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Anatomy of an innovation ecosystem: how do circular economy and social impact actors interrelate? A case study on Catalonia

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Abstract

This work contributes by advancing innovation ecosystem (IE) mapping by proposing a novel Information System (IS) for policy-makers to identify synergies and barriers between different fields in a regional IE. Drawing on Information Systems Design Theory, a three-step methodology was tested on the Catalan ecosystem by analysing the description of more than 70,000 LinkedIn webpages to identify the relationships between Circular Economy (CE) and the Social and Solidarity Economy (SSE). Thematic similarities, potential synergies and existing barriers between CE and SSE-engaged actors were highlighted via structural topic modelling. Findings show how CE and SSE actors are still quite far away from each other, as the former are focused on technical issues, while the latter mainly on branding, communication and accounting activities. The convergence may be supported by ad-hoc policies to facilitate, on one side, actors focused on circular economy to better communicate their positive impacts, and, on the other side, social actors to avoid the risk of impact washing by linking more their activities to real actions. The tested IS artifact demonstrated to be highly scalable and generalizable and may support data-driven policies based on a more comprehensive picture of local IEs.

Keywords

Stakeholder Mapping; Innovation ecosystem; Quantitative Text Analysis; Circular Economy; Social and Solidarity Economy; Information System Design Theory

1. Introduction

This work contributes to the investigation of innovation ecosystems (IE) in management research by advancing ecosystem mapping with new data-intensive approaches and by proposing a novel Decision Support System (DSS) for practitioners and policy-makers to analyse emergent topic trends and potential convergence between sectors. In IEs, which have become popular in the last two decades by constructing an analogy with biological and natural ecosystem [1, 2], every organization exists within an external network of relations [3, 4, 5] and individual, or collective (considering a whole ecosystem), success intrinsically depends on the dynamics and strategies among local, national or international actors [6] and their capacity to develop, test, and adopt complementary products and services [7]. In recent times, policymakers at different levels have tried to leverage such dynamics to steer organizations, their energies and resources toward socially desirable outcomes. This is particularly true for sustainability issues, as it is well acknowledged that their wicked nature requires a variety of resources that no single actor possesses, as well as an interactive and cumulative approach that only IEs or similar social phenomena provide [8, 9].

For this aim, being able to identify local actors and characterize them in terms of industry, size, capabilities, and thematic focus is fundamental and motivates this study. Indeed, as a major gap, few empirical studies have undertaken the effort to leverage the massive and diverse data and algorithms which are necessary to perform such mapping [10]. Even fewer studies have focused on the design of approaches and tools that could go beyond academia and benefit policymakers by informing them with data-driven analyses and results on IEs [11]. Most importantly, even when such practice-oriented studies exist, they focus on the use of traditional sources of data such as academic articles, patents, or business registries [12]. These are fundamental to characterize actors in terms of scientific and technological capabilities, but often fall short in assessing equally relevant aspects for organizations and IEs. Indeed, addressing complex sustainability issues requires effective stakeholder engagement [5] and tacit knowledge [13] which hardly emerge from the above-mentioned data sources.

To address these gaps, the current research presents an innovative methodology for an Information System (IS) artifact, developed following the approach of the Information Systems Design Theory (ISDT) [14], to map an IE and provide demonstrative data-driven results which could inform policymaking on the interrelations between two or more different subjects and themes. Specifically, we applied the developed IS artifact to the Catalan ecosystem in Spain and to two apparently different, but potentially complementary, subjects and themes, the Circular Economy (CE) and the Social and Solidarity Economy (SSE).

The rationale for choosing and exploring the convergence of SSE and CE is mainly due to the potential complementarity of the two concepts in the sustainability landscape. The CE is an economy restorative and regenerative by design that aims to gradually decouple economic growth from the consumption of finite resources to improve efficiency, secure the availability of strategic materials, and reduce environmental degradation [15]. On the other hand, the SSE focuses mainly on ethical and moral principles, and how these should guide businesses to take care of their stakeholders rather than on economic growth and environmental protection [16]. These features make the two concepts highly different but potentially complementary [17]. However, current research studies on CE and SSE are still very punctual (taking single businesses as case studies) and large-scope ecosystem perspectives are missing [18, 19].

The methodology consists of a three-step general process: 1) creating a dataset of IE actors, 2) mapping and classifying individual actors via quantitative textual analysis, and 3) topic modelling on textual information to perform policy-relevant analyses. This approach was applied to the Catalan ecosystem in Spain, mapped from over 70,000 LinkedIn pages of local organizations. This would enable mapping and analyzing the Catalan IE to understand differences between organizations engaged with CE and organizations engaged with SSE [17]. In turn, this information could support policymakers in promoting synergies among actors and even some convergence across the two paradigms [20].

Accordingly, the following research questions were investigated:

1. What thematic affinities and differences emerge from the engagement of IE actors with CE and SSE?
2. What are the main opportunities for thematic convergence for IE actors engaged with CE and SSE?

Since part of the objective of this paper is to provide a proof-of-concept for an Information System artifact, however, after answering these research questions attention was also dedicated to discussing the specific benefits of this approach compared to existing ones.

The rest of the paper is structured as follows. The section 2 briefly presents the relevant literature about IEs CE and SSE. Section 3 presents the methodology and briefly introduces the case study, i.e., the Catalan ecosystem, while sections 4, 5 and 6 highlight the main findings from the case study, the benefits and limitations of this approach, and sketch future directions for research and practice.

2. Literature Review

2.1. Innovation Ecosystem

Drawing from multiple literature streams and theories, IEs have become of growing interest in the last two decades [21]. On the one hand, the concept of IE relies on Innovation Theory and the Schumpeterian creative destruction [22] to describe the ever-evolving nature of products, services, and processes, and their key contribution to competitiveness and economic growth. On the other hand, the term ecosystem is inherited from ecology and the natural sciences to describe the synergistic and complementary interactions between a multiplicity of functionally different actors [23, 24, 25]. The most recent antecedents, however, can be found in the literature on innovation systems and industrial clusters, which respectively focus on the relevance of synergistic interactions and agglomerations for innovation and productivity [7]. For these diverse origins, there is no unique definition of IEs. For instance, Jackson [2, p.2] defined IEs as "*the complex relationships that are formed between actors or entities whose functional goal is to enable technology development and innovation*", while Adner [26] described an IE as "*the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution*". For this lack of a commonly accepted definition, the concept of IE has sometimes been criticized as a buzzword with little differences from the above-mentioned concept of innovation system [7, 1]. However, we believe that the concept does possess unique traits as long as it is used to: 1) go beyond synergistic interactions between traditional innovation actors (namely universities, governments, and businesses); 2) to embrace also non-technological actors and their interaction with technological ones; 3) to account for the co-evolution of these actors as they provide complementary innovations which aren't only techno-scientific but also social [27].

This is consistent with the Quadruple Helix, according to which IEs emerge through the continuous, co-operative, and cumulative interactions among various actors in society, typically universities, governments, businesses, and civil society groups, each providing unique resources and contributing to the development, test, and adoption of innovations [27]. While other perspectives frequently focus on the role of technologies, the Quadruple Helix distinguishes itself by recognizing a key responsibility also to non-technological actors and processes, as they often provide the demand for specific innovations to emerge or provide the necessary cultural context for innovations to be effectively adopted [28]. One immediate example is the role of governments in guiding sustainability-oriented innovations by directing resources and media attention towards social or environmental issues [29, 30], or the role of civil society in legitimizing and adopting specific innovations (e.g. wind turbines for green electricity generation) but not others (e.g. nuclear plants) [31, 10, 32]. While civil society is more likely to focus on social acceptance and cultural framing of innovation, however, in the Quadruple Helix all actors (regardless of their type) are potentially contributing to social phenomena, as the following subsections show [27, 33].

Accordingly, policymakers have been particularly keen to adopt the concept of IE as a broad framework to encourage and foster innovation and growth [8, 30], and particularly to address sustainability issues, where involving a diverse range of actors with various knowledge and resources is crucial [34]. These actors, as part of their coordination efforts, not only guide the development of new technologies but also facilitate the collaborative evolution of ecosystem participants, creating mutually beneficial and supportive relationships [9, 35, 24]. To achieve this and effectively orchestrate IE to sustainability objectives, however, being able to effectively identify IE actors and map their engagement with specific issues becomes crucial [10, 36].

2.2. Mapping IEs

While the complexity of IEs and the relevance of different types of actors and dimensions is recognized, research on IEs has been traditionally conceptual and efforts to quantitatively and systematically map IEs have only recently been undertaken (see table 1), particularly with the combined usage of web scraping [37], natural language processing [38], and network analysis [20]. Social network analysis is by far the most common tool to provide higher-level insights on ecosystem actors, and has been used to study micro-, meso-, and macro-level connections between actors to identify keystones, bottlenecks, and clusters [4, 39]. Alternatively, semantic network analysis has been employed to identify thematic affinities and patterns by analyzing and classifying texts, and multi-layer approaches have been implemented to identify thematic affinities or mismatches [40, 41]. Even so, most studies have primarily focused on mapping the production of novel scientific and technological knowledge due to the abundance of scholarly and patent repositories to tap into [38], as only very recently new data sources such as social networks have been taken into account [37, 36].

