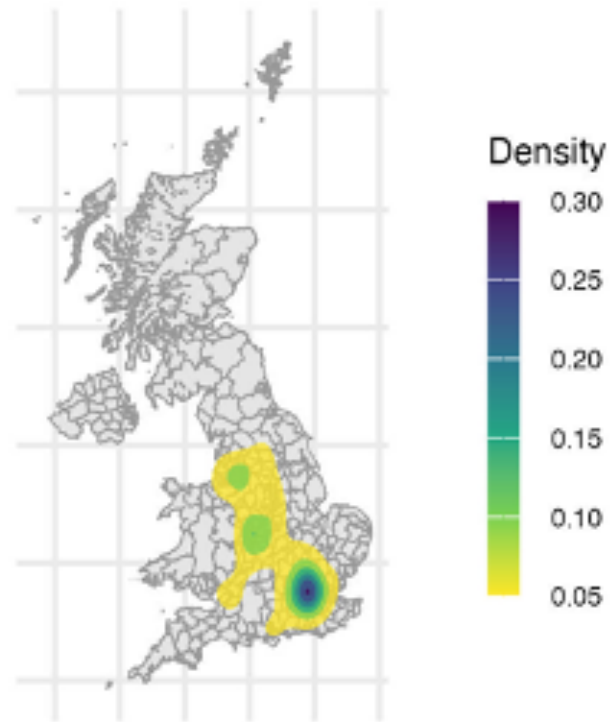


Kernel Density Estimation of Patents 1980 - 2010

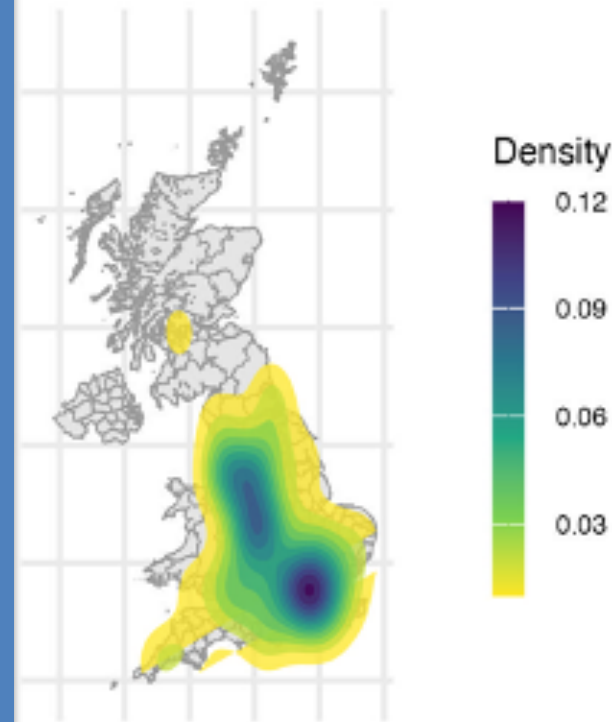
A. Human Necessities



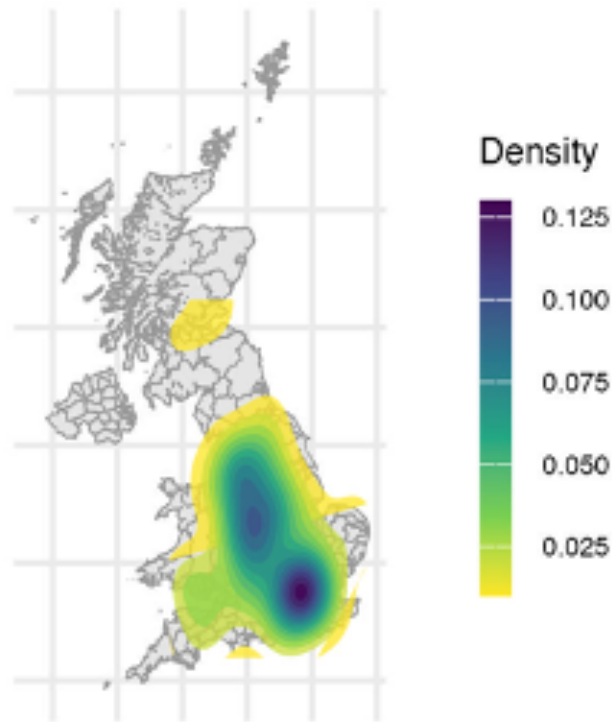
