Semantic analysis of RDI achievements in the priority areas of the Slovenian Sustainable Smart Specialisation Strategy (S5)

May 7th, 2025

I FEEL SLOVENIA

Sofinancira Evropska unija

REPUBLIKA SLOVENIJA
MINISTRSTVO ZA KOHEZIJO IN REGIONALNI RAZVOJ

S5

SIRIS ACADEMIC

Contents

1. Objectives and summary of the methodology

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Objective of the project: To perform **a semantic analysis** of Research, Development and Innovation **(RDI) activities and results** from selected international databases **using artificial intelligence tools,**

- **as a basis for upgrading the development specialisation and RDI ecosystem** of the Republic of Slovenia
- and to **support the process of Entrepreneurial Discovery Process (EDP)**

1. Objectives and summary of the methodology

Increasing expectations and changing priorities for R&I

How to think about priorities, policy instruments and indicators when **expectations and external trends an inputs** on Research and Innovation **keep on expanding and shifting?**

Produced by ChatGPT

1. Objectives and summary of the methodology

But institutions, forms of organisation and skills don't change as quickly

An adapted approach to bridge this gap:

- **Thematic analysis of R&I activities and results as expressed by the R&I actors**
  - AI - Natural Language Processing on granular textual data (titles and abstracts)
- **Analysis of the specialisation of R&I actors, by type of actor, and how they organise**
  - Research, industrial, public admin., others
  - SRIP membership (in 2022)

Produced by ChatGPT

1. Objectives and summary of the methodology

Type of document	Data Source	Number of documents in Slovenia	Number of distinct actors in Slovenia
Scientific publications (only those with a DOI)	OpenAlex	~84,000	~7,400 disambiguated actors across the data sources
Patents (applications, to any patents office)	Patstat	~8,200 application ids, ~4,100 patent families	
Horizon projects	Cordis	~1,600	
ERDF projects	Kohesio	~8,400	
Interreg projects	Interreg	~930	

Period: 2014 - mid 2024.

Thematic analysis of R&I activities and results

Top-down: given an area of interest → identify the related R&I activities

- Smart cities and communities
- Sustainable Food Production
- Materials as end products
- ICT
- Smart Buildings and the Wood Chain Home
- Factories of the Future
- Health - Medicine
- Sustainable Mobility
- Sustainable Tourism
- Transition to a Circular Economy

Bottom-up: For a whole ecosystem (region, EU, ...) → identify the most frequent topics in R&I activities

1. Objectives and summary of the methodology

Smart Cities and Communities	Information and Communications Technology (ICT) – Horizontal Network	Smart Buildings and
Health	**Digital transformation**	**Smart, almost passiv**
Smart devices, sensors and tele-medicine	New business models and promotion of entrepreneurship related to digital transformation, including user experience	Modular and mobile de
Monitoring the functional health parameters and the quality of living in smart living environments	Green & Digital – Digital transformation related to digital and green transition	Fast construction syste
Personalised long-term care for patients, the elderly and other target groups	Digital transformation of the economy and public administ	Wooden constructions
Smart integrated healthcare and patient care system	**IoT (Internet of Things, embedded systems and sensors)**	Massive constructions
Establishing a smart integrated healthcare and patient care system	Mobile, wireless and edge infrastructure and communications for IoT (including 5G and 6G)	Interior and architectur
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Carbon neutral society	Open urban data platforms	Special, covering and f and systems
Using aggregate mobility data for better understanding of the migration dynamics within a municipality, as well as between municipalities	Innovative IoS services related to the Blockchain technology	Forest, timber and woo
Smart city traffic planning	**Cyber security**	**Interior elements**
Multimodal mobility platform	Development of security products and services	Light and lighting solut

"the baseline table"
(S5 Priloga Tabela)

Target analytical taxonomy

S5 - 1st level

Slovenian S5 **Priority Areas**

Smart Cities and Communities ... Factories of the Future

Classification method: **Top-down classifiers for the 10 S5 PAs**

S5 - 2nd level

Automatically identified topics

Smart Cities and Communities - **Topic 1**
Smart Cities and Communities - **Topic 2**
...
(10-20 topics per Priority area)

...

Factories of the Future - **Topic 1**
Factories of the Future - **Topic 2**
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Classification method: **Automatic identification of topics within a S5 PA, via topic modelling**

Transversal level

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(50 topics)

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Added-value: **Bottom-up identification of topics**, independent from the Slovenian S5

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AI-powered classification - Methodology overview

Challenge

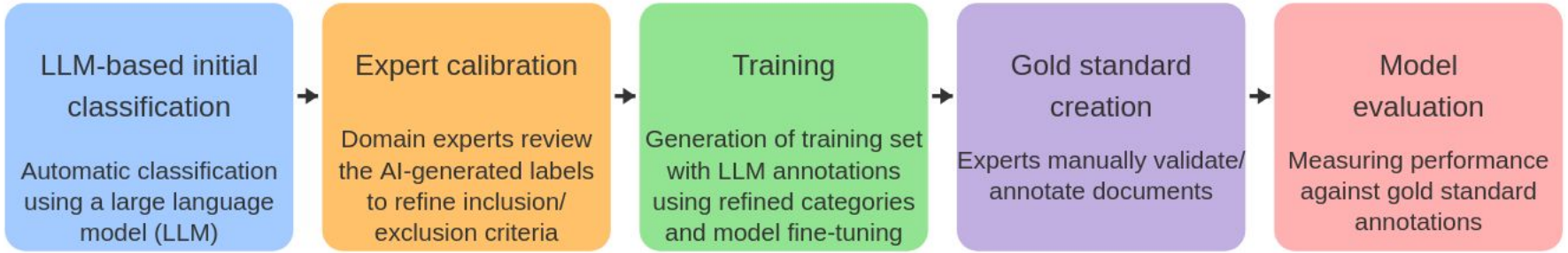
- Classifying 100,000+ documents into 10 Slovenian S5 priority areas require innovative AI-human expert collaboration.
- Large amount of training (pre-classified) data is needed for models to learn patterns in the data and make predictions.

Innovative approach

- Combining AI capabilities with **expert annotations** ensure accurate and scalable classification across diverse RDI documents.

Key contribution by six **thematic experts from the Cohesion Ministry's S3 Unit** for Calibration and Evaluation in January and February

Methodology breakdown



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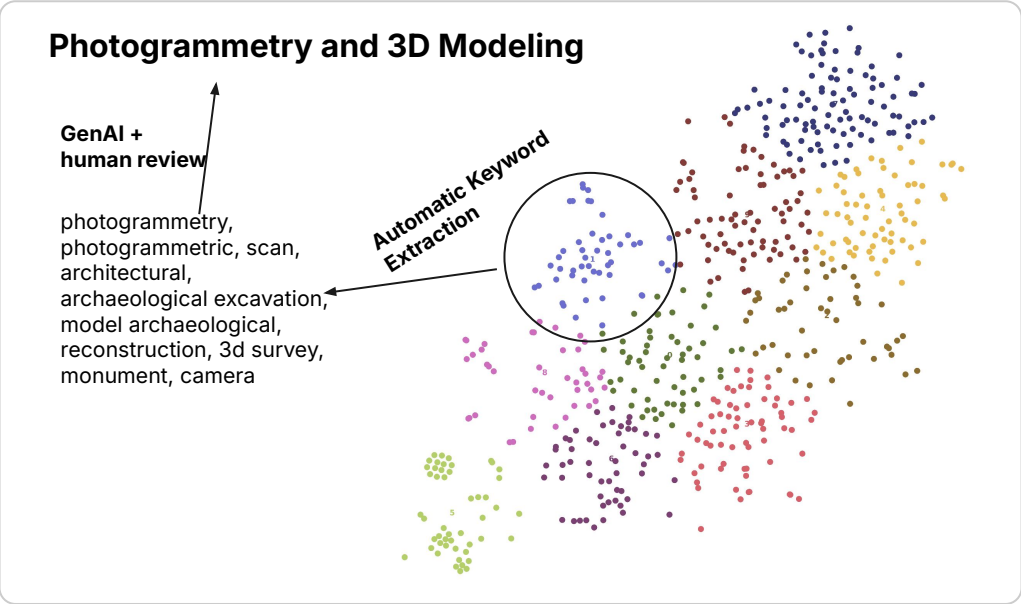
Identifying relevant RDI topics automatically via Topic Modeling: How does it work?

Topic Modelling (TM) is a **machine learning technique** that serves to **automatically "discover" the topics from a collection of texts** (in this case, titles and abstracts of scientific publications and R&I projects).

Semantically-similar texts, identified by deep learning models, **are clustered together, forming the topics.**

Advantages:

- **Custom taxonomy to a specific perimeter**
- **Find interdisciplinary topics**
- **Find new topics**
- **Mix data from different sources (e.g. publications + projects + patents)**



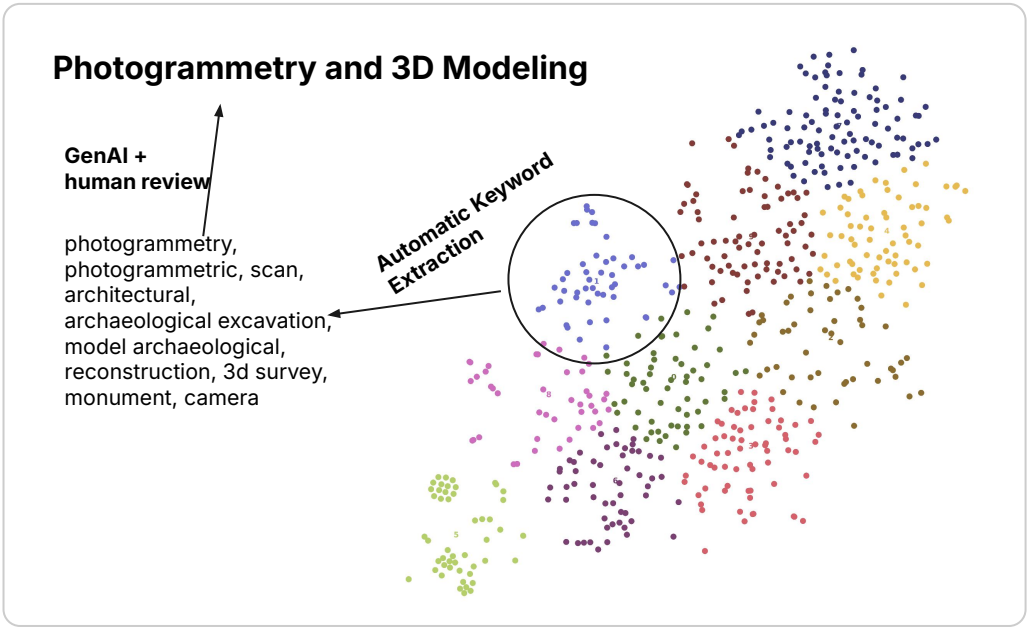
Identifying relevant RDI topics automatically via Topic Modeling: How does it work?

First, we use SPECTER*, a transformer-based model to convert texts into vectors.

Second, vectors are clustered into topics (using clustering method called K-Means).

Third, we use generative large language models and human expert curation to produce labels for each cluster.

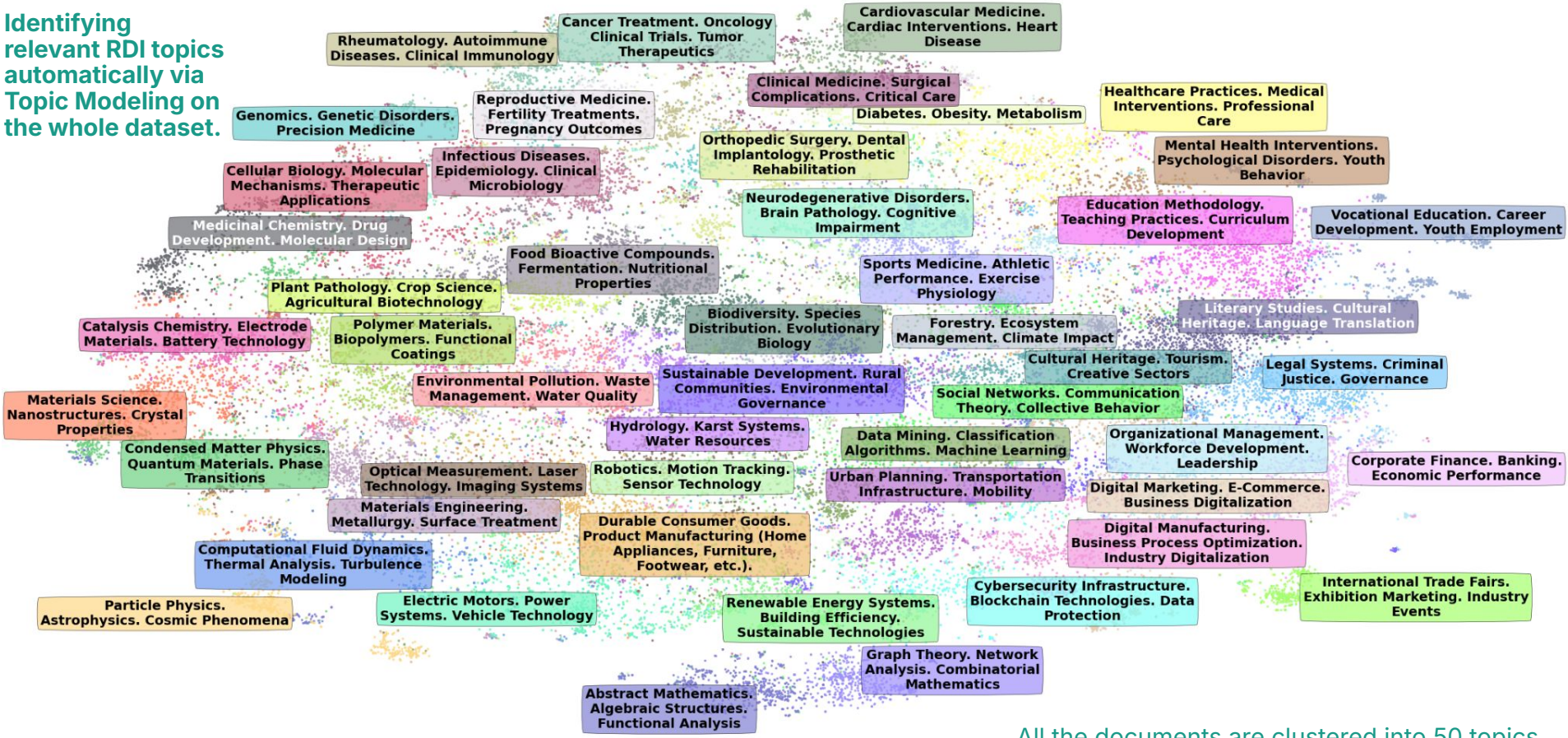
Example of a topic modelling, unrelated to Slovenia



* "SPECTER [is] a new method to generate document-level embedding of scientific documents based on pretraining a Transformer language model on a powerful signal of document-level relatedness: the citation graph."

1. Objectives and summary of the methodology

Identifying relevant RDI topics automatically via Topic Modeling on the whole dataset.



All the documents are clustered into 50 topics, and the topics automatically labeled for human inspection

Period: 2014 - mid 2024

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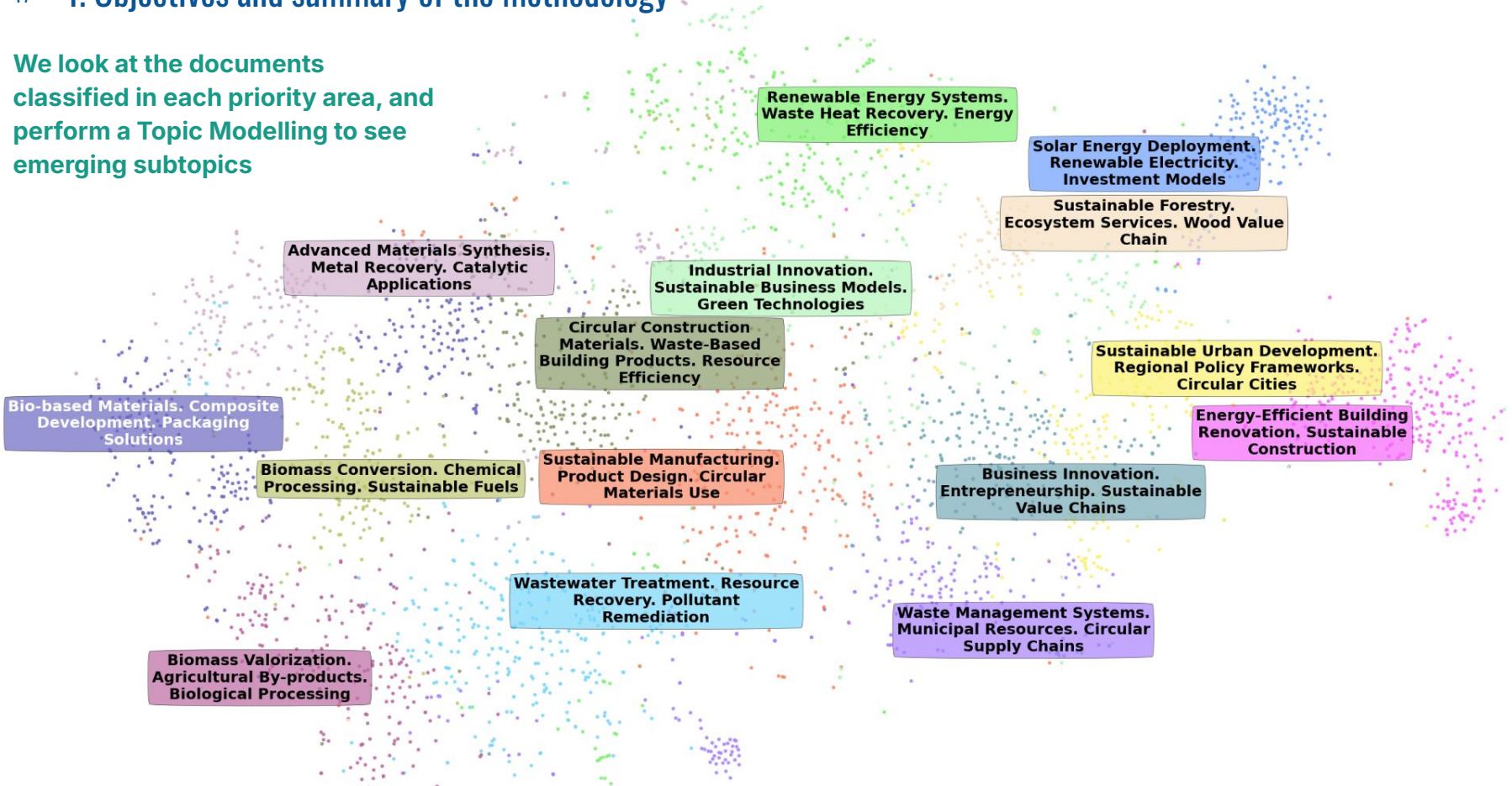
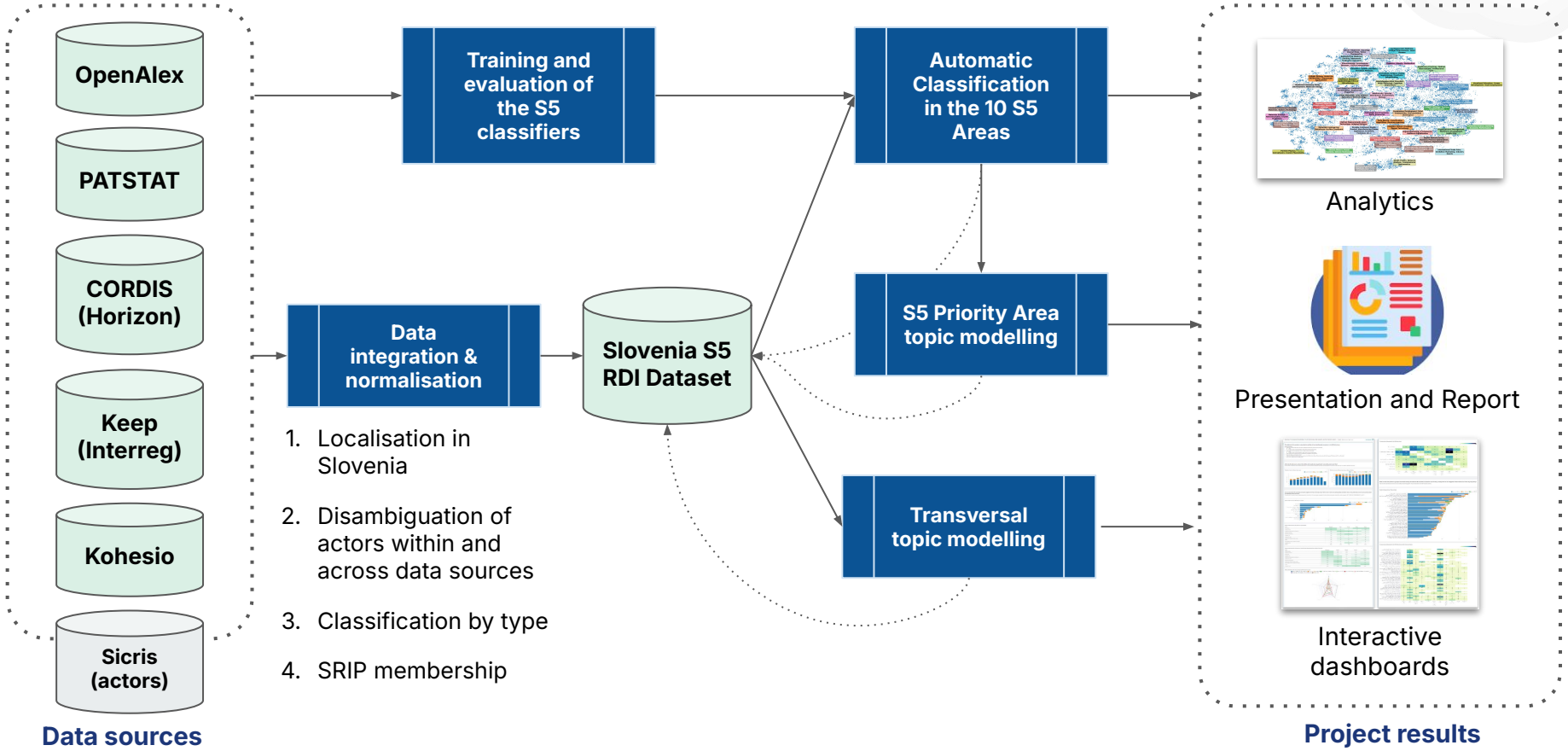
We look at the documents classified in each priority area, and perform a Topic Modelling to see emerging subtopics



Identifying relevant RDI topics in “Networks for the Transition to Circular Economy”

Summary scheme of the full methodology



1. Objectives and summary of the methodology

Data integration & normalisation

Methodological note

The 2,061 undefined organisations only represent 2% of the documents of the dataset. They are typically small public actors (eg. municipalities) active in one or few Kohesio projects.

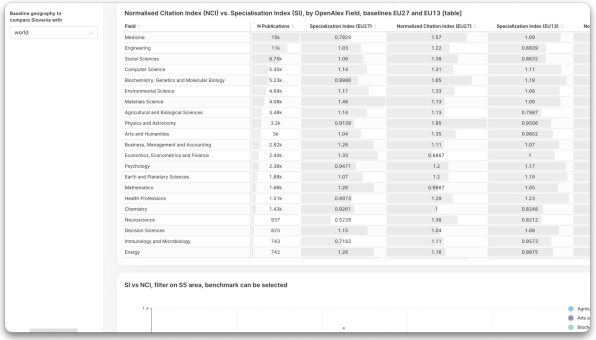
Organisation Macro type merge	*Organisation type merge*	Initial organisations	Merged organisations	Total RDI documents
Academic and research actors, incl. hospitals	**Higher or Secondary Education Establishments**	314	119	66,184
	Research Organisations	572	239	44,964
Industry	**Private for-profit entities (excluding Higher or Secondary Education Establishments)**	5,365	4,122	15,424
Public sector and Others	**Other (non-for profit non-gov)**	316	243	1,089
	Public bodies (excluding Research Organisations and Secondary or Higher Education Establishments)	955	795	5,315
Individual patent applicant	*Individual patent applicant*	*358*	*297*	*1,063*
None	*Undefined*	*2,061*	*1,912*	*3,339*
Grand Total		**9,941**	**7,727**	**137,378**

1. Objectives and summary of the methodology

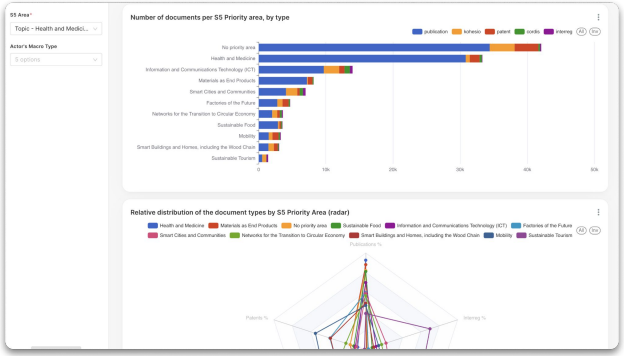
An interactive dashboard is built using this methodology: this presentation showcases the main results.