As a result, most policy initiatives have also made little use of data-driven tools and rather relied on unstructured and highly qualitative approaches to orchestrate IEs towards desirable, effective and efficient evolution [8, 42]. Examples include smart cities, living labs, and innovation platforms [43, 44], which aim to connect citizens, governments, universities, and firms to co-create solutions for local and global challenges [45, 40] via sustainability-driven and innovation-oriented participatory governance [28, 46]. As for the advancements in academic research, for a lack of relevant data, the role of civil society and socio-cultural dimensions has also been largely neglected.

To bridge this gap, the current paper proposes the utilization of social networks, specifically LinkedIn, as an untapped data source for mapping ecosystems [37, 36]. With more than 850 million users globally, each with its own description and details, LinkedIn offers a novel and largely untapped data source. Some issues must, however, be acknowledged: on the one hand, when using information from the organizations' websites or their social network webpages, reliability may suffer as all content is self-produced and self-reported and may hence be positively biased [37]; on the other hand, collecting data from the web often requires the use of scraping techniques which may violate existing regulations on copyright, database protection, and privacy [47]. The first matter must be taken into account when interpreting the results, as some initial studies have shown that LinkedIn pages performed relatively well for different tasks, including evaluating organizations' engagement with novel technologies [36] and entrepreneurial performance [48]. Moreover, public authorities (such as the European Commission) have highlighted that the abovementioned regulations are not intended to restrain academic research as long as it is intended to benefit the public good and tries to minimize potential risks and unintended damages [47].

Reference	Data Source	Methodology	Objective	Scale
(Xu et al., 2018)	Bibliometic information, Patent information, Business registries	Text mining, Semantic network analysis	Mapping IE to identify synergies between science, technology, and business activity	County
(Kinne and Axenbeck, 2020)	Organizations' websites, Business registries	Text mining, Semantic network analysis, Web scraping	Mapping IE to identify businesses engaged with a specific technology	Region
(Cottafava and Corazza, 2020)	Organizations' websites, Surveys	Text mining, Semantic network analysis, Social network analysis, Participatory mapping	Mapping IE to identify sustainability issues and relevant stakeholders	City
(Spinazzola et al., 2022)	Organizations' social network	Text mining, Web scraping	Mapping IE to identify organizations engaged with sustainability-enabling technologies	Region
(Qi et al., 2022)	Bibliometric information, Patent information	Natural language processing, Social network analysis	Mapping IE to identify organizations with aligned knowledge and recommend collaborations	Global

Table 1: Key empirical papers employing quantitative methods to map IEs

2.3. IEs and the Circular Economy

The CE term has its origin in the Nineties [49] and refers to the need to disentangle economic growth from resource consumption by implementing regenerative and restorative strategies [15]. It has its root in several schools of thought: from the biomimicry [50] to the environmental economics [51], from the regenerative design [52] to the cradle-to-cradle [53], till the performance economy [54] or the industrial ecology [55]. What is new in CE is the strong focus on business practices and on the introduction and development of new circular business models [56], such as product-as-a-service [57], material passport [58], design for disassembly [59] and others. Basically, each strategy and business model aims to slow, narrow, or close the material and energy loops in order to avoid any possible waste generation [60]. The adoption of CE practices and business models can be highly benefitted by innovation ecosystems. On the one hand, within IEs new ideas and technologies can be developed, tested, and refined more easily. The diverse expertise and resources available in these ecosystems help to overcome barriers and facilitate the implementation of sustainable business models. Through open innovation and collaboration, businesses can access a wide range of inputs, such as materials, technologies, and expertise, necessary to redesign products, optimize resource use, and close the loop in value chains [61]. This is particularly true for startups and small and medium-sized enterprises, as they often lack sufficient capacities and are more dependent on their network for adopting any form of innovation [62]. Overall, IEs provide a fertile ground for the development and widespread adoption of CE practices [31] and an efficient utilization of CE knowledge and capabilities from within the organization [63] as well as from outside its boundaries [24].

However, the CE concept is severely under scrutiny. Although, one of the most famous circularity certifications, i.e., the Cradle-to-Cradle certification, includes social fairness (to monitor the equity and safety of workers) within the assessment process [64], the CE recently is being criticized for an excessive focus on materials usage, also determined by geopolitical calculations, and environmental protection, and a limited interest in social and human aspects

[17, 65]. Indeed, critics argue that the transition to a CE could inadvertently exacerbate existing social disparities and inequalities. They contend that while the CE promotes resource efficiency and waste reduction, it may prioritize economic efficiency over social equity. One concern is that the implementation of CE practices may lead to job losses in certain sectors, particularly those associated with linear, resource-intensive industries. This could disproportionately affect workers in lower-income communities who are already vulnerable to economic instability [66, 67]. Furthermore, the shift could require significant investment in new technologies and infrastructure, which may favor larger corporations with greater financial resources, potentially leaving smaller businesses and marginalized communities at a disadvantage [68].

To address these criticisms and ensure social equity within the circular economy, it is essential to incorporate principles of environmental justice and inclusivity. This entails actively involving affected communities in decision-making processes, ensuring fair and just labor practices, and promoting access to education, training, and opportunities for all individuals, regardless of socioeconomic background [68]. By prioritizing social equity alongside environmental sustainability, the CE has the potential to become a more inclusive and transformative framework that benefits both the environment and society as a whole.

2.4. IEs and the Social and Solidarity Economy

The SSE has properly its focus on equity, fairness, safety, democratic decision processes and governance. The term social dates back to the XIX century when the Rochdale Equitable Pioneers Society, the first cooperative, was founded in UK. Accordingly, it highlights the type of ownership as one that values each contributing person rather than uniquely acting for the shareholders' profit maximization [69]. In modern times it includes, among others, the legal status of cooperative and of non-governmental organizations (NGOs). The concept of solidarity economy is younger and traces back to the Eighties of the last century. It emerged from the practitioners and the volunteering communities, especially in France and South America, particularly aiming to "offer a set of economic initiatives of associative character based on an ethics of egalitarianism and diversity" that could contrast the contemporary capitalist system [17]. In the last decades, this second dimension has gained importance as the debate about the SSE moved from the ownership to the aim of the company, enlarging the focus on every organization acting with a social purpose. Examples include the BCorp certification, released by B Lab, that globally certifies certain social standards and that a social purpose, alongside profit aim, is actively pursued [70, 71]. Similarly, in the United States, the United Kingdom, France, and Italy, among other countries, benefit corporations are legally recognized by ad-hoc laws [72]. Accordingly, they have recognized the progressive hybridization of social enterprises, startups, and NGOs [73] that with their unique capabilities and resources contribute to local IEs.

The social economy has not been immune to criticism either, as various concerns have been raised regarding its effectiveness and impact. One major criticism revolves around the potential for the social economy to perpetuate dependency and undermine individual motivation. Critics argue that by providing various forms of assistance and support, the social economy may inadvertently discourage self-reliance and hinder personal growth [74]. Additionally, skeptics question the scalability and long-term sustainability of social economy initiatives, expressing doubts about their ability to generate sufficient revenue and maintain their impact over time [75]. Indeed, critics argue that the social economy can sometimes lack the necessary efficiency and competitiveness to effectively address social issues, particularly when compared to market-driven solutions. These criticisms highlight the need for ongoing evaluation and refinement of social economy models to address their limitations and maximize their potential for positive social change, specifically if interested at addressing structural and complex issues such as most sustainability ones [76, 46].

2.5. Combining the Circular Economy and the Social and Solidarity Economy

In the last years, scholars started to analyze common aspects and differences between the CE and the SSE. For instance, Zaccone et al. [18] discussed how circular economy business models can foster and support sustainable development in social entrepreneurs and hybrid organizations. Through six case studies in different sectors (from manufacturing to retail or textile) they theorized a grounded model based on educational and pedagogical activities for social entrepreneurs focused on circular economy. Similarly, other scholars, in the framework of society 5.0, are focusing on the analysis of society and social impacts within the industry 4.0 innovation [77] or on the new emergent paradigm of Circular Social Innovation (CSI), as mentioned by Prasad and Manimala [78, 65] in their article on Stanford Social Innovation Review. In the authors' opinion CSI has three fundamental characteristics: 1) holistic and sustainable development, including the three sustainability pillars (social, economic and environmental), 2) restorative and regenerative activities, and 3) innovation in terms of processes, products or services. In addition, again in authors' discussion three drivers are necessary: active engagement of stakeholder, multi-sided benefits and low or zero costs (of input). In this sense, it is clear that a CSI strategy cannot simply focus on reducing raw material usage or to reduce environmental impacts, but should fully focus on the social part, too. The social benefit in the the medium or long-term (outcome or impact, recalling the theory of change) may have different forms and consequences, and may activate positive virtuous feedback loops, back and forth from the environmental to the social aspects, as demonstrated by Marchesi and Tweed [19] who analysed the interrelation between social innovation and circular economy in social housing by identifying how communities in social housing can stimulate and promote circular economy practices. These considerations, and the mutual benefits are even more clear by adopting a holistic and complex vision of wicked challenges through a system dynamics perspective [79]. However, despite the increasing interest in the CE and SSE convergence, to the present day most of the studies still focus on specific case-study and there is a lack of analysis at the IE level.

3. Methods

This work primarily draws from the approach of Gregor and Jones [14] to design and test an Information System (IS) artifact according to the ISDT as introduced by Walls et al. [80] starting from the theory-research cycle [81].