B. Transporting



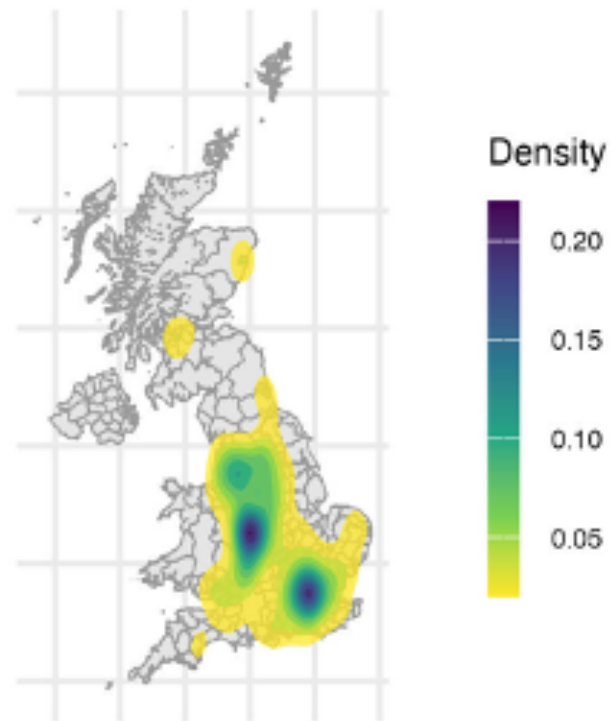
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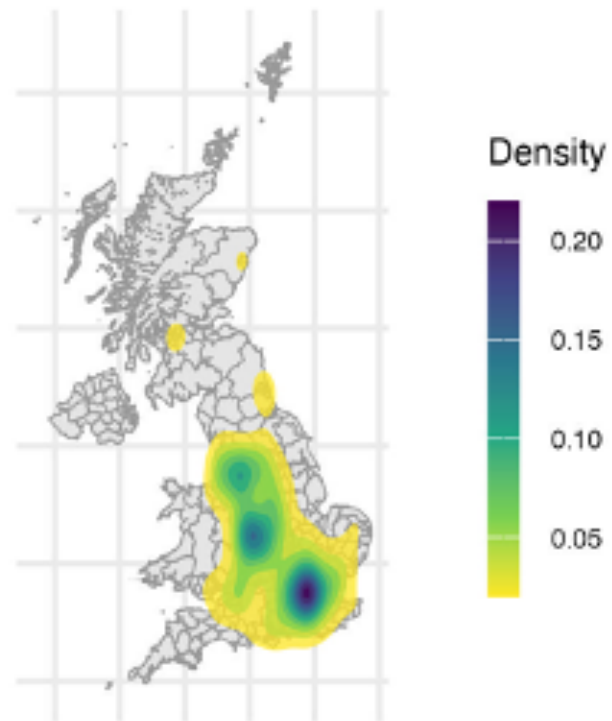
D. Textiles; Paper



