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Insights

Welcome to Issue 7/8 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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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

Mika Westerlund & Gregory Sandstrom

Welcome to Issue 7/8 of the Technology Innovation Management Review. This edition is a collection of insights across a range of topics from SME ecosystem engagement, integrated trust sites, technology in the customer journey, action research with a participant-observer approach, web text analytics on digital health companies, and energy transition, including renewables.

Ermela Bashuri & Tony Bailetti lead off the issue with “Strategies for a Small to Medium-sized Enterprise to Engage in an Existing Ecosystem”. Their aim is “to explore applicable ecosystem engagement strategies from the perspective of SMEs” (pg. 5). Their research indicates strategies for SMEs to apply when joining value-creating ecosystems. They follow the work of Jacobides et al., 2018 in defining key components within ecosystem types as: 1) keystone, 2) complementors, 3) complementarities, 4) resources, 5) activities, 6) value proposition, 7) governance, 8) customer, and 9) others. From this, they identify reasons for actors in an ecosystem to collaborate, along with prerequisites for ecosystem engagement. They conclude by recommending that SMEs “collaborate with ecosystem complementors by mapping complementarities (in production/consumption) that are unique or supermodular” (pg. 16).

Michaela Keßelring, Stéphane Ruiz-Coupeau, Moritz Kirsch, Frank Wagner, & Richard Gloaguen follow this with “Integrated Trust Sites for Innovative Ecosystems”. The paper contributes to the literature on corporate and public test site practices by analyzing multi-industrial test sites. They show “how converging test sites may provide opportunities for multiple industries and regions” (pg. 20) using both qualitative and quantitative research designs. The results indicate that the suitability of multi-industrial test sites depends on the market and research fit of the test target, the quality of the benchmark data, as well as logistical, organizational, legal, social, and ecological factors. Their general conclusion notes that “multi-industrial test sites increase and strengthen the absorptive capacity of regions” (pg. 20), and that “integrated test sites add value beyond a single industry” (pg. 28).

In the next paper, William Boscardini Helouani asks “How Can Firms Effectively Use Technology in Customer Journey Management”. The research outlines how customer journey (CJ) mapping provides a view of the customer experience (CX) taken from a customer's standpoint. The paper suggests that even though CJ mapping has proven helpful in various use cases, applying the technology to make it effective has been difficult for companies. The author conducted a literature review from a selected 33 articles sourced from Web of Science and found three main drivers for technology adoption in the CJ context: mapping, enabling, and monitoring the journey. The report elaborates on the drivers and shows how IT and digital assets can be used in the CJ context, giving practical examples that may be useful for organizations aiming to implement a consumer-centered IT strategy.

Paul J. Woodfield, Katharina Ruckstuhl, & Rafaela C.C. Rabello continue the edition with “Charting a Course of Action: An Insider-Outsider Approach”. Here they take a participant-observer research approach, which is “where a researcher is also part of the same community of practice as those being observed” (pg. 48). They present a case where social scientists carried out action research on a natural science and technology research programme where they were embedded within a longitudinal history of relationship building. The case study is centred on New Zealand’s National Science Challenge: Science for Technological Innovation - Kia kotahi mai - Te Ao P taiao me Te Ao Hangarau (To come together, to join as one, the world of Science, the world of Innovation). Their work offers a way to map the research journey using action research through navigation, iteration, and reflection phases. They conclude that “embedding social science early in an upstream innovation programme can lead to a better understanding of the best action and intervention to address an innovation mission” (pg. 62). They promote the idea of moving away from “employing” action researchers toward “being” action researchers, with social scientists working on multidisciplinary projects alongside of natural science and technology researchers.

A students-with-professor team contribution comes next, with Abdulla Aweisi, Daman Arora, Renée Emby, Madiha Rehman, George Tanev & Stoyan Tanev “Using Web Text Analytics to Categorize the Business Focus of Innovative Digital Health Companies”. The authors categorize the areas of application for innovative companies operating in the digital health sector using information provided on their websites. Their aim is to

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help aspiring technology entrepreneurs, organizations supporting new ventures, and business accelerators interested to enhance their services to new venture clients by improving our understanding of what innovative digital health companies offer. The paper makes a contribution to the literature by shaping an automated text analytics approach to categorizing large samples of company-created information in specific business domains.

The final paper by Petra Berg, Rumy Narayan & Arto Rajala focuses on "Ideologies in Energy Transition", with particular attention to "Community Discourses on Renewables". The paper examines energy transition processes in five Finnish municipalities through discourse to identify and explain different ideologies among its members. The authors take a social constructivist approach to deal with the implications of ideologies embedded in municipal, multi-partner networks involving energy transition that affect who is heard in local contexts. The authors believe that the various ideologies facing energy transition, which they label as Clan, Solarpunk and Native, impact peoples' future choices directly related to sustainability outcomes. They propose that discourses involving multi-partner networks for energy transition, when conceptualized from the perspective of municipal energy systems, help us to uncover underlying ideologies that imperil change.

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. Potential contributors could also consult the TIM Review topic model (https://topicmodeling.timreview.ca/#/model) to examine the dominant publication themes so far, which might help with ideas for valuable future contributions. Please contact us with potential article ideas and submissions, or proposals for special issues.

This edition also marks the start of the tenure of Prof. Mika Westerlund as Editor-in-Chief of the TIM Review. On behalf of the Editorial Team, the International Advisory Board, and the Review Board of the Journal, its authors and readers, we would like to thank our outgoing Editor-in-Chief, Prof. Stoyan Tanev, who has invested significant efforts to advance the profile of the TIM Review over the past two years. In the future, we will add changes and additions to the Journal as part of our commitment to improve the quality, impact, and relevance of articles in the fields of technology innovation and entrepreneurship. We warmly welcome submissions contributing to our current domains of interest and novel areas that supplement the already existing TIM Review topics, including blockchain, artificial intelligence and quantum computing. We also appreciate the indispensable contributions made by guest editors and reviewers of the Journal. Finally, we welcome suggestions and thoughts from the authors and readers of the TIM Review to help us to deliver these objectives.

Mika Westerlund
Editor-in-Chief, TIM Review &
Gregory Sandstrom
Managing Editor, TIM Review

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Strategies for a Small to Medium-sized Enterprise to Engage in an Existing Ecosystem

Ermela Bashuri and Tony Bailetti

> *"Strategy is about making choices, trade-offs; it's about deliberately choosing to be different."*
>
> Michael E. Porter
> Professor at Harvard Business School

Recent advances in ecosystem theory prescribe that companies need to develop offers that are modular and form unique or supermodular complementarities with other offers. However, both academic and managerial knowledge of the strategies that especially small and medium sized enterprises (SMEs) can use to engage in existing ecosystems for value creation remains scattered and predominantly vague. This article thus aims to explore applicable ecosystem engagement strategies from the perspective of SMEs, as discussed in previous scholarly literature. In so doing, the article puts forward and elaborates three distinct strategies that SMEs can apply to become part of value-creating ecosystems. In this way, the findings contribute to the literature on ecosystems.

Introduction

Recent advances in ecosystem theory prescribe that small and medium sized enterprises (SMEs) need to develop offers that are modular and form complementarities with other offers that are unique or supermodular (Jacobides et al., 2018). Supermodular complementarity takes place when "more of A makes B more valuable". For example, the more widespread availability of applications increases the value of an operating system, and the ever-larger number of operating system installations increases the value of those applications (Jacobides et al., 2018). However, SME strategies to engage with ecosystems do not always seem to incorporate what theory prescribes. SMEs are therefore too often left without understanding how to engage with ecosystems in a manner that provides them value. One of the challenges that SMEs face when trying to engage in an existing ecosystem is the lack of an explicit process that guides them on how to engage in an existing ecosystem.

Hence, this article aims to explore applicable ecosystem engagement strategies from the perspective of SMEs. Specifically, the article follows the widely used knowledge translation approach (see Dal Mas et al., 2020) to review previous literature on ecosystems. As a result, the article suggests: 1) a strategy for a SME to engage in an ecosystem that builds on ecosystem theory as articulated by Jacobides et al. (2018), 2) a strategy for a SME to engage in an ecosystem based on a summative model that synthesizes findings from literature review, and 3) a strategy for a SME to engage in an ecosystem based on the concept of Minimum Viable Footprint (MVF) advanced by Adner (2012). In this vein, the article contributes to the extant body of literature on SME engagement in ecosystems by discussing three alternative engagement strategies.

The article is structured as follows. First, it reviews previous literature on ecosystem types and related key components. Then, it discusses reasons and pre-requisites for collaboration in ecosystems. Thereafter, the article elaborates on ecosystem engagement strategies and their success factors, and presents three different ecosystem engagement strategies for SMEs. Finally, the article concludes by summarizing the results, discussing the implications for theory and practice, as well as providing limitations of the study and future research avenues.

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Ecosystem Types and Components

Adner (2017) defines an ecosystem as "the alignment structure of the multilateral set of partners that need to interact for a focal value proposition to materialize". What makes an ecosystem powerful is its ability to create and deliver dominant value propositions through interorganizational collaboration. Ecosystem participants mutually influence each other because of simultaneously existing interdependencies and complementarities (Jacobides et al., 2018; Kaapor, 2018; Baumann, 2019; Autio & Thomas, 2020).

Ecosystem research can be organized by its focus into three distinct streams: 1) business ecosystems, 2) innovation ecosystems, and 3) platform ecosystems (Jacobides et al., 2018). A business ecosystem is comprised of a set of partners that contribute to the value proposition of the ecosystem's focal firm (Baumann, 2019). An innovation ecosystem is anchored on the innovation that enables customers to use the end-to-end product, with a functional goal to enable technology development and innovation (Jackson, 2011; Jacobides et al., 2018). It includes three sub-ecosystems: science, technology, and business innovation (Xu et al., 2018). Finally, a platform ecosystem is comprised of a platform and the applications that interoperate with it (Tiwana, 2014). There are two types of platform ecosystems: 1) innovation platforms and 2) transactional platforms (Cusumano, 2019).

While innovation platforms serve as technological building blocks that both platform owner and other ecosystem actors can share to build new complementary products and services, transaction platforms serve as intermediaries or online marketplaces that enable businesses and people to buy, sell and access a variety of goods and services (Cusumano, 2019). Of note, some platform ecosystems can be a hybrid of the two types. Overall, the key components that exist in ecosystem types include: 1) keystone, 2) complementors, 3) complementarities, 4) resources, 5) activities, 6) value proposition, 7) governance, 8) customer, and 9) others (Jacobides et al., 2018).

Keystone
Playing a key role in ecosystem regulation, the keystone is the most significant member of an ecosystem (Weber & Hine, 2015). The keystone's actions influence the success of all ecosystem members (Mäkinen & Dedehayir, 2012). An ecosystem's keystone makes a set of trade-offs favorable to complementors, by 1) attributing the added value to the complementor that generates it, 2) building and structuring complementarities between ecosystem members, 3) stimulating complementarity investments, 4) reducing transaction costs, 5) promoting flexibility, and 6) designing value capture tools for all ecosystem members (Marty & Warin, 2020). Moreover, the number of keystone players in a specific industry has a high impact on an ecosystem's innovation rate, as the industry is likely to obtain a higher innovation rate with multiple keystone players (Marty & Warin, 2020).

Complementors
Complementors are ecosystem actors that produce modules which contribute to the focal offer's value system (Kapoor, 2018). In this vein, complementors have a key role in facilitating and promoting the focal firm's product, and for providing complementary products and solutions to the end-user (Rong et al., 2013). Complementors are obliged to innovate continuously, be connected, and develop a recognizable brand to help the focal offer succeed (Worner et al., 2019). Subsequently, the focal firm needs support and commitment from complementors to commercialize its products; meaning, the success of the focal firm's product commercialization may largely depend on the complementors' efforts (Rong et al., 2013).

Complementarities
Complementarities are products or services that are sold separately but used together, each creating value for the other (Kapoor & Lee, 2012). Complementors in an ecosystem create value by dealing with unique or supermodular complementarities that are non-generic (Jacobides et al., 2018). Unique complementarities are complementarities that lead to co-specialization, for example, complementarities that require each other, while supermodular complementarities increase the value of each other. For example, a variety of apps increases the value of an operating system (OS), and vice versa, thus yielding higher returns (Jacobides et al., 2018).

Resources
The resources of the ecosystem enable the interaction of actors and enable them to create value (Talmar et al., 2020; Weber & Hine, 2015). There are different types of resources, including "intangible" resources such as knowledge and information, cultural and social capital,

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access to important social relationships, specific skills and capabilities, as well as "tangible" resources including, for example, financial resources, human resources, along with novel technologies and services (for example, wireless technology, web services, cloud technology) (Battistella et al., 2013).

Activities
Activities in ecosystems are considered as the mechanisms by which an actor generates its productive contribution to the ecosystem (Talmar et al., 2020). For example, an actor's ability to create value from a new technology depends on the accompanying changes by ecosystem complementors that may need to adapt their activities for the new technology to be successfully commercialized (Kapoor & Lee, 2012). According to Battistella et al. (2013), technologies typically constitute the necessary tools through which an ecosystem's activities can be deployed.

Value proposition
The ecosystem's value proposition is "the intended value arising from the system-level overarching offering by the supply-side agents in the ecosystem" (Talmar et al., 2020). In accordance, Frow et al. (2014) stress that in an ecosystem, value proposition is "a shaper of resource offerings", as it positions a firm in a market by highlighting their favourable points of difference compared to competitors, determining their promises of delivered value to customers in terms of benefits and price, and forming a foundation for a supply–customer relationship.

Governance
What makes ecosystems distinct from other arrangements is the non-hierarchical structure of governance. The non-hierarchical structure of shared governance rights and control ensures that the ecosystem keystone acts in the interest of overall ecosystem actors. That said, Adner (2017) notes that while the keystone often sets and enforces the governance rules, it ultimately reaps the lion's share of gains after the ecosystem is aligned. Nonetheless, Koch and Kerschbaum (2014) found that developers in technology industries tend to perceive their ecosystem and its governance as an important whole, rather than as hardware, software, marketplace, and other aspects separately.

Customer
Ecosystem customers (or end-customers) represent the variety of requirements from the demand side and tend to "assemble" the offers of different suppliers and other ecosystem actors (Rong et al., 2013). That is, customers in ecosystems can choose among the components of an offer that are supplied by each participant, and can also, occasionally, choose how the offers are combined (Jacobides et al., 2018). In some cases, a customer may even become themself a producer, sometimes referred to as a "prosumer" (Battistella et al., 2013; Leminen et al., 2015).

Others
Business, innovation, and platform ecosystems can also include other components and intermediaries, such as suppliers, system integrators, distributors, operators, advertisers, finance providers, universities, research institutions, regulatory authorities, government agencies, standard-setting bodies, and the judiciary (Mäkinen & Dedehayir, 2012; Battistella et al., 2013; Rong et al., 2013).

Reasons for SMEs' Ecosystem Collaboration

SMEs wish to engage in ecosystems to create and capture value in effective ways (Kapoor, 2018; Zhu, 2019). Davidson et al. (2014) note that, while "in traditional markets, value creation is incremental as organizations typically cover costs plus some return on assets, in ecosystems, organizations create value through their engagement within the ecosystem". Ecosystem actors are thus simultaneously influenced by their own capabilities and by their interactive ties with other players in the ecosystem (Heikkilä & Kuivaniemi, 2012). SMEs in an ecosystem are therefore not just interconnected with each other, but indeed also depend on each other to develop mutual benefits.

To make their engagement in an ecosystem beneficial not only for themselves but for all participants alike, SMEs need to consider how to help others in the ecosystem create value (Heimala, 2020). Being part of an ecosystem requires co-developing or co-evolving (Moore, 2006), value co-creation (Ritala et al., 2020), and collaboration with other ecosystem members. In ecosystems, collaboration and competition occur simultaneously. Thus, SMEs engaging in ecosystems may also have the opportunity and/or need to collaborate with their direct and indirect competitors to achieve mutually beneficial outcomes (van Angeren et al., 2013).

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Reasons for actor collaboration in ecosystems
Ecosystems are built on voluntary collaboration and strategic interactions between independent actors (Pidun et al., 2020). Ecosystem actors, such as SMEs, collaborate with each other mainly for the following reasons:

- *Collaboration to bundle additional functionalities to the core ecosystem offer:* In a platform ecosystem, for example, platform sponsors and complementors collaborate to bundle additional functionalities to the core platform as a way to enhance its value by creating complementary technologies (Agarwal & Kapoor, 2018)

- *Collaboration to share resources and take advantage of network synergy:* SMEs engaged in an ecosystem collaborate together to share information or resources and also to complement each other with products and technologies, thereby taking advantage of the network synergy (Tang & Qian, 2020)

- *Collaboration to complement offerings:* In this type of collaboration, SMEs engaged in an ecosystem collaborate mainly with complementors that provide complementary products, which are customized or compatible with a focal product (innovation) or platform (Tang & Qian, 2020)

- *Collaboration to commercialize products:* Ecosystem actors engage in this type of collaboration when they wish to commercialize complementary products that were previously released for free (Eckhardt et al., 2018)

- *Collaboration to build capabilities:* Ecosystems enable SMEs to access and share resources and collaborate to build capabilities that were previously cost-prohibitive (Tata Consultancy Service, 2019). For example, digital technologies help organizations in ecosystems to collaborate and build new capabilities or products or to help in further advancements in science and technology (Ringel et al., 2019)

Prerequisites of Ecosystem Engagement

The ecosystem keystone has a key role in attracting SMEs and other actors to engage in an ecosystem, by creating a compelling image of the future ecosystem, and by clearly defining the ecosystem value proposition and associated structures of governance and interaction (Dattée et al., 2018). A SME wishing to join an ecosystem needs to both fulfill certain prerequisites and, at the same time, strategize their mode of entry in an ecosystem. The key prerequisites are 1) having a modular or non-generic complementarity (Jacobides et al., 2018), 2) technological compatibility with other ecosystem complementors, 3) developing the right capabilities for digital partnering, and 4) adopting an ecosystem mindset.

Modularity and complementarity
To successfully engage in an ecosystem, a SME needs to produce a modular part that complements other parts, which are then offered together as a whole to a customer (Jacobides et al., 2018). Customers expect a value proposition focused on their needs, not the offerings of individual SMEs that they must piece together themselves (Jacobides, 2019). SMEs need to make their offerings modular to allow “inter-firm offer modularity” (Schilling, 2000). This will allow customers to increase the range of possible product combinations that they can make by combining components from a variety of complementors.

Technological compatibility
If a SME wants to join a platform ecosystem, they need to make sure that they have the necessary technological compatibility to complement and gain access to offerings of other ecosystem complementors. Technology compatibility is often a prerequisite for gaining access to the complements of other ecosystem complementors, and it also increases a SME’s ability to appropriate the returns from the innovation (Ceccagnoli et al., 2012).

Developing the right capabilities for digital partnering
Developing the right capabilities for digital partnering is key for getting value from an ecosystem. To create digital partnering, a SME needs digital readiness that consists of three key characteristics: 1) being distinctive, 2) being digitally organized, and 3) being open (Sebastian et al., 2020). Digital partnering requires SMEs to leverage data analytics and create operation models that are optimized for partnering with ecosystem partners that operate in a digital environment (Sebastian et al., 2020).

Adopt an ecosystem mindset
SMEs that wish to engage in an ecosystem need to have

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an ecosystem mindset and make an ecosystem engagement objective part of their scaling masterplan. Adopting an ecosystem mindset requires shifting from profit-focused strategy to purpose-focused strategy, from strictly competition to cooperation with competition, from subcontracting and risk-sharing to partnering and opportunity-sharing, and from owning to sharing resources with other ecosystem complementors (Ritala et al., 2013).

Success Factors of Ecosystem Engagement

While ecosystem engagement strategies help SMEs thrive, they are also effective in promoting joint learning, making an ecosystem more efficient in innovating, and allowing a higher degree of flexibility by enabling partners to constantly adjust their activities to changing circumstances (Williamson & De Meyer, 2020). In fact, ecosystem strategies have even more to offer, given that “actions required to grow a SME's revenue and to implement growth formulas can greatly benefit from embracing the business ecosystem approach” (Bailetti, 2010). That said, ensuring an ecosystem’s engagement strategy success becomes essential for SMEs in joining an ecosystem.

Previous literature on ecosystems suggests that SMEs need to do the following to ensure that their engagement strategy is successful:

1. *Provide modular and non-generic complementarities* (Jacobides et al., 2018; Talmar et al., 2020). SMEs should modularize their offer so that it can complement other ecosystem products or services that customers are going to consume (Jacobides et al., 2018). Moreover, to become part of an existing ecosystem SMEs need to customize their offering so that the complementarity they provide is non-generic (Talmar et al., 2020).

2. *Adopt a standardized interface* (Schilling, 2000). SMEs should adopt a standardized interface that makes their product compatible with the components of other SMEs. Such SMEs can employ inter-SME product modularity that enables customers to assemble their own multivendor configuration (Schilling, 2000).

3. *Balance specializations trade off within and across ecosystems:* Ecosystem complementors that focus on a specific product category (that is, category specialization) can scale by engaging in various ecosystems, while ecosystem complementors that are specialized in many products and or services can scale better by engaging in one ecosystem only (Tavalaei & Cennamo, 2020).

4. *Ensure alignment with ecosystem’s focal value proposition:* Complementors must align their strategies with objectives and value propositions set by a focal SME in the ecosystem and, at the same time, ensure a unique value proposition to create a distinct position from other ecosystem members (Tavalaei & Cennamo, 2020).

5. *Focus on a narrowed segment to achieve competitive advantage:* Complementors can achieve distinctiveness in an ecosystem by focusing on a narrowed segment of the market within the platform ecosystem (Moore, 2006).

6. *Adopt an outward-facing culture:* Participating in an ecosystem requires an outward-facing culture and the ability to manage relationships with a host of complementors (Jacobides, 2019).

Engagement strategies in the existing ecosystem context
A successful engagement in an ecosystem is not about what a SME does with its offer, but rather how that SME brings to the table all the other complements it needs to succeed. “Technological integration” and “partnerships” with other complementors seem to be the two main ways SMEs prefer to use as entry strategies for an existing ecosystem. Technological integration with existing ecosystem complementors suggests that small complementors can engage in an existing ecosystem by increasing specialization and technological integration with existing complements in the ecosystem, thereby benefiting from their established reputation (Van Angeren et al., 2013). On the other hand, new entrants need to choose between entering alone or partnering and cooperating with a local partner (Estrin, 2019). Partnerships play a great role in helping SMEs overcome societal grand challenges such as health (for example, COVID-19), global warming, water shortage, energy concerns, emissions, and poverty. These societal grand challenges cannot be addressed by one SME alone, but rather require a collaborative approach (De Stobbeleir, 2020) and cross-sectorial partnerships with partners from different industries to develop innovative solutions (Doh et al., 2019).

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Strategies for SMEs to Engage in Existing Ecosystems

This section suggests three strategies that SMEs can follow to engage in an existing ecosystem. These strategies include, 1) a strategy for a SME to engage in an ecosystem that builds on ecosystem theory as articulated by Jacobides et al. (2018), 2) a strategy for a SME to engage in an ecosystem based on a summative model that synthesizes findings from literature review, and 3) a strategy for a SME to engage in an ecosystem based on the concept of Minimum Viable Footprint (MVF) advanced by Adner (2012).

1) Ecosystem engagement strategy for a SME based on the ecosystem theory (cf. Jacobides et al., 2018)
Jacobides et al. (2018) define ecosystems as "distinct forms of organizing economic activities that are linked by specific types of complementarities." Subsequently, a SME's engagement strategy in an existing ecosystem consists of mapping complementarities both in production and in consumption. Complementarities in production happen when offers by existing ecosystem complementors complement the ecosystem's focal offer (ecosystem focal value proposition) by adding more value to it. Complementarities in consumption happen due to choices by customers who combine the ecosystem's focal offer (ecosystem focal product/service) with complements from individual complementors. The constructs of this engagement strategy are illustrated in Figure 1 and elaborated thereafter.

- *Complementarities.* According to Jacobides et al. (2018), "ecosystems are groups of firms that must deal with either unique or supermodular complementarities that are non-generic". Thus, creating offers that directly complement an ecosystem's focal offer or other ecosystem complementors' offers enables SMEs to connect to the ecosystem's focal innovation provider either directly or indirectly. Given that complementarities help to jointly add value to customers, SMEs should offer products and services that are either unique (that is, the ecosystem offer requires the SME's offer) or supermodular (meaning, the SME's product or service offer makes the ecosystem offer more valuable).

- *Modularity.* Creating a modular offer (that is, an offer that can be combined with other ecosystems offers) enables SMEs that want to engage in an existing ecosystem to easily interconnect their offer with the offer of other ecosystem complementors in pre-defined ways. Modularity also facilitates mapping of complementarities in consumption by enabling customers to choose and bundle together among components offered by different complementors whose offers are bound together by interdependencies.

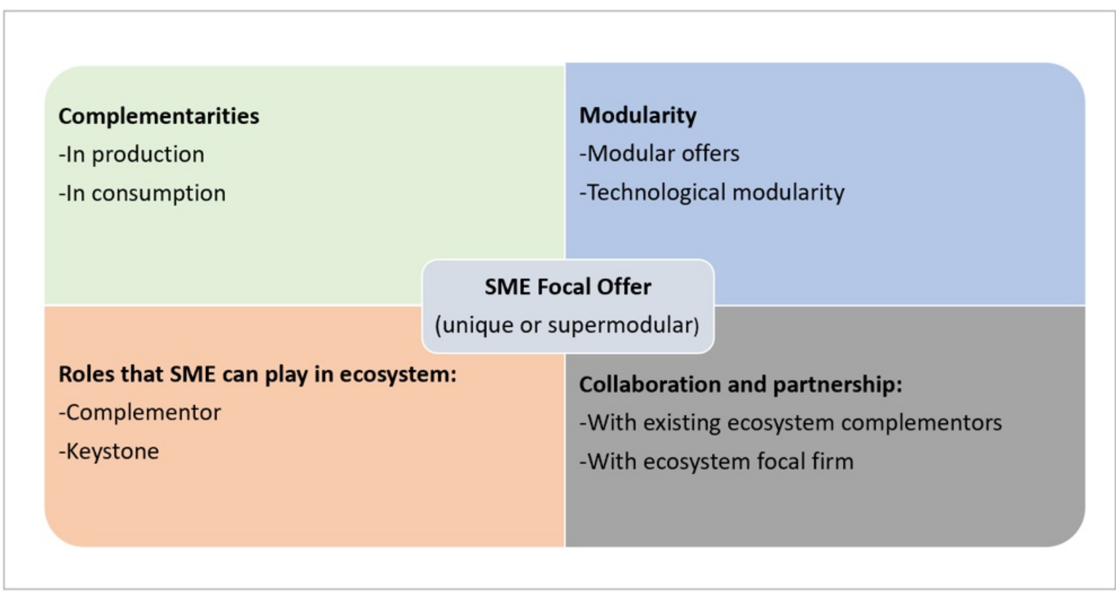

Figure 1. Ecosystem engagement stategy based on Jacobides et al. (20218)

- *Collaboration and partnerships*. SMEs need to establish partnerships and collaborate with existing ecosystem actors to interact with them and commercialize together offers that benefit the end customer. Technological modularity is a key element in enabling collaboration and coordination between SMEs and other ecosystem complementors.

- *Role that a SME should play in the existing ecosystem*. To successfully execute their ecosystem engagement strategy, SMEs should secure their role in a competitive ecosystem. A SME should assess whether it can join an ecosystem as a complementor or as a keystone that can shape the rules in the existing ecosystem. The latter is more difficult to achieve because to become an ecosystem keystone and prime mover of an existing ecosystem, an SME needs a superior product or service that is hard to replicate (Jacobides, 2019). For this reason, the common strategy mainly proposes SMEs to join as complementors.

2) Ecosystem engagement strategy based on a model that synthesizes findings from the literature.
The strategy described in this section is based on a model that more widely synthesizes findings from literature on ecosystems, representing the views of multiple authors. The proposed model (Figure 2) has three building blocks: 1) a SME's entry strategy, 2) outcomes of the entry strategy, and 3) ecosystem attributes that produce these outcomes. These building blocks are further elaborated after the illustration.

The synthesized model is based on five "ecosystem attributes" that consist of the following:

- *Ecosystem type*. In a digital world of connected interdependencies, firms need to analyze the ecosystem in which their product or service will operate. Before engaging in an ecosystem, a SME should decide on the ecosystem type they should engage to better strategize their ecosystem entry strategy.