1. Overview of the Slovenian RDI activities in the S5 Priority Areas, their evolution, and their thematic content

3. RDI International benchmarking in publications and patents, using the original classifications systems of their data sources

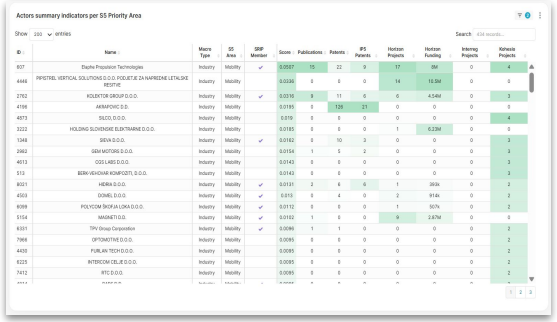


2. Focus on individual S5 Priority Areas



4. Indicators on Slovenian R&I actors in the S5 Priority Areas and the SRIPs

5. Indicators on Slovenian R&I actors in the transversal topics



2. Analysis of Slovenian RDI activities and results in the S5 Smart Specialisation Priority Areas

- **Understanding the distribution and evolution of the Slovenian RDI activities in the S5 Priority Areas**
- Comparing Slovenian RDI positioning in the S5 Areas with Europe and selected national benchmarks
- Understanding the overlap between S5 Priority Areas and the distribution of data sources per Area
- Identifying and comparing the RDI presence of research and industrial actors in the S5 Priority Areas
- Identifying key Slovenian S&T specialisation areas in an international comparison
- RDI in the S5 Priority Areas: synthetic overview for future evolution

Relevance

- **Understanding how much of all Slovenia RDI activities are aligned with the S5 Priority Areas** and how do they distribute across the Priority Areas.
- Understanding **the evolution of Slovenian RDI activities** within each priority area is key to understand their dynamics : are they growing, stagnating or shrinking?

These are key information for assessing the relevance of the current areas.

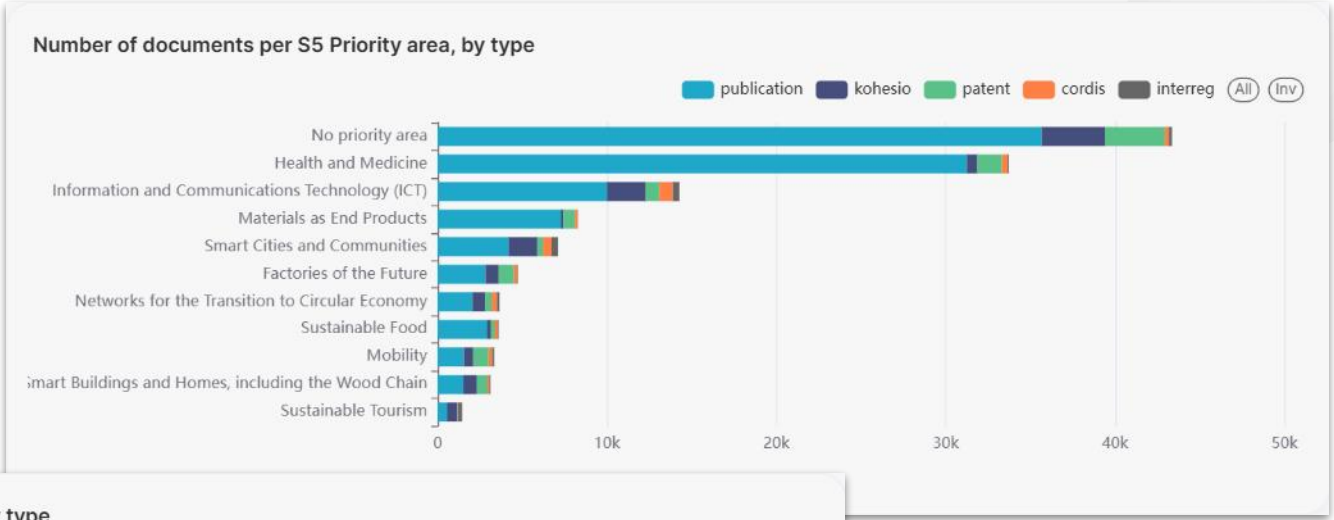
- Understanding **the distribution of Slovenian RDI activities** within each priority area helps define their nature.
    - For instance : a larger proportion of publications may indicate a priority area focused on science and technology.

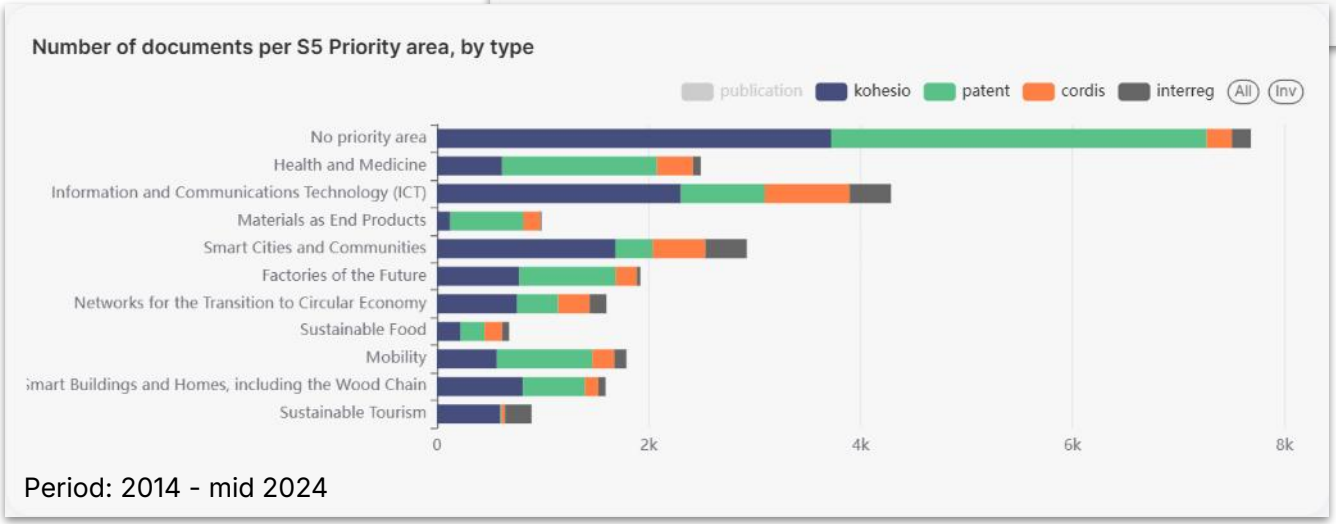
Understanding the distribution and evolution of the Slovenian RDI activities in the S5 PAs

Health and Medicine and **Materials as End Products** are strongly driven by scientific publications

Of the largest S5 Priority areas, **ICT** is the most balanced across the different data sources.

The rest of the S5 Priority areas, except for **Sustainable Tourism**, have similar sizes.





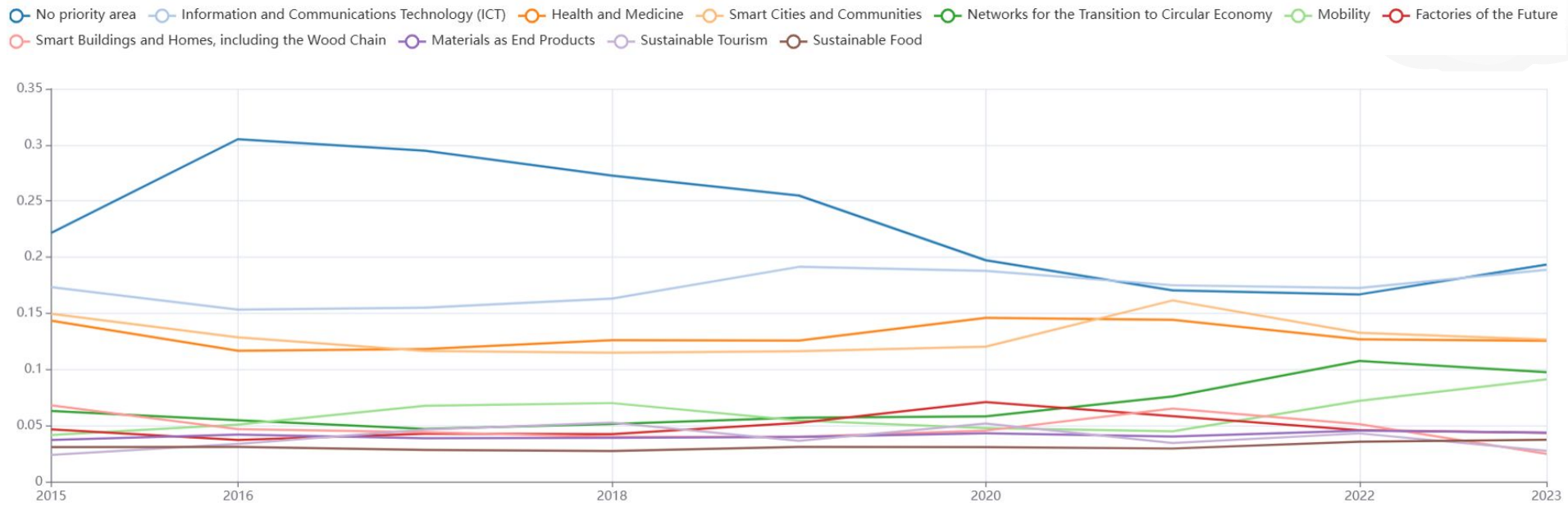
Period: 2014 - mid 2024

When excluding publications, all S5 priority area display an even higher degree of homogeneity, despite relatively lower levels of activity in priority areas Sustainable Food, Sustainable Tourism and Materials as End Products.

It is not easy to decide "where to cut", if a reduction of S5 Priority Areas is expected

Understanding the distribution and evolution of the Slovenian RDI activities in the S5 PAs

Temporal evolution of the concentration of RDI activities per S5 Priority Area (as % of the total, normalised by data source size)



- **"No priority area" has been decreasing since 2016,** showing the effect of S5 priorisation on RDI output.
- **Focusing on the S5 Priority Areas, no significant trends are identified,** except for the **recent relative growth of Circular Economy and Mobility**

Key insights on the volume and trends of RDI activity

- All Priority Area display a significant volume of RDI activity, with a relative **homogeneous decrease in size and in trends.**
- **Outliers are Health - Medicine, at the top, and Sustainable Tourism, at the bottom.** As shown in the next section, these are expected to be the largest and smallest such priorities in any R&I ecosystem.
- **The share of "No priority" documents has decreased over the period,** demonstrating the pertinence and dynamism of the S5 priority-setting in aggregate.

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Comparing Slovenian RDI positioning in the S5 Areas with Europe and benchmarks

To have a clearer view of the positioning of Slovenia inside the international context in terms of S5 areas, we need to perform a benchmarking against relevant countries.

- For **publications** and **patents**, the benchmark is against 4 comparable European countries in terms of size and vocation: Austria (AT), Croatia (HR), Czechia (CZ), and Estonia (EE).
- For **Horizon projects**, all the projects in Cordis (around 76k) have been classified, therefore the benchmark baseline is the whole programme.

The benchmarking indicator is the ***specialisation index (S.I.)***, which measures the extent to which the country's documents focus in certain fields compared to another region (here EU27 and EE, AT, HR, CZ, SI), useful to see the distinctive features of a country's specialisation profile.

An S.I. > 1 indicates a specialisation in that field.

Formally, it is here computed as:

$$\frac{\%\ \text{of total Slovenian publications in field X}}{\%\ \text{of total EU publications in field X}}$$

Comparing Slovenian RDI positioning in the S5 Areas with Europe and benchmarks

Overview table of benchmarks for publications, patents, and projects

S5 priority area	Publications S.I. (2020-2023) [baseline: EE, AT, HR, CZ, SI]	Patents S.I. (2019-2022) [baseline: EE, AT, HR, CZ, SI]	Horizon project S.I. (2020-2023) [baseline: Europe]	Horizon funding S.I. (2020-2023) [baseline: Europe]
Health and Medicine	1.02	1.44	0.67	0.74
ICT	0.97	0.82	1.64	0.94
Materials as End Products	1.18	0.73	1.20	1.07
Smart Cities and Communities	1.21	1.20	2.13	1.21
Sustainable Food	1.07	1.87	2.00	1.05
Factories of the Future	1.06	0.82	1.59	0.99
Circular Economy	1.30	1.44	2.22	1.51
Mobility	0.83	0.98	2.30	1.25
Smart Buildings and Homes, including the Wood Chain	1.61	1.76	3.31	3.49
Sustainable Tourism	1.63	1.29 (only 2 patents)	2.95	1.28
No priority area	0.98	0.98	0.57	0.87

Comparing Slovenian RDI positioning in the S5 Areas with Europe and benchmarks

S5 priority area	Publication S.I. (2020-2023) [baseline: EE, AT, HR, CZ, SI]	Patent S.I. (2019-2022) [baseline: EE, AT, HR, CZ, SI]	Horizon project S.I. (2020-2023) [baseline: Europe]	Horizon funding S.I. (2020-2023) [baseline: Europe]
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Sustainable Tourism	1.63	1.29	2.95	1.28
No priority area	0.98	0.98	0.57	0.87

- *Smart Buildings and Homes, including the Wood Chain* is the priority area with the most transversal specialisation (publications, patents, and projects);
- Overall, the S5 areas where it is more specialized are:
  - *Sustainable Food*;
  - *Networks for the Transition to Circular Economy*;
  - *Sustainable Tourism*.
- Slovenia is very specialized in patents in *Health and Medicine*, which is the largest S5 priority area;
- Slovenia is very specialised in the S5 Priority areas in Horizon by number of projects, except in Health

Period: 2014 - mid 2024, if not differently specified

Comparing Slovenian RDI positioning in the S5 Areas with Europe and selected national benchmarks

Key insights :

- Overall, Slovenia is quite specialised in its priority areas.
- Levels of specialisation vary accordingly

Very specialised in publications (top 2 across the benchmark countries)

- Factories of the future
- Materials as End Products
- Network for the Transition to Circular economy
- Smart Buildings and Homes
- Smart Cities and Communities
- Sustainable Tourism

Very specialised in patents (top 2 across the benchmark countries)

- Network for the Transition to Circular economy
- Smart Buildings and Homes
- Sustainable food

Very specialised in Horizon projects (average SI >1.5 of Horizon projects and funding)

- Smart Cities
- Sustainable food
- ICT
- Factories of the Future
- Circular Economy
- Mobility
- Smart buildings
- Sustainable Tourism

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- Comparing Slovenian RDI positioning in the S5 Areas with Europe and selected national benchmarks
- **Understanding the overlap between S5 Priority Areas and the distribution of data sources per Area**
- Identifying and comparing the RDI presence of research and industrial actors in the S5 Priority Areas
- Identifying key Slovenian S&T specialisation areas in an international comparison
- RDI in the S5 Priority Areas: synthetic overview for future evolution

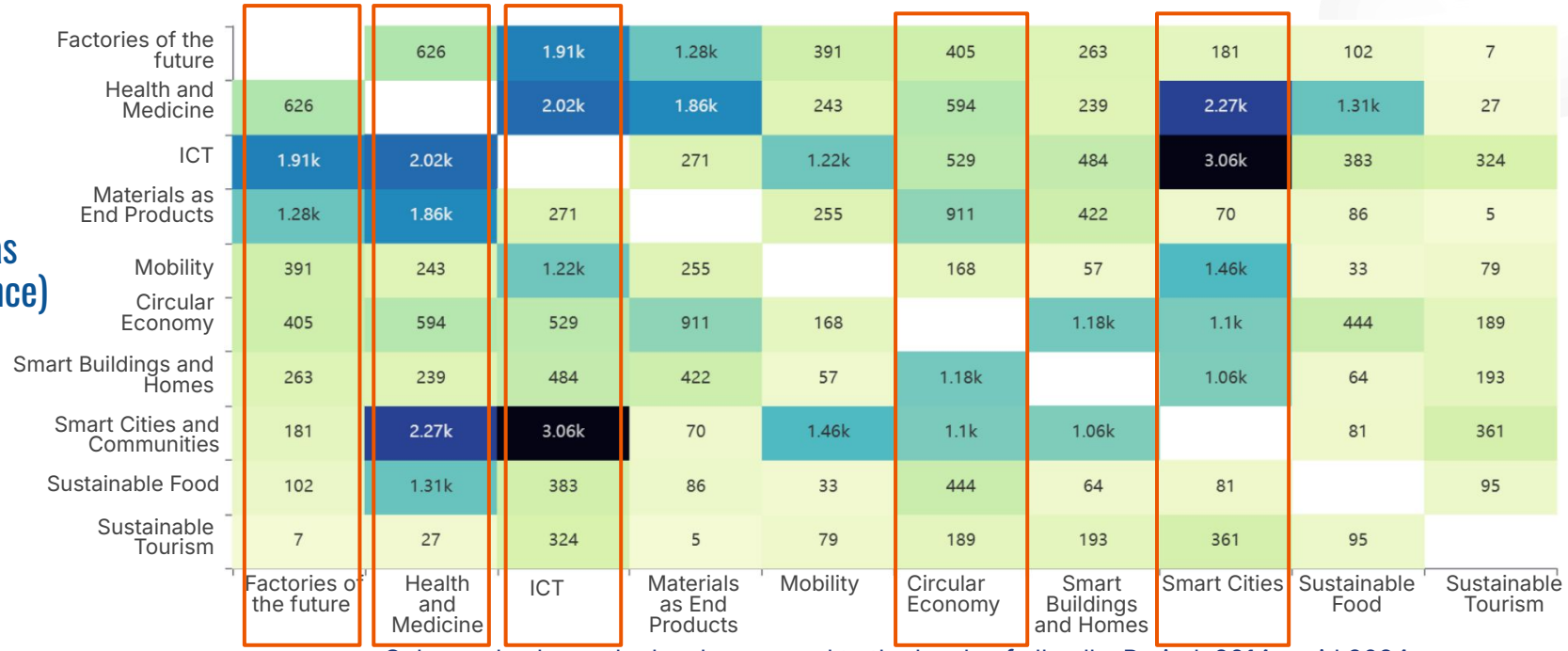
Context and relevance of understanding the overlaps between priority areas

- Understanding the existing overlaps between priority areas is a key element to consider when reviewing the structure of areas
  - It can help **decide where a merger or split of priority areas is possible**
  - It can help **distinguish between highly transversal priority areas and vertical ones**
- It is also a key element when designing policy tools that aim at addressing several areas at once, especially for infrastructure policy

Our analysis allows for such analysis by looking at the co-occurrence of classification of a document in several priority areas

Understanding the overlap between S5 Priority Areas and the distribution of data sources per Areas

Documents classified in multiple S5 Priority Areas (co-occurrence)



Color scale shows the level compared to the levels of all cells. Period: 2014 - mid 2024.

- **Some S5 Priority Areas are very transversal,** with significant output shared with several Priority Areas : this is the case of **Factories of the Future, Health and Medicine, ICT, Smart Cities and Circular Economy.**
- In contrast, other S5 Priority Areas have lower levels of co-occurrence of their scientific output with other Priority Areas, except with the most transversal ones : this is the case of Sustainable Food, Sustainable Tourism, Smart Buildings and Homes, and Mobility

Understanding the overlap between S5 Priority Areas and the distribution of data sources per Areas

Documents classified in multiple S5 Priority Areas (Relative co-occurrence)

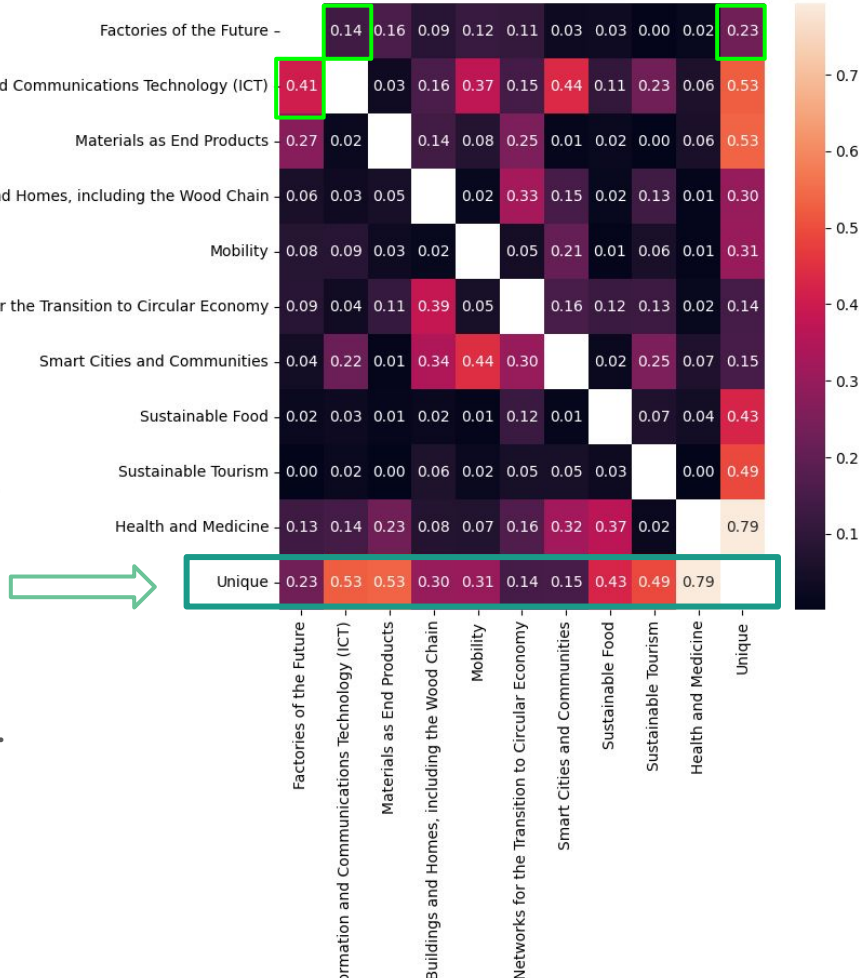
How to read this graph?

We are looking at documents which have more than one classification, that is, co-occurrence of S5 Priority Areas.

Documents that are only classified in one area can be found in the last row and column as "**Unique**"

41% of documents in FoF are also in ICT, while 14% of ICT documents are also in FoF.

23% of documents in FoF are not classified in any other Priority.



Period: 2014 - mid 2024

Understanding the overlap between S5 Priority Areas and the distribution of data sources per Areas

Factories of the Future presents a high relative overlap overall, notably with ICT (41%), Materials (27%) and Health (13%). Few documents are unique to FoF, **with a low share of unique documents (23%).**

Smart cities presents high contribution to many other areas (Mobility, Smart Buildings, Circular economy, Smart cities, Tourism, etc.), showing its transversality and diversity. **Only 15% of its documents are unique to this priority area.**

Circular economy presents high contribution to many other areas, notably Smart Buildings, Smart Cities and Materials showing its transversality. **Only 14% of its documents are not classified in any other category, the lowest share**.

ICT presents high contribution to many other areas (FoF, Mobility, Smart cities, Tourism, etc.) **while having still a distinctive core (53%)**. As such, it is both a transversal tool, and a distinct discipline/industry in terms of research and technology.