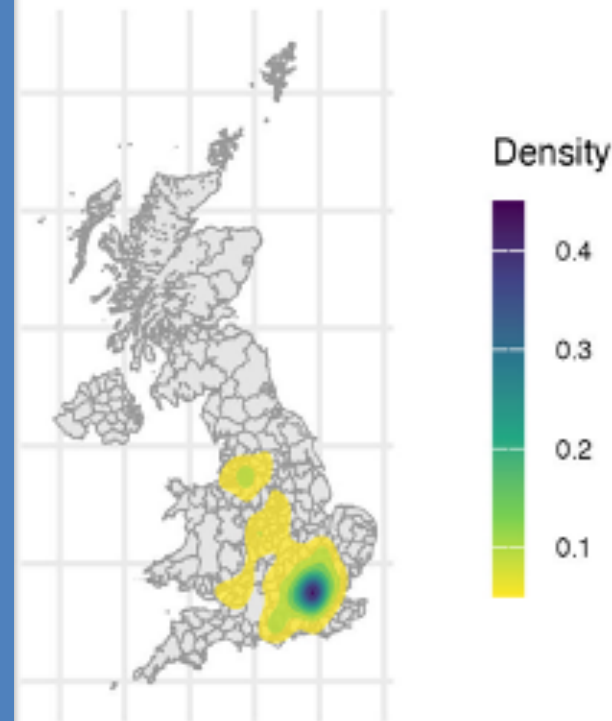
E. Fixed Constructions



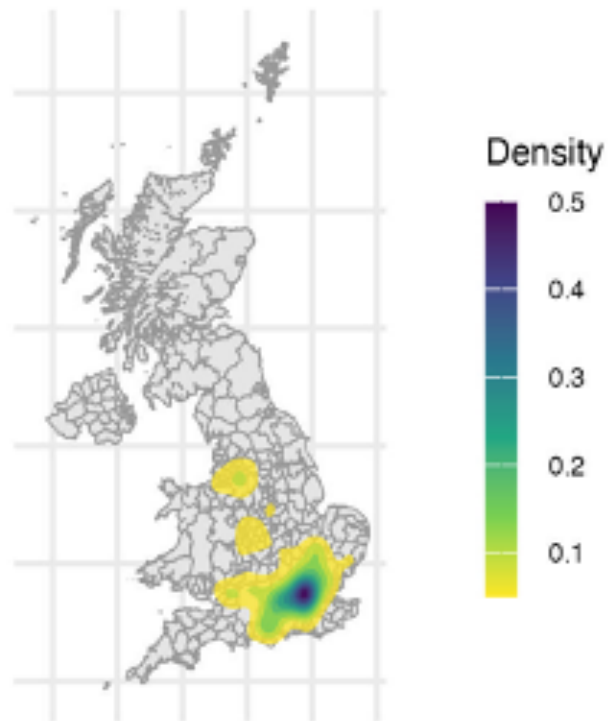
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