Regional diversification into green and digital economic activities
The case of UK Local Authorities

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Introduction

- Two transitional challenges: a **digital transition** driven by novel technologies and a **green transition** propelled by the imperative to reduce the environmental impacts of economic activities.
- The "twin transition" is becoming increasingly important in economic geography and regional studies, as it holds **significant implications for regional development** (Diodato et al., 2023; Cicerone et al., 2023; Yue-Jun Zhang & Mengfan Du, 2023).
- The twin transition might lead to increasing **spatial inequalities.**
- Our analysis aims to shed light on the **geographic distribution** of this phenomenon **across the UK,** providing insights into **how the twin transition is unfolding in different regions** and **what it implies** for the overall economic landscape.

Motivation - Contribution

- Our research introduces a framework for identifying local **diversification opportunities in green, digital and twin domains.**
- The urban scaling analysis highlights the potential concern for **spatial inequalities** resulting from the twin transition, emphasizing the need for **place-specific strategies** to harness the benefits of these transitions, considering the unique economic and industrial structure of UK local areas.
- By employing an **innovative Real-Time Industry Classification (RTIC) system**, this study surpasses traditional methods in capturing the evolving landscape of green, digital, and twin sectors.

What does the twin transition mean for regions?

- The twin transition has the potential to **reshape** the economic productive structures of regions and local areas.
- The **benefits of the twin transition may not be evenly spread** across different regions (more economically **advanced areas** vs **less developed regions**)
- **Proactive and inclusive policy measures** are essential to ensure that the benefits of the twin transition are distributed more evenly across regions: investment in digital infrastructure, support for education and training in new technologies, and incentives for sustainable practices in various industries.

What kind of diversification for the twin transition?

- The relationship between the digital and green sectors and how they can benefit each other is still **unclear**. It is not yet fully understood how a region that is successful in green industries can use that success to **gain a competitive edge** in digital sectors, and vice versa.
- In exploring local industrial diversification and development, mainly through the lens of the twin transition, the role of **industry-relatedness** emerges as a **pivotal factor.**
- Industry relatedness provides a strategic pathway **for leveraging existing local strengths and capabilities** to embrace **new opportunities** in green and digital domains and navigate the twin transition effectively.

Data

- **Digital and green** sectors are **challenging to classify** in rigid, top-down categories due to their evolving nature. The application of SIC codes to digital and green industries has resulted problematic because of the dynamic nature of these industries.
- There is growing consensus on the **need for innovative and 'unstructured' data sources**, such as company websites and databases with advanced tagging systems.
- One of the key strengths of this type of data is their ability to provide a more nuanced and comprehensive view of the economy, **capturing emerging sectors that traditional classifications may overlook.**

Data

- In this paper, **Real-Time Industrial Classifications (RTICs)** from **The Data City** (www.thedatacity.com) are employed to identify the activities in which companies are involved and also to flag specific **emerging subsectors** within the three broader categories.
- The RTIC data from The Data City includes information on over 200,000 UK companies and employs a sophisticated approach that blends **machine learning algorithms** with specialized training by experts within business, consultancy, policy and academia to accurately classify and understand the activities of the UK companies.
- The dataset encompasses 51 RTICs, **385 subsectors (verticals)**, of which 166 grouped into digital sector, 45 associated with green sector, and 13 pertaining to the twin domain.

Methodology: Relatedness

- Relatedness allows us to determine whether a region possesses the relevant capabilities to diversify into a new industry favoring **structural change toward those activities that reveal an affinity** to the regional economy (Asheim et al., 2011; Foray et al., 2012; Boschma, 2014; Valdaliso et al., 2014; Foray, 2015; McCann & Ortega-Argilés, 2015; Iacobucci & Guzzini, 2016; Boschma, 2017; D'Adda et al., 2019b; Whittle, 2020; Boschma, 2021).

- According to the '**principle of relatedness**' (Hidalgo et al., 2018), the likelihood of regions entering an economic activity depends on the **cognitive proximity** between the new activity and a **region's prior activities** (Hidalgo et al., 2018).

Methodology: Relatedness

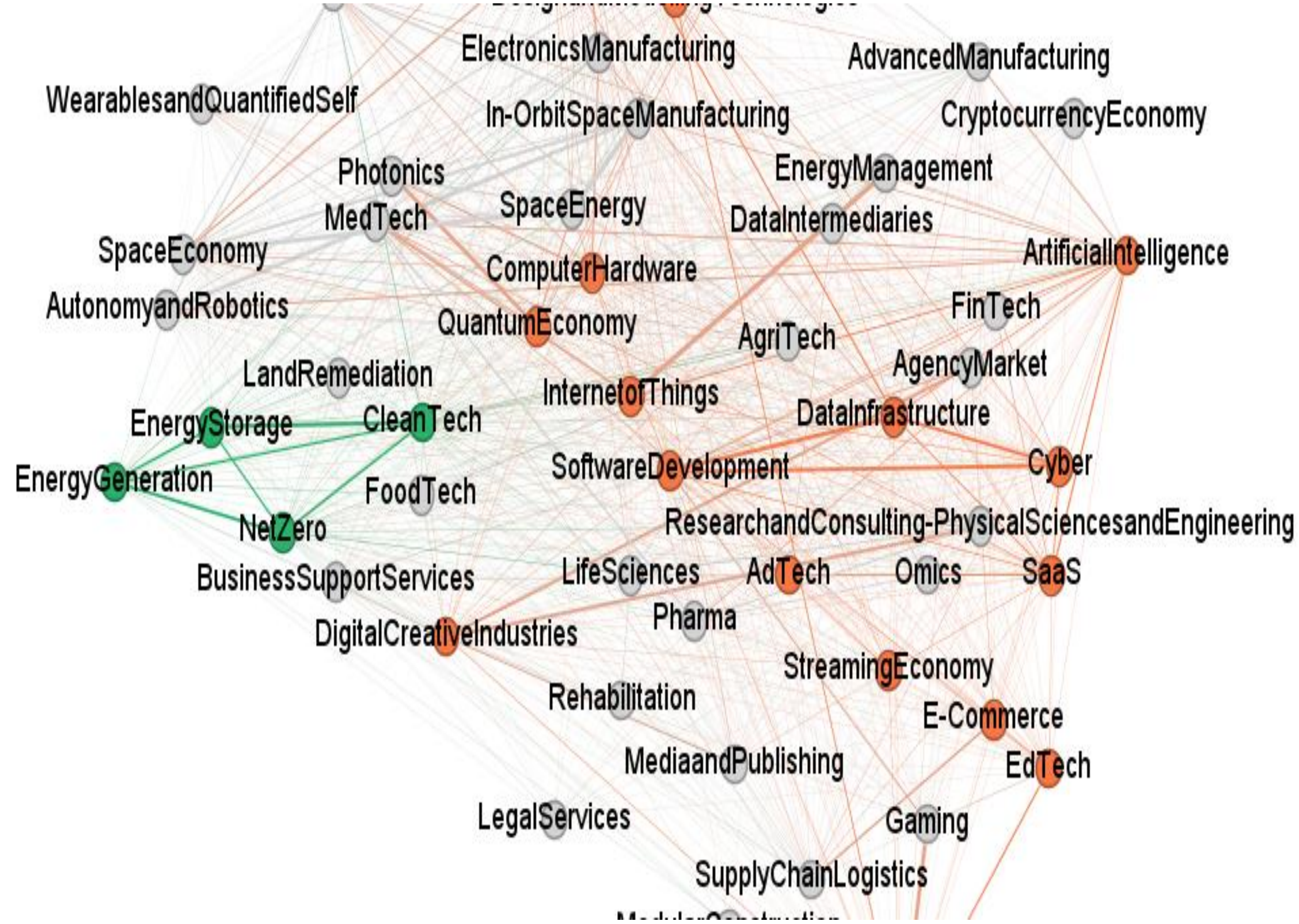
- Relatedness is an industry and place-specific index which measures the **average proximity of an industry to the productive structure of the economy** (Boschma et al., 2012; Boschma, 2017; Cortinovis et al., 2017) - or, in other words, its *diversification potential* - and can be used to anticipate changes in specialization patterns.

