Technology Innovation Management Review

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Insights

Welcome to the January issue of the Technology Innovation Management Review. We invite your comments on the articles in this issue as well as suggestions for future article topics and issue themes.

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Overview

The Technology Innovation Management Review (TIM Review) provides insights about the issues and emerging trends relevant to launching and growing technology businesses. The TIM Review focuses on the theories, strategies, and tools that help small and large technology companies succeed.

Our readers are looking for practical ideas they can apply within their own organizations. The TIM Review brings together diverse viewpoints —from academics, entrepreneurs, companies of all sizes, the public sector, the community sector, and others —to bridge the gap between theory and practice. In particular, we focus on the topics of technology and global entrepreneurship in small and large companies.

We welcome input from readers into upcoming themes. Please visit timreview.ca to suggest themes and nominate authors and guest editors.

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Contribute to the TIM Review in the following ways:
- Read and comment on articles.
- Review the upcoming themes and tell us what topics you would like to see covered.
- Write an article for a future issue; see the author guidelines and editorial process for details.
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About TIM

The TIM Review has international contributors and readers, and it is published in association with the Technology Innovation Management program (TIM; timprogram.ca), an international graduate program at Carleton University in Ottawa, Canada.

Editorial: Insights

Stoyan Tanev, Editor-in-Chief, Gregory Sandstrom, Managing Editor

Welcome to the January issue of the *Technology Innovation Management Review*. This issue consists of a mixture of "Insights".

The opening paper "Enabling and Promoting Sustainability through Digital API Ecosystems" is a team collaboration between **Maurizio Brioschi, Michele Bonardi, Nadia Fabrizio, Alfonso Fuggetta, Emiliano Sergio Verga,** and **Maurilio Zuccalà**, all from Cefriel in Italy. Their research study shows "an example of successful implementation in the smart city domain" based on the Cefriel Digital Ecosystem Toolkit approach. This approach was first adopted to foster digital interoperability during the 2015 World Exposition in Milan, Italy. The authors frame their work with a goal "to combine technologies for building API-based solutions with governance processes and common participation guidelines" (pg. 4). Their strategy of data sustainability approach provides an example of how others could respond to the need of addressing the FAIR (Findability, Accessibility, Interoperability, Reusability) principles for data management and stewardship in the context of API ecosystems used for smart cities.

Marko Mäki and **Tuija Toivola** follow this up with "Global Market Entry for Finnish SME eCommerce Companies". Their background focus on digital disruption sets the stage for a discussion of internationalization and university-business cooperation through global eCommers (eCom) prospecting. The main goals of their study were "to acquire knowledge and boost participants' learning of fast-growing digital business models" (pg. 11), and "to increase understanding of the internationalization processes of eCom companies" (pg. 19). The authors review the literature on eCom, describe their project and share their experiences of consulting participating Finnish eCom firms in this sector. The study is an example of practical outcome-oriented research.

Next, **Angelo Dossou-Yovo** and **Christian Keen** explore "SMEs and the Innovation Management Process" with their newly constructed "multi-level process conceptual framework". The authors base their research on 11 case studies of the Montreal software industry. They use contingency and resource dependency theories to study the innovation process in SMEs. Their overall aim in the paper is "to propose a conceptual framework to manage the innovation process in small businesses" (pg. 22). One of their basic conclusions is that "innovation processes are highly interactive and involve important actors that help SMEs to innovate" (pg. 30-31). Their findings offer helpful guidelines for SME innovation managers or company founders, particularly in high tech industries.

Behrooz Khademi, Hannele Lampela, and **Kosmas X. Smyrnios** close out the edition by detailing "A Roadmap for Systematically Identifying Opportunities in Ecosystems Using Scientific Publications Data". Their article presents "a methodological roadmap that utilizes scientometric and text mining techniques" (pg. 34), using data from the Web of Science database. It contains many graphs, figures, and tables for visualisation. The Nordic countries' renewable energy ecosystem is the topical use case, for which they track documentation and research on resource saving, strategic planning, investment, and policymaking. Their roadmap aims to benefit ecosystem actors and stakeholders, across a range of social, economic, environmental, and political dimensions.

For future issues, we invite general submissions of articles on technology entrepreneurship, innovation management, and other topics relevant to launching and scaling technology companies, and for solving practical business problems in emerging domains such as artificial intelligence and blockchain applications in business. Please contact us with potential article ideas and submissions, or proposals for future special issues.

Stoyan Tanev
Editor-in-Chief
Gregory Sandstrom
Managing Editor

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Enabling and Promoting Sustainability through Digital API Ecosystems: An example of successful implementation in the smart city domain

Maurizio Brioschi, Michele Bonardi, Nadia Fabrizio, Alfonso Fuggetta, Emiliano Sergio Verga, Maurilio Zuccalà

> *"Digital ecosystems can provide every company, regardless of vertical or size, with the tools and expertise it needs to gain a competitive edge. But their biggest long-term potential may be societal, not just economic. Their unique, collaborative characteristics can enable them to tackle problems and challenges greater than those of any one company. Digital ecosystems could, for example, prove to be instrumental in slowing climate change."*
>
> Ibrahim Gokcen
> CTO at Schneider
> The Power of Digital Ecosystem is greater than their parts
> Forbes, May 2020

Recent studies have recognized that digital ecosystems can enhance the transformation of enterprises and the sustainability of cooperation networks by enabling a regulated and governed exchange of data between different stakeholders according to common rules. Thanks to digital ecosystems, data can be effectively distributed and leveraged to build innovative services in various contexts, such as smart cities or corporate solutions. In this paper we apply the Cefriel Digital Ecosystem Toolkit approach, which was first adopted to foster digital interoperability during the 2015 World Exposition in Milan, Italy. The goal of this lightweight approach is to combine technologies for building API-based solutions with governance processes and common participation guidelines. Moreover, we argue that this approach fosters data sustainability responding to the FAIR (Findability, Accessibility, Interoperability, Reusability) principles for data management and stewardship. Since 2015, this approach has been applied in several projects and featured by the European Commission's JRC and the US NIST. The Cefriel Digital Ecosystem Toolkit approach now supports the creation of many-to-many digital relationships between stakeholders operating in various domains, allowing the discovery and reuse of digital assets owned by companies and organizations of any type and size, as well as supporting the development of added value services for citizens and other end-users.

Introduction

In complex contexts like smart cities, tourism, and healthcare, the digitization of processes and services is based on a combination of many platforms, operating systems, and technologies. For instance, e-car navigation systems need to interact with the infrastructure of charging stations to plan a trip and schedule the stops required to recharge car batteries along the route. To reach the goal of comprehensive and effective digitization, digital systems and technologies should first be able to interoperate and exchange information between different players within coordinated and governed networks. These sociotechnical networks of organizations and technologies that collectively co-create value are called "digital ecosystems" (Nachira et al., 2007; Stanley et al., 2010). The term "ecosystem" originated with respect to biological communities to essentially describe the interactions between organisms of different species and their environment as an integrated system (Moore, 1993). Digital ecosystems now emerge spontaneously in the digital world, mainly because of the need for promoting data exchange between different players (Gelhaar & Otto, 2020).

For applications to real cases, the approach of creating digital ecosystems should tackle the following aspects:

- Digital ecosystems should not focus only on technologies and standards, they should also —or in particular —address the definition of proper governance processes and common guidelines for participation. While ecosystems sometimes emerge spontaneously, they require governance as well as rules for surviving in the long-term and for scaling (Immonem et al., 2014; Zeleti & Ojo, 2017; Gelhaar & Otto, 2020).

- Digital ecosystems can require many different legacy systems to exchange data. This is made possible by approaches based on Application Programming Interfaces (APIs) that are adopted by all parties as a grounding rule (Immonem et al., 2014). Digital ecosystem architectures should therefore be easily adaptable to legacy systems, in order to be widely adopted with affordable set up and running costs.

- Digital ecosystems should foster sustainability, meaning the capability of avoiding the depletion of resources (Dixon & Fallon, 1989). In particular, the ability to exchange data with related digital transformation, has passed from a specific need of software systems to a need at the enterprise level (Grzenda & Legierski, 2019). Very recent advances in ecosystem approaches to smart cities (Raghavan et al., 2020) show that the reuse and sharing of data with APIs can promote knowledge transfer. This also prevents wastage of physical and intellectual artifacts in recreating digital assets that already exist, for example, at the city or organization level.

In this paper, we present the Cefriel Digital Ecosystem Toolkit, a lightweight approach to creating digital ecosystems that combines interoperable technologies (APIs) with a special focus on governance processes and common participation guidelines. This approach supports data sustainability, and responds to the FAIR (Findability, Accessibility, Interoperability, Reusability) principles for data management and stewardship (Wilkinson et al., 2016). This approach is presented together with the example of a successful implementation of the toolkit applied to the smart city domain.

A Digital Ecosystem Model Fostering Sustainability

Various approaches can be adopted to build a digital ecosystem (Gelhaar & Otto, 2020).

First, it is essential to break down digital silos that typically exist within organizations so to unlock the access to heterogeneous systems and interconnect

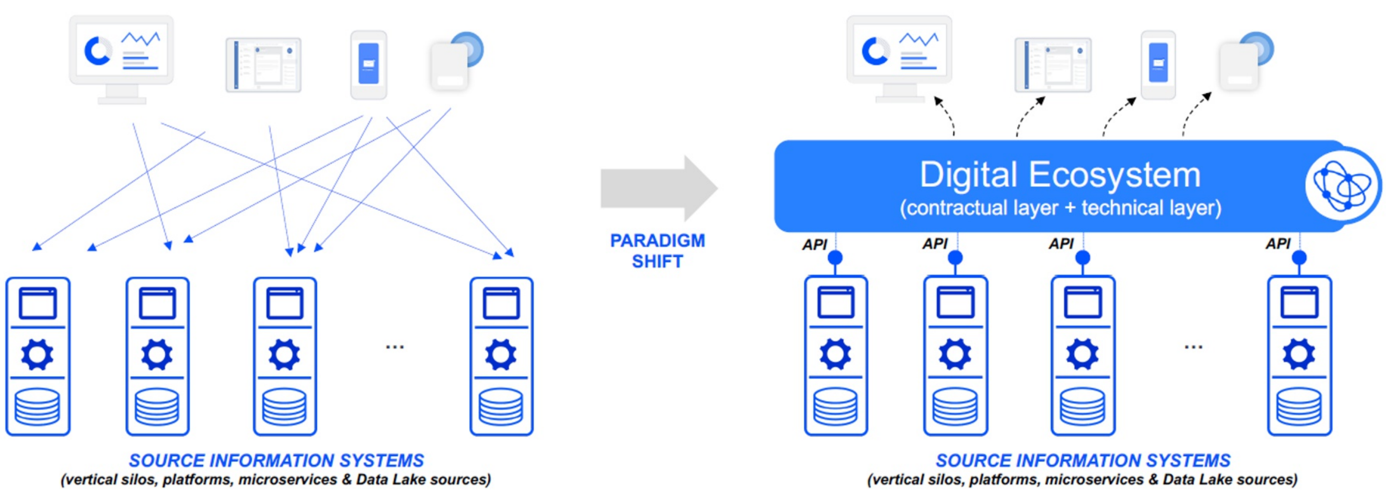

Figure 1. Digital Ecosystem (contractual framework and technical layer)

them. This interconnection can be made without the invasive intervention to a legacy data system, but rather just by promoting interoperability with the addition of APIs. Thanks to this cheap technical intervention, additional business value from data can be unlocked in a sustainable way because data can be reused to create different services, decoupling the backend databases from end-user applications. Furthermore, APIs can be considered reusable building blocks for the same data in different user scenarios. This is not just a technical issue, since APIs must be exchanged according to common rules and processes. For this reason, a digital ecosystem should consider not only the technical interoperability layer, but also a regulated contractual framework. The APIs exchanged are defined as "e-APIs" (ecosystem APIs), which take into consideration also the fulfilment of comprehensive rules of adoption (see Figure 1).

The Cefriel Digital Ecosystem Toolkit addresses the combination of a contractual framework and a technical layer. This toolkit consists of a "visible" part (an online environment to foster communication and the findability of e-APIs), while the most important core components of it are "intangible" (see Figure 2):

- Technical guidelines addressing both interoperability standards and metadata to make technical interfaces reusable from a business point of view.
- Processes that rule the way e-APIs are requested and their lifecycle.
- A supporting team for comprehensive ecosystem governance and dissemination/onboarding actions.

According to this toolkit, participants within a digital ecosystem can exploit one or both of the following capabilities:

- Unlocking additional business value from digital assets and sharing them in a regulated way in the form of e-APIs.
- Enriching the software solutions (for example, websites, mobile apps, and monitoring dashboards) they offer to end-users by using e-APIs made available by other participants.

The most important role within the toolkit (composed of common rules, processes, and roles, see Figure 3) is the governance exercised by the Ecosystem Management Board. The Board takes care of:

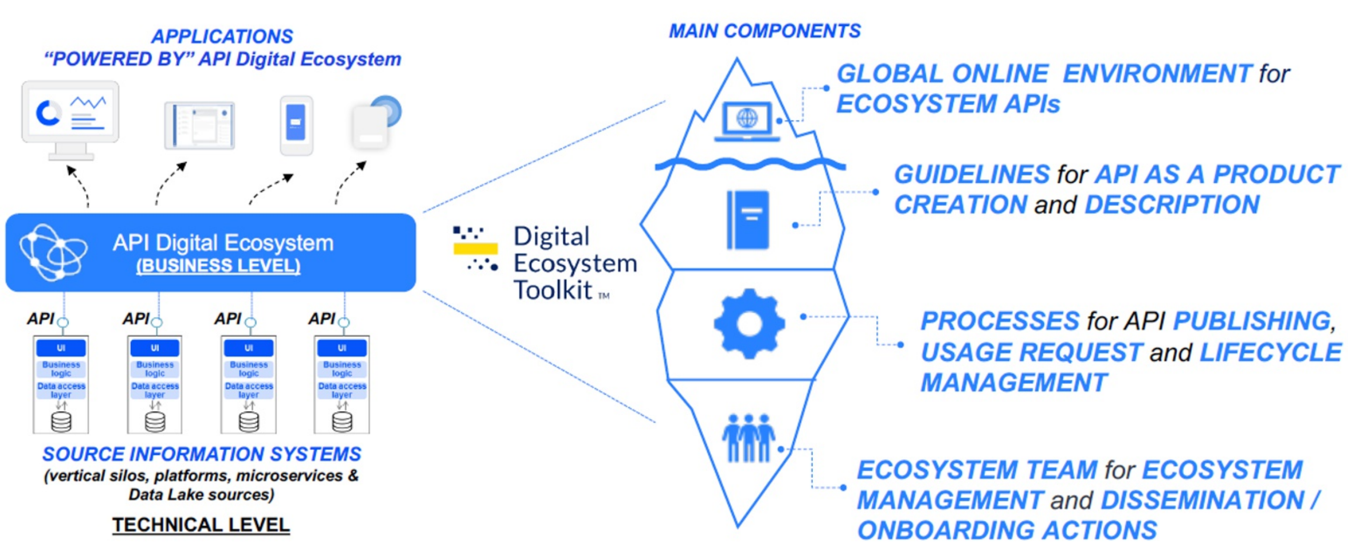

Figure 2. Cefriel Digital Ecosystem Toolkit - Main Components

- Operational governance to manage processes and the online environment to describe, share, and request e-APIs.

- Technical governance, including the interoperability technical standards to exchange data (for example, REST APIs).

- Onboarding governance to promote sharing and usage of e-APIs, in order to create valuable business scenarios.

- Strategical governance to define the trajectory and main areas of interest for ecosystem development.

The contractual framework is based on the concept of "coopetition" (Luo, 2004), where individual ecosystem players compete according to their own business needs, while at the same time cooperating with other players in the ecosystem according to common rules.

The Cefriel Digital Ecosystem Toolkit approach can be exploited at various levels: within a single organization (intranet), in a closed set of organizations (extranet), or at the Internet level. At the time of writing, this framework has been applied in a variety of scenarios (for example, mobility, energy, crisis management), settings (extranet partners networks and Internet), and with different software technologies and platforms. In the following section, we present a real use case.

A Digital Ecosystem Case Study: E015

The E015 Digital Ecosystem (https://www.e015.regione.lombardia.it/) was the first case for implementing the Cefriel Digital Ecosystem Toolkit approach. The E015 initiative was initially promoted by the main Italian associations of companies (Confindustria, Confcommercio, Chamber of Commerce). The E015 Digital Ecosystem Chamber of Commerce of Milan, Assolombarda and Unione del Commercio, with the scientific coordination of Cefriel) to serve the Milano 2015 World Exposition. It was conceived as a relevant opportunity to introduce innovation in many aspects of the urban daily life of visitors and citizens, including infrastructures, tourism, cultural and social life, services, and facilities. At the end of Expo 2015, the regional government of Lombardy took over governing the E015 Digital Ecosystem as a strategic asset to promote sustainable digitalization in the surrounding territory.

