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Innovation ecosystem: from emergence to sustainability through collaboration between actors

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Résumé

Les chercheurs utilisent de plus en plus l'écosystème comme concept au sein et au-delà des sciences sociales et étudient les écosystèmes sous diverses perspectives, notamment le lien entre les écosystèmes d'innovation et le développement durable. Les études existantes ont montré que l'innovation est importante pour le développement durable, que la collaboration est importante pour l'innovation et que les intermédiaires créent les liens et les opportunités nécessaires à la collaboration entre les différents acteurs d'un écosystème. Cependant, on en sait moins sur la manière dont les écosystèmes émergent, qui en sont les acteurs ou comment les acteurs des écosystèmes d'innovation collaborent. Nous manquons également de preuves empiriques indiquant si une telle collaboration entre acteurs fait une différence dans leur innovation, ainsi que d'une analyse explicite du processus de collaboration dans les écosystèmes d'innovation pour garantir la durabilité et le rôle des intermédiaires dans le processus. Pour répondre à ces questions, nous étudions l'écosystème de l'Intelligence Artificielle au Québec. Premièrement, nous constatons que le principal mécanisme sous-jacent à l'émergence des écosystèmes d'innovation à Montréal est l'articulation de de séries de communs d'innovation par les *commoners*. Ensuite, nous trouvons des preuves empiriques de la domination des acteurs producteurs de connaissances au centre de l'écosystème et de l'association positive entre différents types d'innovation et de collaboration entre les acteurs de l'écosystème. Enfin, nous constatons que le processus de collaboration entre acteurs des écosystèmes d'innovation est un processus itératif facilité par des intermédiaires. Nos résultats ont des implications pour comprendre l'importance des technologies émergentes et construire des écosystèmes d'innovation durables, ainsi que pour identifier les capacités d'innovation régionales et atteindre les objectifs de développement durable (ODD).

Mots clés : Écosystème d'innovation; émergence d'écosystèmes; innovation commune; collaboration; structure du réseau; types d'innovations; écosystème d'innovation durable

Méthodes de recherche : Recherche quantitative, analyse des réseaux sociaux; étude de cas; analyse de contenu

Abstract

Scholars have increasingly been using ecosystem as a concept within and beyond social science and studying ecosystems from a variety of perspectives, including the link between innovation ecosystems and sustainable development. Extant studies have found that innovation is important for sustainable development, that collaboration is important for innovation, and that intermediaries create necessary links and opportunities for collaboration between different actors in an ecosystem. However, less is known about how ecosystems emerge, who the actors are, or how actors in innovation ecosystems collaborate. We also lack empirical evidence on whether such collaboration between actors makes a difference in their innovation, and an explicit analysis of the process of collaboration in innovation ecosystems to ensure sustainability and the role of intermediaries in the process. To answer these questions, we study the Artificial Intelligence ecosystem in Quebec. First, we find that the main mechanism underlying the emergence of innovation ecosystems in Montreal is the articulation of a series of innovation commons by *commoners*. Next, we find empirical evidence for the dominance of the knowledge-producing actors at the center of the ecosystem and for the positive association between different types of innovation and collaboration between actors in the ecosystem. Finally, we find that the process of collaboration between actors in innovation ecosystems is an iterative process facilitated by intermediaries. Our findings have implications for understanding the importance of emerging technologies and building sustainable innovation ecosystems, as well as for identifying regional innovation capabilities and achieving the Sustainable Development Goals (SDGs).

Keywords: Innovation ecosystem; emergence of ecosystems; innovation common; collaboration; network structure; types of innovation; sustainable innovation ecosystem

Research methods: Quantitative research; social network analysis; case study; content analysis.

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Introduction

Innovation ecosystem: from emergence to sustainability through collaboration between actors

Research on innovation ecosystems has received increasing attention from scholars and practitioners in the last decade. An innovation ecosystem provides an environment for the actors with a wealth of technical expertise, business experience, and access to capital that supports innovation (Adner, 2006; Autio & Thomas, 2014; Granstrand & Holgersson, 2020; Jackson, 2011; Vladut, 2017). The concept of the innovation ecosystem is built on Moore's definition of the business ecosystem - a community of interacting organizations and individuals including customers, lead producers, competitors, and other stakeholders (Moore, 1993). There are different ecosystems including but not limited to business ecosystem, innovation ecosystem, open innovation ecosystem, knowledge ecosystem, entrepreneurial ecosystem, platform ecosystem, and service ecosystem. The term innovation ecosystem has also been mentioned in different contexts including regional and national innovation ecosystems, digital innovation ecosystems, corporate or open innovation ecosystems, high-tech SME-centered ecosystems, hyper-local innovation ecosystems, and university-based ecosystems (Oh et al., 2016).

Despite different names, these ecosystems share common themes such as diversity of actors, cooperation and competition, interaction and interdependence, and sharing of knowledge, technologies, and skills, etc. A common understanding is that ecosystems include entrepreneurs, investors, researchers, venture capitalists, business developers, policymakers, and students (Witte et al., 2018). Innovation ecosystems can transcend the boundaries of a single industry or sector (Autio & Thomas, 2014) and often extend across organizational, sectoral, regional, national, and international boundaries (Pombo-Juarez et al., 2017). The level of interaction in the ecosystem is defined

by the operating environment, such as industry alignments or country economic dynamics (Ngongoni et al., 2021). The boundaries of an ecosystem are related to the nature of the value proposition as well as to the structure of interdependencies (Adner & Kapoor, 2010; Ngongoni et al., 2021).

Given that an innovation ecosystem can extend across different layers including the organizational, sectoral, regional, national, and international dimensions (Brusoni & Prencipe, 2013; Pombo-Juarez et al., 2017), the concept often overlaps with other concepts such as national innovation system, regional innovation system, industrial cluster, value chain, and supply chain. It is important to note that these concepts can be used interchangeably with the innovation ecosystem depending on the research context. However, they are not synonymous with the innovation ecosystem concept. To begin with, a national innovation system encompasses elements and relationships that are either located within or rooted in the boundaries of a nation-state (Carayannis et al., 2018; Lundvall, 1992). Well-informed government support is necessary to foster a national innovation system (Rong et al., 2021; Tamayo-Orbego et al., 2017). Similarly, in a regional innovation system, the institutional infrastructure supports innovation within a region's production structure (Asheim and Gertler, 2005; Rong et al., 2021). In the global innovation systems perspective, regional or national levels remain the key scales for externality formation, but an international interaction layer is added (Binz & Truffer, 1917).

Next, the concept of ecosystem is often compared to cluster. Clusters encompass an array of linked industries and other entities important to competition and ensure the flow of knowledge and technologies among firms in the cluster (Porter, 1998). However, an industrial cluster is a geographic concentration of interconnected firms, suppliers, and institutions in a particular field; innovation ecosystems can span across different levels to achieve collective goals. From the perspective of industrial ecology and competitiveness, industrial ecology cannot always be counted upon to yield competitive advantage at the firm level or within corporate settings (Esty & Porter, 1998).

Finally, the value chain and supply chain. Value chain and supply chain perspectives are significantly different from an ecosystem perspective in terms of both focus and research interests. The value chain perspective is centered on a focal firm that is viewed through a set of discrete activities. These activities jointly determine the firm's costs and the value it can create for the customer. In the case of a supply chain, the perspective is centered around a focal product. A supply chain is a chain of actors directly involved in the upstream and downstream flows of inputs and outputs from a source to a customer. It emphasizes the set of upstream and downstream actors that underlie the input-output flows for the focal product. Whereas the ecosystem perspective takes a macro view of the external actors that contribute to the focal firm's value creation, the value chain and supply chain perspectives take a micro view of the firm's internal activities that underlie its performance relative to its competitors and the input-output flows for a focal product, respectively (Kapoor, 2018).

The concept of innovation ecosystems started to gain currency after Adner (2006) defines an innovation ecosystem as the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution. In an innovation ecosystem, the focus is usually on the introduction of a new product or service or a new way to create value for customers by introducing a new or changing an existing business model (Yaghmaie & Vanhaverbeke, 2020). Actors in an innovation ecosystem interact and collaborate toward a shared aim of the whole innovation ecosystem (Su et al., 2018). An innovation ecosystem provides an environment for the actors with a wealth of technical expertise, business experience, and access to capital that supports innovation (Vladut, 2017). However, there is not yet a conceptual consensus on the definition of the innovation ecosystem, which often leads researchers to address partial or complementary concepts and define an innovation ecosystem differently. Accordingly, there has been a consistent call to study ecosystems, align with theories, and ascertain how ecosystems emerge (Ritala & Gustafsson 2018).

To begin with, there is not a conceptual consensus on the theoretical and empirical understanding of how an ecosystem emerges yet. The literature on the emergence of ecosystems is fragmented with one stream arguing in favor of the bottom-up approach, another stream arguing in favor of the top-down approach, and yet another stream arguing in favor of a combination of both approaches. (Spigel, 2018; Sun et al., 2019; Fu, 2021). The bottom-up approach assumes that ecosystems evolve like natural ecosystems, whereas the top-down approach assumes that ecosystems can be created from the scratch and shaped by policymakers (Colombo et al., 2019; Gifford et al., 2021; Lenkenhoff et al., 2018). These contradictions arise primarily because of ambiguous terminologies used interchangeably across different types of ecosystems without sufficient theoretical support (Smorodinskaya et al. 2017).

Therefore, in the first article, we investigated the Artificial Intelligence (AI) ecosystem in Montreal to obtain a detailed understanding of the mechanisms underlying the emergence of innovation ecosystems. We identified that the mechanism underlying the emergence of the AI innovation ecosystem in Montreal is the articulation of innovation commons by *commoner*s. *Commoners*, as members of a community (Ostrom, 1990, 2009) or a core group of the professional community (Amin & Roberts, 2008), have access as well as the right to use, preserve, and develop the common belonging to the community. They are the key actors who facilitate the articulation of a series of “innovation commons” (Allen and Potts, 2015) that enable knowledge to be progressively revealed, enhanced, nurtured, interpreted, and enacted collectively, leading to the emergence of innovation ecosystems. Based on the actions of *commoner*s in different steps of the development of the ecosystem, we identified three sub-mechanisms: orchestration of social commons, orchestration of symbolic commons, and orchestration of knowledge commons. At first, *commoner*s orchestrate social commons by connecting actors from diverse backgrounds. Next, the decentralized structure of the community of actors leads to the orchestration of symbolic commons. Finally, the orchestration of knowledge

commons occurs due to the collaboration between actors across boundaries and their attendant knowledge.

The findings highlight that the bottom-up initiatives of *commoners* are at the origin of the formation of an innovation ecosystem. *Commoners* play crucial roles in the formation of rich and vibrant innovation ecosystems that have significant impacts on society by enabling knowledge to be progressively revealed, enhanced, nurtured, interpreted, and enacted collectively (Allen & Potts, 2016; Cohendet, 2022; Helfrich & Hass, 2009). Our observation of the bottom-up approaches in the emergence of the AI innovation ecosystem in Montreal sheds light on the challenges in innovation ecosystems at the beginning and during evolution. This article provides new insights into the dynamics and mechanisms contributing to the emergence of innovation ecosystems in a region. Our findings contribute to our understanding of how to facilitate the creation of a successful ecosystem of innovation and formulate favorable innovation policies. The article is published in the European Planning Studies journal.

Next, we know that knowledge and technology are key elements of innovation ecosystems that evolve through interaction between participants (Oh et al., 2016). Innovation ecosystems foster the continuous accumulation of knowledge and insights that enable heterogeneous actors to explore new innovative endeavors (Cohendet et al., 2021). Actors in an innovation ecosystem interact and collaborate towards a shared aim of the whole innovation ecosystem - to facilitate innovation and technology development (Adner & Kapoor, 2016; Granstrand & Holgersson, 2020; Kapoor, 2018; Yaghmaie & Vanhaverbeke, 2019). Such interactions between actors in innovation ecosystems allow them to explore and retain knowledge which is a key element for improving their innovation performance (Robertson et al., 2023; Scaliza et al., 2022). However, the extant literature lacks a clear understanding of whether such collaborations between actors make a difference in their innovation and lacks empirical evidence thereof. There are calls to study the context of innovation and collaboration from the perspectives of different types of innovations (Varis & Littunen, 2010) and pay

attention to different types of actors and the roles they play in the ecosystem (Yaghmaie & Vanhaverbeke, 2019)

Therefore, the purpose of the second article is to add to the theories of the innovation ecosystem by focusing on the collaborative linkages between actors in the innovation ecosystem. We aim to provide a detailed understanding of the links between innovation and the extent of collaboration between actors in an innovation ecosystem by exploring the Artificial Intelligence (AI) ecosystem in Quebec. Two research objectives guide this research. The first seeks to explore the structure of the AI ecosystem. The second seeks to find empirical evidence of the association between the extent of collaboration between different actors and types of innovations in the ecosystem. To attain the objectives: we develop a collaborative network model and conduct further analyses to understand the connection between an actor's innovations and collaborations in the innovation ecosystem. By building the network model of the AI ecosystem, we will be able to understand the structure of the ecosystem, for example, whether some actors are more connected to one another and form a core while less connected actors remain in the periphery or whether there are several well-connected groups instead of a core. We will also be able to identify the central actors who facilitate collaboration between different actors and do further analyses to understand the role of intermediaries in the innovations of actors in the ecosystem.