$$Rel_{i,r} = \frac{\sum_z \varphi_{i,j}\, x_{j,r}}{\sum_j \varphi_{i,j}}$$

where:

$$x_{j,r} = \begin{cases} 1 & if\ RCA_{j,r} \geq 1 \\ 0 & otherwise \end{cases}$$

Methodology: Relatedness



- Network representation of **51 RTICs (nodes)** and their **connections or proximities φ (links).**
- orange nodes = **digital RTIC**
- green nodes = **green RTIC**
- grey nodes = no digital, no green RTIC.

- $\varphi_{i,z} = min(P(x_{i,c}|x_{z,c}), P(x_{z,c}|x_{i,c}))$ calculated using all the 200.000 companies c in the DataCity.

- Example: the **proximity** between NetZero and CleanTech is **high** because the **number of companies in which the two tags coexist is high**.

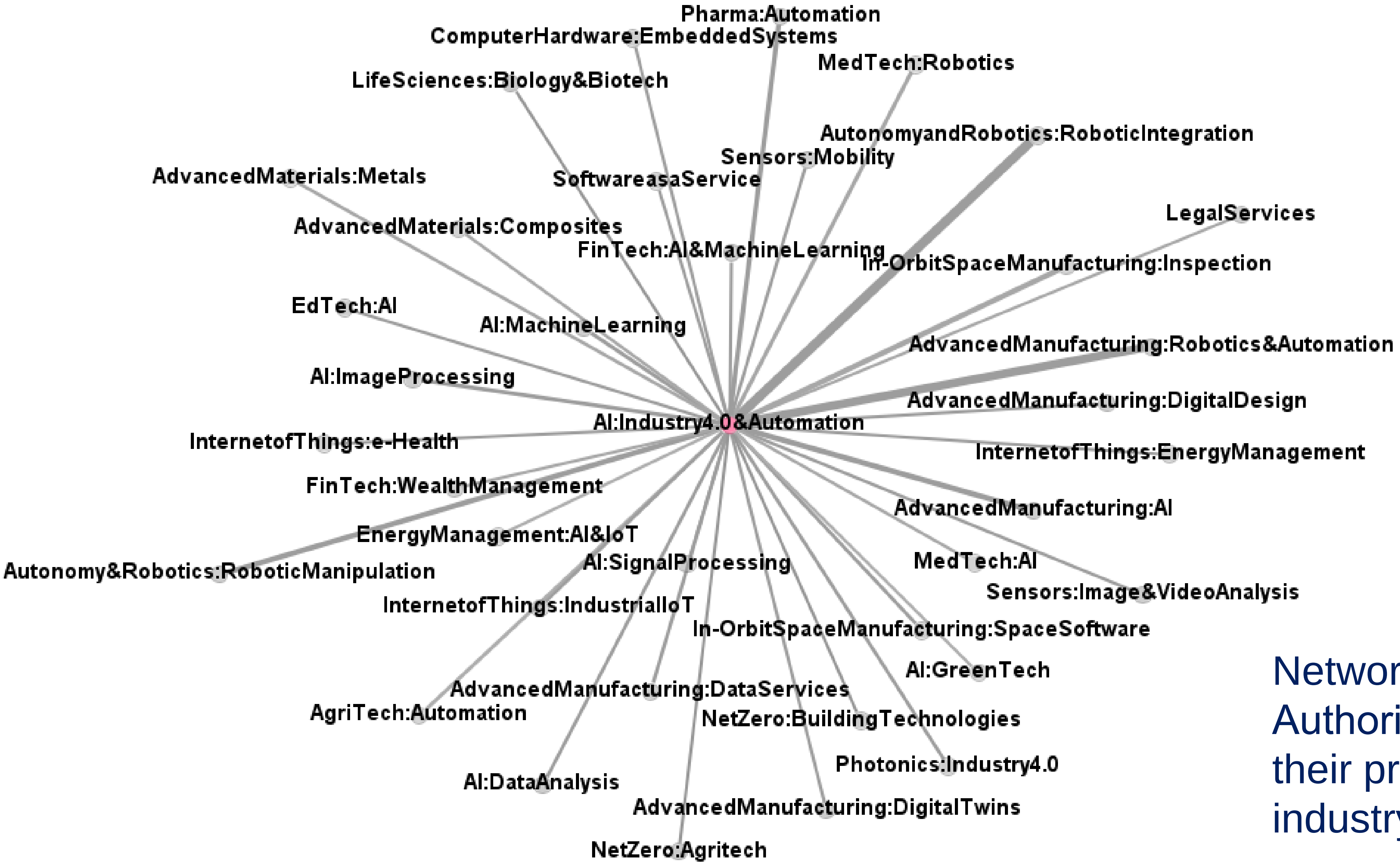
Example

Figure 1: Network representation of the RTICs (51 nodes). Thicker links represent stronger connections.