Health and Medicine, overlaps with many other Priorities (notably Smart cities, Food and Materials) also thanks to its large size. At the same time, it **presents the largest share of unique documents (79%), showing its autonomy in most subtopics.**

Period: 2014 - mid 2024

Understanding the overlap between S5 Priority Areas and the distribution of data sources per Areas

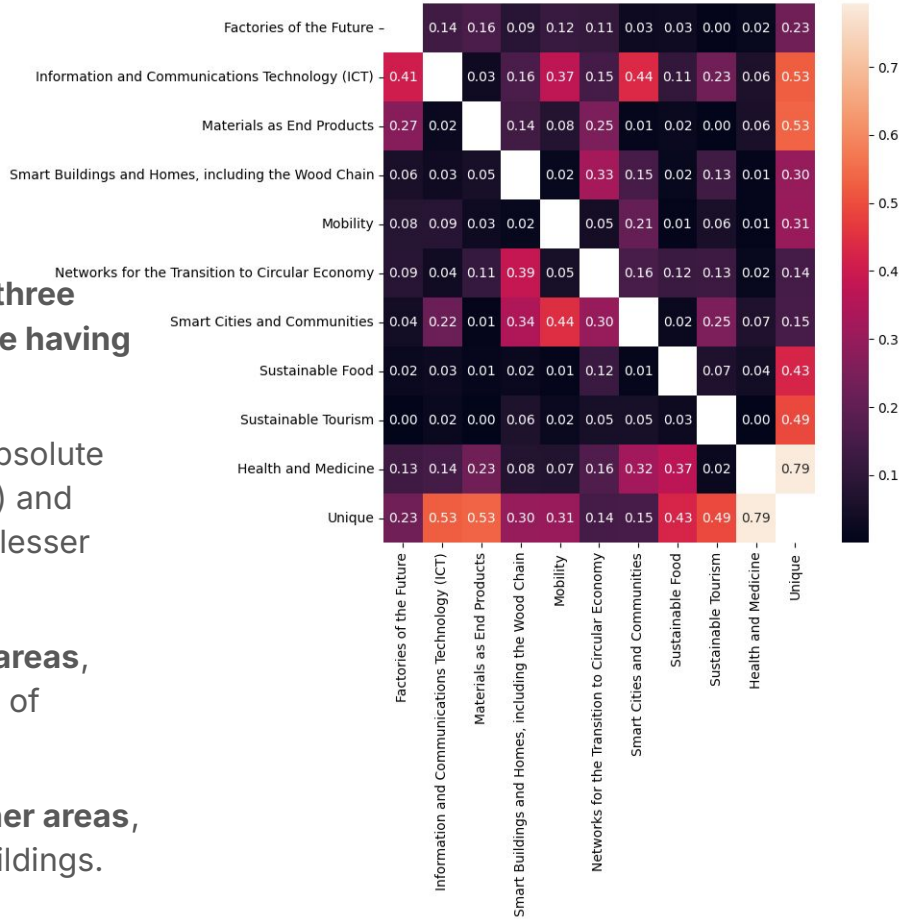
Smart Buildings has a relatively strong core (30%), and overlaps mostly with the most transversal topics, notably with Circular Economy (39%), Smart Cities (34%) and ICT (16%).

Materials as End Products presents high contribution to three other areas (FoF, Smart Buildings, Circular economy) **while having still a distinctive core (53%)**

Mobility does not contribute much to the other areas in absolute terms, except for Smart Cities. Conversely, both ICT (37%) and Smart Cities (44%) have high overlap with it, and FoF to a lesser extent (12%).

Sustainable Food overlaps relatively little with the other areas, except for Health. In detail, in overlap is mostly in domains of nutrition, nutraceuticals and food safety.

Sustainable Tourism overlaps relatively little with the other areas, except for the large co-occurrence with ICT and Smart Buildings.



Period: 2014 - mid 2024

Understanding the overlap between S5 Priority Areas and the distribution of data sources per Areas

Key insights

Mainly transversal Priority-areas

3 of the S5 Priority Areas are very transversal.

They contribute to many other, without having a large unique activity on their own :

- **Factories of the Future**
- **Smart Cities**
- **Circular Economy**

Contributions to other priority areas > 0.85 and share of unique documents is <0.5

"Unique-core" + Transversal Priority areas

3 of the S5 Priority Areas are highly transversal while also having a strong unique activity on their own

- **Health - Medicine**
- **ICT**
- **Materials as End Products**

Contributions to other priority areas > 0.85 and share of unique documents is > 0.5

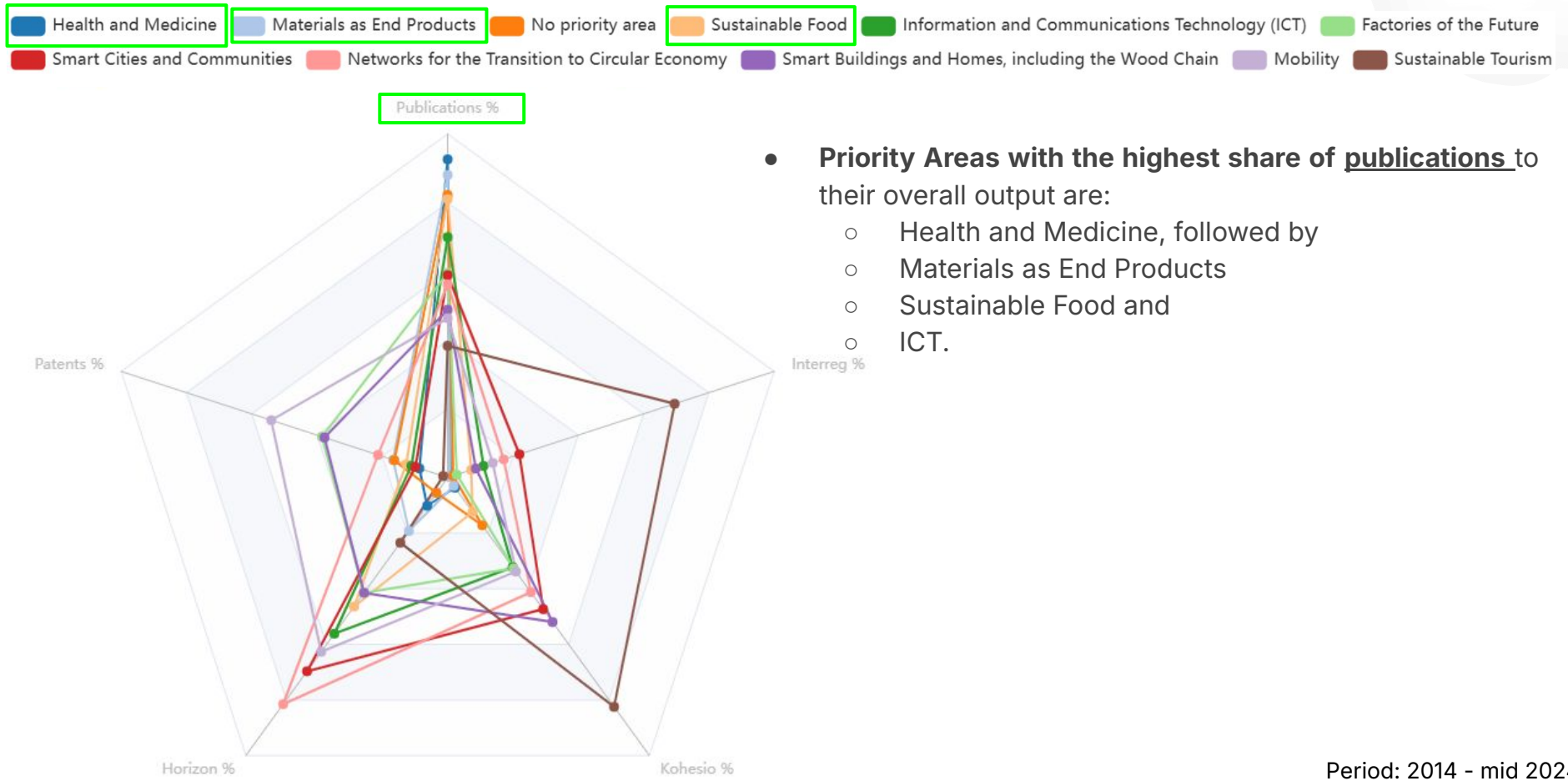
"Unique core" Priority-areas

The 4 remaining priority areas have a much more unique core :

- **Mobility**
- **Sustainable Food**
- **Sustainable Tourism**
- **Smart Buildings**

Contributions to other priority areas < 0.85

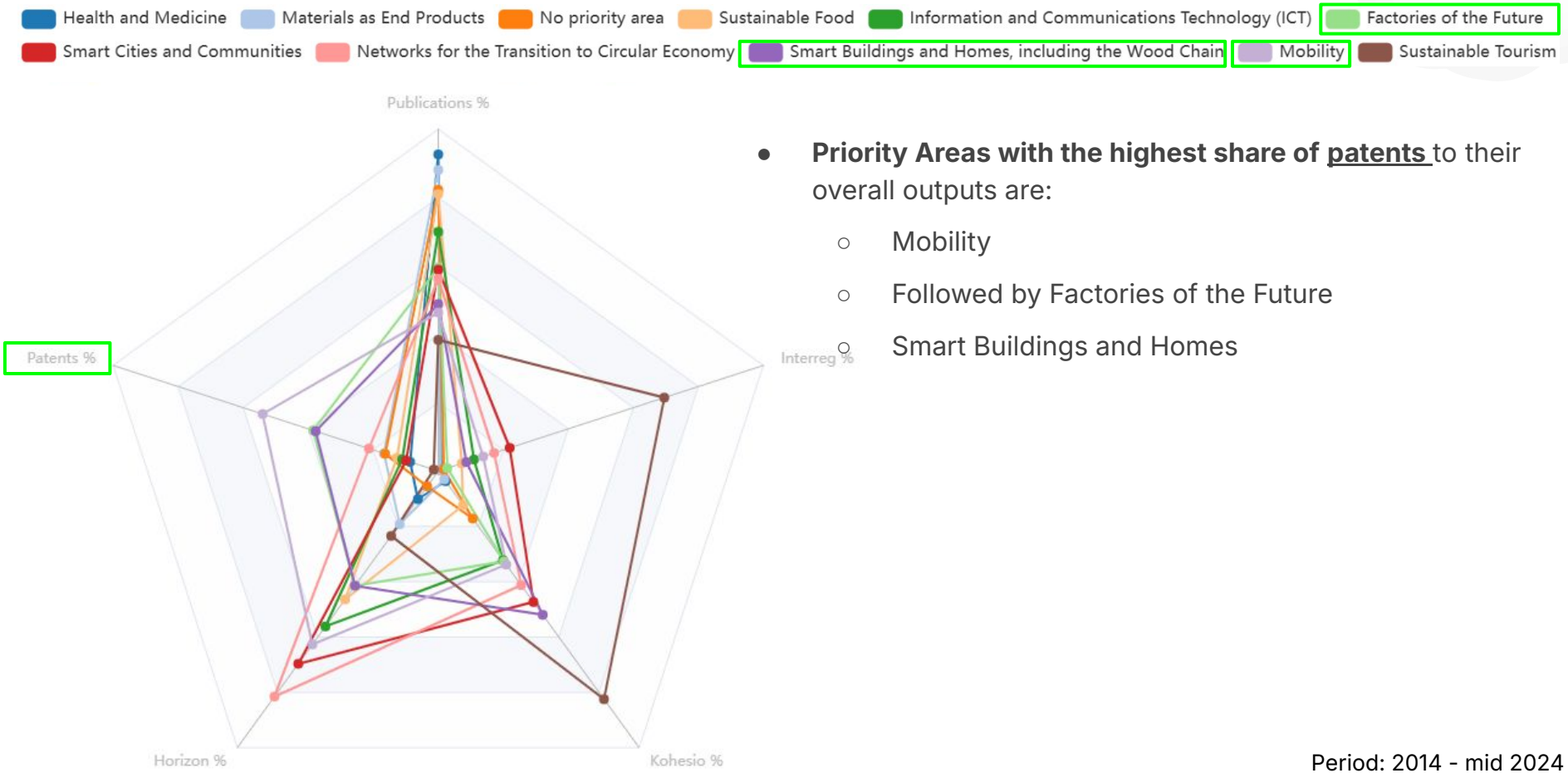
Understanding the overlap between S5 Priority Areas and the distribution of data sources per Areas



- **Priority Areas with the highest share of <u>publications</u>** to their overall output are:
  - Health and Medicine, followed by
  - Materials as End Products
  - Sustainable Food and
  - ICT.

Period: 2014 - mid 2024

Understanding the overlap between S5 Priority Areas and the distribution of data sources per Areas



- **Priority Areas with the highest share of <u>patents</u>** to their overall outputs are:
  - Mobility
  - Followed by Factories of the Future
  - Smart Buildings and Homes

Period: 2014 - mid 2024

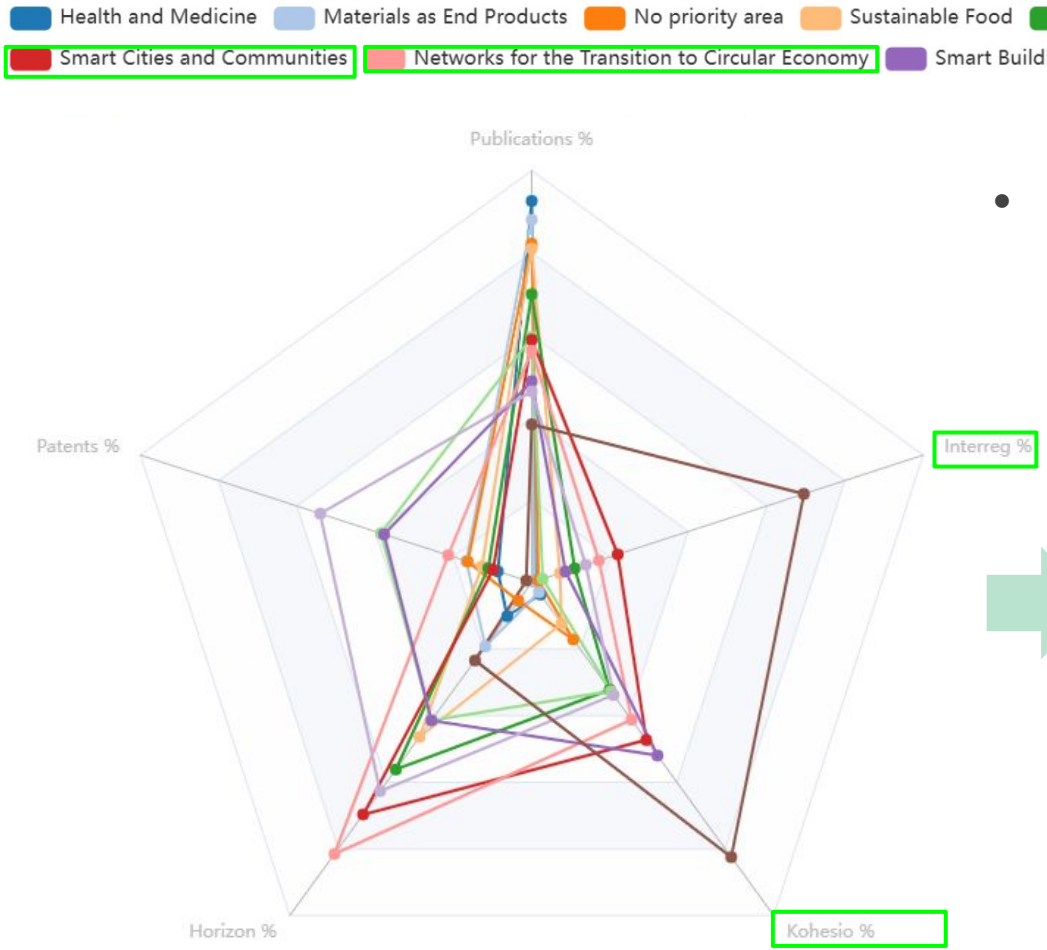
Understanding the overlap between S5 Priority Areas and the distribution of data sources per Areas

- **Priority Areas with the highest share of <u>Horizon projects</u>** to their overall output are
  - Networks for the Transition for the Circular Economy followed by
  - Smart Cities and Communities
  - Mobility
  - ICT
  - Food

Again, this is expected as these priority areas are more closely aligned with the priorities of Horizon 2020 and Horizon Europe (with societal challenges as smart transportation, food security, clean energy and climate action).

Period: 2014 - mid 2024

Understanding the overlap between S5 Priority Areas and the distribution of data sources per Areas



- **Priority Areas with the highest share of <u>Kohesio and Interreg projects</u>** to their overall output are
  - Sustainable Tourism (with a clearly higher share than any other S5 Priority Area)
  - Smart Cities and Communities and Networks for the Transition for the Circular Economy.

This is expected as these are closely aligned with the public-policy priorities of these programs (especially around competitiveness and digitalization of SMEs, transportation and sustainability).

Period: 2014 - mid 2024

Key insights on the nature of the activities of the Priority Areas

Priority Areas with a relatively important basis in publications

- Health and Medicine (also high in total volume)
- Materials as End Products (also high in total volume)
- Sustainable Food* (but with medium total volume)
- ICT* (also high in total volume)

Priority Areas with a relatively important basis in patents

- Mobility
- Factories of the Future
- Smart Buildings and Homes

Priority Areas with a relatively important basis in Kohesio, Interreg and Horizon

- Sustainable Tourism (with a clearly higher share than any other S5 Priority Area)
- Smart Cities and Communities
- Networks for the Transition for the Circular Economy
- Sustainable Food* (only for Horizon)
- ICT* (only for Horizon)

Items marked with an asterisk appear twice

2. Analysis of Slovenian RDI activities and results in the the S5 Smart Specialisation Priority Areas

- Understanding the distribution and evolution of the Slovenian RDI activities in the S5 Priority Areas
- Comparing Slovenian RDI positioning in the S5 Areas with Europe and selected national benchmarks
- Understanding the overlap between S5 Priority Areas and the distribution of data sources per Area
- **Identifying and comparing the RDI presence of research and industrial actors in the S5 Priority Areas**
- Identifying key Slovenian S&T specialisation areas in an international comparison
- RDI in the S5 Priority Areas: synthetic overview for future evolution

Objective

- **To get a clear view of the different nature of the S5 Priority Areas, we need to understand the type of actors contributing to each Priority Area.** We are mostly interested in distinguishing the participation of more classific research-focused actors (eg. universities) from businesses.
    - For each Priority Area, we compare the contribution of each type of actor both to the other S5 Priority Areas and to the rest of the RDI output in Slovenia (“non priority” category)
- As one of the main intent of S5 and SRIPs is to promote collaboration among academic and industry stakeholders, we also look at the **share of “collaborative” publications (co-affiliation) and patents (co-patent application)**

Methodology

To do so, we classify each actor as :

- Academic, including hospital: this category corresponds to the classical research actors
- Industry
- Public and other : all public organisations (excluding academic and research organisations and hospitals), and “Other” (non-for-profit non-governmental institutions)
- Unknown, for the remaining actors non-classified actors

Technical note

The classification of actors is done by processing the SICRIS, CORDIS, Interreg classification into a macro-categories. This step was necessary as these various databases use heterogenous taxonomies.

Identifying and comparing the RDI presence of research and industrial actors in the S5 Priority Areas

Distribution of different organisations macro-types by S5 area, normalised by size of the data source

S5 Area	Academic and research actors, incl. Hospitals	Industry	Public and Others	Unknown
Health and Medicine	88.4	5.9	3.3	2.3
Materials as End Products	88.2	10.1	0.5	1.3
No priority area	87.8	7.5	2.3	2.5
Sustainable Food	84.8	9.5	3.4	2.2
Information and Communications Technology (ICT)	77.1	14.2	6.1	2.6
Networks for the Transition to Circular Economy	72.9	17.9	5.9	3.3
Factories of the Future	71.7	23.8	1.1	3.3
Smart Cities and Communities	67.9	16.5	11.7	3.9
Smart Buildings and Homes, including the Wood Chain	67.6	23.3	3.6	5.5
Sustainable Tourism	58.4	7.8	26.1	7.6
Mobility	58.1	30.6	6.1	5.3

- **Across all S5 areas, the weight of academic and research actors including hospitals is dominant.**
  - This reflects the dominance of these actors in RDi activities in general in Slovenia (88% of organisations in “no priority” are also academic and research stakeholders)
- **Participation of actors from the industry is highest in priority areas Mobility, Factories of the Future and Smart Buildings.**
  - It is the lowest in Health. This should not be seen as an indication of low R&D activity in Slovenia's health industry. While academic researchers in the health sector frequently publish their work, innovative companies in the same sector often do not.
- **Participation of public actors is generally low, except in sustainable tourism and smart cities and communities.**

Key insights : Priority Areas classified depending on their relative coverage of each actor type, **top 4 for each category (from highest to lowest)**

Relatively higher: Academic, including hospital

- Materials as End Products
- Health and Medicine
- Sustainable Food
- ICT

Relatively higher: Industrial

- Mobility*
- Factories of the Future
- Smart Buildings*
- Network for the transition to a Circular Economy

Relatively higher: Public and others

- Sustainable Tourism
- Smart Buildings*
- Mobility*
- Smart Cities

Items marked with an asterisk appear twice

Identifying and comparing the RDI presence of research and industrial actors in the S5 Priority Areas

Number of co-publications between academic and industrial actors, and share of the total per Priority Area

S5 priority area	Academia-Industry collaborations	Total documents	Academia-Industry collaborations (%)
Factories of the Future	320	2,763	11.58%
Networks for the Transition to Circular Economy	180	1,998	9.01%
Mobility	125	1,482	8.43%
Smart Buildings and Homes, including the Wood Chain	120	1,456	8.24%
Materials as End Products	532	7,184	7.41%
Smart Cities and Communities	250	3,852	6.49%
Information and Communications Technology (ICT)	574	9,437	6.08%
Health and Medicine	1,411	30,069	4.69%
Sustainable Food	123	2,820	4.36%
No priority area	851	33,733	2.52%
Sustainable Tourism	12	518	2.32%

There is a relevant amount of Academia-Industry collaborations in scientific publications. Most collaborations concentrate in **Health - Medicine, ICT and Materials**, while **FoF, Circular Economy, Mobility and Smart Buildings** present high relative figures.

Identifying and comparing the RDI presence of research and industrial actors in the S5 Priority Areas

Number of co-patent applications between academic and industrial actors, and share of the total per Priority Area

S5 priority area	Academia-Industry collaborations	Total documents	Academia-Industry collaborations (%)
Materials as End Products	42	470	8.94%
Networks for the Transition to Circular Economy	8	247	3.24%
Sustainable Food	4	156	2.56%
Smart Cities and Communities	5	202	2.48%
Information and Communications Technology (ICT)	8	358	2.23%
Health and Medicine	18	940	1.91%
Smart Buildings and Homes, including the Wood Chain	7	381	1.84%
Factories of the Future	4	514	0.78%
No priority area	14	1,917	0.73%
Mobility	1	491	0.20%
Sustainable Tourism	0	4	0.00%

Collaborations in patenting are much scarcers, with Only Materials and Health - Medicine presenting some such collaborations. **Materials** is a positive outlier, with the **highest amount and the highest intensity**.

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- **Identifying key Slovenian S&T specialisation areas in an international comparison**
- RDI in the S5 Priority Areas: synthetic overview for future evolution

Objective

- **The objective of the next section is to grasp the science and technology strength of the Slovenia, independently of the S5 Priorities**
    - To do so, we look at both its performance in publications and patents, using classical international taxonomies and compare its results with other countries
- Our baselines are the EU27 and the EU13 (countries that joined the EU in 2004 or after)
    - These regions comprise the main economic and RDI partners and competitors of Slovenia
    - They are also comparable to Slovenia in terms of their research performance, making it a relevant benchmark

Thematic specialisation in publications

Presentation and indicators for the benchmarking

- **To get an overall understanding of the scientific and technology strengths of Slovenia**, we use in the next section **categories that are independent of the S5 Priority Areas.**
  - **We use OpenAlex "fields".** This database automatically classifies publications 26 fields based on a publication's title, abstract, source (journal) name, and citations.

- **Normalized specialisation Index** : compares the level of citation of articles to the expected level of citation in that field and year, useful to get a contextualised view of the impact of an article, and when aggregated of a country in the field.

  Formally, it is here computed as:

$$\frac{\textit{Number of time the publication is cited}}{\textit{Expected citation rate (same document type ef. publication, year of publication and subject area)}}$$

- **Specialisation Index (SI) :** measures the extent to which the country's publications focus in certain fields compared to another region (here EU27 and EU13), useful to see the distinctive features of a country's scientific profile.

  Formally, it is here computed as:

$$\frac{\textit{\% of total Slovenian publications in field X}}{\textit{\% of total EU publications in field X}}$$

Interpreting the following graphs

- **The size of the bubble corresponds to the number of publications.**
- To understand the relevance of a field in Slovenia *relative* to other countries, look at its position on the x axis (Specialisation Index, S.I.).
  - An SI > 1 indicates a specialisation in that field.