The findings complement the literature on the ecosystem by shedding light on the structure of an innovation ecosystem and the factors related to the innovations of actors. We find that the ecosystem is centered around the knowledge-producing actors. The higher presence of the universities and research institutions in the center of the ecosystem confirms the presence of the attributes of an innovation ecosystem in the AI ecosystem in Quebec and signals the strength of the ecosystem (Saxenian 2018). We have also proposed and found empirical evidence, regarding our hypotheses on collaboration and innovation. Of the types of innovation studied, we find that the extent of collaboration between actors in the ecosystem is positively and significantly

associated with process innovation and that collaboration with actors from industry is positively associated with marketing innovation and organizational innovation, whereas collaboration with intermediaries is positively associated with process innovation, marketing innovation, and organizational innovation. It is important to understand connections between actors in innovation ecosystems to facilitate innovation, create shared knowledge, and obtain sustainability (Ketonen-Oksi & Valkokari, 2019). Policymakers will find insights from this study helpful in taking initiatives based on the specific circumstances of different actors to foster innovations in the ecosystem.

Finally, we know that actors in an innovation ecosystem interact and collaborate toward a shared aim of the whole innovation ecosystem. Although innovation ecosystems can be virtual because of digitization and globalization, they need some grounded hub as members need to physically meet to interact and co-create, to develop new ideas benefiting from their multidisciplinary skills and competencies (Costa & Matias, 2020; Gamidullaeva, 2018; Jacobides et al., 2019). Innovation ecosystems are also seen as the crossing boundaries of a single industry or sector (Autio & Thomas, 2014) that result in innovation (Valkokari, 2015). For example, participants in an innovation ecosystem might decide to leave the ecosystem if the environment is no longer favorable or more relevant innovations are produced elsewhere (Asplund et al., 2021). Scholars find that intermediaries are key facilitators in intra- and inter-ecosystem linkages (Hernandez-Chea et al., 2021; Valkokari et al., 2017). Intermediaries support ecosystem actors in searching for knowledge, monitoring their activities, navigating different interests and avoiding conflicts of interest, and lowering coordination costs (Perkmann & Schildt 2015; Reischauer et al., 2021). However, how the collaboration between actors in innovation ecosystems comes about and the role of intermediaries in the process has remained relatively underexplored.

Therefore, the purpose of the third article is to move toward a nuanced understanding of the process of collaboration in innovation ecosystems and the role of intermediaries in the process, building on the literature on open innovation

and innovation ecosystems. Conducting multiple case studies, we find that the process of collaboration between actors in innovation ecosystems is an iterative process with four steps and that intermediaries facilitate collaboration between actors across ecosystems. Our findings highlight three steps in which intermediaries can play roles to facilitate the collaboration between actors in different ecosystems to support the diffusion of innovation. First, by having connections with different actors, intermediaries can provide information about potential partners and arrange different events to meet individuals from different organizations. Second, intermediaries can collect and provide specific information about an organization or find an organization to match the innovation interest of another organization. Finally, intermediaries facilitate the integration of the incoming organization into an ecosystem.

This study highlights the relational development roles of intermediaries, in which they support actors to access knowledge, technologies, and other resources for innovation. Our findings contribute to the literature on innovation ecosystems by providing a detailed understanding of the process of collaboration in innovation ecosystems as well as providing an empirical foundation for the roles of intermediaries in relational developments across ecosystems. This paper establishes an interdisciplinary bridge between the different literature and provides an empirical foundation for the role of intermediaries in relational developments in the process of collaboration between actors in different ecosystems. With an understanding of the roles of intermediaries, organizations can make efficient use of their resources, and policymakers can devote resources to fostering ecosystems and developing target sectors. Given that innovation requires integrated collaboration, co-creation, and value-sharing between different actors (Costa & Matias, 2020) and that ecosystem management is generally synonymous with sustainable development (Szaro et al., 1998), the findings will guide actors toward efficient collaboration to obtain sustainable innovation ecosystems and ensure sustainable development. This article is published in the Sustainability journal.

Chapter 1

The mechanisms underlying the emergence of innovation ecosystems: the case of the AI ecosystem in Montreal

Abstract

Scholars have increasingly been using ecosystem as a concept within and beyond social science, but less is known about how ecosystems emerge. In this study, we investigate the context of the Artificial Intelligence (AI) ecosystem in Montreal to understand the mechanisms underlying the emergence of innovation ecosystems. Building on the work of Ostrom and the literature on innovation commons and conducting content analysis and network analyses, we find empirical evidence for a bottom-up approach in the emergence of the AI ecosystem in Montreal. We find that the main mechanism underlying the emergence of innovation ecosystems in Montreal is the articulation of a series of innovation commons by *commoners*. Our findings have implications for understanding the importance of emerging technologies and the digitalization of industries and for identifying regional innovation capabilities.

Keywords: Innovation ecosystem; emergence of ecosystems; bottom-up approach; innovation common; commoner

1.1 Introduction

Research on innovation ecosystems received increasing attention from scholars and practitioners in the last decade. An innovation ecosystem provides an environment for the actors with a wealth of technical expertise, business experience, and access to capital that supports innovation (Adner, 2006; Autio & Thomas, 2014; Granstrand & Holgersson, 2020; Jackson, 2011). Scholars have examined the origin of innovation ecosystems, trying to identify the mechanisms underlying the emergence of these innovation ecosystems. These mechanisms reflect the efforts and actions of different actors in their intention to innovate (Lacouture et al., 2015; Tsujimoto et al., 2018).

However, there is not yet a conceptual consensus on the theoretical and empirical understanding of how an ecosystem emerges. The literature on the emergence of ecosystems is fragmented with one stream arguing in favor of the bottom-up approach insisting on the efforts and actions of diverse actors to achieve collective goals (Colombo et al., 2019; Gifford et al., 2021; Lenkenhoff et al., 2018), another stream arguing in favor of the top-down approach by highlighting diverse processes and programs, such as financing projects and facilitating spin-offs, put in place by a given authority to create the ecosystem (Song et al., 2018), and yet another stream arguing in favor of a combination of both approaches (Sun et al., 2019; Fu, 2021). The fragmentation in the research on innovation ecosystem arises primarily because of ambiguous terminologies used interchangeably across different types of ecosystems without sufficient theoretical support (Smorodinskaya et al. 2017). Accordingly, there has been a consistent call to study ecosystems, align with theories, and ascertain how ecosystems emerge (Ritala & Gustafsson 2018). To answer this call, we investigate the context of the AI ecosystem in Montreal[1] to understand the mechanisms underlying the emergence of innovation ecosystems.

[1] All information used to describe and analyze the AI ecosystem in Montreal comes from the sources mentioned in Appendix B.

In less than two decades, Montreal has become one of the most active ecosystems of innovation in AI in the world. In terms of scientific research, the AI academic community of Montreal is now the largest in North America. In particular, the city hosts the Montreal Institute for Learning Algorithms (MILA) – a research institution internationally recognized for its significant contributions to machine learning. Another key institution is IVADO – an advanced multidisciplinary center for professionals and researchers to develop resources and expertise in data science, operational research, and AI. Montreal is also at the forefront of responsible AI with the Montreal Declaration for responsible AI development. The development of AI in Montreal has found in particular a rich milieu of applications in the domain of health. One of the main initiatives is the creation of the CHUM School of Artificial Intelligence in Healthcare (SAIH) in 2018 at the Montreal University Hospital Center (CHUM), in conjunction with the University of Montreal. The objective of the SAIH is to support and assist healthcare system stakeholders in the adoption, implementation, and promotion of AI. The CHUM also initiated the CITADEL project to facilitate the access of data and use of AI. The concentration of talents and expertise in the domain of health and AI has led to collaborations between different actors in hospitals, universities, and research centers and to the development of numerous Montreal-based companies using AI in healthcare. One of the most active companies is Imagia, which has invested in deep learning to analyze medical imaging data to predict cancer patient outcomes with increasing accuracy.

With regards to the issue of factors and antecedents to the formation of the innovation ecosystem in AI in Montreal, it appears that none of the traditional top-down modes of explanation in terms of regional structural preconditions of the formation of an ecosystem of innovation applies to the case of AI in Montreal. There was no pre-existing anchor firm or dominant firm in the domain, such as in the case of the videogame ecosystem of innovation in Montreal, which has been driven by the anchor firm Ubisoft (Cohendet et al., 2021). There was a concentration of firms and labs in information and communication technology

(ICT) in the city leading to a strong ICT cluster. However, the cluster was not comparable, by size or strength, to other main ICT clusters in Canada such as Toronto, Vancouver, and Calgary. Additionally, the activities were not focused on innovation in AI. There was no active and deliberate initial public funding to build an ecosystem of innovation, such as in the case of the massive funding in biotech academic centers in California (Feldman, 2005) that led to the formation of a myriad of university spin-offs as knowledge externalities, or such as the development of the aeronautic ecosystem of innovation in Toulouse (Longhi, 2005) heavily subsidized by the French government.

The federal government of Canada and the provincial government of Québec have recently been increasingly investing in AI. Among the flagship institutions supported by public funds is IVADO – an advanced multidisciplinary center for professionals and researchers to develop resources and expertise in data science, operational research, and AI. To ensure the responsible use of AI, the provincial government of Québec supported the creation of the International Observatory on the Societal Impacts of AI and Digital Technology (OBVIA). However, such financial support was not at the origin of the formation of AI ecosystem but came later in the process to reinforce already existing successful initiatives.

Therefore, we aim at understanding the mechanisms underlying the emergence of such a vibrant ecosystem of innovation in AI in Montreal. Considering the observations mentioned above, our view is that the emergence of the AI innovation ecosystem in Montreal is issued from a more systemic and multi-actor perspective that incorporates non-firm actors, non-local sources, future expectations and visions, and inter-path relations (Hassink et al., 2019; Jolly et al., 2020). There are key local individual actors, who were not only at the origin of the emergence of the ecosystem of innovation in AI in Montréal but also through their collective actions, orchestrated the different steps of development of the ecosystem and supported the institutionalization process of new path creation that helped to push the industry forward (Doloreux & Turkina, 2021).

These key actors, called *commoners*, facilitate the articulation of a series of "innovation commons" that enable knowledge to be progressively revealed, enhanced, nurtured, interpreted, and enacted collectively, leading to the emergence of innovation ecosystems (Allen and Potts, 2015). Therefore, the main mechanism underlying the emergence of innovation ecosystems in Montreal is the articulation of a series of innovation commons by *commoners*. Based on the actions of *commoners* in different steps of the development of the ecosystem, we identified three sub-mechanisms: orchestration of social commons, orchestration of symbolic commons, and orchestration of knowledge commons.

We aim to contribute to the literature on ecosystems by using the notion of innovation commons to highlight that the bottom-up initiatives of *commoner*s are at the origin of the formation of an innovation ecosystem. We also aim to improve the understanding of the emergence of innovation ecosystems, and thereby, bridge the gap between different streams of research on innovation ecosystems. The findings also provide means to support the development of innovation ecosystems. The paper is structured as follows: we dedicate the next section to the theoretical background. We present the research design in section three and the findings in section four. In sections five and six, we discuss the implications of our findings and conclude by providing future research directions.

1.2 Theoretical background and hypotheses

Although scholars are becoming increasingly interested in studying innovation ecosystems, there remain conceptual ambiguity, methodological challenges, and a lack of rigorous assessment guidelines (Oh et al. 2016; Ritala & Gustafsson 2018). Following the assemblage theory by Manuel Delanda (2016, 2019), it can be said that ecosystem is a concept with knobs that can be set to define different ecosystems. The knobs can be value propositions, structures, scopes, or functions. For instance, actors in an innovation ecosystem are defined according to scope, affiliation, or organizational boundaries, and the interaction level of an ecosystem is defined by the operational environment such as industry

alignments or country economic dynamics (Ngongoni et al., 2021, p. 5). Accordingly, we can say that in an innovation ecosystem, the collective goal or the knob is set around the activities related to innovation. In this section, we discuss the literature on innovation commons and the role of *commoner*s in innovation ecosystems and build hypotheses on the mechanisms in different steps of the emergence of innovation ecosystems.

1.2.1 Innovation Ecosystem: Innovation commons and role of *commoner*s

The concept of innovation ecosystems has gained considerable research interest from scholars in different domains during recent years (de Vasconcelos Gomes et al., 2018; Faissal Bassis & Armellini, 2018; Granstrand & Holgersson, 2020). The concept has its root in the related concept of business ecosystems as used by Moore (1993). Moore defined business ecosystem as a community of interacting organizations and individuals including customers, lead producers, competitors, and other stakeholders (Moore, 1993). The concept of innovation ecosystems started to gain currency after Adner (2006) defined an innovation ecosystem as the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution. In an innovation ecosystem, the focus is usually on the introduction of a new product or service or a new way to create value for customers by introducing a new or changing an existing business model (Yaghmaie & Vanhaverbeke, 2020). The functional goal of actors or entities in innovation ecosystems is to enable technology development and innovation (Jackson, 2011). The notion of the ecosystem of innovation has been increasingly discussed in the management literature (Iansiti & Levien, 2004; Adner, 2006; de Vasconcelos Gomes et al., 2018), which argues that the dynamics of the development of innovation in a given domain result from heterogeneous interdependencies between different stakeholders including informal groups and communities.