- *Ecosystem shared objective*. Given that ecosystems are purpose-oriented, SMEs that want to engage in an existing ecosystem should make sure that what they will offer to an ecosystem is in alignment with the ecosystem's shared objective.

- *Number of dominant players*. The theory prescribes that ecosystems with more than one keystone player tend to be more innovative. Thus, if a SME

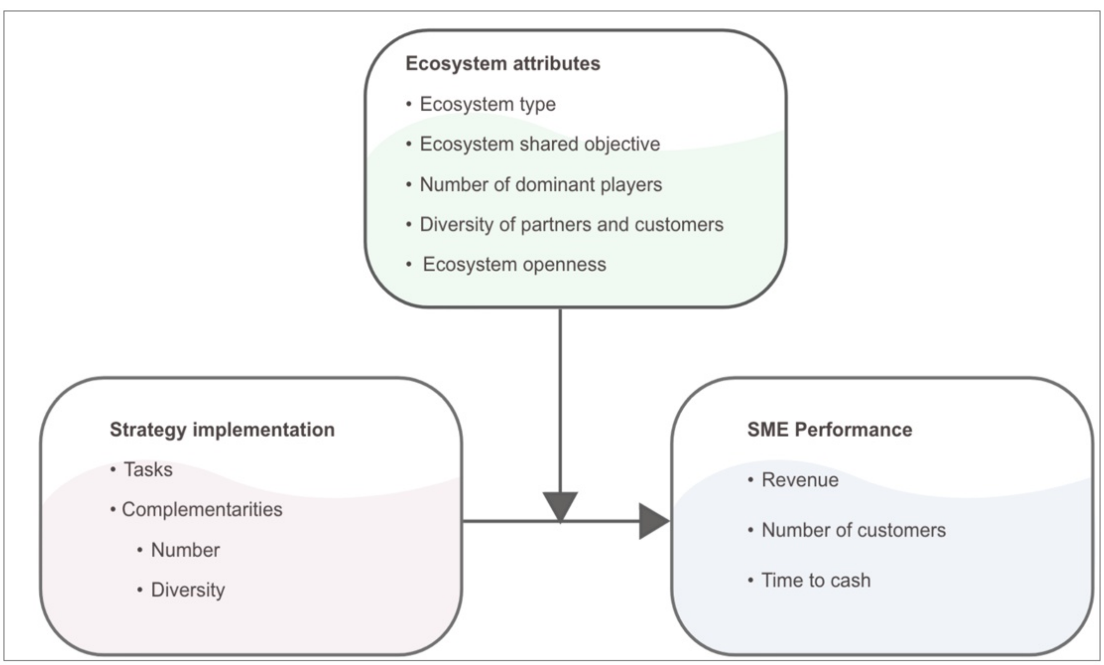

Figure 2. Model that describes what a SME needs to do to strategize its entry into an ecosystem.

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strives for innovation, it should probably look for ecosystems with more dominant players as keystones.

- *Diversity of partners and customers*. The more diverse an ecosystem is in terms of partners and customers, the more opportunities a SME can find for partnerships and collaboration. Further, diversity of partners and customers contributes positively to innovativeness.

- *Ecosystem openness*. Ecosystem openness has a great impact on a SME's entry strategy. An open ecosystem provides complementors with increased flexibility to engage in innovation and operations, while closed ecosystems tend to have tighter rules of engagement that ask for approval (Jacobides, 2019).

Regarding the outcomes, or the "SME's performance", the synthesized model focuses on three key performance indicators (KPIs), namely revenue, the number of customers, and time to cash. Finally, ecosystem "strategy implementation" is conceptualized to have two building blocks: 1) complementarities and 2) tasks sequence.

- Complementarities. Collaborating with existing ecosystem complementors is one of the strategies that SMEs can follow to engage in an ecosystem (Jacobides et al. 2019). A company that wants to join an ecosystem needs to start small to demonstrate impact in the ecosystem by integrating with existing ecosystem complementors to benefit from their established relationship, and then grow. If the SME holds an IP protected complementarity, the best approach to engage in an ecosystem is to establish partnership with a large complementor that could buy into it (Jacobides et al., 2019). Another option of selling a unique and supermodular complementor is by joining the ecosystem as a certified complementor solution provider to conform to a series of quality specifications in product design, and to pass a rigorous certification process conducted by the platform owner (Ceccagnoli et al., 2012). Table 1 shows six complementarities that can be grouped into unique and supermodular in accordance with the theory of ecosystems (see Jacobides et al., 2018).

- Engagement strategy tasks: Table 2 displays a list of engagement strategy tasks that a SME should perform to make its ecosystem engagement successful and achieve the desired outcome.

3) Ecosystem engagement strategy for a SME based on the Minimum Viable Footprint

Adner (2012) proposes that to successfully build value in an ecosystem, SMEs should follow a step-by-step approach and build initial value by using an ecosystem Minimum Viable Footprint (MVF) approach. This approach consists of "the smallest configuration of elements that can be brought together and still create unique commercial value" (Adner, 2012; Leavy, 2012). After building the MVF, the SME can use it as a base for enhancing the ecosystem's focal value proposition. In this vein, the MVF-based strategy allows SMEs to begin with a subset of problems that they are better positioned to solve and that ensure the highest level of ecosystem

Table 1. Diversity of complementarities based on Jacobides et al. (2018).

Nr	Complementarity	Type
1	More of X's product makes SME's product more valuable	Supermodular
2	More of SME's product makes X more valuable	Supermodular
3	SME's product requires X's product	Unique
4	X's product requires SME's product	Unique
5	X's product and SME's product require each other	Unique (co-specialization)

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Table 2. Engagement strategy tasks to achieve a SME's performance objectives

Nr	Task	Expected outcome	Required complementor(X)	Complementarity
1	Market research	• Identify the ecosystem the SME should interact with	Intermediary /Internal Sales team	SME's product requires X's services *(Unique)*
2	Engage in ecosystem with multiple keystone players	• Higher innovativeness	Ecosystem keystone	Interacting with more keystone players makes SMEs innovate more and their products more valuable *(Supermodular)*
3	Make your offer compatible with ecosystem shared objective	• Access to many customers • Increased chances to collaborate and partner with existing ecosystem actors	Ecosystem focal value proposition	SME's product requires integration with ecosystem focal product or service to provide a joint IP solution *(Unique)*
4	Provide a joint IP solution	• Integrating with platform solutions • Increase the total value to the customer beyond the existing solutions by integration	Platform owner	Existing ecosystem complementor's product and SME's product necessitate each other *(Unique)*
5	Establish partnership with existing ecosystem players	• Lower entry barrier • Co-create to leverage continuous innovation • Share resources and capabilities • Bridge a capital gap in SME's capabilities	Existing ecosystem complementors	Existing ecosystem complementor's product and SME's product necessitate each other *(Unique)*
5	Invest in novel technologies and AI	• Gain competitive advantage • Stay ahead of the game	AI solution providers	More of AI and novel technology makes SME's product more valuable *(Supermodular)*
6	Sell to existing ecosystem customers or complementors	• Generate revenue • Increase customer base	Customers and existing ecosystem complementor	X and SME require market transactions

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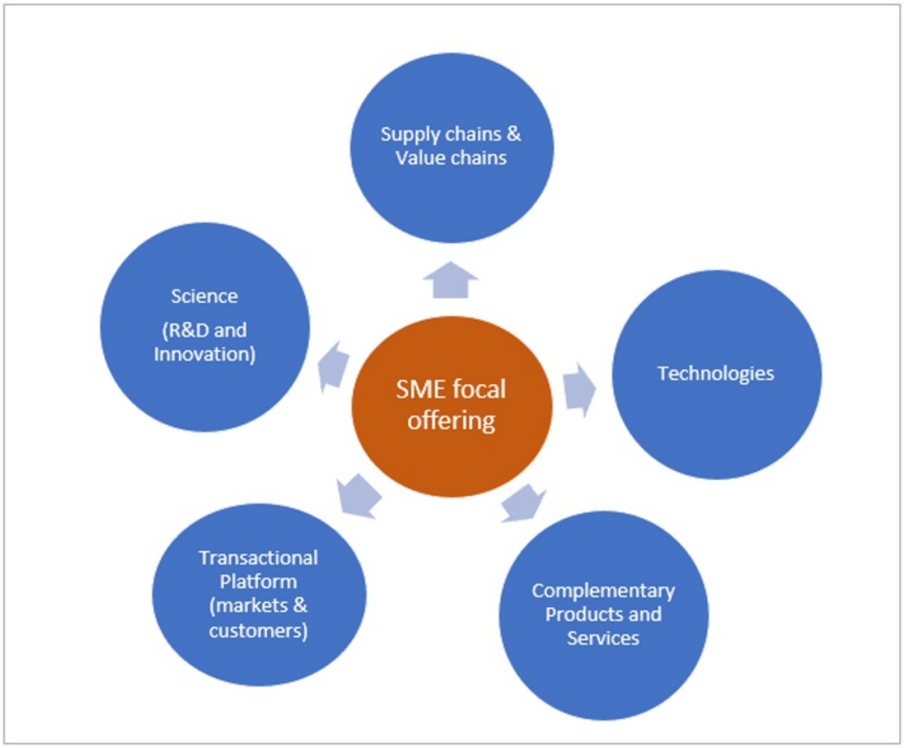

Figure 3. Sub-ecosystems that an SME can engage in based on its focal offer and desired outcomes

partners' motivation (Adner, 2012). This enables SMEs to strategize their ecosystem engagement with a limited scope (Heising et al., 2021) that seeks to achieve full scale by quickly establishing a dense network of partners and customers. In later phases, the SME can expand their value proposition by collaborating with new complementors. Overall, the MVF strategy is essentially a sub-ecosystem engagement strategy based on the SME's focal offer and the outcomes it wants to gain from engaging in a specific ecosystem (Figure 3).

A SME can create an ecosystem MVF by engaging in any of the following sub-ecosystems of an existing ecosystem:

- *Supply chains and value chains sub-ecosystem:* An SME should engage in this sub-ecosystem if its focal offer is related to accelerating digital transformation in logistics or creating value-added services.

- *Technologies sub-ecosystem:* In this case, a SME's engagement in the ecosystem consists in providing foundational technologies to the existing ecosystem.

- *Complementors sub-ecosystem:* In this case, the SME joins an ecosystem as a complementor by providing complementary products or services that complement (complete or bring to perfection) one or more existing products or services in the existing ecosystem.

- *Transactional platform sub-ecosystem:* Transactional sub-ecosystems are characterized by a central platform (for example, Amazon, Alibaba, Trip Advisor, and Google Play) that links independent producers of products and services with independent customers. In this type of sub-ecosystem, value creation is driven by the number of successful transactions (Pidun & Reeves, 2019). SMEs should engage in such an ecosystem when their intent is purely transactional, to buy or sell by getting access to the platform's existing market and customers. In this case, the SME's engagement in an ecosystem is low and the company is not significantly dependent of others in the ecosystem.

- *Science sub-ecosystem:* SMEs should engage in a science sub-ecosystem of an existing innovation ecosystem when their focal offer is 1) R&D services

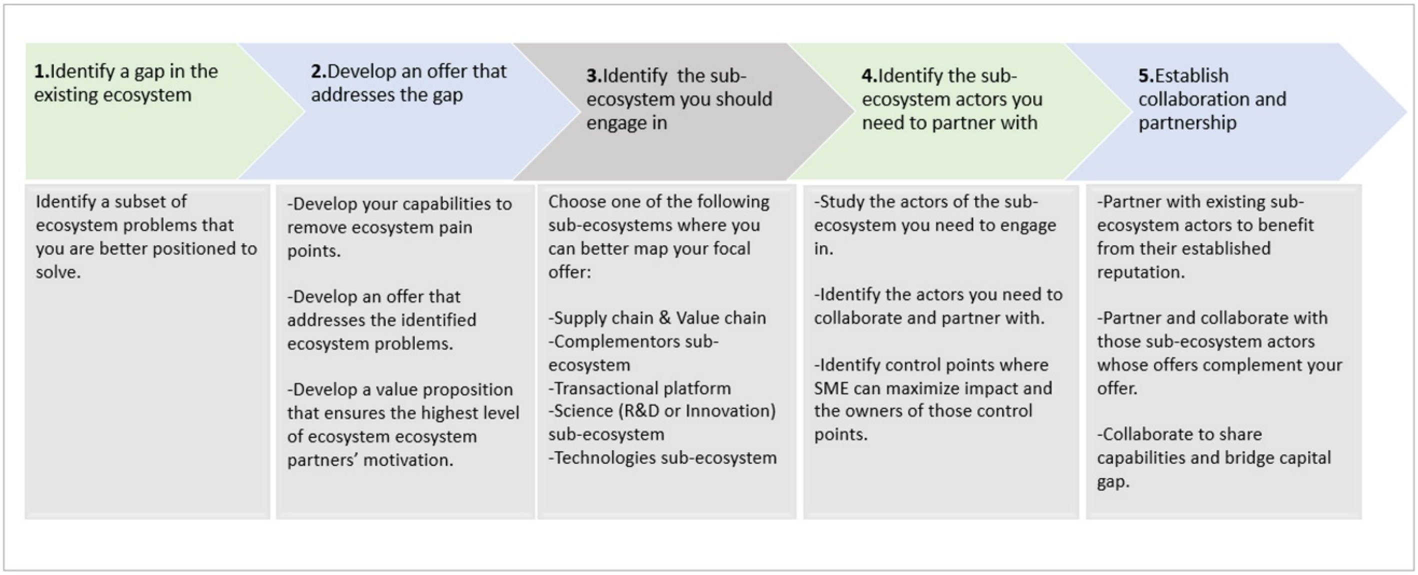

Figure 4. Process for an SME to enact MVF engagement strategy in a sub-ecosystem

or 2) a niche innovation. As a niche player developing foundational technology or products/services that complement the innovation ecosystem's focal value propositions, the SME should have a thorough expertise in a well-defined area that ties in well with the innovation ecosystem.

The identified process that will enable SMEs to enact their MVF engagement strategy consist of five steps as illustrated in Figure 4 and elaborated in the following.

1. *Identify a gap in the existing ecosystem that a SME wants to engage in.* To successfully engage in an ecosystem, a SME should start by identifying a subset of problems in the ecosystem and prioritize the ones that SME is better positioned to solve.

2. *Develop an offer that addresses the identified problem.* After identifying the ecosystem problem that it wants to resolve, the SME should develop an offer that addresses that problem and provide a compelling value proposition that ensures the highest level of ecosystem partners. This will enable the SME to gain competitive advantage over other SMEs that might try to address the same problem.

3. *Identify the sub-ecosystem within the ecosystem that a SME can better engage in.* To better enact its MVF ecosystem engagement strategy, the SME should choose a sub-ecosystem where it can map its focal offer in the ecosystem that it wants to engage in, by choosing among the following: i) supply chain and value chain sub-ecosystem, ii) complementors sub-ecosystem, iii) transactional platform sub-ecosystem, iv) science (R&D and Innovation) sub-ecosystem, and v) technologies sub-ecosystem.

4. *Identify and study the sub-ecosystem actors that a SME needs to partner and collaborate with.* Successful sub-ecosystem engagement requires SMEs to study the actors of that sub-ecosystem and identify the ones it should strategically collaborate and partner with. For this purpose, the SME needs to identify both control points within the sub-ecosystem where it can maximize its impact and who are the owners of those points.

5. *Establish collaboration and partnership with required sub-ecosystem actors.* After identifying the sub-ecosystem actors that it needs to collaborate with, the SME needs to establish partnerships and collaborate with those actors. By collaborating with them, the SME can benefit from the ecosystem actors' expertise and experience, as well as complement or share capabilities and bridge a capital gap.

Discussion and Conclusion

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This article aimed to explore applicable ecosystem engagement strategies from the perspective of SMEs as discussed in previous literature on ecosystems. The findings showed that various strategies are possible for SMEs to engage in existing ecosystems. The first strategy proposed in this project was based on the theory of ecosystems as articulated by Jacobides et al. (2018). The second strategy was built based on a summative model that synthesizes the findings from the literature by several authors, which also includes the definition and classification of complementarities proposed by Jacobides et al. (2018). Both strategies suggest that SMEs should collaborate with ecosystem complementors by mapping complementarities (in production/consumption) that are unique or supermodular. Another point of similarity between these two strategies is that they emphasize the importance of collaborations and partnerships with existing ecosystem actors.

The approach suggested in the third strategy is different from the previous two strategies, as this strategy is based on Adner's (2012) concept of Minimum Viable Footprint (MVF). It recommends SMEs to strategize their engagement in an existing ecosystem by identifying the minimum configuration of ecosystem elements they need to create and commercialize a unique value proposition. Further, the strategy recommends that SMEs should start small by engaging in a sub-ecosystem of an existing ecosystem and, only in later phases, expand its ecosystem presence by collaborating with new complementors or by providing further offers that add more value to the ecosystem's focal value proposition. The comparison of the three existing ecosystem entry strategies contributes to the literature on ecosystems (see, for example, Koch & Kerschbaum, 2014; Adner, 2017) by highlighting the differences between the strategies proposed in separate instances in the previous scholarly literature.

Implications to practice

The findings also contribute to the managerial practice of SMEs in multiple ways. The first identified ecosystem entry strategy informs SME managers that 1) complementarity, 2) modularity, 3) the role that the SME wants to play in an ecosystem, and 4) collaboration and partnerships with other ecosystem actors, are keys for successful engagement in an existing ecosystem. The second strategy suggests that, apart from the above listed four building blocks, a successful ecosystem engagement strategy requires SME managers to also consider the attributes of the ecosystem they want to engage in. The third strategy means that before entering an existing ecosystem, the SME needs to identify the MVF they need to establish in an ecosystem. To achieve this, the SME should start by engaging in a proper sub-ecosystem of an existing ecosystem. In so doing, the small business and its managers can increase their odds of success when entering into an ecosystem for value creation.

Limitations and future research avenues

There are at least three obvious limitations in this article. First, the article only examines a subset of literature on ecosystems, by focusing on studies related to three well-known types of ecosystems, namely innovation ecosystems, platform ecosystems, and business ecosystems. Scholarly studies focusing on other, perhaps lesser known and more novel types of ecosystems, such as digital ecosystems and partner ecosystems, were not included. The replication of this research by including other types of ecosystems could extend the generalizability of the deliverables. Second, the strategies provided in this article are general by their nature and are not specific regarding each possible scenario or outcome that a SME might have through ecosystem engagement. SMEs need to tailor their ecosystem engagement strategy based on other factors that are specific to the current SME's situation, or specific to the industry and environment that the SME operates in.

Third, this article does not include any quantitative assessment of SME ecosystem engagement strategies, nor did it collect any empirical primary data to support or illustrate the ideas drawn from the scholarly literature. For example, multiple case studies, let alone quantitative assessment of the strategies, would help to validate the theoretical constructs in a real-world context. Such approaches would allow observation and clarification of how applying strategies impacts SMEs' engagement in existing ecosystems. Further, the findings from such approaches could help to enhance the strategies and customize them based on SMEs' specific characteristics. Overall, future research could expand our understanding on ecosystem engagement strategies by including more ecosystem types and collecting information from SMEs that have engaged in existing ecosystems. Further, future research could study the sequencing and prioritization of engagement strategy tasks that SMEs can follow.

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Strategies for a Small to Medium-sized Enterprise to Engage in an Existing Ecosystem *Ermela Bashuri and Tony Bailetti*

About the Authors

Ermela Bashuri is a MEng graduate of Carleton University's TIM program. She also holds a MSc degree in European Economic Studies from the University of Tirana in Albania. Ermela is an experienced finance officer who has worked in the government, telecommunications, IT, and banking sectors. During her studies at Carleton University, Ermela held the position of Research Assistant and is currently working as a Business Analyst for Lixar IT (Lixar- BDO) in Ottawa, Canada. Her research interests include innovation ecosystems, e-commerce, and cross border trade.

Dr. Tony Bailetti holds a faculty appointment in Carleton University's Sprott School of Business and the Faculty of Engineering and Design (carleton.ca). Dr. Bailetti is the past Director of Carleton's Technology Management Innovation (TIM) program (timprogram.ca). He is the founder of the Scale Early, Rapidly and Securely community (globalgers.org) and the TIM Review (timreview.ca). He is the Chair of the Board of the Nigeria-Canada Trade and Investment Group (nctig.org). He is the lead for the AI for Local Value and Cross-border for Local Value, two global programs designed to scale the value of companies early and rapidly. His areas of expertise include: i) Technology entrepreneurship; ii) Scaling companies early, rapidly, and securely; and iii) Cross-border ecommerce.

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Keywords: Ecosystem, SME, Strategy, Engagement, Entry, Value creation, Complementarities

Integrated Test Sites for Innovation Ecosystems

Michaela Kesselring, Stéphane Ruiz-Coupeau, Moritz Kirsch, Frank Wagner and Richard Gloaguen

"To stay ahead in innovation, look at horizontal industries and the ones leading your current industry, someone is always doing something new."

Jeff Butler
Keynote Speaker/ Scholar

Natural test sites are resource-intensive and often limited to single industries or technologies. Drawing upon two strands of research into technology development and innovation strategies, the research question in this paper investigates how converging test sites may provide opportunities for multiple industries and regions. The paper analyzes multi-industrial test sites regarding, (i) the requirements of the social and physical environment, logistic requirements, as well as technical requirements, (ii) the added value for technology developers, as well as, (iii) the absorptive capacity of the region. Qualitative and quantitative research designs were adopted to analyze multi-industrial test sites. The results indicate that the suitability of multi-industrial test sites depends on the market and research fit of the test target, the quality of the benchmark data, as well as logistical, organizational, legal, social, and ecological factors. The study shows that multi-industrial test sites increase and strengthen the absorptive capacity of regions. Additionally, the study discusses managerial and political implications of multi-industrial test sites. Until now corporate and public test site practices have received only scant recognition in technology management literature, a gap closed by this paper.

Introduction

Performance uncertainty and switching costs often hinder novel technologies, methods, and tools (Guerin, 2000). Regulatory, scientific, engineering, and investment communities require proof of concepts to overcome adaptation reticence (Kreijns et al., 2018). Test sites are physical places where public or private entities allow technology developers and their customers to access and perform technology tests. However, demonstrating the performance of technologies such as sensors comes with several requirements. Requirements include detailed knowledge of the test sites, testing, and land access permits, and compliance with socio-economic and ecologic conditions of the host country (Kesselring et al., 2020).

The literature on test sites and their development is scarce. Previous work has focused on technical specification, reports, and maintenance manuals. It appears that test site literature hardly includes new findings in innovation management or technology development. For example, scholars such as Zhao et al. (2018) report that pooling skills across industries can increase the understanding of technologies and decrease duplicate research. Contrary to these insights, most of the test sites today cater to single industries only. Examples supporting this statement include the Kauring test site for mineral exploration (Lane et al., 2009), the Järvselja test site for forestry applications (Kuusk et al., 2005), and the agricultural test sites in Groß-Umstadt (Borg & Fichtelmann, 2014). In addition, existing sites elaborate on the technical and economic potential of testing. Other emerging criteria such as social (for example, distance to residential networks or acceptability) or environmental (for example, distance from areas of environmental interest) have seen little consideration (Vagiona & Kamilakis, 2018). Reasons for omitting the emerging criteria involving test sites include economic and industry constraints.

On a similar note, innovation management literature reports that innovators' geographical proximity and connectivity increase the absorptive capacity of regions (Jong & Freel, 2010; Cortinovis & van Oort, 2017). Proximity and connectivity could imply co-location of similarly geared industries for test sites (for example, agriculture and forestry test sites). Surprisingly, a

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systematic understanding of spatial dispersion of test sites is lacking.

In this context, the question emerges about how the expansion of test sites beyond a single industry might benefit technology developers, that is, whether technology developers from multiple industries can develop proofs of concept in the same physical environment. In this way, technology developers might be able to: (i) exploit the potential of their existing technology and rapidly move innovations toward implementation, while (ii) exploring new angles to innovation management and technological innovation. This document seeks to analyze the concept of what we call “integrated test sites”. The term defines integrated test sites, as test sites which multiple industries and technology developers can use to improve or demonstrate their technologies. The objective of this research is to assess how converging test sites may provide opportunities for multiple industries and regions.

The study follows a mixed-method case-study design, with in-depth analysis of (i) the requirements that a physical environment must fulfil to cater to more than a single industry, (ii) new innovative angles to test sites, and (iii) support the absorptive capacity of regions. With experts from groundwater exploration, environmental sciences, civil engineering, agriculture, forestry, archaeology, cultural heritage, geothermal sciences, and military applications, this research analyzed the case of European Reference Sites (ERS) for innovative and non-invasive, but fully acceptable exploration technologies.

The following research takes the form of five sections. Drawing upon research into technology development and innovation strategies this paper begins with a literature review. It will then outline the research design and methodology used. The next section presents the results of the quantitative and qualitative data collection. The subsequent section discusses the findings of the research, focusing on the two key themes of requirements for and innovativeness of integrated test sites. The paper closes discussing limitations and future research requirements in the last section.

Literature Review

Natural Test Sites

Natural test sites allow for the testing "of technical and other aspects of a new technology [..] in a limited, but real-life environment" (Ballon et al., 2005). For technologies where the end-setting is a natural environment, field studies are crucial. Here state-of-the-art test laboratories and simulation models often fail to replicate an end-setting that is as complex as nature (Yang & Steensma, 2014). Across disciplines in natural sciences, challenges such as accessibility of the test target (for example, in forestry and mineral exploration) or dusty environments (for example, at mine sites) hold. Consequently, a broad range of industries employs similar applications and technologies. One example is Uncrewed Aerial Vehicle-LiDAR data, used for mineral exploration (Raval, 2018), archaeology (Inomata et al., 2017), environmental management (Charlton & Ternan, 2002), cultural heritage documentation, forestry (Cunningham et al., 2006), and agriculture (McCoy et al., 2011) alike. Common test and demonstration targets suggest that a single natural test site could serve more than one technological branch.

At present, however, test sites are mostly limited to one single branch of technology. Innovation literature nevertheless suggests the economic and technological advantages of joint test site usage (Ji, 2019). Economic reasons come down to transaction costs, by reducing overhead for license and permit management (Kreijns et al., 2018). From a technological perspective, joint test sites would lead to the acquisition of different pheromones (for example, different physical properties). Different data may increase the context essential to judge the accuracy of test outcomes (Christiansen et al., 2011).

All these outlines suggest that integrating additional branches into one natural test site might be feasible and increase the innovativeness of the test site. Throughout the paper the term “integrated test sites” will be used to describe test sites that can be used by different branches. Hence, integrated test sites are test sites that provide a research and development infrastructure for different industries and technologies.

Requirement Modelling for Joint Innovation

Requirement modelling is a common approach to identify test site locations (Li et al., 2016). The most common requirements are political, economic, social, technological, legal (Vagiona & Kamilakis, 2018; Spyridonidou et al., 2020), and environmental factors (Vagiona & Kamilakis, 2018). Within a region, economic, social, political, and legal aspects remain relatively fixed. Conversely, environmental conditions (for example, vegetation, topography, logistics) are variable (Vagiona & Kamilakis, 2018). As environmental conditions change, some places within the same regions can be more suitable than others. Reasons include the type of topography, vegetation, or artificial infrastructure. Literature by Apfelbeck, Kuß, Wedler, Gibbesch, Rebele, and Schäfer (2009) indicated that environmental factors are increasing in importance. Light pollution (Papalambrou & Doulos, 2019), fauna, and flora protection are topics to consider in this context (Apfelbeck et al., 2009). Depending on the test target, the importance of single requirements differs. Several studies show how to weigh the importance of requirements (Vagiona & Kamilakis, 2018). However, little is known about the characteristics that define joint testing spaces. Missing requirements challenge the feasibility of integrated test sites.

Absorptive Capacity
Scholars argue that physical spaces where innovators co-exist allow companies to exploit the capability of their existing inventions while exploring new angles to innovation (Audretsch & Feldman, 2004; Davies et al., 2020). Exploratory innovation strategies relate to radically new products, services, technologies, or the penetration of new markets (Danneels, 2002; Benner & Tushman, 2003). In contrast, exploitative innovation strategies utilize existing sources of knowledge and structures to optimize features and increase technologies, services, and products (Danneels, 2002). According to Jansen, van den Bosch, and Volberda (2006), exploratory and exploitative innovation are critical to remaining competitive. A fundamental challenge is to realize both concepts at an early stage in the technology development cycle. In doing so, Geiger and Makri (2006) argue that it enhances the absorptive capacity of organizations and regions. Innovation clusters (for example, start-up ecosystems) already support and reinforce the absorptive capacity of companies, industries, or entire regions (Jansen et al., 2006). Similarities to innovation clusters may be observed when considering integrated test sites.