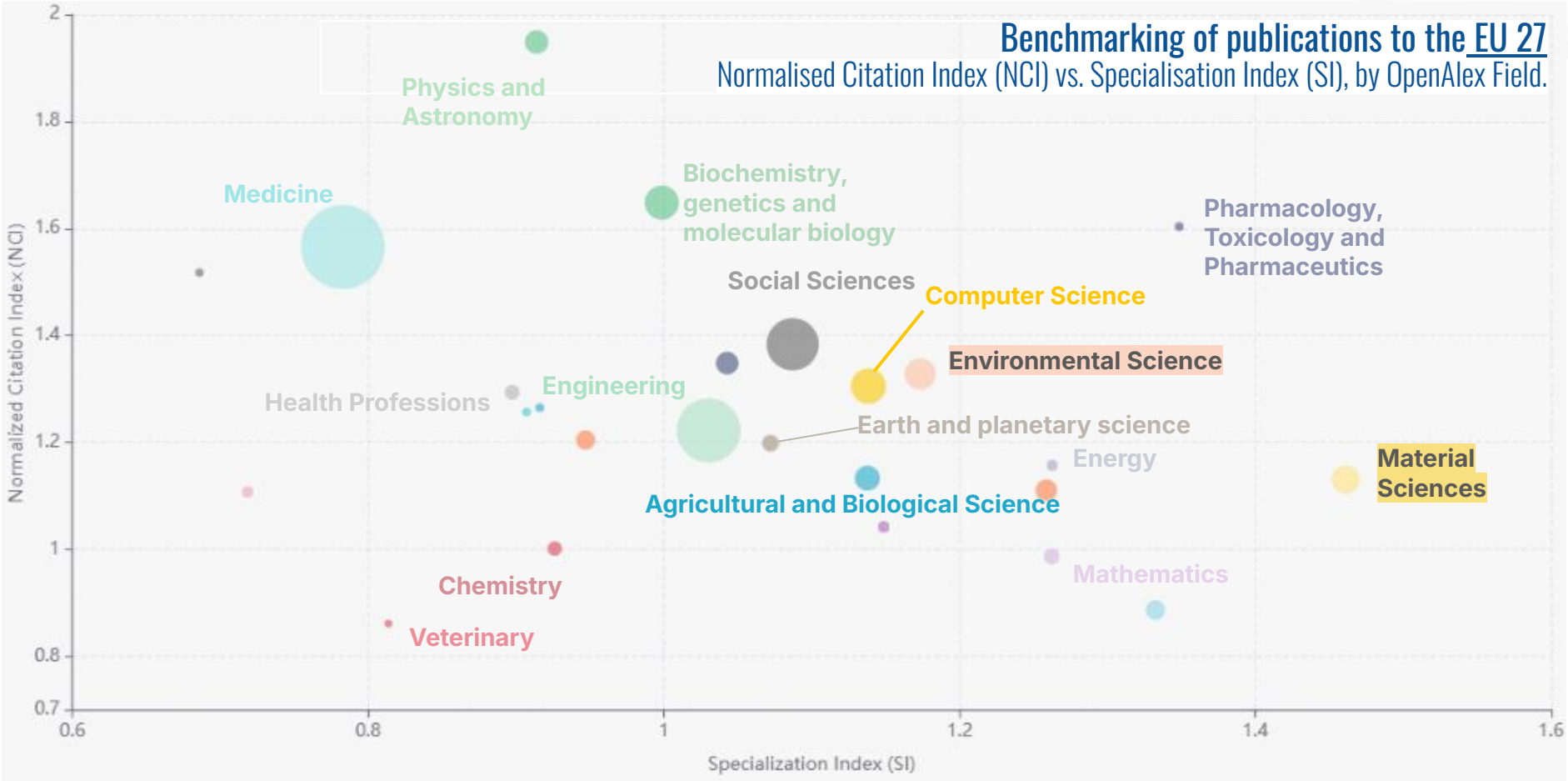
This means that a country's first field of publication might actually be an area of underspecialization, if other countries produce a higher share of their publications in that field.

- To assess the impact of the Slovenian activity in a field, look at its position on the y axis (Normalised Citation Index, N.C.I).
  - An NCI > 1 indicates an impact higher than in the countries of the benchmark.

Identifying key Slovenian S&T specialisation areas in an international comparison

Benchmarking of publications to the EU 27

Normalised Citation Index (NCI) vs. Specialisation Index (SI), by OpenAlex Field.



Benchmarking of publications to the EU 27

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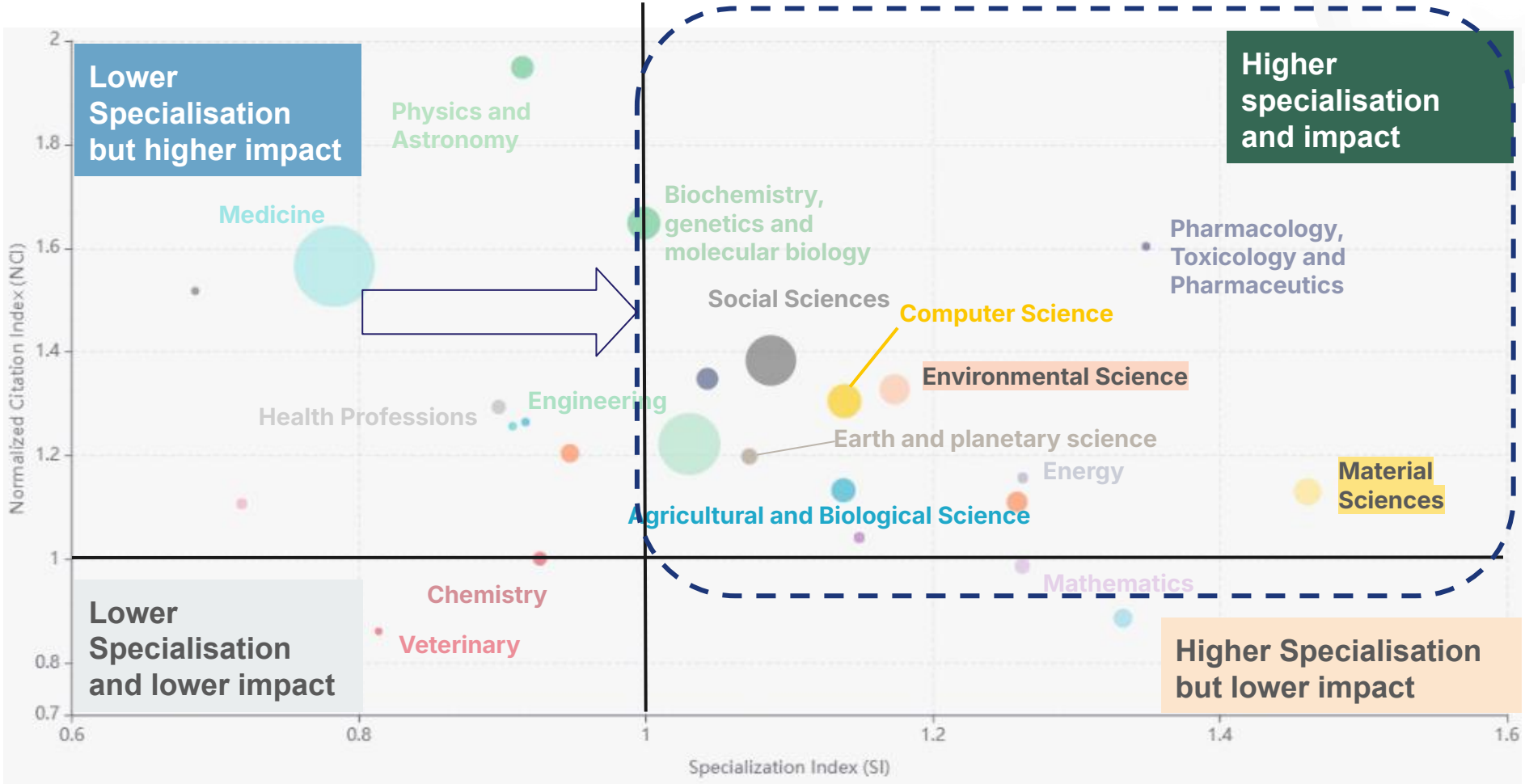


Benchmarking of publications to EU 27

Fields of specialization and relatively stronger impact

- Fields where Slovenia publishes relatively more than the EU 27 and has a higher citation index : **material science, pharmacology, environmental science, computer science and energy**

This is the most interesting category, showing the most distinctive strengths of Slovenia (in the upper right corner of the graph)

Fields of underspecialisation but relatively stronger impact

- Fields where Slovenia publishes relatively the same or less than the EU 27 but has a higher citation index than EU27 countries are mostly in topics of **health** (biochemistry and genetics, medicine and health professions)

The underspecialsiation in health related topics is due to a high specialisation of several countries of the benchmark in this area (ex. Netherlands)

A low level of publication but a high citation index can show a strong potential for growth.

Fields of underspecialisation and relatively weakness

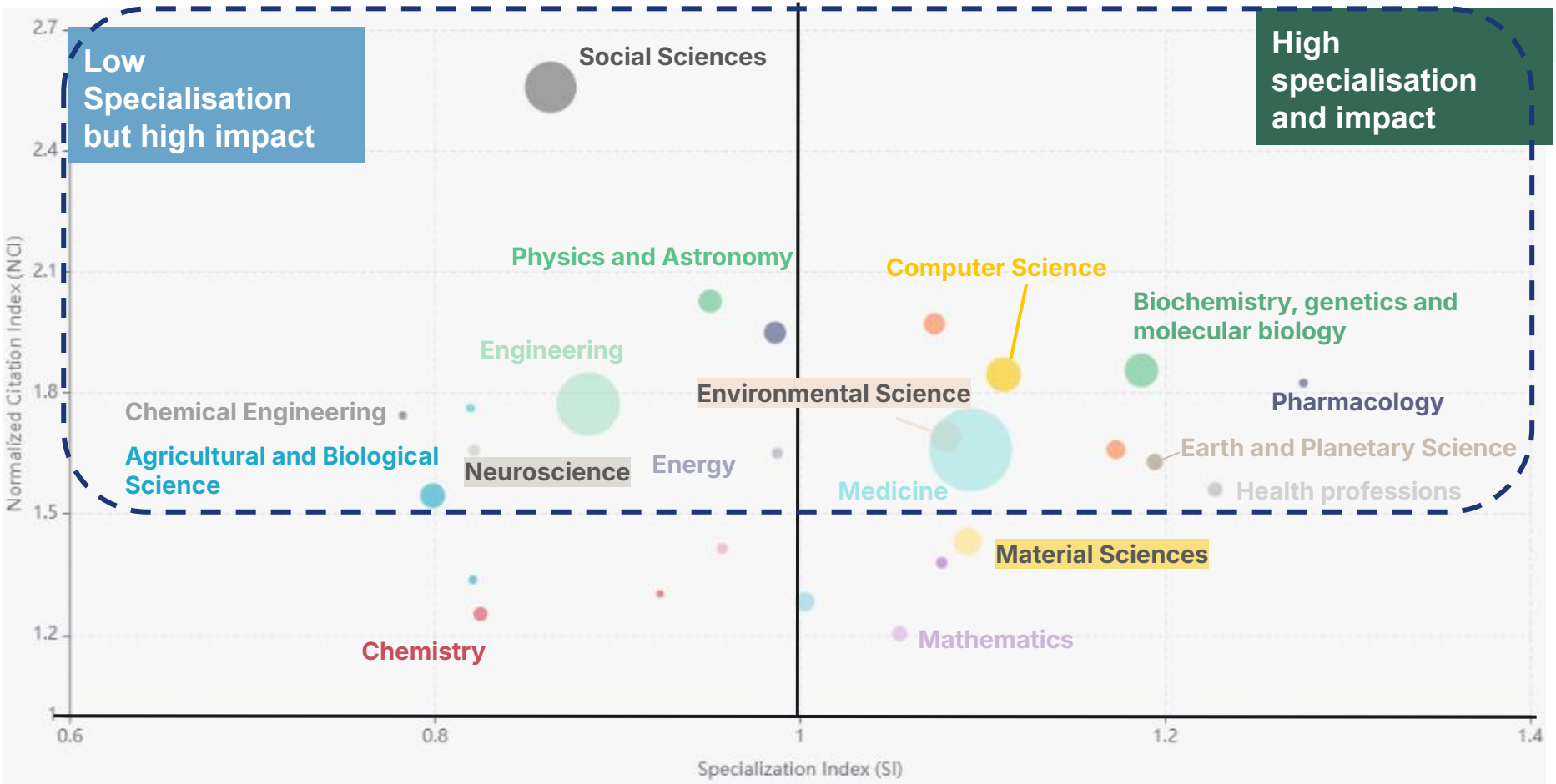
- Among the fields where Slovenia publishes relatively less than the EU27 and with a low citation index (<1) : veterinary and chemistry

Overall impact of RDI in Slovenia is high compared to EU27, therefore few fields fall under this category.

We replicate this exercise in the next slides, comparing Slovenia to EU 13 countries (accessed the EU in 2004 or after). This time, we focus particularly on the relative competitiveness of Slovenia to these countries, hence looking at the fields with the highest NCI

Benchmarking of publications to the EU 13

Normalised Citation Index (NCI) vs. Specialisation Index (SI), by OpenAlex Field.



Identifying key Slovenian S&T specialisation areas in an international comparison
Benchmarking of publications to EU 13

Key difference in the findings when contrasting Slovenia with the EU13 versus the EU27

- The overall impact of publications in all fields is higher in Slovenia (normalized citation index >1 in all fields) compared to EU13
- There are again fields of specialisation of Slovenia compared to these countries, but the levels of specialization are not as strong as compared to EU27
    - This is an expected result : EU 27 countries include bigger countries with a larger critical mass in RDI, leading a much more diverse scientific output than EU13
- Key fields of strength and specialisation are confirmed : **material science, pharmacology, environmental science, computer science**

Fields of higher impact contrasting in Slovenia compared to the EU13

- Relevant fields with an NCI > 1.5 : engineering, agricultural and biological sciences, energy, biochemistry, computer science, chemical engineering.

Specialisation in patents

Benchmarking of patens to the EU 27 and EU13

Normalised Citation Index (NCI) vs. Specialisation Index (SI), by IPC class

- **To get an overall understanding of the scientific and technology strengths of Slovenia**, we use for patents two **categories that are independent of the S5 Priority Areas.**
  - **We use the International Patent Classifications**
  - Patents are classified into 132 level-2 IPC classes and 654 level-3 sub-classes
  - We focus here on level-3 as they allow for a more detailed understanding of the RDI activity.

- To understand the relevance of a domain in Slovenia *relative* to other countries, we look at their Specialisation Index (S.I.).
  - An SI > 1 indicates a specialisation in that domain.

Identifying key Slovenian S&T specialisation areas in an international comparison

Benchmarking of patents to the EU 27 and EU 13

Specialisation Index (SI), by IPC level 3 classes : top 20 by volume

Title	Slovenia	EU27 Applications	EU13 Applications	SI (vs EU27)	SI (vs EU13)
(A61) MEDICAL OR VETERINARY SCIENCE; HYGIENE	921	435k	23.6k	1.21	1.2
(A47) FURNITURE; DOMESTIC ARTICLES OR APPLIANCES; COFFEE MILLS; SPICE MILLS; SUCTION CLEANERS IN GENERAL	750	76.9k	4.54k	5.59	5.07
(H01) ELECTRIC ELEMENTS	568	223k	7.92k	1.46	2.2
(H02) GENERATION, CONVERSION, OR DISTRIBUTION OF ELECTRIC POWER	497	120k	6.45k	2.38	2.36
(G01) MEASURING; TESTING	450	269k	14.1k	0.96	0.98
(F16) ENGINEERING ELEMENTS OR UNITS; GENERAL MEASURES FOR PRODUCING AND MAINTAINING EFFECTIVE FUNCTIONING OF MACHINES OR INSTALLATIONS; THERMAL INSULATION IN GENERAL	439	179k	7.9k	1.41	1.71
(C07) ORGANIC CHEMISTRY	413	167k	10k	1.42	1.26
(G06) COMPUTING; CALCULATING OR COUNTING	351	235k	14.8k	0.86	0.73
(H04) ELECTRIC COMMUNICATION TECHNIQUE	349	257k	11.9k	0.78	0.9
(C12) BIOCHEMISTRY; BEER; SPIRITS; WINE; VINEGAR; MICROBIOLOGY; ENZYMOLOGY; MUTATION OR GENETIC ENGINEERING	334	93.1k	5.61k	2.06	1.83
(A01) AGRICULTURE; FORESTRY; ANIMAL HUSBANDRY; HUNTING; TRAPPING; FISHING	293	93.7k	5.97k	1.79	1.51
(B01) PHYSICAL OR CHEMICAL PROCESSES OR APPARATUS IN GENERAL	288	95.7k	5.54k	1.72	1.6
(A63) SPORTS; GAMES; AMUSEMENTS	281	22.3k	2.68k	7.23	3.21
(B60) VEHICLES IN GENERAL	242	244k	9.33k	0.57	0.8
(E05) LOCKS; KEYS; WINDOW OR DOOR FITTINGS; SAFES	210	34.2k	1.97k	3.52	3.27
(B66) HOISTING; LIFTING; HAULING	192	24.6k	1.09k	4.47	5.42
(F24) HEATING; RANGES; VENTILATING	175	40.2k	3.69k	2.5	1.46
(H05) ELECTRIC TECHNIQUES NOT OTHERWISE PROVIDED FOR	150	59.2k	2.56k	1.45	1.79
(B65) CONVEYING; PACKING; STORING; HANDLING THIN OR FILAMENTARY MATERIAL	148	118k	5.73k	0.72	0.79
(E04) BUILDING	143	57.6k	6.13k	1.42	0.72

High specialisation in both benchmarks and significant critical mass

Identifying key Slovenian S&T specialisation areas in an international comparison

Benchmarking of patents to the EU 27 and EU 13

Specialisation Index (SI), by IPC level 3 classes :

- Among fields with over 150 patent applications, highest specialisation to EU27 and EU13 is found in :
  - Furniture and domestic appliances ; sport and games ; hoisting and lifting ; locks and keys
  - Medical or veterinary science ; organic chemistry ; physician or chemical processes.
  - Electric elements ; generation of electric power ; electric techniques.
  - Biochemistry, beer, spirits and microbiology ; agriculture and forestry.

These are very applied categories much closer to the activity of industries.

Formally linking directly patent categories to scientific fields of publications is very complex, and would involved further study.

However, some connections can be made between these results and previous analysis of publication strengths

Science and Technology strengths of Slovenia

A summary

Identifying key Slovenian S&T specialisation areas in an international comparison

Publications	Patents	Summary
○ Material Science ✚ ○ ○ Computer Science ✚ ▲ ○ Engineering ▲ ○ Mathematics ○	And relevant strength in patents e.g. furniture and appliances ; hoisting and lifting ; textiles.	Key S&T strengths in **advanced materials and manufacturing** and **formal sciences**
○ Pharmacology ▲ ○ ○ Medicine ✚ ▲ ○ Biochemistry and genetics ✚ ▲	And relevant strength in patents e.g. medical science ; physician or chemical processes.	Key S&T strengths in **biomedical research**
○ Environmental Science ✚ ▲ ○ Agricultural and Biological Sciences ✚ ▲ ○ Energy ○ ▲ ○ Computer Science ✚ ▲	And relevant strength in patents e.g. agriculture, preserving food and disposal of waste.	Key S&T in **green tech, sustainability and environmental science**

Legend

✚ High critical mass
(>3 000 publications between 2014 and 2024)

▲ High impact
(>1.2 to EU27 or >1.5 to EU13)

○ Highly specialised
(>1.2 to EU27)

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- **RDI in the S5 Priority Areas: synthetic overview for future evolution**

RDI in the S5 Priority Areas: synthetic overview for future evolution

To provide a synthetic view of the different indicators, a **Summary table of key indicators per S5 Priority Area has been built**, considering absolute and relative indicators indicators on:

- the **critical mass** of the S5 Priority Area compared to other Priority Areas in publications, patents, Horizon Cohesion, and Interreg Projects
- **relative specialisation index** comparing the share of output in the Priority Area to the share of output in the priority area in the benchmarked countries (Czechia, Austria, Estonia and Croatia) or to EU in the case of
- **temporal evolution: relative growth** against the whole Slovenian RDI activities and results, excluding Cohesion Projects as they are only available until 2020
- the **presence of industrial actors**: looking at the normalised participation of businesses to the overall output
- the **collaboration between academic-scientific actors and industry** (in publications and patents), both in absolute and relative terms

The following table presents the above synthetic indicators, which are a summary of the different indicators and analysis presented in the previous sections.

RDI in the S5 Priority Areas: synthetic overview for future evolution

"Top 4" compared to the 10 Priority Areas

	Critical mass of the S5 Priority Area in Slovenia				
Priority areas	**1.1 Top 4 by number publications**	**1.2 Top 4 by number of patents**	**1.3 Top 4 by number of Kohesio projects**	**1.4 Top 4 by number of Horizon projects**	**1.5 Top 4 by number of Interreg projects**
Factories of the Future	☐	☑	☑	☐	☐
Health and Medicine	☑	☑	☐	☑	☐
Information and Communications Technology	☑	☑	☑	☑	☑
Materials as End Products	☑	☐	☐	☐	☐
Mobility	☐	☑	☐	☐	☐
Networks for the Transition to Circular Economy	☐	☐	☐	☑	☑
Smart Buildings and Homes, including the Wood Chain	☐	☐	☑	☐	☐
Smart Cities and Communities	☑	☐	☑	☑	☑
Sustainable Food	☐	☐	☐	☐	☐
Sustainable Tourism	☐	☐	☐	☐	☑

RDI in the S5 Priority Areas: synthetic overview for future evolution

Priority areas	Relative specialisations against benchmark countries and geographic baselines			Temporal evolution	
	2.1 Average > 1.5 of the SI by Number of Horizon projects and SI of Horizon funding	2.3 Top 2 by SI of publications in benchmark against 4 benchmark countries	2.4 Top 2 by SI of patents in benchmark against 4 benchmark countries	3.1 Has the priority area relatively grown?	3.2 Top 4 by growth?
Factories of the Future	☐	☑	☐	☑	☐
Health and Medicine	☐	☐	☐	☑	☐
Information and Communications Technology	☐	☐	☐	☑	☑
Materials as End Products	☐	☑	☐	☑	☐
Mobility	☑	☐	☐	☑	☐
Networks for the Transition to Circular Economy	☑	☑	☑	☑	☑
Smart Buildings and Homes, including the Wood Chain	☑	☑	☑	☐	☐
Smart Cities and Communities	☑	☑	☐	☑	☑
Sustainable Food	☑	☐	☑	☑	☑
Sustainable Tourism	☑	☑	☐	☑	☐

"Top 2" means Slovenia is one of the 2 highest scores compared to the benchmark countries (AT, EE, HR, CZ, SL)

"Top 4" compared to the growth of the 10 Priority Areas

RDI in the S5 Priority Areas: synthetic overview for future evolution

	Presence of industrial actors	Science-industry collaboration			
Priority areas	**4. Top 4 by activity of industrial actors?**	**5.1 Top 4 by number of co-publications between science and industry**	**5.2 Top 4 by intensity of co-publications between science and industry**	**5.3 Top by number of co-patents between science and industry** (above 10 co-patents)	**5.4 Top by intensity of co-patents between science and industry** (above 5%)
Factories of the Future	☑	☑	☑	☐	☐
Health and Medicine	☐	☑	☐	☑	☐
Information and Communications Technology	☐	☑	☐	☐	☐
Materials as End Products	☐	☑	☐	☑	☑
Mobility	☑	☐	☑	☐	☐
Networks for the Transition to Circular Economy	☑	☐	☑	☐	☐
Smart Buildings and Homes, including the Wood Chain	☑	☐	☑	☐	☐
Smart Cities and Communities	☐	☐	☐	☐	☐
Sustainable Food	☐	☐	☐	☐	☐
Sustainable Tourism	☐	☐	☐	☐	☐

"Top 4" compared to the other Priority Areas.

RDI in the S5 Priority Areas: synthetic overview for future evolution

Priority areas	Critical mass of the S5 Priority Area in Slovenia Subtotal	Relative specialisations against benchmark countries and geographic baselines Subtotal	Temporal evolution Subtotal	Presence of industrial actors Subtotal	Science-industry collaboration Subtotal	TOTAL
Factories of the Future	2	1	1	1	2	7
Health and Medicine	3	0	1	0	2	6
Information and Communications Technology (ICT)	5	0	2	0	1	8
Materials as End Products	1	1	1	0	3	6
Mobility	1	1	1	1	1	5
Networks for the Transition to Circular Economy	2	3	2	1	1	9
Smart Buildings and Homes, including the Wood Chain	1	3	0	1	1	6
Smart Cities and Communities	4	2	2	0	0	8
Sustainable Food	0	2	2	0	0	4
Sustainable Tourism	1	2	1	0	0	4

The final ranking must be interpreted in light of the indicators chosen and not as a grade *per se*.

RDI in the S5 Priority Areas: synthetic overview for future evolution

Key insights

- **Some priority areas have a large critical mass** : ICT, Health and Medicine and Factories of the Future.
  - These are areas with a high degree of transversality, with high co-occurrence with many other areas
  - These are areas that also typically attract funding and are also large in other countries : despite their size, Slovenia does not show any particular specialisation in those areas.
- **Some priority are a distinctive feature of Slovenia when compared to other countries**
  - They **are typically smaller in terms of total publication, patents and projects.**
  - This is the case of circular economy, sustainable food, and smart buildings.

Setting RDI priorities often presents a dilemma: between a focus on highly distinctive but smaller domains, or a focus on larger, less distinctive areas that however represent a critical mass, including often in terms key economic dimensions like employment.