Industry A	*Industry B*	*Proximity*
InOrbitSpaceManufacturing	SpaceEnergy	234,9398
EnergyManagement	InternetofThings	215,7497
Gaming	ImmersiveTechnologies	206,8445
Photonics	QuantumEconomy	180,7732
SpaceEconomy	SpaceEnergy	179,2175
DataInfrastructure	SoftwareDevelopment	165,5329
CleanTech	EnergyStorage	164,1695
Cyber	SoftwareDevelopment	151,5033
AutonomyandRobotics	InOrbitSpaceManufacturing	149,9331
DigitalCreativeIndustries	ResearchandConsultingPhysicalSciencesandEngineering	140,7239

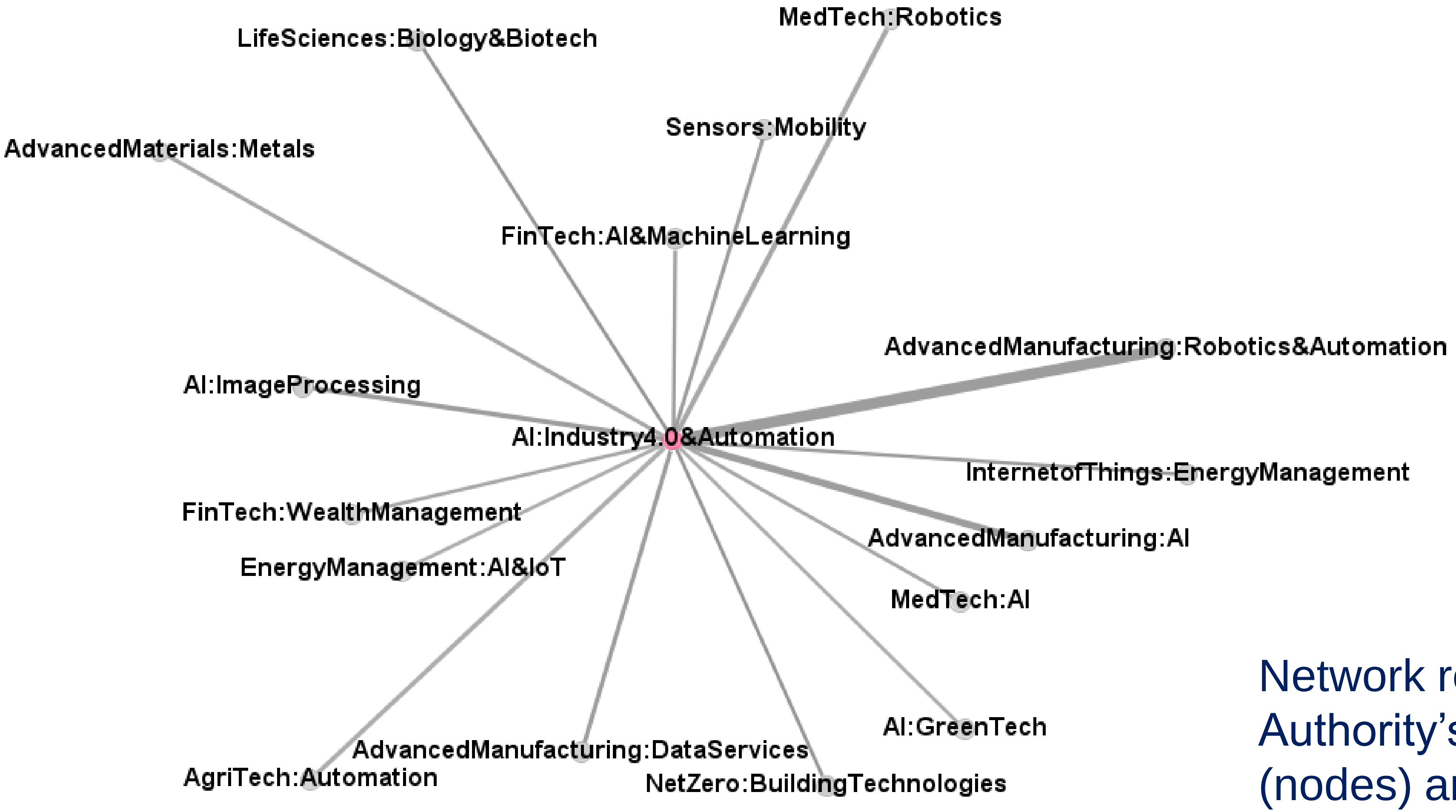
Figure 2: The 10 highest proximity values in the RTIC network