In this study, we define the groups of key passionate individuals as *commoners* who are linked together by a common goal, a common cognitive framework, and a shared understanding of their work. *Commoners*, as members of a community (Ostrom, 1990, 2009) or a core group of the professional community (Amin & Roberts, 2008), have access as well as the right to use, preserve, and develop the common belonging to the community. Ostrom defines commons as a "collective action governance mechanism over a common pool resource shared by the members of a community ("the *commoners*") who jointly manage the use and access to this resource as well as its preservation or development" (Zimmermann, 2020). While Ostrom refers to a resource environment, in particular natural resources, by commons, scholars have extended the scope of the term to refer to other resources including but not limited to knowledge, culture, and innovation (Allen & Potts, 2016).

Allen and Potts highlighted, through the notion of innovation commons, that the institutional origin of new technologies may be related to "self-organizing groups of technology enthusiasts who develop effective governance rules to pool distributed information resources. The 'innovation commons' alleviate uncertainty around a nascent technology by pooling distributed information about uses, costs, problems, and opportunities" (Allen & Potts, 2016, p.1), which reveals innovative opportunities and reduces uncertainty in innovative processes. Our view is that *commoners* facilitate the articulation of a series of "commons", which enables knowledge to be progressively revealed, enhanced, nurtured, interpreted, and enacted collectively (Allen and Potts, 2016; Cohendet, 2022; Helfrich & Hass, 2009). We argue that the mechanisms underlying the emergence of innovation ecosystems are the bottom-up initiatives of *commoners* leading to the articulation of a series of commons, namely, social commons, symbolic commons, and knowledge commons.

1.2.2 Mechanisms underlying the emergence of innovation ecosystems

A mechanism results in the interaction between human agents, intervention, and structures and evolves within an open space-time and social system of relationships (Lacouture et al., 2015). According to the literature, the mechanisms underlying the emergence of innovation ecosystems result from the efforts and actions of actors (Lacouture et al., 2015; Tsujimoto et al., 2018). The theories that explain the formation of high-technology innovation mostly rely on the analysis of top-down initiatives such as the public funding of research projects (Sun et al., 2019), the key role of an anchor firm (Iansiti & Levien, 2004), the positive externalities of research resulting from a dense innovation system (Romero & Molina, 2011), or the spin-offs from university research (Thomas et al., 2021). In such a perspective, these top-down initiatives mostly rely on the organization of specific local clusters of activities to trigger the innovation processes they initiate. These theories do not generally attribute the rise of high levels of entrepreneurship and innovativeness to cooperation and collaboration, especially a collaboration mode that is issued from bottom-up initiatives carried out by an informal community.

Innovation ecosystems can be formed autonomously when a sufficiently large group of actors aligns strategic interests (Tsujimoto et al., 2018). For example, scholars have studied the role of diverse informal communities in the dynamics of knowledge formation at the local level (Bathelt et al., 2004; Cole & Barberá-Tomás, 2014; Von Krogh & Geilinger, 2014). Similarly, scholars have highlighted the role of grassroots initiatives in tackling some of the challenges that drive transformational change (Grandadam et al., 2021; Smith & Stirling 2018). However, this rich literature does not specify the precise initiatives of local communities of passionate individuals to orchestrate the process of innovation or the mechanisms underlying the emergence of innovation ecosystems.

Understanding the mechanisms of innovation ecosystems will enable us to better perceive not only the activities and relationships between actors but also changes in the structure of the ecosystem (Bettiol & Sedita, 2011; Simmonds et al., 2021). Below, we build hypotheses to highlight the bottom-up approach and the relevant mechanisms underlying the emergence of innovation ecosystems.

1.2.2.1 Orchestration of social commons

Commoners play important roles in the emergence and development of radical ideas leading to the formation of rich and vibrant innovation ecosystems in a location that does not necessarily have a prior history or antecedent in the field or sector (Cohendet, 2022). Initially, based on the openness and active cross-fertilization of a network of like-minded professionals, *commoners* contribute to the formation and maintenance of social commons (Amin & Roberts, 2008). The *commoners* are strongly involved as a core group of active members in different types of communities. They share the ideas, skills, and various types of knowledge necessary to achieve their objectives (Brigstocke, 2015). The efforts undertaken by members of the diverse communities are eventually translated into social commons (Helfrich & Hass, 2009). The main attributes inherent to social commons are consensus, equity, moral legitimacy, and transparency in decision-making (Willis, 2012).

The efforts undertaken by the professional community in Montreal, can therefore, be translated as the development of a *social commons* focused on the active opening of personal networks and the conceptualization and promotion of relationships between the diverse members of the community. Following Hassink et al. (2019) and Jolly et al. (2020), our view is that the emergence of the AI innovation ecosystem in Montréal is issued from a more systemic and multi-actor perspective that incorporates non-firm actors, non-local sources, future expectations, visions, and inter-path relations. There are key local passionate actors who connect actors from diverse backgrounds, leading to the orchestration

of *social commons* and contributing to the emergence of the ecosystem of innovation in AI in Montreal. Therefore, we argue:

> Hypothesis 1: Commoners are the facilitators of linkages between actors, leading to the orchestration of social commons and contributing to the emergence of innovation ecosystems.

1.2.2.2 Orchestration of symbolic commons

In an ecosystem, a collective of firms or organizations is connected by a shared interest to materialize their product or service innovation (Lenkenhoff et al., 2018). For example, innovation ecosystems are defined as complex relationships formed by an interdependent network of actors with a functional goal to enable value creation and appropriation through innovation and technology development (Ashton, 2009). Innovation ecosystems are not controlled by one large focal firm, but activities in an ecosystem center around the firm, activity, or technology that influences an ecosystem's responses to externalities and its evolution (Ngongoni et al., 2021). There are different activities and functions in an ecosystem involving resources, institutions, contexts, and technologies that connect relevant actors. The structure of an ecosystem allows participants to collaborate and solve coordination challenges without following a full hierarchy (Jacobides et al. 2018).

With the emergence of an innovation paradigm and the opening of innovation processes to society, companies, technical schools, and research institutes are no longer the only relevant agents in the process of innovation (Domanski et al., 2020). Innovations occur within a complex context of interaction between different actors (Faissal Bassis & Armellini, 2018). The diversity of the relevant actors and the structure of their network affect innovation in a region (Innocenti et al., 2022). The collaborative environment required in innovation ecosystems often results from bottom-up initiatives carried out by an informal group of passionate individuals. These individuals frame the ideas from collective

endeavor in a shared vision and develop symbolic commons to facilitate the process of innovation (Bettiol & Sedita, 2011; Bowers, 2004). The decentralized structure of the community of actors leads to the development of a shared understanding and orchestration of symbolic commons (Bowers, 2004; Hassink et al., 2019). Therefore, we argue:

> Hypothesis 2: A decentralized structure of the community of actors leads to the orchestration of symbolic commons and contributes to the emergence of innovation ecosystems.

1.2.2.3 Orchestration of knowledge commons

Ecosystems are increasingly being studied as a collaborative context where actors with complementary resources come together to create and capture value (Adner & Kapoor, 2010; Radziwon et al., 2017). For example, ecosystems in a region can be conceptualized as complex systems in which individuals and organizations have multiple connections between them as well as the ability to learn and adapt to external and internal changes (Ashton, 2009). There are complex and dynamic interactions in an ecosystem involving individuals, business organizations, government agencies, industrial players, universities, and research institutes (Lenkenhoff et al., 2018). It is not necessary for the background of actors to be constrained by the scope of the ecosystem and vice versa; it is the collective goal that defines the scope or nature of an ecosystem (Adner & Kapoor, 2010). Creativity, connectivity, collaboration, and community are crucial competencies of the actors involved in an ecosystem (Karakas, 2009). The collaborative activities between actors play critical roles in all phases of successful innovation (Arena et al., 2017; Radziwon et al., 2017).

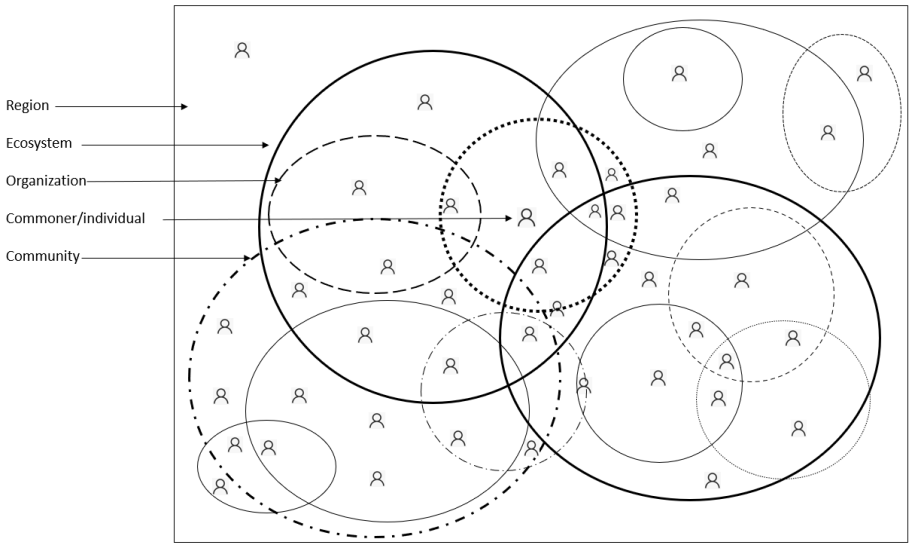
Innovation ecosystems are seen as the crossing boundaries of a single industry or sector (Autio & Thomas, 2014) that result in innovation (Valkokari, 2015; Paasi et al., 2022). The boundaries of an ecosystem are related to the nature of the value proposition as well as to the structure of interdependencies

(Adner & Kapoor, 2010). The network of relationships between actors in innovation ecosystems allows them to exchange knowledge (Amin & Roberts, 2008; Brigstocke, 2015). For example, the actors coming from different domains establish bridges between different communities and sustain knowledge creation (Bettiol & Sedita, 2011). Accordingly, actors in innovation ecosystems come from diverse backgrounds and bring complementary knowledge and resources across boundaries, which leads to the orchestration of knowledge commons. Therefore, we argue:

> Hypothesis 3: The collaboration between actors from diverse backgrounds and across boundaries leads to the orchestration of knowledge commons and contributes to the emergence of innovation ecosystems.

To sum up, in emerging innovation ecosystems, the bottom-up initiatives of *commoners* lead to the articulation of a series of innovation commons. At first, *commoners* orchestrate social commons by connecting actors from diverse backgrounds. Next, the decentralized structure of the community of actors leads to the orchestration of symbolic commons. Finally, the orchestration of knowledge commons occurs due to the collaboration between actors across boundaries and their attendant knowledge. Figure 1 shows the relationship between *commoners,* organizations, ecosystems, and communities in a region.

Figure 1.1: The relationship between commoners, organizations, communities, and ecosystems in a region



In the following sections, we elaborate on the research setting, conduct the analysis, report the findings, and discuss the implications of our findings.

1.3. Research design

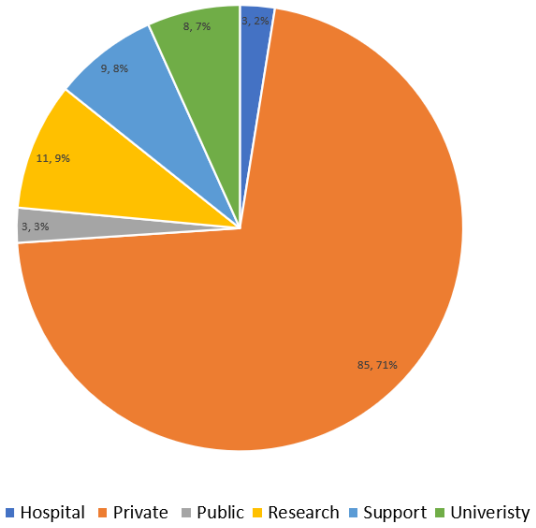
1.3.1 Research setting: The AI ecosystem in Montreal[2]

The AI ecosystem in Montreal provides a solid ground to investigate how innovation ecosystems emerge. An innovation ecosystem can generate new output without using input from the originator, is resilient, and attract new external actors to enhance the innovative potential of the system (Saxenian, 1994). These attributes are present in the AI ecosystem in Montreal. For example, Appendix A presents some of the world leaders who are developing their AI expertise in Montreal. With regards to the issue of factors and antecedents to the formation of

[2] All information used to describe and analyze the AI ecosystem in Montreal come from the sources mentioned in Appendix B.

the innovation ecosystem in AI in Montréal, none of the traditional modes of explanation in terms of regional structural preconditions apply. For instance, there was no pre-existing anchor or dominant firm in the domain. Besides, the region has become home to one of the world's largest deep-learning university communities, and global leaders including Google, Microsoft, and Facebook are setting up research labs in the region[3].

Figure 1.2: Distribution of actors by type in the AI ecosystem in Montreal



A representation of the AI ecosystem, using the data available from Montreal International,[4] is shown in Figure 2. The current AI ecosystem of Montreal consists of more than 400 different types of organizations including business firms, research institutions, and governmental units. As a result of this exceptionally high concentration of scientific expertise in AI, major industrial

[3] https://www.montrealinternational.com/en/publications/greater-montreal-an-artificial-intelligence-hub/

[4] https://business-map.montrealinternational.com/en/map/?companysearch=&chk_sector%5B%5D=3&chk_sector%5B%5D=12&chk_sector%5B%5D=13&chk_sector%5B%5D=30&chk_sector%5B%5D=15&chk_sector%5B%5D=11&chk_sector%5B%5D=10&chk_sector%5B%5D=29&chk_sector%5B%5D=28

players from other countries have been recently investing in Montréal's AI industry.