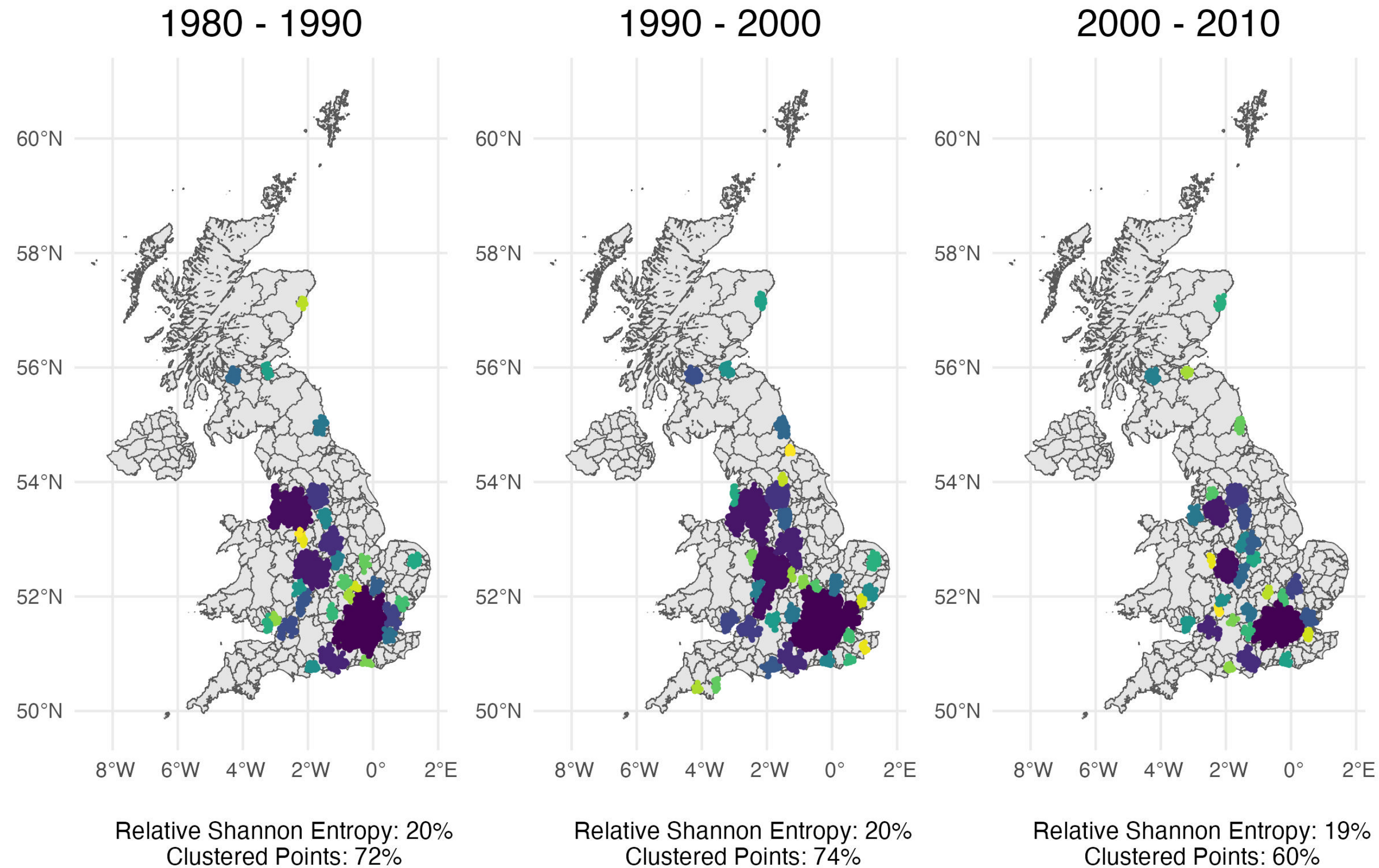
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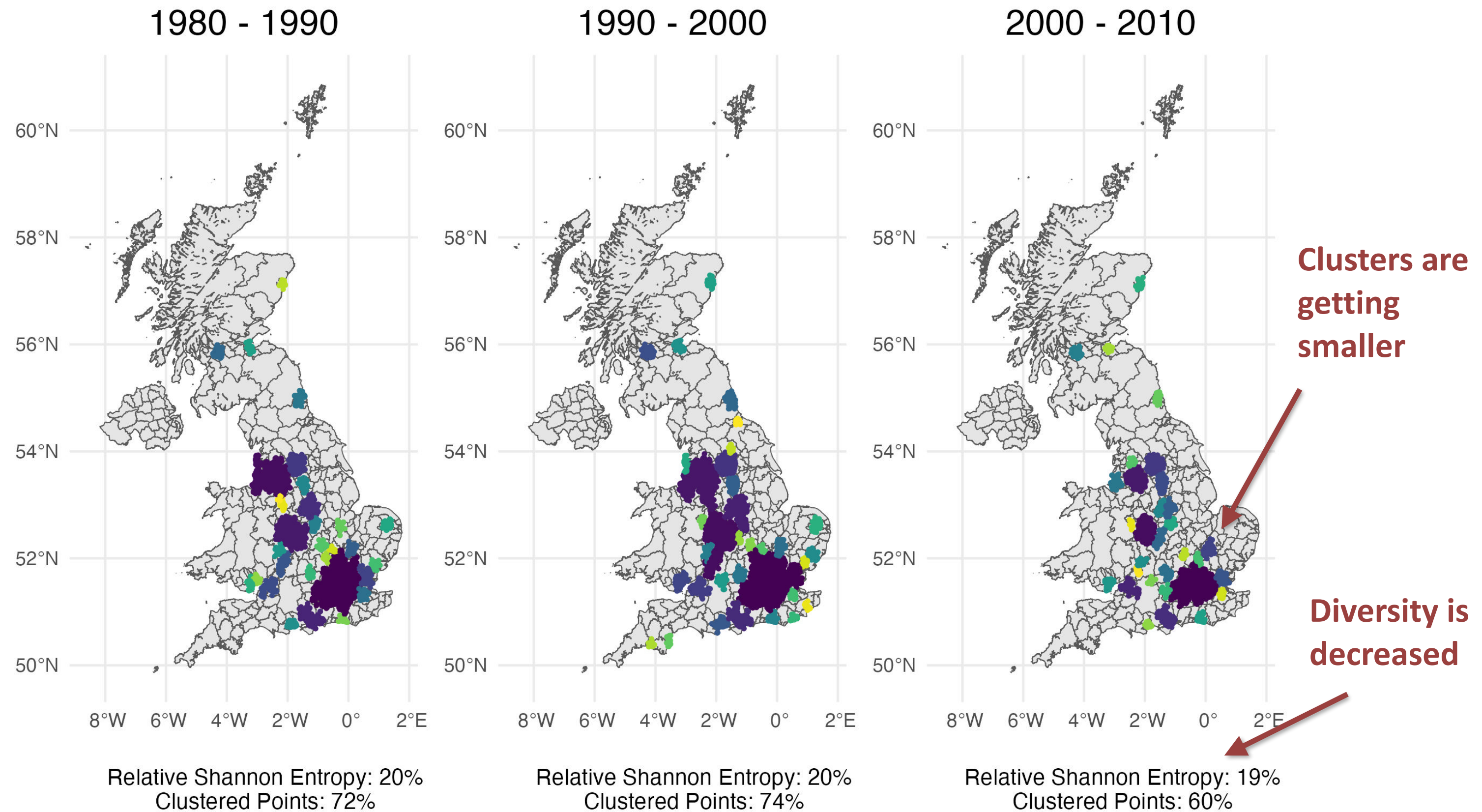
H. Electricity