At the time of writing, more than 170 e-APIs have been shared in the E015 Digital Ecosystem. These e-APIs have been used in developing more than 100 end-user digital solutions, thus enabling the creation of more than 460 digital business relationships. The National Institute of Standards and Technology of the United States (NIST) considered E015 in developing an IoT-Enabled Smart

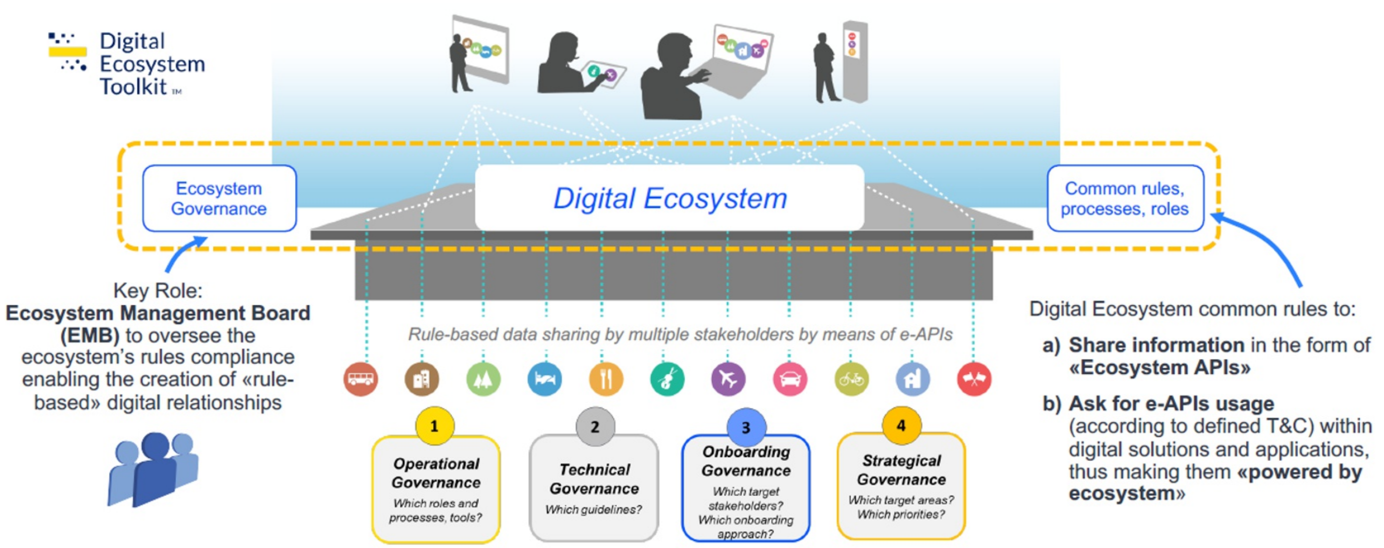

Figure 3. The Ecosystem Management Board Roles

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City Framework (Burns et al., 2018), while the European Commission's Joint Research Center (JRC) cited E015 as a best practice for governments as ecosystem owners/controllers (Vaccari et al., 2020).

The E015 Digital Ecosystem used in Italy was first adopted for sustainable development to promote the use of public transportation. For example, the main Italian airport and rail/road transportation companies provide citizens with real-time integrated information about the status of flights, trains, and buses by sharing their data via the E015 ecosystem.

E015 transportation data has been used also to support infrastructure planning and developing cost-benefit analysis. The LINKS Foundation, on behalf of the Piedmont Region and Rete Ferroviaria Italiana, has leveraged information available in E015 to assess the impact and accessibility of railways between Milan and Turin. Such information is being used for several purposes, for example, to make decisions about creating new rail stations.

E015 has been adopted also for environmental protection. The Lombardy Region created an integrated inter-regional dashboard to coordinate local actions that could mitigate air pollution, where the municipalities of regions overlooking the river Po's fluvial basin get updated in real-time about restrictions. The restrictions are automatically defined by an algorithm that uses e-APIs with weather data, while data about real-time restrictions get shared in turn by means of an e-API.

The same e-API about pollution restrictions has been used to build the requalification sector within the SPICA project (Zuccalà et al., 2019). Thanks to a web application that collects and elaborates data from indoor and outdoor sensors, the inhabitants of 80 apartments in various areas of Milan could better understand the impact of their behaviors on the environment and energy savings.

The same data for weather stations is also used to monitor the water levels of the Pagnona Dam (located in Premana, Italy) in real-time, as a way to improve the territory's resiliency and safety. In case of heavy rains and severe weather, it is possible to forecast the water level in the dam, thus preventing damage scenarios and properly defining evacuation models and emergency plans.

Discussion

The E015 use case presented above shows how adopting the Cefriel Digital Ecosystem Toolkit enables the creation of useful digital solutions to help citizens make smarter decisions or improve the efficiency of smart city processes. Moreover, digital solutions can be created in a quick and simple way by reusing digital assets shared as e-APIs and unlocking additional business value from data. The toolkit framework is lightweight and scalable at different levels to create a digital ecosystem at the level of a single place, for example, airport, railway station, or shopping mall, where different players interact with and need to exchange data, or all along complex supply chains by enabling data exchange between companies and suppliers. Sharing technical APIs to access existing databases promotes a smooth transition from legacy systems and conventional solutions to innovative scenarios, yet without having to make excessive investments, thus ensuring sustainability also from an economic point of view.

The Cefriel Digital Ecosystem Toolkit can be considered also as an enabler for adopting FAIR principles with interoperability and information exchange among multi-stakeholder systems. The toolkit framework meets the main FAIR principles defined by Wilkinson and colleagues (2016):

- *Findability*: e-APIs to access data enable both a technical and business point of view, and can be searched inside the digital ecosystem's online environment.
- *Accessibility*: data gets compiled according to vendor-independent interoperability technical protocols (for example, REST APIs).
- *Interoperability*: the framework fosters interoperability among databases and promotes standardized glossaries for data representation.
- *Reusability*: the approach promotes a sustainable valorization of existing data, which can be used according to digital ecosystem rules and processes.

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In the Lombardy Region, the E015 Digital Ecosystem has been included into a regional law as an official way of promoting data transparency and data exchange between public and private players. Thanks to this law, the Lombardy regional government can ask utilities that win public contracts to share the data generated with those public contracts as e-APIs on the E015 Digital Ecosystem. For example, the utility which wins a contract for installing and managing charging stations for electric cars has to share into the E015 Digital Ecosystem data about position and availability of the charging infrastructure. This approach has been used to promote the territory's digitalization in a sustainable and shared way, at no cost for the public administration. In addition, it assures the availability and accessibility of digital assets, which can be used by other players in creating new services. The vision is to create a live "digital twin" of the territory, with the possibility of accessing in real time all the unlocked digital assets in a common digital ecosystem.

Conclusion

This paper presented an approach to lightweight digital ecosystems. The main achievement of this approach, on the basis of the E015 Digital Ecosystem experience, has been to enable business relationships based on data sharing between different entities, decoupling the IT from the business aspects, and thus achieving a concrete way to reuse and discover data and digital artifacts. This constitutes a sustainable and FAIR approach in practice, especially for reusability. The given examples show how the approach proposed in E015 can be successfully adopted not only within various business sectors, but also in promoting fluid data exchange between different sectors. From this point of view, the digital ecosystem toolkit approach combines simplicity and adoption velocity (because it is lightweight and allows using legacy systems) with transverse effectiveness in addressing data exchange issues between heterogeneous players (including public institutions, big companies, and startups). We continue to work on developing the technical and logical aspects of the model, including the introduction of blockchain-based components and smart contracts to automate internal processes in a secure way. Likewise, we aim to further federate and complement various API-based digital ecosystems built according to the Cefriel Digital Ecosystem Toolkit.

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About the Author

Michele Bonardi has been working in Cefriel since 2008. From 2010 to 2015, he was manager of the Technical Management Board of the E015 Digital Ecosystem. He is now the Head of Digital Ecosystems Practice in Cefriel.

Maurizio Brioschi is a Business Developer, Director and Foresight Manager in Cefriel. Since April 1997, he has worked in distributed architectures and the strategic development of complex IT systems, ranging from e-government solutions to industrial infrastructure. He was the project manager of ICT planning for Expo 2015, helping to foresee and shape digital innovation scenarios through digital ecosystems.

Nadia Fabrizio is a Senior Manager at CefrieL, where she has worked since 2004. In recent years, she has been working as the principal investigator for H2020 and EIT projects in the field of distributed ledger technologies.

Alfonso Fuggetta is a Full Professor at Politecnico di Milano and Scientific Director of Cefriel. He has been a member of several committees in the Italian Government. He has also collaborated with AIPA, CNIPA, the Department of Innovation, and the Ministries of Health, Labour, and Education and University.

Emiliano Sergio Verga has been working at Cefriel as a Digital Ecosystem Manager since 2013. His main role is the Scientific Coordination of the Lombardy Region's E015 Digital Ecosystem.

Maurilio Zuccalà has been principal investigator in research projects (FP6, FP7, H2020, EIT) since 2004 in the field of API economy, smart cities, digital platforms, and service ecosystems. He has authored texts in peer reviewed journals, books, and conferences and is a technical leader for the urban data platform of the H2020 "Sharing Cities" lighthouse project in Milan.

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Global Market Entry for Finnish SME eCommerce Companies

Marko Mäki and Tuija Toivola

"Online shopping is quickly becoming a preferred way to shop for consumers around the globe."

Scalefast, 2021

The aim of this paper is to contribute to knowledge about the expansion of eCommerce (eCom) operations by small and medium-sized enterprises (SMEs) to global markets. We investigate the literature on eCom and reflect on our experiences working with several Finnish eCom companies and consulting firms to boost their global sales. In addition, one important goal of our study was to acquire knowledge and boost participants' learning of fast-growing digital business models. Our findings show that digital disruption and digitalization in general are driving forces behind eCom growth. The study's conclusions underline the importance of targeted marketing activities, knowledge sharing, and capability building for global eCom operations.

Introduction

Competition in many fields of business today has become global in nature. This trend has been accelerated by the rapid digitalization of markets and communication channels. In the global arena, companies compete in environments that deal with diverse online channel formats, including electronic or eCommerce (eCom), mobile commerce, and social media (Bilgihan et al., 2016). Here we focus on eCom and note the influence of the expansion of eCom and digital channels on companies, and also other parts of society.

The current COVID-19 pandemic situation has accelerated the sales and popularity of eCom around the world. Customers have in some ways radically modified their shopping behavior on digital platforms. In Finland, for example, one can see 60% growth in eCom sales since the pandemic began (Vilkas, 2020).

ECom growth has been global. In Vietnam, China and India, for example, eCom companies have acquired many new customers, while customers generally have changed their buying behaviours from brick-and-mortar stores to digital platforms (Pantelimon et al., 2020). Logistical challenges and slower global transportation have had some negative effect to this trend, but global eCom growth has become a reality. Even in current strong eCom growth, there is still a lack of studies addressing the influence of digitalization on the internationalization management of SMEs (see Dethine et al., 2020).

Digitalization, in general, offers companies attractive strategic opportunities (Abaidi, & Vernette, 2018). For the first time, almost any company can reach global markets with relatively easy to use digital eCommerce technology platforms. The adoption of a Direct-to-Consumer (DTC) business model means that a company sells its products directly to consumers without any intermediaries (see CBInsights 2019). This has initiated a market disruption, mainly based on both consumers` digital competence development and digital tools and cloud services development offered to companies, provides many opportunities. Digitalization has influenced both companies and customers by enhancing the digital aspects of their assets, processes and value chains. ECommerce can be defined as a key element of business models operating in global markets, typically with DTC format. In general, the term "business model" describes how company does its business. In other words, a business model is "described as a system of interconnected and interdependent activities that determines the way the company 'does business' with its stakeholders" (Zott & Amit, 2017). However, e-

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commerce may also have a narrower meaning, it can be defined as a channel alternative to deliver goods or services to customers. In broader and more general terms, eCommerce represents the economic activity of buying and selling products and services through online platforms (Pantelimon et al., 2020).

New disruptive channel developments like those in digital and mobile channels have recently gained attention. Studies had previously focused on channel related perceived risk (Youn, 2009; Fernández-Sabiote & Román, 2016; Chiou et al., 2017), information collection, and analytics perspectives. (Aguirre et al., 2016). Companies operating with digital platforms like eCom SMEs seemed to internationalize their operations faster than "traditional" firms. However, very little was known about the internationalising process of e-commerce firms, that is, why and how these firms internationalise and what mechanisms drive the process (Grochal-Brejdak & Szymura-Tyc, 2018). Our study therefore aimed to contribute to this defined research gap.

Several theoretical models had been previously applied to the adoption of e-commerce in SMEs. These models reflected the influence of internal-, external-, and technological factors on adapting to eCom (Sanchez-Torres & Juarez-Acosta, 2019). One eCom benefit for companies is the possibility to internationalise sales. B2C eCom seems to be more complex at the international level than at the national level (Macchion et al., 2017), even though modern eCom platforms, like Shopify, offer a variety of tools and plug-ins for facilitation.

Topics in international business and international marketing have gained much attention among academics in recent decades. Global eCom growth has exploded, yet less discussion has taken place about modern types of international operations, like global eCom. In general, the academic research on online-based SMEs using digitalization for internationalization remains sparse (Westerlund, 2020). Moreover, "growth hacking" (,Needleman 2014; Conway & Hemphill, 2019) has gained very limited interest as a marketing approach among researchers and academics, even though this agile, fast, and experiment-orientated marketing approach has become popular among practitioners, especially in the eCom industry.

In September 2017, Haaga-Helia started a European Union (EU) funded project (eComLab project) to help Finnish eCom SMEs internationalize their eCom operations. The aim of the project was to:

- help businesses expand their eCom operations to global markets in a multi-channel context
- study the development, needs, and aims of small Finnish eCom companies that want to expand and globalize their operations
- acquire knowledge and boost companies' and professionals' learning about fast growing online and digital business models.

Following this research, our aim in this paper is to expand on the pragmatic knowledge of eCom operation possibilities and challenges in the global arena and thus to fill the research gap mentioned. This paper reflects our experiences during the project. It highlights the need for new business competencies and use of digital tools to successfully operate in global eCom markets.

The objectives of the study are to: 1) analyze Finnish eCom SMEs' internationalization readiness, 2) evaluate growth hacking processes in the internationalization of eCom, and 3) highlight the need for new competences in order to succeed in global eCom markets.

Summary of Insights from Literature on Global eCom Markets

eCom as part of global business models

Business model scalability and internationalization have become a general necessity for SME's due, for example, to the limited size and demand of domestic markets (Westerlund, 2020). Hence, companies must internationalize their operations to grow and develop. Two fundamental explanations or models for international operations can be found in the literature. First, the incremental or stages (Uppsala) model, and second, the rapid or "Born Global"-model (Gulanowski et al., 2018). In addition to those, "digital internationalization" has been defined as a mode for global entry (Hervé et al., 2020). According to Lee and Falahat (2019), in this type of internationalization, firms apply different types of digital technologies, such as ecommerce, big data analytics, internet of things, and others for value creation and building competitive

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advantage. This internationalization approach pinpoints data, information, and knowledge flows. In this classification, e-commerce is defined as an example of digital internationalization, while in practice, e-commerce offers a platform and business model for global market operations.

Knowledge is a key driver of internationalization (Gulanowski et al., 2018). eCom business models are heavily operated through market and customer knowledge, and market-related data analysis. In other words, the eCom business with its marketing operations should be agile and data-driven. The agility of international marketing is an organizational capability that allows firms to better formulate domestic market approaches, while customizing their existing strategies to approach international markets (Li et al., 2019). In our study, "agility" refers to adopting growth hacking principles in marketing and in eCom business generally.

Similarly, eCom possesses many features that support internationalization activities, like "extended market reach" (Rahayu & Day, 2017) . However, eCom adoption also has attributes that reduce its expansion among businesses. The lack of support, internal constraints, security issues, internal resistance, and insufficient human and IT resources, have been mentioned as factors that discourage eCom adaptation (Ibid). Nonetheless, eCom constitutes an operational mode that aids in the leapfrog development of SMEs' internationalization (see Saeed et al., 2017). In practical terms, global eCom needs strategies for its mode of operations, together with agile marketing tactics and actions in selected markets.

Mode of eCom Operations

Companies can enter global markets with eCom in various ways. They can build localized language versions of their domestic eCom shop and conduct market specific activities in order to drive them traffic. Alternatively, companies can build a separate eCom shop for a different target market. Another option that can be used simultaneously or as a separate strategy is to use marketplaces like Amazon or Rakuten. A hybrid mode of international operations that combined brick-and-mortar retailers together with online sales has also gained popularity. As a result, managing global operations in diverse markets has become a critical task (Schu et al., 2016).

According to Ghazawneh and Henfridsson (2015), "Marketplaces facilitate the exchange of products and services, the transfer of information and payments, and the creation of economic value for parties such as buyers, sellers, and market intermediaries". Different global markets are dominated by different marketplaces. For example, when entering Russian markets, one option is to use Yandex Markets, which has a strong position in Russia. Rakuten has over 87 million active customers in Japan, and many international brands sell products there. Amazon dominates the U.S. and Canadian markets and is also strong in some other countries.

The development of online marketplaces has been rapid in recent years. One example of this is customers' changing search behavior, which is important because eCom companies get traffic to their sites through customer internet searches. This source of traffic is valuable for companies because customers typically need something when they search for items online. Customer search behavior has been changing, however, and in the U.S.A. now almost 40% of searches start on Amazon, not on search engines like Google (IRCE, 2018). This creates pressure for eCom businesses regarding their global operations planning.

"Dropshipping" offers another mode to run eCommerce operations on a global scale. In this mode of operations, an eCom company does not have to invest in warehouses, as products are delivered to customers directly from the manufacturers. Advantages of this model include low market entry barriers and instant order processing (Witkowski et al., 2020).

Growth Hacking Approach to eCommerce Internationalization

SMEs can internationalize their operations at various speeds. Slower internationalizing companies are named "born globals" (Rennie, 1993; Paul & Rosado-Serrano, 2019). eCom business models offer many ways to internationalize SME businesses so that global markets can be reached in short period of time. "Growth hacking" is a marketing framework where digital marketing tools and platforms are used in domestic or global markets. This marketing approach draws on the explosive growth of marketing technologies (Conway & Hemphill, 2019), relying on testing, implementing, and measuring various digital marketing tactics and contents fast, and with a relatively small budget. After figuring

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out which tactics attract most customers, the aim is to automate the digital marketing process (Dow Jones Institutional News, 2014). The growth hacking framework is suitable for eCom SME internationalization, due to its flexibility and ability to change marketing activities and target areas in a short period of time. In general, the faster and better a firm understands a global market, the higher the speed of internationalization for a SME (Neubert, 2018).

Methodology

In September 2017, Haaga-Helia started an EU funded project to help Finnish eCom SMEs that were seeking to internationalize their eCom operations. Our aim was to start with a small group of companies and to increase this number at a later stage by a few more. However, when we marketed the opportunity for companies to participate in our research, we immediately received enquiries from over 20 companies wishing to expand their online operations to global markets.

In our study, we applied a qualitative approach and used mixed methods to gather and analyze data. We conducted the study following action research principles whereby companies, researchers, and students collaborate closely during the research process (Reason & Bradbury, 2009). Moreover, we underlined the practical knowledge, results, and actions throughout the research project. Action research, in general, requires researchers to work with practitioners in a way that research and practice can create results together (Lim et al., 2018).

In the first phase, we asked the companies to fill in an online survey, in which they self-evaluated their current eCom status, their knowledge of and experience in global business, and their aims and resources in terms of global eCom operations. The relatively short survey was inspired and derived from Foscht, Swoboda, and Morschett's (2006) line of thinking, where they discussed the potential of small eCom companies to internationalize their operations in a relatively short time period and international market selection.