- The more applied priority areas present higher indicators of Cohesion and Interreg projects but less so in terms of publications : sustainable tourism and circular economy.

The results of Horizon, Cohesion and Interreg indicators are more reflective of the priority-setting of these programs than of the distinctiveness of these areas in Slovenian RDI activities. They however matter as they correspond to relevant funds invested in Slovenia in these areas.

RDI in the S5 Priority Areas: synthetic overview for future evolution

- Priority areas with the highest relative share of industrial actors are : Mobility, Factories of the Future, Smart Buildings, and Network for the transition to Circular Economy.
- Science-industry collaboration, more frequent in publications than in patents, concentrates particularly in Materials as end products. When focusing only on publications, collaborations are also significant in Factories of the Future and Health - Medicine.
- **The total score of all Priority Areas is relatively homogeneous, with lowest set at 4 and the highest at 9** (while the highest possible mark would have been 15).

There is **no obvious threshold under which to cut priority areas : overall results are compact, and depending on the category of indicator chosen, the Priority Areas that score the best vary.**

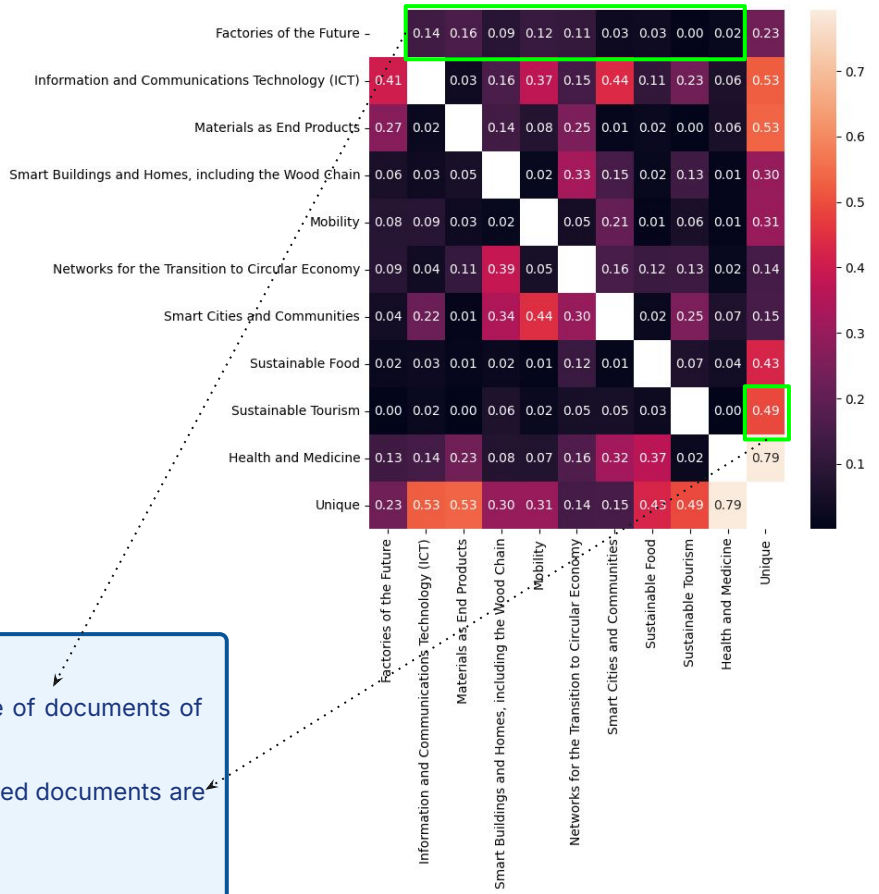
We also see that **Priority Areas scoring the highest have a different nature than the ones scoring the lowest**, being generally more transversal and related to recent innovation trends (vs. longer-established areas).

The following slide comes back to this distinction, between more or less transversal Priority Areas, which is a key takeaway of this analysis.

RDI in the S5 Priority Areas: synthetic overview for future evolution

As presented in a previous section “Understanding the overlap between S5 Priority Areas and the distribution of data sources per Area”, the following indicators present **a synthesis of the "nature" of each Priority Area**, based on the size, and the intensity, of **overlap (classification co-occurrence) with other priority areas**, to provide an indication about **their uniqueness and transversality**

- Larger Priority areas can both have a "unique" core, showing relatively little overlap, while co-occurring frequently with other priority areas.



Indicator definition

- ✓ We consider that an area is transversal if it overlaps with a high share of documents of other priority areas: sum of the overlap with other priority areas > 0.85
- ✓ We consider that an area has a “Unique core” when its uniquely classified documents are more than 30% (0.3)
- ✓ Priority areas can fulfill both conditions at the same time

RDI in the S5 Priority Areas: synthetic overview for future evolution

Priority areas	Uniqueness and transversality of the S5 Priority Areas		
	A.1 Does this priority have a unique core?	A.2 Does this priority overlap significantly with other priorities ?	Uniqueness and transversality of the S5 Priority Areas
Factories of the Future		✅	Transversal
Networks for the Transition to Circular Economy		✅	Transversal
Smart Cities and Communities		✅	Transversal
Health and Medicine	✅	✅	Unique Core + Transversal
Information and Communications Technology (ICT)	✅	✅	Unique Core + Transversal
Materials as End Products	✅	✅	Unique Core + Transversal
Mobility	✅		Unique core
Smart Buildings and Homes, including the Wood Chain	✅		Unique core
Sustainable Food	✅		Unique core
Sustainable Tourism	✅		Unique core

In this table, the S5 Priority Areas have been reorganised according to their Uniqueness and transversality, presenting three different blocks counting 3, 3 and 4 priorities respectively

RDI in the S5 Priority Areas: synthetic overview for future evolution

	Uniqueness and transversality of the S5 Priority Areas	
Priority areas	**Total score**	**Uniqueness and transversality of the S5 Priority Areas**
Factories of the Future	7	Transversal
Networks for the Transition to Circular Economy	9	Transversal
Smart Cities and Communities	8	Transversal
Health and Medicine	6	Unique Core + Transversal
(ICT) Information and Communications Technology	8	Unique Core + Transversal
Materials as End Products	6	Unique Core + Transversal
Mobility	5	Unique core
Smart Buildings and Homes, including the Wood Chain	6	Unique core
Sustainable Food	4	Unique core
Sustainable Tourism	4	Unique core

Comparing the total scores of Priority Areas with their nature as defined previously, we see that :

- the S5 Priority Areas with a more “transversal” nature present higher aggregate scores,
- those with both a Unique core and a transversal role present intermediate-high scores,
- While the ones with a “unique core” present lower scores. We see that these areas are generally more connected to specific economic sectors.

This diversity invites to reinterpret the different S5 Priority Areas and propose an **approach that would lead to a diversified policy-mix, including tailored forms of organisation of the actors related to each priority**, as presented in the following slide, and the next section.

RDI in the S5 Priority Areas: synthetic overview for future evolution

Priority areas	Uniqueness and transversality of the S5 Priority Areas: Total score	Uniqueness and transversality of the S5 Priority Areas
Factories of the Future	7	Transversal
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Materials as End Products	6	Unique Core + Transversal
Mobility	5	Unique core
Smart Buildings and Homes, including the Wood Chain	6	Unique core
Sustainable Food	4	Unique core
Sustainable Tourism	4	Unique core

Final qualitative interpretation and characterisation of the S5 Priority Areas

Transformation Drivers (digitalisation and sustainability & circularity)

Deep Tech - Science and Technology Foundations

Deep Tech - Science and Technology Foundations

Sectoral Innovation Clusters

Sectoral Innovation Clusters

3. Exploring a new approach for the Slovenian S5 priority-setting and for the Slovenian RDI ecosystem organisation and dynamisation

3. Exploring a new approach for the Slovenian S5 priority-setting and for the Slovenian RDI ecosystem organisation and dynamisation

- **Context and Rationale : heterogeneity of the current S5 Priority Areas and SRIPs**
- A proposed new approach articulated around:
  - Sectoral Innovation Clusters
  - Deep Tech - Science and Technology Foundations
  - Transformation Drivers
- Policy-mix recommendations for the new approach

Context and rationale

Following the recent evolutions of the R&I policy panorama both in Slovenia and in the EU, and as introduced in the first Chapter, **we would recommend an evolution of the priority-setting** (S5 Priority areas) **and of the organisation of the ecosystem** (SRIPs) which:

1. Acknowledges that **capacities and forms of organisations have relevant start-up costs and inertia**
2. Thus, takes stock and **valorises**, as much as possible, **the current priorities and existing forms of organisation of the RDI ecosystem**
3. **Integrates smoothly,** and not disruptively, **with**
   a. **recent evolutions coming from the EU, notably STEP, competitiveness and technological sovereignity**, which translates into new or updated funding opportunities for large impact and critical projects
   b. **and with the new legislative framework, distribution of responsibilities and forms of coordination of the Slovenian R&I Policies**
4. **Acknowledges and valorises different approaches to priority-setting** (see slide below**), and the diverse nature of different R&I thematic specialisations** (as per the previous section), that is, those more transversal (both transformation drivers and S&T foundations), and those more sectorial.

Context and rationale - Defining relevant R&I priority areas

Different valid approaches can be used to define priority areas for smart specialisation, and more generally, R&I thematic priorities:

- **Relevant economic sectors** (added value, employment, exports, strategic importance, restructuring and upskilling, etc.)
- **Market needs and opportunities** (international innovation and market trends, position in global value chains, disruptive new entrants, changing cost structures, etc.)
- **Distinctives science and Technology foundations**, relevant for many sectors, and **fast-moving deep tech emerging trends**
- **Societal and sustainability transitions,** which anticipate desirable social, economic and environmental transformations and opportunities

The Slovenian S5 has integrated all of the above, within and across S5 Priority Areas. But different approaches, needs and opportunities require also different policies and different types of cooperation between the actors, and within the public sector

The diversity of justifications of each priority area should be made explicit to **tailor adapted policy tools and establish the right criteria for success**

The current analysis has focused on the scientific and technological basis of a the S5 Priority areas : while this is a key element, it cannot be used as a standalone justification to redesign the S5 Priorities, disregarding:

- **the economic and industrial basis,**
- **internal and external innovation and societal trends**
- **the reality of the actors and networks in the terrain**

Context and rationale - SRIPs and the Slovenian ecosystem organisation

Finally, regarding RDI ecosystem organisation, **SRIPs are the main tool in Slovenia to promote long-term RDI collaboration between businesses, research organizations, public bodies and civil society**

SRIPs were created in 2016 as the main structure to implement the Slovenian Smart Specialisation Strategy

- While the Slovenian R&I policies have historically been "science driven" based on excellence, the purpose of smart specialisation and the SRIPs is to support R&D and industry-academia collaborations
- SRIPs further refine the S5 priority areas and drive EDP, with regular updates of their action plans.

10 SRIPs with heterogenous profiles

- As intended in their creation, all 10 SRIPs gather a diversity of members
- However, looking at other features, the **10 SRIPs are quite heterogeneous**, with different features in terms of Coordination/leadership (academic, mixed, Chamber), Weight of academic actors, Size, and coverage of actors in the sector
- As presented in the previous Chapter, the Priority Areas connected to each SRIP are also heterogeneous in nature.
- While up to now, they all have **benefited from the same policies**

It must be noted that, while SRIPs were created ex-novo, networks and actors with similar thematic perimeter (eg. clusters, or centers of excellence) already existed, finding different accommodations in the SRIPs.

In this context, the continuity of the different SRIPS should not depend on a one-to-one link with the Priority Areas, but on their dynamism and capacity to advance the developmental and policy objectives of the future priority areas.

Accounting for the diverse nature of S5 Priority Areas and SRIPs

- As we have seen, **the nature and RDI activities of the Priority Areas are heterogeneous**
- A new design of Priority Areas should **better account for this diversity**, from its design
- We propose **a restructuring around three types of priorities:**
  - **Innovation in the sectors**
  - **Excellent transversal S&T foundations**
  - **Transformation drivers**

We propose an integrative approach, reviewing both the configuration of the S5 thematic priorities and of the SRIPs, as their definition are highly intertwined.

- The goal is to **preserve the success of the current policies and SRIPs, having created a lasting structure to promote collaboration between public research organizations and businesses.**
- While **adapting it to a clearer framework to facilitate the development of adequate policy tools** to answer the diverse needs of the priority areas.
- And **supporting other types of public-private and private-private forms of association**, such as the Clusters

3. Exploring a new approach for the Slovenian S5 priority-setting and for the Slovenian RDI ecosystem organisation and dynamisation

- Context and Rationale : heterogeneity of the current S5 Priority Areas and SRIPs
- **A proposed new approach articulated around:**
  - **Sectoral Innovation Clusters**
  - **Deep Tech - Science and Technology Foundations**
  - **Transformation Drivers**
- Policy-mix recommendations for the new approach

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  - **Transformation drivers**

Proposing a new approach for S5 priority-setting

Our proposal distinguishes 3 main types of RDI priorities

Transformation Drivers

↳ These are **cross-cutting socio-technological innovations** that enable **broad transformation across multiple sectors** in a desired direction.

Sectoral Innovation Clusters

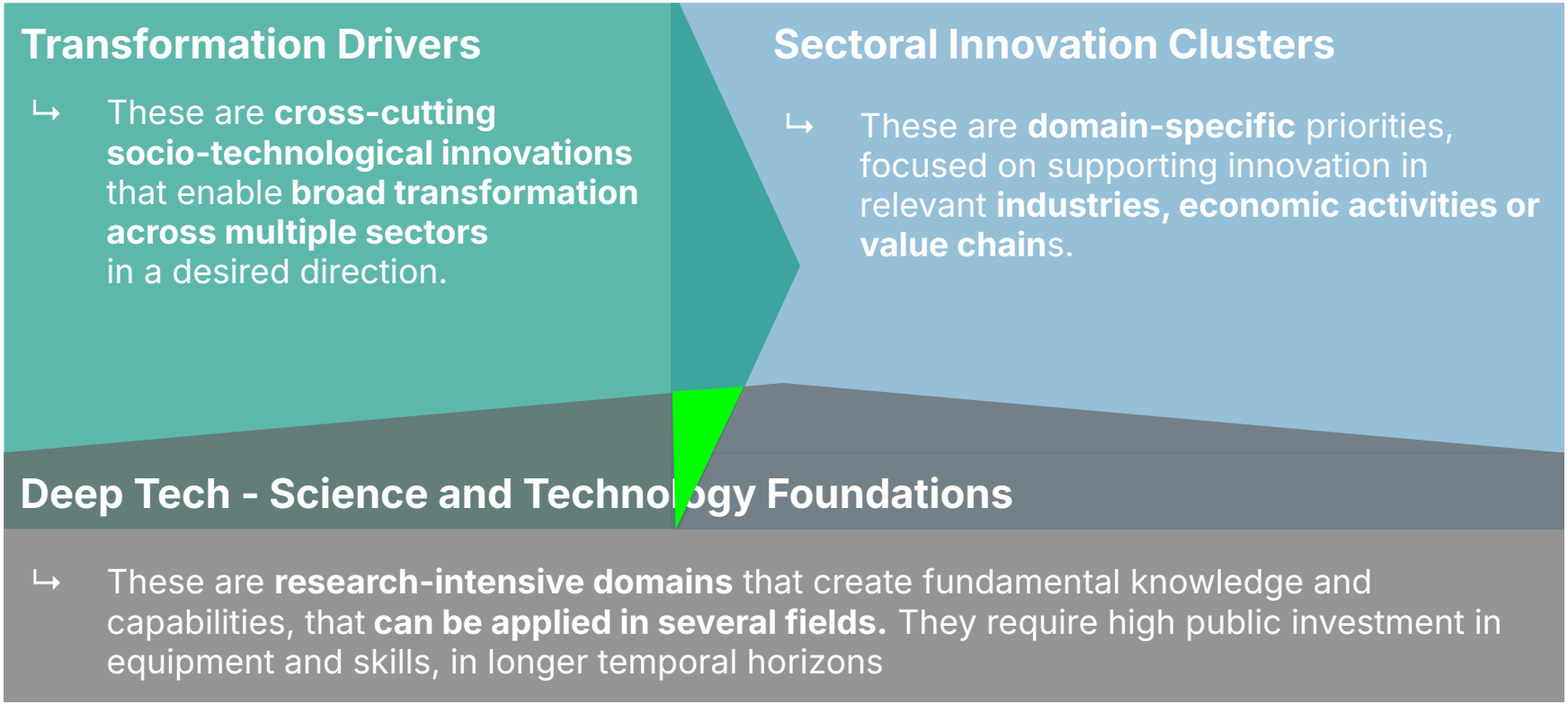
↳ These are **domain-specific** priorities, focused on supporting innovation in relevant **industries, economic activities or value chain**s.

Deep Tech - Science and Technology Foundations

↳ These are **research-intensive domains** that create fundamental knowledge and capabilities, that **can be applied in several fields.** They require high public investment in equipment and skills, in longer temporal horizons

Proposing a new approach for S5 priority-setting

R&I policies should support each type of Priority per-se, while maximising the overlap, collaboration and cross-fertilisation between them (see triangle in green below)



Proposing a new approach for S5 priority-setting

Preliminary proposal of S5 Priority Area restructuration, based on the semantic analysis, the nature of the priorities and the underlying RDI actors and forms of organisation

Transformation Drivers

- Digitalisation
- Sustainability and Circularity

Sectoral Innovation Clusters

Smart cities is "dissolved" into 2, 4 and 5

- Agrifood
- The built environment
- Mobility
- Advanced industrial sectors (incl. Machinery, Materials, Defense)
- ICT / Digital, as a sector
- Health industries and healthcare services
- Tourism

Deep Tech - Science and Technology Foundations

- Advanced materials and advanced manufacturing, including robotics and optics/lasers
- Green tech & energy and environmental sciences
- Biomedical research and biotech

3. Exploring a new approach for the Slovenian S5 priority-setting and for the Slovenian RDI ecosystem organisation and dynamisation

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  - Deep Tech - Science and Technology Foundations
  - Transformation Drivers
- **Policy-mix recommendations for the new approach**

Tailoring the R&I support policy mix to the different types of priority, and maximising the interactions between them

Policy-mix recommendations for the new approach

Transformation Drivers

1. Digitalisation
2. Sustainability and Circularity

In R&I policy, **Transformation Drivers** should:

- Be taken into account in the **evaluation of projects** targeting the Sectorial Clusters and S&T Foundations
- Inform EDP and the **identification of transformative niches** in the Sectoral Clusters. Develop **mission/challenge-oriented innovation** collaborative activities with coalitions of the willing
- Be targeted in higher education, vocational training and LLL (**skills**)
- Be targeted for **entrepreneurship support** and **VC investment** for start-ups and scale-ups (new companies with new business models)
- Be targeted for **public procurement of innovation** and **regulatory sandboxes**

Policy-mix recommendations for the new approach

In R&I policy, **Science and Technology Foundations** should

- Concentrate **S&T infrastructure investment** and **support S&T talent attraction (early, mid and established), development and retention**
- Be taken into account in the **evaluation of projects** targeting the Sectorial Clusters and the Transition Drivers
- Provide support to **increase competitiveness in Horizon** and other EU and international funding schemes
- Drive **science-push knowledge transfer**, to increase science-industry cooperation as well as **deep tech entrepreneurship**
    - **Be targeted for entrepreneurship support and VC investment for start-ups and scale-ups**
    - Be targeted for **R&D investment attraction** (private and by the EU, such as STEP or ESFRI)
- Support advancements towards **technological sovereignty** and **strategic autonomy**
- Explore the establishment of **wide-ranging framework contracts with academic/research institutions to support and monitor long-term alignment with the S5 priorities,** covering (some of) the elements above

Deep Tech - Science and Technology Foundations

1. Advanced materials and advanced manufacturing, including robotics and optics/lasers
2. Green tech and Environmental sciences
3. Biomedical research and biotech

Policy-mix recommendations for the new approach

In R&I policy, **Sectoral Clusters** should:

- Drive EDP
  - In **transformative niches**, informed by the *Drivers* (*Digitalisation* and *Sustainability and circularity*)
  - in intra and inter-sectoral niches to foster **industry-industry collaboration**
- Drive **market-pull knowledge transfer**, to increase science-industry cooperation
- Foster **internationalisation** (exports and GVCs) and **investment attraction**
- Be targeted for public support to **large R&D investments** (such as IPCEI - Important Projects of Common European Interest)
- Be targeted for **public procurement** of **innovation and regulatory sandboxes**

Sectoral Innovation Clusters

1. Agrifood
2. The built environment
3. Mobility
4. [Other] Advanced industrial sectors (incl. Machinery, Materials, Defense)
5. ICT / Digital, as a sector
6. Health industries and healthcare services
7. Tourism

Ensuring a coherent and efficient RDI policymix via intra-governmental coordination

A comprehensive approach to coordinate and complement these 3 blocks of RDI priority

As for any successful R&I support framework, following the "Objective 1. Effective governance of the scientific research and innovation system" of the Resolution on the Slovenian Scientific Research and Innovation Strategy 2030 (ReZrIS30, 2023), this approach based on three categories of RDI policy **needs to go hand in hand with close inter-ministerial and inter-agency coordination:**

- in priority-setting (with relevant interaction with line ministries related to the priority thematics)
- in instrument design, to maximise complementarity and synergies
- in the establishment and support to ecosystem organisation and coordination facilities and networks (such as the SRIPs)
- in the interaction with key actors
- in monitoring, evaluation and steering

This is key to **avoid building vertical and horizontal silos** and ensure that the transformation drivers and the science and technology foundations contribute effectively to the sectoral clusters, and create new business and prosperity per-se.

4. Semantic analysis and granular RDI data to support EDP

(not presented during May 6th-7th, added here for information)

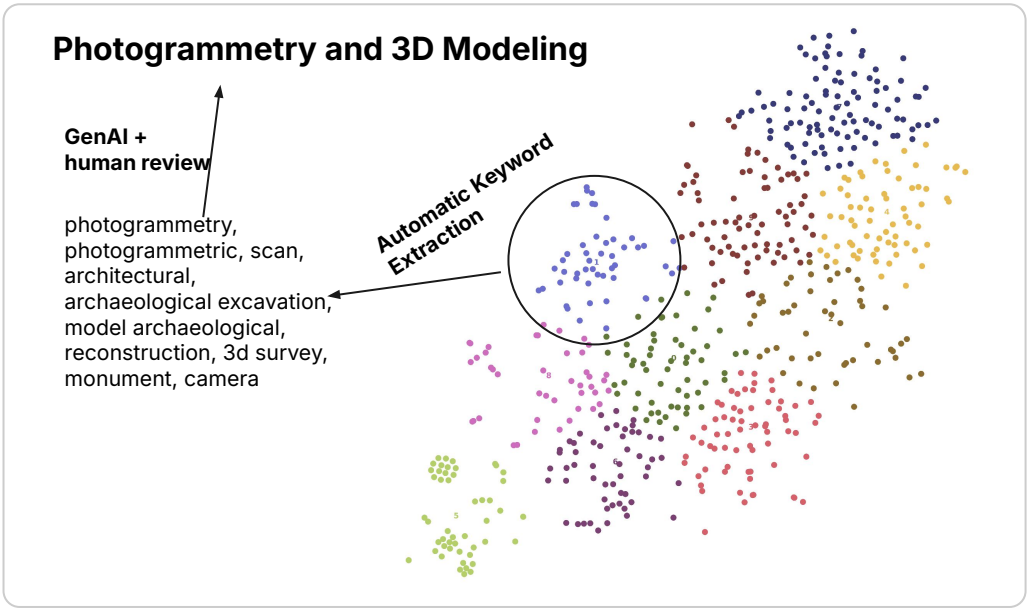
Identifying relevant RDI topics automatically via Topic Modeling: How does it work?

Topic Modelling (TM) is a **machine learning technique** that serves to **automatically "discover" the topics from a collection of texts** (in this case, titles and abstracts of scientific publications and R&I projects).