The dynamics of the innovation ecosystem in AI in Montreal showed a broad range of partnerships with famous global companies including Google, Facebook, Microsoft, and Samsung. Nonetheless, many of the AI companies in Montreal are small units; over 90% of Montreal's firms in AI are startups, and a large part of the vibrancy of AI activities in the city comes from informal communities of passionate engineers, techno-geeks, or individual entrepreneurs. The concentration of talents and expertise in the domain of AI and health in Montreal has led to collaborations between different actors and the development of numerous Montreal-based companies using AI in healthcare. Given the context, the majority of the actors we studied have collaborative relationships in AI and healthcare.

1.3.2 Methods and data

In this study, we adopt an abductive approach – combining qualitative content analysis and social network analysis to identify the connection between *commoners* and organizations and unfold the story of ecosystem emergence from bottom-up approaches (Boreus & Bergstrom, 2017; Borgatti et al., 2018; Sætre & Van de Ven, 2021). We conducted semi-structured interviews with five experts in the AI ecosystem in Montreal to validate our findings. The interviews were typically from 45 to 55 minutes long. The abductive approach is fitting in this research because generating explanations of the emergence of innovation ecosystems by exploring the AI ecosystem in Montreal involved iteration between the analyses and findings: first, we observe the initiatives of *commoners* in the context of the emergence of the AI ecosystem in Montreal; next, both the findings from network analysis and the conversation with experts confirm our observation (Sætre & Van de Ven, 2021).

The data used in this research come primarily from secondary sources. We compiled data from the information and documents available online for the period from August 2021 to July 2022. First, we prepared a list of *commoners* and organizations in the AI ecosystem in Montreal based on the information available from Montreal international and complemented the list using information from other sources. All data used to describe and analyze the AI ecosystem in Montreal come from the sources mentioned in Appendix B. Our final sample includes 19 *commoner*s and 102 organizations that have at least one linkage. Next, we consulted the websites of *commoners* and organizations; we identified the linkages by looking into whether a *commoner* is connected to more than one organization and whether an organization has partnership connections with other organizations. Finally, we interviewed the experts to validate our findings.

To begin with, we conducted a qualitative content analysis of the data we collected to analyze the history of AI in Montreal. The analysis provides us with an understanding of the emergence of the AI ecosystem as well as the role of *commoners* in the process. Next, we map the ecosystem based on partnership linkages between actors and conduct network analyses to ascertain the structure of the ecosystem. To conduct the network analyses, we built a binary matrix showing the connection between actors: we coded the existence of a linkage between *commoners* and organizations as 1, and the absence of any linkages as 0. We used two letters for individuals and three letters for organizations in our coding. A sample of the binary matrix showing the connection of the first ten actors in the matrix is presented in Table 1. We used the UCINET software to conduct network analyses.

Table 1.1: A random sample of the binary matrix prepared to conduct the network analysis.

Name of actors	ADB	BO	DEP	EA	IMG	KM	LS	PL	UDM	YB	…
ADV	0	0	0	0	0	0	1	0	0	0	
BO	0	0	0	0	0	0	1	0	0	0	
DEP	0	0	0	0	0	1	0	0	0	0	

EA	0	0	0	0	0	1	1	0	0	0	
IMG	0	0	0	0	0	0	1	0	0	0	
KM	0	0	0	0	0	0	1	0	0	0	
LS	0	0	0	0	0	1	0	1	0	0	
PL	0	0	0	0	0	0	0	0	0	0	
UDM	0	0	0	0	0	1	1	1	0	0	
YB	0	0	0	0	0	1	1	0	0	0	
…											

1.4. Analyses and findings

We track down the history of AI in Montreal since the 80s and identify the *commoners* crucial for the emergence of the AI ecosystem in Montreal by conducting qualitative content analysis. Below, we elaborate on our findings of different phases and mechanisms underlying the emergence of the AI ecosystem in Montreal.

1.4.1 Findings from the content analysis: The emergence of the AI ecosystem in Montreal and the articulation of commons

In Montreal, initially, the *commoners* emerged as a core group from a professional community and contributed to the orchestration of the social commons based on the openness and active cross-fertilization of a network of like-minded professionals in AI. Next, in the form of an epistemic community, the actors elaborate on a shared understanding – the symbolic commons. Finally, as communities of practice, the actors orchestrated the knowledge commons. Table 2 provides a summary of the emergence of the AI ecosystem in Montreal in terms of the periods, communities involved, and commons in different phases.

Phase I: The development of a professional community in AI and the orchestration of social commons

During the 1980s, following a period of disenchantment with the possibilities of AI and expert systems in the 1970s, a group of passionate researchers working in these fields during the 1980s was convinced of the possibilities of breakthroughs in these domains. Under the influence of Geoffrey Hinton, who was working on artificial neural networks modeled after the human brain, now considered among the "godfathers of deep learning[5]", a professional community of researchers progressively formed in Montreal. Among the members of the professional community, were Yann LeCun, a researcher in AI considered one of the inventors of deep learning, and Yoshua Bengio, a professor in the Department of Computer Science and Operations Research, Université de Montréal.

One of the key individuals in Montreal is Yoshua Bengio who founded the Montreal Institute for Learning Algorithms (MILA), in collaboration with the University of Montreal and McGill University, while serving as the scientific director of the Institute for Data Development (IVADO). In 2000, Bengio made a major contribution to natural language processing with the paper "A Neural Probabilistic Language Model." The approach has led to a major shift in machine translation and natural language understanding systems. Members of this community, who were fully convinced of the potential of deep learning and visual recognition, combined specialized knowledge acquired through extended periods of research and training and created institutional trust based on standards of professional conduct. By sharing common experiences and values, this professional community created social commons (Helfrich & Hass, 2009).

[5] https://fortune.com/2019/04/02/eye-on-ai-godfathers-deep-learning/

Phase II: The development of an epistemic community in AI and the orchestration of symbolic commons

At the beginning of the 2000s, despite some significant advances in terms of publications in the domain, the group of *commoners* in Montréal was experiencing a dry period for AI. Over-promising marketing efforts generated expectations that the products could not meet. At that time, only a few groups of researchers were working on AI in Canada and internationally, and Canadian researchers were attracted by sky-high salaries in Silicon Valley. The brain drains to Silicon Valley attracted many, but a pool of die-hard AI researchers including Yoshua Bengio, Yann LeCun, Joelle Pineau, and some other key researchers in the field decided at the last minute to stay in Quebec. The perseverance and determination of the group of *commoners* laid the groundwork for the Montreal AI renaissance in the 2010s, attracting governmental, academic, and industrial support, that lead to the foundation of the Montreal Institute for Learning Algorithms (MILA), the Institute for Data Development (IVADO), Element AI, an AI intelligence incubator that aims at turning AI research into real-world applications for deep learning technology, etc.

This was a turning point that led the *commoner*s from moving and sharing ideas and reinforcing professional relationships to focusing on their visionary projects and finding ways to test their innovative ideas. At that time, the main cognitive objective of the group shifted toward the elaboration of a symbolic common in the form of a vision accompanied by a declaration of intent, expressing the breaking of established rules, to collectively develop a world-class ecosystem of innovation in AI in Montréal. The group of researchers as *commoners* were at the origin of the formation of a new community in Montreal that can be described as epistemic, according to the definition of Cowan et al. (2000: 234). The community developed significant efforts in bringing together important actors who adhered deeply to the values and the vision of the *commoners*, thereby creating shared values or symbolic commons (Cohendet, 2022).

Table 1.2: The emergence of the AI ecosystem in Montreal

Phase	Period	Community	Commons
Phase-I	1980 – 2000	Professional community	Social commons
Phase-II	2001 - 2010	Epistemic community	Symbolic commons
Phase-III	2011 – 2022	Communities of practice	Knowledge commons

Phase III: The development of communities of practice and the orchestration of knowledge commons

Finally, the community gained momentum as *commoners* from diverse communities of practice started collaborating to manage, preserve, and enrich the commons in Montreal. Building on the existing social commons and symbolic commons, the main actors in AI in Montréal progressively turned their focus to the application of scientific research in AI and innovations in industrial domains. By creating a pool of distributed knowledge and application of such knowledge leading to innovation, the communities of practice created knowledge commons. The network of relationships between actors allows them to exchange knowledge, and the actors coming from different domains establish bridges between different communities and sustain knowledge creation that would benefit the whole community.

Researchers and entrepreneurs in Montreal are emerging and working to shape the future of AI in Montreal. Hugo Larochelle leads the Google Brain practice in Montreal. Joelle Pineau teaches at McGill University and leads the Facebook Artificial Intelligence Research (FAIR) Lab at Facebook. Jean-François Gagné, co-founder and CEO of Element AI, brings the latest AI discoveries to companies. Alexandre Le Bouthillier and Nicolas Chapados in

collaboration with Yoshua Bengio founded Imagia. Imagia contributes to the growth and prominence of Quebec's AI sector. Beginning in 2018, the government of Canada and Quebec recognized the importance of these developments and announced their support for the creation of an international AI hub in Montreal.[6] Some actors in this hub are shown in Appendix C.[7]

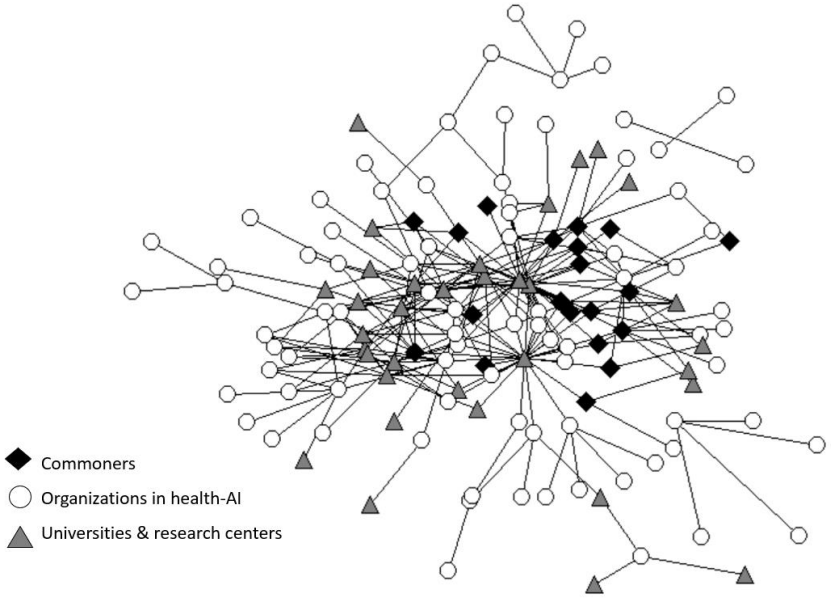
While challenges are certainly part of the future of AI in Montreal and elsewhere, there is no doubt that a new generation is coming and that the story is far from over. Therefore, tracing the formation of this sequence of commons highlight the simultaneous dynamics of the main dimensions of the commons.

1.4.2 Findings from network analysis: The bottom-up approach and relevant mechanisms

Following the literature on the emergence of innovation ecosystems, we build three hypotheses on the mechanisms underlying the emergence of innovation ecosystems and conducted network analyses to test them. In our first hypothesis, we argue that *commoner*s facilitate the connection between actors, leading to the orchestration of social commons and contributing to the emergence of innovation ecosystems. To test this hypothesis, we draw a network model of the ecosystem using the binary matrix illustrating the connection between actors. In Figure 3, we present a network model of the ecosystem by identifying the linkages between *commoners* and the organization they are directly or indirectly connected. It is evident from the diagram that there are linkages between heterogeneous actors, and there is no specific core or core of actors in the ecosystem.

[6] https://www.montrealinternational.com/en/news/the-global-partnership-on-artificial-intelligence-officially-launched/
[7] AI for Health (montrealinternational.com)

Figure 1.3: The network diagram of the AI ecosystem in Montreal



From the different shapes used to represent *commoner*s and organizations, we observe that *commoners* are indeed the agents connecting not only different *commoners* but also different organizational actors, universities, and research centers. Due to their connection to multiple organizations and expertise, *commoners* in the AI ecosystem in Montreal play crucial roles in connecting actors throughout the history of the ecosystem. In other words, *commoner*s facilitate the connection between multiple actors in the ecosystem. The findings provide support for our first hypothesis.

Our second hypothesis is about the structure of the ecosystem. Since an innovation ecosystem is defined as a collaborative arrangement where actors from different domains come together to find innovative solutions, we argue that innovation ecosystems have a decentralized structure and that the decentralized structure of the community of actors leads to the orchestration of symbolic commons and contributes to the emergence of innovation ecosystems. Findings from the core-periphery analysis and the closeness centrality analysis provide support for our argument. We presented the descriptive statistics in Table 1.3 and findings in Table 1.4. First, we conducted the core-periphery analysis to

investigate whether there is a core in the AI ecosystem in Montreal. The findings of the core-periphery analysis, presented in Table 4, indicate that there is not much distance between the core and the periphery in the AI ecosystem in Montreal (the core/periphery fit = 0.3099) providing support to our second hypothesis. A deeper look at the findings reveals the presence of *commoners* at the core of the ecosystem, which provides further support to our first hypothesis.