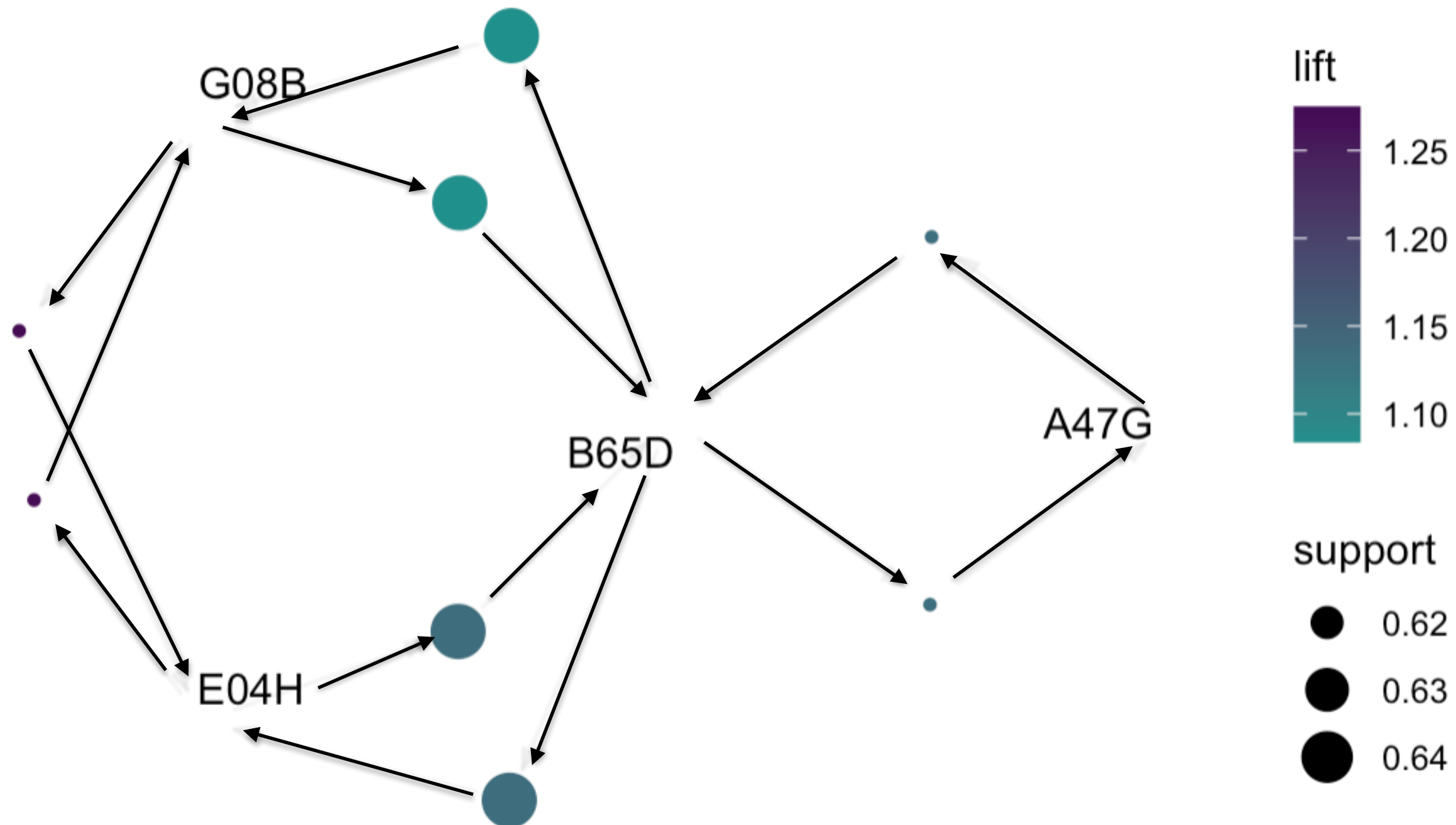
Density Based Clustering Of Patents