An IS artifact aims to collect, manipulate and disseminate information to a target end user. In particular, this work develops a Decision Support System (DSS) for decision and policy-makers aimed at analysing emerging trends in local and regional innovation ecosystems. Specifically, the proposed IS artifact presents a novel methodology to analyze a local innovation ecosystem and to study emergent trends among two, or more, subjects, as well as their similarities or differences. Fig. 1 shows the most general flowchart of the designed IS artifact. The designed DSS includes three main steps: 1) Database Creation, i.e. the setup of a dataset of actors for a specific territory or ecosystem (see section 3.1.1), 2) Mapping and Classification, a quantitative analysis to prioritize and select the identified actors of the ecosystem according to specific subjects, geographical areas or economic activities (see section 3.1.2), and 3) Topic Modelling and Policy-relevant analysis, to provide useful insights to policy and decision-makers in order to facilitate and support IE-wide policy-relevant analyses (see section 3.1.3).

In the following subsection, all the details related to the IS artifact, according to the ISDT as discussed by Gregor and Jones [14] are discussed, presenting all Information System Artifact components, as well as all technical and methodological steps and minimum requirements.

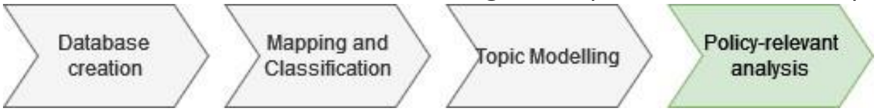


Figure 1: General flowchart of the proposed IS artifact. Source: authors' own elaboration.

3.1. Information System Artefact

To define an IS artifact eight single components must be defined [14]. Table 2 shows the summary of the eight components with a brief description of each one. According to Gregor and Jones [14], the first six components are necessary to design a novel IS artifact following the theory-research Dubin's cycle, while the last two components (principles of implementation and expository instantiation) simply refer to the application of the artifact to one or more experiments to test it. As briefly anticipated, the purpose and scope and the principle of form and function of the proposed DSS are to identify emergent trends between two or more subjects and sectors - such as between the circular economy and the social and solidarity economy –and to provide policy-relevant analyses at the scale of entire innovation ecosystem (local or regional for instance). Thus, the boundaries refer to the selected geographical area and to all the types of actors according to the quadruple-helix [82], i.e., government, academia, industry and society; therefore, actors such as NGOs and associations, research centers and universities, public administrations and institutional bodies, and private firms and corporations have to be considered. The scalability (i.e. artifact mutability and testable propositions) are ensured by guaranteeing robustness in change in topics and subjects, types of actors, system size (e.g. from towns to province or entire regions). To guarantee the scalability the basic constructs represent the smaller functional unit i.e. a single actor - and corresponding necessary information to classify each actor according to the geographical area, the economic sector and the selected subjects. To analyse according to specific subjects that have not a perfect and precise correspondence with traditional economic sectors (e.g. circular economy), textual information are necessary to label and analyse each actor.

Table 2: Information System artefact components

Component types	Description
Purpose and scope	The aim is to map IE actors' engagement with specific subjects (e.g. circular economy, social impact) to identify emergent trends between two or more subjects and sectors. The boundary condition of the system includes all the actors belonging to the selected ecosystem (businesses, associations, public administrations, research centers and universities).
Constructs	The fundamental constructs are 1) the single actors of the ecosystems, 2) their related information and 3) a set of keywords per subject (necessary to select and filter the actors with respect to each subject). In particular, the following information are required for each actor: name, textual description, economic sector, and geographical location. Additional information

	such as specialities, year of foundation, or the number of employees may be added to improve, or to narrow down, the output of the analysis.
Principle of form and function	The artifact should be able to 1) map IE actors to a multiplicity of subjects, 2) to compare the different subjects starting from the selected actors and their textual information and 3) to point out eventual synergies and barriers between the actors and entities belonging two different subjects and sectors.
Artefact mutability	Scalability: the artifact should apply to any ecosystem of any scale (from a local and regional scale to a national and international scale), any number of actors and any composition (from a few hundreds to thousands or millions actors), as well as to any chosen topic.
Testable propositions	Robustness: the artifact should be adaptable to different ecosystem sizes and compositions and chosen subjects.
Justificatory knowledge	The stream of literature about 1) innovation ecosystem [83], 2) typologies of actors [84, 82], 3) inter-sectoral relationships among clusters of innovation [85, 86] are the foundation of the study.
Principles of implementation	The IS artifact consists of three main modules (see Fig. 1): 1) Database Creation, module aimed at populating a dataset of actors from different sources, 2) Mapping and Classification, module necessary to classify IE actors according to different information, such as geographical area, economic sector, and subjects, Topic Modelling and Policy-relevant analysis, module necessary to identify synergies and barriers between the actors belonging to the selected subjects .
Expository instantiation	The Catalan regional ecosystem has been analysed as an information-rich case study. The robustness of the methodology has been tested by focusing on sub-regional areas of different size and on different topics (Circular Economy and Social and Solidarity Economy). The detail about the implementation are provided in Fig. 2.

Finally, the Principle of implementation are fully described in Fig. 1 and 2. The former shows the three main modules while the latter expands and describes in detail each necessary component and methodological step for each module. For demonstrative purposes, this methodology was here applied to a purposeful case study [87] focused on the Catalan IE as expository instantiation. To allow generalization and evaluate the robustness (Testable proposition) of its usage [88], two policy-relevant analyses were performed, one concerning actors' engagement with CE and one with SSE. The three steps are now presented as part of the methodology to map the Catalan ecosystem.

Figure 2: Detailed and specific flowchart of the proposed IS artifact. Source: authors' own elaboration.

3.1.1 Database Creation

As reported in Fig. 2, the first module refers to the database creation. First, the relevant categories has to be defined in addition to the required one. The database must contain at least the following information for each actor of the selected ecosystem: 1) name of the actor, 2) general description, 3) main sector / keywords, and 4) geographical location. Therefore, the proper online data sources have to be chosen. The database may derive and be created from different sources of data as official databases from local chambers of commerce, regional or national statistical offices, social networks such as Linkedin, or other private and public database (e.g. Bureau van Dijk). Other information may be useful to weigh or filter the actors of the selected ecosystem such as the number of employees, or the turnover.

In our case, the database has been created from the social network LinkedIn, which is an information-rich source containing data for public and private actors, legally and not legally recognized, such as NGOs, businesses, public administrations, civic initiatives, as well as research projects and groups, universities, incubators, venture capitals, and so on. Every (complete) LinkedIn page contains the following information: name of the organization, description, sector, followers, number of employees, specialties/keywords, location, year of foundation, and associated website (if any).

Once defined the categories and information, the data sources to be used, through data scraping techniques the database can be created. In our case, the data from LinkedIn have been scraped thanks to the UiPath automation software (version 2022.4.4) for all the Catalonia region in Spain, following the methodology described by Spinazzola et al. [36] [1]. Once downloaded, all the information has been translated in English through the Google Translate API and RStudio software (version 2021.09.1+372). Finally, conventional post-processing of the textual information needs to be done by removing stop words, cleaning punctuation and stemming words.

Therefore, the database was parsed and analyzed in order to point out and select only relevant actors within the selected ecosystem as described in the following subsection.

3.1.2. Mapping and Classification

In the second module, Mapping and Classification, three consecutive labelling processes have to be performed.

First, each one of the 149 Linkedin industrial categories (under the industry flag on Linkedin) was mapped to a corresponding NACE (Nomenclature statistique des Activités économiques dans la Communauté Européenne, i.e., Statistical nomenclature of economic activities in the European Community in French) to facilitate future comparisons with other European regional ecosystems. The detail of the mapping can be found in Appendix B.

Second, the geographical analysis was performed by aggregating actors by Comarca, which is a sub-regional aggregation of towns in the Spanish administrative system, starting from the locations declared on the Linkedin web pages of each actor.

Finally, each actor was mapped to one, or more, of the selected subjects (i.e. circular economy and social impact). This step consists in filtering the actors based on ad-hoc keywords related to a specific subject (e.g. circular economy), following the methodology described in Cottafava et al. [90]. First, a set of keywords, for each chosen subject, has to be selected. The list can be obtained through multiple ways and methodologies such as extracting relevant keywords from a Scopus query [91], from existing dictionary published in the literature [92, 90] or through ad-hoc focus group or expert interviews. In our case, to simplify the test of the IS artifact, the words "circular economy" and "social impact" have been used. The full list of used keywords for circular economy is shown in Appendix A and was obtained as described in Cottafava et al. [91]. Second, a score is assigned to every actor within the dataset according to the following equation:

$$K_j = \sum_{i=1}^{N_t} K_{ij} = \sum_{i=1}^{N_x} \left(\sum_{x=1}^{3} w_x \, n_{x,ij} \right) = k_i \left(w_1 n_{1,ij} + w_2 n_{2,ij} + w_3 n_{3,ij} \right)$$

where K_j is the total score for the actor j and K_{ij} for actor j and keyword i and N_t is the total number of keywords for the topic t. The terms k_i, w_x and $n_{x,ij}$ are respectively the weight for

[1] As already mentioned in the previous section, web scraping social networks for research purposes has been increasingly common in recent years [129, 125] and also legitimized and stimulated by the European Commission [86]. Specifically, no personal information was web scraped for this paper nor did it infringe existing regulations on copyright and databases [86, 137].

keyword i, the weights for the three parameters x - 1,2,3, refers to the name of the actor, the sector and specialties, and the general description - and the keywords' occurrences in the text of the corresponding parameter and actor. The occurrence of a keyword is rewarded differently according to w_x, i.e. w_1 = 10; w_2 = 5; w_3 = 1. Each keyword is equally weighted (k_i = 1), although different choices may be taken (e.g. rewarding more certain specific n-grams). Finally, according to a chosen threshold[2], only the actors with a score higher than a threshold has to be selected. This methodology allows to quickly select only relevant actors by filtering out all actors not related to a specific topic. Limitations and possible improvements (e.g. through supervised or not supervised machine learning algorithms) of the filtering process are described in details in Cottafava et al. (2022) [90].