The main purpose of our survey, however, was pragmatic. The results guided our action research activities and the target market selected. Based on this information, we ended up working with 14 companies. In 2017, we started with a pilot group of four companies, and during 2018, 10 more companies joined in. Additionally, we recruited three eCom consulting companies and two foreign universities. Around 30 Finnish and 40 foreign students took part in the research during various phases of the project.

We subjected the quantitative data collected to frequency analysis. The qualitative data consisted of consulting session memos, target market analysis and other text materials. Consulting session themes were derived per the overall objective of the study. We created a loosely defined type of code list derived from theoretical themes and used it as the basis for qualitative analysis. The main themes relate to eCom operative issues, globalization progress, domestic/global marketing, and growth hacking activities. This kind of approach is generally considered suitable to avoid data overload (Miles & Huberman, 1994).

The aim of our project was to contribute to the expansion of businesses' eCom operations to global markets in a multi-channel management context. We also wanted to study the development needs and aims of Finnish eCom SMEs that wanted to expand and globalize their operations. In addition, one important goal was to develop knowledge that could boost companies and professionals' knowledge and awareness of fast growing online and digital business models. Thus, our findings and conclusions were based on a starting point analysis, with one-to-one consulting, and common workshops. We were part of the research process, including online survey, consulting sessions and company workshops, right from the planning phase. During this period, we had many discussions with CEOs and other company representatives to understand their experiences and challenges.

Summary of Results

Our action-based research approach had three phases. First, the project started with a baseline analysis to map participating companies' wishes and wants related to their global eCom development needs. Second, we analyzed summary materials for each participating company based on two consulting workshops. And, third, two participating universities conducted country specific analyses in Russia and in Japan. In Table 2, we summarize the basic information about the companies.

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Table 1. Qualitative and quantitative data collection during the eComLab project

Study type	Method	Sample/ data
Baseline analysis	Web-based questionnaire	10 companies responded
One-to-one consulting process	Participation in growth hacking activities in selected countries and digital marketing campaigns	14 companies around 30 pages of session summaries
Target market analysis	Mixed student teams, including local and native students from new target markets St. Petersburg State University of Economics (Russia) Toyo University (Japan)	Three companies chosen for the Russian market and two for the Japanese market Altogether 14 presentations and 100 pages of reporting material
Artificial Intelligence (AI) in eCom	Hackathon/designathon involving teams of business and engineering students Three teams worked for two days and came up with new ideas and concrete solutions	Business partner Elisa Ltd, a Finnish telecom company Hackathon reports
Workshops	Sharing experiences and learning	All teachers, consultants, companies, and university staff

Summary of insights from baseline analysis

In the web-questionnaire, in addition to basic facts, we assessed companies' level of internationalization, their technological eCom solutions, and their preferred target markets. All companies were interested in international eCom, and all companies recognised that their markets were global, not local. This outcome was good for our project because in Finland over 80% of eCom companies operate in only one language, Finnish, meaning that they can only reach the national market in Finland. The technological eCom solutions adapted by companies varied, ranged from international cloud-based platforms, like e-Pages or Shopify, to smaller domestic solutions, like MyCashFlow. Only a few used open-source solutions like WordPress or WooCommerce. According to our analysis and discussions in the development process, all of solutions proposed had pros and cons, but all the platforms enabled companies to successfully launch in global markets.

We also asked participating companies about their most desired global target markets. Countries that belong to the EU, like Germany, were mentioned. We believe that the reason for the popularity of EU markets was the ability of companies to quickly and easily access them without entry barriers or tariffs. Moreover, Russia and Japan were also mentioned as target markets for global entry. Despite sanctions, Russia has a large population in many customer segments. For example, St. Petersburg has the same population as the whole of Finland, with around 5.5 million people. Given its close proximity to Finland, this was an attractive market for many Finnish eCom companies. Japan, on the other hand, has a large population where Finnish natural food companies have gained popularity.

In their starting point analysis, companies evaluated the strongest elements of their online shop, where they most needed help, and what they wanted to develop. Below, we provide a summary of the most common stated strengths and weaknesses by these companies. The main reason for applying to our project was that they lacked resources and competence in online sales and marketing. All of the participating companies had a strong motivation to internationalize and increase their

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Table 2. Summary of key company facts and starting point analysis

Company	Industry	Number of language options in online shop	Experience in global business Y/N	Online shop established	Where are your customers at the moment?	Self-evaluated eCom competence
Company 1	Consumer Electronics	3–4	Yes	2011	Europe	Basic, lots to learn
Company 2	Production and selling of children's clothes	3–4	Yes	4.5 years	Europe, Asia, and Russia	Advanced
Company 3	Style and fashion	3–4	No	2 years	Finland	Basic
Company 4	Design	1	Yes	3 years	Europe	Basic
Company 5	Design	1	Yes	5 years	Europe, Asia and the U.S.	Basic
Company 6	Shoe production	2	Yes	2014	Europe, Russian, USA and Asia	Basic
Company 7	Industrial design	2	No	2 years	Europe	Basic
Company 8	Mattress production	2	Yes	2018	Worldwide	Beginner
Company 9	Design/ fashion	1	Yes	2017	Europe	Basic
Company 10	Interior design	1	Yes	2015	Worldwide	Basic

global online sales.

Summary of insights from consulting sessions

Three consulting companies took part in the eComLab project. Of these, two of them specialized in eCom business, with expertise in marketing, general competitiveness, and user interface development. The third consulting company was an expert in eCom entry and managing global marketplaces, like Rakuten (Japan), Amazon (Germany), Yandex Market (Russia), and WeChat (China). Summary and key action points in the consulting sessions of the study are shown in Table 4.

The marketplace consulting done concentrated first on Rakuten and Yandex Market. Later, one company wanted to enter Amazon, and five participating companies opened a WeChat account to boost sales in Chinese markets. All participating companies took part in general eCom consulting sessions that aimed to boost sales in international markets.

Companies took part in two consulting sessions. The first session focused on a general evaluation of the strengths and weaknesses of each company's online shop. The second session focused on marketing activities in defined markets and was carried out using growth hacking principles.

The following topics and development areas were

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Table 3. Companies' perceived strengths and weaknesses for global eCom entry

Strengths	Weaknesses
Good brand and products Customer support in English Motivation to grow and develop Finnish design and good quality products	Attracting visitors and increasing sales Effective online marketing to target market Lack of language options in online shop Insufficient knowledge of customer journey in online store Unknown customer buying behavior in international target market Poor mobile optimization of online shop Lack of analytic tools used and retargeting leads

assessed and discussed in the evaluation session: site speed, customer journey, ease of shopping, product card content, level of marketing activities, and user experience in offering products and services via mobile and desktop channels. The main areas identified for development related to mobile and desktop user experience.

"Focus not very clear. Is this a webshop or a catalog? Mobile works well and is even faster than desktop."

"Mobile needs some scrolling and buttons were quite small."

"Always recommended to measure customer journey activities with Hotjar or Lucky Orange."

"Site optimization both in domestic and English sites recommended."

In many cases, the companies' online shops seemed to work well either on desktop or mobile devices, but not on both. Some product cards had very little product information, which negatively affected customer experience. Page speed analyses revealed some problems in page loading speeds. In addition, the companies' found they had an inadequate level of global marketing activities.

"Problems start in latter phases of customer journey … (the) product card information is not clear and the button has some problems in mobile interface."

"What are the operative plans to internationalize eCom, language versions, or separate shops to target markets?"

"Quite a lot of sales arguments for international markets need A/B -testing."

"Domestic payment methods are ok for domestic customers, but do not create trust among international customers. These have to be modified for international audience."

The consultants recommended that companies increase their marketing activity, especially via Facebook, Instagram, and Google ads. Remarketing or retargeting was not used as much, though it made up one development phase.

"Web shop traffic is at a good level, but retargeting activities in Google Ads, Facebook and in Instagram is recommended."

"You have great product pictures. Now share vertical pictures & videos in mobile for global customers."

The second consulting session was carried out using growth hacking principles. This meant that rapid marketing activities were implemented, typically using Facebook, Instagram, and Google Ads activities, in a couple of foreign markets. In general, results were achieved and participating companies had an opportunity to sell their product to new markets. The results of this latter growth hacking phase are summarized below.

Key results from the growth hacking sessions:

- Over 300,000 potential clients reached
- Online store visitors via paid traffic from Europe, Asia, and America
- Visitors from more than 10 countries, such as Sweden, Belgium, Germany, Switzerland, Singapore, the U.S.A., and the Netherlands

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Table 4. Key observations from consulting sessions

Consulting topic	Participants	Aim and length of consulting	Key results
Entering international marketplaces	Five (5) participating companies	Help companies to launch their product to global marketplaces like Rakuten, Amazon and Yandex Markets; several one-to-one sessions	One market entry
eCommerce analysis, evaluation session	All (14) participating companies	Analysis of company's eCommerce site; about 2 hours session	Analysis report
eCommerce marketing in target market	All (14) participating companies	Growth hacking, digital marketing actions in target market; length	Customer acquisition, sales boost, and conversion boost

- Purchases from five to seven different countries
- Single purchases from 6 euros to 500+ euros each
- Average order value was a key variable; it is important to sell more expensive goods with larger orders when selling globally.

The importance of the customer journey analysis was also underlined in the consulting sessions. None of the participating companies had experience with or were using analytic tools like Lucky Orange or Hotjar to acquire knowledge of how customers navigated their online shops. The use of customer journey analytics was strongly recommended.

Conclusions

This study found new insights in expanding eCom international operations by SMEs. This topic is important because online sales are growing and domestic companies are facing high levels of global competition. All companies, whether they operate in hybrid channels or pure eCom formats, must build their capabilities to operate in a digital and global environment.

The study showed that eCom as a business model has many advantages. In general, the adoption of eCom could allow companies to gain access to new customer segments, develop new markets, and improve their profitability (Macchion et al., 2017). Moreover, increasing capabilities in information technology has a positive effect for a company's internationalization (Lecerf & Omrani, 2019). By adopting an eCom business model, companies enter a digital learning process, especially if they adopt growth hacking principles in marketing and business development. However, many SMEs struggle to engage in a coherent global digital transformation process (Dethine et al., 2020). This means problems both in technology implementation and skills development.

According to our study, the participating companies initially had quite a limited view about the opportunities eCom could offer them for international expansion. None of the companies we studied had utilized global marketplaces for their internationalization efforts, and only a couple had language versions of their on-line stores for foreign markets. The capabilities these companies had to utilize digital marketing and analytics tool was also quite limited.

According to a recent article (Kaushik et al., 2020), the main challenges faced by online retailers today include providing a superior customer service experience, reducing the perceived risks of online shopping in the mind of consumers, and producing an effective website design. Our findings strengthen the argument that running an eCom business requires solid business, digital marketing, and information and communication technologies (ICT) to expand sales domestically and internationally.

While eCom basics must be delivered, like a smooth

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mobile device customer experience, our findings show that companies must also pay special attention to marketing activities. This concerns companies that operate in global marketplaces and also those whose aim is to drive traffic directly to their localized online shops. Moreover, in many cases, we were confronted with companies that lacked resources to concentrate on the global dimension of eCom. Companies that do not have the necessary time, knowledge, or capabilities for eCom will likely find global market-related aims difficult to achieve. Our study thus underlines taking active approach to different possibilities that eCom can offer so that SMEs may develop their businesses and scale their international operations. In practical terms, this means learning new skills and adopting available technologies.

Another goal of this study was to increase understanding of the internationalization processes of eCom companies. As mentioned by Grochal-Brejdak and Szymura-Tyc (2018), companies that operate with digital platforms, like eCom SMEs, seem to internationalize their operations faster than traditional companies. By engaging directly with companies attempting to internationalize, our study contributed to closing the gap regarding how these firms internationalize, as well as what mechanisms drive the process. Our findings pinpointed the differences between global market entry modes and strategies inside eCom business models. While growth hacking and other marketing activities resulted in positive commercial results for the companies in our study, marketplace entry activities faced many challenges, especially in Japan and Russia, for the Finnish companies involved. More research is therefore needed to better understand global eCom marketing processes and eCom entry mode characteristics of SMEs.

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SMEs and the Innovation Management Process: A multi-level process conceptual framework

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> *"Ideas are like rabbits. You get a couple and learn how to handle them, and pretty soon you have a dozen."*
>
> John Steinbeck

The aim of this paper is to propose a conceptual framework to manage the innovation process in small businesses. It is based on research from 11 case studies in the Montreal software industry using contingency and resource dependency theories. This conceptual framework provides a view of the innovation process that differs from the linear approach often used in many studies to investigate innovation in small and medium sized businesses (SMEs). The linear approach considers the process as a set of activities that includes developing from one stage to another, while depending on the previous one. We conceptualize the innovation process in small businesses as an interactive process that involves a set of six subprocesses and several keys points of resources mobilization, which requires interacting with both internal and external business actors. Successful mobilization of innovation resources at all key points determines the success or failure of SMEs' innovation processes

1. Introduction

Innovation management in small businesses has been of interest to researchers for many years. One of the reasons is that innovation in small and medium sized enterprises (SMEs) occurs in a different way than in large companies. Small businesses face a resource challenge that differs from large companies. The ability to successfully manage the innovation process can be a particularly challenge for small businesses in high technology industries that need to innovate in order to survive. In the software industry, for example, research on innovation in small businesses tends to focus mainly on identifying resources (Romijn et al., 2002; Cho & Linderman, 2020; Harel et al., 2020), and seems to consider the process as a "black box" that ignores how the type, needs, and availability of resources arise throughout the innovation process (Pustovrh et al., 2017; McDowell et al., 2018). Interest in conceptualizing the innovation process has received attention by researchers from multiple disciplines such as technology management, engineering, and strategy. However, the focus tends to be on the process of new product development, with the majority of works focused on identifying organizational and strategic success factors (Dunne et al., 2016; Kim et al., 2018; Bailetti et al., 2020).

Several conceptual frameworks (Eveleens, 2010; Bagno et al., 2017) have been suggested in the literature, however few of them approach innovation in SMEs as a process involving multiple actors and resources at the various stages of innovation. The purpose of this paper is therefore to suggest a framework that can be used by researchers to investigate the innovation process, as well as practitioners such as SME owners to manage it. We start in the following section by presenting what we mean by "innovation" and providing an overview of the research around SMEs' innovation. We suggest in section three a conceptual framework, which is further tested through a case study of the Montreal software industry that we present in section four. We then conclude with a discussion of the results and our suggestions for SME innovation managers.

2. Innovation and SMEs

In the third edition of the Organisation for Economic Co-operation and Development (OECD) "Oslo manual" (2005), "innovation" is defined as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations". Nevertheless, according to the literature (see Table 1), innovations can be defined among several types. Innovation may thus refer to products, production processes, or organizations. Product innovation occurs when a new product or a significant improvement of an existing product is brought to the market. An innovation process occurs when there is an improvement of the production process or a modification of technologies.

What are the factors that make some SMEs more innovative than others? This question has been investigated by several studies that identified several possible factors related to the SME under consideration, the industry, and the market (De Jong &Vermeulen, 2006; Ferradas et al., 2017; Arendt & Grabowski, 2019). One important factor related to SME innovation is the network that can facilitate access to new markets, new knowledge, and risk sharing (Pittaway et al., 2004; Adner & Feiler, 2019; Gupta et al., 2019). Romijn and Albaladejo (2002) suggested a classification of two groups of factors: external and internal. Internal factors include the training and previous experience of the founder, the professional qualifications of the staff, and activities that improve the knowledge base, such as research and development (R&D), informal and formal learning, among others. External factors include the intensity of networking with a variety of actors and institutions, the advantages of geographical proximity to the network, as well as complementary institutional support. The classification of external and external factors was also used by Nizar et al. (2003), Caloghirou et al. (2004), and Vladimirov and Williams (2018) in their studies of the product innovation process in manufacturing, software, and hospitality industries. Internal factors include: company characteristics, strategies, structure, culture, and management team. External factors consist of: industry, region, networks, knowledge, public policy, and local culture.

Hausman (2005) introduced another factor in the client relationship as an actor in a SME network, which influences the capacity for innovation. By adopting a customer-oriented approach, it is thus possible to improve creativity and subsequently the ability to create new products. Indeed, social networks constitute a factor that increases the innovation performance of SMEs in the software industry (Fang, 2017; Belderbos et al., 2018). These networks provide access first to experts and knowledge, second to financial resources, and finally to intermediaries that can facilitate connections with other networks. This way SMEs can find new opportunities. Networks supply access to quality information, especially tacit knowledge for innovation when trust is established between the actors (Acheampong & Hinson, 2019; Partanen et al., 2020). However, the value of knowledge available through these networks depends on the SME's absorptive capacity (Zhai et al., 2018; Limaj & Bernroider, 2019). The concept of "absorptive capacity", introduced by Cohen and Levinthal (1994), refers to a company's ability to take advantage of knowledge from external sources, including the ability to assimilate and integrate it into a process for creating new products. This ability gets developed by the company through investments, such as covering the costs of staff training in new technologies.

Table 1. Types of innovations

Authors	Types of innovation
Schumpeter & Backhaus (2003) Cantner & Vannuccini (2018) Malerba & McKelvey (2020)	• New products • New production methods • New supply sources • Exploiting new markets • New ways of organizing business
Edquist (2001) Azar & Ciabuschi (2017) Markard (2020)	• Technological innovation • Organizational innovation
Freeman & Soete (1997) Christensen et al. (2015)	• Incremental innovation • Disruptive innovation

All of these studies showed that an SME's network contributes to enabling its access to resources. However, few authors have focused on the mechanisms that explain how SMEs use their network to mobilize innovation resources, innovate, and commercialize new products or services. Networks are comprised of actors that may be individuals or institutions (nodes) with weak and strong ties (Oskam et al., 2018; Vedres & Cserpes, 2020). Weak ties often offer more valuable knowledge than strong ties, the latter wherein actors basically access the same sources of information. An intermediary may be contacted to fill a structural hole (Wu et al., 2020) in the network and play a bridging role that results in additional connections from other networks.