Methodology

Research Method
Investigating exploratory and exploitative innovation through integrated test sites is a complex task. Qualitative research designs are often used to analyse complex topics. Sampling methods include interviews, (participant) observation, ethnography, as well as group discussion and focus groups (Hennink et al., 2019). Critics argue that qualitative data is often subjective and flawed by researcher biases. Quantitative research, in contrast, involves a numerical data collection procedure (Watson, 2015). To test hypotheses or gain new insights, quantitative research data is statistically processed. The statistical approach reduces research bias. Critics argue, however, that quantitative research is limited by the descriptiveness of mathematical sample processing and is mostly explanatory (Choy, 2014).

To overcome the limitations of each method, McGrath and Kravitz (1982) encouraged the combination of qualitative and quantitative research within one or more interrelated studies. By combining qualitative and quantitative data, a more informed picture about reality emerges. Innovation research in particular as a result sees rising interest in mixed methods (Wipulanusat et al., 2020). Reasons are the type of research questions asked and the requirement to involve interdisciplinarity to answer the research questions.

For the present study, mixed-methods were found to be appropriate as they (i) help to address, refine, and assess a common objective, (ii) add breadth to scholarly interaction for inter- and multidisciplinary subjects, (iii) elucidate more information from only quantitative or qualitative research alone, and (iv) have proven appropriate for the analysis of practically oriented topics in technology and innovation management Our research team developed strict procedures in collecting and analyzing data to increase the validity and reliability of the research results (Leech et al., 2010). The present study contributes to theory-building through dialectic interaction between field studies and existing theory.

Case Selection
This study investigates how different industries and technologies can benefit from the EU-funded INFACT test sites, referred to above as ERS. What we call “ERS” is a test site infrastructure for mineral exploration technologies. Four test sites, one in Finland and Germany respectively, and two in Spain, constitute the core of ERS. The test sites have extensive physical resources capable of catering to technology developers beyond mineral exploration (for example, hydrology, geophysics, archaeology, unexploded ordinances).

The physical environments of ERS are characterized by a diverse set of technical, social and ecological conditions and have the potential to cover many applications. In addition, benefits to the creative economy of ERS-hosting regions have already been explored (Kesselring et al., 2020).

Currently, the test sites cater to a single sector, which is mineral exploration. Integrating additional branches into ERS might increase the possibility of exploiting proof of concept, while exploring new angles to technology development (Ji, 2019).

Samples
For sampling, we conducted two focus group workshops. Initially, we approached 60 companies and universities from the branches of mineral and groundwater exploration, environmental applications, civil engineering, agriculture, archaeology, cultural heritage, geothermal, and mining. The final participation was 39 experts. An expert here means an individual who has experience in interdisciplinary exchange between their industry and the mineral exploration sector.

We selected the companies and universities based on whether they operate a technology or research technologies, processing methods, or platforms that require proof of concepts. Purely service-based firms, such as consultancies, were not part of the sample. Participants originated from Spain. The sample selection allowed us to investigate diverse groups of test site users, which typically have comparable systemic requirements (Freeman, 2006). The data were obtained through online meetings conducted in July 2020.

Study Design
The study period fell in the COVID-19 pandemic, which banned physical meetings. As a result, the study employed MSTeams as a communication platform, Mentimeter (www.mentimeter.com) for empirical data collection, and padlet (www.padlet.com) for documenting qualitative input and real-time assessment. Mentimeter is a web-based, real-time polling system. Padlet provides an online, real-time interface that encourages participation and evaluation of each research participant.

For qualitative data collection, the participants were asked to discuss which requirements a test area should have. The participants were encouraged to note the requirements on padlet, write down insights, freely discuss open topics, and exchange their thoughts. The initial data collection via padlet helped to clarify the statements and prevent misunderstanding. The follow-up interpersonal communication between participants helped to clarify similarities and differences in their accounts. Padlet was displayed and open for posting during the whole session. In that way, participants could capture their thoughts during the discussions and make connections between their statements and the statements of others.

We obtained the empirical data through an online survey via Mentimeter. Of the 39 participants, the researchers received 37 responses. Given the focus group design, the response rate is not representative. The online survey consisted of 3 parts. The first two parts targeted (i) the exploratory, and (ii) the exploitative potential of integrated test sites, followed by (iii) the potential to increase absorptive capacity. For both exploratory and exploitative innovation strategy, we identified five research items from Jansen et al. (2006).

Table 1. Research Items for the quantitative data sample

Exploratory	Exploitative	Absorptive Capacity
Interdisciplinary cooperation	Cooperation within industries	Quality of regional innovation sources, e.g. cooperation
New collaboration	Deep existing collaborations	Increasing R&D expenditure
Visibility beyond the own industry	Visibility of the company in the industry	Increase the region's innovation infrastructure, e.g. investment opportunities
Creative thinking	Knowledge gains	Optimize the culture of innovation in the region, e.g. open innovation
Develop new markets	Customer satisfaction	Contribute to improving regional competitiveness, e.g. workforce, GDP, exports

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Table 2. Mixed Methods Study Design

Agenda point		Description
1	Introduction	Introducing the concept of (integrated) test sites.
2	Theoretical Background	Introducing characteristics of exploitation and exploratory innovation strategies. The material presented was aligned to the definitions of Jansen et al. (2006).
3	Quantitative Data Collection	5-point Likert scale-based evaluations of the potential impact of integrated test sites on absorptive capacity, exploratory and exploitative innovation. The questionnaire was aligned with the work of Jansen et al. (2006). Data collection followed Sulivan et al., (2012)
4	Qualitative Data Collection	Open discussion to elaborate the requirements of integrated test sites. Discussion points were captured on padlet. The discussions followed the principles of openness by Mayring and Fenzl (2019).
5	Closing Note	Closing statements and clarification of open topics and questions.

We also adapted five items from Fernhaber and Patel (2012) measured absorptive capacity. Table 1 lists the items.

The participants were able to rate each item on a 5-point Likert Scale. The range was between 1 (strongly disagree) to 5 (strongly agree). Reflective scales were used for all constructs (Diamantopoulos & Winklhofer, 2001). The mean for the individual items was displayed after all responses were captured.

Participants were encouraged to question the overall approach and each others' responses to generate comprehensive, unbiased insights. The sessions lasted 2 to 2.5 hours. The sessions only ended when the topics were covered to the satisfaction of all the participants. For previous similar projects, researchers have mainly used face-to-face focus groups. Table 2 illustrates the five parts of the study.

The workshops were recorded and we transcribed the recordings. The criteria for achieving methodological trustworthiness that guided the research include validity, reliability, and robustness (Lincoln & Guba, 1990). We examined quantitative data using analysis of means and variances. Using content analysis, we analyzed the qualitative data. The contents were compared and carefully discussed. If necessary, synonymous statements of participants were synthesized. Lastly, the content data were juxtaposed and analyzed for balancing and reinforcing interdependencies.

Results

Integrated Test Site Requirements

Six aspects that determine the suitability of integrated test sites emerged from the qualitative research. Namely: operations, physical environment, technical infrastructure, and legal environment, as well as organizational infrastructure and operational infrastructure. Within each aspect and requirement category, we identified subfactors. Table 3 illustrates a formulation of our critical findings.

In a second instance, the participants discussed how the requirements are influenced by and likewise influence the attractiveness for different interest groups. We identified three interest groups, namely, policymakers, test site users, and companies. Participants identified two levels of requirement and interest group interplay. First, the local and thus site-specific level. Second the regional level. Starting with the local level, participants indicated that policymakers could influence:

i. The operational infrastructure through investment in logistics.

ii. The legal environment through reducing bureaucracy barriers.

iii. The technical infrastructure by making proprietary data available.

Adding to this, the degree to which an area meets or

Table 3. Integrated Test Site Requirements

Operations

Technical
- Disturbance reduction

Social
- Operations in accordance with protective measures for fauna and flora

Environmental
- Operations in accordance with protective measures for fauna and flora

Technological Perspective

Physical Environment

Test target
- Topography and geology
- Land-use diversity (e.g. archaeology, mining)
- Different test context (antrophothenic, physical, chemical, biological)
- Different interlocking contexts

Test area
- Availability of different physical parameters
- Public benchmark datasets

Technical Infrastructure

Detailed site model
- Availability of different physical parameters
- Public benchmark datasets

State of the art technology
- State of the art technologies of the respective industries were tested at the very site

Infrastructure

Organizational Infrastructure

Open and evolving infrastructure
- Reference support system
- Joint data portal
- Documentation of activities performed for networking
- Environmental, geophysical, and related challenges are reported and outlined

3rd party verification
- Allow technology analysis by neutral, disinterested parties

Communication
- Comprehensive communication management

Operational Infrastructure

Accessibility of test area
- Roads
- Existence of runways

Internal infrastructure
- Test area access roads
- Grid structure
- Aviation zones
- Broadband infrastructure

Legal Infrastructure
- Permits
- Accessibility
- Legal security

exceeds requirements concerning the physical environment, the operational infrastructure, the legal environment, and the technical infrastructure positively influences its suitability for cross-industrial testing. At the regional level, participants argued that social and environmental protection and maintenance are essential. The organizational infrastructure, however, was not subject to interest group alignment.

Figure 1 illustrates the identified dependencies and dynamics at integrated test sites. Within the figure, the direction of the arrow indicates the direction of the relationship. The notation used on the arrow is [relation (+); variable; object]. For example, the notation [+ Level of Fulfillment; Attractiveness] reads as follows: as the level of fulfilment of criteria x increases, the level of attractiveness of the test site increases.

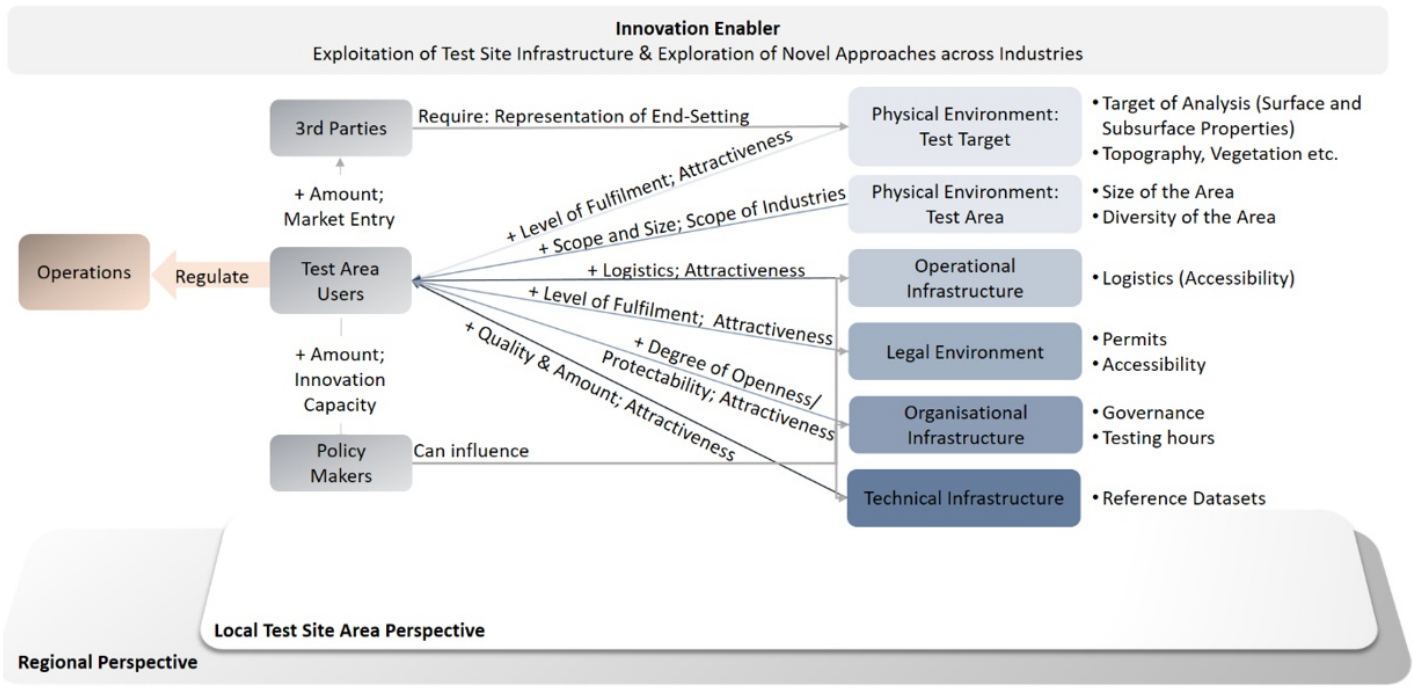

Figure 1. Integrated Test Sites, Interplay and Boundary Conditions

We analyzed the impact of integrated test sites on innovation through quantitative evaluation. The participants ranked the likelihood to which integrated test sites might be beneficial, in descending order. For each category —exploratory and exploitative innovation and absorptive capacity —we designed a pre-defined set of questions. Statistical data analysis of responses to the questions included derivation of the mean (M) and standard deviation (SD).

Table 4 displays the outcome of our quantitative data analysis. During the study, participants evaluated each item (for example, interdisciplinary cooperation, new collaboration). The study framed the questions as follows: “How well do integrated test sites support [item]”.

Table 4. Factor Evaluation Metrics for Exploratory, Exploitative an Absorptive Capacity

Exploratory	**M**	**SD**	**Exploitative**	**M**	**SD**	**Absorptive Capacity**	**M**	**SD**
Interdisciplinary cooperation	4.3	0.36	Cooperation within industries	3.9	0.95	Quality of regional innovation sources	3.82	0.77
New collaboration	3.78	0.80	Deep existing collaborations	3.87	0.99	Increasing R&D expenditure	3.85	0.90
Visibility beyond the own industry	3.65	0.90	Visibility of the company in the industry	3.75	0. 90	Increase the region's innovation infrastructure	3.85	0.89
Creative thinking	3.59	0.89	Knowledge gains	3.83	0.90	Optimize the culture of innovation in the region	3.7	0.99
Develop new markets	3.07	0. 99	Customer satisfaction	3.26	0. 89	Contribute to improving regional competitiveness	3.65	0.92

Overall, the data show that integrated test sites add to the exploitative and exploratory innovation of industries and support the absorptive capacity of an industry and region.

Innovative Capacity of Integrated Test Sites
The research juxtaposed three concepts to analyze the relationship between exploratory and exploitative innovation, and absorptive capacity. The group discussions informed the juxtaposition. The analysis merged the qualitative and quantitative data. The debate showed that a simplification of the five capacity items is possible. The participants summarized the R&D expenditures and innovation infrastructure according to "Funding Availability".

Figure 2 shows the overall contribution of exploitative and exploratory innovation to innovation capacity. The illustrated ties indicate how participants recognize that exploitation and exploratory innovation contribute to absorptive capacity. During the discussion, we identified the moderators of exploratory and exploitative innovation. Data sharing, quality of data, and linkages are moderators for exploitative innovation. Data sharing was also recognized as an exploratory moderator. Participants recognized that lateral exchange between different parties supports innovation. Moreover, the quality of test site users strongly influences the ability to innovate through integrated test sites.

Next, we discussed dependencies between absorptive capacity and integrated test site requirements. In the absence of a holistic and logico-rational framework, the analysis of the interplay was fragmented. Putting exploratory, exploitative innovation, moderators, and requirement fulfilment into perspective helped to analyze the interplay. Figure 3 illustrates the operating direction of each factor regarding their interplay (direct >> or reverse).

The type and dimensions of innovation were understood and appraised at the macro level in three categories (axes). These axes determine, compare, and evaluate microlevel activities and areas with potential benefit. The Y-axis represents the exploitation of existing resources (including available data) and cooperation. The Z-axis is the exploratory axis. Exploratory activities relate to the exploration of novel sources of information. As shown in Figure 3, this axis illustrates the degree of openness. Openness was identified as a precondition for exploratory exchange.

The X-axis is the degree of requirement (Figure 1). The higher the requirement fulfilment, the higher the diversity of technical backgrounds and industries at a site. The more significant the amount of test site users, the higher the availability of resources (like data). Summing it up, the Y-axis sets the degree of openness upon which the Z-axis builds and dictates the amount of available data, as well as the quality of linkages through its particular function.

The interdependencies indicate that overemphasizing either exploitation or exploratory innovation strategies may lead to shortages and unsatisfactory payback of test site operations.

Discussion

This study examined the relationship between integrated technology test sites and their innovation potential. Technical, environmental, organizational, and

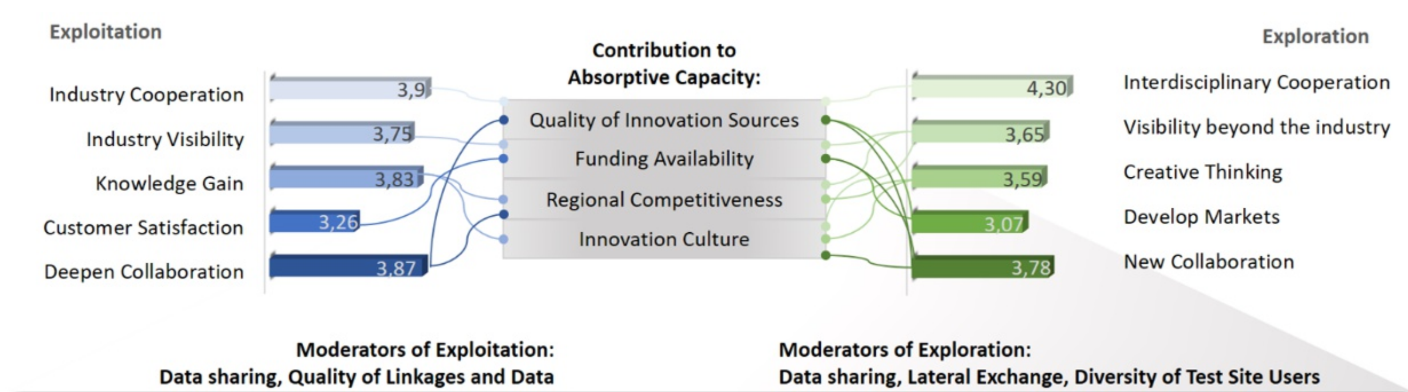

Figure 2. Expected Exploration, Exploitation, and Absorptive Capacity Potential

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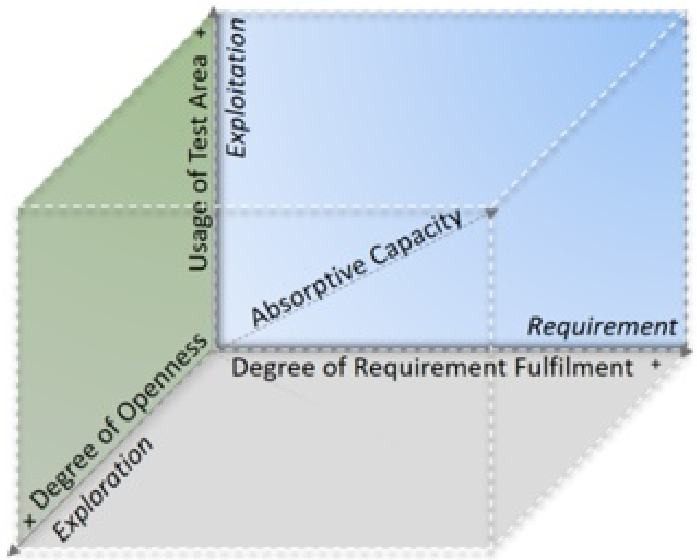

Figure 3. The three-axes of innovation capacity at test sites: Y (Exploitation), X (Requirement Fulfillment Axis), and Z (Exploration)

operational characteristics and industry conditions dictate the general feasibility of integrated test sites. The findings help to prioritize areas and evaluate different integration scenarios.

According to the results, fixed and variable conditions exist. Fixed conditions relate to natural conditions, such as geology and topography. Variable conditions include the infrastructure at and around the test site. The study showed that integrated test sites support the exploitation and exploration of innovation sources depending on the requirement fulfilment. The study found that heightened access or visibility of innovation sources increases the absorptive capacity of a test site region.

Absorptive capacity has a higher positive relationship with exploratory innovation than exploitative innovation (see Figure 2). The approach's novelty and expected benefits from interdisciplinary exchange account for the unbalanced recognition.

The fulfilment of fixed and variable requirements shapes capacity-related outputs. The results indicate a co-dependence between the realisation of integration requirements and the degree of absorptive capacity. According to the results, absorptive capacity results from exploitative and exploratory innovation aspects, which mediate the degree of integrated requirement fulfilment. Unsurprisingly, the degree of requirement fulfilment heightens the number of potential customers and, therefore, the overall chances of realising exploitation and exploration of innovation sources.

Together the findings support the conceptual premise that integrated test sites add value beyond a single industry. Previous authors such as Audretsch and Feldman (2004), analyzed geographic requirements together with technological proximity, while Yang and Steensma (2014), as well as Davies et al. (2020), added the perspective of innovation ecosystem analysis. This paper adds to these studies a novel approach by introducing “moderators” for early-stage technology development in ecosystems. The study expands thereby the literature by identifying that for technology development-centred ecosystems, moderating factors for cross-lateral exchange include interdisciplinary cooperation and mutual openness on data-related and technology-related topics. The research insights imply that multi-criteria requirement design can enhance an ecosystem's turnover.

Conclusion

The findings of this study show that expanding technological initiatives across industries enables the exploration and exploitation of technical knowledge. Both exploitative innovation and exploratory innovation strategies may result in increasing the absorptive capacity of regions and companies. Multidisciplinary networking enhances exploratory innovation potential.

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Exploiting performance improvements and data-driven learning enables companies to optimize their technologies alongside existing innovation trajectories. Participating in exchange-driven ecosystems can lower innovation barriers with a resulting increase in absorptive capacity.

Being limited to focus-groups, the study lacks an in-depth understanding of the motives behind the requirements and scoring. The heterogeneous sample allowed us to reflect the multidimensional issue of integrated test sites. However, the sample did not include social sciences. Not considering the knowledge of social scientists, the results have limited generalizability involving governance and legal conditions. The study was limited to Spanish and German experts, which raises the possibility of regional and cultural biases.

The idea for integrated test sites originated from an EU-funded project, initially designed only for trialing mineral exploration technologies. The research on ERS' integrated test sites showcases how the integration of different disciplines can increase innovation outputs of grants. The research suggests that current funds do not fully exploit the innovation potential of integrated test sites. Cooperation between other technology developers and industries can also increase the innovative potential of projects.

The study shows that both individual companies and regional governments can benefit from interdisciplinary collaboration involving test sites. To increase the absorptive capacity of test sites, policymakers can provide both logistical and legal support. Policy support is especially relevant, where inefficient bureaucracy increases the time to bring initiatives into operation. We found that sharing and exchanging knowledge supports the quality of linkages, cooperation, research institutions, and universities. Hence, integrated test sites can be transformed into innovation ecosystems.

Future research could add value by analyzing the numerical relationship between exploratory innovation, exploitative innovation, and absorptive capacity in more depth. For more informed site selection, studies following this one could assign weights to the identified requirements. Randomized trials under controlled conditions could provide results with more definitive evidence about the moderating roles of requirements and innovative strategies in developing integrated test sites.

The information from the study can be used to develop targeted strategies for expanding current test sites. We believe it should be a priority for future projects to ensure the consideration of innovation strategies, and inclusive requirement mapping for test sites.

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About the Authors

Michaela Keßelring, obtained her M.Sc. in Industrial Management from the Friedrich-Alexander University Erlangen-Nürnberg, Germany in 2018. Since then, Michaela Keßelring has been working as a research fellow at the University of Stuttgart, at the Institute for Human Factors and Technology Management. Her expertise lies in technology management with a focus on sustainable R&D, Advanced Systems Engineering and Strategic Cooperation. Michaela Keßelring is affiliated with the University of Stuttgart, Institute for Human Factors and Technology Management (IAT).

Stéphane Ruiz-Coupeau studied industrial engineering at the University of Malaga and receive a master's degree in European business at ESCP Europe. Currently he is a PhD candidate at the University of Seville in international business and strategy. He has a sound experience in giving advisory, partnership and innovation management services to local companies willing to innovate and grow internationally. He co-leads the Enterprise Europe Network activities in the region (Andalucia) from his position as project officer at the Agency of Innovation and Development of Andalucía IDEA. Stéphane Ruiz-Coupeau is affiliated with the Agency of Innovation and Development of Andalusia in Málaga, and the Department of Accounting and Financial Economics at the University of Seville, Spain.

Integrated Test Sites for Innovation Ecosystems

Michaela Kesselring, Stéphane Ruiz-Coupeau, Moritz Kirsch, Frank Wagner, Richard Gloaguen

In 2007, Dr. Moritz Kirsch obtained a M.Sc. in Geology at the Technische Universität Bergakademie Freiberg, Germany. He earned his Ph.D. degree in 2012 in Earth Sciences at the Universidad Nacional Autónoma de México. After that, Moritz Kirsch joined Helmholtz-Institute Dresden Rossendorf (HZDR). At HZDR, he is the Group Leader in "Outcrop Exploration and Geological 3D Modelling". His research fields include tectonics, structural geology, and magmatic processes. Moritz Kirsch is affiliated with the Helmholtz Zentrum Dresden Rossendorf, Helmholtz Institute Freiberg for Resource Technology in Freiberg, Germany.

Prof. Dr. Frank Wagner is an engineer with more than 25 years of experience in applied research and industrial R&D management. Prior to joining the University of South Australia as Dean of Industry and Enterprise, he was head of Strategic R&D Management at Fraunhofer Institute for Industrial Engineering IAO, part of Fraunhofer, Europe's largest application-oriented research organisation. Frank Wagner is still affiliated with Fraunhofer IAO in Stuttgart, Germany and is also an Adjunct Professor at QUT, Queensland University of Technology in Brisbane.

Dr. Richard Gloaguen is head of the Division of Exploration at Helmholtz Institute Freiberg for Resource Technology. He earned his doctor's degree (Doctor Communitatis Europeae) at the Universities of Brest (F) and Göttingen (D), as well as at the Royal Holloway University of London (GB) in the year 2000, which was then followed by a post-doc position. In 2003, he was appointed to a junior professorship in remote sensing at TU Bergakademie Freiberg. In 2013, he changed to HZDR. His professional focus and experience are on quantitative, non-linear analysis of remote sensing data. He serves on the editorial boards of various journals and has published more than 80 peer-reviewed articles in remote sensing and geo sciences. Richard Gloaguen is affiliated with the Helmholtz Zentrum Dresden Rossendorf, Helmholtz Institute Freiberg for Resource Technology in Freiberg, Germany.

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How Can Firms Effectively Use Technology in Customer Journey Management

William Boscardini Helouani

> *Everyone from the CEO down to the contact center agent should know what it feels like to be a customer.*
>
> Blake Morgan
> Keynote speaker, best-selling author & futurist

Customer Journey (CJ) mapping offers a view of the Customer Experience (CX) from a customer's standpoint, which acts as the first step towards a myriad of actions that can be performed to improve CX. While CJ mapping has proven to be helpful in a wide range of use cases, companies still struggle to apply technology to make it effective. This research performs a literature review to identify how IT and digital assets can be used in the CJ context, providing practical examples for organizations willing to implement a consumer-centered IT strategy. As a result, it was found that IT can be used in three primary contexts for CJ: mapping, enabling, and monitoring.

Introduction

As societies and markets are being continually transformed by digital technologies, the workaround where the customer is found has become complex, going through multiple ordering channels, interactions, advertisements, and influences, with a mixture of both physical and digital touchpoints. Under this reality, organizations rely on a digital transformation to enable customer-centricity and improve customer experience (Columbus, 2020). A recent study estimated that 55% of organizations with high digital maturity focus on digital transformation to create a unified customer experience (Gurumurthy et al., 2020).

The restrictions imposed by the Covid-19 pandemic have impacted the Consumer Journey (CJ), pushing organizations to quickly adapt by embedding digital-led experiences to overcome limitations on even simple activities, such as going out to a grocery store or dining in a restaurant (Diebner et al., 2020). Organizations need a Total Experience (TX) strategy to continuously enhance their Customer Experience (CX) and Employee Experience (EX), especially while these interactions become more digital, mobile, and distributed (Wong et al., 2021). CJ mapping is the first step toward improving the TX by identifying how their CX currently looks and where it can be improved.

A global Gartner research assessing companies that have mapped their CJ revealed that for 54% of them, their artifacts became wall art, as they failed to create digital services and IT developments that improved customer experience (Chiu & Daigler, 2019a). Moreover, firms expect from technology a 360˚ view of the purchase stages in order to identify which stage of the journey each customer is on, with all the many variables involved, thereby creating abstract and unrealistic expectations (Davis et al., 2019).