Finally, only the relevant actors were filtered out based on geographical areas and on the score given in the previous steps according to the different subjects. The filtered and reduced database, thus, was used, on one side for a descriptive analysis of the regional innovation ecosystem, and on the other side, to point out synergies and barriers between the two selected subjects. Results from both analyses were visualized with R packages heatmaply, rgeos, and maps.

3.4. Topic Modelling and policy-relevant analysis

In the last module, i.e. Topic Modelling and policy-relevant analysis, to answer the research questions and highlight similarities and differences between CE and SSE, a structural topic model was constructed employing R packages including topicmodels, lda, ldatuning, and stm. The right number of topics for the topic modelling (twenty in our case) was selected with the Griffiths [93] and the Arun [94] methods. Results from the convergence of the tuning method can be found in Appendix C. Once selected the proper number of topics, the structural topic modelling approach enabled to point out details about top topics within the ecosystem, and the correlations between CE and SSE have been analyzed to underline similarities and differences. Results from both analyses were visualized with R package LDavis.

Finally, both the descriptive analysis and the topic distribution and prevalence analyses have been used to identify synergies and barriers among the selected subjects and topics to reporting policy-relevant findings.

4. Results

4.1. Case Study Description

Catalonia is a vibrant and innovative region in the North-East of Spain with a total population of more than seven millions of people (and a population density of 241 persons per km square) and an average GDP per capita of 32,800 euros. Nationally, it represents almost the 20% of Spanish total GDP and it is one of the most innovative region of Spain [95]. According to the Global Talent Competitiveness Index 2021, Barcelona, the capital of Catalonia, is in the top-forty of the most talented cities in the world [96].

In terms of digital and technological innovation, Barcelona is leading European rankings as one of the most popular and attractive cities. According to the Innovation Cities Index, it is ranked as the fourth most innovative city in Europe (21st in the World) in 2019, while by the StartUp Heatmap Europe Barcelona is ranked as the 3rd most popular city in Europe or the5th most attractive city for digital talents in the world (according to the Decoding Global Talent 2019from

[2] in our case equal to 1 since a single word has been used

The Boston Consulting Group) [97]. In 2022, in the entire Catalonia there were more than 2000 startups and more than 400 scaleups [98]. The region, thus, is in line with others of the most innovative regions in Europe such as Lombardy in Italy that counts 2.282 startups in 2021 [99]. In terms of innovation, the Catalan region is particularly consolidated and robust; it counts more than 25 innovation clusters covering almost every economic sector, from food and water services, and corresponding packaging, to digital and audiovisual enterprises, from renewable energy, bioenergy and energy efficiency to the design and fashion sectors [100].

Moreover, several others initiatives and entities exist to boost and support the whole ecosystem, both in terms of innovation and its sustainability, from the adopted strategy for sustainable development [101] to Barcelona Sostenible [102] - an online public portal with more than 1800 mapped activities related to sustainability, from civic initiatives to large organizations - until the Tech Barcelona, a network of more than 1000 technological startups [103], or the District 22 and the association 22@Network [104], launched in 2004, to aggregate large companies, institutions and universities, as well as research centers, SMEs and startups in the neighbourhood of Poblenou-Sant Martí, the most innovative hub in Catalonia.

Similarly, in terms of circular economy practices the Catalan region is investing many efforts and there are several private and public relevant initiatives, from public investments and policies to private startups' programmes. For instance, in the Comarca of Maresme, close to the area of Barcelona, the Consortium for the Treatment of Urban Solid Waste of the Maresme in collaboration with the Council of Barcelona planned to build the Mataró-Maresme circular park, the first industrial park of South Europe [105] based on the principles of the Industrial Ecology [106], the city council adopted the strategic plan Circular Mataró [107] and the first national Circular Economy and Sustainability Chair has been set up [108]. The Catalan ecosystem related to Circular Economy is rapidly emerging in the last decade. According to the Government of Catalonia, that released a first mapping report, in 2014 there were almost 400 companies with more than 70 thousands employees and generating a total turnover of 4 billions euros yearly. The Catalan ecosystem includes both large and small companies, private and public institutions; although large organizations and institutions are present in the territory, the majority of the Circular Economy actors (the 91%) is composed by SMEs [109]. On top of the ecosystem composition, several initiatives and public entities to promote the adoption and the spreading of the Circular Economy have been launched during the last years such as the Circular Economy observatory been set up in 2008, which includes more than 30 members, from city councils to research and education institutions [110].

Finally, in terms of social and solidarity economy entities the Catalan ecosystem is a frontrunner in the European Union. In the Catalan ecosystem, indeed, since more than a decade there exist various venture capitals and philanthrophy foundations entirely dedicated to social impact such as the Ship2B Foundation [111], pioneer actor in the social impact ecosystem, or the most recent Norrsken Foundation [112] or Impact Hub Barcelona [113]. Similarly, the academic community is deeply engaged on the social impact ecosystem, with dedicated and ad-hoc research centers or Business Schools such as the Esade Center for Social Impact [114] or the EADA Business School [115], hardly focused on social and environmental impact assessment, just to mention a few relevant examples. On top of the vibrant community, it is noteworthy to mention that, currently, according to a report released by Impact Hub Spain on social impact entrepreneurship Barcelona represents one of the most advanced local ecosystems, in terms of social impact, in Spain [116]. According to the report, Barcelona ranks at 3rd, and 7th position with respect to economic-entrepreneur and socio-cultural axes, respectively, while in terms of environmental aspects it is only at the nineteen position.

Therefore, the Catalan innovation ecosystem, acting in-between technological innovation, on one side, and social and solidarity economy and circular economy, on the other side, is a noteworthy and relevant case study. In addition, its leading role as international and worldwide recognized hub and as a bridge towards the LATAM area (mainly due to language and cultural reasons) makes Barcelona a relevant case study worldwide.

4.2. Mapping and Classification

Figure 3 presents the total number of actors per Comarca. The majority of the mapped actors belongs to the city of Barcelona and to the closest areas (Baix Llobregat, Vallés Oriental, Maresme). The highest concentration of actors is in the southern regions (the ones close to the seaside). With respect to the inner regions, a particularly high number of actors was found in the region of Segriá. The poorest area corresponds to the two Comarca of Alta Ribagorça, and Pallars Sobirà.

Table 3: Total number and percentage of actors for each NACE economic sector.

NACE	A	B	C	D	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	NA
N°	1634	264	16073	169	4619	1590	1348	297	9761	4518	349	8042	3697	3476	4032	2825	6691	275	1201	236	176
Percentage	2,3%	0,4%	22,6%	0,2%	6,5%	2,2%	1,9%	0,4%	13,7%	6,3%	0,5%	11,3%	5,2%	4,9%	5,7%	4,0%	9,4%	0,4%	1,7%	0,3%	0,2%

In terms of economic sectors, the total number per NACE sectors and the percentage over the total is shown in Table 3. The majority of the mapped actors belong to the C, J, M and R NACE sectors (Manufacturing, the Information and Communication, the Professional, Scientific and Technical activities, and the Arts, Entertainment and Recreation sectors) that represent respectively the 22.6%, the 13.7%, the 11.3% and the 9.4% of the total. The percentages, hence, well represent the strategy of the Catalan region and its leading position as an innovation and research hub, as well as a cultural and creative area in Europe.