Semantically-similar texts, identified by deep learning models, **are clustered together, forming the topics.**

Advantages:

- **Custom taxonomy to a specific perimeter**
- **Find interdisciplinary topics**
- **Find new topics**
- **Mix data from different sources (e.g. publications + projects + patents)**

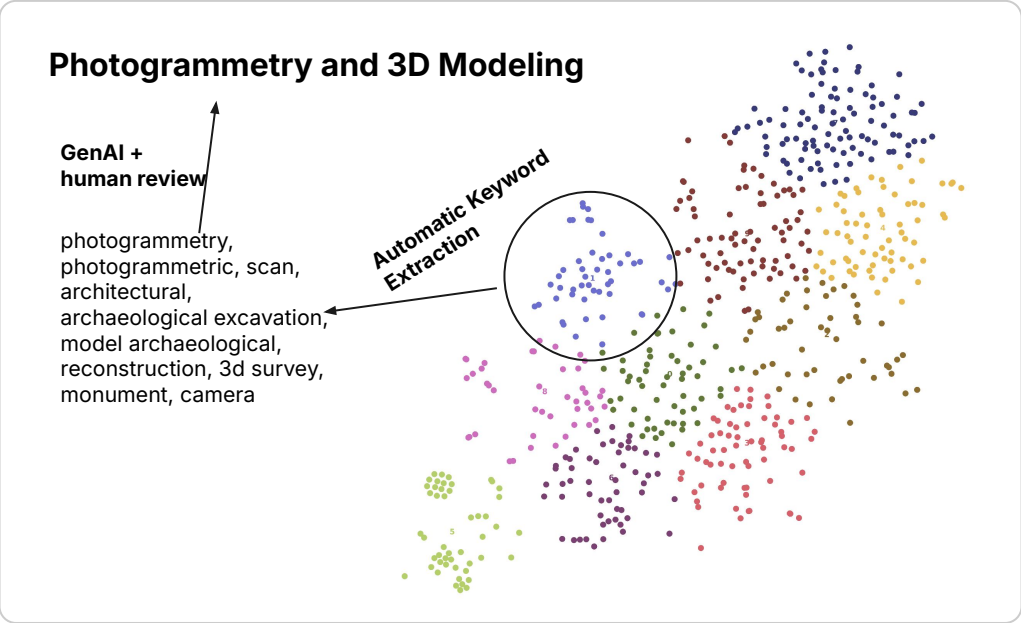


Identifying relevant RDI topics automatically via Topic Modeling: How does it work?

First, we use SPECTER*, a transformer-based model to convert texts into vectors.

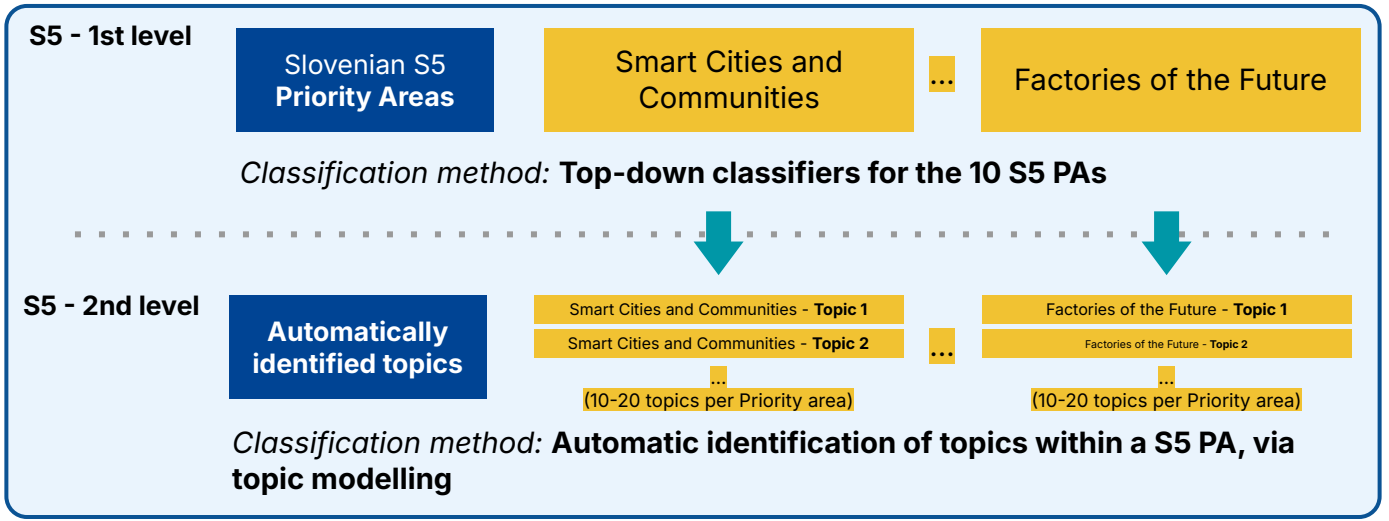
Second, vectors are clustered into topics (using clustering method called K-Means).

Third, we use generative LLMs and human expert curation to produce labels for each cluster.

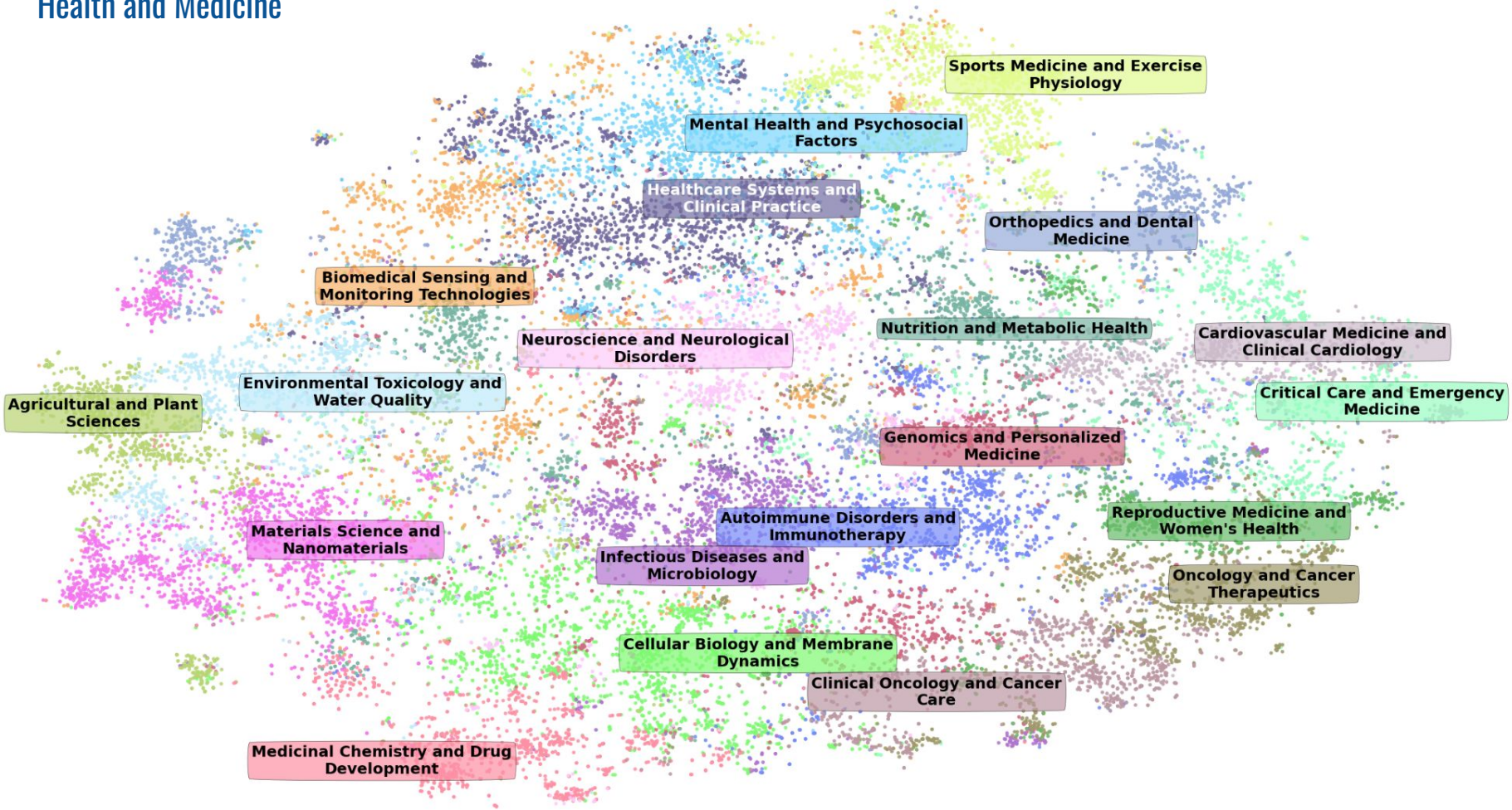


* "SPECTER [is] a new method to generate document-level embedding of scientific documents based on pretraining a Transformer language model on a powerful signal of document-level relatedness: the citation graph."

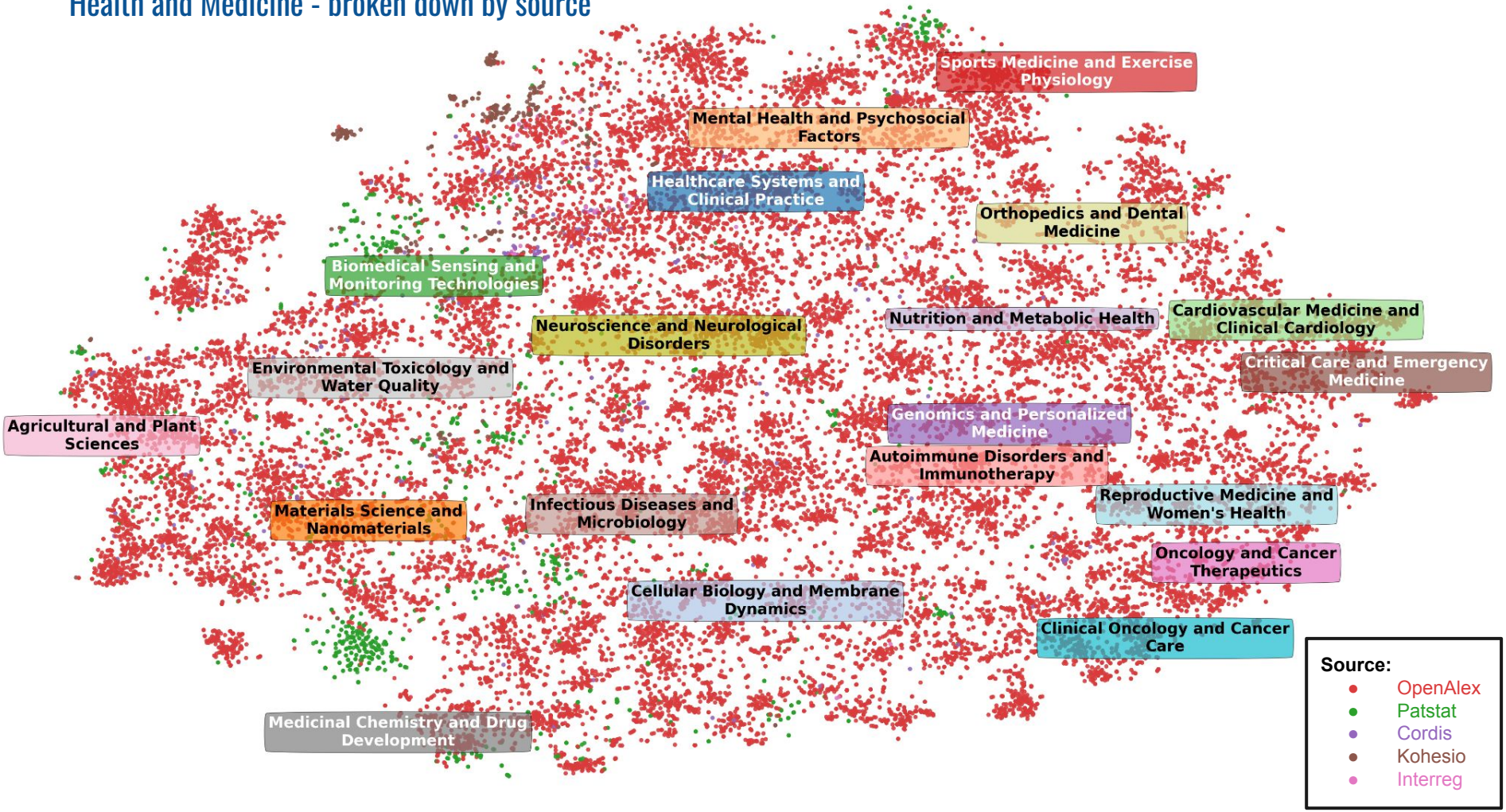
Topic modelling at the 2nd level of the S5 Priority Areas



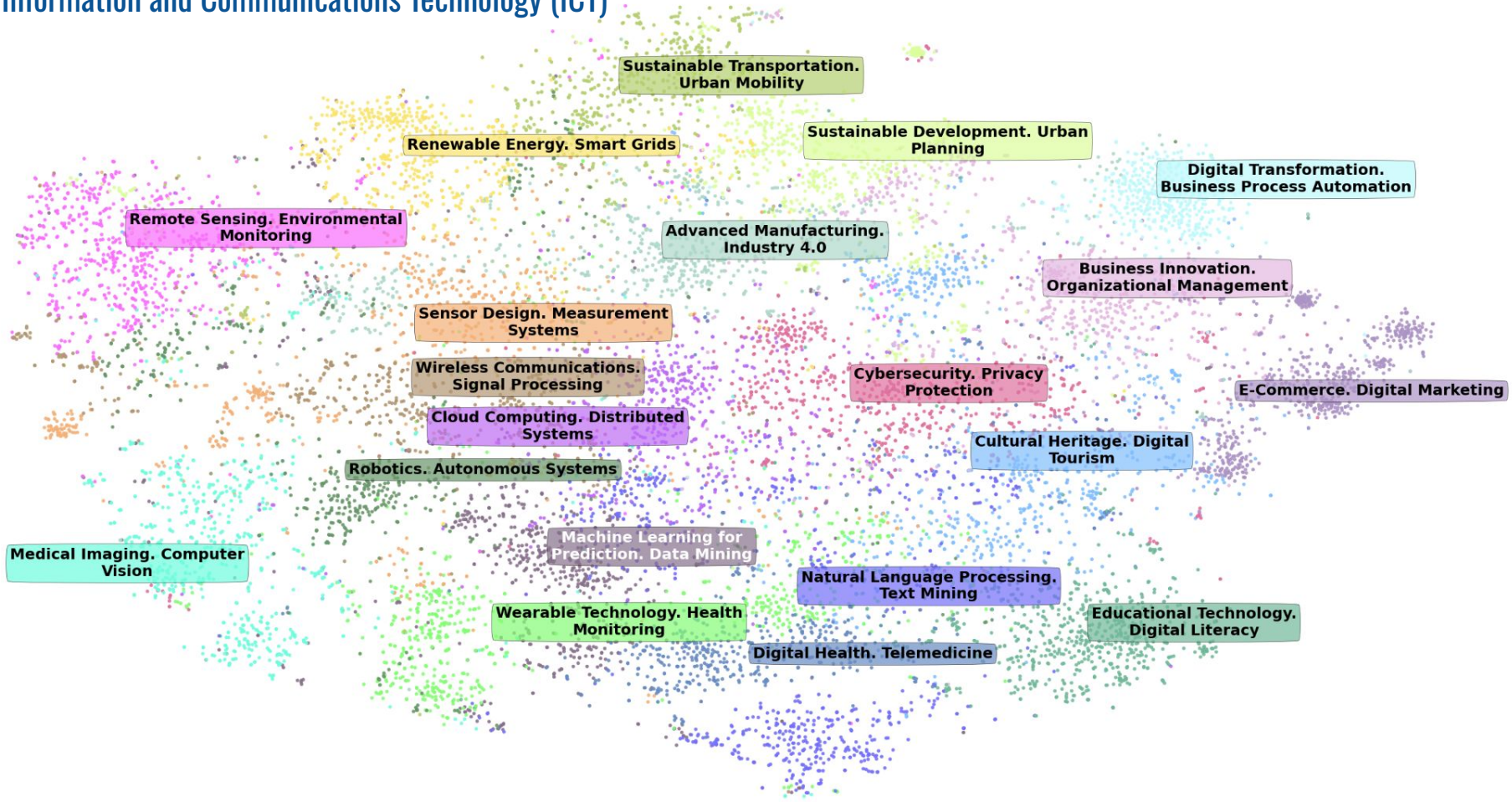
Health and Medicine



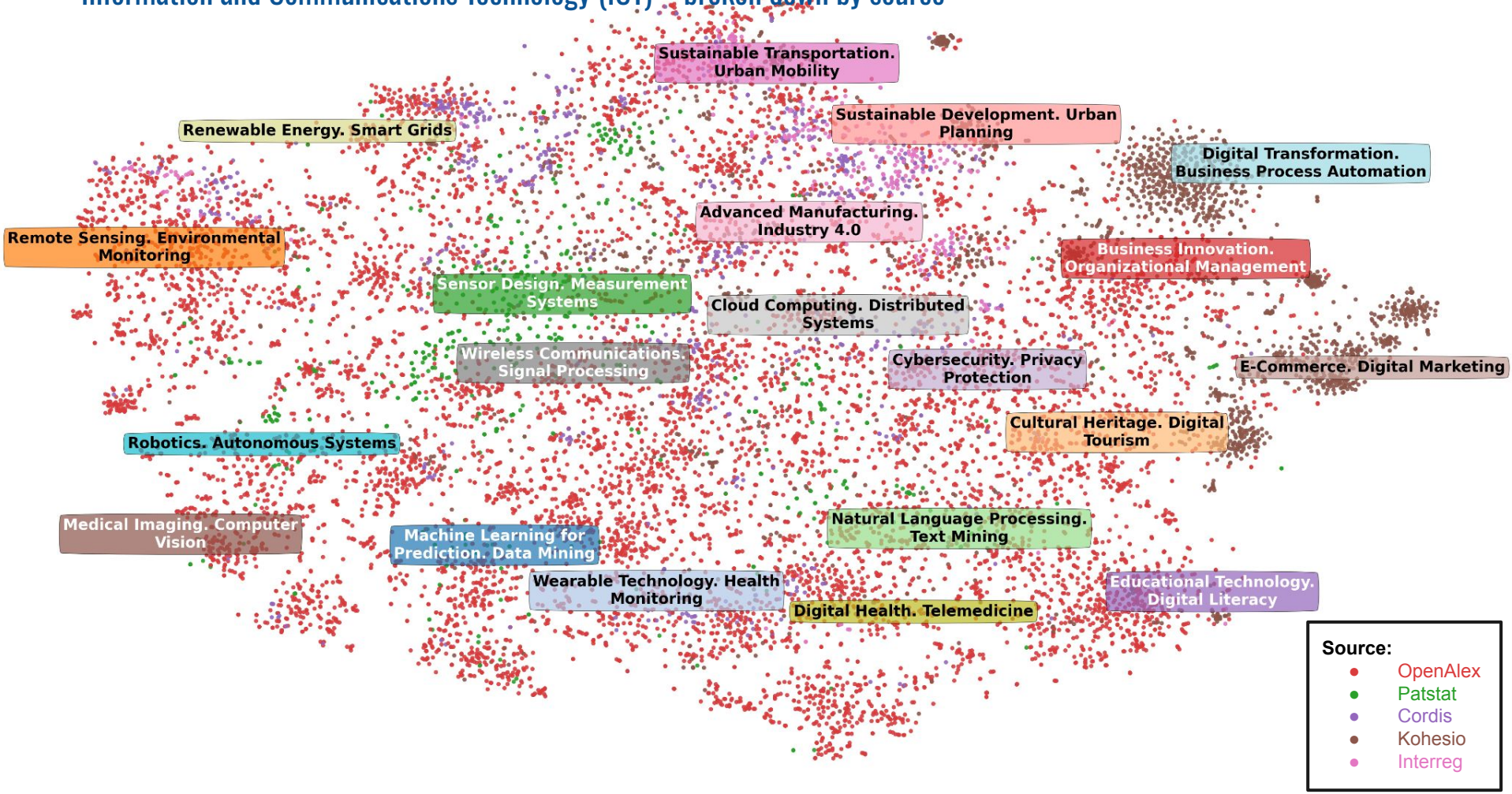
Health and Medicine - broken down by source



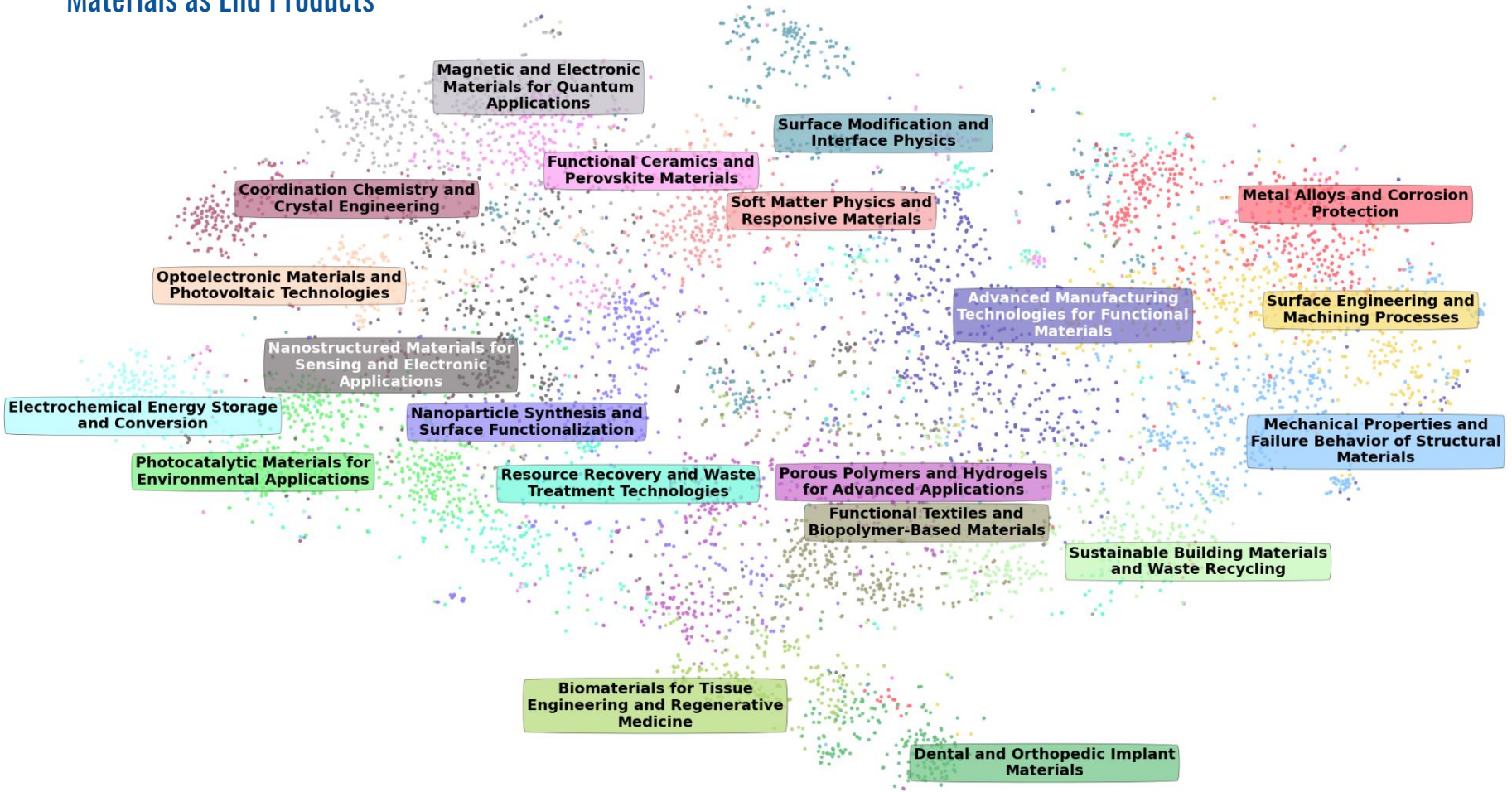
Information and Communications Technology (ICT)