Methodology: Relatedness



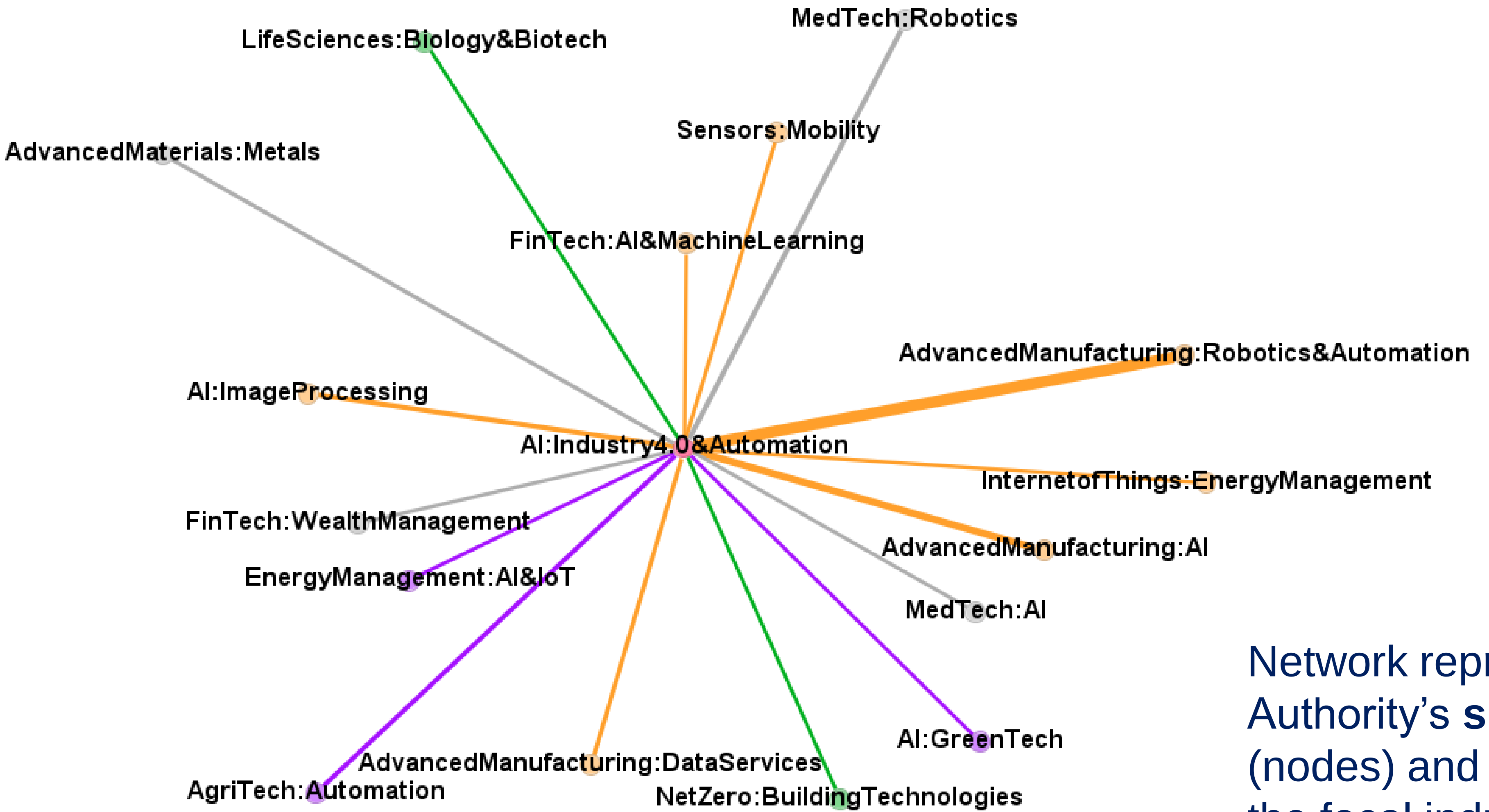
Network representation of **all** Local Authority's **industries** (nodes) and their proximities (links) with the focal industry (red node)

Methodology: Relatedness



Network representation of the Local Authority's **specialization industries** (nodes) and their proximities (links) with the focal industry (red node)

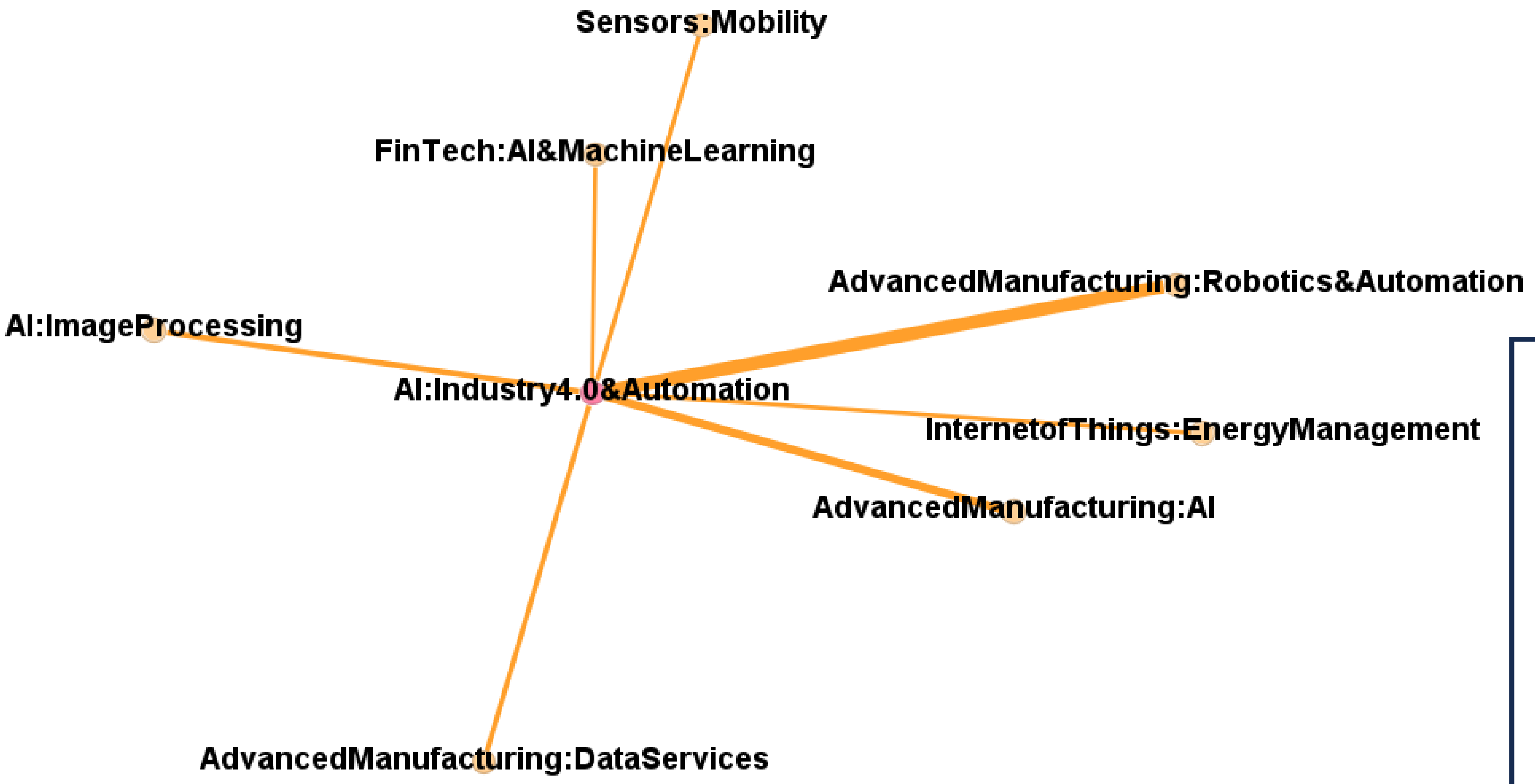
Methodology: Green/Digital/Twin Relatedness



Network representation of the Local Authority's **specialization industries** (nodes) and their proximities (links) with the focal industry (red node).