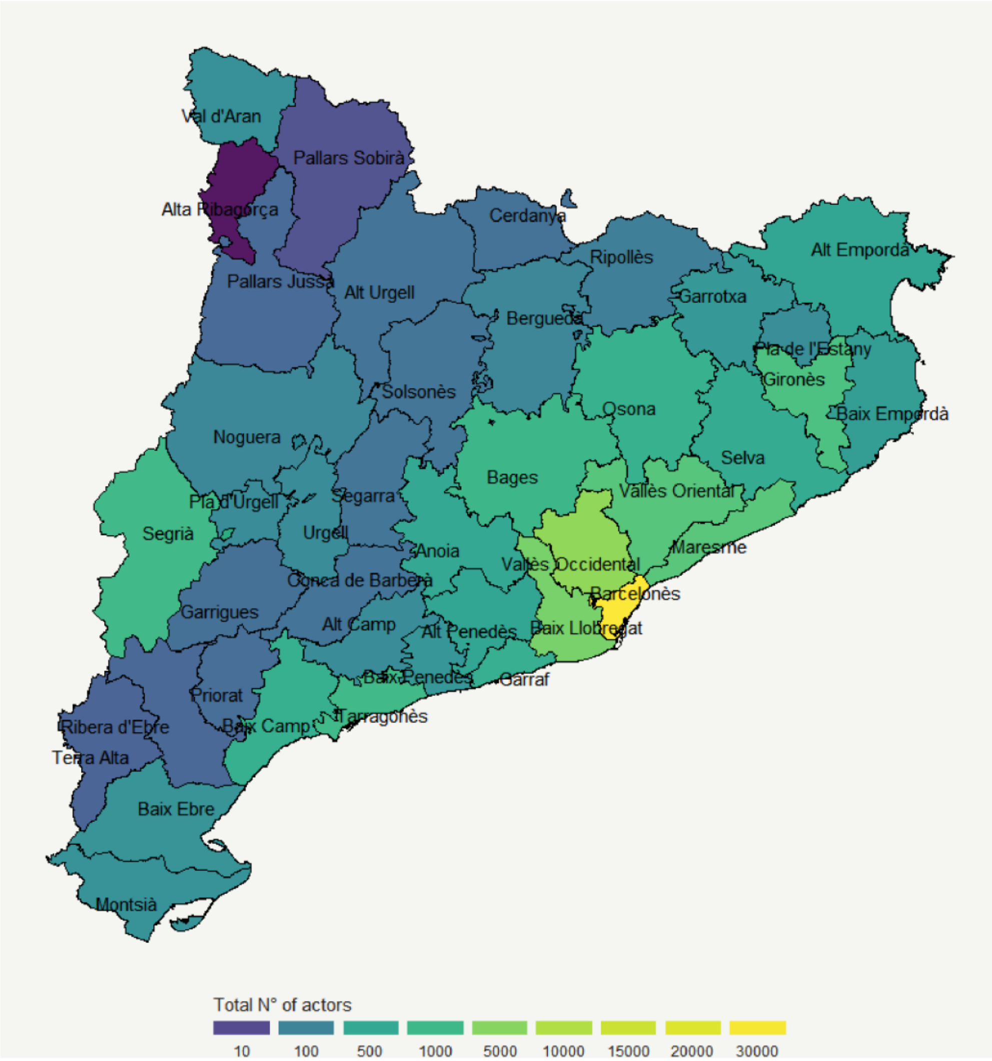


Figure 3: Total number of actors in Catalonia (Spain) for each Comarca. Data Source: Linkedin.

The distribution of the different activities is not completely homogeneous throughout the Catalonia (Figure 4). In particular, in the area of Barcelona the agricultural sector (NACE code A) is almost completely absent and the Manufacturing sector is not very important over the total, while the majority of actors belong to the J (Information and Communication), I (Accommodation and Food services), P (Education), and R (Arts, Entertainment and Recreation) sectors, confirming the role of Barcelona as an innovative, cultural and research pole. The Manufacturing sector (NACE code C) is well-spread over the entire region with certain exceptions, i.e., the Prioriat, Alta Ribagorça and Cerdanya Comarcas (and the area of Barcelona). This overview is consistent with official statistics on economic activities in the region, thus confirming the reliability of the database [117].

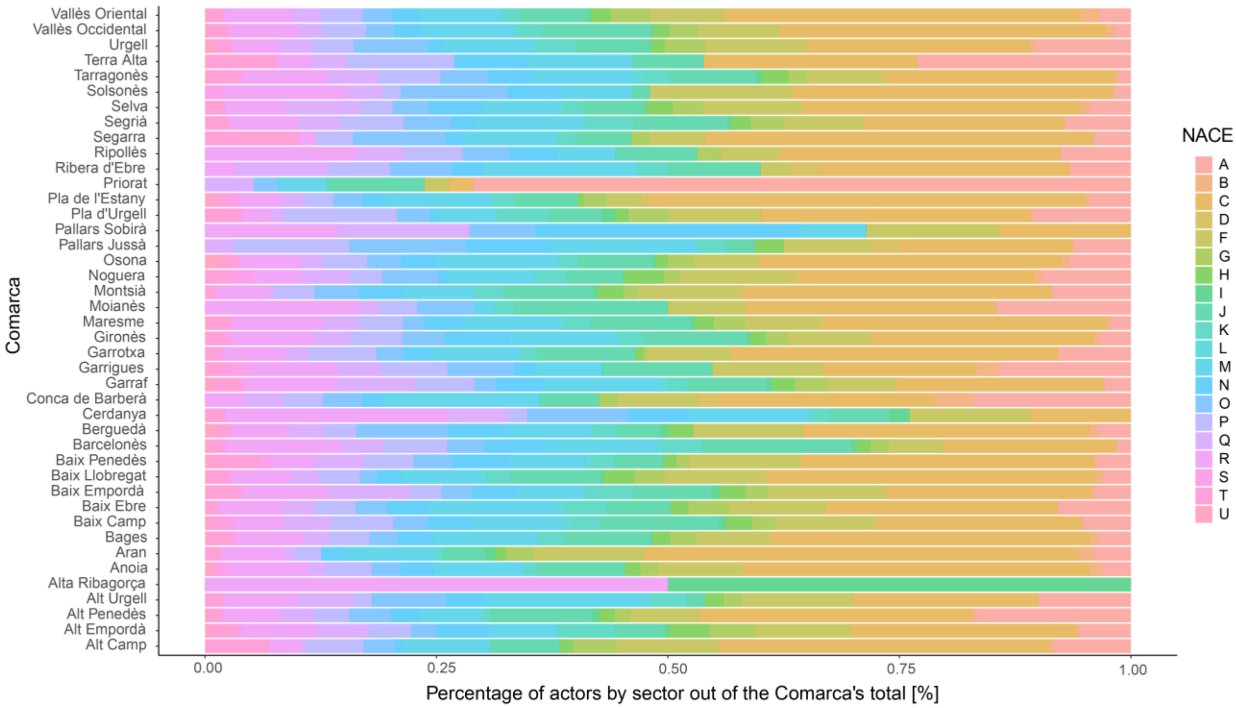
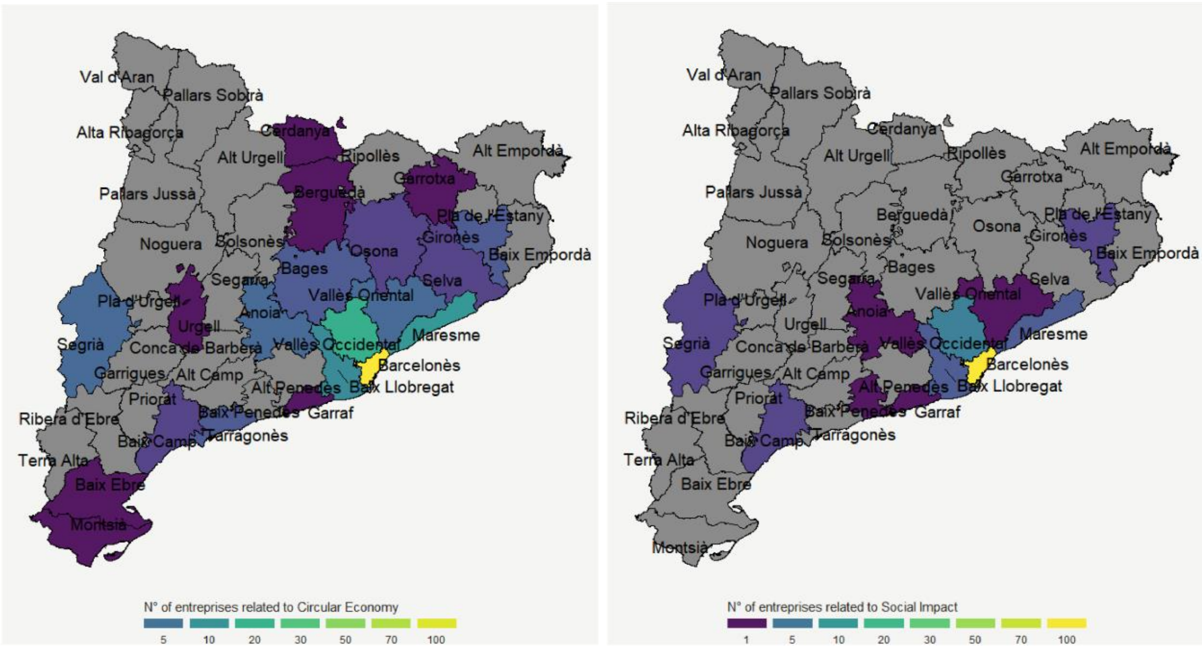


Figure 4 Percentage of actors per sector and geographical area.

Similarly, engagement with CE and SSE was visualized for each Comarca (Figures 5a and 5b). What emerges from Figure 5 is that the two topics are mainly present in the city of Barcelona, and in the closest areas (Baix Llobregat, Vallés Oriental, and Vallés Occidental, and Maresme). In addition, a few actors may be found in the area of Baix Camp and Segriá with respect to SSE. CE appears to be more widespread in the region, including in certain Comarcas in the North (Cerdanya, Bergueda, Garrotxa, Osona, Gironés, Selva and Osona) and in the South (Baix Camp, Baix Ebre, Montsiá).



(a) Circular Economy

(b) Social and Solidarity Economy

Figure 5: Total number of actors for every Comarca in Catalonia related to the Circular Economy (Fig. 5a) and Social Impact (Fig. 5b).