Table 1.3: Descriptive statistics

Description	Eigenvector 1	Eigenvector 2
Mean	0.053	7.531
Standard deviation	0.066	9.336
Sum	7.402	1046.855
Variance	0.004	87.164
SSQ	1.000	20000.002
MCSSQ	0.606	12115.790
Euc Norm	1.000	141.421
Minimum	-0.000	-0.000
Maximum	0.369	52.250
Number of observations	139.000	139.000
Number missing	0.000	0.000

Next, we conducted the closeness centrality analysis to understand the structure of the ecosystem. Closeness centrality is a measure of centrality in a network and indicates how close a network is to all other nodes in the network. The result, the network centralization index = 49.23%, indicates the decentralized structure of the ecosystem (Table 4). In addition, we conducted the eigenvector centrality analysis to confirm the robustness of our finding in the closeness centrality analysis. We found the ratio between the first and second eigenvalues is less than 1.5, confirming our earlier finding. Thereby, our second hypothesis is supported.

Table 1.4: Findings of network analyses

Analysis	Findings
Core/periphery	Core/Periphery fit (correlation) = 0.3099
Closeness centrality	Network centralization index = 49.23%
Eigenvector centrality	Ratio between the first and second eigenvalues = 6.906/4.216 = 1.424

Our third hypothesis is about the diversity of actors and overlapping boundaries in innovation ecosystems, leading to the orchestration of knowledge commons and the emergence of innovation ecosystems. Analyzing the data, we found evidence to support the hypothesis. We observed that actors in the AI ecosystem come from diverse backgrounds and overlapping boundaries, including private companies, public authorities, major hospitals, universities, research centers, and other support organizations. Many of the actors in the AI ecosystem in Montreal are private companies, and a deeper look into the data shows that over 90% are startups. Further analysis of the data provides us with a detailed understanding of overlapping boundaries in the ecosystem. We found that a *commoner* can be part of different organizations, and more than one *commoner* can be connected to one organization. For example, Yoshua Bengio is connected to the University of Montreal and McGill University as well as to MILA and IVADO.

Table 1.5: Overlapping boundaries and diversity of actors in the AI ecosystem in Montreal

Organization / Commoners	Support	University	Private	Research	Hospital
C-1		2	9		
C-2		2	7		
C-3		2	6	1	
C-4	1	1	1	3	
C-5		2	2	3	
C-6		2	1	3	
C-7	2	2	1		1
C-8		3			2
C-9		2	3		
C-10		2		3	
C-11		2		3	
C-12		1	1	2	
C-13		1		2	
C-14		1		1	1
C-15		1	1	1	
C-16		1			2
C-17			3		
C-18			1	1	
C-19		1		1	

We present the details of the connection of *commoner*s to different organizations in Table 5. One important point to note here is that although there are some public actors in the AI ecosystem in Montreal (Figure 2), none of the *commoners* we identified is a public actor (Table 5). This finding further supports the bottom-up approach in the emergence of innovation ecosystems.

1.5. Discussion

In this study, we investigated the AI ecosystem in Montreal to obtain a detailed understanding of the mechanisms underlying the emergence of innovation ecosystems. We identified that the mechanism underlying the emergence of innovation ecosystems in Montreal is the articulation of innovation commons by *commoners*. Based on the actions of *commoners* in different steps of the development of the ecosystem, we identified three sub-mechanisms: orchestration of social commons, orchestration of symbolic commons, and orchestration of knowledge commons. At first, *commoners* orchestrate social commons by connecting actors from diverse backgrounds. Next, the decentralized structure of the community of actors leads to the orchestration of symbolic commons. Finally, the orchestration of knowledge commons occurs due to the collaboration between actors across boundaries and their attendant knowledge. Below, we discuss the implications of our findings.

To begin with, our findings highlight that the bottom-up initiatives of *commoner*s are at the origin of the formation of an innovation ecosystem. *Commoners* play crucial roles in the formation of rich and vibrant innovation ecosystems that have significant impacts on society by enabling knowledge to be progressively revealed, enhanced, nurtured, interpreted, and enacted collectively (Allen & Potts, 2016; Cohendet, 2022; Helfrich & Hass, 2009). Individuals in society can develop private collective actions and solutions to address social dilemmas that may act comparatively well with the hazards of uncertainty as compared to firms, markets, and states (Allen & Potts, 2016). For example, collaborative spaces around the world associated with major innovations in society were not issued from a top-down decision from a public authority or a private organization but were the result of a bottom-up initiative carried out by an informal group of passionate individuals (Cohendet, 2022). The interplay between actors at different levels plays important role in industrial restructuring and development (Doloreux & Turkina, 2021; Isaksen et al., 2019).

The *commoners* jointly manage the use, access, preservation, and development of the common resource pool including natural resources, culture, knowledge, and innovation (Allen & Potts, 2016; Bettiol & Sedita, 2011; Ostrom, 1990, 2009). The collective efforts of the individuals result in a rich and diverse resource pool (Helfrich & Hass, 2009; Willis, 2012). The dynamics of the development of innovation in a domain result from heterogeneous interdependencies between different stakeholders including informal groups and communities (Adner & Kapoor, 2010; Iansiti and Levien 2004; Smorodinskaya et al., 2017; Yaghmaie, & Vanhaverbeke, 2020). The decentralized structure of the community of actors is, therefore, required to develop a shared understanding and symbolic commons to work collectively. The network of relationships in innovation ecosystems creates opportunities for the *commoner*s to exchange knowledge and orchestrate knowledge commons. It is important to identify the knowledge and information among a pool of resources and the community that manages such resources to understand the process of innovation and support the development of innovation ecosystems.

Next, our study contributes to the debate on the top-down vs. bottom-up approach to ecosystems. Scholars arguing in favor of the bottom-up approach suggest that the bottom-up perspective provides a detailed understanding to define the challenges at the starting period of an ecosystem, as self-organizing mechanisms evolve slowly from the actions and reactions of participants (Lenkenhoff et al., 2018). For example, Majava et al. (2016) demonstrate the bottom-up nature of San Diego's health and life sciences ecosystem and find that the top-down approach may not be successful in fostering ecosystems. The ideas, knowledge, and information available in society are usually gathered in an open innovation environment through a bottom-up approach which is required for an innovation ecosystem to be successful (Gifford et al., 2021; Panetti et al., 2020). The bottom-up creation of synergies and cooperative mechanisms between local actors often makes an innovation ecosystem successful (Panetti et al., 2020). Our observation of the bottom-up approaches in the emergence of the

AI innovation ecosystem in Montreal sheds light on the challenges in innovation ecosystems at the beginning and during evolution.

Ecosystems may require the combination of top-down exploration of policy alternatives by policymakers and bottom-up knowledge-intensive entrepreneurial activity to progress toward sustainable development (Colombo et al., 2019; Gifford et al., 2021; Lenkenhoff et al., 2018). For example, a combination of the top-down exploration of policy alternatives by policymakers and the bottom-up knowledge-intensive entrepreneurial activity is necessary for sustainable development (Gifford et al., 2021). To demonstrate the variance in digital business ecosystem development, Lenkenhoff et al. (2018) illustrate the top-down approach by studying a big company and the bottom-up approach by studying an SME. Policies do play roles in the evolution of an ecosystem, but the roles are different in different ecosystems and played at different times. For example, although the federal and provincial governments recently invested heavily in AI in Montréal, public financing was not at the origin of the emergence of AI activities in the city. In Montreal, the bottom-up initiatives of *commoners* led to the emergence of the ecosystem of innovation in AI; the top-down support of the AI ecosystem has come mainly during phase III of the emergence. The openness of policymakers to develop bottom-up and place-based digital initiatives is important for the transition to the new digital era (Hervas-Oliver, 2021).

Finally, our findings have important implications for understanding the importance of emerging technologies and the digitalization of industries as well as for the development of firms, districts, clusters, cities, regions, and innovation to cope with digital transformations. Emerging technologies such as AI are rapidly changing the status quo in many industries (Hervas-Oliver, 2021). For example, in industry 4.0, the logic of the relationship between companies moves from a simple chain to a network, and the capacity of companies to create and capture value would depend on the capability of building and maintaining networks (Gotz & Jankowska, 2017). Therefore, a successful transformation towards industry 4.0

requires mutual close cooperation between actors and shared norms (Gotz & Jankowska, 2017). The new industrial revolution and digital transformation will affect not only the high-tech industrial sectors but the whole society. With the emergence of an innovation paradigm, the perspective on innovation processes, their integration into societal structures and processes as well as the object of innovation all are changing (Domanski et al, 2020). For example, cultural organizations and creative industries may face significant challenges due to the emergence and rapid adoption of digital technologies (Lazzeretti et al., 2022). Industrial clusters and ecosystems facilitate the flow of knowledge and technologies among firms in a location and are highly important for accelerating regional economic performance and innovation (Boix & Trullen, 2007; Feldman and Audretsch, 1999).

To sum up, it is important to study the relationship between digital transformation and the changes in relevant industries to understand the new dynamics and challenges generated by digital transformation (Lazzeretti et al., 2022). This paper provides new insights into the dynamics and mechanisms contributing to the emergence of innovation ecosystems in a region. Innovation is a fundamental source of wealth generation within an economy (Jackson, 2011). Our findings contribute to our understanding of how to facilitate the creation of a successful ecosystem of innovation and formulate favorable innovation policies. For example, contexts along with norms and behaviors shared by a specific group of individuals play crucial roles in the evolution and development of ecosystems (Colombo et al., 2019). By elucidating the role of individuals in the emergence of innovation ecosystems, we provide a reference point for ecosystem analysis.

1.6. Conclusion

In this study, we investigated the AI ecosystem in Montreal to obtain a detailed understanding of the mechanisms underlying the emergence of innovation ecosystems and find that the mechanism underlying the emergence of innovation ecosystems in Montreal is the articulation of innovation commons by *commoner*s. Based on the actions of *commoner*s in different steps of the development of the ecosystem, we identified three sub-mechanisms: orchestration of social common, orchestration of symbolic common, and orchestration of knowledge commons. At first, *commoners* orchestrate social commons by connecting actors from diverse backgrounds. Next, the decentralized structure of the community of actors leads to the orchestration of symbolic commons. Finally, the orchestration of knowledge commons occurs due to the collaboration between actors across boundaries and their attendant knowledge.

Given that collaborations between actors from diverse backgrounds have a positive effect on innovation (Innocenti et al., 2022; Nieth et al., 2018), studying the relationship between digital transformation and the changes in relevant industries can help understand the new dynamics and changes generated by digital transformation (Lazzeretti et al., 2022). For example, participants in an innovation ecosystem might decide to leave the ecosystem if the environment is no longer favorable or more relevant innovations are produced elsewhere (Asplund et al., 2021). Our findings indicate the relevance of a systemic and multi-actor perspective on the emergence of innovation ecosystems that incorporates non-firm actors, the relationships between individual and organizational actors, and a shared understanding and vision (Bettiol & Sedita, 2011; Hassink et al., 2019; Jolly et al., 2020). Therefore, the knowledge of various actors needs to be identified and combined in novel ways to define regional capabilities and cope with challenges in the digital era (Boix & Trullen, 2007; Nieth et al., 2018).

We acknowledge that ecosystems may require a combination of top-down and bottom-up initiatives. The top-down approach makes sense when the necessary information is available at the top level, and there exists a supportive system to communicate strategies and plans from top to down (Colombo et al., 2019). For example, potential participants of a digital business ecosystem need to establish mechanisms similar to those of natural ecosystems (Lenkenhoff et al., 2018). Policymakers and regulatory bodies might play the central role at some points in an ecosystem, but their role might not be as important at the beginning – while innovation ecosystems emerge. We also acknowledge that our study is not free of limitations, mainly, because of the aspect that we did not compare the dynamics of AI in Montréal to that of other innovative territories. Another aspect is that in the case of Montreal, we concentrate on the successful application of AI in the domain of health. In Montreal, the application of AI in health is particularly strong, but it is important to investigate the deployment of AI in other domains including manufacturing, energy, mobility, or entertainment.

To sum up, our findings provide a detailed understanding of the initiatives of *commoners* and the mechanisms underlying the emergence of innovation ecosystems as well as offering insights to deal with the rising challenges of digital transformation. The perspective adopted in this contribution opens avenues for future research to understand the dynamics of ecosystems in different domains.

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Chapter 2

Innovation ecosystem: Collaboration between actors and innovation

Abstract

In this study, we investigate the relationship between innovation and collaboration using the ecosystem lens. Knowledge and technology are key elements of innovation ecosystems that evolve through interaction between different actors in the ecosystem. However, the extant literature lacks a clear understanding of whether such collaborations between actors make a difference in their innovation. We investigate the AI ecosystem in Quebec focusing on different types of innovations and actors. Adopting a combination of network analysis and regression analysis. we find empirical evidence of the dominance of the knowledge-producing actors in the center of the ecosystem and of the positive association between different types of innovation and collaboration between actors in the ecosystem. Of the types of innovation studies, we find that the extent of collaboration between actors in the ecosystem is positively and significantly associated with process innovation and that collaboration with industry is positively associated with marketing innovation and organizational innovation, whereas collaboration with an intermediary is positively associated with process innovation, marketing innovation, and organizational innovation. The study contributes to the literature on innovation ecosystems and provides insights for policymakers to take initiatives to support and increase collaboration between actors to foster innovation in the ecosystem.