Links are colors: digital/green/twin

Methodology: Digital Relatedness

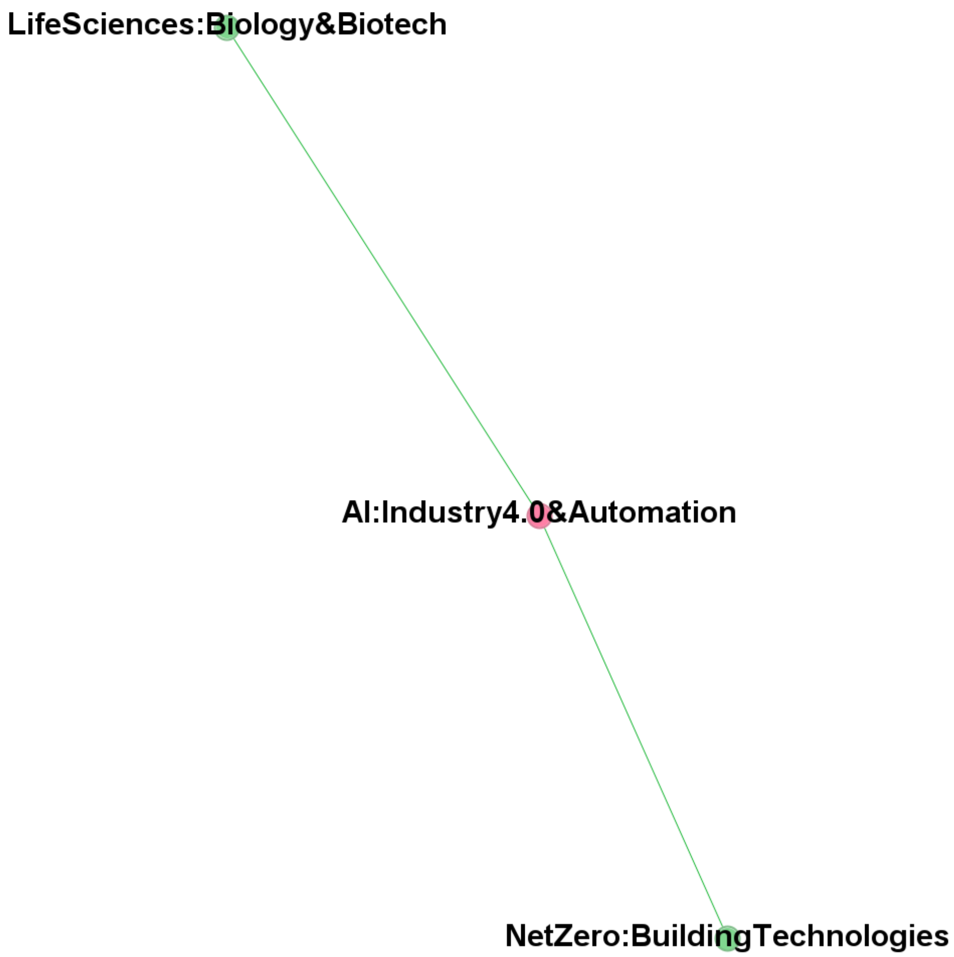


$$Dig\_Rel_{i,r} = \frac{\sum_z \varphi_{i,j}\, x_{j,r}\, i}{\sum_j \varphi_{i,j}}$$

$$x_{j,r} = \begin{cases} 1 & if\ RCA_{j,r} \geq 1 \\ 0 & otherwise \end{cases}$$

$$i = \begin{cases} 1 & if\ i\ is\ digital \\ 0 & otherwise \end{cases}$$

Methodology: Green Relatedness

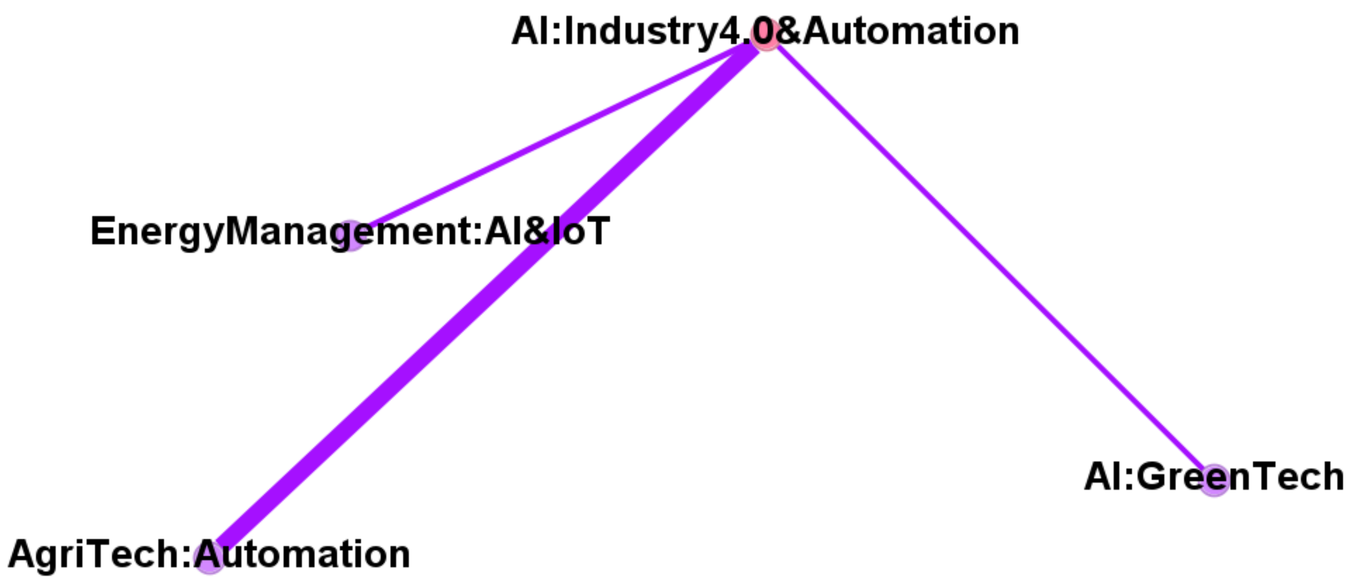


$$Green\_Rel_{i,r} = \frac{\sum_z \varphi_{i,j}\, x_{j,r}\, i}{\sum_j \varphi_{i,j}}$$