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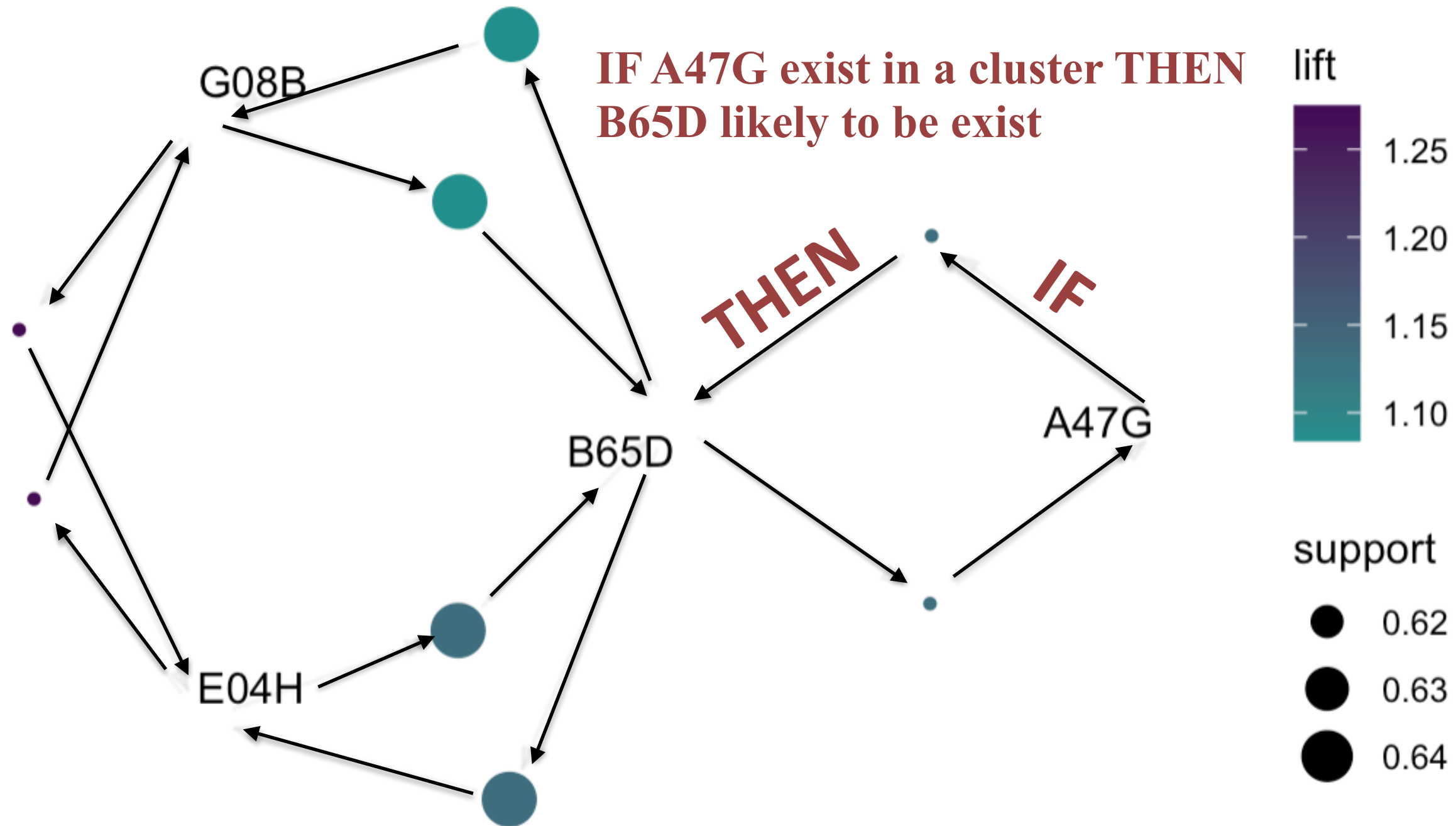