Keywords: Innovation ecosystems; types of innovation; Collaboration; Network structure

2.1 Introduction

Knowledge and technology are key elements of innovation ecosystems that evolve through interaction between participants (Oh et al., 2016). Innovation ecosystems foster the continuous accumulation of knowledge and insights that enable heterogeneous actors to explore new innovative endeavors (Cohendet et al., 2021). An innovation ecosystem refers to an interconnected network of organizations and other entities that operate around a shared set of knowledge, technology, and other resources (Gifford et al., 2021; Jucevičius & Grumadaitė, 2014; Panetti et al., 2020). Actors in an innovation ecosystem interact and collaborate towards a shared aim of the whole innovation ecosystem - to facilitate innovation and technology development (Adner & Kapoor, 2016; Granstrand & Holgersson, 2020; Kapoor, 2018; Yaghmaie & Vanhaverbeke, 2019). Such interactions between actors in innovation ecosystems allow them to explore and retain knowledge which is a key element for improving their innovation performance (Robertson et al., 2023; Scaliza et al., 2022). Overall, an innovation ecosystem can be defined as an evolving set of actors, activities, and artifacts, and the institutions and relationships, including complementary and substitute relationships, that are important for the innovation performance of an actor or a population of actors (Granstrand & Holgersson, 2020; Jucevičius & Grumadaitė, 2014).

However, we have a limited understanding of whether the innovations of an actor are associated with the extent of the actor's collaboration with different actors in an innovation ecosystem. For instance, the innovations of an actor depend not only on its internal resources but also on the knowledge and skills developed through partnerships with external actors (Aarikka-Stenroos & Ritala, 2017; Filippetti & Guy, 2020). A review of the innovation ecosystem literature points out that studies considering different perspectives on innovation and collaboration between actors are still scarce (Granstrand and Holgersson, 2020). Actors in innovation ecosystems can engage in either cooperation or competition because they often collaborate with competitors due to the need for innovation

(Granstrand & Holgersson, 2020; Klimas & Czakon, 2022; Scaliza et al., 2022). Scholars in earlier studies considered such collaborations a process of value creation in environmentally conditioned inter-organizational networks (Autio & Thomas, 2014; Robaczewska et al., 2019). In innovation ecosystems, cross-sector actors may collaborate to develop a business model around emerging sustainability-oriented innovation or to solve major societal problems (Oskam et al., 2021; Yaghmaie & Vanhaverbeke, 2019). Thereby, innovation ecosystems are also seen as crossing the boundaries of a single industry or sector (Autio & Thomas, 2014) that result in innovation (Valkokari, 2015). However, the extant literature lacks a clear understanding of whether such collaborations between actors make a difference in their innovation and lacks empirical evidence thereof. There are calls to study the context of innovation and collaboration from the perspectives of different types of innovations (Varis & Littunen, 2010) and pay attention to different types of actors and the roles they play in the ecosystem (Yaghmaie & Vanhaverbeke, 2019)

Therefore, the purpose of this study is to add to the theories of the innovation ecosystem by focusing on the collaborative linkages between actors in the innovation ecosystem. We aim to provide a detailed understanding of the links between innovation and the extent of collaboration between actors in an innovation ecosystem by exploring the Artificial Intelligence (AI) ecosystem in Quebec. Two research objectives guide this research. The first seeks to explore the structure of the AI ecosystem. The second seeks to find empirical evidence of the association between the extent of collaboration between different actors and types of innovations in the ecosystem. To attain the objectives: we develop a collaborative network model and conduct further analyses to understand the connection between an actor’s innovations and collaborations in the innovation ecosystem. By building the network model of the AI ecosystem, we will be able to understand the structure of the ecosystem, for example, whether some actors are more connected to one another and form a core while less connected actors remain in the periphery or whether there are several well-connected groups

instead of a core. We will also be able to identify the central actors who facilitate collaboration between different actors and do further analyses to understand the role of intermediaries in the innovations of actors in the ecosystem.

The findings complement the literature on the ecosystem by shedding light on the structure of an innovation ecosystem and the factors related to the innovations of actors. It is important to understand connections between actors in innovation ecosystems to facilitate innovation, create shared knowledge, and obtain sustainability (Ketonen-Oksi & Valkokari, 2019). Policymakers will find insights from this study helpful in taking initiatives based on the specific circumstances of different actors to foster innovations in the ecosystem.

The paper is structured as follows: we dedicate the next section to discussing relevant literature and developing hypotheses. We present the methodology and data descriptions in section three and the findings in section four. In sections five and six, we discuss the implications of our findings and conclude by providing future research directions.

2.2 Literature review

We build on the innovation ecosystem perspective and investigate firms' innovation in light of their direct and indirect relationships with different actors in the ecosystem. The innovation ecosystem lens is most appropriate in this context because innovation is increasingly understood as the collective efforts of different actors embedded in ecosystems (Baldwin et al., 2024). Successful innovations require firms to coordinate activities and align their interests, and innovation ecosystems facilitate the flow of resources and ideas to facilitate innovation. (Yaghmaie & Vanhaverbeke, 2019). Firms embedded in ecosystems may not have direct transactional connections with each other but may build relationships to achieve collective goals (Dong et al., 2023; Jacobides et al., 2018; Jiang et al., 2020; Kapoor & Lee, 2013; Shipilov & Gawer, 2020). Furthermore, understanding innovation requires considering both linear and holistic approaches and considering multiple influencing factors (Robertson et al., 2023; Scaliza et al., 2022). The innovation ecosystem lens will provide us with a deeper understanding of these factors and their influence on innovation.

In earlier studies, the discussion on innovation capability is focused on the inputs whereas innovation performance is usually focused on the outputs (Calik & Bardudeen, 2016). However, the outputs may not be achieved without the relevant inputs. For example, innovation in an organization is understood as the new products and services it has introduced as well as the new processes, practices, and strategies it has implemented (De Silva et al., 2018; Jugend et al., 2018; Robertson et al., 2023; Scaliza et al., 2022). Moreover, different types of innovations rely on different types of knowledge, sources, and links (Tödtling et al., 2009; Varis & Littunen, 2010). Therefore, we decided to explore the context focusing on different types of innovations and collaborators.

2.2.1 The structure of the innovation ecosystem

Innovation can often be complex and ambiguous, and therefore, it is important to consider the specific organizational and contextual dimensions to understand innovations (Dziallas & Blind, 2019). The same innovation may create different values for different organizations and in different contexts. Due to the emergence of new technologies and disruptive innovations, innovation through collaboration has become unavoidable (Veilleux & Queenton, 2015), and firms are changing the ways they used to search for ideas and relying more on external sources and actors for successful innovation (Laursen & Salter, 2006; Muller & Peres, 2019). Collaboration between actors in an ecosystem is also important for the reason that the impact of local knowledge on innovation quality is higher for locally embedded technologies (Gao & Rai, 2023). Actors from diverse backgrounds collaborate to achieve collective goals in innovation ecosystems (Granstrand & Holgersson, 2020; Yaghmaie & Vanhaverbeke, 2019). The resources or activities are more likely to be decentralized because the actors come from diverse backgrounds. As a result, the presence of less hierarchical control in the ecosystem allows actors in ecosystems to collaborate more effectively (Dong et al., 2023).

Innovation in organizations is impacted by their ability to interact with other organizations in the environment and their contribution to knowledge creation, diffusion, and transformation (Muller & Peres, 2019; Robertson et al., 2023). Such interaction leads to new perspectives leading to positive innovation performance and value creation (Adner & Kapoor, 2010). In the extant literature, innovation performance is described as the result of the innovation process comprising the development and implementation of innovation (Chen & Huang, 2009). Innovation performance and innovation capacity are strongly and significantly related (Prajogo & Ahmed, 2006). Innovation performance has usually been seen as the transformation of innovation inputs into implemented innovative outputs (Robertson et al., 2023) as well as the adoption of those outputs (Muller & Peres, 2019). Knowledge creation is the biggest driver and strongest predictor of

innovation performance (Robertson et al., 2023). Similarly, knowledge transfer as well as knowledge exploration and retention are also important for improving innovation performance (Scaliza et al., 2022). Successful innovation requires a collaborative network of different actors and involves the sharing and application of knowledge.

There lies the significance of innovation ecosystems – in facilitating the flow of information, providing access to resources, and assisting with strategic innovation development beyond the organizational and industrial boundary (Klimas & Czakon, 2022). Innovation ecosystems underscore the dynamic nature of innovation to understand innovation outcomes and performance better (Robertson et al., 2023). Although some actors orchestrate network activities to ensure value creation and capture in innovation networks, all actors are autonomous in an innovation ecosystem (Dhanaraj & Parkhe, 2006). This is especially true in the case of the AI ecosystem because such emerging technologies are reshaping human action and interaction (Bailey et al., 2022). With the emergence of a new innovation paradigm and the opening of innovation processes to society, companies, technical schools, and research institutes are no longer the only relevant agents in the process of innovation (Domanski et al., 2020). However, although much of the recent progress in the AI industry can be attributed to a handful of big tech companies that provide AI technologies for others to use, these firms depend on academic institutions to strengthen their positions (Jacobides et al., 2021).

Therefore, we posit that the knowledge-producing actors including academic and research institutions have dominance over other actors in an innovation ecosystem. We summarize our argument in the following hypothesis:

> Hypothesis 1: The AI ecosystem in Quebec is centered around the knowledge-producing actors.

2.2.2 Collaboration and innovation in the ecosystem

The idea of an ecosystem reflects interdependent relationships, not only between those who are directly related but also between those who are indirectly related, as well as the collaborative activities between them to achieve collective goals. For example, resources are employed and shared between actors in an ecosystem, which changes the availability of resources and the attractiveness of respective offerings in an ecosystem (Frow et al., 2016). The innovation ecosystem has long been viewed as a collaborative arrangement through which actors combine their individual efforts for broader solutions (Adner & Kapoor, 2010). The interdependent relationship between actors in an ecosystem provides complementary resources crucial for achieving innovation success (Jacobides et al., 2018). For example, Innovation performance depends not only on internal resources and activities but also on knowledge and skills obtained from external sources through collaboration (De Silva et al., 2018; Filippetti & Guy, 2020; Scaliza et al., 2022; Song, 2016). In an ecosystem, collaborations between actors from diverse backgrounds have a positive effect on their innovation (De Silva et al., 2018; Rauter et al., 2019).

The process and models of innovation have evolved. Firms are increasingly adopting strategies that involve opening the process of innovation by coordinating with and sourcing ideas from external actors. Innovation ecosystems play a significant role in shaping the innovation strategies of actors (Scaliza et al., 2022). Ideas coming from external sources help actors improve and sustain their innovation performance (Laursen & Salter, 2006). For successful innovations, actors in an innovation ecosystem need to have the ability to create knowledge, diffuse it through the ecosystem, and efficiently transform and apply the newly acquired knowledge into innovation (Robertson et al., 2023; Scaliza et al., 2022). Actors can capitalize on both internal and external knowledge that eventually affects their innovation (De Silva et al., 2018). Collaboration not only benefits the innovation of large firms by facilitating knowledge production but also creates opportunities for start-ups to connect with actors who have valuable knowledge

(Corvello et al., 2023; Leckel et al., 2020; Manent et al., 2023). Collaboration between actors in an innovation ecosystem can result in innovations such as the development of new products, technologies, market knowledge, and intellectual property (De Silva et al., 2018; Scaliza et al., 2022).

Innovation usually refers to different kinds of newness regarding products, production methods, markets, and organizational configurations, among others. In earlier studies, innovations have been seen as the new products and services introduced as well as the new processes, practices, and strategies implemented by organizations (De Silva et al., 2018; Jugend et al., 2018; Scaliza et al., 2022; Varis & Littunen, 2010). Innovation can be related to organizational activities, new products or services, technological processes, and managerial procedures (Robertson et al., 2023). However, due to the intangible nature of organizational innovations, they are not easily associated with a firm's growth and rather have an indirect impact (Varis & Littunen, 2010). Thus, the extent of collaboration may not contribute much to organizational innovations. There are also context-specific factors that may impede or foster innovations. For example, ethical concerns in healthcare stretch the time for innovations in healthcare (Pacifico Silva et al., 2018). Due to the existing standards, solutions, and societal patterns, innovations in healthcare require a significant amount of time and resources and take a longer time than in other industries (Flessa & Huebner, 2021; Haleem et al., 2021). Similarly, although actors aspire to a higher level of newness in terms of their offerings, a significant amount of novelty may cause innovation failure, which generally applies to product innovations that are new to the market (D'Este et al., 2016).

Concerning the size of firms, smaller firms generally cannot rely solely on internal resources for innovation and are compelled to collaborate with others to source complementary and advanced knowledge. On the other hand, innovations in smaller firms may depend on the innovativeness of the entrepreneur(s), instead of the ideas coming from external sources, since there are fewer gatekeepers to implement new ideas (Varis & Littunen, 2010). Therefore, different types of

innovations require different types of knowledge or source it from different sources through different types of collaborations (Tödtling et al., 2009; Varis & Littunen, 2010). Given the context of our study, we summarize our argument in the following hypotheses:

> Hypothesis 2A: The network centrality of an actor in the innovation ecosystem is positively associated with the actor's process innovation.
>
> Hypothesis 2B: The network centrality of an actor in the innovation ecosystem is positively associated with the actor's marketing innovation.