4.3. Topic Modelling and Policy-relevant analysis

Moving to the structural topic analysis, Figure 6 shows the proportion for each one of the 20 identified topics within the selected actors, related to CE and SSE, in the Catalan ecosystem. The topics are homogeneous between the two concepts, spanning from a focus on branding and marketing (Topics 11 and 12) to funding and investments (Topic 18), from recycling plants (Topic 10) and energy services (Topic 1) to specific sectors and materials such as plastics (Topic 16), fashion and textile (Topic 5), education (Topic 13) or sport (Topic 8). A specific topic of the Catalan ecosystem, linked to a global event hosted yearly in Barcelona, the Mobile World Congress, is directly linked to phone and mobile (Topic 20). Several other topics are more general and related to business models and innovative solutions (Topics 4, 6).

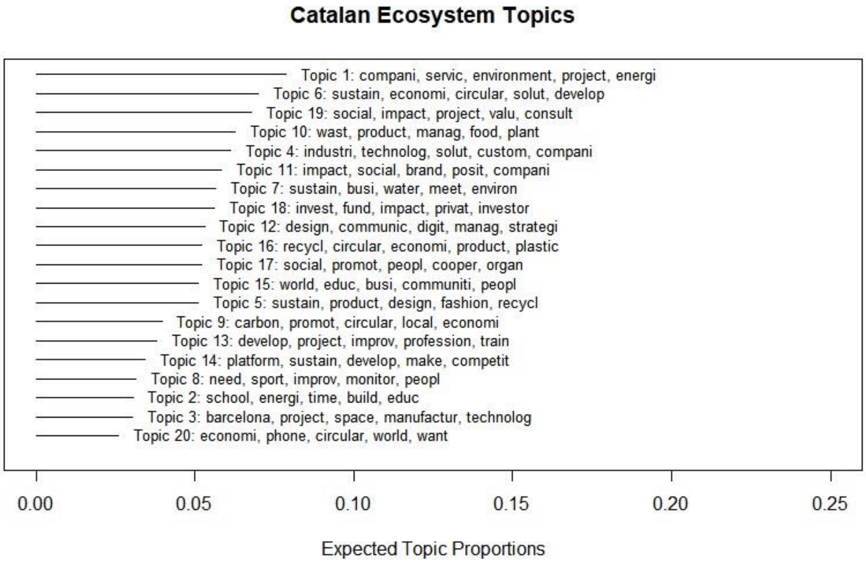


Figure 6: Distribution of Topics and top keywords per topic.

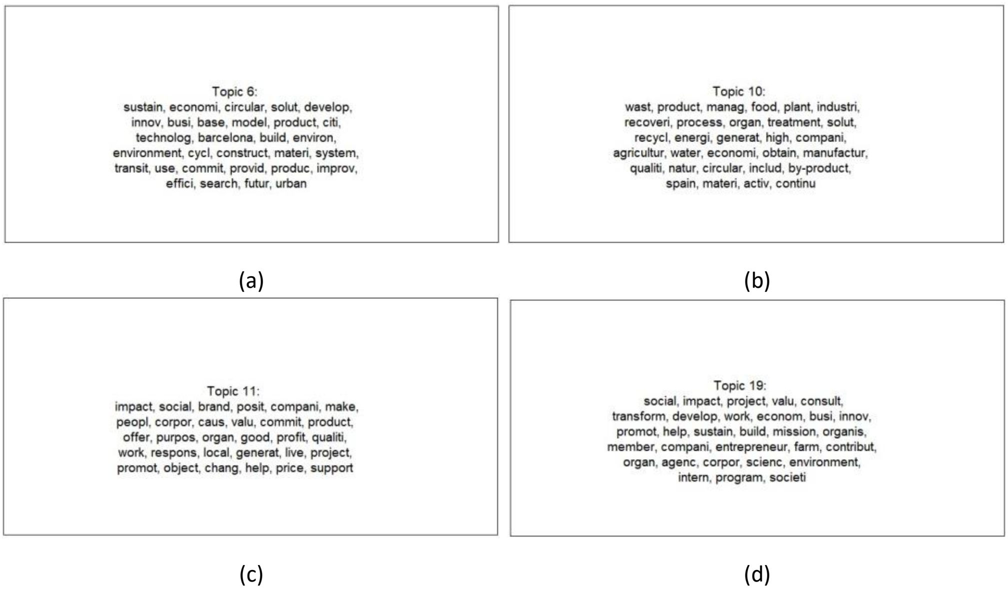


Figure 7: Detail of four selected topics: (a) and (b) are focused on circular economy and waste management while (c) and (d) are completely focused on social impact and brand management.

The top topics (Topics 1, 6, 19, 10, 4 and 11) are distributed between SSE (Topics 11 and 19) and CE (Topics 6 and 10) and generic concepts about technological innovation (Topics 1 and 4). Figure 7 shows four of the six top identified topics, the ones related to CE and SSE. Figures 7a and 7b show the detail of topics 6 and 10 (the first 30 words) of the concepts related to CE. In particular, topic 6 (Fig. 7a) is related to innovation in materials and construction at the urban level and to energy efficiency research and practices, while topic 10 (Fig. 7b) is focused on industrial and recycling sites, including food waste and wastewater treatment plants, energy generation or by-product of industrial activities. With respect to social impact, Figures 7a and 7b exhibit the top 30 words of topics 11 and 19. Topic 11 (Fig. 7c) main focus is on branding, promotion, people's life quality and on generated value, while topic 19 (Fig. 7d) focuses more on entrepreneurial practices (consulting) and missions and their impact on society.

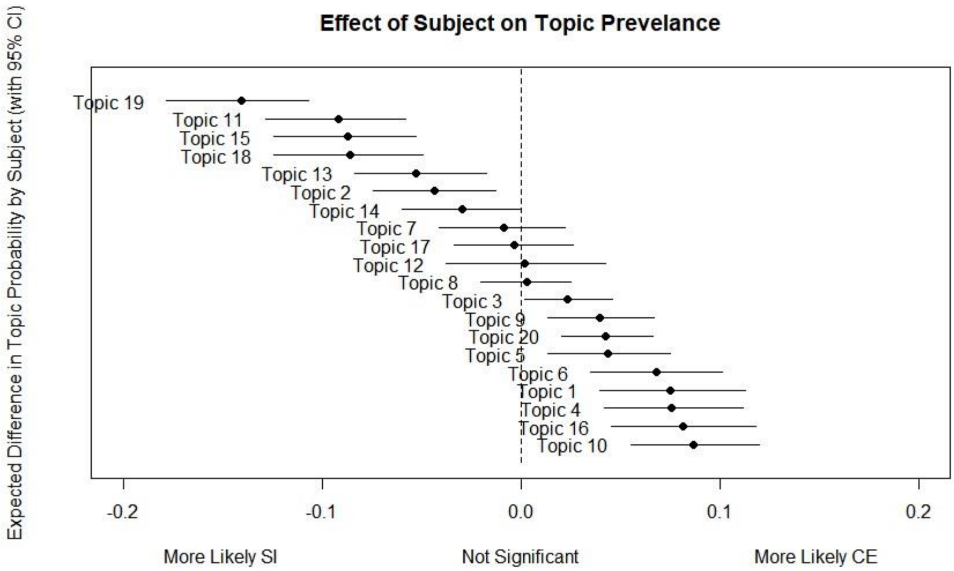


Figure 8: Topic prevalence in circular economy or social impact.

Topic similarities and differences between CE and SSE in the Catalan ecosystem are shown in Figure 8. The more likely topics for SSE (the top five) are respectively Topic 19, 11 (previously described), 15, 18, and 13. Topics 15, 18, and 13 are focused respectively on communication activities, funding and investments, and on training activities. On the contrary, the more likely topics for CE are the 10, 16, 4, 1, and 6. Topics 10 and 6 have been described in the previous paragraph, while Topics 16, 4, and 1 refer respectively to the recycling of plastics products, to industrial technology and supply chain operations, and to renewable energy generation.

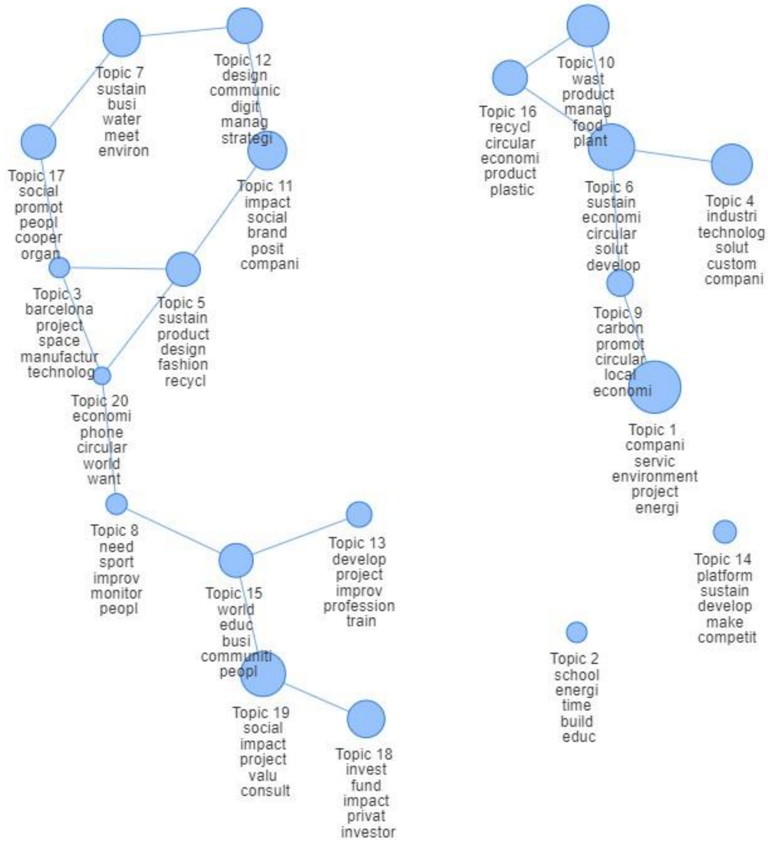


Figure 9: Topics network in the Catalan entrepreneurial ecosystem.