Academic and business literature has explored CJ and CX topics through a myriad of use cases within marketing and service research perspectives. A recent study around methodology used on 143 CX research papers revealed that they rely on surveys (31.15%) and conceptual models (20.28%), with very few practical implications (De Keyser et al., 2020). Although a vast majority of CJ research cites technology broadly (as in Hamilton et al., 2020; Nam & Kannan, 2020) or specifically (as in Graves et al., 2019; McColl-Kennedy et al., 2019; Campbell et al., 2020), the literature still lacks a practical information systems approach that could handle the emerging CJ challenges currently amplified by Covid-19.

The present research study summarizes the results of a literature review to identify how IT and digital assets can be effectively used in CJ efforts by organizations. It extracts valuable insights from 33 unique CJ-focussed articles that directly cite technology, the context used, the enabler technologies, and their role on CJ management. The summary of insights will be relevant to organizations engaged in customer-centric digital transformation by helping them to develop a clear view on the drivers for technology usage in CJ.

In the next section, we discuss the interface between the CJ and technology, including open questions relevant to the theme. The focus is on three main themes identified in the literature review: how technology can map, enable, and monitor the journey. In discussing the results, we determine which technologies are related to each use case and provide practical examples, contributing to the formulation of a digital strategy that focuses on the development of CX capabilities.

Summary of insights from the literature review

The CJ term emerged from customer experience research as a way to represent a set of steps the customer needs to take towards product or service consumption (Tax et al., 2013). Those steps are referred to as “touchpoints” in most related literature and include which actions, feelings, and connections the customer goes through regarding pre-consumption, consumption, and post-consumption (Lemon & Verhoef, 2016). Information systems literature was the first to adopt the term in early 2011 (Teixeira et al., 2011), followed by a wide range of use case studies among business and marketing research.

The derivative term “consumer journey” (CJ) is used in the same context as the “customer journey”. However, the term “consumer” is more likely to be used in a retail scope, while “customer” is used for a broader range of services and B2B relationships.

2.1 Customer Journey Touchpoints
The main activity of CJ mapping is to identify a timeline view of all customer experience events during the purchase process (Rosenbaum et al., 2017). The literature refers to touchpoints as events on the CJ timeline, including moments the customer interacts with a company, as well as their actions, decisions, and feelings.

Touchpoints are organized in three customer experience stages: pre-purchase, purchase, and post-purchase. The pre-purchase stage begins from recognizing a necessity, searching for a solution, and considering buying (De Keyser et al., 2020). Purchase touchpoints include customer interactions with a company during the purchase event, such as choosing the product, purchasing and paying for it, and considering the overall environmental conditions, both physical and digital. The post-purchase stage includes customer interaction with the product, service, or company after the order itself. It includes behaviours such as usage, brand engagement, and after-sales services (Lemon & Verhoef, 2016). Previous consumption experiences generate a general background for the consumer before starting the CJ, which also influences future experiences.

2.2 Customer Journey Use Cases
CJ mapping is revealed to be a powerful resource for a wide range of business perspectives. The CX may differ significantly across global markets, even within the same niche. Through CJ analysis, organizations can adapt their regional go-to-market strategy, identifying local cultural aspects, the level of technology adoption, local regulations, and competitors, among others (Nam & Kannan, 2020).

Customer decisions throughout the CJ may be influenced directly or indirectly by others, known as “traveling companions” (Hamilton et al., 2020). Individually or aggregated, traveling companions affect several stages of the CJ, including driving motivation, offering information, and evaluating the decision process. Simultaneously, traveling companions are also influenced during the CJ according to customer feedback and experience. To have a correct understanding of the influence that travelling companions may have during the CJ is key to an organization's CX design.

As technology adoption to drive marketing strategies intensifies, the amount of data marketing professionals must deal with might become overwhelming. CJ mapping is identifed as an effective tool to teach data-driven marketing discipline, providing a link between theory and practice around CX (Micheaux & Bosio, 2019).

2.3 Customer Journey and IS Alignment
The term “customer journey” was first used in the scientific literature when Teixeira and colleagues (2011) presented a design model for service systems within a human-computer research scope. While not attributing a definition for CJ, their research gave a relevant foundation for the topic, introducing what they called Customer Experience Modeling as a new way to represent and evaluate customer experiences through a systematized view to guide service design and developments.

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The first attribution of a CJ definition, as provided by Kankainen and colleagues (2012), referred to CJ as "one of the concepts applied in service design to emphasize and define the process". To support the definition, they also highlight the CJ objective to use a client's perspective to identify and describe different touchpoints in the CX.

CJ was put at the center of the “service delivery network” concept in the human-computer field, which explains how two or more companies can offer services together while presenting themselves through a single brand from a customer perspective (Tax et al., 2013). In addition to a solid foundation for the CJ, Tax and colleagues (2013) contributed a wide range of future research questions on the topic related to various business perspectives, such as strategic capabilities, customer co-creation, C2C interactions, customer relationships management, and service success.

CJ mapping is appropriate for designing user interfaces and a valuable tool for firms looking for CX improvements. Introducing CJ as a marketing discipline, Lemon and Verhoef (2016) highlighted its relevance as omnichannel became the new standard, where customers rely on several touchpoints in their consumption process. The higher the number of touchpoints a CJ may have, the less control over the experience the firm possesses.

Along with an overview of marketing theory related to consumer experience, Lemon and Verhoef (2016) created a research agenda for the CJ topic, suggesting its analysis through several prisms: drivers for customer experience, CJ mapping, multidevice and mobile journey, customer experience measurement, experience design, and from an internal organization perspective. Among the 35 proposed research questions, eight directly involves the information systems field. While the questions remain unanswered, they nevertheless offer a significant contribution to this research.

Information technology also constitutes a key to digitalizing service-only journeys through connecting and enabling new service encounters. A “service encounter” is a touchpoint in the CJ that includes a service experience perspective (Voorhees et al., 2017). The stages of a CJ may be classified as pre-core, core, and post-core service encounters when viewed from a service prism. Voorhees and colleagues (2017) identified 35 new research questions around service experience, from which eight directly include technology.

From a more recent standpoint, De Keyser and colleagues (2020) also pointed out relevant research questions around information systems and CJ while reviewing 143 publications about CX. Although some of the previous questions remain unanswered, some of the more complex ones were raised. A comprehensive list of information systems-related questions around CJ can be found in Table 1, summarizing the main business research concerns.

Methodology

The current research performs a systematic literature review to identify multiple expectations from adopting IT assets and capabilities in CJ management from a business perspective. To create a replicable and transparent process in the literature analysis, we used a framework proposed by Ali and Usman (2018).

First, we sourced articles within the Web of Science research index platform, applying the filters "Customer Journey OR Consumer Journey." We filtered the 235 results to articles published in journals, excluding books and conference materials, which resulted in a total of 144 different pieces. Then, we used technology-related keywords to refine the search results and identify relevant articles for this research. The complete list of search terms and identified articles is displayed in Table 2.

After removing duplicate results that represented articles citing more than one keyword, the total number of evaluated research articles was reduced to 47. Finally, the context in which such technologies are mentioned was extracted and grouped according to qualitative similarities, summarizing the primary application purpose. During the qualitative analysis, 14 articles were identified that mentioned technology outside of the CJ context, which were thus excluded from further consideration. This additional reduction resulted in 33 articles that served as the foundation for this research.

Key Findings and Discussion

The research found three main drivers for technology adoption in the CJ context: mapping, enabling, and monitoring the journey. First, it was pointed out by 7 of the 33 evaluated articles that technology is fundamental in mapping the journey itself, from which the current experience and different persona CJs emerge. Once the mapping is done, the technology enables the journey through digital assets that serve as touchpoints, giving

Table 1. Open questions around Customer Journey with potential information systems contribution

Open Questions	Authors
How can different sources of data (e.g., surveys, operational data, social media) be linked to further elucidate the formation of CX? How can touchpoints be seamlessly integrated across the CJ (similar to channel integration)? What models will enable firms to accomplish such integration? How can brands exert more control over non-"owned" touchpoints? Can such touchpoints be turned into brand-owned touchpoints? At which stages of the journey? How does the use of multiple devices across the journey influence CX and customer behaviours? How can we capture CX data in situ? How can we capture and analyze the raw components of CX without influencing the customer journey or experience? How can we incorporate new data and analytics into CX analysis (e.g., social listening, text, photo and video analytics, location-based data) to further understand CX and the customer journey? Can machine learning models be used to analyze the customer purchase journey and identify opportunities for intervention and influence? How can firms effectively use technology in CX management?	Lemon & Verhoef (2016)
What is the role of technology in value creation during different encounters? How can mobile technologies, the Internet of Things, and cloud-based systems enable the creation of seamless customer experiences across the encounters? How should the interfaces between the core and the other encounters be designed to improve coordination? How can relevant customer information be captured and shared across encounters? How can information available in social media about the pre- and post-core be used to design and deliver the core? How can the information generated by the Internet of Things and smart services in the core be employed to trigger and customize the post-core encounter? What are the unique effects of service failures caused by customers while using self-service technologies? What is the impact of deviant consumer behaviour in online communities?	Voorhees et al. (2017)
How different is CX in multi-actor settings, such as sharing platforms? How do rapid automation and microtargeting practices along with the CJ impact CX? How can contextual data influence CX strategies and inform new business models? In what way(s) can brands/firms systematically make use of contextual insights to enhance CX? How far can brands/firms go in using contextual data to personalize CX? How do the various dimensions work in combination?	De Keyser et al. (2020)

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Table 2. Research Keywords and Related Articles

Type	Code	Keyword	Articles
IS Topic	IS01	Information Systems	4
	IS02	Information Technology	14
	IS03	Digital	22
Technologies	T001	Platform	14
	T002	Big Data	5
	T003	Artificial Intelligence	6
	T004	Machine Learning	2
	T005	Internet of Things	1

customers physical access to specific touchpoints, helping customers advance in their journey, and personalizing the experience. “Enabling” is the most used context where technology relates to CJ, appearing in 29 articles. Finally, technology can also monitor the whole CJ, both from a specific customer point of view and with a broader perspective on CX performance, as stated in 14 articles. The monitoring phase proved to be crucial to generate improvements on the journey, and once any touchpoint is changed, the map must also be updated.

From each analyzed article, we extracted the specific context in which IT can be applied to CJ management and the technologies used to achieve it. Moreover, it was observed whether the technology was applied to map the CJ, enable touchpoints, or monitor it. Table 3 shows the key outcomes from the literature review.

4.1 Customer Journey Mapping
The first step in improving CX throughout the CJ is to perform a touchpoints mapping. This mapping is often performed manually through cardboards during a physical workshop with around 12 people from different company areas (Chiu & Daigler, 2019b). Still, it only gives a static vision of the journey that might become quickly obsolete. Following the CJ approach's popularization, several specialized mapping software options emerged,

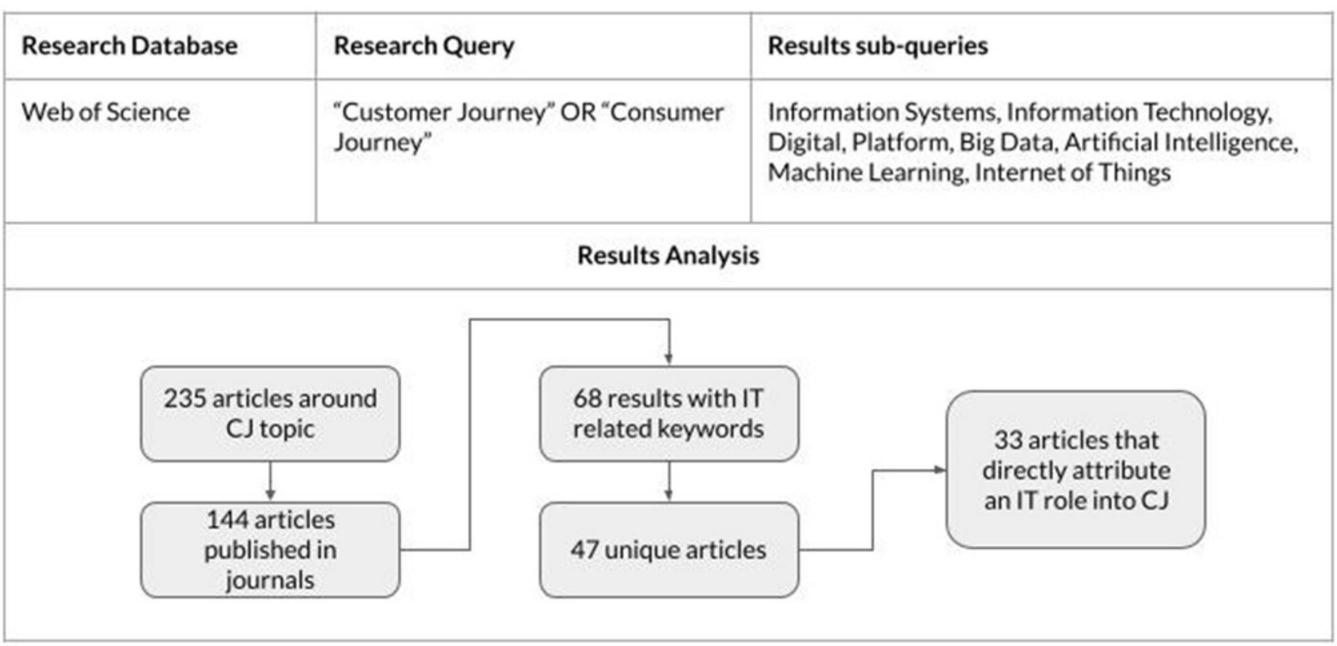

Figure 1. Research stages and results

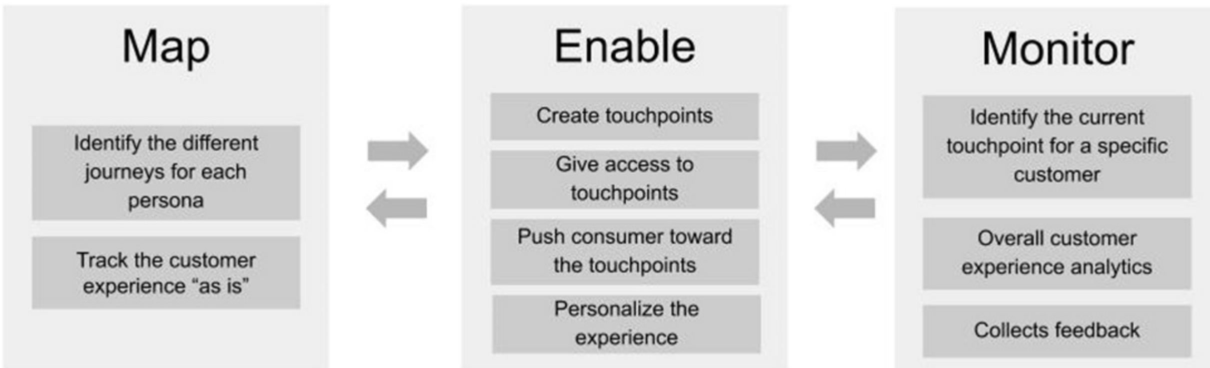

Figure 2. Drivers for technology usage in Customer Journey

usually offered as a service (SaaS).

Ramshaw (2016) performed a complete review of CJ mapping software, which evaluated 12 different digital tools to create maps. He suggested that enterprises should use a tool to do the initial mapping and manage its process improvement, which would be achieved by software such as UX360, Visual Paradigm, and SuiteCX. For small and mid-sized companies that cannot afford or do not need the power of such corporate solutions, a reasonable basic option could start with Microsoft PowerPoint or Microsoft Visio. Once the company gets some practical experience and needs to use CJ mapping as a living document, they can migrate to Smaply or Touchpoint Dashboard. Smaply has also proven to be valuable in teaching CJ as a marketing subject, thus bringing potential for more familiarity among marketing professionals (Micheaux & Bosio, 2019).

Even though identifying touchpoints could be an empirical activity, collecting data on such matters is highly recommended. One of the most popular software to analyze CJ data is Google Analytics, which is useful for exploring consumer behaviour based on digital properties with a simplified view. Dimensions that can be extracted through Google Analytics that help the composition of CJ mapping include the behaviour flow of customer clusters, the customer life cycle, and individual data model view (Google, 2018). Identifying the different flows that a population of users with a particular digital property go through might help to lighten the pain points throughout the journey. Moreover, life cycle analysis offers a promising direction about how long a customer takes to move forward with each touchpoint. Taking the viewpoint of an individual customer allows understanding an outlier's behaviour in the journey. Although valuable, Google Analytics might offer a too simplistic view regarding CJ, as it lacks qualitative data to create decision-ready information (Terragni & Hassani, 2018).

Among other popular alternatives to analytics, Hotjar and Smartlook stand out for offering more in-depth insights through various data-gathering approaches (Filip & Čegan, 2019). By observing real-life customer interaction with digital properties, one can figure out patterns representing a larger population, and thus gain better insights into needed solutions. Customer feedback through page surveys and widgets is also a valuable source of data for CJ mapping, seeding the map with customer thoughts and feelings.

4.2 Enabling the Consumer Journey

Digital technologies have significantly changed the way customers engage with brands and effectively make a consumption decision. CJs that do not have at least a few digital-influenced touchpoints are rare, and there always seems to be room available for more digitization. It might be a digital asset that provides information to consumers around their needs or that enables a transaction itself, such as institutional websites or e-commerce. It could be devices from which the customer identifies a particular store location or compares alternatives, a remarketing advertisement through a social network to remind the consumer to come back to the CJ, or even adapting a provided service to better match customer needs. Research has revealed that technology enables touchpoints in four main areas: creating digital touchpoints themselves, giving access to touchpoints, pushing the consumers toward the CJ, and personalizing the consumer experience.

Create touchpoints

Organizational digital properties are technology-enabled

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Table 3. Technology applications around Customer Journey

Authors	IT Usage Context	Enabler Technologies	CJ Driver		
			Map	Enable	Monitor
(Klein et al., 2020)	Map the consumer journey; Gather individual data along with CJ; Manage the bottom-line communication performance	CJ Mapping Software; Social Network; Data Analytics;	X		
(Mosquera et al., 2018)	Analyze CJ through an omnichannel perspective; improve the in-store experience;	In-store technologies; E-commerce;		X	X
(Cortinas et al., 2019)	Explore the CJ from a deeper customer's perspective;	IoT; Eye-tracking software;		X	
(De Bellis & Venkataramani Johar, 2020)	Let customer advance towards the CJ through autonomous shopping software;	AI; Virtual Assistants; Robots; Drones; Autonomous Shopping Systems;		X	
(Wang, 2020)	Increase customer's brand engagement and loyalty on the CJ through mobile apps;	Mobile; Apps; CRM;		X	
(Tupikovskaja-Omovie & Tyler, 2020)	Segment customers on the CJ through eye-tracking analytics;	E-commerce; Eye-tracking system; Artificial Intelligence;		X	
(Kaczorowska-Spychalska, 2017)	Increase the customer's awareness, abilities, and requirements through the CJ; Performs a multidimensional analysis of online and offline data;	Mobile; E-commerce; Cloud Computing; AI; IoT; Big Data;		X	X
(Micheaux & Bosio, 2019)	Improve the CJ with data; Map the consumer journey;	Data Management Platform, Data Lake, CJ Mapping Software	X	X	X

Table 3. Technology applications around Customer Journey (cont'd)

(Graves et al., 2019)	Control the billing according to the origin and destination; Live CJ monitoring; Metrics;	IoT; Big Data;		X	X
(Nyström & Mickelsson, 2019)	Supports the delivery of the suitable advertisement for the customer during the CJ, leveraging the value-creation;	Automated Systems; Machine Learning; AI; Advertising Platforms;		X	
(Nam & Kannan, 2020)	Enhance the engagement level at CJ; Track touchpoint contribution to the purchase conversion;	Wearables; Mobile; Social Media; AI; IoT; Virtual Reality; Augmented Reality;		X	X
(Damnjanović et al., 2020)	Engage with the consumer on every touchpoint; Provide opportunities to create personalized experiences;	Mobile; Cloud; AI; Blockchain; IoT; AR; VR;		X	
(Kim et al., 2020)	Track the consumer towards the CJ;	Data Analytics; Digital Platform; Social Network;	X		X
(Marino & Lo Presti, 2019)	Helps consumer to move forward the CJ through enabling communication between him and the brand; Gets customer feedback;	Mobile Instant Messages; CRM; Social Networks;		X	
(Matsuoka, 2020)	Enables personalization on the CJ; Allows firms to build customer relationships; Increase revenues;	Big Data;		X	X
(Grewal & Roggeveen, 2020)	Influence consumer decision process along with the CJ; Provide personalization;	Mobile; AI; IoT; In-store technologies; Social Network; 3D Printing;		X	
(Campbell et al., 2020)	Predict customer demands on the CJ; Assist employees on serving customers; Provide insights about the customers; Engage with customers; Conduct ROI	Artificial Intelligence; Machine Learning; Big Data;	X	X	X

Table 3. Technology applications around Customer Journey (cont'd)

	analysis; Analyse and map the CJ; Segment customers; Generate insights for strategy definition, pricing, channels, logistics, and communication;				
(Steward et al., 2019)	Enables the mapping and modeling of CJ; Assess the buying process and its consequences through data analytics;	Big Data; Analytics Software;	X	X	
(McColl-Kennedy et al., 2019)	Gain insights around pain points along with the CJ; Extract rich insights; Identify root causes; Uncover hidden risks; capture customer's emotional and cognitive responses; Spot and prevent decreasing sales; Prioritize actions to improve CX;	Text mining; Big Data;	X	X	X
(Sperkova, n.d.)	Collect customer sentiment and feedback; Generate insights to improve CJ;	CRM; BI; Data Mining; Customer Review Software;			X
(Wilson-Nash et al., 2020)	Offers contactless touchpoints in customer service through social bots, preferred by young adults; Provides an opportunity to firms to meet consumer needs during the CJ; Enhance segmentation and target marketing;	Artificial Intelligence, Chatbots, Social Networks;		X	
(Mosquera et al., 2017)	Generates new touchpoints in the CJ through mobile;	Mobile; Wifi;		X	
(Inversini, 2017)	Enables meaningful relationships between the customer and the company throughout the CJ;	Mobile; Self-service kiosks; Social Network;		X	
(George & Wakefield, 2018)	Identify the touchpoints from a CJ; Forecast the consumer's churn during the CJ based on behavioural data;	Big Data	X		X

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Table 3. Technology applications around Customer Journey (cont'd)

(Hu & Tracogna, 2020)	Enable B2B and C2C touchpoints;	E-commerce; Mobile; Social networks;	X	
(Lynch & Barnes, 2020)	Enable the touchpoints on the fashion retail CJ;	Mobile; Desktop; Apps; Websites; Social Network;	X	
(Singh et al., 2020)	Creates a unique customer engagement voice in a digital environment;	Big Data; API; AI; Chatbots; CRM; Robotics; Automation Software; Digital Ordering System; ERP;	X	
(Wagner et al., 2020)	Enable the conversion touchpoints on the CJ;	App; Mobie; E-commerce;	X	
(Paluch & Tuzovic, 2019)	Gather consumer data during the CJ;	Wearables;	X	
(Wozniak et al., n.d.)	Create implicit touchpoints, such as online advertisements; Conduct explicit touchpoints, including brand content and reviews; Track the customer's conversion;	Mobile; Websites; App; Messenger; Augmented Reality; Virtual Reality; Chatbot;	X	X
(Pallant et al., 2020)	Enable customer's co-creation of the product during the CJ;	Digital Platforms	X	
(Dellaert, 2019)	Enable consumer co-creation of products during the CJ; Collect consumer feedback;	Digital Platforms; Big Data; Predictive Analytics;	X	X
(Shen et al., 2020)	Enable several touchpoints on the tourism CJ; Analyse and enhance the CJ; Collect tourist feedback;	IoT; Cloud computing; AI; Mobile; Big Data; Wifi; Virtual Reality; Augmented Reality; Chatbots; Wearable; devices; Beacon	X	X

touchpoints where customers can perform one or more stages of the CJ. The most basic application starts with non-transactional websites, which have a strategic role in informing consumers about a product or service, along with raising awareness about a specific need. Firms can use content websites with a branded or unbranded approach, which often serves as a starting point to the journey when aligned with inbound communication and Search Engine Optimization strategies (Ehrlich et al., 2017). The next level of technology-enabled touchpoints includes transactional behaviour, which enables conversions to happen with reduced friction in an omnichannel environment. This can consist of a retail e-commerce platform or a B2B web ordering application.

Mobile apps and responsive websites might play both instructional and transactional roles. Customers that interact with branded mobile applications during the consumption process increase their engagement throughout the journey, spending more on such brands than on non-engaged ones (Wang, 2020). The most common purpose of mobile apps in a CJ context is to support Customer Relationship Management (CRM) practices, activate promotions, and leverage customer loyalty. In addition to explicit mobile touchpoint opportunities, consumers also face implicit touchpoints daily that might influence the CJ, such as reading news or accessing social media, which can be impacted by sponsored content (Wozniak et al., 2018).

Digitizing the in-store experience is also a trend in retail, with the growing adoption of technologies such as complimentary Wifi, interactive screens, virtual mirrors for fitting, self-service kiosks, and QRCode interactions, among others (Mosquera et al., 2017).

Providing access to digital touchpoints
Organizations perceive a given digital property as a single touchpoint, while at the customer level, it might be experienced with variety depending on the device the customer uses to interact with them. These devices are referred to as e-channels, which include computers, mobile devices, Smart TVs, Smart Glasses, Smart Watches, and other new devices that now emerging (Wagner et al., 2020). Wearable technology opens up a new alley of possibilities within the CJ, for example, with self-tracking incentives explored by insurance companies (Paluch & Tuzovic, 2019).

Push the consumer toward the journey
One of the most fundamental roles technology plays in CJs is to help customers move through their journey, accomplishing the consumption process in a trustable yet dynamic way. The journey is not the same for every customer, but instead, each one has different timings and needs (De Keyser et al., 2020). Technologies such as machine learning and artificial intelligence help segment, target, and position consumers according to data clusters (Campbell et al., 2020). A navigation footprint made by consumers on digital properties can be translated into intentions, serving as a trigger for proper impulses that an organization can push. Data Management Platforms (DMPs) and Operational Marketing Databases (OMDBs) are technology alternatives to control consumer intentions in a digital environment and generate custom audiences for advertisements (Micheaux & Bosio, 2019). For example, suppose a particular customer navigating on the "Store Locator" page of a specific chain. In that case, its digital marketer could define a strategy to display relevant content through social media advertisements related to in-store behaviour.

Consumers often need some level of support during their journey. Organizations can use digital tools to communicate with consumers, such as mobile instant messaging apps, thereby reducing friction generated by traditional communication methods such as email and telephone (Marino & Lo Presti, 2019). Within instant messaging, firms can use chatbots to create 24-hour first-level customer service powered by Natural Language Processing (NLP) technology, which captures user intentions based on unstructured messages (Singh et al., 2020). For creating more customer proximity, social bots can be used by organizations that simulate human behaviour in social networks, thus generating frictionless interactions (Wilson-Nash et al., 2020).

Personalizing the Journey
When a customer feels actively part of the decision-making process along the journey, they have greater engagement. Technology is a strong ally in various levels of personalizing the consumer experience, and supporting a sharing economy (Dellaert, 2019). Digital platforms offer product individualization via mass customization, allowing consumers to co-produce, co-build, co-design, and co-configure (Pallant et al., 2020). In such an approach, the organization and consumer take on the product design, component selection, and assembly, and use the product together.

By focusing on improving sales conversion on e-commerce platforms, eye-tracking technology allows one to understand the customer's point of view and to customize the experience, generating easier-to-use interfaces (Tupikovskaja-Omovie & Tyler, 2020). By performing an ongoing competitor analysis, dynamic pricing algorithms powered by machine learning and artificial intelligence can suggest and automatically set the most appropriate price for products and services while avoiding pricing anomalies (Campbell et al., 2020). For example, the New York bus service's electronic ticketing system controls the origin and destination of the passenger, making proportional charges to the travel duration. All data from this customization are processed via big data, which enables new customizations on the journey by identifying customer clusters that allow optimizing the service as a whole (Graves et al., 2019).