3. Theoretical Conceptualization of SME Innovation Processes

Innovation processes have been the subject of studies by researchers from multiple disciplines, such as technology management, engineering, and strategy. However, most works in this area have focused on identifying organizational factors, strategic factors, and other factors related to innovation that determine its success (Hart & Baker, 1994; Pierre & Fernandez, 2018; Usai et al, 2018). One of the most useful classifications was made by Rothwell (1992, 1994), who identified five generations of innovation process models: 1) technology push, 2) market pull, 3) coupling or research and development (R&D) and marketing, 4) integrated models, 5) system integration and networking models. However, they can be regrouped into two categories: linear and network models. Examples of these models are presented in the following section, along with their limits as identified in the innovation management literature.

3.1. Linear models

A common feature of these models is their focus on new product development considered as a set of steps or sequential activities that includes developing from one stage to another while depending on the previous one. For example, Holt (2000) suggested a model with four steps as follows:

a) The production of new ideas (identifying a need and technology to meet this need);

b) The use of ideas (acquiring technology or development within the company);

c) The preparation phase, which consists of production planning and marketing the new product;

d) The implementation phase (introducing the product to market, production, and marketing).

Another approach is to consider the process of new product development as a group of seven main stages, each with specific activities. These stages are separated by evaluation points ("GO/KILL") where evaluations are made to decide whether to continue to the next step or not (Cooper & Kleinschmidt, 1996). These seven stages are described as follows:

a) Defining the product idea through a process of idea generation that relies on sources of internal ideas (R&D departments, sales, or marketing) and sources of external ideas (customers, research centers, suppliers, and government officials).

b) Preliminary assessment regarding the feasibility of the project based on a commercial and technical evaluation;

c) Defining and identifying the market, product benefits, attributes, and specifications;

d) Developing or producing a prototype;

e) Testing in the laboratory or with the client to identify faults and improvements;

f) Pre-commercialization;

g) Commercializing and large-scale production.

These linear models obscure the fact that the innovation process may be iterative or circular, since a basic idea may be revised when testing before marketing or market introduction. In addition, the fact that external actors intervene in the process is not highlighted in these models, especially when considering SMEs. Ultimately, these models do not seem especially applicable to the case of SMEs.

3.2. The Multiple Convergent Processing Model

Hart and Baker (1994) suggested the "multiple convergent processing" (MCP) model of new product development, which incorporates lessons learned from research on success factors for the developing new products. It also takes into account the interactions among various parties involved in the innovation process.

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In this model, the authors present innovation as a series of activities that involve information gathering and evaluation activities. Throughout the process, different points and types of evaluations relate to market or product functions with multiple points of convergence. The process also involves focal points with moments where certain activities are performed simultaneously by different parties (actors in the network, different departments). These focal points are used to exchange information between the different parties and integrate the information exchanged. The actors involved are from both internal and external networks. The internal network is comprised of different departments or project teams, while the external network includes other companies, R&D institutions (universities, laboratories), and customers. The MCP model's authors approach innovation with a dynamic perspective that includes a network of internal and external actors.

3.3. A proposal of a multi-level process model

Linear models see innovation as a set of sequential activities that integrate a very limited number of actors, essentially internal actors such as organizational functions. They therefore ignore the learning process and interactions with external actors, the role of entrepreneurs, and resource mobilization. The integrated and networking models add the learning process and more external actors in innovation, but still limit the role of the entrepreneur and the resource mobilization process is not explicit. Most of these 2 types of models lean more toward a corporate model of innovation, instead of an entrepreneurship model of innovation.

The model put forward here builds on the combination of contingency theory and innovation management (Tidd, 2001; Ahmed et al., 2020) along with resource dependency theory (Pfeffer & Salancik, 1978; Ghosh, 2019). Following contingency theory, this article suggests that organizational structure should adapt to both internal and external factors. Thus, processes should also be change depending the most efficient structure given the contextual factors. Thus, firms require several strategies depending on the context (Brandon-Jones et al., 2014). We consider the contingency approach especially in relation to characteristics of innovation that we consider as dynamic and interactive. In addition, we assume that SMEs are innovation resource-dependent and that innovation occurs through an interactive process with a series of activities and resource-acquisition points by analogy to the focal points from Hart and Baker's (1994) model. The resource acquisitions points are critical for accessing innovation resources (see Figure 1).

At the resource acquisition points, SMEs must connect with external actors to access the resources needed for innovation to move ahead. For example, R&D activities require funding or access to a research laboratory. If SMEs have constrained resources, funding can then only be external (public or private sources). We thus posit that SMEs' innovation depends on external resources in its environment, and that therefore they need to build a network that enables them connect with actors that hold the resources needed for them to complete the innovation process. For this, we propose the following six subprocesses:

1) Idea generation and selection
This first subprocess involves interactions with internal and external actors that will generate the inputs that will be transformed into outputs, such as new ideas and tools, or selection criteria for the new idea that will result in further projects.

2) Transformation
Transformation involves interactions with actors that will generate inputs such as activities undertaken to create outputs like new products (for example, prototype or final product).

3) Learning
Learning involves interactions with internal and external actors that will generate inputs such as new knowledge, which can be transformed into outputs such as a repository of new tools or routines for innovating.

4) Resource mobilization
Resource mobilization is mostly performed by entrepreneurs that involve interactions with actors that will generate new contacts to create outputs such as social capital and a network that will help to access external innovation resources.

5) Commercialization
Commercialization involves all interactions with internal and external actors that will generate inputs such as alliances and partnerships that will be transformed into outputs, such as a new market or sales growth.

6) Coordination
Coordination involves the interactions that will

facilitate the identification of relevant actors and integrate their interventions throughout the innovation process.

In the following section, we make a case study of the Montreal Software to test our multi-level process model.

4. Case study: the Montreal software industry

a. Overview of the Montreal software industry

The Montreal software industry is a subsector of the information and communication technology (ICT) industry in Quebec, Canada. It is an important pillar of the Canadian and Quebec economies according to its contribution to gross domestic product (GDP), job creation rate, and impacts on others sectors that benefit from applications made by the software industry. The software industry includes multimedia and telecommunications services.

In this research, we were particularly interested in companies that produce software for multimedia application. These companies are involved in an industry that requires constant innovation, and therefore requires much R&D.

The multimedia software applications industry includes companies that develop software for video games, 3D animations, websites, search portals, interactive advertising, transactional web sites, simulations, and interactive imagery. According to Ministère de l'Économie et de l'Innovation du Quebec, in 2019 the information and communications technologies sector employed close to 137,000 workers and generated revenues of close to $32.5 billion, in addition to being the source of approximately $1.7 billion in annual research and development (R&D) investment.

This sector is also characterized by a strong presence of SMEs, which have an average of 18 employees and make up a significant concentration in Montreal. The Quebec ICT sector has built an international reputation with the creation of special effects software for Hollywood productions. Large companies in this industry include Ubisoft and Electronic Arts.

b. Methodology

We used a qualitative research method with multiple cases studies (Yin, 1984, 2003; Miles & Huberman, 2003). We chose an in-depth analysis of the phenomenon, according to an inductive approach to better understand our research subject. We chose to study multiple cases so as to identify differences and constants to better understand the research problem (Miles & Huberman, 2003). Our goal was to understand SMEs' innovation process from our sample so that we might design a framework for managing the innovation process. The data come from several different sources, which we believe is key to obtaining the information needed to study the cases (Halinen & Törnroos, 2005).

These sources include: 1) data from the literature and websites of companies, 2) field notes, 3) semi-structured interviews with company CEOs. The interviews were conducted, transcribed, and analyzed with the qualitative software Nvivo 8. In this research, we focussed on the innovation process in eleven (11) small businesses in the Montreal software industry which were selected after an exploratory study that targeted 83 small businesses. We used open-ended questions during the interviews that were organized around the following themes: A general description of the business, type of innovations, innovation intensity, and a description of the innovation process, including actors, interactions, challenges, and resources. The interviewees and several characteristics of SMEs in this study are presented in Table 2 below.

c. Findings

Product innovation

The results show that the SMEs in our study differ in terms of the type of innovation introduced in the market. Most of the SMEs introduced a new product except two. One introduced a service innovation and the second a process innovation (see Table 3).

We found that there were three critical steps in the innovation process where external resources were needed to perform related activities (see Figure 1). These three steps are conceptualizing a technological solution, R&D, and marketing. During idea development, new innovation ideas were the most valuable resources for conceptualizing a technological solution. The resources needed for R&D are knowledge, competences, and financial support. Finally, the resources needed for commercialization include financial support, knowledge, and new markets.

Critical steps during the innovation process

While innovating, these three main stages involve the intervention of external actors to acquire necessary resources (see Figure 2). The client is the most important actor that helps especially during the technological conceptualization. This actor helps to

Table 2. List of SMEs and characteristics

SME	Services offered	Actual market	Number of employees	Age (years)	Interviewees
E1	Software development businesses	Canada	35	12	Chairman
E2	Quality monitoring software	Canada and International	400	12	Chairman
E3	Video games	Canada and International	148	15	CEO
E4	Software for website development	Canada and International	5	25	Chairman
E5	Video games	Canada and International	500	10	COO
E6	Software for information management	Canada and International	95	21	Chairman
E7	Software for developers	Canada and International	2	14	Chairman
E8	Multimedia software	Quebec	8	15	Chairman
E9	Video games	Canada and International	6	5	Chairman
E10	Software development for document editing	Canada and International	12	10	Chairman
E11	Software for email management	Canada	10	7	Chairman

identify and validate the functions that the final product should perform to satisfy users. R&D activities acquire resources from the client and other actors, such as associations, virtual networks, universities, research centers, educational institutions, universities, government organizations, consulting firms, incubators, and suppliers. Commercialization activities with the actors involve: associations, government programs, government organizations, incubators, and suppliers.

The importance of external factor during the innovation process

Our results show that SME innovation processes depend on external resources available in their environment, at least during critical development stages. The actors cited in the study were already part of the SME network. SMEs, represented by the founder, were in connection with most actors through networking activities organized by associations. Therefore, we can conclude that a dependency relationship exists between SMEs and their innovation network of actors that play a bridging role to acquire either directly the necessary innovation resources, or indirectly by helping to connect with other actors (see Figure 3).

Our findings show multiple external actors with different roles involved in interactions around innovation processes. During the idea generation and selection stage interactions are mostly with the clients. For example, SME's E3 and E4 used feedback from

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Table 3. Type of innovations

SME	Type of innovation	SME	Type of Innovation
E1	Product innovation	E8	Product innovation
E2	Service innovation	E9	Product innovation
E3	Product innovation	E10	Product innovation
E4	Product innovation	E11	Product innovation
E5	Process innovation		
E6	Product innovation		
E7	Product innovation		

clients to generate and select new ideas:

> *"We have suggestions from clients each year. We receive them and keep them somewhere and when we finish a project and [are] about to start another, we meet and put everything on the table" (CEO, E4).*

> *"Feedback is constant. We have a friendly relationship with our customers, which means that we have their feedback very quickly: listen, your product does not work, can you improve it?" (CEO, E3).*

The transformation process follows the first stage and consists of several outputs that develop upon the preliminary ideas generated, as illustrated by the CEO of SME4.

> *"The process begins with a generation of ideas that meet the market needs during a meeting between engineers. Thereafter, a list of product characteristics and priorities is determined. This information helps to launch the research and development (R&D) project that leads into a product that will undergo several tests. The first group of tests is performed by the R&D team, and*

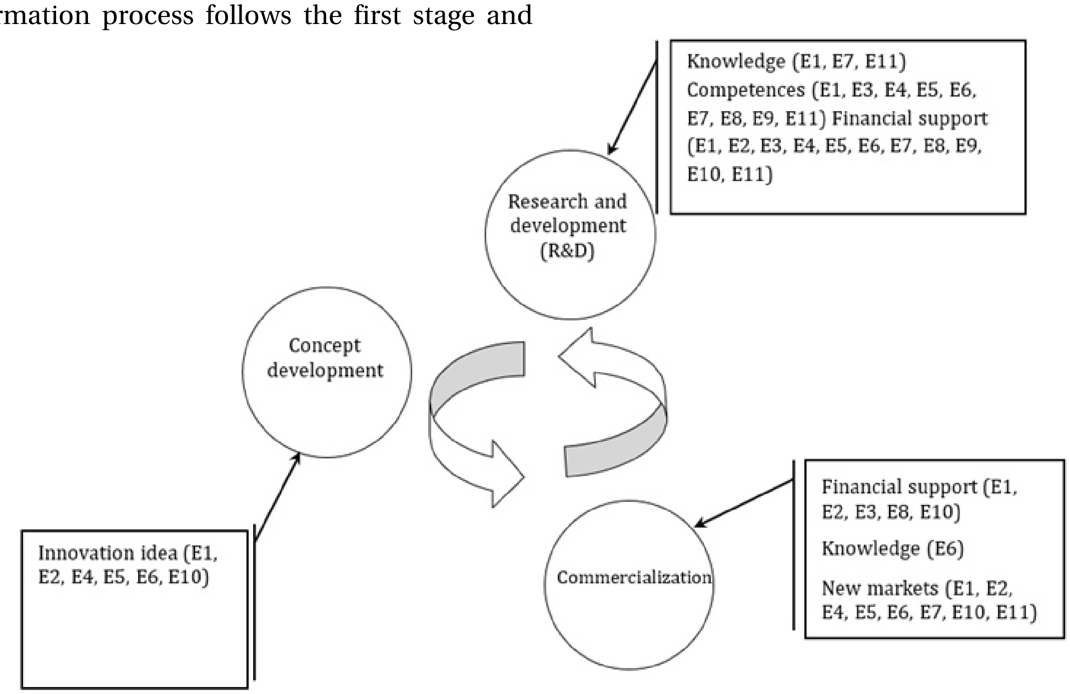

Figure 1. Critical stages of the process and resources

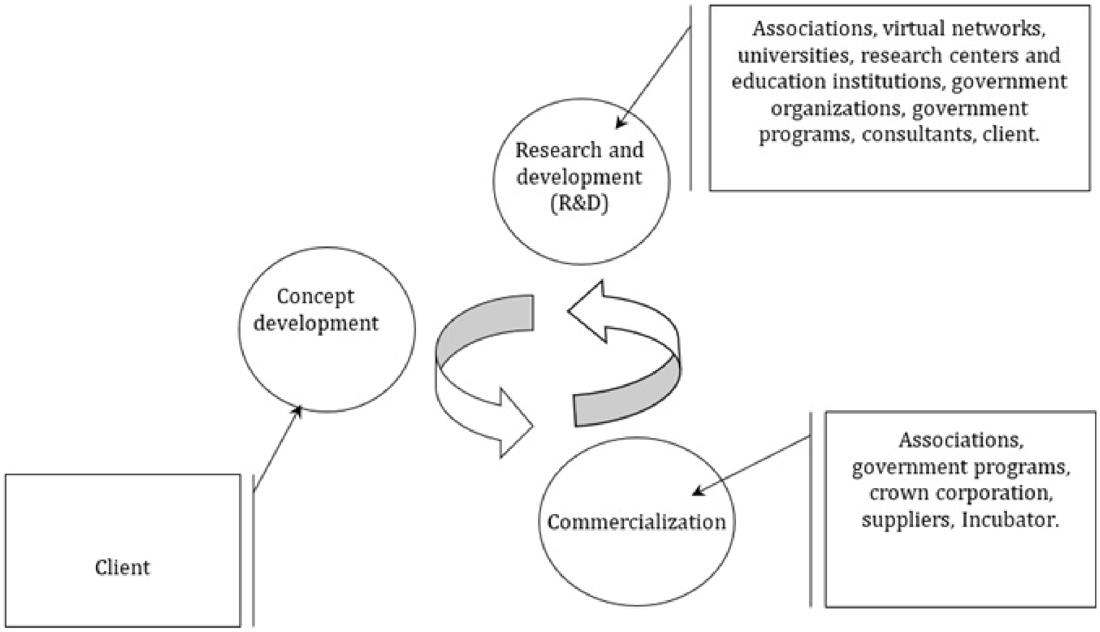

Figure 2. Critical stages and actors involved in resource acquisition

the second one is done with external collaborators. A third group of tests is done with the client as we send the product to a limited number of clients that will provide us with information to improve the product before starting a large-scale commercialization" (CEO, E4).

As stated in our model, the learning process also involves several actors. For example, R&D specialists in E1 use online communities and forums to gain new knowledge. E2 brought changes in its product based on the CEO's own experience with suppliers in France.

"It is more with the underground networks: groups, online communities, forums. Our R&D specialists use frequently these networks. … You will have to contribute before you receive" (CEO, E1).

"The initial concept for multimedia products and video games was acquired in France. But we noticed that there were too many bugs, it was often poorly translated or not translated or partially translated, so I thought of developing a new method" (CEO, E2).

While mobilizing resources, the entrepreneur's role of is very important. E3 uses its contact with universities to get new trainees, while E4 goes through its partners in Europe. These partnerships would not possible if the entrepreneur did not invest time and resources to find them and build a trustworthy relationship.

"It's been years [that] we are dealing with Cegep, University of Montreal, UQAM a little less because it is less adapted to our needs. … I have contacts with instructors who can suggest trainees to me, so it works very well with universities" (CEO, E3).

"We have editors who make boxes in Europe, Spain, and Germany. We have partners in e-commerce, Internet marketing specialists who take care of the indexing, referencing" (CEO, E4).

The commercialization process also involves interactions. For example, E2 used the international missions organized by its association to travel to China and make contacts to expand its market. E3 uses industry events like game summits to promote its products.

"It allowed me to meet directly with Chinese officials, to visit two cities and make good contacts to start development in China" (CEO, E2).

"The game summit will take place in November this year; we will send several of our employees … and maybe this year we will have a booth to promote our products" (CEO, E3).