$$x_{j,r} = \begin{cases} 1 & if\ RCA_{j,r} \geq 1 \\ 0 & otherwise \end{cases}$$

$$i = \begin{cases} 1 & if\ i\ is\ green \\ 0 & otherwise \end{cases}$$

Methodology: Twin Relatedness

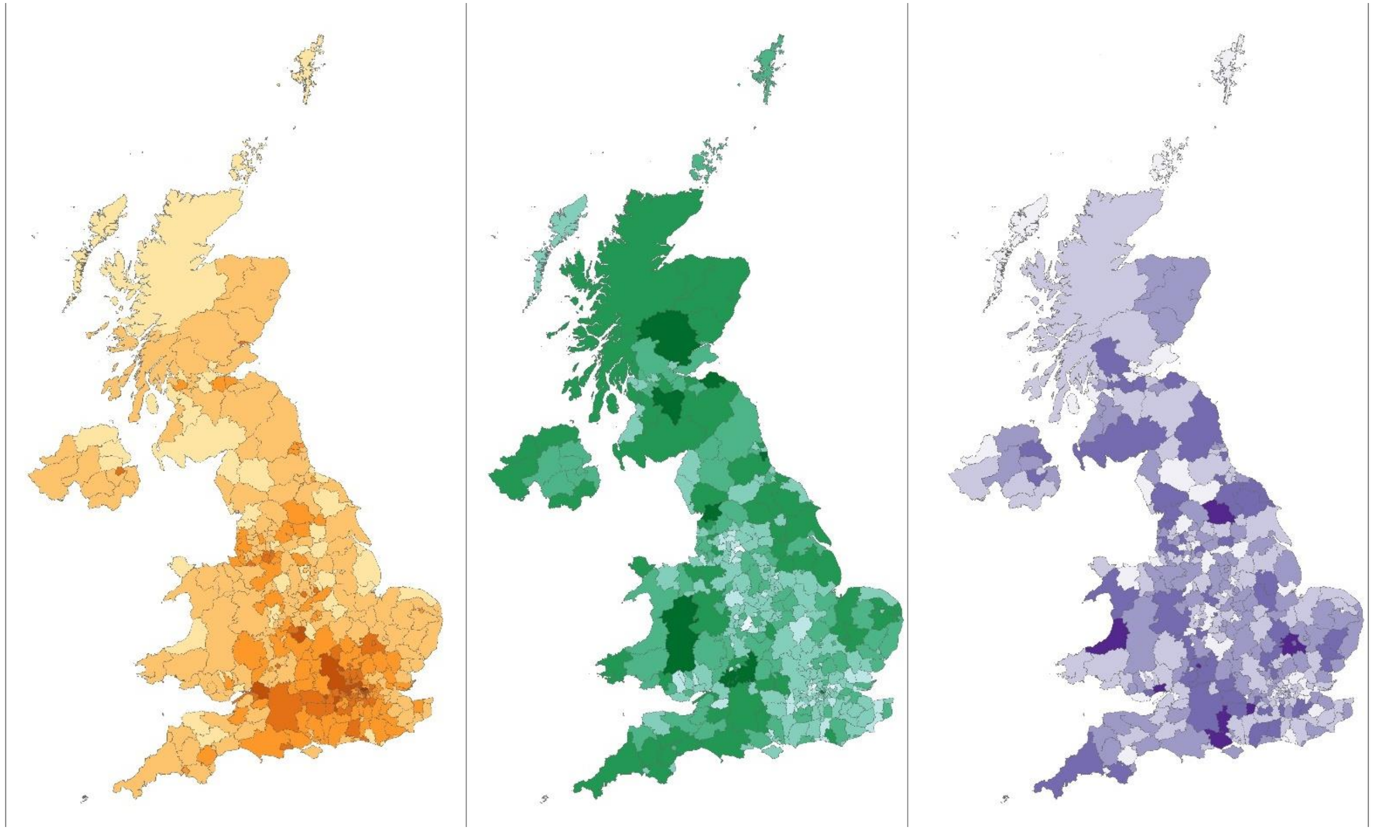


$$Green\_Twin_{i,r} = \frac{\sum_z \varphi_{i,j}\, x_{j,r}\, i}{\sum_j \varphi_{i,j}}$$

$$x_{j,r} = \begin{cases} 1 & \text{if } RCA_{j,r} \geq 1 \\ 0 & \text{otherwise} \end{cases}$$

$$i = \begin{cases} 1 & \text{if } i \text{ is twin} \\ 0 & \text{otherwise} \end{cases}$$

The geography of the twin transition in the UK



- This figure shows the **relatedness** of UK local authorities to **digital** (left panel), **green** (central panel) and **twin** (right panel) technologies.
- The values used are relatedness density scores averaged across all digital, green and twin subRTIC.
- A darker color denotes a higher potential.

Source: Own calculations based on The Data City data

The geography of the twin transition in the UK

- We investigate the urban scaling laws of green, digital, and twin industries.

- Drawing from existing literature on urban scaling, we hypothesize a relationship between the **number of firms active in these innovative industries Y** in a given region i at time t, and its **population N**. This relationship is modelled by the power law function:

$$Y_{i,t} = \alpha N_{i,t}^{\beta}$$

where α is a normalization constant, and β is the scaling exponent that captures the nonlinear relationship between industry size and population size.

- we estimate β using a log-transformation of the original function:

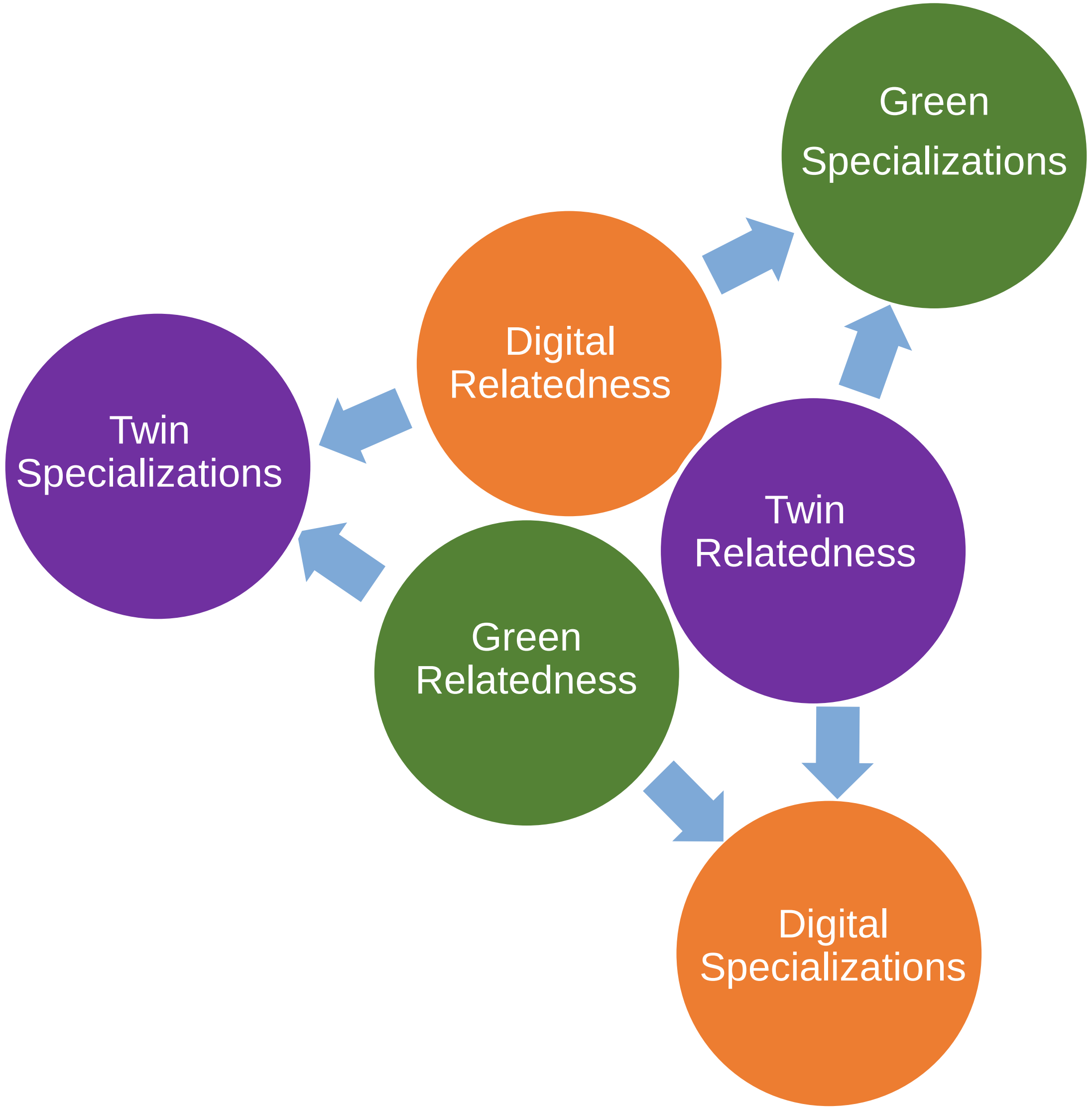
$$\ln Y_{i,t} = \alpha + \beta \ln N_{i,t} + \epsilon_{i,t}$$

where ϵ represents Gaussian white noise.

Results: Urban scaling of companies in UK

Dependent variable:						
	Digital Companies	Non-digital Companies	Green Companies	Non-green Companies	Twin Companies	Non-twin Companies
Population	1.276***	1.062***	0.918***	1.176***	0.887***	1.115***
	(0.060)	(0.040)	(0.049)	(0.048)	(0.062)	(0.044)
Constant	-9.633***	-6.044***	-5.734***	-7.319***	-7.803***	-6.381***
	(0.718)	(0.479)	(0.588)	(0.576)	(0.745)	(0.528)
Observations	373	373	373	373	373	373
R^2	0.548	0.654	0.483	0.616	0.352	0.631

Empirical strategy: Relatedness and regional diversification



Empirical strategy: Relatedness and regional diversification

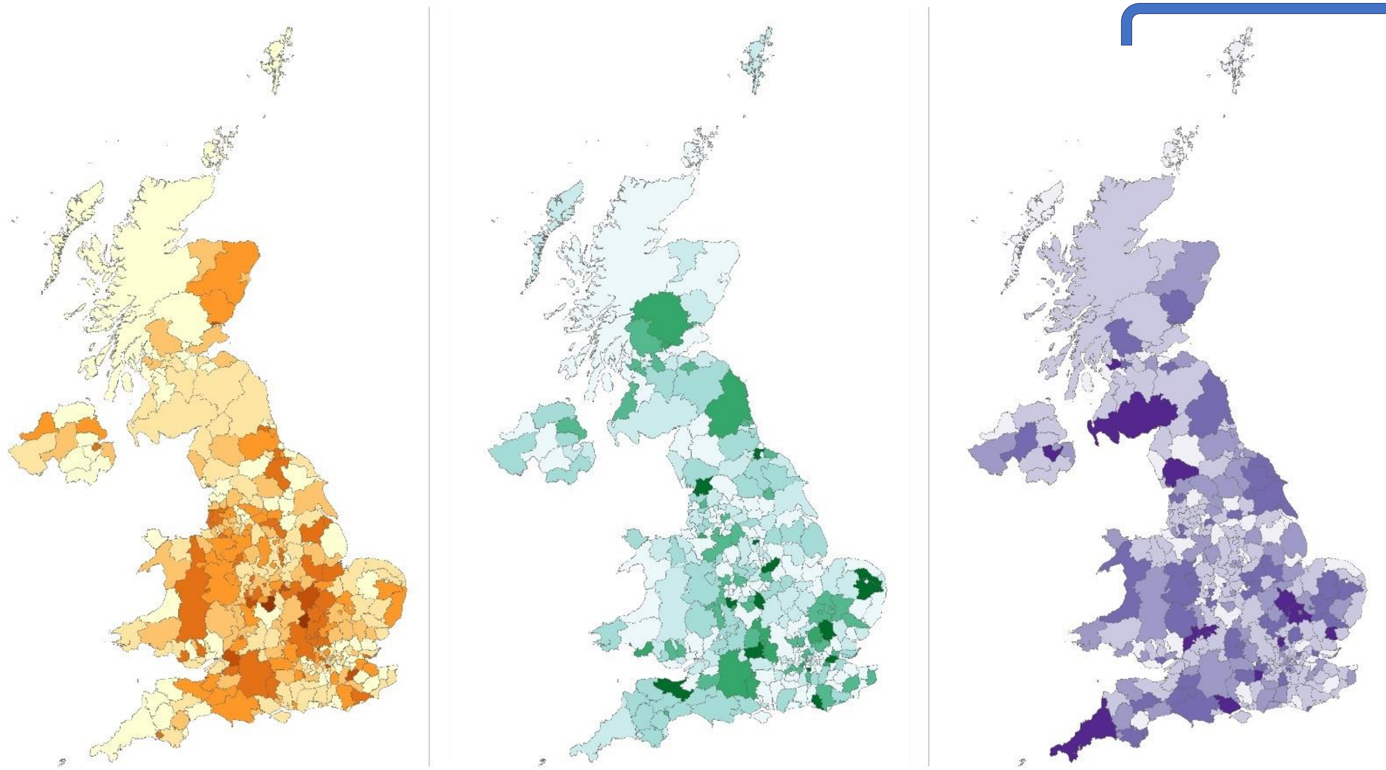


Figure 1: Digital/Green/Twin Relatedness of “AI:Industry4.0 and Automation” industry