We understand that collaboration with different actors has a significant effect on innovation in firms. However, the innovations of an actor may also vary according to the types of actors it is collaborating with since the success of an innovating firm often depends on the efforts of other innovators in its environment (Adner & Kapoor, 2010). For example, changes in the technologies of upstream actors affect a firm's innovation offers due to ecosystem-level interdependencies (Dong et al., 2023). Similarly, actors benefit from the unique expertise of researchers and knowledge coming from research and higher education institutions to improve their innovation (Rodriguez et al., 2017; Veilleux & Queenton, 2015). There could be both cooperation and competition, there might be some dominant actors while others remain in niches, and there might be both strong ties between some actors and weak ties between others (Adner & Kapoor, 2010; Scaliza et al., 2022). Intermediaries play important roles in this context by facilitating the process of collaboration in ecosystems. As typical inhabitants of ecosystems, intermediaries connect diverse actors within and between ecosystems (Reischauer et al., 2021; Thomas & Autio, 2020). Within innovation ecosystems, intermediaries are in a position to identify, qualify, and select collaboration opportunities to foster successful innovations (Veilleux & Queenton, 2015). Therefore, we extend the previous hypothesis:

Hypothesis 3: The association between innovation and collaboration between actors varies according to the types of innovations and collaborators.

2.3 Methodology and data description

In this study, we explore the configuration of the network structure and the variety of inter-organizational relationships in the AI ecosystem in Quebec. An innovation ecosystem can generate new output without using input from the originator, is resilient, and attracts new external actors to enhance the innovative potential of the system (Saxenian 2018). These attributes are present in the AI ecosystem in Montreal, and therefore, the ecosystem fits the definition of an innovation ecosystem (Sultana et al., 2023). Montreal has become home to one of the world's largest deep-learning university communities and global leaders setting up research labs[8].

We adopt a research approach combining social network analysis and regression analysis to identify the connection between actors and to understand the association between collaboration and innovation in the ecosystem. Studying innovation using the social network analysis approach is important because the scope of collaboration between organizations is becoming broader and wider with emerging technologies (Muller & Peres, 2019; Veilleux & Queenton, 2015). Scholars in earlier studies used social network analysis to examine the structure of innovation networks as well as the formation of innovation networks concerning the system innovation performance (Dhanaraj & Parkhe, 2006; Kapoor & Lee, 2013; Van Der Valk et al., 2011). However, these studies were focused on the network structure of individual organizations, while we aim to explore the network structure of the ecosystem. Using the UCINET software, we conduct network analyses to understand the structure of the ecosystems and to identify the

[8] https://www.montrealinternational.com/en/keysectors/artificial-intelligence/

positions of different actors. In the next step, using the network centrality indicator, we conduct regression analyses to understand the association between the innovation and collaboration status of actors. The STATA statistical software is used to conduct the regression analyses. The data used in the analyses were collected over the period from Summer 2022 to Winter 2024.

Table 2.1 Binary matrix of ten random actors in our sample

Collaboration	…	IPN	INR	TRA	INS	ORT	KAT	KEE	KEY	KOG	LIN	LING	…
…	0												
IPN		0	0	0	0	0	0	0	0	0	0	0	
INR		0	0	0	0	0	0	0	0	0	0	0	
TRA		0	0	0	0	1	0	0	0	0	1	0	
INS		0	0	0	0	1	0	0	0	0	1	1	
ORT		0	0	1	1	0	0	0	0	0	0	0	
KAT		0	0	0	0	0	0	0	0	0	0	0	
KEE		0	0	0	0	0	0	0	0	0	0	0	
KEY		0	0	0	0	0	0	0	0	0	0	0	
KOG		0	0	0	0	0	0	0	0	0	0	0	
LIN		0	0	1	1	0	0	0	0	0	0	0	
LING		0	0	0	1	0	0	0	0	0	0	0	
…													0

At first, we prepared a list of firms in the AI ecosystems in Quebec, using different sources including Ministère de l'Économie et de l'Innovation (MEI), Montréal Invivo, and Montréal International. To ensure the feasibility of the project, we limited the scope of the project to collaborative linkages. Two firms are considered to have a collaborative relationship if they are working together on a project or receive support for their projects. For example, Appendix D presents some of MILA's partners. The presence of collaborative relationships between two actors was coded as "1", and the absence of such relationships was coded as "0". A sample of the data is presented in Table 2.1. The data on collaborative linkages was collected by consulting the websites of each actor and the information available online.

2.3.1 Dependent variables

There is no single measure of innovation applicable to all organizations, and there exist more innovation indicators for process innovation than product innovation in the literature (Dziallas & Blind, 2019). The most common measurement of innovation performance used in the literature is the number of patents an organization has obtained as well as the new products and services it has introduced and the new processes, practices, and strategies it has implemented (De Silva et al., 2018; Jugend et al., 2018; Robertson et al., 2023; Scaliza et al., 2022). These measures provide concrete evidence of the organization's innovation. However, such measures apply to larger firms that are in business long enough to obtain patents and innovations that can be patented, leaving out a significant number of smaller firms and different types of innovations.

Another way to understand innovations in organizations is by using innovation surveys. Researchers in earlier studies measured innovation in terms of the number of new products and services introduced, new processes applied in the production or delivery method, new ways used to organize and manage work (Jugend et al., 2018; Scaliza et al., 2022). Scholars often measured these items using scales (Jugend et al., 2018) or by asking whether the firm has

introduced an innovation within the study period or not i.e., using a binary variable (Cosh et al., 2012). However, using a scale to measure innovation comes with the subjective interpretation of the actors because the same innovation may create different values for different organizations and in different contexts, and therefore be graded differently. Such a measure is more appropriate to understand the value created by an innovation instead of the innovation itself (De Silva et al., 2018). Thus, the binary variable remains the most appropriate measure applicable to all actors regardless of their size and age, and free of the subjective judgment in terms of value created by innovation.

Therefore, following earlier studies, we identified four types of innovation: product innovation, process innovation, marketing innovation, and organizational innovation (De Silva et al., 2018; Jugend et al., 2018; Robertson et al., 2023; Scaliza et al., 2022). Product innovation includes the introduction of new or improved goods and services to the market. Process innovation includes the introduction of new or improved production methods and delivery methods. Marketing innovation includes the introduction of new or improved product design or packaging strategies, product placement strategies, and promotion or pricing strategies. Organizational innovation includes the introduction of new or improved business practices, methods to organize the workplace, and methods to maintain external relations. We collected the relevant data by conducting a survey. The survey questions were prepared by following the guidelines for collecting and interpreting innovation data by OECD and the surveys conducted by Statistics Canada[9].

In the survey questionnaire, we asked whether the actor introduced any new or improved goods, services, methods, strategies, etc. to the market. For example, one question included in the survey was “Since 2011, has your company introduced any new or improved goods to the market?” We decided to use 2011 as the reference period because it is observed that the AI ecosystem in

[9] https://statics.teams.cdn.office.net/evergreen-assets/safelinks/1/atp-safelinks.html

Montreal gained momentum in 2011 when the actors started collaborating to manage, preserve, and enrich their knowledge, and progressively turned their focus to the application of scientific research in AI and innovations in the industrial domain (Sultana et al., 2023). A detailed description of the variables and sources is presented in Table 2.2.

2.3.2 Independent variables

We perform the eigenvector centrality analysis to determine an actor's position in the ecosystem network and use the resulting network centrality indicator to perform regression analyses. An actor's centrality position in a network depends not only on the extent to which it maintains strong connections with other actors but also on the extent to which those actors extend strong connections with other actors, and so on (Bonacich, 1987). Table 2.1 presents the binary matrix we use to conduct the network analysis and obtain the eigenvector centrality indicator. Since we investigate the innovation ecosystem, and innovation is often understood as the transformation of knowledge, the eigenvector centrality measure of collaboration is the most opportune measure to understand the collaboration status of the actors in the ecosystem. In earlier studies, the eigenvector centrality measure has been associated with various network resources such as status, power, and performance (Benjamin & Podolny, 1999; Faulk et al., 2017; Lin et al., 2009).

Eigenvector centrality measures an actor's position in the network based on the number of links it has to other actors in the network as well as considering how well connected an actor is, how many links their connections have, and so on through the network. It calculates the eigenvector of the largest positive eigenvalue as a measure of centrality and gives information on the dominance of the largest eigenvalue in the network (UCINET 6). For the eigenvector centrality analysis to be robust, the ratio of the largest eigenvalue to the next largest eigenvalue should be at least 1.5 (Bonacich, 1972). In our study, the ratio of the

largest eigenvalue to the next largest eigenvalue is 1.7 suggesting the robustness of the centrality measure.

Furthermore, to understand the association between innovation and collaboration in terms of different types of collaborators, we used different variables. We classified the collaborators into two types: industry and intermediary. The industry variable measures whether the actors have a collaborative relationship with actors from different industries, whereas the intermediary variable measures whether the actors have collaborative relationships with different intermediaries including the actors from governments, universities, research centers, incubators, and accelerators.

2.3.3 Control variables

We control for the size and age of the actors in this research. Compared to larger firms, smaller firms typically have fewer resources to invest in innovation and rely on external resources (Varis & Littunen, 2010); compared to younger firms, older firms rely more on internal resources to advance innovations (Kim et al., 2016). Following earlier studies, we measure the size of the actors by using the number of employees (Scaliza et al., 2022). The number of employees can also be seen as the human capital of an organization, and human capital is found to have a significant influence on national innovation performance (Suseno et al., 2020) as well as on firm innovation capability (Al Dabouba et al., 2023). Actors can capitalize on existing knowledge vested in employees and collaborators to understand and shape the knowledge base of the innovation ecosystem, which can eventually affect their innovation (De Silva et al., 2018). It is also important to consider the age of an organization to have a detailed understanding of its innovation. For example, young firms with informal structures in high-technology sectors are known to have a greater tendency to be innovative; although young firms benefit from informal structures and decentralized decision-making, they will perform better when supported by formal structures and written plans (Cosh et al., 2012).

Table 2.2: Descriptions of variables used in the study

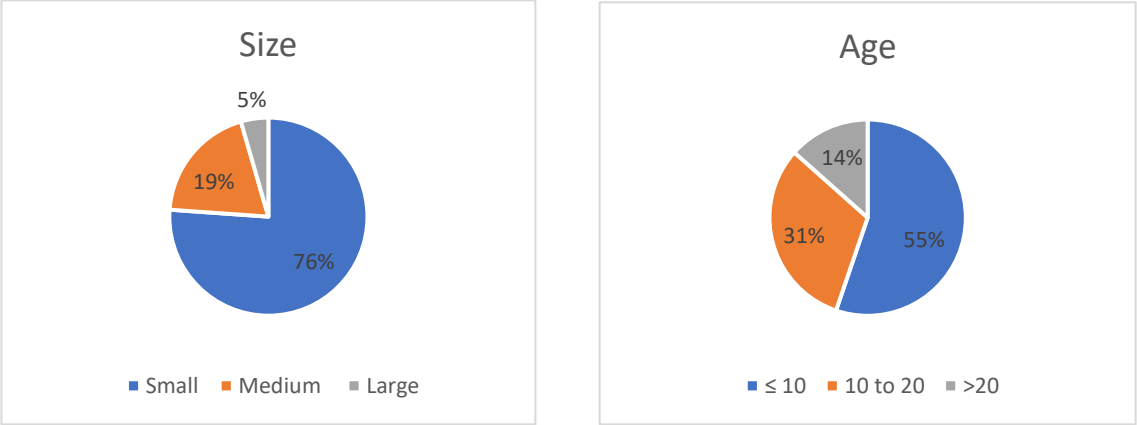
Variables	Description	Sources
Dependent variables	Innovation without classifications	
Innovation	Total innovation	Survey questionnaire
Product Innovation	Measures the introduction of product innovation. 1 = Innovation 0 = Otherwise	Survey questionnaire
Process Innovation	Measures the introduction of process innovation. 1 = Innovation 0 = Otherwise	Survey questionnaire
Marketing Innovation	Measures the introduction of marketing innovation. 1 = Innovation 0 = Otherwise	Survey questionnaire
Organizational Innovation	Measures the introduction of organizational innovation. 1 = Innovation 0 = Otherwise	Survey questionnaire
Independent variables		

Network centrality	Eigenvector centrality position of the actors in the ecosystem network model	Author's calculation of the eigenvector centrality using the network data collected from actors' websites
Collaboration	Collaboration with all types of actors	Survey questionnaire
Industry	Collaboration with industrial actors 1 = Existence of collaboration 0 = Otherwise	Survey questionnaire
Intermediary	Collaboration with academia, government, and other support actors 1 = Existence of collaboration 0 = Otherwise	Survey questionnaire
Control variables		
Size	Number of employees	Actors' websites
Age	Age of the actors in years	Actors' websites

2.4 Findings

We investigate the AI ecosystem in Montreal to understand the structure of the ecosystem as well as how the presence of different actors and their collaboration affect their innovations. The AI ecosystem has emerged from the bottom-up activities of different actors and gained momentum since 2011. Given the specific context of our study, we begin by exploring the specificity of the actors in the ecosystem. Before investigating the association between innovation and collaboration between actors, we want to develop a detailed understanding of whether the actors have been in this ecosystem for a long time or are relatively young as well as whether there are more large actors than small actors.

Figure 2.1 Distributions of actors used in this study in terms of size and age.