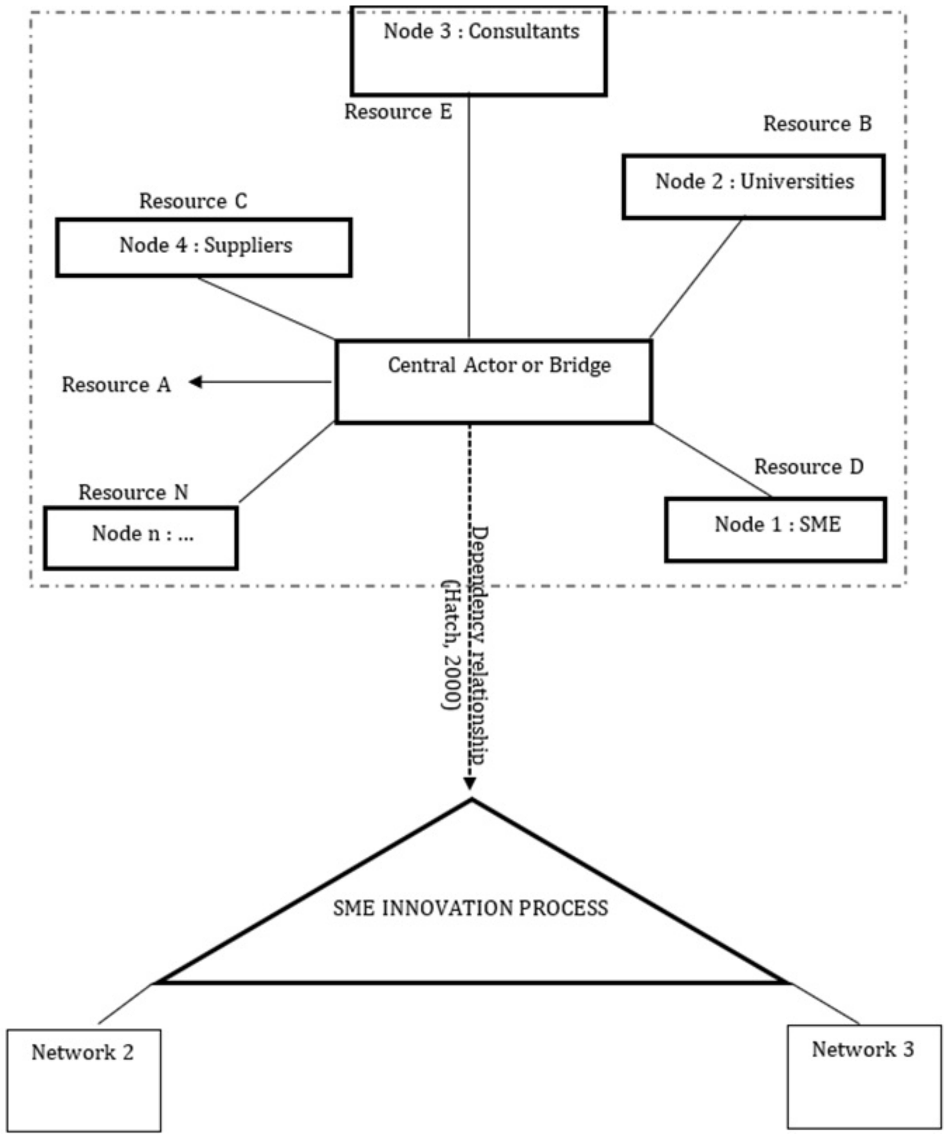

Figure 3. Innovation process and network of actors for innovation resource

5. Conclusions and Implications for SME Innovation Management

In this paper, we suggested a framework that is comprised of different subprocesses that make up the overall innovation process. Our empirical study showed that the innovation process in small businesses can be viewed through the lens of different subprocess that consider the data collected from SMEs.

We believe our framework is a useful tool for SMEs innovation managers as it offers a novel approach to manage interactions with multiple actors and stimulate resource mobilization through focus on specific subprocesses, as opposed to the whole innovation process at once. Further studies could improve the framework by looking at differences between sectors. In addition, our results suggested that the innovation network an SME belongs to can benefit the innovation process. This is particularly the case for SMEs with resource constraints. It is also consistent with other studies that have shown firms tend to network to innovate, and also that a diversity of actors benefits innovation (Scott et al., 2019; Brunetta et al., 2020). Our results contribute to the existing research on innovation in small businesses by offering an additional approach to conceptualizing innovation through contingency theory and the resource dependency approach. Our results show also that innovation processes are highly interactive and involve important actors that help SMEs to innovate. Successful acquisition of innovation resources at all key points of the innovation process (critical stages) depends on the network and type of actors.

SME innovation managers or company founders, particularly in high technology industries, should therefore focus on building an innovation network where key actors or bridges for innovation get included. They also should pay particular attention to the critical innovation stages where resources are available only through external actors. Hence, it is important to identify and connect with external actors that can help during focus points on innovation. The network also needs to be built based on the requirements for each subprocess. Finally, a monitoring system should be put in place around each subprocess to ensure proper oversight of activities, resources, interactions, and both internal and external actors involved.

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A Roadmap for Systematically Identifying Opportunities in Ecosystems Using Scientific Publications Data

Behrooz Khademi, Hannele Lampela, Kosmas X. Smyrnios

“ Opportunity identification process enables groups or individuals to screen a large volume of ideas quickly and methodically. ”

Dr. Rajiv Tandon (27.08.2015)
Serial Entrepreneur

Opportunity identification is a continuous process in ecosystems. However, ambiguities and challenges associated with knowledge exploration and exploitation can retard opportunity recognition processes. This in turn may culminate in excessive expenditure of resources or loss of latent opportunities. The present study adopts an analytical approach and proposes a methodological roadmap that utilizes scientometric and text mining techniques. The roadmap uses data from Web of Science as input, and generates insights that support decision-making about resource saving, strategic planning, investment, and policymaking. Our roadmap extends methods used in studying ecosystems by combining existing and novel techniques in data analytics. Using Python and VOSViewer, we show an exemplary application of the new roadmap, framed in the context of the Nordic countries’ renewable energy ecosystem.

1. Introduction

Managers and policy-makers are increasingly attracted to ecosystems. Actors constantly seek opportunities in knowledge (Jarvi, 2018; Almpanopoulou et al., 2019), innovation (Valkokari, 2015; Valkokari et al., 2017; Ketonen-Oksi & Valkokari, 2019), and entrepreneurial (Autio et al., 2014; Stam, 2015; Thomas & Autio, 2020) ecosystems. However, ambiguities and challenges associated with knowledge exploration (for example, lack of resources) (Jarvi et al., 2018; Almpanopoulou et al., 2019) and exploitation (for example, actor engagement, governance) (Clarysse et al., 2014; Jarvenpaa & Välikangas, 2014, 2016) make opportunity recognition processes time-consuming, resource-intensive, and risky for ecosystem actors (Khademi, 2019). As no systematic way exists for mitigating the effects of these challenges, the present paper develops an analytics-driven roadmap for systematically identifying opportunities in spatially bounded ecosystems. The roadmap enables better decision-making with respect to strategic planning (collaboration, investment), promulgating innovation policy instruments, and saving resources (time and budget).

Since James Moore used the metaphor “ecosystem” (Moore, 1993) to show similarities between technology-driven networks and natural ecologies in terms of their “co-evolution” process and the symbiotic interrelationships required, thousands of scholarly contributions have extended our understanding of ecosystems. Scholars have identified various types of ecosystems such as business, innovation, knowledge, entrepreneurial, and service ecosystems (see Scaringella & Radziwon, 2017; Valkokari, 2015 for distinctions between ecosystem types). This study mainly deals with knowledge, innovation, and entrepreneurial ecosystems.

It is no secret that opportunity identification is of paramount importance for organizations. In business word, opportunity recognition is usually known as seizing those initiatives that are directly translated into financial value. Examples of such business opportunities include new market segmentation and diversification of solution portfolio. Given today’s competitive markets, businesses do not survive without exploiting new opportunities.

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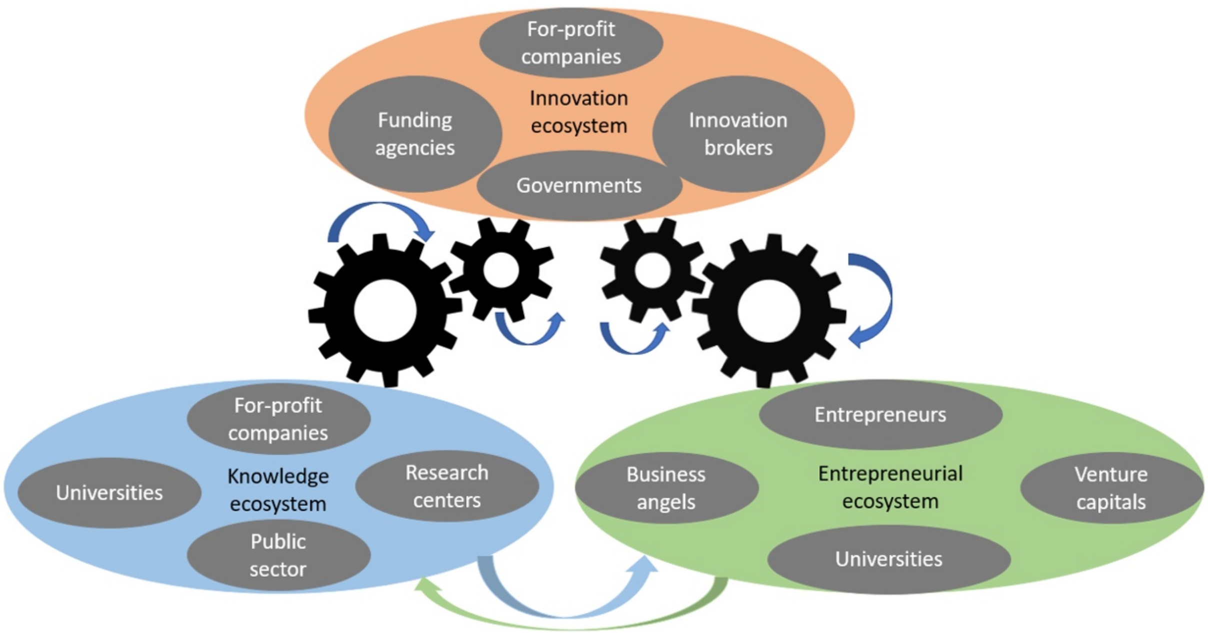

Figure 1. Interacting and integrating mechanisms between ecosystems

As it pertains to ecosystems, opportunity identification is critical for survival. Research shows that more than 85% of ecosystems fail at some point, with lack of adequate problems and opportunities being among the major failure reasons (Pidun et al., 2020). In ecosystems, opportunities are different from merely gaining short-term financial value. Depending on the type of actor and ecosystem, actors seek different ways of contributing to the value co-creation process and coming up with final solutions. In knowledge ecosystems, actors (universities, research organizations, public sector, for-profit organizations) need to identify collaborative research partners, aim to win research grants, and seek external funding. Entrepreneurial ecosystem actors (tech start-ups, university spin-outs, investors) emerge around knowledge hubs to commercialize new knowledge and enhance their investment portfolio (Autio et al., 2014; Stam, 2015; Thomas & Autio, 2020). To facilitate knowledge exploration and exploitation, innovation ecosystem actors (policy-makers, funding agencies) support new knowledge creation (for example, financing, providing co-working spaces) and engage actors through incentivization (Valkokari, 2015; Ketonen-Oksi & Valkokari, 2019).

Figure 1 shows interacting and integrating mechanisms between the three types of ecosystems. Table 1 shows examples of existing ecosystems, actors, objectives, and opportunities for the three ecosystem types.

However, opportunity identification is a sophisticated process because of ambiguities and challenges associated with knowledge exploration, knowledge exploitation, and integration mechanisms. In knowledge ecosystems, actors face issues such as resourcing, absence of consensus involving knowledge domains and participating actors (Jarvi et al., 2018), lack of prior knowledge of other actors (Lindkvist, 2005), and policy and cognitive constraints (Almpanopoulou et al., 2019). Governments face challenges when integrating knowledge exploration and exploitation with respect to selecting areas of excellence in research for the region, making valid decisions to provide research grants, and organizing for collaborative research partnerships, which requires facilities and governance (Valkokari, 2015; Ketonen-Oksi & Valkokari, 2019). Industry players and private-sector investors should decide whether and to what extent investing in knowledge exploration and exploitation is profitable. Tech start-ups should find ways to persuade public and private sectors to fund their ideas or prototypes. Otherwise, potential opportunities may remain latent, or their untimely exploration can pose noticeable expenses to actors.

Previously, scholars have studied these challenges mainly using inductive approaches. They have suggested practices such as open innovation, selective and interactive revealing and governing, collective action and orchestration, and knowledge formalization through

Table 1. Ecosystem structures, objectives, opportunities and examples

Type of ecosystem	References	Participating actors	Empirical examples	Objectives	Opportunities
Knowledge ecosystem	• Almpanopoulou et al. (2019) • Jarvi et al. (2018)	• Universities • Research centers • public sector • For-profit organizations	• Australian Research Centers • Region of Flanders (Belgium) • Strategic Centers for Science, Technology, and Innovation (Finland)	• Co-create new knowledge • Gain scientific reputation • Recruit talented researchers	• Identify collaborative research partners • Win research grants and awards from funding agencies • Achieve external funding from private sector and technology firms
Innovation ecosystem	• Valkokari (2015) • Valkokari et al. (2017) • Ketonen-Oksi and Valkokari (2019)	• Governments • Funding agencies • Innovation brokers • companies	• Mobile and telecommunication ecosystems (Deutsche Telekom) • Smart city innovation ecosystems (e.g., London, Stockholm) • Federal government-led innovation ecosystems (e.g., Australia, Singapore)	• Integrate knowledge exploration and exploitation mechanisms • Incentivize actors for technology commercialization • Provide space for co-innovation and knowledge co-creation	• Discern areas of research excellence • Identify potential collaborative research opportunities • Fund the most popular and impactful research in knowledge hubs • Regulatory instruments for private sector investment in targeted research areas
Entrepreneurial ecosystem	• Thomas and Autio (2020) • Stam (2015) • Autio et al. (2014)	• Entrepreneurs • Universities • Business angels • Venture capitalists	• Silicon Valley • Calgary's energy ecosystem • Melbourne's med-tech ecosystem	• Expand entrepreneurial activity • Increase regional GDP • Attract investors	• Identify promising areas of research for technology commercialization • Make informed decisions for investment portfolio analysis

virtual collaboration (Rohrbeck et al., 2009; Perry et al., 2010; Pellinen et al., 2012; Alexy et al., 2013; Jarvenpaa & Välikangas, 2014, 2016; Jarvi et al., 2018) in specific contexts. Yet, no systematic method for accelerating opportunity recognition in ecosystems currently prevails.

Within this content, the objective of the present study is to bridge the above-mentioned research gap by adopting an analytical approach and proposing a roadmap for systematic opportunity identification in ecosystems. Specifically, we aim to develop a roadmap that inputs data from Web of Science (WoS), utilizing scientometric and text mining techniques, and enables actors of different ecosystem types to systematically identify opportunities. To show how the roadmap operates in practice, we demonstrate its application using bulk scientific data collected on renewable energy from the Nordic region (Finland, Sweden, Norway, Denmark, and Iceland). The main research question navigating our paper is as follows: *How can opportunity recognition processes in ecosystems be accelerated and enhanced systematically and parsimoniously?*

We begin by delineating the details of the proposed roadmap. Next, we describe the methods used for an example application of the roadmap. Subsequently, we present findings of the exemplar. Finally, we discuss contributions of the study, and conclude by outlining limitations as well as potential future research avenues.

2. A Roadmap for Systematic Opportunity Identification in Ecosystems

The roadmap enables actors of a region to systematically identify opportunities in a specific knowledge domain using data derived from Web of Science (WoS). It can be applied to different settings in terms of domain, region, and timeframe. Figure 2 illustrates the ten sequential steps used when implementing the roadmap, which we elaborate on below.

2.1 Boundary Definition

The first step is to make decisions regarding the knowledge domain (for example, renewable energy), regional boundaries (for example, the Nordic region), and time span for analysing bibliographic data (for example, 1999-2019). Such decisions depend on the project in hand and the value creation rationale for actors.

2.2 Question Formulation

Step 2 involves formulating questions that can be answered by implementing the roadmap. A non-exhaustive list of the example questions that can be formulated and answered using this roadmap is shown in Table 2.

2.3 Journal Selection

The third step is to select highly ranked journals in the ecosystem's field. In so doing, one can use Scimago Journal & Country Rank (SJR) or national ranking systems. SJR is a well-known source, which assigns each academic journal to a "quartile" (Q), with Q1s as the most respected journals.

2.4 Database Selection

The fourth step is to select a database for data extraction. We recommend selecting WoS when using this roadmap because in comparison with SCOPUS it provides a longer time span and wider coverage of citations, more comprehensive metadata for funding agencies, and harmonized names for research organizations and universities.

2.5 Sampling and Information Retrieval

The fifth step is to prepare a thorough list of keywords and terms to search for the relevant publication records. Sampling strategies for scientific publications are implemented with the continuous involvement of field experts to optimize percentages of recall and precision.

2.6 Data Extraction

The roadmap's inputs consist of two types of data: WoS

Figure 2. Methodological roadmap for systematic opportunity identification in ecosystems

Table 2. Example questions to be answered by using the roadmap

Stage	Analytics type	Prerequisites	Question	Unit of analysis in WoS data
1	Descriptive	Data from WoS	Which research departments have been most productive?	Research departments
			Which departments have been most productive over time?	
			What are the major clusters of research departments based on research similarity?	
			What are the major clusters of research departments based on collaborative research?	
			Which funding agencies have been listed as financial sponsors most frequently?	Funding agencies
			Which funding agencies have been listed as financial sponsors most frequently over time?	
			Which journals have been of interest the most?	Journals
			Which journals have been of interest the most over time?	
			What are the main research themes of interest for the scholars?	Abstracts
			How have the themes of interest transitioned in recent years?	
			What research themes have been more impactful in recent years?	
2	Predictive	Descriptive results	How can the productivity of the most productive departments be anticipated?	Research departments
			Which possible collaboration opportunities between research departments can be systematically identified?	
			Which funding agencies will financially support the scholarly research in future?	Funding agencies
			Which journals will publish contributions from the scholars of the region the most?	Journals
			Which research themes will be more popular in the region?	Abstracts
			Which research themes will be more impactful in the region?	
3	Prescriptive	Descriptive and predictive results	How can novice and experienced research scholars improve their productivity and find grants for new projects?	All four units above
			How can academics benefit from the analyses in course design and development?	
			How can the department managers improve department productivity?	
			In what ways can academic entrepreneurs benefit from the analyses for commercialization of potential ideas?	
			How can journal editors organize special issues based on specific problems of the region?	
			How can funding agency managers benefit from the analyses in organizing new funding programmes?	
			How can industry managers identify university-industry collaboration opportunities?	
			How can industry managers and investors benefit from the analysis for investment?	
			In what ways policymakers can benefit from the analysis to promulgate policies?	

Reports and bibliographic records. The Reports consist of descriptive statistics from the sample, as well as citation reports on the sample. It is necessary when extracting bibliographic data to consider in advance the tools employed for data munging, analysis, and visualization. Since employing programming languages increases the accuracy of analysis, we recommend extracting tabular datasets (for example, tab-delimited text files) to maximize accuracy.