Finally, the relationship among the twenty identified topics is shown in Figure 9 as correlations among different topics (links between nodes) with a cutoff of 0.01 in the correlations matrix and their absolute prevalence. The size of each node precisely shows their prevalence and the top five keywords are plotted for each node, according to Fig. 6. What clearly emerges is that there are two distinct blocks, one related to SSE and one to CE. In addition, there are two uncorrelated nodes, i.e. Topics 2 and 14, representing more generic concepts such as, among others, energy, education, and sustainable development. Similarly to what has been already discussed, Fig. 9 shows how SSE is mainly focused on branding, communication and promotion activities, funding and investments, as well as on value creation and people's behavior. Specific economic and industry sectors can be easily recognized, such as sports, education and life coaching, mobile, or fashion. The last two concepts (phone and fashion), according to Fig. 8 are slightly correlated to CE but they are not in the top five Topics (see Fig. 6). On the contrary, all five top Topics for CE (1, 4, 6, 10, and 16), belong to the second group (on the right in Fig. 9).

5. Discussion

5.1. Key Findings in Context

Answering to the first research question, what emerged is that CE and SSE organizations are still far from each other, although punctual convergences and contact points at the actor level already exist, as shown in Figures 8 and 9. This conclusion can be useful both for future public policies and for entrepreneurial strategies. In general, the CE can promote sustainable development by creating jobs, reducing environmental impacts, and increasing access to resources, especially in disadvantaged communities. SSE, conversely, can play an important role in the implementation of CE principles by supporting the creation of new business models, promoting sustainable consumption, and providing access to resources and employment opportunities. These statements are in line with other punctual studies [118, 19] but show the long path still necessary for a full circular transition at the level of regional IEs. In particular, it highlights how investments only in circular and green industries may not be enough to support a corresponding transition in society. Indeed, the two concepts are currently highly complementary. This isn’t surprising as actors in an IE tend to specialize in synergistic and complementary activities [7]. Nonetheless, previous research has shown that expanding an actor’s perception of existing issues and how it could contribute to their solution (e.g. enabling a CE-focused actor to see it’s social impact and opportunities) may significantly improve effectiveness and sustainability [119, 120], thus motivating policy interventions in this direction.

Hence, also answering to the second research question, a convergence between the two could nonetheless be sought. On one side, CE-engaged organizations (private or public) should strengthen their connection with marketing, branding, and communication activities, and, on the other side, relevant actors on social impact should act closer to more technical and industrial firms or research centers active on environmental, recycling and other activities. In this vein, the convergence between the two concepts may include socially excluded groups and accelerate the creation of sustainable cities and communities [121, 122]. Thus, specific public policies may support this transition towards a circular social economy [65] and the social dimension of the CE [123, 19]. This transition, in particular, may be supported by initiatives towards recognizing and supporting hybrid organizations, such as benefit corporations and Bcorps [18] as pointed out by recent studies. Alternatively, policymakers may focus on fostering synergies among these actors and opportunities for interactions. While, in the short-term, this would improve the efficiency of the ecosystem in addressing sustainability problems [124], in the long run, it could favor learning by and between ecosystem actors [125, 62, 63].

Moreover, stimulating this convergence may generate benefits in both sectors. On one side, if firms focused on SSE tie their activities to environmental and technical issues, they may benefit in terms of reliability and credibility overcoming critics about the emerging phenomenon of the green and impact washing [126, 127], while, on the other side, CE firms may take advantage of their progress and better communicate the environmental benefit they generate by communicating better their results and activities, in order to achieve a critical mass of consumers and early adopters. In this sense, it is enlightening, thinking about the case of the slow adoption of renewable energy from end users, although it is evident both the economic and environmental benefit in the medium term. Therefore, well-planned marketing and communication strategies (the main focus of organizations related to SSE) may attract and move more investments and funding actors to environmental and green activities (or increase the rate of adoption by end users) supporting and accelerating the circular transition. Similarly, communicating and disseminating results from industrial activities may stimulate awareness in consumers about certain complex issues such as climate change and environmental impacts, spreading sustainable lifestyles and improving consumers’ behavior. In turn, this will further improve the collective innovation output and the IE’s capacity to pursue sustainability [128].

Ultimately, what emerged from our study in terms of CE and SSE convergence is what is (partially) occurring at European and international level in terms of impact accounting [129, 130]. Indeed, recently, sustainability accounting protocols, standards and methodologies are experiencing a rebirth and a new wave of attention both from practitioners, investors and policymakers. The complexity of impact accounting and the aggressive nature of certain large corporations and multinational companies within the ecological and green transitions largely demonstrated the need to account both for social and environmental impacts, for carbon dioxide emissions or for biodiversity losses in order to avoid just moving the externalities from one side to another one, as it is occurring with the electrification of the energy and the transport system [131, 132]. Similar considerations can be done with respect the rebound effect of certain circular practices that, if not properly accounted, may be neglected and negative externalities may be disregarded [133]. On the other side, proper impact accounting protocols may also support the evaluation of the benefit and positive impact by, for instance, evaluating the value-per-weight or labour-per-weight ratios as proposed originally by the Performance economy [134]. Similarly, the convergence between CE and SSE may successfully assist existing circular economy standards such as the Cradle-to-Cradle certification, which since decades already asks for this convergence (one of the macro-group of indicator in the Cradle-to-Cradle certification is properly social fairness).

5.2. Policy and managerial implications

This approach, thus, has several managerial and practical implications both for practitioners and for policy and decision-makers.

First, for decision and policy-makers it can be particularly helpful to analyze in detail the specificities of a local territory, by looking at the emergent trends in specific sectors or emergent subjects or technologies, pointing out convergence among sectors and identifying strengths and opportunities, as well as threats and weaknesses, for future policies with a comprehensive and ecosystem-wide analysis [12]. Indeed, this approach can avoid the possible biases and misleading results that an ad-hoc survey may incur. In this sense, our methodology and the DSS artifact proposed can be considered an operationalization of the quadruple-helix model [82] at the micro level but with a ecosystem point of view, overcoming more traditional statistical analysis of innovation clusters. Indeed, drawing on the concept of industrial clusters of Porter et al. [135], the proposed DSS allows reproducible and scalable statistical analysis for every interdisciplinary subject or technology that traditional statistical economic analysis (based on NACE or official database from statistical offices) cannot capture. Indeed, if it is easy and straightforward to analyse company belonging to a certain economic sector, it is not to identify the emergent trends interdisciplinary subjects such as the circular economy can provoke. In addition, the topic modelling analysis further permits the comparison between apparently far-away subjects and topics that traditional analysis cannot identify. The need of interdisciplinary collaboration for innovation management is a known fact [136], as well as in the development of efficient and innovative industrial clusters [85, 86].

Second, large corporations or public institutions (such as research centers and universities) may use the developed methodology to analyze present trends in particular geographical areas by identifying shortcomings and underdeveloped sectors and/or topics [36]. Indeed, the proposed DSS may support and facilitate ad-hoc policy interventions necessary to, on one side, stimulate and accelerate the convergence between different innovation topics and, on the other side, overcome eventual cultural or social barriers between different fields, avoiding mono-disciplinary innovation and thinking in silos. Identifying emergent trends and convergences, hence, may facilitate the creation of nudges [137] and small incentives, or micro-interventions. Indeed, once identified a barrier or a gap between subjects, as described by Iaconesi and Persico [138] in their Digital Urban Acupuncture methodology, micro-interventions may be properly planned. In this sense, deep tech innovation and Impact tech startup [139] represent a particular interesting field where to apply in future the DSS we are proposing in order to explore the convergence between deep technologies such as quantum computing, blockchain or artificial intelligence and their environmental or social impact, following the growing trend of both young generation of new startups, on one side, and of venture capitals, on the other side, to invest in Zebra rather than in unicorn [140].

Finally, small and medium enterprises or small NGOs may benefit of results and findings from a similar DSS, if properly released into open data and public web platform. Indeed, SMEs typically do not have the strenghts to develop a holistic knowledge and view regarding an entire ecosystem; hence, the proposed DSS may support small actors that have not the capabilities to have a holistic and detailed vision over a local ecosystem [11].

5.3. Limitations and further improvements

As a proof-of-concept, the effectiveness of this methodology was assessed against existing approaches to IE mapping (see sec. 2.2) with the help a dedicated scorecard (see tab. 4).

	Data variety	Data novelty	Methods of analysis	Objective novelty	Scalability
Proposed approach	Low	High	Average	High	High
[12]	High	Low	Average	Low	Average
[37]	Low	High	Average	Low	Average
[5]	Average	Average	High	High	Low
[36]	Low	High	Average	Low	High
[38]	Average	Low	High	High	High

Table 4: Benchmark analysis of different methodologies and IS artifacts.