4.3 Monitoring the Consumer Journey

The CJ is a rich source of information for organizations seeking to make more data-driven decisions. Large volumes of data captured at different touchpoints can be processed to generate insights into specific pains in the process, including mining unstructured texts from comments and social networks (McColl-Kennedy et al., 2019). Technologies such as machine learning applied to big data allow firms to analyze the current scenario and understand the market and customer dynamics (Campbell et al., 2020).

Firms that manage to leverage data effectively through advanced analytics have a strategic marketing competitive advantage (Dellaert, 2019). An accurate analysis of the CJ must deal with the heterogeneity of journies, thus allowing an interactive view that does not reduce the user's activities to a small set of actions (Kim et al., 2020). From a practical perspective, once a company learns in which stage a particular consumer is on the journey and combines this knowledge with predictive analytics, it makes a very assertive approach.

Conclusion

By answering one of the open questions around CJ that need the contribution of information systems, the present research sought to offer companies a generalist view on how technology can be used in the context of CJs. By identifying that digital tools can play a relevant role during journey mapping, enabling touchpoints, and the overall monitoring of the journey, this research offers a direction for companies seeking to create effective initiatives to improve their CX. Digital tools play a fundamental role in CX, although many businesses have not yet assimilated the most appropriate technologies for this purpose. New opportunities therefore exist for technology firms to create easy-to-use and affordable products for CJ management. In addition to addressing unanswered questions found in the literature, it is also necessary to perform a detailed review at each of the identified stages of technology usage in CJ, thereby deepening the discussion with case studies and a technical approach.

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About the Author

William Boscardini Helouani, Lic.Sc.(Tech.) is the Latin America IT Director for Customer Experience at Electrolux. He has more than 15 years of working experience in the manufacturing industry in different digital areas, including IT, product, marketing, and e-commerce. Pursuing an M.Sc degree at Sao Paulo School of Business Administration (FGV EAESP), he researches the impact of companies' IT capabilities on the Customer Experience.

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Charting a Course of Action: An Insider-Outsider Approach

Paul Woodfield, Katharina Ruckstuhl and Rafaela C.C. Rabello

"Give me six hours to chop down a tree and I will spend the first four sharpening the axe."

Abraham Lincoln
16th president of the United States (1861 to 1865)

We explore an alternative approach to action research that can be implemented throughout the lifespan of a science and technology research programme. We do this by examining the emergence and development of a participant-observer research approach - where a researcher is also part of the same community of practice as those being observed - in the technology and innovation management context. Our motivation stems from the need to understand innovation processes and management over a long period. Typically, consultants are employed for a given period to carry out action research. We present a case where social scientists, as opposed to action research consultants, carried out action research after a history of relationship building and becoming embedded within a longitudinal science and technology research programme. This allowed the social science researchers to build trust and rigor with those being observed before engaging an action research approach. We present our case as a narrative of experiences, events and turning points, reporting on what was observed and experienced by these social scientists. Our study extends current knowledge by mapping the research journey toward action research through three phases: navigation, iteration, and reflection phases. We argue that richer insights are generated when participant-observers engage early, and that their insights lead to action research that is more informed.

Introduction

Recent research discusses the merits and reasons to engage action research in the technology and innovation management context (McPhee et al., 2019a, 2019b; Guertler et al., 2020; Ollila & Yström, 2020). With a foundation in earlier action research conversations in management and organization (Israel et al., 1992; Huxham & Vangen, 2003; Ottosson, 2003), a good argument exists for introducing action research into innovation management projects to generate rich insights that support rigorous qualitative research and change in practice (Ollila & Yström, 2020). We depart from recent innovation management studies focused on action research models, by 1) focussing on a large research programme rather than a single industry or research project, and 2) concentrating on phases that in our experience are precursory to action research frameworks. There is a vast difference between innovation management in an industry context where social scientists are employed to carry out research for a defined period, and a research programme where the social science research is carried out in real-time. In our case, the real-time feature was integral to the innovation management environment across numerous projects within a research programme.

Innovation management, as a social science discipline, sits outside the natural sciences and technology disciplines. However the interaction between social sciences, natural sciences, and technology is increasingly a feature of global discussion (Bastow et al., 2014a). Put another way, convergence occurs between disciplines, which calls into question "the artificial gulf

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between the 'social' and the 'technical' —and thus between the social sciences and natural science and engineering" (Williams & Edge, 1996). Despite the increasing recognition of social science as a key contributor to interdisciplinary natural science and technology contexts (Lutzenhiser & Shove, 1999), social science is still a marginal player, with social researchers often being incorporated only late in the process, and without clear frameworks or guidelines of how to integrate social and natural sciences (Sievanen et al., 2012).

However, a further need is present for social scientists to integrate with natural science and technology disciplines, as the latter "require building many strong relationships, which in turn, means real engagement and mutual understanding of different concepts and cultures" (Jones, 2012). Given that major publicly funded research projects typically focus on natural sciences and technology, along with the sociological and economic aspects of innovation (Chanal, 2012), we believe that innovation management research needs to create evidenced pathways between social sciences, natural sciences and technology in innovation projects to promote successful interdisciplinarity.

In this paper, we propose a structured methodological process for social scientists tracking early upstream research and development (R&D). This is when science aims and pathways are still unclear, and knowledge of a phenomenon has yet to be revealed. We discuss the journey from the perspective of a social science team exploring a complex mission-orientated (Mazzucato, 2018) natural science and technology programme that has a mission to grow a high-tech New Zealand economy through mission-led physical science and engineering research.

Ultimately, we are guided by two broad research questions: *"In what ways can researchers engage early to build relationships with respondents before conducting action research?"* and *"Can richer insights be generated by mapping a research pathway toward action research?"* In answering these questions, our contribution maps a pathway toward action research that can be sustainable and recursive. This contrasts with typical engagements involving an external consultant or researcher that facilitates action research without prior and in-depth knowledge of the science and technology research team which they are studying. We therefore do not aim to replicate the typical action research process. Instead, we contribute toward elucidating the precursory phases prior to conducting action research. In other words, we nudge the experience of a more transactional action research approach, by stepping back and speaking to the journey that leads up to carrying out authentic and meaningful action research built on trust and rigour.

Research Programme Context

This study is centred on New Zealand's National Science Challenge: *Science for Technological Innovation - Kia kotahi mai - Te Ao Pūtaiao me Te Ao Hangarau* (To come together, to join as one, the world of Science, the world of Innovation), herein referred to as SfTI. As one of 11 mission-led national science challenges, SfTI has received USD65 million over a 10 year period to deliver research that enables the New Zealand Government to implement a more strategic approach to public science investment (Daellenbach et al., 2017). The SfTI mission is designed to "enhance the capacity of New Zealand to use physical sciences and engineering for economic growth" (Hazel, 2017). SfTI is a community of practice (CoP) that involves researchers in all universities across New Zealand, Crown Research Institutes and private research institutes, industry, and Māori (indigenous people of New Zealand). In this virtual organization context, researchers were encouraged to investigate "stretch-science" that addresses industry challenges and issues 5 to 10 years in the future. In doing so, the objective is to target novel technologies.

To achieve its mission, SfTI is organized into 5-8-year programmes (also known as "spearheads") and shorter "seed" projects (1-3 years). One of the spearheads is called "Building New Zealand's Innovation Capacity" (BNZIC), which comprises a team of social scientists positioned to examine national physical science spearhead projects. Having a social science research team like BNZIC in a National Science Challenge (NSC) is unique across all of New Zealand's NSCs. Within SfTI, innovation activity that develops *"technical capacity"* is mandated for the other spearhead projects that are natural science and technology-led. However the BNZIC spearhead addresses two perceived weaknesses in the New Zealand innovation system: *"human capacity"* (skills and attributes that enable and drive researchers to be entrepreneurial), and *"relational capacity"* (industry networking, engagement capabilities and experience) (Science for Technological Innovation, 2018). Importantly, the BNZIC spearhead is driven by the

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assumption that New Zealand science teams typically promote a closed model of R&D, which can be an impediment to maximising the benefits of physical science and engineering for enterprises and communities (Science for Technological Innovation, 2016). A more "open innovation" approach, whereby enterprises create value by acquiring, assimilating, and exploiting knowledge from both internal and external sources (Chesbrough, 2003; Gassmann et al., 2010), may help develop pathways to shift "stretch science" in ways that achieve economic growth. BNZIC's research to this end aims to provide theoretical insights into open innovation processes.

Research Method

To answer the two research questions we draw on primary data and employ a narrative approach (see Creswell, 2018) to investigate ways researchers engage early to build relationships with respondents before conducting action research. We had open access to participants and the ability to collect data early in an upstream innovation programme. This enabled us to conduct interviews with respondents and attend their team workshops and meetings. Ultimately, this meant as social scientists we became "insider-outsiders", that is, we were part of the SfTI community of practice, but outside the research projects or spearheads being investigated. As highlighted through this section, we were in a fortunate position to be able to develop our approach by being reflexive over a long period. In so doing, we generated rich insights that contributed toward mapping a research pathway toward action research.

We draw on data derived from longitudinal social-science research of two separate cross-organizational science team spearhead research programmes (hereon collectively referred to as "spearheads"). One involved research on additive manufacturing and 3D and/or 4D printing of bio-composites (hereon in "Additive Manufacturing"), and the other adaptive learning robots to complement the human workforce (hereon in "Robotics") (Science for Technological Innovation, 2019).

We employ a narrative approach (Polkinghorne, 1995; Elliott, 2005; Gubrium & Holstein, 2008; Savin-Baden & Major, 2013; Creswell, 2018), which is a well-recognized qualitative method useful for organising and giving meaning to experiences (Elliott, 2005; Creswell, 2018). The narrative approach also allows us to make sense of unusual events or issues by creating and constructing stories of experiences and their meanings (Savin-Baden & Major, 2013). Of the many ways to undertake narrative approaches, we adopt a researcher and participant co-constructed approach to capture meanings and "conceive, capture and convey the stories and experiences of individuals" (Savin-Baden & Major, 2013).

Data that inform our narrative approach were derived from a longitudinal research approach over four years since their inception to investigate the management processes of the Additive Manufacturing and Robotics spearheads. Data included observation of both spearheads' workshops and meetings, including a cross-disciplinary workshop attended by both the Additive Manufacturing and Robotics spearheads, which facilitated an ideation process across the teams. We conducted semi-structured interviews with the researchers of both spearheads. Subject to ethical guidelines under the SfTI umbrella, all interviews were recorded and transcribed, then organized and managed through NVivo, a qualitative research software (refer to Table 1).

Each of the authors of this paper was involved in both collection and participation of the research carried out. This involvement means as researchers we recognize that we were not outside of the subject or process, but rather integral and integrated parts of the research (Savin-Baden & Major, 2013). This position allowed us to document an "episode" of our social science teams' experience from both the experience of the ones being "researched" (through interviews and observations) and as researchers (through reflexivity) (Finlay, 2002; Hibbert et al., 2010).

Findings and Discussion

The BNZIC team took a guided (that is, with research objectives) exploratory approach to their research. Derived from their experiences, Table 2 identifies the research phases the team went through, the rationale for each stage, and who in the overall research programme influenced each phase.

Our research questions are answered below in succession as we discuss the phases. First, we answer the question relating to ways researchers engage early by discussing our journey through the Navigation and

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Table 1. Participant Summary

Spearhead/ Pseudonym	Role	Discipline	Time with SfTI	Career length
Building New Zealand's Innovation Capacity (BNZIC) spearhead				
BNZIC-PO1	Participant-observer (PO)	*Social Scientist*	*6 years*	*20-30*
BNZIC-PO2	Participant-observer	*Social Scientist*	*5 years*	*10-20*
BNZIC-PO3	Participant-observer	*Social Scientist*	*2 years*	*0-10*
BNZIC-PO4	Participant-observer	*Social Scientist*	*3 years*	*0-10*
Additive Manufacturing (AM) spearhead				
AM-TL1	Team Leader (TL)	*Natural Scientist*	*5 years*	*20-30*
AM-TL2	Team Leader	*Natural Scientist*	*5 years*	*10-20*
AM-TL3	Team Leader	*Natural Scientist*	*5 years*	*20-30*
AM-R1	Researcher (R)	*Natural Scientist*	*5 years*	*20-30*
AM-R2	Researcher	*Natural Scientist*	*5 years*	*10-20*
AM-R3	Researcher	*Natural Scientist*	*5 years*	*20-30*
AM-R4	Researcher	*Engineer*	*5 years*	*10-20*
AM-R5	Researcher	*Designer*	*5 years*	*20-30*
AM-R6	Researcher	*Designer*	*5 years*	*20-30*
AM-R7	Researcher	*Natural Scientist*	*3 years*	*20-30*
AM-R8	Researcher	*Natural Scientist*	*<1 year*	*20-30*
AM-R9	Researcher	*Natural Scientist*	*5 years*	*20-30*
AM-R10	Researcher	*Natural Scientist*	*5 years*	*20-30*
AM-R11	Researcher	*Natural Scientist*	*5 years*	*10-20*
AM-R12	Researcher	*Natural Scientist*	*2 years*	*0-10*
AM-R13	Researcher	*Natural Scientist*	*<1 year*	*20-30*
AM-R14	Researcher	*Natural Scientist*	*<1 year*	*20-30*

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Table 1. Participant Summary (cont'd)

Robotics (ROB) spearhead				
ROB-TL1	Team Leader (TL)	*Engineer*	*3 years*	*10-20*
ROB-TL2	Team Leader	*Engineer*	*3 years*	*20-30*
ROB-TL3	Team Leader	*Engineer*	*3 years*	*30-40*
ROB-TC2	Team Coordinator (TC)	*Project Manager*	*3 years*	20-30
ROB-R1	Researcher (R)	*Engineer*	*2 years*	*10-20*
ROB-R2	Researcher	*Engineer*	*2 years*	*30-40*
ROB-R3	Researcher	*Engineer*	*2 years*	*10-20*
ROB-R4	Researcher	*Engineer*	*2 years*	*10-20*
ROB-R5	Researcher	*Natural Scientist*	*2 years*	*30-40*
ROB-R6	Researcher	*Engineer*	*2 years*	*30-40*
ROB-R7	Researcher	*Engineer*	*2 years*	*30-40*
ROB-R8	Researcher	*Engineer*	*2 years*	*0-10*
ROB-R9	Researcher	*Engineer*	*2 years*	*0-10*

Table 2. Reserach design approach in an innovation management context

	Navigation phase	***Iteration phase***	***Reflection phase***
Research design	Exploratory 'grounded' approach - Interviews - Observations - Relationship building	Participant-observer approach - Interviews - Observations - Ethnographic	Action research approach - Ethnographic - Innovation processes recognized - Action research engaged
Rationale	Allowed methodologies to emerge and brought social science, natural science and technology researchers together	Embedding the social science team as *'insider outsiders'* to build a collaborative, knowledge-sharing environment between social science, natural science and technology researchers	Research intervention providing a feedback loop throughout the community of practice
Influence	Senior management team and advisors; international assessment panel	BNZIC team guided by senior management team and advisors	BNZIC team guided by senior management team and advisors, industry 'Mission Lab'
Stage	Research design	Data gathering and organization	Reflection and action
RQ answered	RQ1: "In what ways can researchers engage early to build relationships with respondents before conducting action research?"		RQ2: "Can richer insights be generated by mapping a research pathway toward action research?"

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Iteration phases. To this end, we establish ways researchers engage by developing relationships, trust, and rigor, by first taking an exploratory approach then a more embedded participant-observer approach as "insider-outsiders". This leads to answering the second question relating to whether richer insights can be generated by mapping a research pathway toward action research. Thus, the Reflection phase discusses the emergent action research design that reflects richer insights informing this approach. As the next sections will make clear, the research process responded to the activities of the project participants and their research as they emerged in real-time.

Navigation phase

With experience and knowledge on their side, SfTI management could safely explore what might - or might not - work when bringing a social science lens to a natural science and technology forum. The navigation phase was the time for BNZIC leaders to experience ambiguity and uncertainty in the knowledge that their pursuit would shape and enhance innovation processes and performance. In doing so, the BNZIC researchers found themselves in two types of researcher roles. On the one hand, they were "participants" as part of the SfTI community of practice, while on the other being an "observer" in their data-gathering role. This "participant-observation" approach (Merriam & Tisdell, 2016) within SfTI has advantages and disadvantages, albeit the approach became central to identifying ways R&D moves from closed to open innovation processes. Participant-observation research carried out, aims to enable researchers to observe how people behave and interact in their natural environment. As an ethnographic research method, participant-observation is a process where the observer is part of the social situation in order to carry out an investigation, as well as being part of the research context observed, that is, they can modify and influence this context by their own behaviour (Schwartz & Schwartz, 1955).

In our case, participant-observation was most appropriate given (1) it provided participants with time and space to get used to the social scientists, and (2) the actors observed had little knowledge of certain phenomenon, such as innovation processes, and (3) they were unaware of when knowledge is obscured from outsiders, or that sometimes there is monopolistic or privileged access to knowledge (Merton, 1972). We also utilized participant-observation when the problems under scrutiny were complex and not easily studied by direct observation or case study. For example, collaboration in teams and between teams and stakeholders, where participant-observation facilitates "sense-making" of underlying structures and mechanisms (Weick, 1995).

The "here and now" time factor plays a major part in participant-observation. It delimits where the research begins by defining and redefining issues or problems, while aiming to provide practical and theoretical explanations for each situation. As such, practical decisions can be made based on the concepts, generalisations, and interpretations stimulated through participant-observation (Jorgensen, 1989), for example, identifying capacity development needed in spearheads.

Given the complex character of each spearhead and that they were largely developed from scratch, the BNZIC team likewise grounded its methodology in observing what was being experienced by the science and technology participants. This approach is constructionist in that the researchers were not "detached" from the participants they were studying (Miles & Huberman, 1994). This allowed them to construct meaning in various given situations (Creswell, 2009), in turn enabling both objectivity and subjectivity without promoting one over the other in terms of being valid or true (Crotty, 1998). As such, the researchers needed to remain balanced in both their subjective and objective roles, while being tasked with understanding how the technical, human, and relational capacities of the participants relate to each other, along with navigating the innovation outcomes. This was supported by using active methods such as interviewing, or through more passive direct observations (Jorgensen, 1989; Creswell, 2018).

There were several advantages when, for example, observation criteria and ethical considerations for gathering information was needed. A distinguishing and advantageous feature of integrating participant-observation from the outset is SfTI's inclusive culture of knowledge sharing across projects, and its all-researcher workshops, including all spearheads, BNZIC researchers, senior leadership, the SfTI advisory group and Board.

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> *"Initially, the way they [SfTI] have managed it is they have put really big emphasis on meeting each other, which I think was key for success, because we are such a big group and we didn't really - I mean, we knew a little bit of each other, and we have worked in past programs, but not everyone. I think by spending more time and having this organized meeting where we have to see each other was really important to take the next step". (AM-R2)*

> *"I think there's mutual respect, even though you come from different disciplines, and you work in slightly different ways. I think there's mutual respect between the actual group as to what [those] benefits the individuals could actually bring to the table". (AM-R6)*

Through SfTI workshops and their research contracts, the BNZIC team was given access to all research teams, for the most part via interviews, workshops, and meetings.

However, two disadvantages of observations include time constraints, and situations where events may proceed differently because they are being observed (Yin, 2003). Firstly, with research teams spread across the country, a lot of time was spent travelling to and from meetings, workshops, and interviews, making participant-observation somewhat time-consuming and costly. However, sufficient resources were allocated to carry out the research within a reasonable timeline provided. That said, researchers who have been given the time and resources to work on the project still needed to refine and sensitize themselves to insure greater validity of the collected data (Schwartz & Schwartz, 1955). Secondly, when only interviews were carried out, there can be some variance in the interview format, for example, by phone or videoconferencing. Although some basic observations can be made through these mediums, we required *in loco* presence in our attempt to capture the interactions between team members, industry, and other stakeholders. The following "iteration stage" provides examples of how the BNZIC team balanced the insider and outsider roles as the navigation phase happened.

Iteration phase

As an ethnographic method, participation often requires the researcher to adopt an outlook and acclimatize to those being observed (Malinowski, 1922; Denzin & Lincoln, 2011), and tailor the role according to the setting (Schwartz & Schwartz, 1955; Creswell, 2013). In our case we were not acclimatising as an outsider coming in, but rather as an "insider-outsider" (Headland et al., 1990; Bartunek & Louis, 1996; Dwyer & Buckle, 2009; Colville et al., 2014). As argued by some, insider-outsiders are located on a continuum (Hellawell, 2006), meaning they are neither inside nor outside the community of practice, but rather "in-between" (Breen, 2007; Dwyer & Buckle, 2009).

When approaching participant-observer research, the researcher's impact on the participants should be established, along with the extent to which the researcher is culturally embedded in the research (Butcher, 2013). As outlined earlier, some assert that a perspective where the researcher is not part of the research's cultural group is best. The fear here is that an insider approach would make it difficult for a researcher to distinguish values, practices, or behaviours that are typically part of everyday life (Morse & Richards, 2002).

The insider-outsider issue is one that BNZIC researchers had to acknowledge for two reasons. The first is that while the researchers were outside the professions or industries of those being observed, they were still part of the same SfTI research programme and tasked with achieving its goals. The issues that this raised included a need to acclimatize to jargon being used, or at least being able to discern enough to understand the conversations during meetings, interviews, and the like. For example:

> *"It just – the lead times – it takes – you've got a lot of different people from different disciplines – to find a common language, shared interest – all that sort of stuff; it just takes a while". (AM-R5)*

> *"Yeah, and that's why I keep trying to use the language midstream, but it doesn't seem to have quite connected yet". (BNZIC-PO1)*

> *"I guess one of the key things of bringing a new team together, and particularly when they're coming from really diverse disciplinary areas, is how do you get them all into working in the same way? People come with their own language and their own expectations. Most people, when you use a term like 'stretch science', everybody's got their own take on what it means from a disciplinary perspective". (BNZIC-PO2)*

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Linked to the insider-outsider concept, a notable challenge as participant-observer for our team was balancing rapport so that there is no lack of engagement, or too much rapport with a loss of objectivity (Miller, 1952; Brayboy & Deyhle, 2000). In other words, establishing rapport with effective engagement works alongside not having so much familiarity and risking a loss of objectivity. For example, maintaining a closer relationship with the leaders of the spearheads to maintain good access to their teams, while maintaining some distance from forging close relationships with team members so there is an over-familiarity resulting in loss of objectivity.

The BNZIC social science team was able to reflect on their experience through a sense-making process in organizational learning across the SfTI Challenge (Weick, 1995; Vince & Elkjaer, 2009; Colville et al., 2014). This sense-making helped the team to conclude that there was actionable knowledge being produced (Argyris, 2005; Antonacopoulou, 2009), that:

> *"[I]llustrates the impact that management scholarship can have by connecting theory and practice, knowledge and action, promoting the power of connectivity and the significance of judgement in defining intentions, actions and the outcomes sought could be implemented". (Antonacopoulou, 2009)*

Through both the navigation and iteration phases, the BNZIC researchers developed relationships, trust, and rigour, to the extent that there a call arose to position social science as a "call to action". Table 3 displays examples of relationship building and establishing embeddedness through interactions between social science, natural science, and technology researchers via navigation and iteration phases.

In answering the first research question, social science researchers engaged early by entering the field of research to explore phenomenon through interviews and observations. As a longitudinal programme, this approach made way for methodologies to emerge that brought social science, natural science, and technology researchers together. Then as participant-observers the approach required the BNZIC team to become "insider-outsiders". This took them beyond building relationships with the natural science and technology researchers, and toward building a collaborative, knowledge sharing environment founded on mutual respect, that could to some extent support a common language across disciplines. With these factors in mind, a firm foundation for conducting action research was established. The following "reflection" phase plots out how action research design emerged and transitioned from the precursive navigation and iteration phases.

Reflection phase

As the BNZIC spearhead progressed through the precursive navigation and iteration phases, an action research design emerged. Action research was considered an appropriate intervention to "improve collaborative leadership and [for] trialling new approaches to organizing and funding science" (Daellenbach et al., 2017). What distinguishes action research from other research designs is that it is an "enquiry with people rather than research on people" (Altrichter et al., 2002). It is also a design that requires the researcher to be reflexive (Willig, 2001) and, when actively embedded in research, to continuously and systematically improve the research objectives and research process (Kemmis et al., 2014; Ruckstuhl et al., 2019).

According to Piggot-Irvine (2009), action research is defined by some as collaborative work to address problems that are of group concern, or as the participatory process that seeks to bring together practice, theory, and reflexivity in order to develop practical solutions to social research problems (Reason & Bradbury, 2001). Moreover, action research is "practice-changing-practice" (Kemmis, 2009) as a result of a systematic inquiry of social practice, through a collaborative process that employs self-reflection during the research project (Sandretto, 2007).

The fundamental purposes of doing action research are to determine what is actually occurring, to change what is not working, and to test a hypothesis (Sagor, 2010). Sagor (2010) suggests that the best way to identify action research is to ask three questions: Is the focus on your professional action? Are you empowered to adjust future actions based on the results? Is improvement possible? In the context of the SfTI Challenge, the BNZIC team can answer these questions positively.

From the outset, the BNZIC team planned to conduct action research, although the phase and timing of this were uncertain. As a longitudinal programme, the BNZIC team was fortunate to have been able to explore,

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Table 3. Examples of trasitioning from the Navigation phase to the Iteration phase

Phase	Context	Quote	Observation
Navigation	Science and Technology (S&T) researcher shared their concern about academic researchers' engagement in the challenge with participant-observer (PO); PO responded they were going to look deeper into that issue.	AM-TL1: And that tension gives you all of the cost tensions, the 'how involved are the university people, or do they just sit out' … are they committed into it, or do they have a student in there … and they're sitting on the top type of thing? **BNZIC-PO1: And that's something I am going to be interested to watch because … it is the same inside the university.**	Science and Technology (S&T) researcher **sharing concern** with participant-observer (PO); PO willing to let **social science work be influenced by active concern** ⇨ Shows social researchers took on board a concern from the participant (relationship building)
Navigation	S&T researcher asked for advice on how to structure a thoughtful knowledge exchange with Māori; PO happily suggested, drawing on her expert Māori knowledge; S&T researcher took on board the suggestion	AM-TL2: It's probably the offer – how would we structure a course [that enables thoughtful knowledge exchange]? **BNZIC-PO2: What about if it was perhaps something with for example, at the Māori arts and crafts – a sort of an understanding that presenting – like a stakeholder engagement – that's your stakeholder.** AM-TL2: It could be done … maybe bring in aligned programmes – we bring in some of their knowledge, and then presenting to us, kind of thing. It could be done, yeah.	S&T researcher tried to **tap into PO's Māori expert insider knowledge**; PO willingly **offered advice**; S&T researcher and PO **jointly mapping out** potential intervention; PO's suggestion was then taken on board ⇨ Shows an emergence of trust through the advice provided by PO (relationship building)
Navigation	S&T researcher asked PO to explain Māori worldview (i.e. to close a gap in understanding of a core concept in the science challenge); PO willing to answer, but hesitant due to own non- Māori background	ROB-R1: You'll need to explain to me what the Māori worldview is. **BNZIC-PO4: Well, I mean examples – I wouldn't know explicitly, because I'm not Māori myself, but at the same time, some of the concepts would be around sustainability, longevity, the community side; science that's been around for them for many years.**	S&T team member seeking an explanation from PO on SfTI core concept; **PO not an expert** in the field with an implicit acknowledgement that they too could learn more about the Māori worldview ⇨ Shows an emergence of sharing knowledge through concepts provided by the PO (relationship building)
Iteration	S&T researcher noted they didn't know if their research was benefitting Māori communities and that they hadn't managed to gain	AM-R4: I don't quite understand if I benefit [an industry or organization], does it really get back to the Māori community? Is it going to be that one family around – or that one iwi around [an industry or organization], that is going to benefit? Is it going to be of	S&T researcher shared wish to learn more about Māori communities and their economy with expert insider PO; PO open to taking action to satisfy desire to learn more

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Table 3. Examples of trasitioning from the Navigation phase to the Iteration phase (cont'd)

	further insights into Māori economy; PO seemed willing to take action in response to that.	societal benefit? I've got no real feel for that. **BNZIC-PO2: That might be the same with any of these projects though, mightn't it?** AM-R4: Absolutely. So, I don't really have a feel for that because I just don't know. One of the things that I wanted out of this challenge that I haven't quite received or haven't engaged enough, is I wanted to learn about Māori people and the Māori economy. I ticked that on one of the boxes on day one, two years ago, and I'm still not there. **BNZIC-PO2: Okay, so let's see if we can do something about that.**	⇨ Shows an emerging 'insider-outsider' interaction that could benefit the wider SfTI Challenge (establishing embeddedness)
Iteration	S&T researcher complained to the PO about team leaders not doing much research themselves, but rather delegating the work to PhD students and post-docs; the PO explained the rationale for the system and responded why the set up may make sense the way it was.	ROB-R8: It also makes me wonder why all these researchers are managing the project, but then hiring someone to manage and do the project. It's like, why are you managing the project, if you're not actually going to manage the project? Does that not mean you're on too many projects, and you should delegate them out? **BNZIC-PO4: Well, I think part of that comes into – so, people that are like professors and so-on, have very long-term relationships in the science system, in industry and so-on … and it's almost like they're a lynchpin for other things to happen, like being able to get a post-doc."**	S&T team member used PO to **vent his frustration** about the team leaders' (lack of) engagement in the research; PO responded with a justification for the current system by **sharing insider knowledge** into SfTI challenge ⇨ Shows an emerging 'insider-outsider' interaction by responding to concerns (establishing embeddedness)
Iteration	S&T team member complained to PO about how the researchers' voices do not get heard; PO suggested opportunities did exist and shared insights into the process/mechanism to hear researchers' voices/suggestion; S&T researcher noted that they actually had the chance, but did not take up the chance to engage.	ROB-R3: Yeah, is anybody ever asking the researchers what would be the best way of doing things? That doesn't seem to happen. **BNZIC-PO4: We've got a new [national] chief science advisor, and I know that [they have] done the rounds, and also, [they have] concentrated on, obviously, the sciences. … So, I think we do see a bit of that. Have you had any engagement with…** ROB-R3: [Chief Science Advisor]? **BNZIC-PO4: [Chief Science Advisor] … what was her role, as well, and –** ROB-R3: Yeah, I was going to go along to one of her talks, but – she came down and gave a talk, but I didn't end up doing that. I don't know why; other things to do, I expect. So, yeah, I haven't really engaged very much in what she's doing.	PO able challenge a S&T researcher with **a probing question that revealed information** about not engaging with the Chief Science Advisor ⇨ PO found out info only because they had knowledge of how researchers could voice their views through a process/mechanism that exists in the wider national science system (establishing embeddedness)

observe, participate in, and then reflect on how to best enhance scientists' professional action to improve innovation outcomes in a community. This only happened after a three-year process whereby the first action research "intervention" took place with two of the spearhead teams. This intervention involved facilitated workshops that aimed at accelerating radical innovation with new natural science teams.