2.7 Data Wrangling

Downloaded data usually require "wrangling" prior to analysis. The main tasks are filling in missing values, entity (funding agencies and journals) name harmonization, pre-processing abstracts, and preparing new datasets for data analysis. Separate datasets are generated for each unit of analysis with a column related to the year of publication for each record. In addition to publication year, funding agency dataset should include a column related to country names, while abstracts should include the number of publication citations (see 2.8).

2.8 Data Analysis

Except for network clustering, data are analyzed both statically and dynamically. In static measurement, the entire timeframe *T* is taken into account, whereas in dynamic analyses, *T* is divided by the number of years.

Productivity

Static productivity of research departments is measured via four metrics: the *h*-index, share of departments in the total number of records, share of departments from all citations received by the sample, and percentage of self-citations for each department. Dynamic analysis of the number of publications and citations provides rigorous insights regarding business productivity over time.

Clustering

Departments are clustered based on research similarity and collaboration using bibliographic coupling and co-authorship analysis, respectively. We recommend using VOSViewer (van Eck & Waltman, 2009), as it provides specific features and configurations for clustering and visualization.

Analysis of funding agencies

The absolute number of high-quality publications in a specific domain positively correlates with the size of research grants (Gralka et al., 2019). Accordingly, higher number of papers published in prestigious journals by grantees in a specific knowledge domain positively correlates with larger sizes of grants allocated by funding agencies in that knowledge domain. As a novel measure, we rank funding organizations statically based on their share in the total pair number of paper-sponsor records. A dynamic analysis calculates the yearly frequency of support for each agency.

Journal analysis

Journals in the sample are analyzed statically via their publishing share. The share of each journal is calculated via the frequency of published outputs in that journal divided by the total number of records in the sample. Dynamic analyses calculate the yearly number of papers published by each journal.

Topic modelling

For a static analysis, latent Dirichlet allocation (LDA) is employed for theme exploration by analyzing abstracts over the timeframe *T*. Dynamic analyses of abstracts are divided into two types of analysis: popularity and impact. For the former analysis, theme transitions are based on the yearly frequency of terms used in the abstracts. The results indicate themes that have been more popular over time in the region, where emphasis on recent years can be helpful for forecasting. For the latter analysis, the same method is employed by using only a slice of data that contains the most cited papers for each year. The analysis output shows the most impactful research themes conducted in the region on a yearly basis.

2.9 Visualization

To report the results in an informative way, roadmap users should employ different types of visuals for each type of analysis. For static representation of analyses involving productivity, funding agencies, and journals, bar charts are often the best options. To visualize outputs related to dynamic analyses, line charts can be employed. Network visualizations provided by VOSViewer demonstrate clusters of research departments based on similarity and collaboration. Word clouds report the output of static topic models.

2.10 Interpretation

At this stage, the outputs of all descriptive and predictive insights are used collectively to discover prescriptive implications for different actors and ecosystems. Table 3 is a non-exhaustive list of implications depending on the types of ecosystem and actor.

Table 3. Prescriptive implications of the roadmap

No	Ecosystem type	Actor type	Prescriptive implications
1	Knowledge ecosystems	Novice and experienced research scholars	- identify collaborators in academic organizations for future publications - evaluate PhD and post-doc applicants based on their proposal impact and promise - identify funding agencies with possible sources of financial sponsorship to fund future research projects - draft new projects based on promising research themes - modernize course curriculum based on popular and impactful research themes in the region
		PhD and post-doc applicants	- identify productive academics with possible sources of funding for their proposed research - develop proposals with higher chance of approval (in collaboration with academics) based on popular and impactful research themes - predict possible outlets (journals) when drafting proposals - explore relevant funding agencies for possible grant applications
		Research department managers	- strategic planning for increasing productivity - identify research partners based on productivity and research similarity - draft new grant applications based on promising research themes - informed recruitment decision-making when evaluating research job applicants
		Industry managers	- identify potential university-industry collaboration opportunities based on organization productivity and research similarity - identify academic allies for core technology development - identify academic allies for development of complementary technologies - systematic investment in basic research - commercialization of the explored knowledge focal actor strategy planning and business ecosystem genesis or expansion
		Journal editors and managers	- organize special issues (or joint special issues) for practical problem-solving in the region
2	Innovation ecosystems	Grant allocation managers	- informed evaluation of grant allocation process based on (individual and organizational) productivity and the promise of submitted proposals - identify partners for collaborative funding programmes in the areas with practical, financial and societal value
		Federal and state-level governments	- monitor productivity of academic organizations and individuals - supportive and regulatory policies for improving productivity of academic organizations - supportive and regulatory policies for directing private sector investments towards popular and impactful areas of research - systematic job creation for researchers based on promising research themes - Incentivizing systematic research partnerships - coordinating knowledge, innovation, entrepreneurial and business ecosystems
3	Entrepreneurial ecosystems	Academic entrepreneurs and university spin-outs	- encourage students to focus on promising research ideas - identify sources of financial sponsorship for developing prototypes and patents
		Tech start-ups	- identify sources of financial sponsorship for developing prototypes and patents - access to information regarding most relevant research themes for better drafting of research proposals or grant applications
		Investors	- informed decision-making for investment in basic research - informed decision-making for investment in university-industry partnerships - enhanced decisions when investing in start-ups and spin-outs

3. Example

In this section, we discuss the relevance of the Nordic renewable energy ecosystem and delineate multiple methods used to test the roadmap. Note that this example does not refer to any specific existing ecosystem within the Nordic region. Rather, we show how a hypothetical application of the proposed roadmap can support decision-making for those who may would like to consider forming a new ecosystem, expanding an existing one, or joining an existing one.

3.1 Relevance

The Nordic renewable energy ecosystem supplies a relevant exemplar for our roadmap application for three reasons. First, renewable energy is well-known for heterogeneity of actors and taking a collective approach to creating new knowledge (Dougherty & Dunne, 2011). Second, Nordic countries have consistently ranked among the top 15 countries worldwide in terms of percentage of gross domestic product (GDP) spent on research and development for the last two decades (OECD, 2018), which has enabled the extraction of rich bibliographic data resources. Third, an emphasis is placed by Nordic countries on the need for identifying opportunities through empirical scientific energy research within the Nordic region (NEA).

3.2 Data Extraction and Sampling

SJR was the most suitable journal ranking system for this study with its category that designates “Renewable Energy, Sustainability and Environment” (SCImago). This made it reliable to filter our search of scholarly journals relevant to renewable energy. The choice of journals was limited to Q1 and Q2 journals to ensure a sample of the most scholarly research (79 journals). WoS has a subscription for 74 out of the 79 identified sources (94%), where all Q1 journals were covered.

Data extraction and sampling processes were conducted in April 2020. We used the keyword “energ*” in the search field “Topic” in WoS to ensure extraction of a sample related to renewable energy. Our search strategy filtered the results to those papers published in English, with at least one author affiliated to a Nordic organization. We also limited the results to the timeframe $T1$ = (1999-2019) both because of the upward trend in funding greenhouse gas emissions reduction research (Overland & Sovacool, 2020), and a rise in renewable energy research outputs (Ziegler, 2011) since 1999. It is noteworthy that data from 2020 were excluded due to being incomplete. The final sample included N = 6,148 journal articles. Yearly number of publications, citations, self-citations and h-indices for the top 15 research departments were extracted from WoS Reports.

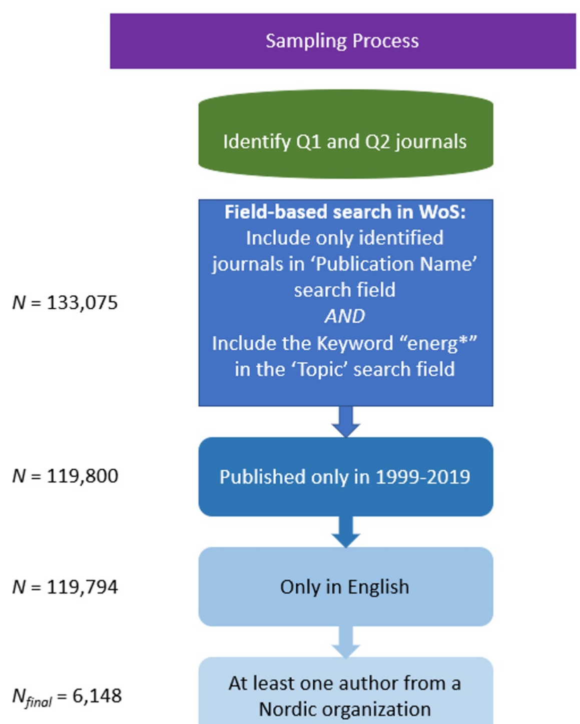

Figure 3. Step-by-step sampling process

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Table 4. Scientific productivity of Nordic renewable energy research departments

Rank	Department of renewable energy research	*h*-index	Number of records	Share in number of records (%)	Number of citations	Share in total number of citations (%)	Number of self-cited papers	Percentage of self-citations
1	Technical University of Denmark (DTU)	86	805	13.1	30,212	22.08	616	2.04
2	KTH Royal Institute of Technology	56	576	9.37	13,592	9.93	496	3.65
3	Uppsala University	55	351	5.71	12,380	9.05	276	2.23
4	Aalborg University	54	498	8.1	12,015	8.78	344	2.86
5	Lund University	52	328	5.34	9,286	6.79	265	2.85
6	Norwegian University of Science and Technology (NTNU)	51	405	6.59	10,396	7.60	220	2.12
7	Chalmers University of Technology	51	377	6.13	11,743	8.58	286	2.44
8	Linkoping University	48	238	3.87	6,396	4.67	278	4.35
9	Aarhus University	46	270	4.39	6,987	5.11	249	3.56
10	Swedish University of Agricultural Sciences	44	206	3.35	5,278	3.86	233	4.41
11	Aalto University	42	381	6.2	6,846	5.00	313	4.57
12	SINTEF	31	167	2.72	3,624	2.65	80	2.21
13	VTT Technical Research Center Finland	31	140	2.28	3,165	2.31	59	1.86
14	Lappeenranta University of Technology (LUT)	29	136	2.21	2,284	1.67	194	8.49
15	University of Southern Denmark	27	103	1.68	2,630	1.92	30	1.14

Figure 3 illustrates the step-by-step sampling process.

3.3 Data Wrangling, Analysis and Visualization

We filled the missing values in the column containing publication years. Next, we created harmonized entity names using Python string manipulation techniques, regular expressions, a Fuzzywuzzy library, and human intervention. Also, we generated a VOSViewer thesaurus file containing disambiguated names of research departments. Subsequently, new datasets were formed according to the roadmap instructions. Finally, we conducted abstract pre-processing and topic modelling using the Python Spacy and genism LDA libraries, respectively.

We took into account two timeframes $T1$ = (1999-2019) and $T2$ = (2014-2019) for the static and dynamic analyses, respectively. Selecting the last six years ($T2$) for a dynamic analysis provided the proper line plots for forecasting. We utilized Python (Matplotlib and Word Cloud modules) and VOSViwer to present the results.

4. Results

Here we present the results of the roadmap application based on the types of analysis described in the roadmap.

4.1 Productivity

As we filtered the data to find renewable energy research

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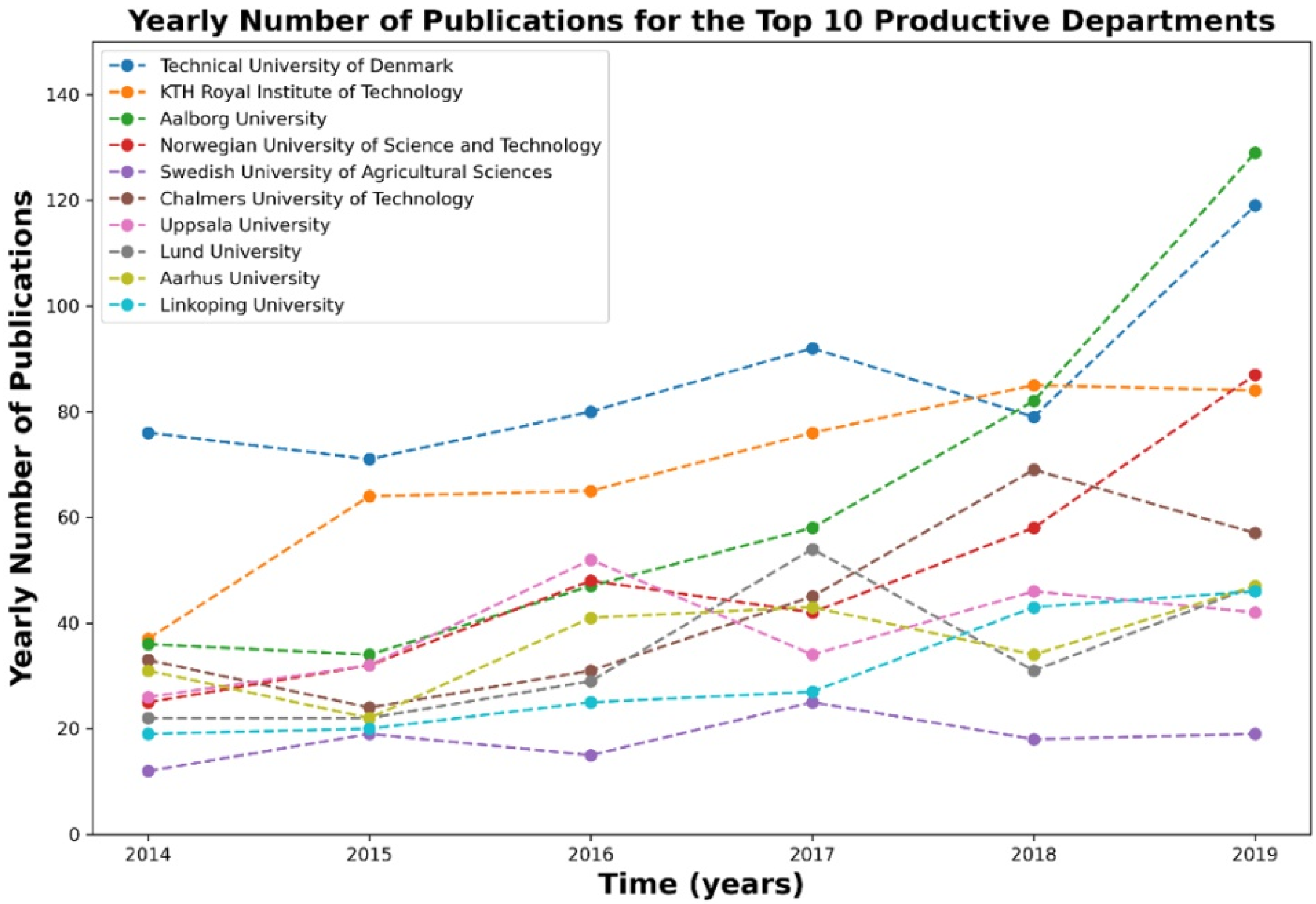

Figure 4. Yearly number of publications for the top 10 productive departments

only, we did not compare productivity of entire organizations. Rather, we limited the comparison to departmental research about renewable energy. We thus used the term "department" to refer to renewable energy research groups (or units) in universities and research organizations.

Table 4 illustrates the top 15 productive Nordic departments in renewable energy research. Arguably, the renewable energy department at DTU ranks first with an h-index of 86. Departments for KTH and Uppsala University are the laggers. Besides the renewable energy department for NTNU, all top 10 departments belong to Sweden and Denmark. Taking the number and share of papers associated with renewable energy departments of Uppsala University and Lund University into account, their number and share of citations were relatively high. In general, the percentage of self-citation is relatively low for all departments.

Figure 4 depicts the yearly number of publications by each of the top 10 most productive departments in *T*2. The yearly number of publications has been growing for most departments. The records for DTU's renewable energy department have fluctuated over time, then spiked in 2019. Among the top 10 departments, the slope for yearly number of publications for Aalborg University, KTH, and NTNU is steep. The renewable energy department for Aalborg University shows the fastest recent publication rise, overtaking DTU's renewable energy department in 2018. The number of published papers by the renewable energy departments of Uppsala University, Lund University, and Aarhus University increased significantly in 2016-2017, but have since fluctuated.