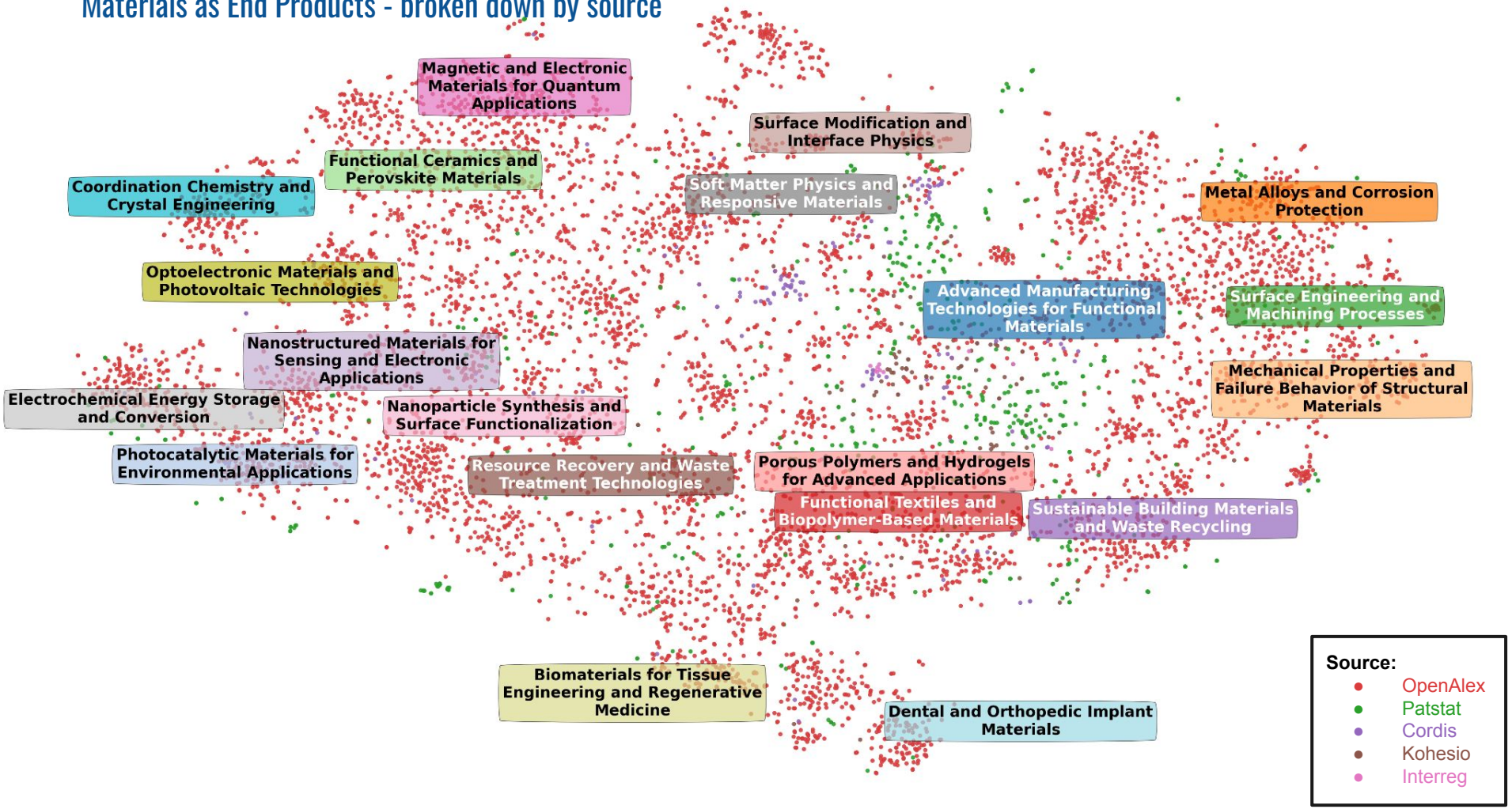
Information and Communications Technology (ICT) - broken down by source



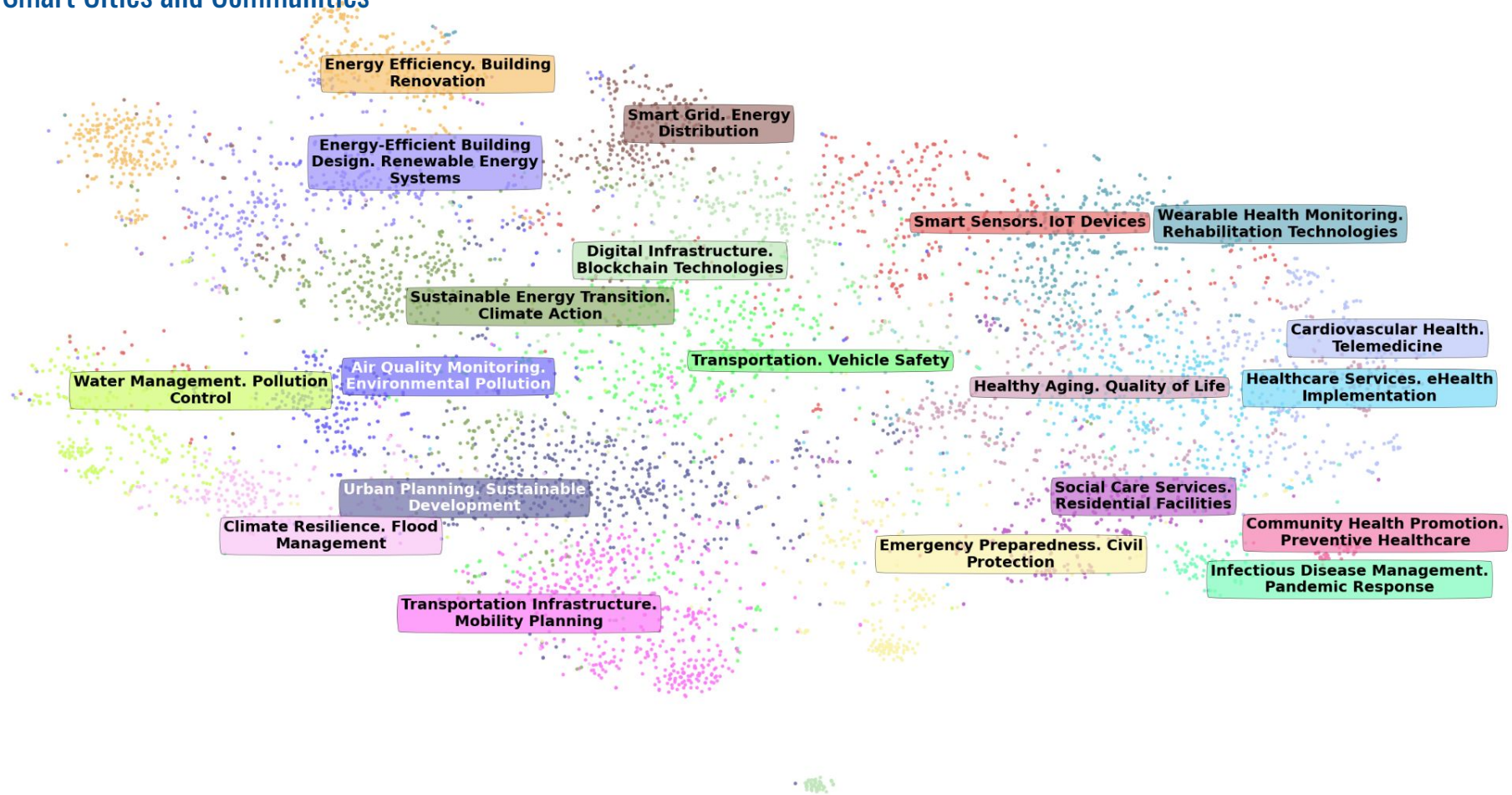
Materials as End Products



Materials as End Products - broken down by source

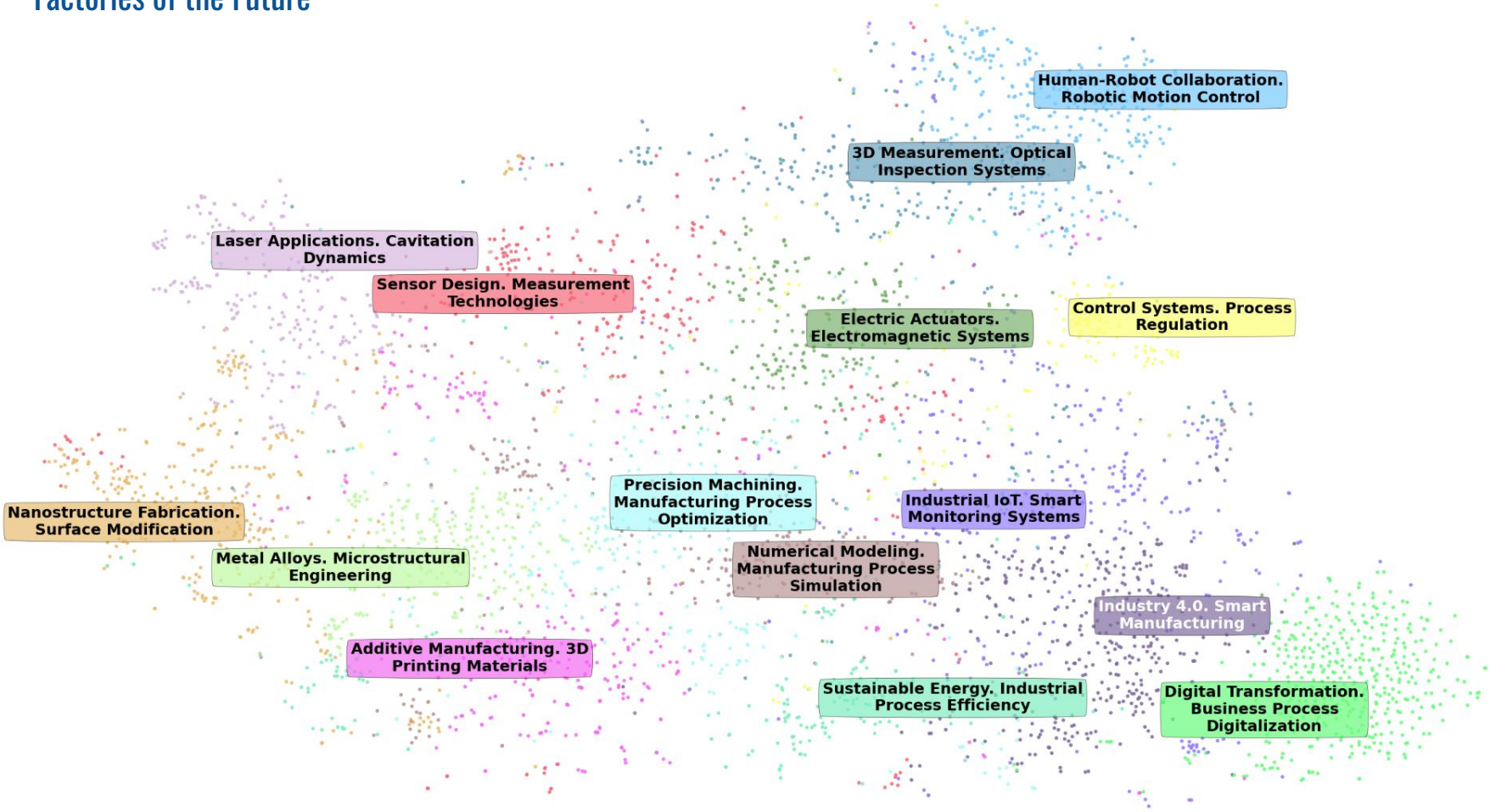


Smart Cities and Communities

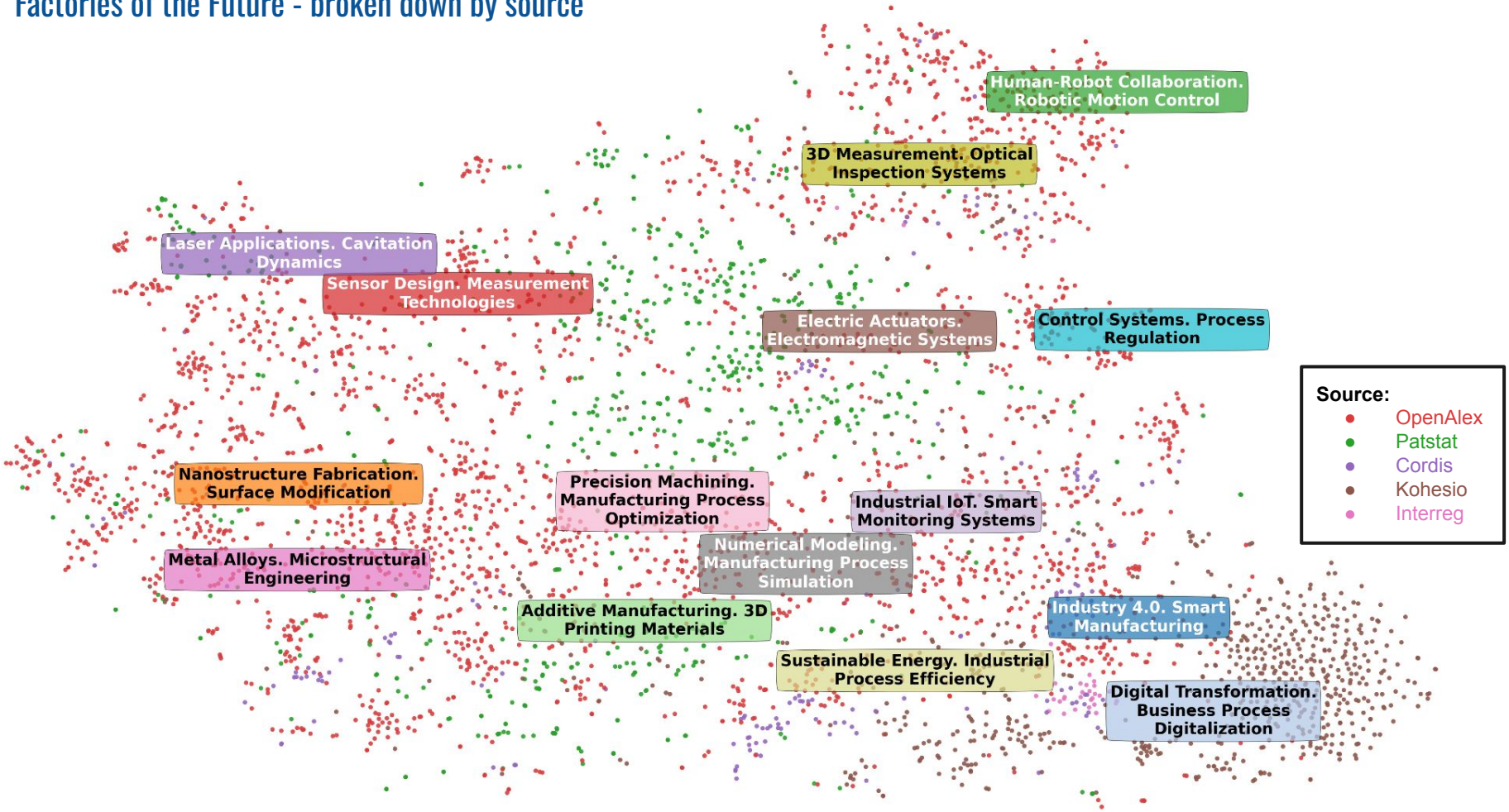


Smart Cities and Communities - broken down by source

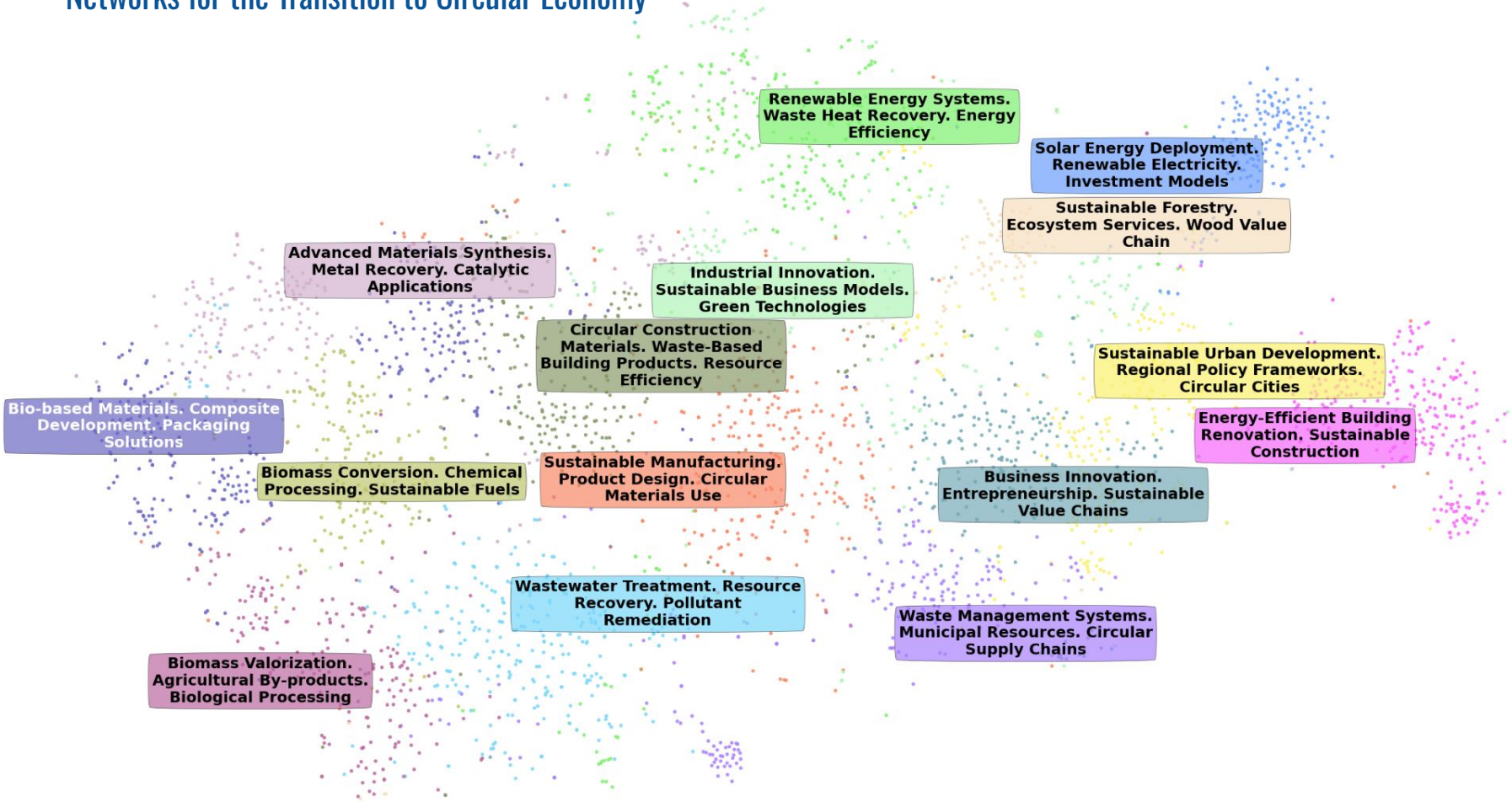
Factories of the Future



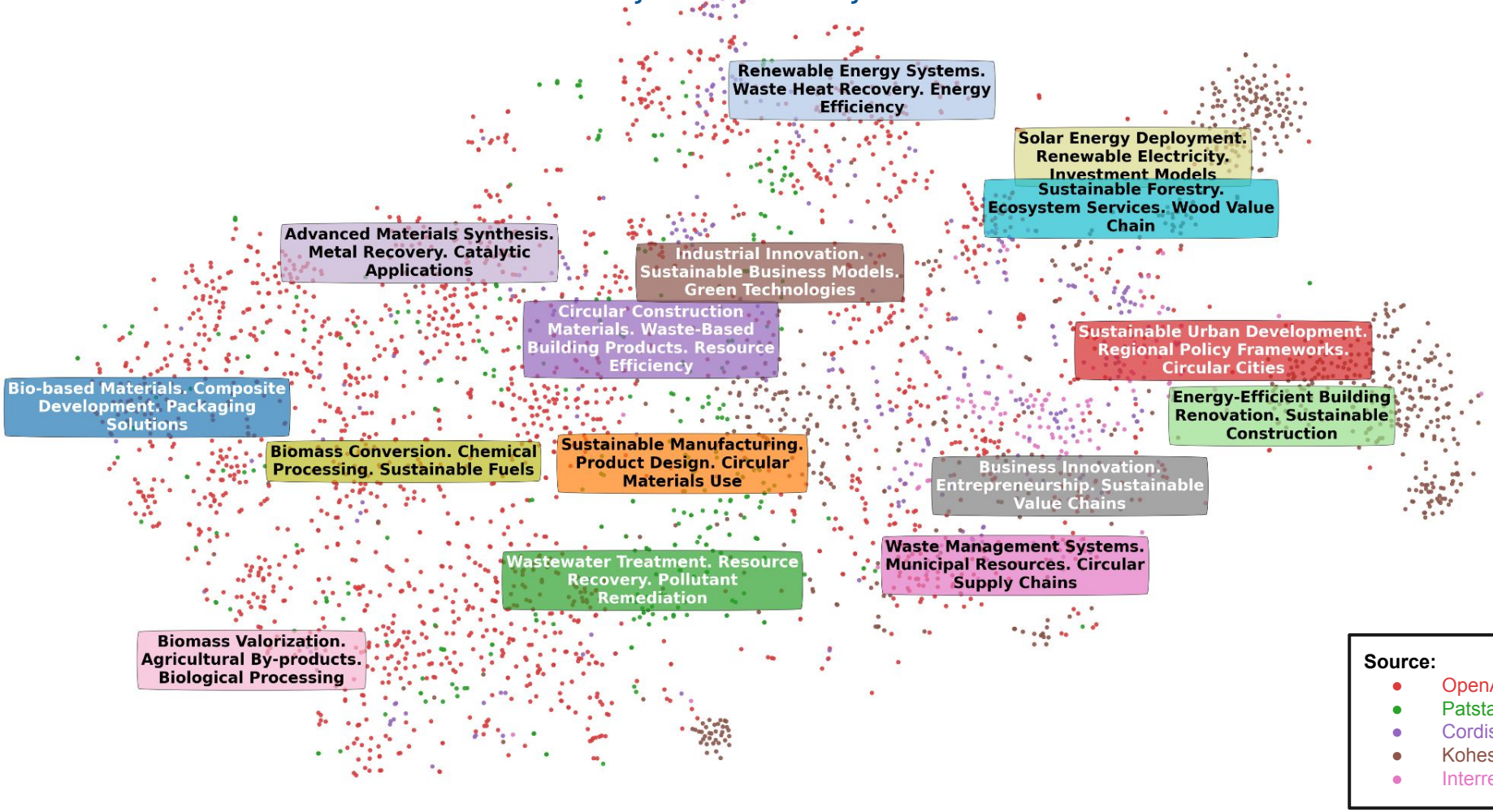
Factories of the Future - broken down by source



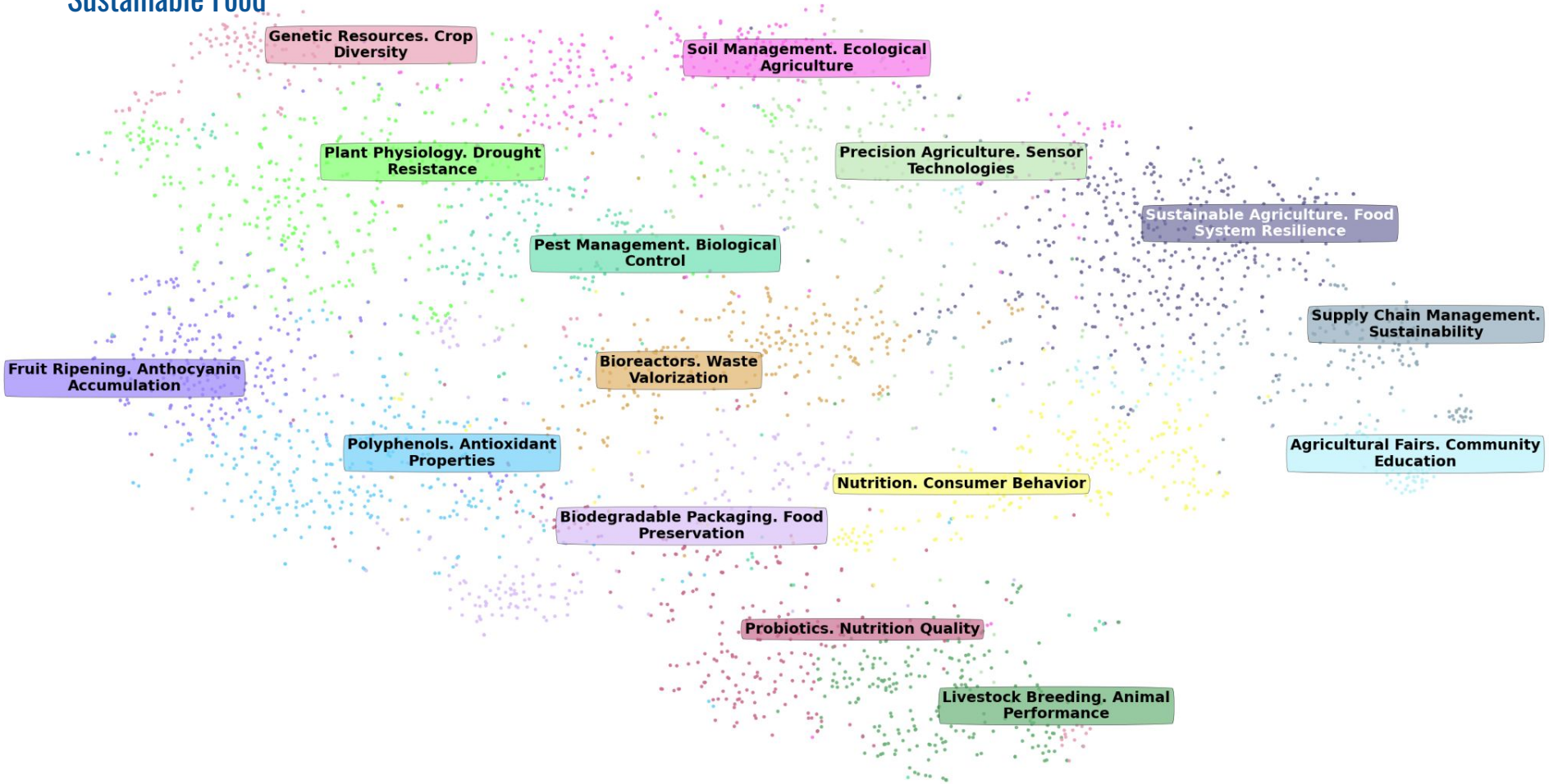
Networks for the Transition to Circular Economy