Finally, the research process shifted from a formative navigation phase to a normalized research process through the iteration and reflection phases. With the BNZIC team becoming normalized within the SfTI framework, the navigation phase would become redundant, except perhaps where tranche funding required a need to regroup, pivot, or address capabilities in the team. In this scenario, the navigation phase might be restricted to the inclusion of new research aims, or where new spearhead projects begin. However, the navigation stage would be informed by research already carried out and, although exploratory, is likely to be less organic with an established framework in place. Thus, an external consultant may need to start from the beginning each time they are engaged.

Beyond the research process, our findings concur with Bastow et al.'s (2014a) suggestion of three areas that provide a compelling rationale for social scientists being more embedded in natural science and technology projects. First, as natural science and technology disciplines are typically better funded, including social science in well-funded natural science and technology projects can encourage and improve future funding for social science projects (see also, Bastow et al., 2014b). Second, with natural science and technology subjects reflecting better citation and review practices, social scientists that work closely with natural science and technology disciplines can expect increases in citation rates. Third, with social impact gaining ground and incentives growing to improve social, political, and economic problems, an impetus exists for cross-disciplinary group cooperation with the involvement of social scientists. Ultimately, we found that investing time to create a greater connection between disciplines, led to disrupting "business-as-usual" with action research.

In summary, we can answer the second research question by recognizing that richer insights were generated by mapping a research pathway toward action research. Social science researchers on our team were able to determine what was occurring in real time, and then reflect on how to best enhance processes to improve innovation outcomes. Moreover, these insights informed the action research interventions that provided a feedback loop throughout the community of practice.

Conclusions

This article showed ways researchers can engage early to build relationships with respondents before conducting action research. Through our insights we answered two research questions: *"In what ways can researchers engage early to build relationships with respondents before conducting action research?"* and "*Can richer insights be generated by mapping a research pathway toward action research?"* We demonstrated how richer insights can be generated when social science research is included earlier in a natural science and technology-led research programme. Thus, we were able to map a research pathway toward action research over a long period.

We further reflected upon why action research was not employed from the outset. From an initiative that promoted social science to understand human and relational capacity, the "Building New Zealand's Innovation Capacity" (BNZIC) team moved toward an interventionist approach, using an action research methodology to change research (and researcher) behaviour. By exploring and communicating this process of navigation, iteration and reflection phases, we framed a way for researchers in the innovation management field - and wider management discipline - to adopt the ethnographic techniques outlined in this research. We believe it serves as a rich and rigorous foundation from which a bank of data could be drawn from to contribute to the action research process.

Highlighted below are key insights from the navigation and iteration phases:

• **Navigation Phase**

- o The project timeline needs to provide the participant-observer time and space to build trust with the participants.

- o Having open access to participants is preferred (for example, to interview, attend workshops and meetings, etc.), especially when the problems under examination are complex and not easily studied by direct observation or case study.

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- To observe interactions between team members, industry, and other stakeholders it is preferable to be present *in loco*.
- Ultimately, the navigation phase focussed on relationship building.

• **Iteration Phase**

- By building trust in the navigation phase, participant-observers in the iteration phase were no longer acclimatising as an outsider coming into a new environment. Instead researchers became "insider-outsiders" where they were neither inside nor outside the community of practice, but in-between.
- With trust having been built, researchers were perceived and accepted as an insider, however the tension of being "in-between" needed to be managed, for example, in balancing rapport so there was no under-rapport, and thus a lack of engagement.
- Maintaining a close relationship with spearhead leaders supported good access to their team. This needed to be done while balancing over-familiarity and blurring of boundaries, which sometimes results in a loss of objectivity.
- Ultimately, the iteration phase focussed on establishing embeddedness.

By building on the navigation phase, participant-observers through the iteration phase continued to develop relationships, trust, and rigor, which were embedded in that environment. These phases generated rich insights that led to increased confidence in mapping a research pathway toward action research that included the reflection phase:

• **Reflection Phase**

- With relationships developed and embeddedness established, the research team used insights they gathered to intervene from an informed position.
- Leading into an action research approach with precursory phases, a more comprehensive and rigorous understanding of innovation processes was revealed.
- With the researchers' role now being as insider-outsiders, they were able to be empathetic, reflexive, and objective, which ultimately led to actionable interventions that may have far reaching implications and be long-lasting.
- Ultimately, an embedded research team with established relationships can gain richer insights that support the implementation of a robust action research approach.

Contribution and implications
The paper makes two prominent contributions. First, through the navigation, iteration, and reflection phases, we identified that giving time to the social science process (for example, engage earlier rather than later) can have an incremental impact on social scientists' sense of insiderness, building trust and relationships, and respect from those being observed, before suggesting actionable improvements. We propose that embedding social science early in an upstream innovation programme can lead to a better understanding of the best action and intervention to address an innovation mission. An alternative view might be to engage an external consultant (Davison et al., 2004; Davison & Martinsons, 2007; Nosek, 2007) - without building the rapport an 'insider-outsider' can build - who is less empowered to have an impact on adjusting future actions (Sagor, 2010).

Second, our study showed that action research consultants may find themselves in a vulnerable position of not having enough knowledge, or may be following techniques and styles that do not suit the myriad of circumstances as required (Davison et al., 2004). Our approach aligns with Nosek's (2007) findings that it may be difficult for outside consultants/researchers to gain sufficient trust or organizational knowledge to establish the true story known only to insiders. In this paper, we have gone beyond that, and have contributed by providing a structured methodology that prepares the ground for implementing a robust action research approach. In this approach, social scientists can "step back", analyse a situation, and intervene to modify the direction of decision-making processes or unproductive patterns of behavior. As such, we propose moving away from

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"employing" action researchers toward *"being"* action researchers, as social scientists alongside the natural science and technology researchers. That is, engaging social scientists early to build rapport and to generate insights that will ultimately inform action research.

Implications and future research

Treading lightly and keeping loose boundaries at the outset meant a bespoke methodology could emerge, serving the needs of our team's complex research programme. Naturally, this "open agenda" was supported by the long timeframe and incredible access afforded to the social scientist team. Our findings could influence the way longitudinal research programmes are designed through the navigation, iteration, and reflection phases, toward action research, where actionable feedback can be provided. Furthermore, we have presented a scenario that challenges the norms and increases our overall understanding of how innovation management research can be improved. By addressing the ways social science can become embedded in a natural science and technology research environment, we can see how gradual convergence of social science, natural science, and technology research will enhance the quality of research from all sides. We thus found that being an "insider-outsider" brought challenges, but was overall advantageous in mapping toward an action research framework (Colville et al., 2014).

Finally, future research could draw attention to specific ways our phased "insider outsider" approach to action research differs from current applications of the action research process. While the broader management discipline has adopted action research frameworks, the question is whether these are transferable or generalisable to the innovation management context. Do they represent or mirror the added complexity of concepts in the innovation and entrepreneurship space? Are there ways to better conduct social science research in closed vs. open innovation contexts? We hope in some small way this paper will encourage authors toward a trajectory of research designs, methods, and approaches that are rigorous and support the advancement of cross-disciplinary research (Conn & Ritala, 2019). In doing so we envisage research being generated that is relevant to practice and provides a basis for research translation and communicating results outside academia.

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About the Authors

Dr. Paul Woodfield is a Senior Lecturer at Auckland University of Technology (AUT), Auckland, and holds a PhD from the University of Auckland. Building on his entrepreneurship and family business PhD research he received funding to investigate “Innovation in New Zealand’s Traditional Industries.” He is in the Department of International Business, Strategy, and Entrepreneurship at AUT and is also part of the “Building New Zealand's Innovation Capacity” spearhead for the National Science Challenge: Science for Technological Innovation. He has published in the areas of family business, entrepreneurship, wine business, methods, and science, technology, and innovation.

Dr. Katharina Ruckstuhl is an Associate Dean at the Otago Business School, University of Otago, New Zealand and holds a PhD from Otago. Dr. Ruckstuhl co-leads the “Building New Zealand’s Innovation Capacity” social science research of the National Science Challenge, Science for Technological Innovation. She is also the Vision Mātauranga (Māori knowledge) leader, a “Theme” that crosses all the Challenge’s research activities. She has published in the areas of Māori language, resource extraction in Māori territories, Māori entrepreneurship in SMEs, Indigenous science and technology, and Indigenous Knowledge.

Dr. Rafaela C.C. Rabello currently holds a PhD in social investment in the oil and gas sector and a Master’s in Education, awarded with distinction by the University of Otago, New Zealand. Rafaela also holds a B.A. in Psychology from Centro Universitário de Brasília - DF, Brazil. Rafaela has worked within the fields of corporate social responsibility - in the oil and gas sector - and education for more than 10 years. She has published in the areas of corporate social responsibility; social investment in the oil and gas sector, higher education and good teaching and effective learning methodologies in higher education.

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Using Web Text Analytics to Categorize the Business Focus of Innovative Digital Health Companies

Abdulla Aweisi, Daman Arora, Renée Emby, Madiha Rehman, George Tanev and Stoyan Tanev

"It's a good sign that this sector isn't niche anymore. It's actually attracting some of the most prolific brand-name funds because of the potential. … It's not just funding that has accelerated, I genuinely feel that the ecosystem shifted in such a way to allow for more rapid and scaled adoption."

Megan Zweig
Rock Health's Chief Operating Officer

Categorizing the market focus of larger samples of companies can be a tedious and time-consuming process for both researchers and business analysts interested in developing insights about emerging business sectors. The objective of this article is to suggest a text analytics approach to categorizing the application areas of companies operating in the digital health sector based on the information provided on their websites. More specifically, we apply topic modeling on a collection of text documents, including information collected from the websites of a sample of 100 innovative digital health companies. The topic model helps in grouping the companies offering similar types of market offers. It enables identifying the companies that are most highly associated with each of the topics. In addition, it allows identifying some of the emerging themes that are discussed online by the companies, as well as their specific market offers. The results will be of interest to aspiring technology entrepreneurs, organizations supporting new ventures, and business accelerators interested to enhance their services to new venture clients. The development, operationalization, and automation of the company categorization process based on publicly available information is a methodological contribution that opens the opportunity for future applications in research and business practice.

1. Introduction

To identify new business ideas and shape opportunities, the founders of new ventures should systematically scan the market environment and search for new information, associate previously unconnected information, and make judgments about the commercialization potential of their business ideas (Tang et al., 2012). This is especially important in emerging technology sectors, such as digital health, where the increased need for novel digital health solutions has inspired many startups to branch into it. One of the ways for new ventures to address this business intelligence need is to benefit from the increasingly available open source web search and text analytics tools as a way to search for, collect, and analyze publicly available competitor information about newly introduced market offers and innovative applications of new and emerging technologies. This can help them generate valuable insights about their competitive market offer (Tanev et al., 2015).

Developing business analytics capabilities offers a research opportunity for scholars who can focus on suggesting and validating applied analytical methods that help new companies interested to engage in market intelligence activities at the early stages of their existence. Developing such capabilities can be highly valuable for researchers themselves, giving them an opportunity to identify innovation trends related to the early stages of commercializing new and emerging technologies.

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The objective of this article is to apply topic modeling (Blei et al., 2012; Hecking & Leydesdorff, 2018) on collections of text documents that include information from the websites of 100 innovative digital health companies and categorize them in terms of their overall business application areas and market offer types. The list of companies was created by the Medical Futurist Organization (https://medicalfuturist.com/the-top-100-digital-health-companies-an-infographic) through the evaluation of four selection criteria: innovation mindset, disruptiveness of technology, business model viability, and clear dedication to digital health domain. The study is part of the deliverables of a research program that was designed to examine the applicability of the topic modeling approach to mapping technology companies in terms of their market offer types (Johnson et al., 2008) and, eventually, to develop business opportunity maps that could be used by new ventures interested to enter a specific business domain (Mamosian et al., 2018).

The research question is: How to apply topic modeling on textual information provided on the websites of a sample of digital health companies to identify their business application areas, dominant market offer types, and most representative companies engaged in offering them? In this sense, the article aims to make a contribution to the literature by shaping an automated text analytics approach to the categorization of larger samples of companies in a specific business domain. One of the key benefits of the suggested approach for technology innovation and entrepreneurship researchers is helping to easily identify highly representative cases within larger samples of companies. Such identification allows for methodological enrichment through the valuable integration of quantitative and qualitative research inquiries related to emerging business sectors and the commercialization of new technologies.

The content of the article is organized as follows. The next section summarizes insights from literature on the innovation and entrepreneurial potential of the digital health sector, as well as introducing the topic modeling approach as an example of a Natural Language Processing (NLP) technique that could be highly valuable for developing of competitive insights for early-stage companies. The third section describes the methodology adopted in our study. The next section includes a summary of the topic modeling results and key findings emerging from post-processing analysis. The article ends with a conclusion describing the contributions and the potential of the method for future studies.

2. Literature review

2.1 The entrepreneurial potential of the digital health sector

Healthcare is entering a new digital era where telemedicine, virtual reality, robotics, smart phones, and other technological advancements are slowly becoming part of regular healthcare practices (Wulfovich & Meyers, 2020). Digital health technologies offer a way to change many of the current challenges faced by healthcare systems. They have the potential to transform the medical field by improving patient outcomes, increasing quality of healthcare, and reducing costs.

A recent study by the Medical Futurist Organization indicates that the global digital health market is expected to exceed $504.4 billion USD by 2025, which is a nearly six-fold increase from its $86.4 billion USD 2018 valuation. The COVID-19 pandemic has accelerated the adoption of digital health and will continue fostering its growth in the near future. For example, one of the growing niches of the digital health market, which is attracting the attention of many aspiring technology entrepreneurs, includes startups that use artificial intelligence in drug discovery, disease diagnosis, and patient monitoring.

Digital health entrepreneurs pursue opportunities under conditions of high uncertainty. They focus on creating healthcare stakeholder value through the deployment of digital health innovations. However, the emergence of the business sector is associated with significant challenges in identifying opportunities, along with the design, development, testing, and commercialization of digital health technologies and products. The challenges of digital health entrepreneurship and innovation start at the very beginning of the technology commercialization roadmap, with a) industry and market analysis, and b) opportunity identification and assessment (Wulfovich & Meyers, 2020). It is important therefore for the founders of new digital health companies to develop the analytical skills they need to carefully examine the latest market offers and value propositions in their business sector, in order to be able

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make differentiations in the marketplace.

2.2 Applications of topic modeling to the categorization of the market offers of innovative firms

Our study uses topic modeling to examine the corpus of text documents corresponding to the webpages of innovative digital health companies. Topic modeling is the process of identifying latent topics in a large set of text documents. It is an example of a NLP method, which examines unstructured text data collections to discover topics that are difficult or impossible to uncover by human efforts alone. The method has often been perceived as a relatively new development in information retrieval sciences.

Topic modeling methods such as Probabilistic Latent Semantic Analysis and Latent Dirichlet Allocation (LDA) have become increasingly popular (Blei, 2012; Hannigan et al., 2019). However, attempts to extract topics from unstructured text using Factor Analysis (FA) techniques can be found as early as the 1960s (Hecking & Leydesdorff, 2018). In all topic modeling methods, it is necessary to build a Document-Term Matrix (DTM) that contains the number of term occurrences per document. The rows of the DTM usually represent the documents and the columns represent the frequencies of the whole vocabulary of distinctive terms used in the documents. The use of the DTM approach in text analytics turn thematic analysis of texts into a quantitative problem based on analysing the relations between the frequencies of words used in each of the documents. The LDA approach to topic modeling uses probability theory to process the DTM (Blei, 2012), while the FA approach is deterministic and uses linear algebra methods (Hecking & Leydesdorff, 2018).

The applications of topic modeling in management research have recently been summarized by Hannigan et al. (2019). The topic modeling algorithm considers every webpage text as a text document that is a mixture of topics, and every topic as a word or mixture of words. Words can be shared between topics and the topics can be shared among abstracts. The algorithm identifies combinations of words that are semantically interrelated and tend to appear together across the different documents. The combinations of words help identify specific themes and patterns that are latently present in the corpus. In addition, the topic model organizes the corpus by clustering the documents corresponding to each topic. The documents associated with a given topic are ranked in terms of the degree of their association with it. A closer examination of the topical organization of the documents enables interpretation of the overall theme and labelling of the topics (Blei, 2012; Hecking & Leydesdorff, 2018; Hannigan et al., 2019).

The topic modeling approach has also been applied to examine the market offers of a sample of companies in a specific business technology sector (Mamosian et al., 2018). Mamosian et al. (2018) adopted the format and logic of the modeling approach to examine a corpus of text documents created by scraping the websites of approximately 140 Canadian photonics technology companies. The main value of the suggested approach comes from a simple practical insight —the fact that the names of the text documents associated with a specific topic could be used to identify the companies from the websites of which provided the texts of these same documents. We can therefore use the topic model to identify the groups of companies that are most highly associated with a specific topic. In this sense, Mamosian et al. (2018) show that topic modeling can be used as a way of categorizing samples of companies based on the information they provide on their websites. And, since most of the information provided by companies on their websites is about what they offer to their potential customers, the topic model will most probably categorize the companies in terms of their market offers. This is a valuable practical insight that was used as a methodological basis for the present study.

3. Methodology

Our research approach is based on the application of WordStat —a commercial tool using FA to perform topic modeling (Hecking & Leydesdorff, 2018). The topic modeling algorithm identifies the key terms and the sets of documents corresponding to each of the topics. The research method included several steps following the logic suggested by Mamosian et al. (2018). First, we identified the sample of digital health companies by choosing a list of the top 100 digital health companies in the world created by the Medical Futurist Organization (see Appendix A). The companies were selected based on four criteria: mindset for innovation, truly disruptive technology, viable business model, and clear dedication to digital health. The second step was scraping the information from their websites and cleaning the data to

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be used in the topic modeling process. We used a commercial tool (https://firescraper.com/) to scrape all accessible company webpages, which resulted in a corpus of nearly 5,000 documents corresponding to the webpages of 92 companies (8 company websites were not able to be scraped, see Appendix A).

The corpus of documents was then subjected to our topic modeling approach to identify the emerging topics and the text documents associated with them. We used the Wordstat software, which enables research based on NLP, statistical, and feature analysis, together with multiple post-processing and visualization options (https://provalisresearch.com/products/content-analysis-software/). Wordstat performs topic modeling based on FA (Hecking & Leydesdorff, 2018). The topic extraction is achieved by computing a (word x document) frequency matrix, or alternatively by segmenting documents into smaller chunks and computing a (word x segment) frequency matrix. Once this matrix is obtained, a FA with Varimax rotation is computed to extract a small number of factors. All words with a factor loading value higher than 0.3 are then retrieved as part of the extracted topic.

Each of the topics is characterized with a set of words that tend to appear together and define an online communication theme that is common to many of the documents and thus, respectively, the companies. The documents were named in a way that they could be easily linked to the corresponding company names. Thus, we identified the companies associated with specific market offer types and examined the information on their websites to confirm our initial associations.

Table 1. List of topcis identified in the topic modeling process together with some of the most frequent words associated with them. The Coherence and Eigenvalue indicate the relevance of the specific topic within the entire topic model.

No	Topic	Most frequent topic words	Coherence	Eigenvalue	% Cases
1	Genetics	Variants; sequencing; genome; genetics; genes; factors; report; customers; testing; DNA test	0.72	8.92	12.76%
2	Diabetes	glucose; invasive; diabetics; continuous; flexible; affordable; developing; diabetes; company; monitor; diabetes prevention	0.71	8.05	8.96%
3	Side effects	Side effects; side effects and cost; treatment reviews; effectiveness major; effectiveness moderate	0.51	2.80	2.54%
4	Remote health care	Smart patients; online community; patient care services; smart patients website; share information; telemedicine; health systems	0.49	3.72	18.38%
5	Women & pregnancy	Natural cycles; birth control; hormonal birth control; birth control methods; pregnancy; ovulation; women; menstrual cycle; early pregnancy; fertile days; fertile window; pregnancy test; pregnant women; after ovulation; negative pregnancy test	0.43	3.18	4.24%
6	Privacy policy & personal information	Privacy; policy; personal; information; security; personal data; committed to protecting; terms; agreement; services	0.42	4.55	8.90%
7	University & medical centers	University; school; medicine; center; director; medical school; school of medicine; medical center; scientific; society; American society	0.41	5.73	6.74%

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Table 1. List of topcis identified in the topic modeling process together with some of the most frequent words associated with them. The Coherence and Eigenvalue indicate the relevance of the specific topic within the entire topic model (cont'd).

8	Clinical trials	Clinical trials; clinical research; clinical studies; FDA cleared; clinically validated personal ECG solution; FDA clearance	0.40	2.58	12.56%
9	Virtual reality	Virtual reality; pain; therapy; virtual care; pain management; VR therapy; pain relief; anxiety	0.40	2.48	5.92%
10	Cancer	Skin cancer; cell carcinoma; ovarian cancer; cancer cells; lung cancer; breast cancer; basal cell carcinoma	0.40	2.98	5.44%
11	Vision	Vision; eye; vision test; vision test from home; personal vision tracker; eyeglass numbers	0.38	1.72	4.24%
12	Nutrition	Gluten; celiac; disease; diet; food; celiac disease; free diet; gluten free; food allergy; untreated celiac disease	0.38	3.07	3.68%
13	Hearing	Hearing loss; hearing screening; hearing health; hearing test; healthy hearing; hearing aids; hearing healthcare; access to hearing	0.38	2.79	2.00%
14	Mental health	Stress; mind; mental; practice; anxiety; mindfulness meditation	0.37	1.58	2.26%
15	Blood pressure	High blood pressure; monitor; blood test; blood oxygen; blood flow; oxygen levels; upper arm monitor; wrist monitor	0.34	1.97	2.12%
16	Asthma	Asthma; medication; asthma symptoms; people with asthma; asthma control; manage; respiratory disease; asthma patients	0.33	1.76	2.34%
17	Wearable devices	Wearable diagnostic devices; wearable technology; wearable sensors; subscription service; personalized lifestyle coaching programs; invasive glucose monitors	0.33	1.93	2.46%
18	Fitness	Activity; rate; sleep; tracking; heart rate; deep sleep; physical activity; quality sleep; heart rate monitor; heart rate variability	0.32	2.34	2.28%
19	Mobile apps	App; apps; users; google play; app store; mobile app; health apps; download the app; free app	0.32	1.62	1.92%
20	Stethoscope	Stethoscope; cardiac; digital stethoscope; electronic stethoscope; core digital stethoscope; heart murmurs; heart sounds	0.31	1.66	1.10%
21	Ultrasound	Ultrasound; lung ultrasound; handheld ultrasound; ultrasound system; portable ultrasound; point of care; ultrasound scanners; ultrasound education; scanner	0.30	1.85	1.86%
22	Artificial intelligence	Artificial intelligence; therapeutic artificial intelligence; human intelligence; machine learning; reinforcement learning	0.28	1.74	4.88%
23	Response to Covid	Covid; pandemic; response to Covid	0.25	1.88	3.06%

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The final analysis included a discussion of the ability of the method to distinguish between topics related to specific market offers or application domains (including the specific companies focusing on them) vs. topics related to issues discussed online by the majority of the companies. This analysis allowed us to develop insights that could help automate the analytical approach and enhance its ability to work with larger samples of companies.

4. Results

The application of the topic modeling approach on the corpus of approximately 5,000 text documents associated with the 92 innovative digital health companies resulted in categorizing the dominant market offer types in the sample and the issues that companies found necessary to communicate online. It is important to note that “dominant market offer type” can also refer to the specific application domain, which could incorporate different but similar market offers.

The post-processing of the topic modeling results identified 23 topics (Table 1) and the companies that are most highly associated with each of the topics. Table 1 includes the topic labels (second column) and the set of most frequent words corresponding to a topic (third column). The Coherence value of the topics is presented in the fourth column. It measures the degree of semantic consistency of the most frequent words in the topic. The Coherence value helps in distinguishing between topics that are thematically interpretable in the context of the specific study, and topics that are artifacts of statistical inference but appear to be irrelevant to the context. The fifth column of Table 1 shows the Eigenvalue of each topic. These are the eigenvalues of the factors derived by means of the FA method and should be larger than 1. The last column (% Cases) shows the percentage of the documents that are most highly associated with a given topic.

The Coherence and Eigenvalue indicate the relevance of the specific topic within the entire topic model.

The topics presented in Table 1 are ranked according to their Coherence value. The selection of exactly 23 topics was based on the choice of a threshold Coherence value of 0.25. This threshold value ensures a reasonable semantic consistency of the topic words and topic eigenvalues larger than 1.

The scope of this article does not allow us to describe the full details of the fine structure of the topic model presented in Table 1. The rest of this section will concentrate on describing selected topic results to demonstrate the ability of the method and identify 2 main types of topics, focusing on: i) a specific digital health market offer type or application domain (for example, genetics, diabetes, blood pressure, vision, artificial intelligence); b) an issue or an online communication theme shared by the majority of the firms (for example, remote health care, response to Covid-19). The set of results shown in Figures 1-7 below were chosen as a concise way of providing some

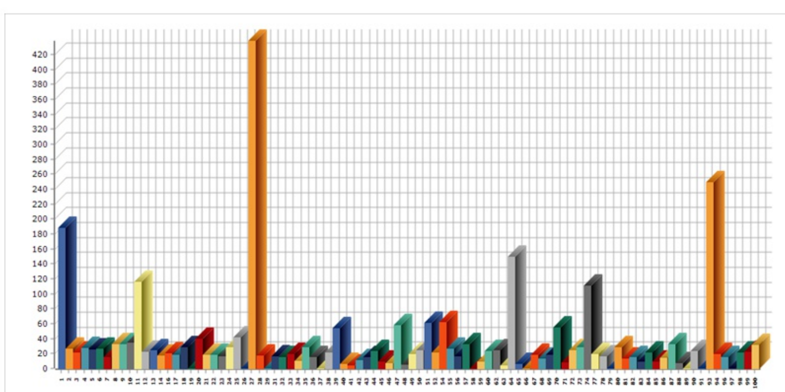

Figure 1. Topic 1 (Genetics) *Rate per 10,000 words* (vertical axe) for each of the companies in the sample (horizontal axe). The numbers on the horizontal axe of the graph correspond to the numbering of the list of companies provided in Appendix A. The graph helps in identifying the businesses that are most highly associated with Genetics.