Figure 5 shows yearly number of citations received by the top 10 most productive departments in *T*2. Except for the renewable energy department at the Swedish University of Agricultural Sciences, the numbers for all

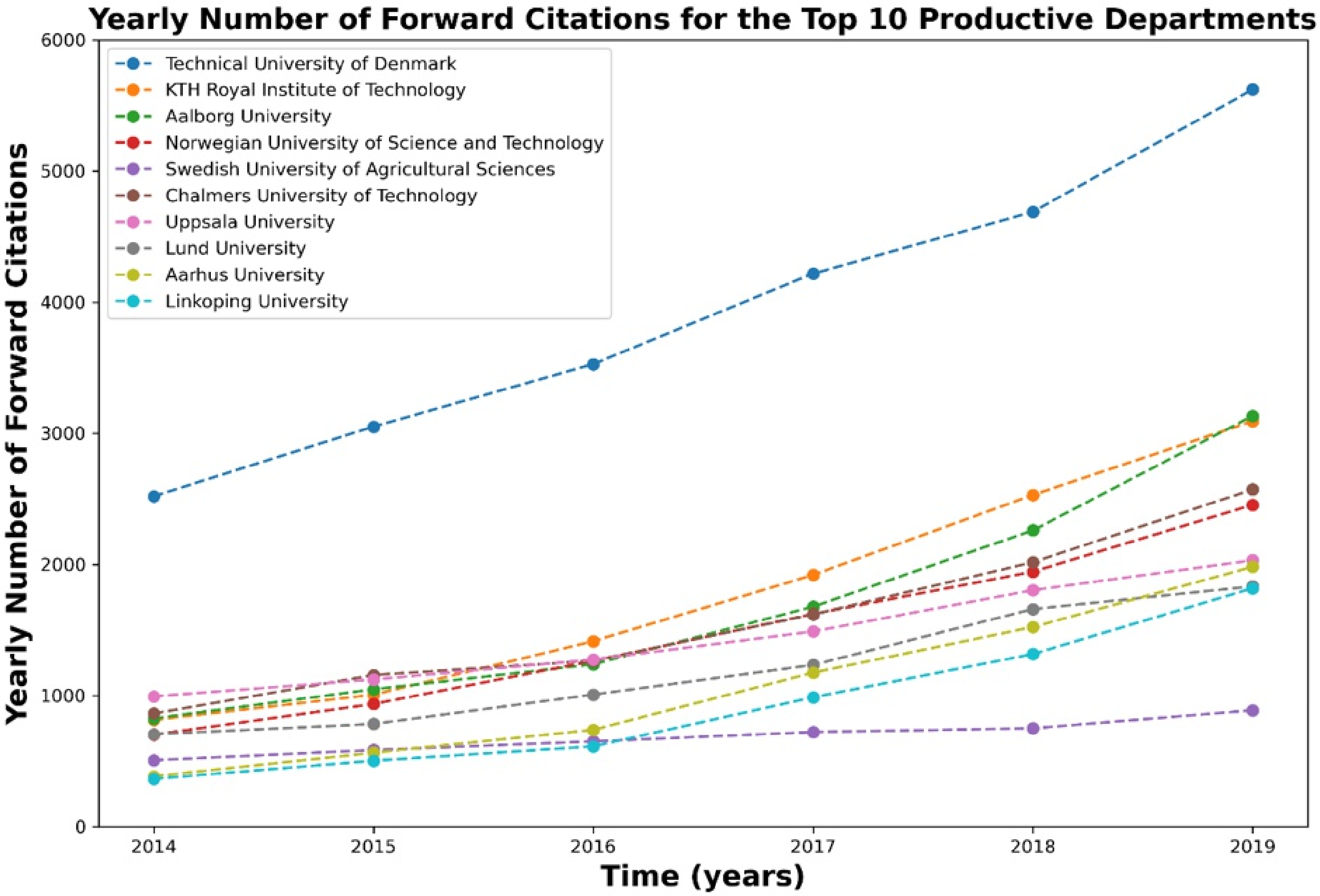

Figure 5. Yearly number of forward citations for the top 10 productive departments

top 10 departments have surged in recent years. The yearly citation slope for DTU's renewable energy department is constant and with a dominant position, while the renewable energy departments for KTH, Aalborg University, Chalmers, and NTNU have been noticeably impactful. Uppsala University, Lund University, and Aarhus University show a significant research impact in renewable energy.

We anticipate that DTU will keep its dominant position in renewable energy research. However, the competition will be tighter among DTU and other institutions. KTH, Aalborg University, and NTNU have been more productive than DTU in renewable energy research within T2. We expect that the renewable energy departments for these institutions will aim to publish more frequently. Renewable energy research affiliated to KTH, Aalborg University, Chalmers and NTNU has been noticeably impactful and we predict that the corresponding departments in these organizations will continue to be increasingly influential in the Nordic scientific community for renewable energy. Renewable energy departments for Uppsala University, Lund University, and Aarhus University have recently shown a significant rise in number of publications and research impact, and their productivity is also expected to rise.

4.2. Clustering

Figures 6 and 7 depict the clusters based on collaboration and research similarity, respectively. Nordic renewable energy research departments tend to collaborate with their parochial counterparts. Finnish and Norwegian departments have been particularly less interested in cross-border collaboration. Swedish and Danish departments, in contrast, have collaborated with renewable energy departments from the EU, USA, and China. International collaboration also contributes to higher levels of productivity.

Although international collaboration between Nordic

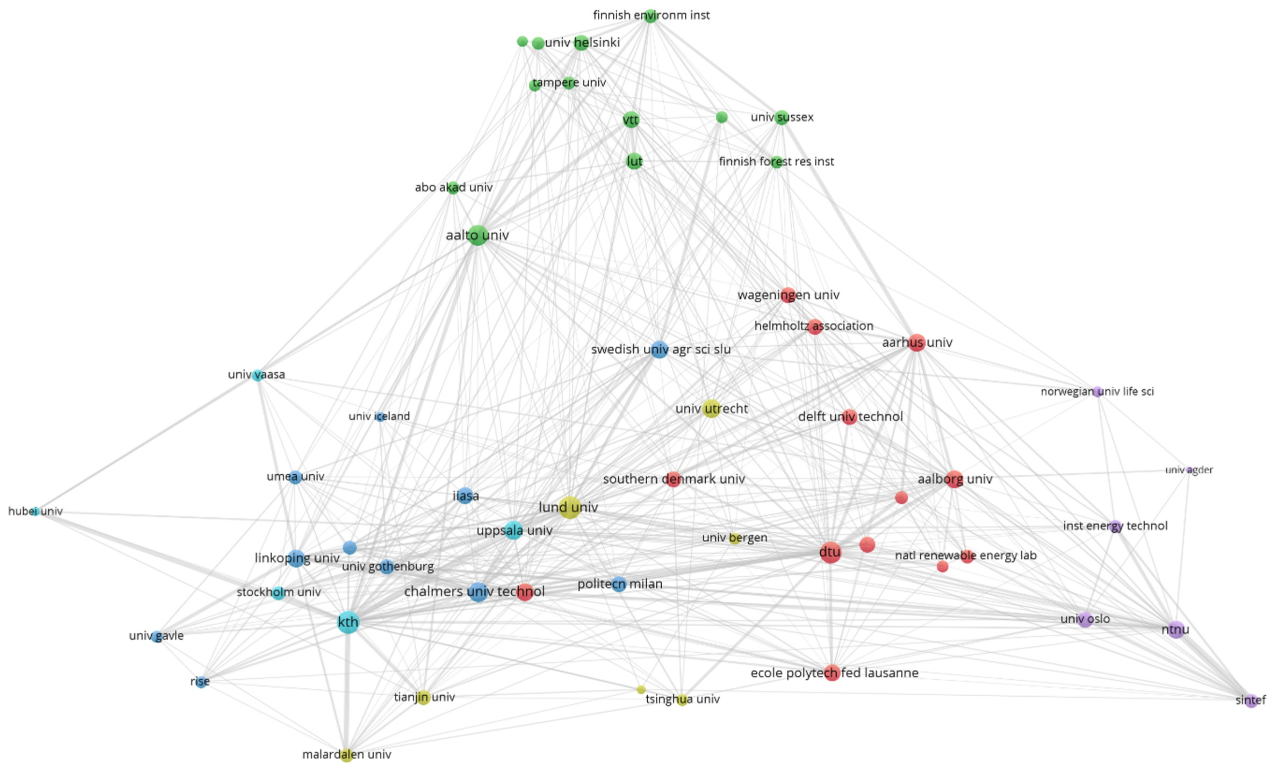

Figure 6. Clusters of Nordic renewable energy departments based on collaborative behaviour

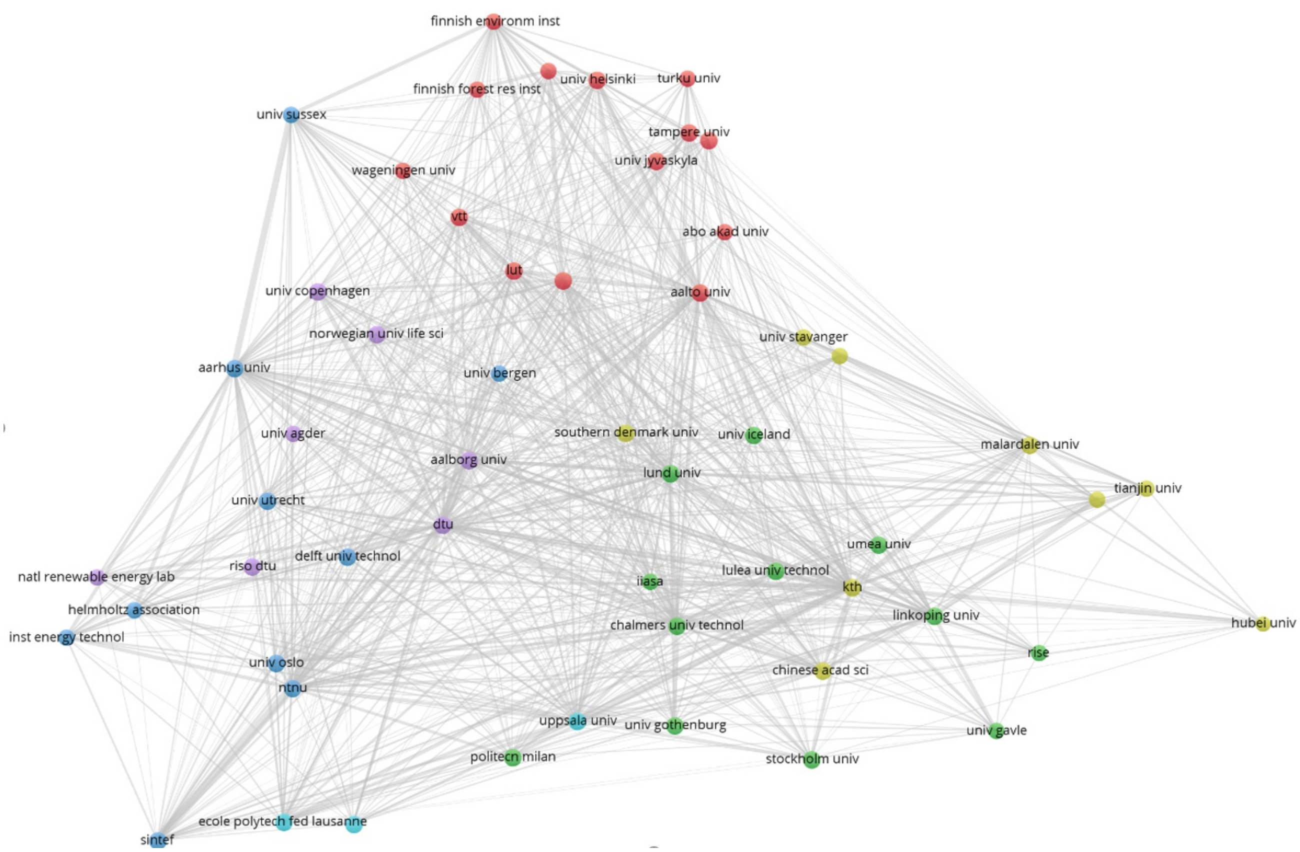

Figure 7. Clusters of Nordic renewable energy departments based on research similarity

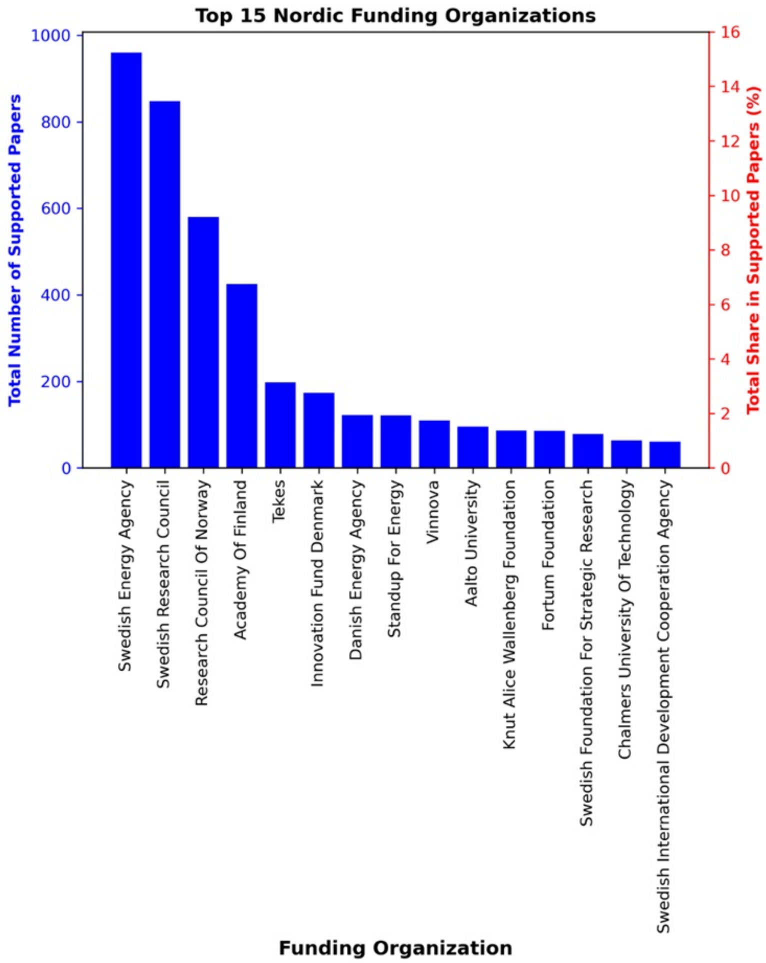

Figure 8. Share of the top 15 Nordic funding agencies in supported publications

countries is not so common, their research outputs nevertheless share similarities (see Figure 7). For example, the clusters of Danish and Norwegian departments that were formed based on their research similarity (see the dark blue and purple clusters in Figure 7) are less distinct in comparison with their clusters based on their research collaboration propensity (see the purple and red clusters in Figure 6). The European organizations are more spread out between clusters in Figure 7, showing similarities in renewable energy research across European countries.

Research similarities cannot be solely justified by collaboration and potential remains open to form new partnerships. For example, while the similarity of research between Wageningen University & Research and VTT is high, no previous record of collaboration exists between these institutions in renewable energy research. The same pattern applies to the departments at the Helmholtz Association and Institute for Energy Technology. Note that although our analyses may assist with systematic identification of possible collaboration opportunities, actual partnership formation between institutions depends on other factors, such as availability of resources.

4.3. Analysis of Funding Agencies

Figure 8 shows the top 15 Nordic funding organizations with the biggest shares in the total number of funded research outputs. The Swedish Energy Agency and Swedish Research Council with 15.5% and 14% shares rank first and second, while the Research Council of Norway (11%) and Academy of Finland (8%) rank third and fourth. Business Finland (Tekes) occupies the fifth position with a share of 3.2%. Among other funding agencies, no single organization has a share larger than 3%. Figure 9 depicts the share of Nordic countries in funding renewable energy research.

Figure 10 depicts the yearly number of papers sponsored

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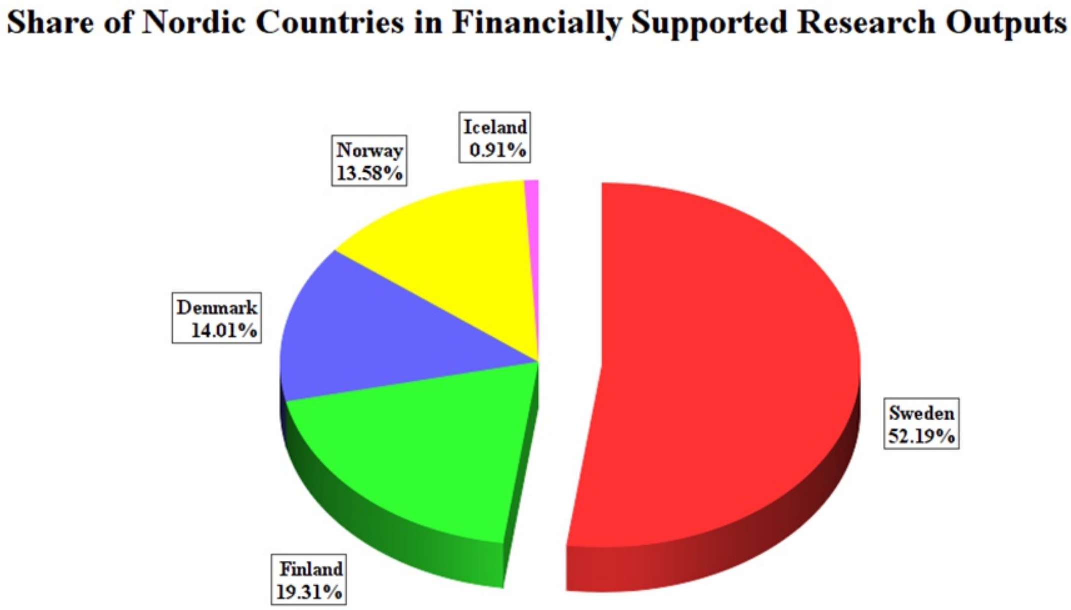

Figure 9. Share of Nordic countries in supported publications

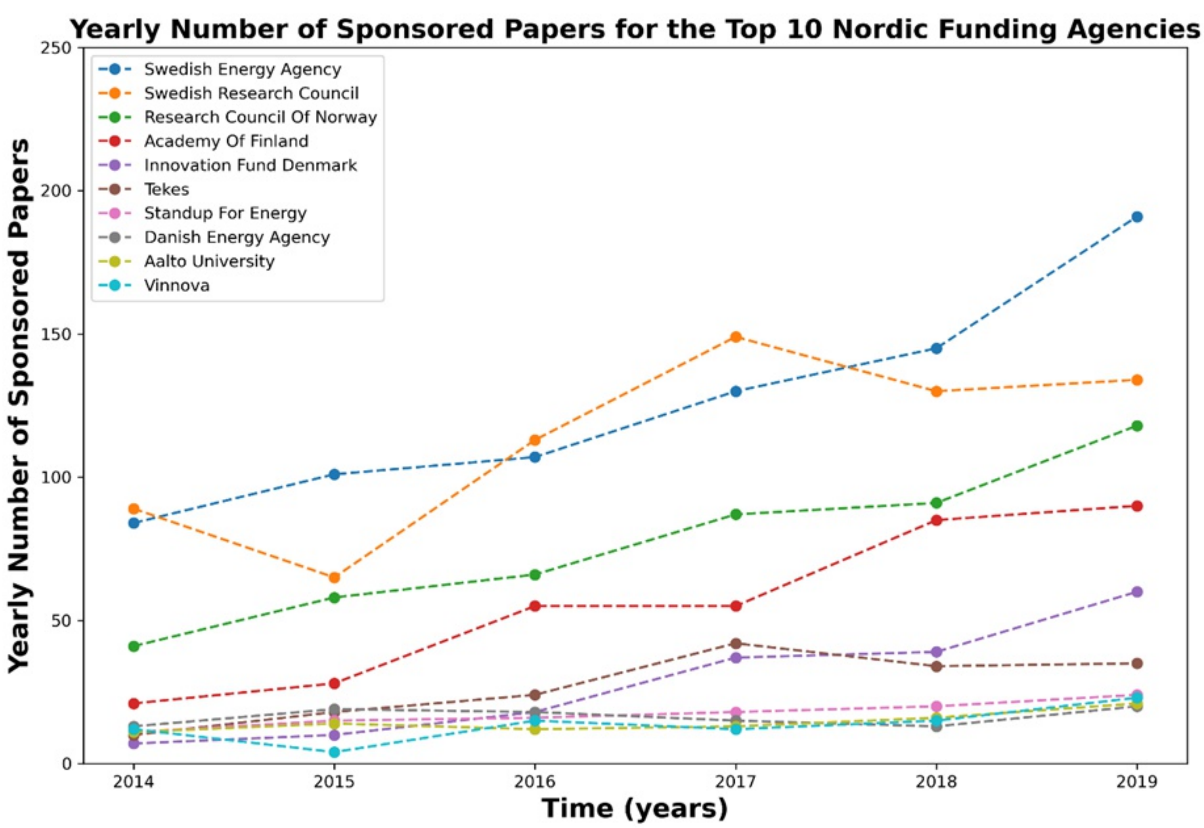

Figure 10. Yearly number of sponsored papers for the top 10 Nordic funding agencies

by the top 10 Nordic funding agencies over *T*2. The yearly number of publications sponsored by the Swedish Energy Agency, Swedish Research Council, Research Council of Norway, and the Academy of Finland has surged. In addition, the yearly number of outputs supported by Business Finland and Innovation Fund Denmark has increased noticeably.