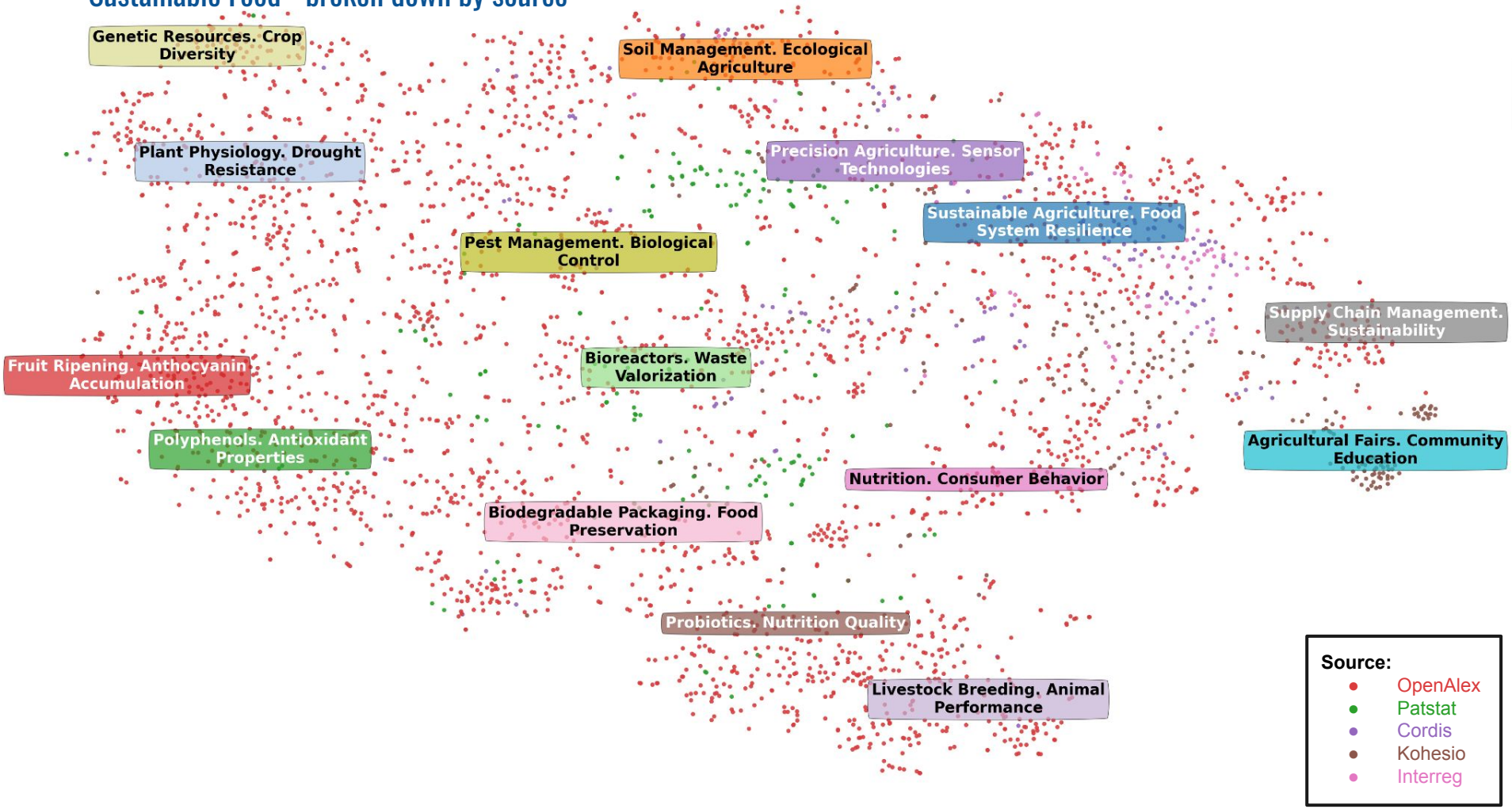
Networks for the Transition to Circular Economy - broken down by source



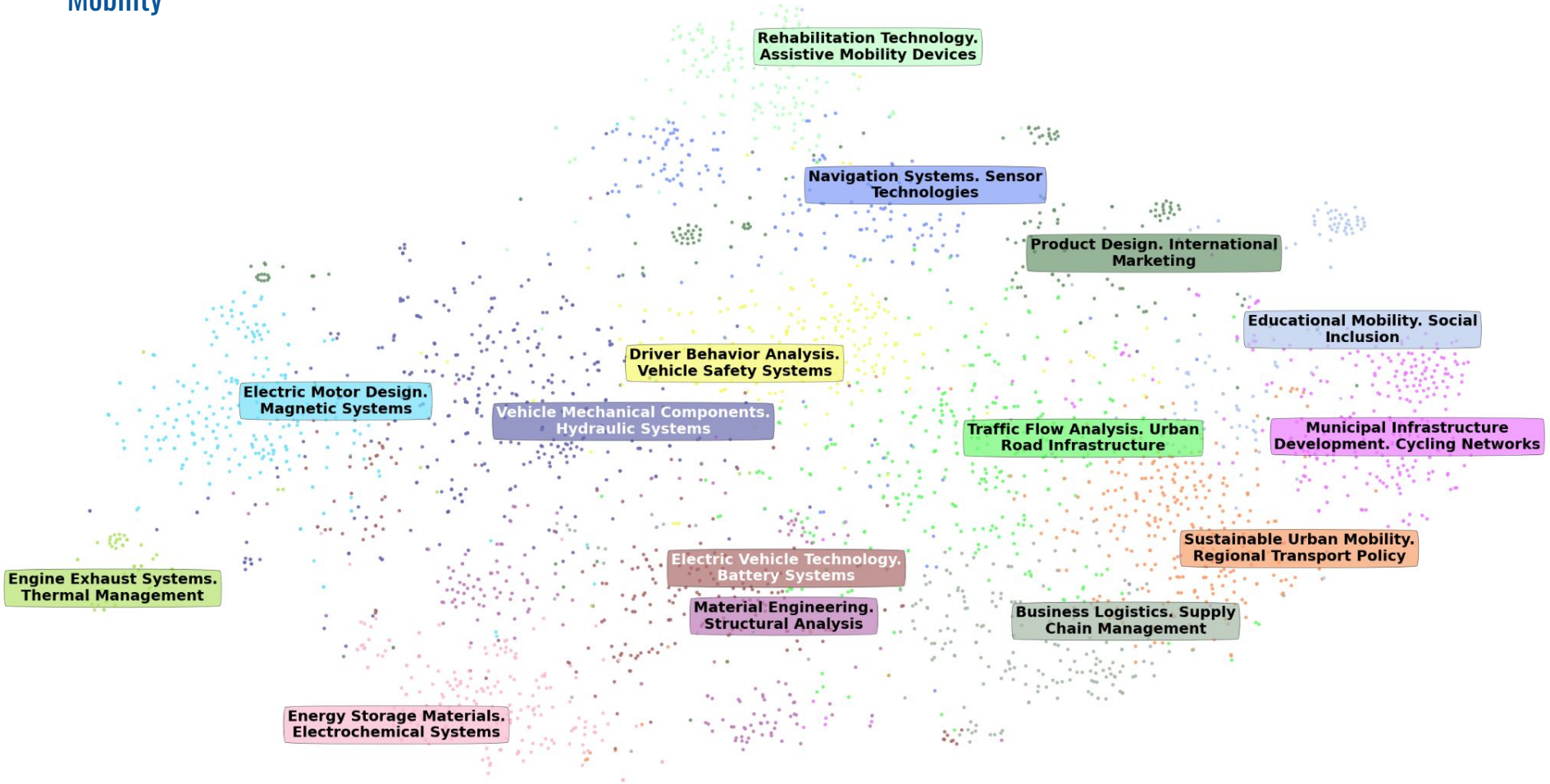
Sustainable Food



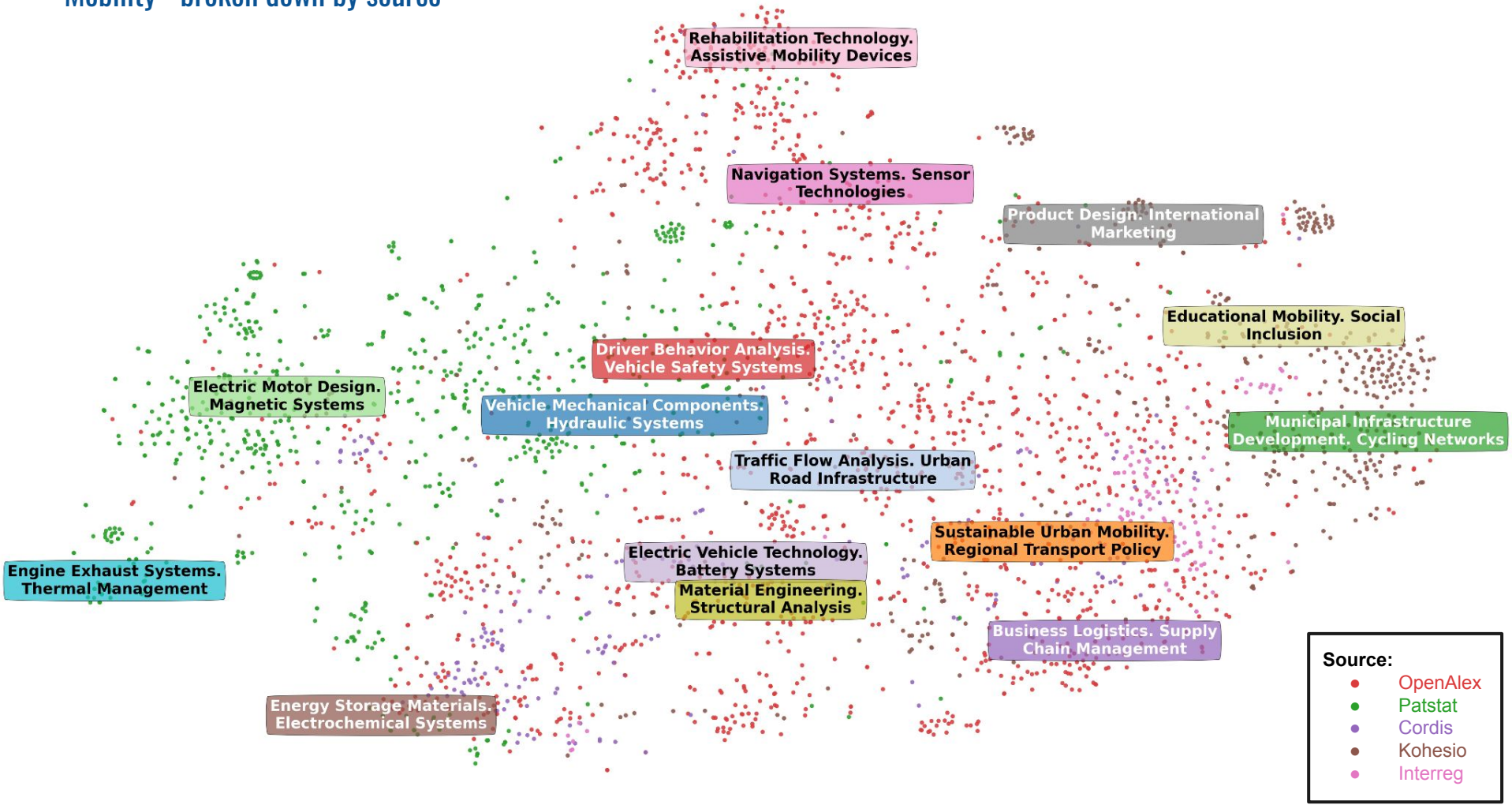
Sustainable Food - broken down by source



Mobility

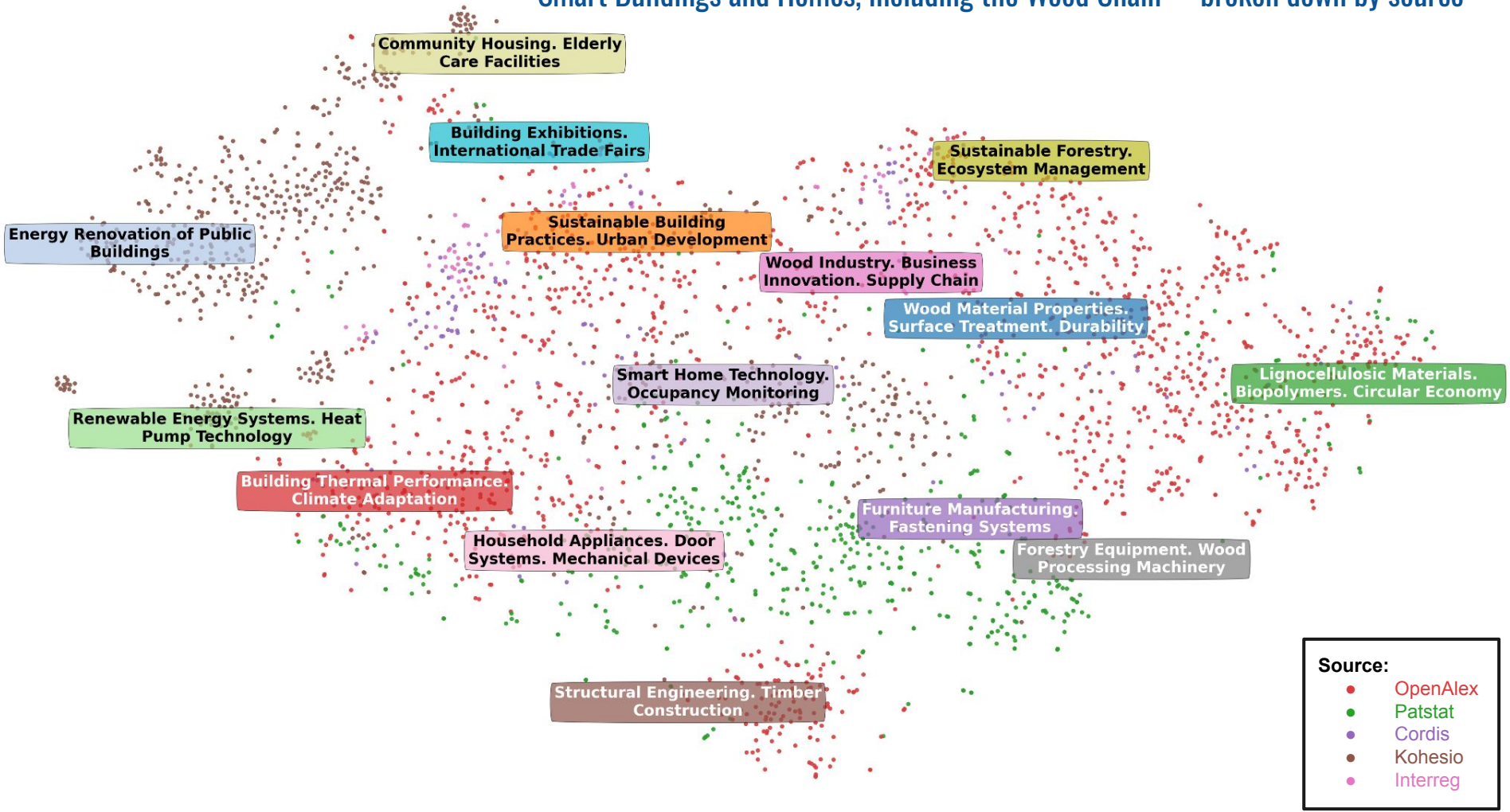

Rehabilitation Technology. Assistive Mobility Devices
Navigation Systems. Sensor Technologies
Product Design. International Marketing
Educational Mobility. Social Inclusion
Driver Behavior Analysis. Vehicle Safety Systems
Electric Motor Design. Magnetic Systems
Vehicle Mechanical Components. Hydraulic Systems
Traffic Flow Analysis. Urban Road Infrastructure
Municipal Infrastructure Development. Cycling Networks
Sustainable Urban Mobility. Regional Transport Policy
Engine Exhaust Systems. Thermal Management
Electric Vehicle Technology. Battery Systems
Material Engineering. Structural Analysis
Business Logistics. Supply Chain Management
Energy Storage Materials. Electrochemical Systems

Mobility - broken down by source

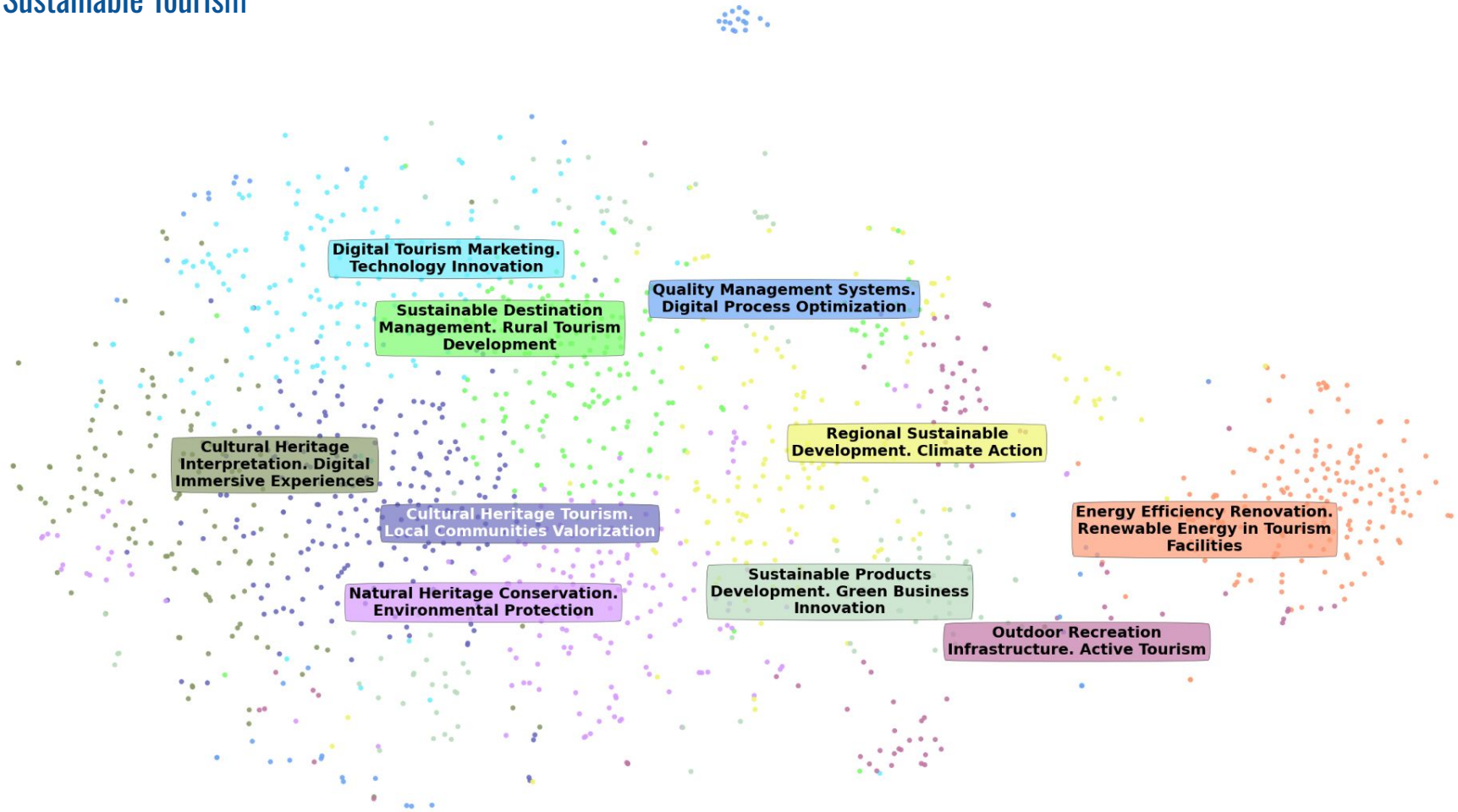


Smart Buildings and Homes, including the Wood Chain

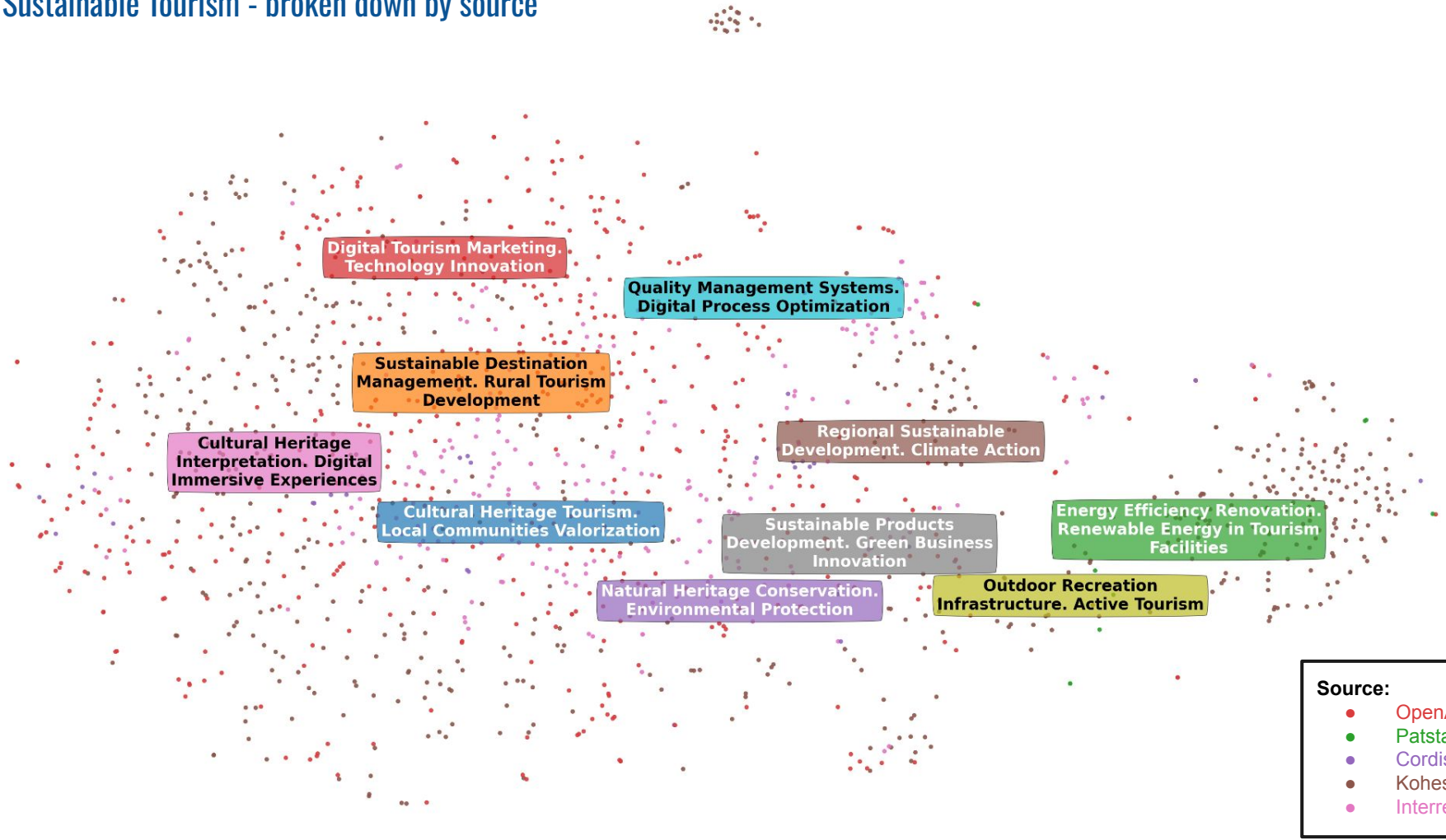
Smart Buildings and Homes, including the Wood Chain - broken down by source



Sustainable Tourism



Sustainable Tourism - broken down by source



Thank you very much

enric.fuster@sirisacademic.com
stefano.duranti@sirisacademic.com
sibylle.margerin@sirisacademic.com

Semantic analysis of RDI achievements in the priority areas of the Slovenian Sustainable Smart Specialisation Strategy (S5)