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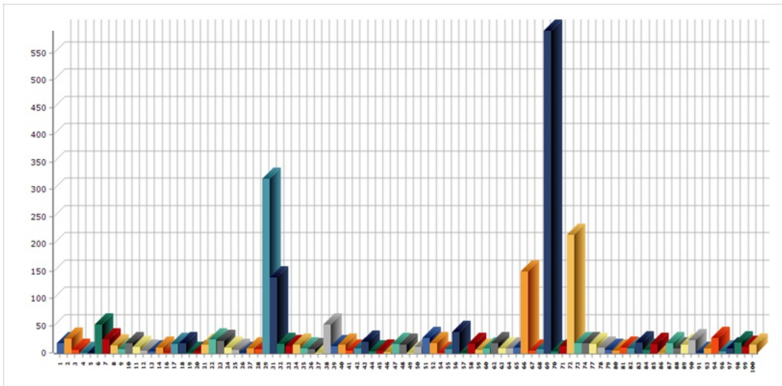

Figure 2. Topic 2 (Diabetes) *Rate per 10,000 words* (vertical axe) for each of the companies in the sample (horizontal axe). The graph helps in identifying the businesses that are associated with diabetes issues.

representative examples of these three types of topics.

Fig. 1 shows the Topic 1 (Genetics) *Rate per 10,000 words* (Rp10KW) for each of the companies in the sample. RP10KW is a variable corresponding to each company's frequency of use of the words associated with the topic Genetics (see the first row of Table 1).

Fig. 1 shows that 5 companies that are most highly associated with the Genetics topic. They correspond to the columns that are relatively higher than the rest of the data. To identify these companies, we have looked for companies with Rp10KW value larger than 120. The choice of the threshold value 120 for the Rr10KW variable was made in a way to allow identifying a manageable number of companies that are most highly associated with the specific topic. Identifying these companies meant that they use genetics-related words on their websites more frequently than the rest of the companies.

The 5 companies are as follows (provided in the priority of their degree of use of the Genetics topic words; the numbering follows the list provided in Appendix A):

- # 27, *Dante Labs*: Takes a proactive approach to health with insights on genetic predispositions, drug response and well-being.

- # 93, *Veritas*: Operates a high complexity next generation sequencing (NGS) laboratory.

- # 1, *23andme*: A genetic and health company involving scientific, data, and genetic insights.

- # 64, *MyDNA*: Leverages the world's leading genotyping technology and scientific algorithms to learn more about DNA.

- # 11, *Atlas Biomed*: Provides a two-feature DNA test (with a detailed genetic profile of one's health, nutrition, physical activity and geographical ancestry) and Microbiome test (analyzing the types of bacteria present and their proportion in the overall microbiome).

The brief description of the focus of the 5 companies shows that they are indeed dealing with a business related to genetics. Fig. 1 is quite representative because it shows that the topic modeling approach can spot companies that are predominantly dedicated to a specific application domain (in this case genetics): next generation sequencing, DNA testing, developing genetic predisposition insights, etc. Our visual examination of Fig. 1 suggests that it could be used as a basis for developing a fully automated web search and business analytics process that would enhance the abilities of both scholars and practitioners to examine the dominant offers and communication priorities of companies in specific business sectors.

Fig. 2 shows that 5 companies are most highly associated with the Diabetes topic. To identify these companies, we have used again an Rp10KW threshold value of 120. The 5 companies are as follows:

- # 69, *Nemura Medical*: Produces a variety of devices

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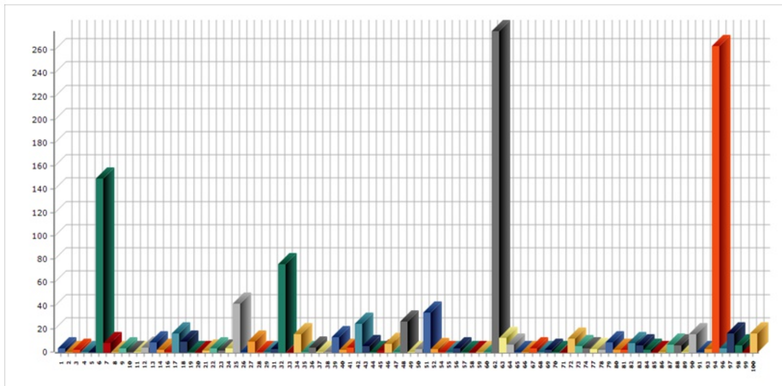

Figure 3. Topic 15 (Blood pressure) *Rate per 10,000 words* (vertical axe) for each of the companies in the sample (horizontal axe). The graph helps in identifying the businesses that are associated with blood pressure issues.

to monitor glucose and weight loss, athletes & viral infection.

- # 29, *Dexcom*: Produces devices for monitoring glucose level.

- # 72, *Omada Health*: Produces a device and application for continuous glucose monitoring.

- # 31, *Diabeloop*: Produces devices for real time monitoring of type 1 diabetes.

- # 66-*MySugr:* Markets app to monitor diabetes, diabetes management kits, and coaching related to diabetes.

The brief description of the focus of the 5 companies above shows that they are indeed dealing with a business related to diabetes.

Fig. 3 shows that 3 companies are most highly associated with the Blood pressure topic (Rp10KW threshold value > 120). The 5 companies are as follows:

- # 62, *Mocacare*: Provides devices to monitor blood pressure.

- # 94, *Viatom*: Designs and manufactures healthcare products (wearable and home medical devices) such as pulse oximeters, portable vital signs monitors, EKG/ECG Holter Monitor and portable blood pressure monitor.

- # 6, *Alivecor*: Delivers intelligent, highly personalized

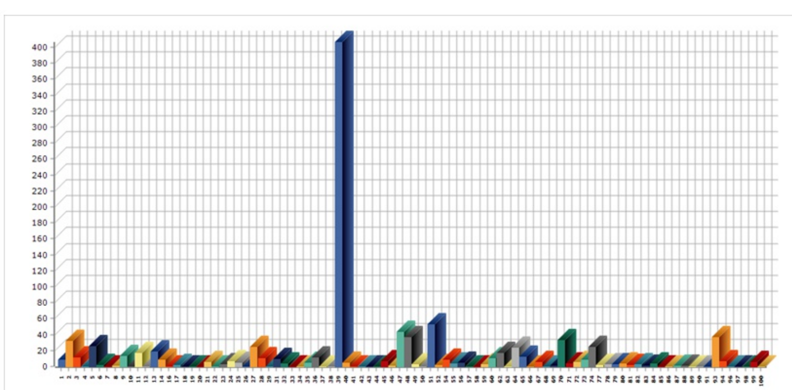

Figure 4. Topic 11 (Vision) *Rate per 10,000 words* (vertical axe) for each of the companies in the sample (horizontal axe). The graph helps in identifying the one company that is most highly associated with vision issues.

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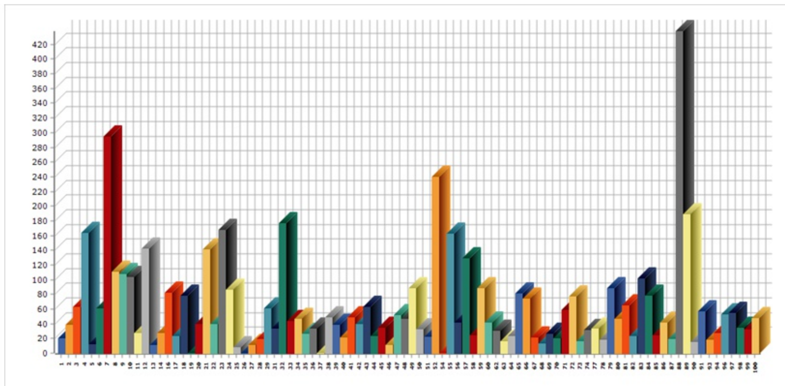

Figure 5. Topic 4 (Remote health care) *Rate per 10,000 words* (vertical axe) for each of the companies in the sample (horizontal axe). The graph helps in identifying the companies that are referring most frequently to Remote health care. However, the graph is qualitatively different from the ones shown above since it shows that the topic is discussed by a relatively larger number of companies compared to the previous cases shown in Figures 1-4.

heart data with advanced determinations.

The brief description of the focus of these 3 companies above shows that they are indeed dealing with a business related to Blood pressure issues.

Fig. 4 shows that there is one company that is most highly associated with vision - # 39, Eyeque, which provides eye care solutions with self-administered eye test devices.

Fig. 5 shows that there are 10 companies discussing more intensively remote health care issues on their websites (Rp10KW threshold value > 120). The top 5 companies associated with this topic are as follows:

- # 88, *Smart Patients*: An online community for patients and families affected by a variety of illnesses.
- # 7, *AmWell:* Market services to accelerate the patient journey combined with opportunities to scale telehealth.
- # 52, *INTouch Health*: Provides a virtual care platform and telehealth devices.
- # 4, *AdhereTech*: Provides a software platform analyzing a number of data feeds, such as: real-time adherence information from our devices, patient messages & feedback, and pharmacy inputs & data.
- # 32, *EKO*: Provides a platform that brings together advanced stethoscopes, patient and provider software, and AI-powered analysis with pharmacy inputs & data.

The visual examination of Fig. 5 shows that the Remote health care topic is both qualitatively and quantitatively different from the previous examples because it is shared among a relatively larger number of companies. Fig. 5 is an example of a "noisier" visual pattern that could be clearly differentiated from the previous ones (Figures 1-4) because of the higher-level background of companies that are less associated with the specific topic. Such a visual pattern can be associated with topics that are not related to a specific application domain, but rather to a particular common feature of many different products developed by a larger number of companies.

Figure 6 shows that there are many companies that are frequently referring to the Covid pandemic with an average intensity that is lower compared to the previous topics. The Rp10KW value of all these companies is visibly lower than the threshold value of 120 that was used in the previous cases. The visual pattern of the graph suggests that the Covid topic may not be associated with a specific application domain, but instead with an issue that is discussed by most of the companies in the sample.

The top 2 companies associated with the Artificial intelligence topic are as follows:

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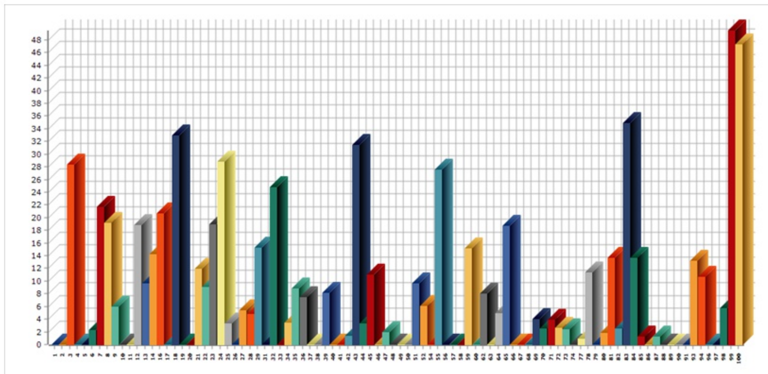

Figure 6. Topic 23 (Response to Covid) *Rate per 10,000 words* (vertical axe) for each of the companies in the sample (horizontal axe).

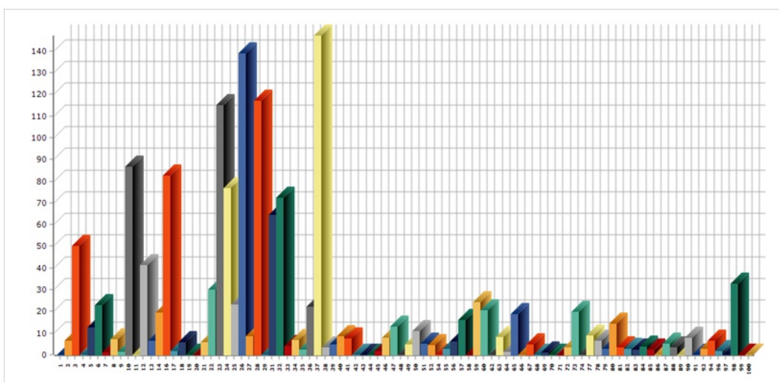

Figure 7. Topic 22 (Artificial intelligence) *Rate per 10,000 words* (vertical axis) for each of the companies in the sample (horizontal axis). The graph helps in concluding that there are more than 5 companies developing artificial intelligence-based products.

- # 26, *Cyberdyne*: Develops a variety of innovative cybernics devices and interfaces and advanced AI-Robot products to enable early detection and prevention for health maintenance, to improve our aging workforce, and to respond to the shrinking workforce.

- # 28, *DeepMind*: Develops safe artificial intelligence systems to provide intelligence solutions and advance scientific discovery for all.

The identification of the two companies was based on the Rp10KW threshold value of 120. However, Fig. 7 shows that the Artificial intelligence topic is associated with a larger number of companies using AI as an enabling technology in different types of market offers or business applications (the value of their Rp10KW is very close to the threshold value). At the same time, the visual pattern of the graph shown in Fig. 7 is different from the "noisy" patterns characterizing the companies associated with the Remote health care and Response to Covid topics. It allows for two potential ways of interpreting the AI topic - as an application domain or as a specific technology that is used in companies' products and services.

The analysis provided here could be extended to the rest of the 23 topics shown in Table 1. A closer examination of the description of the topics will show they that could be categorized in terms of the two main types we identified above - a specific digital health application domain or an online communication theme. The results suggest that we can identify fifteen application domains: Genetics, Diabetes, Women & pregnancy, Virtual reality, Cancer, Vision, Nutrition, Hearing, Mental health, Blood pressure, Asthma, Fitness, Stethoscope, Ultrasound, and Artificial intelligence. We can also identify eight online communication themes that are common to most of the

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companies: Side effects, Remote health care, Privacy policy & personal information, Clinical trials, University & medical centers, Wearable devices, Mobile apps, and Response to Covid. Some of these themes refer to medical issues such as side effects and clinical trials, while others refer to product-related issues or technologies such as wearability and mobility.

5. Conclusion

The above article summarized the results of a research study adopting a text analytics (topic modeling) approach to identifying dominant themes discussed on the websites of a sample of 100 innovative digital health companies. Two major types of topics were identified - market offer types or business application domains, and issues of concern to many companies in the sample that are not directly associated with their specific market offers. Our approach allowed identifying companies that are most highly associated with specific application domains. The combination of business application domains and their most representative companies could be used to map the business focus of innovative companies in the digital health sector. The specific results enhance our understanding of what innovative digital health companies offer, along with their online thematic focus. However, the value of the suggested analytical approach consists in its ability to be replicated in the context of other business sectors. Future studies may focus on developing more powerful post-processing text analytics capabilities that could deepen the insights provided by the topic model.

The article does not pretend to make a specific theoretical contribution. Its main contribution is methodological since it demonstrates the potential of a new application of the topic modeling approach to generate innovation management research insights. The instrumentalization of the methodological approach adopted in this study represents an opportunity to develop valuable insights not only for busines innovation scholars and executive managers of new ventures, but also for managers of incubators, accelerators, and innovation centers interested in enhancing their business intelligence services to their clients. In addition, it could benefit investors looking for promising business areas, or policy makers looking to promote certain types of businesses, as well as ethicists looking to understand similarities and differences in new technology businesses associated with emerging ethical dilemmas, for example, AI and genetics.

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About the Authors

Renée Emby, B.A, MABA, is a Technical Advisor with Shared Services Canada, Ottawa, ON, Canada. Renée currently leads a team of employees as they deliver Information Management and Information Technology services to Canadians and the Government of Canada. Before working with Shared Services Canada, Renée was employed with Canada Border Services Agency where she worked in business analytics pertaining to national and international security. Renée began her academic journey at Carleton University where she obtained an undergraduate degree in Business Law (2020) and a Masters of Applied Business Analytics (2021). Renée is continuing her education at the University of Ottawa, where she is pursing a Certificate in Business Process Improvement (2021). Renée's experience and interests pertain to national security, security of information, data analytics, service management and delivery.

Daman Arora, is a Software Engineer, currently working towards a Master of Applied Business Analytics degree in TIM Program at Carleton University, Ottawa, ON, Canada. Prior to that, Daman studied Computer Systems Technician program (2017, Algonquin College, Ottawa, ON, Canada) and worked as an Intern as well as a Full Time Software Engineer in the Cloud and Cognitive Support business unit of IBM Canada. Daman has a keen interest in the field of Cloud Computing, DevOps, Data Analytics, & Machine Learning. Daman also enjoys contributing to Open Source projects and has made significant code, and non-code contributions to various projects, notably, Kubernetes, TrinoDB, & Apache CloudStack. Daman Arora is member of the Inaugural Class of Community Advocates at Ambassador Labs for the period of 2021-2022. Daman is continuing his education at York University, where he is pursuing a Certificate in DevOps (2021).

Madiha Rehman is a master's degree holder of Business Analytics associated with Technology Innovation Management from Carleton University, Ottawa, ON, Canada (2021). Before that Madiha did her Honors in Bachelor of Computer Science (2002). Madiha is currently working as a Technical Support Engineer and a Business Development Representative. Madiha is a tech-savvy professional skilled in many areas as an analyst, technical support provider, customer support and success and business development. Madiha is a committed professional team player who has passion for continuous improvement and learning and willingness to take on new and advanced roles. Madiha would like to pursue a highly rewarding career, where she can utilize her skills and knowledge, develop new skills and contribute in the accomplishment of organizational goals.

George Tanev, MSc, MEng, is a Product Owner at Export Development Canada in Ottawa, ON, Canada. He works in innovating and developing knowledge based solutions to support Canadian companies go and grow global. George's background spans multiple interdisciplinary fields including systems engineering, medical device research and development, and entrepreneurship. George's academic backround includes a BEng in Biomedical and Electrical Engineering (Carleton University, 2008), a MEng in Medicine and Technology (Technical University of Denmark, 2012), and a MSc in Technology Innovation Management (Carleton University, 2021). George's research interests include applied business analytics, medical technologies, product innovation and cybersecurity.

Abdulla Aweisi, MEnt, B.Sc., currently is working as IT Manager with TechBrew Robotics, Salmon Arm, BC, Canada. Abdulla has more than 15 years of experience in the Information Technology field, with a demonstrated history of working in the Building Materials Manufacturing \ Retail industry. Skilled in IT Digital & Business Transformation, Business Processes re-engineering, ERP Implementations, and IT Strategy. Passionate about Business Intelligence, Data Science, and Entrepreneurial Ecosystems. Holding a B.Sc. in Computer Science (2006) from Princess Sumaya University for Technology (PSUT), Amman, Jordan, and Masters of Entrepreneurship, Technology Innovation Management (TIM) (2021) from Sprott School of Business, Carleton University, Ottawa, ON, Canada.

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Appendix A. List of the digital health companies included in the sample (companies in red did not allow scraping their online text content).

No	Company name	Web
1	23andme	https://www.23andme.com/en-ca/
2	Acurable	https://acurable.com/
3	Ada Health	https://ada.com/
4	AdhereTech	https://www.adheretech.com/
5	AioCare	https://aiocare.com/patient/
6	Alivecor	https://www.alivecor.com/
7	AmWell	https://business.amwell.com/
8	Antidote	https://www.antidote.me/
9	AppliedVR	https://appliedvr.io/
10	Arterys	https://arterys.com/
11	Atlas Biomed	https://atlasbiomed.com/ca
12	Augmedix	https://augmedix.com/
13	Ava Health	https://www.avawomen.com/
14	Babylon Health	https://www.babylonhealth.com/
15	BeatO	https://www.beatoapp.com/
16	Behold.AI	https://behold.ai/
17	Bonzun	https://bonzun.com/
18	Butterfly Network	https://www.butterflynetwork.com/
19	Calm	https://www.calm.com/
20	Cellink	https://www.cellink.com/
21	Circulation	https://www.circulation.com/
22	Clarius	https://clarius.com/
23	CloudMedX	https://cloudmedxhealth.com/
24	Corti.AI	https://www.corti.ai/
25	Curiscope	https://www.curiscope.com/
26	Cyberdyne	https://www.cyberdyne.jp/english/
27	Dante Labs	https://www.dantelabs.com/
28	DeepMind	https://deepmind.com/
29	Dexcom	https://www.dexcom.com/en-CA
30	D-Eye	https://www.digitaleyecenter.com/
31	Diabeloop	https://www.diabeloop.com/
32	EKO	https://www.ekohealth.com/
33	Ekso	https://eksobionics.com/
34	Ekuore	https://www.ekuore.com/
35	Elvie	https://www.elvie.com/
36	Empatica	https://www.empatica.com/en-int/
37	Enlitic	https://www.enlitic.com/
38	etectRX	https://etectrx.com/
39	Eyeque	https://www.eyeque.com/
40	FabRX	https://www.fabrx.co.uk/
41	Firsthand Technology	https://firsthand.com/
42	Fitbit	https://www.fitbit.com/global/en-ca/home
43	Florence	https://florencehc.com/
44	Garmin	https://www.garmin.com/en-CA/
45	Ginger.IO	https://www.ginger.com/
46	Headspace	https://www.headspace.com/
47	Hearscope	https://www.hearxgroup.com/hearscope/
48	HeraBeat	https://herabeat.com/
49	Hocoma	https://www.hocoma.com/us/
50	iDoc24	https://www.idoc24.com/
51	Imaware	https://www.imaware.health/
52	INTouch Health	https://intouchhealth.com/
53	Intuitive Surgical	https://www.intuitive.com/en-us
54	Liftware	https://www.liftware.com/
55	Maven	https://www.mavenproject.org/
56	MC10	https://mc10inc.com/
57	Medical Realities	https://www.medicalrealities.com/
58	Medtronic	https://www.medtronic.com/ca-en/index.html
59	Medwand	https://ces.tech/
60	Microsoft Hololens	https://www.microsoft.com/en-us/hololens/industry-healthcare
61	Misfit	http://www.misfit.com/
62	Mocacare	https://mocacare.com/
63	Muse	https://choosemuse.com/
64	MyDNA	https://www.mydna.life/
65	MySense.AI	https://www.mysense.ai/
66	MySugr	https://www.mysugr.com/en/
67	Natural Cycles	https://www.naturalcycles.com/
68	Natural Machines	https://www.naturalmachines.com/
69	Nemura Medical	https://nemauramedical.com/
70	Nima	https://nimasensor.com/
71	Not Impossible Labs	https://www.notimpossible.com/
72	Omada Health	https://www.omadahealth.com/
73	Omron	https://www.omron.com/global/en/
74	Oncompass Medicine	https://www.oncompassmedicine.com/
75	OneRemission	http://oneremission.com/#/
76	Oscar Health	https://www.hioscar.com/
77	Osso VR	https://ossovr.com/

Using Web Text Analytics to Categorize the Business Focus of Innovative Digital Health Companies

Abdulla Aweisi, Daman Arora, Renée Emby, Madiha Rehman, George Tanev and Stoyan Tanev

Appendix A. List of the digital health companies included in the sample (companies in red did not allow scraping their online text content). (cont'd)

78	Oura	https://ouraring.com/
79	Patients Like Me	https://www.patientslikeme.com/
80	Philips	https://www.philips.ca/c-e/hs/hearing-and-hearing-loss.html
81	Pilleve	https://www.pilleve.com/
82	Polar	https://www.polar.com/ca-en
83	Propeller Health	https://www.propellerhealth.com/
84	Psious	https://psious.com/
85	Rewalk Robotics	https://rewalk.com/
86	Sensely	https://www.sensely.com/
87	Skinvision	https://www.skinvision.com/
88	Smart Patients	https://www.smartpatients.com/
89	Surgical Theater	https://surgicaltheater.net/
90	Thryve	https://www.thryveinside.com/
91	Urbandroid	http://team.urbandroid.org/projects/
92	Veebot	http://www.veebot.com/
93	Veritas	https://www.veritasgenetics.com/
94	Viatom	https://www.viatomtech.com/
95	Virtually Better	https://www.virtuallybetter.com/
96	Wahoo	https://www.wahoofitness.com/
97	Withings	https://www.withings.com/ca/en/
98	Woebot	https://woebothealth.com/
99	Xenex	https://xenex.com/
100	Zipline	https://flyzipline.com/

Author Bios (cont'd)

Stoyan Tanev, PhD, MSc, MEng, MA, is Associate Professor of Technology Entrepreneurship and Innovation Management associated with the Technology Innovation Management (TIM) Program, Sprott School of Business, Carleton University, Ottawa, ON, Canada. Before re-joining Carleton University, Dr. Tanev was part of the Innovation and Design Engineering Section, Faculty of Engineering, University of Southern Denmark (SDU), Odense, Denmark. Dr. Tanev has a multidisciplinary background including MSc in Physics (Sofia University, Bulgaria), PhD in Physics (1995, University Pierre and Marie Curie, Paris, France, co-awarded by Sofia University, Bulgaria), MEng in Technology Management (2005, Carleton University, Ottawa, Canada), MA in Orthodox Theology (2009, University of Sherbrooke, Montreal Campus, QC, Canada) and PhD in Theology (2012, Sofia University, Bulgaria). Stoyan has published multiple articles in several research domains. His current research interests are in the fields of technology entrepreneurship and innovation management, design principles and growth modes of global technology start-ups, business analytics and text mining. He is also interested in interdisciplinary issues on the interface of science and theology.

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Ideologies in Energy Transition: Community Discourses on Renewables

Petra Berg, Rumy Narayan and Arto Rajala

"You have to know the past to understand the present."

Carl Sagan
American astronomer

This paper examines discourses in five Finnish municipalities' energy transition processes to identify and explain different ideological discourses among its members. The study fills a gap in research extending the idea of sense making to capture the ideologies that hide in discourses during socio-technical transitions. We identify three types of ideological discourses labelled as Clan, Solarpunk and Native. The implications of the ideologies embedded in municipal, multi-partner networks that participate in energy transition affect who will be heard in a local context. This impacts future choices directly related to sustainability outcomes. We propose that discourses in these multi-partner networks, conceptualized from the perspective of municipal energy systems, help us to uncover underlying ideologies that imperil change. And yet at the same time, these revelations offer opportunities for sustainability-oriented innovation.

Introduction

Energy transition is a system-wide ongoing process during which transformative initiatives and actions may influence peoples' responses to energy. Energy-related behaviour depends on socio-economic incentive structures, as well as political, institutional, and organizational frameworks (Mannberg et al., 2014). Previous research indicates that strategic orientations regarding energy transitions are often affected by conflicting ideologies (Stirling, 2014). However, this issue has received little attention in transition literature (Geels, 2020).

We believe that especially local level interactions (Dóci et al., 2015) and their resulting views, are critical during energy transition policy making (Sarrica et al., 2016) as well as innovation processes (Ringberg et al., 2019). Municipalities, cities, and other communities are in a key position to further the transition to more sustainable low carbon and cost-effective energy systems (Kostevšek et al., 2016). The energy interactions imply a network of actors (Van Der Schoor, 2015), and thus a social fabric (Wittmayer et al., 2017). As municipalities are deemed appropriate micro-units for establishing sustainable energy systems (Burton & Hubacek, 2007), our study focuses on ideologies and sense making at that level involving actors in the social fabric.

We expect that taking into account the contexts of transition arenas can enhance managerial sense making, while at the same time infusing it with an understanding of the contemporary environmental context of marketing and business strategy. From the perspective of transition studies (Geels, 2020), the process of energy systems transformation in the last few decades has resulted in coordinating energy-related infrastructures and paving the way for new kinds of multi-actor configurations. One such transformation relates to an upcoming transition from current centralized energy systems to more decentralized ones based on renewables (Ruggiero et al., 2015). Such system-wide transformations offer unique co-evolutionary opportunities for innovation and a stream of academic literature has emerged that attempts to understand the dynamics and directions of such socio-technical transformations (Sengers et al., 2016).

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This paper attempts to turn the focus on how the so-called meso-level actors (Schenk et al., 2007) in five Finnish municipalities engage with the idea of sustainable energy self-sufficiency. Here, we define the meso-level actors as a compilation of local decision makers, politicians, businesspersons, researchers, innovators, consultants, NGO's, project leaders, as well as “prosumers” (a mixture of producers and consumers). Thus, individuals are seen as actors with existing roles in a socio-technical system, or with the possibility and interest of entering it (Wittmayer et al., 2017). These actors might either maintain, or challenge, the current regime and, through the acting out of ideological tensions, affect the legitimacy (Press et al., 2014) of energy innovations. By addressing ideological drivers that affect the adoption of sustainable, renewable energy innovations, the aim of this paper is to identify and explain different ideological discourses among members of a municipality. We suggest that uncovering and exploring some of the connections between ideologies and sense making can offer new insights into characteristics and capabilities that could then help identify new decentralized, sustainable energy innovations (Farla et al., 2012).