First, to evaluate IE mapping, the data source must be taken into account. Our choice to use LinkedIn as unique and primary data source is motivated to the completeness of the database for the Catalan ecosystem. LinkedIn turned out to be rich in information about public and private actors, formal and informal groups and initiatives, as well as public administrations, education institutions and other actors; thus, it is very useful for ecosystem analysis since it includes information about the different type of actors such as public administrations, incubators, firms, SMEs, and civic initiatives according to the triple or fourth helix models [84, 82, 141]. However, two main issues emerge from the use of LinkedIn. One is about the reliability of the textual data, the other is related to the completeness of the database. The former issue may be overcome by integrating other sources such as organizations' own websites, official registries, and interviews. The latter is a relevant issue especially for countries and regions where Linkedin is not so much commonly used as in Catalonia. In these cases, other sources of information may be adopted as official databases or different social networks. As already stated in section 2.2, scientific papers [40] and patents [10] have been the main source of data for ecosystem mapping, and only few studies have combined these three sources together so [12]. More recently, organizations' websites [37] and social networks [48, 36] have also been used as the most significant novelty in this field. However, the purpose and aim of the proposed IS, as many DSS, is not to provide a perfect and without error statistical results rather than it aims to support decision of policy-makers and to enhance and improve the knowledge of emerging trends at an ecosystem-level. Obviously, timely and precise "snapshot" of such complex ecosystem are not possible and useless. Accordingly, while certainly lacking in variety (only one source of data was used for this study) this investigation is a frontrunner in the exploration of novel data sources to map IE.

As a second criterion, the methods employed to analyze this data deserve attention. In this paper, several technical aspects could be improved, as the dictionary of keywords and the filtering process to identify topic-related stakeholders. Ideally, this should be constructed in collaboration with local actors and intended users of the information system. This is the approach followed by Cottafava and Corazza [5], which, however, inevitably trades accuracy with scalability. Moreover, while semantic network analysis remains crucial to effectively map thematic affinities between actors [38], LDA - though still widespread - has been progressively surpassed by more performing transformer-based approaches such as BERT (Bidirectional Encoder Representations from Transformers) and LLMs (Large Language Model) [142]. Last but not least, the convergence of two or more topics cannot be entirely explained with a top-down approach at the level of ecosystem. Indeed, a bottom-up process based on relational stakeholder theory and social network analysis [143, 144] may be useful to punctually and specifically understand the relationships among actors at a micro-level. Such interactions may give more detailed insights about some of the findings highlighted in this work, such as where and how interactions between circular economy and social impact related actors occurs, how they can be improved or where they are missing. The proposed top-down approach, thus, can be integrated with focus groups, interviews, or surveys, following for instance the approach proposed in Cottafava and Corazza [5], in order to support for instance micropolicies and strategies as proposed by Iaconesi and Persico [138] with the approach of the Digital Urban Acupuncture. Again, this is not easily scalable. Accordingly, the methodology proposed in this paper appears at the level of existing studies practicing IE mapping from a quantitative perspective, and just as those studies it may significantly benefit from the complementary contribution of qualitative methodologies.

A third, crucial point relates to the objective of this paper and specifically its attempt to assess socio-cultural dimensions of the IE. As previous studies have almost entirely relied upon bibliometric and patent information, attempts to map IEs have focused on adequately portraying the relationship between scientific and technological topics as well as between scientific and technological actors with basically no consideration for socio-cultural dynamics [12]. While this was excused by the lack of relevant data, it nonetheless oversimplified the concept of IE making it much more similar to that of innovation system than it should have been, and neglecting the distinctive components of the Quadruple Helix [27, 28]. Conversely, this paper not only accounts for a larger variety of data and actors, but actually focuses on the identification of socio-cultural dimensions within the IE. Existing research on IE mapping has explored many different applications, including assessments of scientific, technological, and business co-development [12, 10], identification technology-engagement predictors [36], and recommendation systems [38]. However, attempts to analyse thematic overlaps between actors have entirely focused on the scientific and technical dimension in large-scale studies, leaving matters of sustainability orientation to solely qualitative case studies [5]. As such, it constitutes the first large-scale study of its kind.

Last, the general proposed methodology based on the ISDT, the design artifact (see table 2), is robust for a variety of topics, sectors, and regional areas. It can be applied to different scales and levels, from a local and regional level (as in the case study discussed) up to a national and international level. The proposed IS artifact, hence, is highly scalable and replicable although the relevance and materiality of findings may be questioned depending on the chosen boundary conditions. Indeed, if, on one side, analysing a local entrepreneurial ecosystem of actors may reveal the specificity of a territory, its shortcomings and deficiencies and its potentialities, on the other side, enlarging the scale to national or global boundaries the same it is not sure. Findings may be too general and without managerial and practical implications, losing the main aim and objective of the artifact itself. Further tests on the robustness for larger scales should be performed [36]. Indeed, findings about CE and SSE convergence, their similarities and differences, the conclusions can be certainly generalized for similar ecosystems and territories but they may be not globally generalizable since they derive from a single, although relevant, case study. Regions with different cultures, different economic situations, or simply with a different composition of urban and rural areas or any other specific features (for instance the Catalan region is highly touristic and with a strong international influence), may follow different trends and the convergence between the Circular Economy and Social Impact may reveal other features. Nonetheless, compared with existing approaches, this study scores high in scalability: just like science or technology oriented studies [10], it leverages a relatively global source of data which does not suffer from the use of administrative information which are often only available for certain countries or regions [12]. Accordingly, within the limitations already acknowledge when discussing the coverage of Linkedin, it appears well-off in scalability.

6. Conclusion

Scholars from different literature streams such as on innovation ecosystem [81], industrial clusters [85], and relational stakeholder theory [142], agree that innovation emerges from the interaction between different actors and often at the crossing between two, or more, sectors. While there has been a growing attempt to leverage and steer these interactions towards desirable ends [8, 30], the necessary quantitative assessments of IE actors has been lacking behind, particularly neglecting socio-cultural dimensions [27].

Aiming to address this gap, following the approach of Gregor and Jones [14] and the ISDT, an Information System artifact has been designed, developed and tested to analyse and assess the similarities and differences between actors belonging to a specific ecosystem. The IS artifact consists of three main modules, from the creation of a complete database of actors to the prioritization of the identified actors according to particular topics, until the analysis of similarities and differences of the selected actors. Employing LinkedIn data as an example of novel and valuable data source [144], the artifact has been tested on the Catalan ecosystem by studying and comparing two emergent concepts, the CE, on one side, and the SSE on the other. Despite the current convergence between the two concepts in the scientific literature, what emerged from the mapping exercise is that currently, the two concepts are still far from each other. In particular, entities working on SSE are mainly focused on branding, marketing and communication activities, on investment and funding, and on training and people’s lifestyle. On the other side, entities related to CE are more focused on technical and industrial environmental-related activities.

Accordingly, the convergence of the two paradigms should be supported by proper public policies or by ad-hoc entrepreneurial strategies at the ecosystem level [39, 33]. This convergence may benefit both sectors, as SSE-focused organizations may overcome current critics related to the impact washing phenomenon by strengthening their activities to real actions, while, on the other side, CE-related ones may improve their communication by strengthening their relations with social entities. Ultimately, this will foster the capacity of IEs to produce value and pursue sustainability [127].

Beyond the specifics of the Catalonia case study, this paper shows that recent advancements in the automatic collection of web data, such as from organizations' websites and social networks, may provide great benefits to the mapping of IE [144, 36]. Indeed, as long as potential limitations and risks concerning accuracy and legitimacy are taken into account and properly dealt with [46], these data sources could reveal fundamental to go beyond techno-centric visions of innovation [20]. Academically, this will enable to effectively test existing theorisations of the intricate interweaving that diverse actors and processes have with one-another, and particularly concerning the socio-cultural dynamics within the Quadruple and Quintuple Helices [33, 27]. More practically, this approach may support policymakers and practitioners. On one side, policy-makers may take advantage of the analysis of new trends at the ecosystem level in order to properly design new policies to facilitate the circular and the green transition of local territory [8, 41] . On the other hand, practitioners, both from large corporations and SMEs or small NGOs may exploit this methodology to support their businesses. Large corporations may use the methodology to develop proper strategies by identifying shortcomings in a particular geographical area, while SMEs or small NGOs may take advantage of the results, if properly released in open data or public web platform, to have a more comprehensive vision of their territory [5].

Learning from this study, further research could combine social network data with more traditional data sources provide a much more comprehensive picture of IE [20] or expand its geographical scope beyond regional or national boundaries [10]. Moreover, once the fundamental data and algorithms are in place, the academic research could expand its objectives to investigate new questions both in terms of thematic complementarity [39] as well as of how this complementarity influences actors' interactions [11]. Last, addressing emergent issues concerning the efficient use of existing information, a next-generation information system could go beyond providing on-demand policy analyses, and rather turn to predicting or even recommending adequate policy strategies [37, 145]. The use of big data and our ability to learn from it are massively expanding. Despite the contributions of this work, we are but at the beginning of the systematic use of data and algorithms to understand and steer complex societal processes.

Declarations

Conflict of interest Authors declare no conflicts of interest.

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