Asymmetric Association Rules



G08B : SIGNALLING OR CALLING SYSTEMS; ORDER TELEGRAPHS; ALARM SYSTEMS
E04H : BUILDINGS OR LIKE STRUCTURES FOR PARTICULAR PURPOSES
B65D : CONTAINERS FOR STORAGE OR TRANSPORT OF ARTICLES OR MATERIALS
A47G : HOUSEHOLD OR TABLE EQUIPMENT

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Asymmetric Association Rules

	lhs <chr>	<chr>	rhs <chr>	support <dbl>	confid... <dbl>	covera... <dbl>	lift <dbl>	count <int>
[1]	{A47G}	=>	{B65D}	0.6129...	0.9500...	0.6451...	1.1326...	19
[2]	{B65D}	=>	{A47G}	0.6129...	0.7307...	0.8387...	1.1326...	19
[3]	{E04H}	=>	{G08B}	0.6129...	0.9047...	0.6774...	1.2748...	19
[4]	{G08B}	=>	{E04H}	0.6129...	0.8636...	0.7096...	1.2748...	19
[5]	{E04H}	=>	{B65D}	0.6451...	0.9523...	0.6774...	1.1355...	20
[6]	{B65D}	=>	{E04H}	0.6451...	0.7692...	0.8387...	1.1355...	20
[7]	{G08B}	=>	{B65D}	0.6451...	0.9090...	0.7096...	1.0839...	20
[8]	{B65D}	=>	{G08B}	0.6451...	0.7692...	0.8387...	1.0839...	20

8 rows

Asymmetric Association Rules

	lhs <chr>	<chr>	rhs <chr>	support <dbl>	confid... <dbl>	covera... <dbl>	lift <dbl>	count <int>
[1]	{A47G}	=>	{B65D}	0.6129...	0.9500...	0.6451...	1.1326...	19
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[8]	{B65D}	=>	{G08B}	0.6451...	0.7692...	0.8387...	1.0839...	20

8 rows

Lift > 0 means patents are positively related,
Lift < 0 means patents are negatively relate,
Lift = 0 means relation is not significant

Asymmetric Association Rules

	lhs <chr>	<chr>	rhs <chr>	support <dbl>	confid... <dbl>	covera... <dbl>	lift <dbl>	count <int>
[1]	{A47G}	=>	{B65D}	0.6129...	0.9500...	0.6451...	1.1326...	19
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8 rows

Confidence levels are not equal

Summary

- 1) **Diversity** of technological clusters is **decreasing** after 2000.
- 2) **Technological Clusters** are getting **smaller** after 2000.
- 3) Asymmetric **relatednesses** discovered with **Association Rule Mining** Method.

Thank you!

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