The paper is organized as follows. After this introduction section, the paper reviews literature on energy transition and ideological drivers of renewable energy adoption in five Finnish municipalities. The paper then describes the data involved and methods of analysis. Thereafter, it provides results from a qualitative discourse analyses, and, finally, concludes with a discussion on key findings, including their contributions to theory and practice, as well as limitations and future research avenues.

Literature Review

Municipal energy transitions

Municipalities are in direct contact with local stakeholders and play an important role in the transition from carbon-based energy to renewable energy systems (Kostevšek et al., 2016). National energy strategies provide normative and legislative structures that maintain (or try to disrupt) the legitimized energy system by providing guidelines, rules, and research, as well as funding opportunities (Kainiemi et al., 2020). Following the above logic, we consider that municipal, meso-level actors construct their energy roles (Wittmayer et al., 2017) inside a framework of institutionalized-legal, social, economic, knowledge, and belief systems (Press et al., 2014). What is decided outside of municipalities by national governments, the EU, and Globally (COP 21) needs to be considered and acted upon locally (Sarrica et al., 2016). As an example of how the ongoing (global) development has changed the traditional roles of producers and consumers in energy markets is the way consumers have also become producers of energy, also known as “prosumers”; agents that both produce and consume electricity (Olkkonen et al., 2017).

In addition to exogenous influences, another important context affects municipal energy transitions: The unique geography of natural-, material- (existing technology and production facilities), and knowledge-related (education, profession, age, and gender) resources available (Coenen et al., 2012). These are embedded in the local cultural “doxa” (Press et al., 2014), a dominant paradigm with taken for granted personae, values, symbols and beliefs, a sociocultural belief-system that provides a collective agreement and map on “how to make use of those” (Kilbourne et al., 1997), affecting the roles actors can take or can be given (Avelino & Wittmayer 2016).

Ideologies and Sense Making

Adhering to the fact that transitions include aspirations far more complex than the choice of cleaner technology (Geels, 2020), the focus turns towards so-called intangible drivers, such as mind-sets and belief-systems embedded in transition processes. These are expressed in and can be explored as “ideological discourses” (Van Dijk, 2006). The socio-technical transition literature recognizes the role of discourses in learning and adaptation, as well as in facilitating or challenging transitions, as they connect directly with policy and institutions (Späth & Rohracher, 2010). In this paper we explore how local actors use their ideologies and beliefs (Haase & Raufflet, 2017) to make sense of and participate in municipal energy transitions. By conceptualizing ideology as a “sense making” resource (Mees-Buss & Welch, 2019) we open up to the perspective that sense making mediates between deep structures (ideology) and discourse as a surface expression imbued with ideology (Van Dijk, 2006).

Our perspective is that expectations emerging during an energy transition process require actors to consider the

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possibility of needing a new socio-technical order in contrast to their current reality (Wittmayer et al., 2017). The way people make sense of and give meaning to things is rooted in the socio-cultural context they are born and socialized into (Giesler & Veresiu, 2014; Humphreys, 2014). The effects of inherited belief-systems often remain opaque in day-to-day interactions (Kilbourne & Mittelstaedt, 2012), as they have become a legitimized part of habits, and, thus considered as a part of socially constructed reality (Berger & Luckmann, 1967).

Ideologies are, primarily, based on ideas and, thus part of our belief-systems (Haase & Raufflet, 2017). There are no private, personalised ideologies; instead, they are always socially shared beliefs by members of a group regarding social representations that define their identity. This means a shared understanding of fundamental conditions and "ways of existence and reproduction" (Van Dijk, 2006: 116). We explore the sense making and "enactment" (Weick, 1995) feature of ideology, by seeing it as a forward visioning force (Mees-Buss & Welch, 2019) that interacts with culture (Marion, 2006). Ideology builds upon collective belief-systems and knowledge structures about "how things are and why", which support institutionalized ways of doing things that help avoid chaos in decision making and action (Haase & Raufflet, 2017).

Ideological discourses

All discourse is ideologically bounded and grounded (Eagleton, 2007), since "we produce, disseminate, and consume ideologies all our lives, whether we are aware of it or not" (Freeden, 2003:1 cited in Press et al., 2014: 104). Discourses can be approached as a system of statements which constructs an object (Salignac, 2012) and in choosing so, we explore how structured sets of texts come to function as reality constructors, which help constitute the social phenomena in question. It is assumed, that ideologies are largely expressed and acquired by discourse, so when group members explain, motivate, or legitimate their (group-based) actions, they typically do so in terms of ideological discourse (Van Dijk, 2006). Following the constructionist logic toward social phenomena (see Berger & Luckmann, 1967), we focus the research here upon specific ways in which local renewable energy is produced discursively. We link concepts present in the "discursive universe" of talk about renewable energy, in particular ways by several actors with their own agendas.

Methodology

Research context

Finland has set its national goal (ym.fi, 2019) to become a carbon neutral society by 2035, entailing a need for rapid decarbonisation, especially in the mobility, housing, and industry sectors. Municipalities have a central role in Finnish energy transition, as they are responsible for implementing the national energy and climate strategy and its goals in local contexts. In this study, data was collected by utilizing the Energy Self-Sufficient Regions (ESSR) project led by the Levón Institute at the University of Vaasa (2017-2019). It involved five Finnish municipalities, which are situated in the regions of Ostrobothnia (Vaasa/Vähäkyrö and Kristinestad), Central Ostrobothnia (Perho), and Lapland (Tervola and Sodankylä). The ESSR project utilized the so-called Energy Village concept developed by the Levón Institute (Peura et al., 2018). The concept was initially developed to utilize economic opportunities around renewable energy sources (RES) for actors in village communities.

Firstly, others in the project calculated the energy balances for the five participating municipalities. This calculation included the reported amount of electricity consumed, heat and transport fuel used, accompanied by an assessment of the bioenergy and projected wind energy potentials. In general, the energy balance provides an overview of how much money people in the village are spending in energy-related consumption each year. This was used as a starting point for a SWOT analysis carried out together with local actors.

In the first meeting, a SWOT analysis was made, then in the next meeting discussed in depth the results of the SWOT analysis. Here, deliberative democracy-related tools such as the World Café method were used to make sure that the voices of all participants got heard. Based on the visions and illustrations created, thereafter a roadmap was developed for renewable energy production as well as energy efficiency for each municipality. Finally, the ESSR project arranged a kick-off seminar for local actors to engage them in developing potential businesses and new projects.

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Data collection

In exploring ideologies in municipal energy transition dynamics, we used a discourse analysis (Jorgensen & Phillips, 2002). Researchers attended, observed and recorded project meetings and workshops. We enriched this ethnographic approach (see Ellis, 2007) by interpreting the findings though observation and field notes. For the discourses to remain natural and without interference, the researchers mostly remained in the role of observers. Regarding ethical considerations, the researchers always introduced themselves to the participants at the beginning of the workshops and asked for permission to record. Throughout the project, the participants were invited to the meetings and workshops by the ESSR project, either with help from the local contact person (usually someone working for the municipality) or directly via the local newspapers and Facebook pages. To assure the participants' anonymity, we have used fictive names in the quotes. Table 1. gives an overview of the empirical data collected.

Data analysis

Our data analysis followed the standard procedures and principles of discourse analysis (Jorgensen & Phillips, 2002). The analysis process followed the abductive approach by firstly capturing emerging structures from the data sets, and then, comparing them to findings in the extant literature. Our focus was upon how municipal stakeholders structure their social schema regarding renewable energy, for example, categories that cognitively represent major social dimensions in groups, such as membership criteria, typical actions, goals, norms, and values (Van Dijk, 2006). To excavate deep ideological structures, we looked for the "zones of conflict" (Mees-Buss & Welch, 2019), where people in one discourse are openly questioning or trying to persuade those in others, based on either real conflicting ideas, or a perceived contradictory ideology (Press et al., 2014). We can follow or "read" the value-laden, lexical expressions that group members share when they talk, and the presuppositions they make in explaining cause-and-effect relationships (Van Dijk, 1998). Thus, adhering to the above-mentioned logic, all the transcriptions were thoroughly read and sentences about "what, how, who, and why" regarding local energy were coded into categories.

We used NVIVO software to categorize emerging textual structures and arranged them according to larger themes such as "economic opportunities comes from local biogas", or "environmental issues are restricting

Table 1. List of empirical materials

Region (Municipality)	Number of meetings (year)	Background (and number) of participants: MG (representatives of municipality), BF (local businesses/farmers), EC (energy companies), CA (consulting agencies)	Number of Participants & Gender F (female)/M (male) and ~ (average age)
1. Ostrobothnia (Vaasa/Vähäkyrö)	1 (2017)	MG (1), BF (8)	1 F / 8 M (~50)
2. Ostrobothnia (Kristinestad)	2 (2018)	MG (2), BF (1), CA (1) MG (4), BF (1), CA (2)	2 F / 2 M (~45) 4 F / 3 M (~40)
3. Central Ostrobothnia (Perho)	2 (2017) 1 (2018)	MG (1), BF (4), CA (1) MG (1), BF (5), CA (1) MG (1), BF (16), EC (2), CA (1)	1 F / 5 M (~40) 1 F/ 6 M (~40) 1 F/ 19 M (~40)
4. Lapland (Tervola)	1 (2017)	MG (3), BF (2), CA (2)	6 M / 1 F (~50)
5. Lapland (Sodankylä)	1 (2017)	MG (2), BF (2), EC (1), CA (1)	1 F / 5 M (~45)

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Table 2. Ideological Discourses

Ideological Discourses	Clan	Solarpunk	Native
Orientation or Ideals	Utilitarian, altruistic, traditional, collective to individual.	Techno-utopian, individualistic.	Nature-centered, altruistic, individual to collective.
Manner of talk	Realistic, informal language, talk like locals, dialect.	Passionate and innovative, use of formal, expert language.	Emotional language, mix of expert and informal (dialect) language.
Sense-making – rationale "why renewable energy solutions"	Local, bio-based solutions bring local welfare. We need to maintain our traditional system of production, but on a reasonable scale. We need to slow down global growth and focus on small scale, national, and local production and consumption.	New technological solutions and innovations bring local welfare and help save the planet as well. Growth and development must continue "but we can do it better, smarter and more sustainably".	Nature is sacred; we need to change our perspective towards the "native view". We are part of the natural system and need to adapt and change the way we produce and consume products and services. Solutions to tackle climate change and biodiversity loss should drive the transition.
Core beliefs	Relying on experts to measure correct things; trusting and supporting current knowledge.	Facts & figures everything should be measured, we can manage and control nature.	Questioning given truths. Not everything can be measured – quality of life is not measurable.
Attributes given to the discourse	Reliable and trustworthy, getting along with others, "do not upset the clan". Flirtatious.	Expert and "high flier", good contact, outside the clan. Expanding horizons and developing new ideas. "We spirit" – believe in future opportunities.	Preserving nature, utopian, un-realistic, too emotional, does not understand reality. Luddite, even verging on radical. Driving for change.
Contradictions expressed by discourses	Too radical or "foreign" ideas threaten local ways. Outside rules and regulations can be problematic but must be followed. City Greens, vegan "treehuggers", and Luddites, create unnecessary problems!	Slow pace, rigid structures, incremental, conformism are in the way of new opportunities! Wrong technology, stupid choices (not enough knowledge), lack of facts. Too many rules and regulations!	People do not listen; nature is not given a voice. Radical system-wide changes are needed – downshifting, etc. "Redneck" mentality and not being taken seriously!
What drives actors	Safety & reliability Incremental innovations	Progress & technology New Innovations	Biodiversity & climate Radical Innovations
Transition role	The ones maintaining a system - the "doers". Difficult-to-change mindset, together with conflict-avoidance. Needs time to digest and prove of functionality. Securing local balance – security – sustaining.	The leader or catalyst. Lots of knowledge and information that might "get lost" – How to capture it into transition processes? Conflict might be inevitable. Mostly still embedded in the institutions and regime. Hard to make decisions that are truly radical even if this group has the capacity.	Nature's voice – challenger of dominant system. The "hidden" discourse. There could be more "fence sitters" who cannot take this position openly. Constant conflict. Might be capable of thinking outside the box. The energy of cultural "misfits" open for radical innovation. Often lacking the know-how and support from others.

our livelihood". After this initial phase, we merged the emerging textual structures and scrutinized them to find convergence, especially looking for various logics and constructs about renewable energy. As a result, we identified three different ideological discourses and labelled them as: Clan, Solarpunk and Native.

Findings

Ideologies, Meta Discourses, and Sensemaking
We excavated discourses from the texts by merging themes and structures into coherent storylines about the renewable energy reality constructed by different people. The three different ideological discourses and their characteristics are presented in Table 2.

In the following sections, we coded the citations according to the classification in Table 1. Participant backgrounds: MG (representatives of municipality), BF (local businesses/farmers), EC (energy companies), CA (consulting agencies); Regions (1 = Vaasa/Vähäkyrö, 2 = Kristinestad, 3 = Perho, 4 = Tervola, 5 = Sodankylä).

Clan
"Why are you making this so complicated?" The Clan ideological discourse is constructed based on respect of long lasting, local traditions, as well as existing rules and norms. To maintain municipal well-being, local economic growth is necessary. Since the natural resources belong to the people, they can be used thereby continuing the traditional ways of mining, forestry, fishing, farming and agriculture.

> *"There is a need to understand local actors, peoples' needs and wants … the aim is to see the big picture of what the region could gain and not go into technology first" (MG 5).*

In this discourse, traditional values meet the belief in technological solutions. While there is a contradiction between keeping things as they have always been and achieving changes at the same time, there is also a strong belief in technology that has proven its utility. The Clan discourse uses words such as reason, proof and realism as ways to achieve goals. Being cautious and avoiding unnecessary "foolish" risks are Clan virtues. This ideology stands for an "innate predisposition" to look for incremental innovations that do not disturb the existing system.

> *"Yes, and if you take that 'X-pilot' as a good example, they are using the 'company Alpha' as supplier. And the owner told us that indeed, today their biogas production brings more income than the traditional farming" (BF 3).*

In fact, the current Finnish bio-economy agenda provides a supporting rationale for this ideology, as the ownership of land and what is called "everyman's rights" person's-right to use its resources lies at the heart of this discourse. A concern persists about sustainability issues, for example, such as climate change mitigation and making the environment cleaner. These arguments are frequently mentioned and considered as the "positive side effects" of economically rational investments.

> *"Cutting emissions is one of these side effects we want to achieve with this new business … as well as restoring the natural environment" (MG 3).*

Accordingly, the Clan ideology resonates with the rational ideology mentioned by Mees-Buss and Welch (2019), where emphasis is given to logical thinking, seeing systems (nature) rather as machines, with processes driven by objective decisions. In the Clan discourse, emotions get downplayed while duties highlighted. At the same time, human, social aspects such as consensus and mutual agreement are mentioned frequently.

> *"So the main point was to get more projects, new businesses, investments and more jobs for the local people" (CA 5).*

Similarly, incentives to participate in local energy transition often come from the promise of economic gain.

> *"There's many of us here today because meat, milk and cereal production does not bring enough incomes anymore" (BF 3).*

This ideology proposes love of land and its cultivational traditions, which exert a utilitarian approach, centered on the human right to use the land. Accordingly, opportunities in the field of renewable energy are often talked about in connection to bio-economy strategies. The Clan ideological discourse expresses trust towards national institutions and their guidelines regarding the use of natural resources.

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> *"Regarding the bio-economy; we have enough raw materials, we know that the forests are growing faster now as the climate is warming up… and we are very good at working with wood products, and different metals… obviously, the bio-economy requires these skills" (MG 4).*

The Clan ideology appears as "the maintaining discourse of the regime", an incumbent mindset that proposes trust in existing institutional structures and their experts. The national experts are trusted (sometimes reluctantly) to provide the right information about how to use one's resources and make a living. This could also be called the "I told you so" discourse, as it draws from the security of adhering to existing moral codes and norms.

Solarpunk

This ideology consists of a strong belief that modern technology will "save the world" (Humphreys, 2014), making it possible to meet bio-economy goals and at the same time "save the planet". In this view, modern and smart technology can provide biological resources that will bring sustainable and positive change. The Solarpunk discourse uses words like smart, innovation, new possibilities, and competition when talking about future opportunities for Finnish municipalities.

> *"Here, in my opinion, the big thing is that the entire energy sector seems to be in transition. And these new operational models are coming in any case, and the one who grabs this opportunity and starts doing new things, will have a competitive advantage that might turn out as a pretty significant one" (CA 5).*

In this discourse, opportunities are based upon natural resources: forests, minerals, rivers, and soil are all resources that should be used in a modern and sustainable manner. In the Solarpunk ideology, responsible utilization of natural resources will be the next step of energy transition as new technological solutions enable extracting multiple values without causing unnecessary harm. For instance, forest-based biomass can be processed into high value products, and minerals can be mined without environmental pollution. All these are thanks to advanced technological solutions and rigorous control of natural resources by experts.

For this discourse it is important to avoid being accused of irrational "green thinking" or of so-called "Luddite traits" (Humphreys, 2014), even if peoples' underlying values might be in that direction. The best way to avoid accusations of too much "green ideology" is to highlight the economic benefits of sustainable approaches.

> *"The state of the fields should be considered, and you might want to leave the straw on the land as it leads to better soil. … The same goes for stubs as they should be left in the forests. … Many opportunities to make money here!" (BF 1).*

The Solarpunk ideology wants to combine the best of two worlds, nature and technology, in a way that promises social well-being for all people. It also acknowledges various aspirations that might exist in local contexts, indicating possible altruistic motives about why action is required.

> *"Not everyone will just calculate euros, they want to act because of personal principles and environmental reasons" (BF 3).*

The Solarpunk ideology builds mainly upon strong beliefs in scientific knowledge, and the contribution of innovations for building better and resilient societies. It definitely holds a place for new, even radical innovations, within a discourse that can propose the re-making of existing energy systems.

> *"Well, as I looked at these (statistics) for the first time today, I got the feeling that there is a lack of market actors (in the bio-energy sector), and we have business and other actors who might want to join this … but the other part is somewhere else, good networks, collaboration … and we are good at collaboration … so there might be a need for new models of financing that we would come up with, our own models" (CA 3).*

Technological and human development go hand in hand. The choices of energy sources and technological systems, as well as their business logics, are considered as being in transition, while new solutions are emerging. Central to the Solarpunk ideology is the belief that technological solutions, such as AI (Artificial Intelligence) and smart systems, are entering our lives anyway. The radical and the passionate "no-risk-no-fun approach" makes this ideological discourse closer to a

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normative ideology (Mees-Buss & Welch, 2019) by attributing greater importance to contribute something meaningful and make a difference for the world. This discourse also mirrors the findings by von Koskull and colleagues (2018) concerning arguments drawn from logical evidence such as data and rational argumentation.

Native

The Native ideology connects with values that are often referred to as altruistic or "native", meaning where human beings are seen as a part of a bigger, natural order and not its owner. Nature has its limits that should be respected and maintained (Humphreys, 2014). This ideology proposes collective and inclusive actions, where value comes from social and ecological well-being along with economic gains that serve as means to maintain a balanced system.

This discourse includes softer vocabulary such as nurture, care, consideration, well-being, and it might also be used as a disguise to safely express ideas and values that are not considered legitimate within the current system. For instance, talking about "the other" who has some weird ideas but might make a good point about certain things. Interestingly, in the energy village context the Native ideology is often attributed to "Southerners", which refers to people in the capital area living some 500 km south of Ostrobothnia or 1,000 km south of Lapland.

> *"It seems that biogas is a future fuel, in the south they already use gas fueled cars in the cities" (BF 3).*

The Native discourse calls for collaboration and diversity in decision making, as well as avoiding unnecessary hierarchies. As it contests the dominant logic of (market) competition, it easily evokes the fears of green-red coalitions and "hippie" ideologies that have traditionally been associated with organic farming, and Luddites of all kind (Humphreys, 2014). The combination of environmental protection and a green orientation can be perceived as a challenge, as they produce an ideological stance that questions the way land and natural resources should be used. This way it opposes the legitimacy of the current dominant and legitimized system (Press et al., 2014).

> *"And then (seen as a challenge to local energy development), as you can see with RED II (EU Renewable Energy Directive) and the way it directs policy, European environmental protection and green values have a strong impact" (MG 4).*

Expressions of the Native ideology are strongest when it comes to discussions about climate change and its impact on livelihood in municipalities.

> *"I was wondering about the image of renewable energy… Is it taken seriously or is it thought about as nonsense? … I think it is evolving all the time, and now, people talk about changes in the environment a lot, like we've had quite a few grey Christmases" (BF 1).*

Technology is also used in a curious way as an entry point to express green values, as it provides a "neutral space" in the discussions.

> *"My interest is generally in renewable energy, and I have considered buying that solar power system (PV) and otherwise as well … I want more information about other options, biogas would be interesting for the car and so on" (BF 3).*

The Native discourse is constructed as a "weak discourse" in the municipal energy transition context; it is as a third force that it is referred to, mostly as an opposing force, by the other discourses. This ideology draws from both rational and normative stances (Mees-Buss & Welch, 2019), while holding ecological values at its core. This is in line with believing nature is sacred ideology where ecosystems have a value of their own and nature should be protected from extractivism and technology (Humphreys, 2014).

To sum up, our findings show three basic ideological discourses in energy transition at the municipal level: Clan, Solarpunk, and Native. Together these discourses highlight the complexity of socio-cultural structures speeding up, or slowing down, acceptance and action towards using local renewables in energy production and consumption.

Discourses circulate as meaning structures in energy arenas, which are carried by all their actors who then put more emphasis on certain structures. Accordingly, no discourse is exclusive, while at the same time a person can carry and represent multiple discourses. Collective beliefs and ideologies affect a person's choice of

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discourses.

In the following section we will discuss more in depth about the theoretical and managerial implications of these discourses.

Discussion

Contribution to theory

This paper takes a social-constructionist perspective on energy transitions involving municipalities. Our findings show that energy transitions at the municipal level in Finland are strongly affected by small groups of actors in key roles. These findings are in line with earlier research carried out by Ruggiero and colleagues (2015). Wanting radical innovations that enable regions to take leaps towards more sustainable ecosystems creates pressure on transition managers in how far they are prepared to go in putting pressure and challenging the local "doxa" (Press et al., 2014). Entering a municipal context where institutional belief systems have long been fixed, such as in rural areas with actors mostly adhering to the Clan ideology, initially paves the way for certain, mostly incremental innovations, while more radical ones gain less support and interest as they are not founded in the local worldview.

With the expectation that local transition happens in a democratic way (Avelino & Wittmayer, 2016), local people are asked to join and vote for solutions. However, our results show that the underlying social hierarchies also affect who will be active in such collective occasions. We noticed that most workshops and meetings followed the same pattern, where almost all participants were 40+ year-old men. Only in one case (Kristinestad), were half of the participants in the events women (see Table 1.). This lack of diversity might have some interesting implications regarding the dominant ideologies that reflect what kinds of discourses are socially acceptable in local contexts. Especially, the least common Native ideological discourse is driven by values that are traditionally considered as "softer or feminine" (Hultman & Anshelm, 2017). Also, Westerlund (2020) found that women in Finland are more supportive of sustainable energy than men. Thus, women may also favor more radical energy-related innovations to be implemented at the local level as well.

Implications to practice

Most municipal-level renewable energy related activities seem to be connected to bio-based production, and thus the bio-economy agenda. This means the involvement of authorities such as the Finnish Food Authority and the Centres for Economic Development, Transport and the Environment are responsible for regional implementation. The closeness to or distance from institutional requirements, normative and legislative frameworks becomes tangible in the different discourses. This is especially evident in the Solarpunk discourse where better technological solutions and innovations are believed to bring welfare to local communities and municipalities. It is believed that "the planet can be saved" by using enhanced better technical solutions, such as cheaper PV systems, small and effective bio gas reactors, and geothermal or air source heat pumps.

This kind of top-down driven development can be highlighted by a case such as wind power, which is not considered as an opportunity for local business actors due to its complexity and required capital intensity. Simultaneously, the dominant agenda of existing (and new) nuclear power plants and their related agenda seems to be pushing urgency related to climate change issues into the background, ironically while indicating to local energy producers that these issues are too big to be managed by local energy producers. This reveals a top-down decision-making approach, yet part of the climate objective aims clearly to devolve the decision-making processes to regional levels.

The forest sector (and its by-products) appears to be high on the agenda as far as solutions for Finnish renewable energy transition is concerned. As the purpose of the ESSR project was to support more locally produced renewable energy, and as all the participating regions and municipalities have rich forest resources and agricultural production, bio-resources are easily given the upper hand. This focus on the forest sector might create certain kinds of technological (path) lock-ins from the very beginning, especially as the leading ideological discourses in these municipalities seem to lean towards the Clan, and its techno-utilitarian way of doing things. From the perspective of sustainable transitions, the Finnish "forest is our green gold" ideology is tightly interwoven into the dominant ideological landscape of rural Finland. Thus, it becomes clear that local actors want to maintain their rights to

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use their biggest asset. On the other hand, Finland as well as Sweden, have received global and EU-level criticism for unsustainable national guidelines regarding the use of forests, suggesting the post-2020 EU vision of forest-based climate mitigation may be hampered (Ceccherini et al., 2020).

Limitations and future studies

This qualitative study was based on a rather small number of cases. However, these cases are representative examples of the emerging decentralized and renewable energy production in Finland. It seems, that taking into account the traditional and utilitarian tones of the dominant discourses found in municipal energy contexts in Finland, more research is needed on regulative guidelines and their support to put forward more sustainable energy transition. Considering the power of ideological discourses at the local level, the intangible but real discursive forces that have the power either to legitimize or downplay local actors' ideas and aspirations, the managers of transition processes need to become aware of them. We have learned during our research that in one local context, there might exist different ideologies, logics, hierarchies as well as "forbidden" positions. Questions for transition managers include: First, by what means do we need to be clear about how big the changes are that we really need to achieve, and, second, how can we support the change agents who have the hands-on task of engaging local actors?

Conclusion

While collective norms and habits may manifest as ideological constructs, uncovering and understanding what underlies ideologies in municipal collectives is crucial for identifying what kinds of forms and structures these new energy systems might take. The ideological positioning on the municipal level obviously affects the acceptance of new energy solutions. Our findings indicate that ideological structures have the power to create material outcomes. By understanding the ideological map of an energy arena, a transition manager has the opportunity to choose tools and avoid biases that might hamper sustainability outcomes. We suggest that both municipal authorities and regional agencies should strive for a broader sense-making view of the three identified ideological discourses identified in this paper: Clan, Solarpunk, Native. In practice, this means that several actors with different worldviews need to be engaged collaboratively for initializing, designing, and implementing actions needed for local energy transition.

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About the Authors

Petra Berg is a Post Doc Researcher at the School of Marketing and Communication as well as the VEBIC platform, University of Vaasa, Finland. She holds a D.Sc. (Econ.) in Marketing. Dr. Berg has been participating as a project researcher, as well as coordinating proposal writing for national and EU (H2020) projects in sustainability, food and energy related areas. For the moment, she is teaching sustainability transitions and responsible business, while participating in the Biogas Utilization Opportunities in Ostrobothnia Region project. Her research interests are in the fields of Macromarketing, energy behavior and transition management, with sustainability transitions and social-cyber-physical energy systems as her main focus.

Rumy Narayan studies transitions to sustainable energy systems. Her research interests fall within a framework of innovation possibilities that could potentially address pressing global challenges of our time, while stimulating societal and economic prosperity. This entails activating innovations across sectors, actors, and disciplines, while enabling experimentation, a complex process that needs appropriate tools for coordinating and managing diverse networks. Within this context, blockchain has gained in relevance for her research as an institutional and social technology for managing and coordinating disparate networks of actors.

Arto Rajala (M), D.Sc. (Econ.), is a Professor of Marketing at the School of Marketing & Communication in University of Vaasa. He is the leader of the school's marketing research group. He also holds the Title of Docent (Entrepreneurial Marketing) at the Lappeenranta University of Technology, Finland. Rajala's research interest and special expertise are related to business-to-business marketing, business networks, and renewable energy marketing. He has published several articles on business networks and their management, SME growth and innovativeness, and marketing capabilities. Rajala has more than 20 years' experience of teaching and program coordination at the University of Vaasa and Aalto University (Finland). Currently, Rajala is leading and involved in several international and national interdisciplinary projects related to energy, for example, Erasmus+ (Furn360 and EntRNEW), H2020 (IRIS Smart City, OpenInnoTrain, and RIPEET), and Business Finland (FLEXIMAR and SolarX). In these projects, renewable energy, citizen engagement as well as energy communities and prosumers are core topics.

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