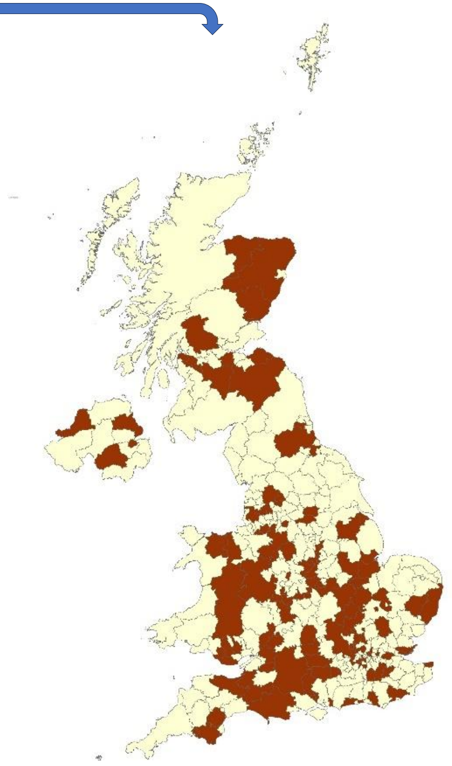


Figure 2: UK Local Authorities specialized in “AI:Industry4.0 and Automation” industry

Empirical strategy: Relatedness and regional diversification

- $\boldsymbol{DigitalRCA}_{i,r} = \alpha + \delta \boldsymbol{GreenRel}_{\boldsymbol{i,r}} + \delta \boldsymbol{TwinRel}_{\boldsymbol{i,r}} + \theta \bar{X}_{r,t-1} + \vartheta_t + \mu_c + \varepsilon_{c,r,t}$
- $\boldsymbol{GreenRCA}_{i,r} = \alpha + \delta \boldsymbol{DigitalRel}_{\boldsymbol{i,r}} + \delta \boldsymbol{TwinRel}_{\boldsymbol{i,r}} + \theta \bar{X}_{r,t-1} + \vartheta_t + \mu_c + \varepsilon_{c,r,t}$
- $\boldsymbol{TwinRCA}_{i,r} = \alpha + \delta \boldsymbol{DigitalRel}_{\boldsymbol{i,r}} + \delta \boldsymbol{GreenRel}_{\boldsymbol{i,r}} + \theta \bar{X}_{r,t-1} + \vartheta_t + \mu_c + \varepsilon_{c,r,t}$

- We conducted separate regressions for **comparative advantages in each sector** (digital, green, and twin), treating them as **dependent variables**.
- The key **independent variable** in these models is the **relatedness** of each region-industry observation to the other two macro-sectors (green, digital, and twin).
- Controls for agglomeration effects, innovation capacity and local GDP.

Results: Relatedness and regional diversification

	Digital Specialization	Green Specialization	Twin Specialization
Green Relatedness	0.053***		0.051***
	(0.012)		(0.004)
Digital Relatedness		0.016***	0.023***
		(0.004)	(0.002)
Twin Relatedness	0.344***	0.233***	
	(0.027)	(0.015)	
PATpp	yes	yes	yes
POP density	yes	yes	yes
GDPpp	yes	yes	yes
Industry FEs	yes	yes	yes
Local Authority FEs	yes	yes	yes
Constant	-0.006	-0.081*	-0.078***
	(0.080)	(0.043)	(0.024)
Observations	126,720	126,720	126,720
R^2	0.241	0.306	0.335

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Results: Relatedness and regional diversification

- While **digital and green sectors mutually support each other**, their **interrelationship** is complex and **moderated** significantly by the presence of **twin industries**.
- This finding underscores researchers' need to focus on the twin transition to broaden their scope. **Instead of solely examining green and digital economic activities**, as is common in many studies, it is **crucial also to consider** activities that are simultaneously green and digital (truly **twin activities**). This broader perspective is essential to understand and leverage the dynamics of the twin transition fully.

Conclusion and Discussion

- **Digital industries tend to cluster in urban, more populated areas**, exhibiting superlinear scaling with population size. In contrast, green and twin industries show less urban concentration, pointing to a more dispersed development pattern. This highlights the **potential concern for spatial inequalities** as a result of the twin transition.
- Regarding the complex interconnections among green, digital, and twin sectors, we find that while **green and digital sectors** already display positive synergies, they benefit even stronger **from the relatedness to twin sectors**, which embody characteristics of both. This insight is crucial for understanding the **dynamics of local economic restructuring in the context of the twin transition.**

Conclusion and Discussion

- Understanding the **geography** and the **complexities and synergies** between the green and digital transitions is crucial for policymakers, businesses, and individuals to navigate the **challenges** and **opportunities** of the future economy.

Our research provides a comprehensive analysis and insights for policymakers and stakeholders regarding the local implications of the twin transition. It emphasizes **the necessity of tailored approaches to harness the benefits of this transition, considering the unique economic and industrial landscapes of UK local areas.**

THANK YOU FOR YOUR ATTENTION

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Methodology: Relatedness

- Relatedness is an **industry-specific** and **place-specific** measure.
- To compute the relatedness, we identify *local specializations*, where specialization is recorded when the region has a revealed comparative advantage (RCA) greater than 1 in the industry. We construct a two-mode **matrix** X, where columns represent the **industries** and rows represent the **374 UK local authorities**. Each cell of the LA specialization matrix indicates if the local authority can be considered specialized in industry i. So basically, to compute relatedness in industry i and local authority r, **we average only the links** (proximities) linking the **focal industry** i to the **industries in which the local authority r is specialized.**