Our analyses suggest that the Swedish Energy Agency will continue to be the top Nordic funding agency in support of renewable energy research. The slope for the number of publications authored by grantees of the Research Council of Norway was steeper than that the Swedish Research Council grantees over *T*2, hence it is likely that the Research Council of Norway will rank second. In a similar vein, the Academy of Finland is considered as a potential rival for the Swedish Research Council. The grantees of Innovation Fund Denmark published a higher number of papers than Business Finland in 2018-2019, and thus, Innovation Fund Denmark might overtake Business Finland. The Swedish Energy Agency, Research Council of Norway, Swedish Research Council, and the Academy of Finland will continue to sponsor renewable energy research more noticeably than other Nordic funding agencies.

4.4. Journal Analysis

Table 5 lists the top 20 journals with publications authored by scholars based in the Nordic region in *T*1.

Figure 11 shows the yearly number of papers published by each of the top 10 journals in *T*2. The number of papers published in Energies and the Journal of Cleaner Production has risen dramatically, whereas the number

Table 5. Top 20 journals of interest for Nordic organizations in renewable energy research

Rank	Source Name	Frequency	Share (%)
1	*International Journal of Hydrogen Energy*	780	13
2	*Journal of Cleaner Production*	625	10
3	*Energies*	573	9
4	*Biomass & Bioenergy*	384	6
5	*Renewable & Sustainable Energy Reviews*	381	6
6	*Renewable Energy*	349	6
7	*Energy Conversion and Management*	237	4
8	*Sustainability*	236	4
9	*Energy Research & Social Science*	168	3
10	*Bioresource Technology*	163	3
11	*Solar Energy*	163	3
12	*Wind Energy*	162	3
13	*Journal of Power Sources*	161	3
14	*Journal of Materials Chemistry A*	156	3
15	*Journal of The Electrochemical Society*	127	2
16	*Solar Energy Materials & Solar Cells*	112	2
17	*International Journal of Energy Research*	99	2
18	*Nano Energy*	91	1
19	*Environmental Research Letters*	85	1
20	*Energy & Environmental Science*	81	1

of papers published in the International Journal of Hydrogen Energy has fluctuated over time, with the closing number in 2019 even lower than the initial number in 2014. Among other journals, scholars affiliated with the Nordic region have published more frequently in Renewable & Sustainable Energy Reviews as well as Sustainability. Recently, scholars based in the Nordic region have been less enthusiastic with publishing in Biomass & Bioenergy, and Renewable Energy.

A significant rise in the number of papers published in Energies and the Journal of Cleaner Production can thus be expected. Scholars affiliated with Nordic organizations are most likely to publish in Renewable & Sustainable Energy Reviews and Sustainability, but less often in Biomass & Bioenergy and Renewable Energy.

4.5. Topic Modelling

Figure 12 depicts the topic coherence (using c_v algorithm) for topics in the range K = (2-50). Although coherence was maximum in K = 14 (0.53 after hyperparameter tuning), we found the number of clusters inadequate. The topics did not encompass socio-techno-economic issues, energy storage and distribution, and renewable energy sources. Therefore, we repeated the analysis until we reached a conclusion that at K = 42, the above issues were addressed sufficiently (coherence of 0.48 after hyperparameter tuning). The word cloud in Figure 13 displays the output of the LDA model, while Table 6 details our subjective clustering of the word cloud.

Dynamic analyses show that the research intensity in all five clusters has risen over time. Growth of interest towards socio-techno-economic issues has been the highest, followed by energy production, storage and distribution. Among socio-techno-economic research themes, energy policy, energy efficiency, market demand, scenario analyses (supply cost and price), sustainable transition, supply chain and logistics, environmental impact, and lifecycle assessment are the

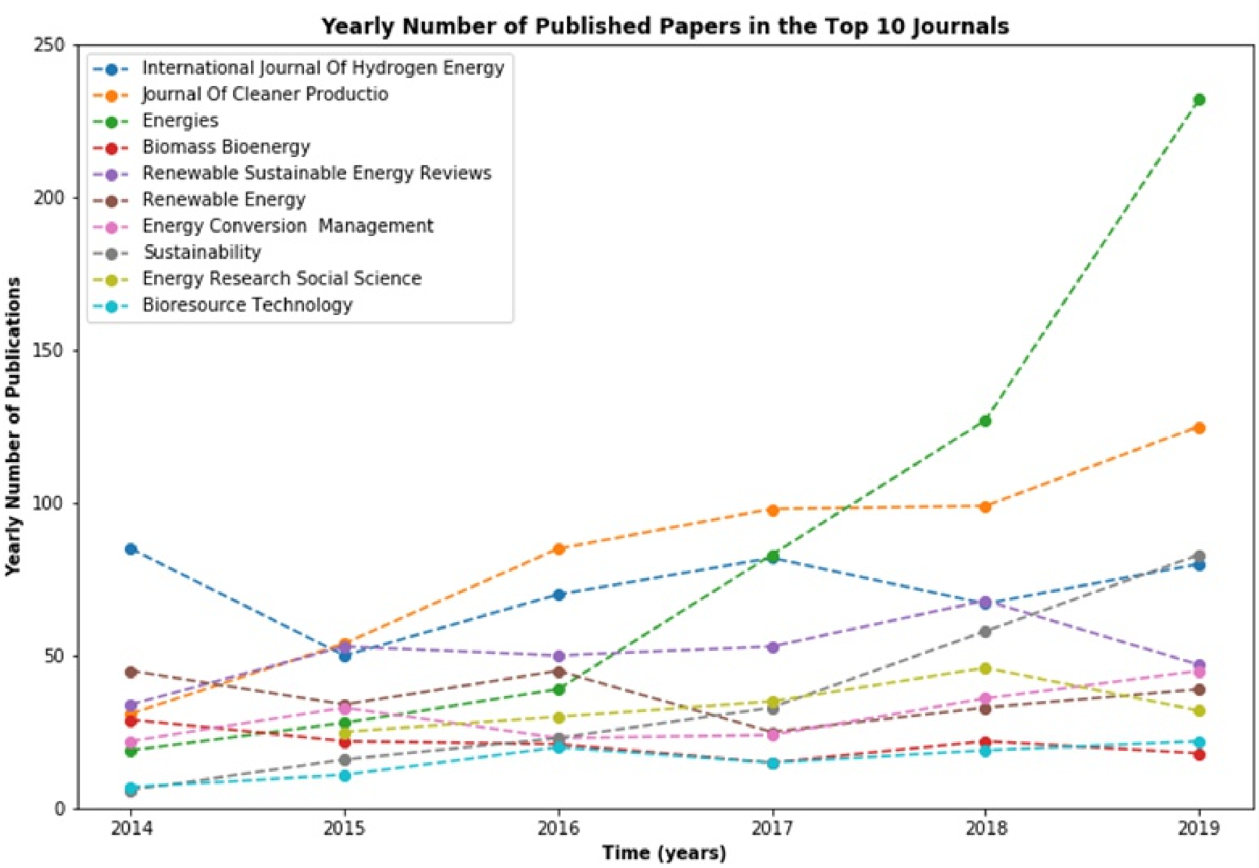

Figure 11. Yearly number of papers published in the top 10 journals

most popular. Biomass and solar energy research received noticeable attention in 2018-2019. In contrast, despite a surge in 2019, wind energy research has been less popular. The rising popularity of bioenergy, biogas, biofuel, wave, geothermal, and hydropower sources is also evident. Hydrogen energy storage and power grids research has gained traction conspicuously since 2014. In energy consumption research, household consumption as well as applications of renewable energy sources in buildings, electric vehicles, and public lighting have been of the most interest.

Dynamic analyses also show energy cost modelling is among the most impactful themes. In a similar vein, solar and biomass energy themes have consistently been among the most cited topics. The impact of hydrogen energy storage research has fluctuated, eventually reaching a peak in 2019. Energy efficiency research has been among the most cited themes since 2017. Despite a surge in 2016-2017, research on environmental issues has not been among the most impactful themes.

5. Discussion and Conclusion

Our study addressed the theoretical debate on challenges in knowledge exploration (Lindkvist, 2005; Jarvenpaa & Välikangas, 2014, 2016; Jarvi et al., 2018; Almpanopoulou et al., 2019) and exploitation (Clarysse et al., 2014) in ecosystems. In contrast to the previous inductive approaches (Rohrbeck et al., 2009; Perry et al., 2010; Pellinen et al., 2012; Alexy et al., 2013; Jarvenpaa & Välikangas, 2014, 2016; Jarvi et al., 2018), our proposed analytical approach resulted in a systematic methodology that saves resources (response to the research question) thanks to the availability of scientific publications data.

5.1 Managerial and Policy Implications

In this paper, we showed a hypothetical exemplary application of the proposed roadmap used on the Nordic renewable energy ecosystem. Below, we show examples of implications for actors of each ecosystem type in the Nordic region. Note that when applying the roadmap to other contexts (with respect to knowledge domain and region) the prescriptive implications will be similar (see Table 3).

As it pertains to the knowledge ecosystem in Nordic renewable energy research, research scholars and department managers can use insights from the roadmap for strategic planning, identifying research partners for prospective projects, drafting publications and grant applications collaboratively, and recruiting new cohorts. C-suite industry managers can evaluate the productivity of their departments and academic allies for collaborative research, as well as discern research areas

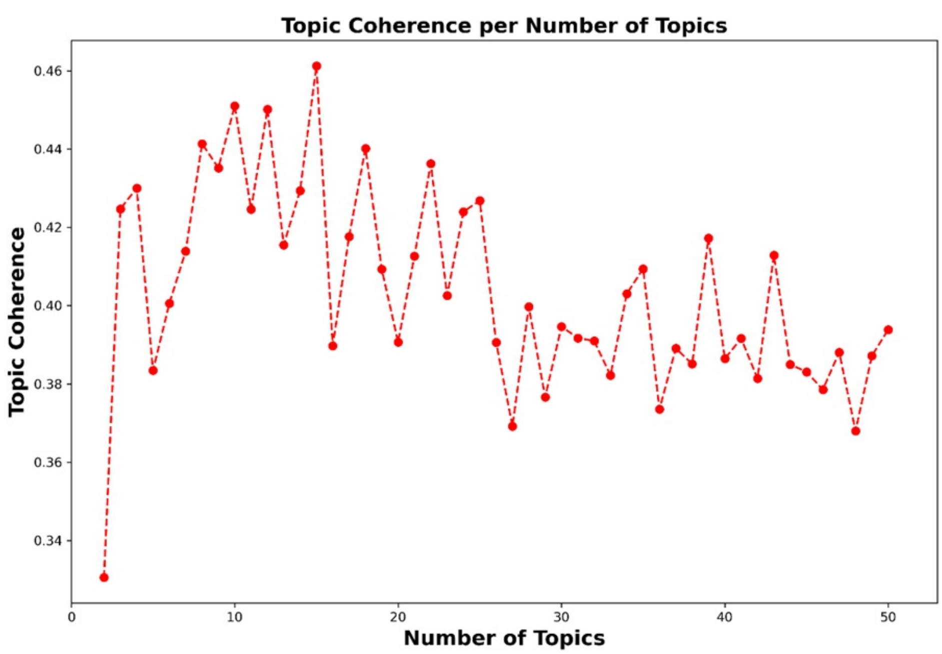

Figure 12. Topic coherence measure for K = 2-50

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Figure 13. Word cloud for 42 topics

with noticeable financial and social value. Journal editors (across the world) can plan to publish special issues (or joint special issues with other journals), applicable to practical energy-related problems within the Nordic region. The knowledge gained about popular and impactful themes through topic modelling can provide opportunities to address grand challenges in the Nordic region.

In innovation ecosystems, federal and state-level policymakers can intervene in research and relevant industry sectors with supportive and regulatory policies to improve research departments' productivity, optimize grant size for funding agencies, systematically organize university-industry-government collaborations, and direct private sector investments towards promising research themes. In addition, governments and research councils can change the direction of job creation programmes towards pertinent areas where research can potentially create financial and social value. Managers in Nordic funding agencies can illustrate their efficiency according to grant allocations. In large funding organizations, the larger share in the number of published papers by grantees in a specific domain can be associated with more efficient research outputs by the grantees, hence giving more validity for decision-making in grant allocation. Moreover, funding agency managers can collectively define new funding programs that focus on crucial research topics in the Nordic region.

In entrepreneurial ecosystems, university graduates, academic entrepreneurs, university spin-offs, and tech start-ups can seek grants from the top funding agencies or private sector investors to servitize or productize their prototypes. In so doing, the focus on more relevant themes will increase the chance for entrepreneurs to persuade public funding agencies and private sector investors to financially support their proposed projects. Furthermore, private sector investors (business angels, venture capitalists) can make informed decisions when evaluating proposals to finance start-ups and university spin-offs, as well as to invest in collaborative research in various knowledge ecosystems.

5.2 Methodological Novelty

Our study's methodological relevance is based on the need for developing new methods in technology and innovation management research (Ritala, Schneider, & Michailova, 2020), and particularly for analyzing ecosystems (Khademi, 2019, 2020), as has been accentuated recently. The proposed roadmap combines techniques in productivity measurement, network-based clustering, and text analytics. We applied four novel techniques when devising the roadmap: 1) simultaneous application of regional, dynamic, and

Table 6. Clusters of renewable energy research in the Nordic region

No	Source of renewable energy production	Energy storage and distribution	Energy consumption	Socio-techno-economic issues
1	Solar (topics 8, 40)	Hydrogen (topics 9, 12, 20, 27, 35, 39)	market demand and energy consumption (topic 16)	Emissions from bioenergy (topic 5)
2	Wind (topics 6, 13, 28	district heating (topic 38)	electric vehicles (topics 1, 19)	Fuel price and investments (topic 17)
3	Wave (topic 14)	power grids and smart grids (topics 1, 25)	Solar energy application in buildings (topic 10)	Renewable energy demand and cost scenario analysis (topic 16)
4	Hydropower (topic 33)	supercapacitor batteries (topic 2)	Solar desalination (topic 26)	environmental life-cycle assessment (topic 37)
5	Geothermal (topic 31)	Polyethylene battery (topic 4)		energy policy and sustainable transition (topic 15)
6	Biomass (topics 21, 22, 29, 30, 42)	Lithium-ion batteries (topic 11)		renewable energy sources and energy efficiency in buildings (topic 41)
7	Biogas (topic 7)	Thermal energy Storage (topic 24)		Recycling and circular economy (topic 18)
8	Thermal (topic 3)			Lifestyle issues in energy consumption and environmental impact (topics 23, 36)
9	Tidal (topic 32)			Environmental education (topic 34)

domain-specific analyses, which can be beneficial for mitigating boundary-related challenges in ecosystem research design (Phillips & Ritala, 2019) by controlling for the boundaries of created scientific knowledge, 2) combining co-authorship analysis and bibliographic coupling, which is helpful for systematically identifying possible collaboration opportunities, 3) extracting insights from the metadata regarding funding agencies, which helps not only the agencies, but also governments, researchers, and practitioners, and 4) employing new techniques when identifying research themes in a geographically-bounded region, which creates value for public and private sectors for investments.

5.3 Limitations and Potential Avenues for Future Research
Our study was subject to four limitations, which can be regarded as starting points for future research. First, our roadmap does not investigate diagnostic analytics. Although exploring causal relationships can be highly valuable for long-term predictions, the process is also highly context-specific and requires primary data collection. Second, we considered only scientific publications along with techniques of our choice to devise the roadmap, whereas other data sources and techniques could have culminated in alternate roadmaps. In the future, researchers can use other WoS metadata or sources (for example, patents and market reports) to devise new roadmaps. Third, we did not take into account the ranking of selected journals for analyzing funding agencies. Employing this strategy could have resulted in deeper knowledge about the impact of outputs per sponsor. Scholars can thus take this shortcoming into consideration for future research. Finally, it could be of interest to see the real financial and social values of the roadmap in experimental projects. For this, researchers can therefore employ the roadmap in projects and report the pros and cons of the roadmap.

In conclusion, this study proposed a novel analytical approach for identifying opportunities in ecosystems. We also showed an example of how the application of our roadmap can benefit ecosystem actors. Data analytics, as this example indicates, can therefore open up several new windows for academics, managers, and policy-makers.

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Keywords: Ecosystem, knowledge, opportunity, roadmap, scientometrics, text mining

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The TIM Review team is a key partner and contributor to the Scale Early, Rapidly and Securely (SERS) Project: https://globalgers.org/. Scale Early, Rapidly and Securely (SERS) is a global community actively collaborating to advance and disseminate high-quality educational resources to scale companies.

The SERS community contributes to, and leverages the resources of, the TIM Review (timreview.ca). The authors, readers and reviewers of the TIM Review worldwide contribute to the SERS project. Carleton University's Technology Innovation Management (TIM) launched the SERS Project in 2019.

We are currently engaged in a project focusing on identifying research and knowledge gaps related to how to scale companies. We are inviting international scholars to join the team and work on shaping Calls for Papers in the TIM Review addressing research and knowledge gaps that highly relevant to both academics and practitioners. Please contact the Editor-in-Chief, Dr. Stoyan Tanev (stoyan.tanev@carleton.ca) if you want to become part of this international open source knowledge development project.