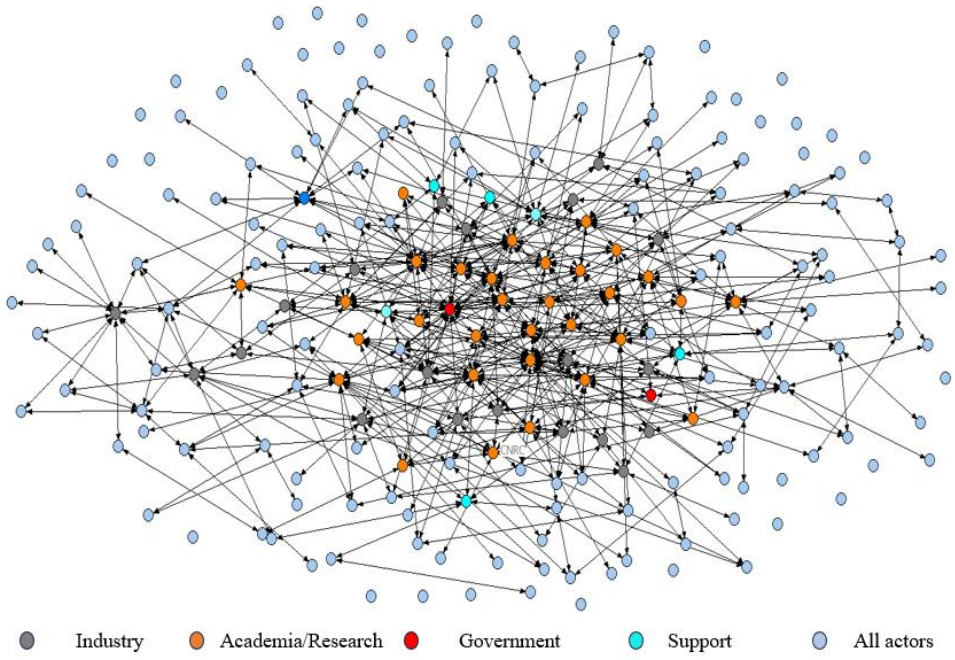
We observe that more than three-fourths of the actors are small firms according to the definition of Statistics Canada[10] and that more than half of the actors are less than 10 years old (Figure 2.1). Thereby, more than half of the actors used in this study are young and small firms.

[10] Small, Medium-sized and Large Businesses in the Canadian Economy: Measuring Their Contribution to Gross Domestic Product in 2005: Main article (statcan.gc.ca)

2.4.1 The structure of the ecosystem

We conduct the network analyses to model a network diagram of the ecosystem and obtain the centrality position of the actors to understand the status of their collaborations in the ecosystem. At first, we build a representative model of the ecosystem based on the collaborative relationships between 230 actors in the ecosystem, representing different industries and sectors. From the network diagram, we observe that most of the central actors in the ecosystem are universities and research centers (Figure 2.2).

Figure 2.2: A network diagram representing the ecosystem.



To further strengthen the finding, we conduct an analysis of variance to analyze the difference between different types of actors (Table 2.3). The finding suggests that the positions of the universities and research centers are indeed different than the positions of other actors in the ecosystem.

Table 2.3 Analysis of variance

Source	SS	df	MS	F	Prob>F
Model	15.284615	54	0.28304843	5.66	0.0027
Centrality position	15.284615	54	0.28304843	5.66	0.0027
Number of observations					67
R-Squared					0.9683
Adjusted R-squared					0.7973

The findings provide us evidence that the AI ecosystem in Quebec is centered around the knowledge-producing actors, and therefore, supports our first hypothesis.

2.4.2 Collaboration and innovation in the ecosystem

Next, we conduct regression analyses to understand the association between the network centrality position of actors in the ecosystem and their innovation. As far as the regression analysis is concerned, we use a final sample including 67 actors. As we have discussed in earlier sections, the innovation of actors can vary with their size and age; Figure 2.1 also shows that a lot of actors in the ecosystem are small and young firms and are not yet in a stage to report innovation. Such actors were not included in the study. The descriptive statistics of the variables are presented in Table 2.4, and the correlation statistics are presented in Table 2.5.

Table 2.4 Descriptive statistics of the variables

Variables	Mean	Standard Deviation	Observations
Innovation	5.61194	2.516342	67
Product Innovation	1.656716	0.5090764	67

Process Innovation	1.014925	0.8070248	67
Marketing Innovation	0.8656716	1.099525	67
Organizational Innovation	1.910448	1.202666	67
Network Centrality	0.0696269	0.0401557	67
Collaboration	2.552239	1.569439	67
Age	12.59701	11.9748	67
Size	1.925373	0.7845754	67

The correlation statistics in Table 2.5 show that both the network centrality and collaboration with different types of actors are positively and significantly related to innovation as expected. The positive correlation suggests that the innovation of the actors increases with the increase in their collaboration with other actors, in terms of both their centrality position and types of collaborators, in the ecosystem. This correlation analysis provides Preliminary support for regression analysis.

Table 2.5 Correlations statistics (star at 10% significance level)

Variables		1	2	3	4	5	6	7	8	9
1	Innovation	1.0000								
2	Product	0.2611*	1.0000							
3	Process	0.5625*	0.1602	1.0000						
4	Marketing	0.7585*	0.1600	0.3267*	1.0000					
5	Organizational	0.6793*	-0.0015	0.2512*	0.4720*	1.0000				
6	Net_Centrality	0.3656*	0.0137	0.1760	0.1773	0.2644*	1.0000			
7	Collaboration	0.4349*	-0.1384	0.2805*	0.4563*	0.5564*	0.4334*	1.0000		
8	Age	-0.0078	-0.0877	0.1261	-0.0283	-0.0225	-0.0965	0.2345*	1.0000	
9	Size	0.0619	-0.0651	0.0736	0.0936	-0.0232	0.0559	0.1201	0.3564*	1.0000

Next, we conduct regression analyses. The analysis is done by preparing fourteen different models, to understand the relationship with different types of innovations and collaborators. We used negative binomial regression. We start by analyzing the relationship between innovation and collaborators without classifying the types of innovations and actors, and step by step, analyze different types of innovations and actors; we control for the age and size of actors in all models. The findings suggest that innovation and collaboration between actors in the ecosystem are positively associated, and the relationship cannot be explained by chance. Regarding the age and size of the actors, the findings do not provide us evidence of significant associations but the general idea that innovation and the size and age of actors are negatively associated.

Table 2.6 presents the findings of the first two models. In model 1, we use innovation (different types of innovations introduced as described in Table 2.2) as the measure for innovation and network centrality to measure the extent of collaboration. The finding (coef. 3.904) provides evidence of the positive and significant relationship between innovation and collaboration between actors in the ecosystem. Next, in Model 2, we change the measure for collaboration and use collaboration with all actors to measure collaboration. The finding (0.141) is similar to the finding in Model 1. Both models are globally significant and provide evidence that collaboration between actors and innovation in the ecosystem is positively and significantly related.

Table 2.6 Results of regression analysis (innovation and collaboration)

Variables	Model 1	Model 2
Innovation		
Network centrality	3.904***	
	(1.252)	
Age	0.000	-0.005
	(0.005)	(0.005)

Size	0.022	0.026
	(0.071)	(0.071)
Collaboration		0.141***
		(0.037)
Constant	1.393***	1.353***
	(0.167)	(0.164)
Prob > chi2	0.0244	0.0014
Number of observations	67	67

*** p < 0.01. **p < 0.05. * p < 0.10.

Next, in Model 3-6, we analyze the relationship between the network centrality of actors and different types of innovations (Table 2.7). We use product innovation in Model 3, process innovation in Model 4, marketing innovation in Model 5, and organizational innovation in Model 6. We find positive coefficients for all innovation types, and only the coefficient for process innovation (14.089*) is positive and significant. The findings provide us evidence that the network centrality of an actor in the innovation ecosystem is positively associated with the actor's process innovation, and thereby, supports hypothesis 2A that the network centrality of an actor in the innovation ecosystem is positively associated with the actor's process innovation. The second highest coefficient is for marketing innovation, but it goes marginally beyond the 10% significance level and does not support, the positive and significant association between an actor's network centrality and innovation, hypothesis 2B.

Table 2.7 Results of regression analysis (types of innovations)

Variables	Model 3	Model 4	Model 5	Model 6
Product Innovation				
Network centrality	0.211			
	(4.501)			

Age	-0.004			
	(0.017)			
Size	-0.037			
	(0.248)			
Process innovation				
Network centrality		14.089*		
		(7.914)		
Age		0.023		
		(0.020)		
Size		-0.306		
		(0.342)		
Marketing innovation				
Network centrality			10.521	
			(8.178)	
Age			-0.016	
			(0.032)	
Size			-0.053	
			(0.323)	
Organizational innovation				
Network centrality				2.196
				(3.897)
Age				0.005
				(0.016)
Size				0.040
				(0.206)
Constant	-0.643	-1.924	-1.191	-0.515
	(0.554)	(0.910)	(0.907)	(0.477)
Prob > chi2	0.9877	0.0296	0.5857	0.9011
Number of observations	67	67	67	67

*** p < 0.01. **p < 0.05. * p < 0.10.

We conduct further analyses, in model 7A-10B, to investigate the association between different types of innovations and different types of collaborators. We classified the collaborators into two types: industry and intermediary. The findings indicate that all types of innovations except product innovation are positively associated with collaboration between actors in the ecosystem (Table 2.8). The most important finding in these models is the positive and significant association between process innovation and collaboration with intermediaries (coef. 0.657). In other words, the findings are consistent with the findings of our previous analyses.

The findings provide us evidence to support our third hypothesis that the association between innovation and collaboration between actors varies according to the types of collaborators.

Table 2.8 Results of regression analysis (types of both innovations and collaborators)

Variables	Model 7A	Model 7B	Model 8A	Model 8B	Model 9A	Model 9B	Model 10A	Model 10B
Product Innovation								
Industry	-0.076							
	(0.218)							
Age	-0.001							
	(0.009)							
Size	-0.015							
	(0.131)							
Intermediary		-0.124						
		(0.215)						
Age		-0.001						
		(0.009)						
Size		-0.014						
		(0.131)						

Process Innovation					
Industry	0.332				
	0.657				
Age	0.005				
	(0.010)				
Size	0.034				
	(0.165)				
Intermediary		0.657*			
		(0.346)			
Age		0.004			
		(0.010)			
Size		0.029			
		(0.162)			
Marketing Innovation					
Industry			3.015***		
			(1.015)		
Age			-0.016		
			(0.014)		
Size			0.171		
			(0.191)		
Intermediary				1.858***	
				(0.612)	
Age				-0.013	
				(0.014)	
Size				0.160	
				(0.195)	
Organizational Innovation					
Industry					1.227***
					(0.305)
Age					-0.007
					(0.008)
Size					-0.022
					(0.122)

Intermediary								1.127***
								(0.294)
Age								-0.005
								(0.008)
Size								-0.026
								(0.119)
Constant	0.607	0.637	-0.373	-0.619	-3.012	-1.908	-0.252	-0.173
		(0.286)						
	(0.288)		(0.400)	(0.424)	(1.060)	(0.686)	(0.355)	(0.344)
		0.9361						
Prob > chi2	0.9751		0.6017	0.0294	0.0000	0.0027	0.0001	0.0002
		67						
Number of observations	67		67	67	67	67	67	67

*** p < 0.01. **p < 0.05. * p < 0.10.

To conclude, we would like to mention here that although not finding evidence of positive and significant association for all innovation types may seem puzzling, the answer lies in the specificity of our research context. The actors in the AI ecosystem in Quebec come from diverse industries, and they do not emphasize the same types of innovation. For example, a lot of actors in the AI ecosystem in Quebec are focused on healthcare. Because of the highly sensitive nature of the sector, compared to other sectors, it takes longer for innovations to happen in healthcare. In addition, as we have shown in Figure 2.1, more than half of the actors investigated in this study are small and young firms.

2.5 Discussion

In this study, we attempt to understand the relationship between innovation and collaboration between actors in an innovation ecosystem and investigate the AI ecosystem in Montreal. First, by conducting network analyses, we find that the ecosystem, per se, does not have a core-periphery structure, but most of the central actors in the ecosystem are universities and research centers. The finding supports our hypothesis regarding the dominance of knowledge-producing actors in the ecosystem. We have also proposed and found empirical evidence, regarding our hypotheses on collaboration and innovation. Of the types of innovation studied, we find that the extent of collaboration between actors in the ecosystem is positively and significantly associated with process innovation and that collaboration with actors from industry is positively associated with marketing innovation and organizational innovation, whereas collaboration with intermediaries is positively associated with process innovation, marketing innovation, and organizational innovation. The absence of a positive association between collaboration and product innovation can be explained by the fact that the majority of actors in the ecosystem are small and young firms are focused on innovation in healthcare. In addition, the introduction of novel products and market innovation may depend more or less on the freely accessible information sources (Varis & Littunen, 2010), suggesting that the collaboration may not have been as useful as it is for other types of innovations for the actors studied in this research.

Our findings contribute to the literature on innovation ecosystems by providing a detailed understanding of different types of innovations in innovation ecosystems as well as by providing empirical evidence of the positive association between collaboration and innovation in innovation ecosystems. Given that scholars in earlier studies described innovation performance as the outcome resulting from innovation (Chen & Huang, 2009; Robertson et al., 2023), the findings of this study will allow us to better understand the dynamics of innovation regardless of whether we are talking about innovation outcomes or innovation performance (Bacon et al., 2020; Robertson et al., 2023).

To begin with, the higher presence of the universities and research institutions in the center of the ecosystem confirms the presence of the attributes of an innovation ecosystem in the AI ecosystem in Quebec and signals the strength of the ecosystem (Saxenian 2018). The knowledge produced by these actors both benefits the existing actors and attracts global actors to set up research labs and collaborate with local actors. Other industrial, government, and support actors are also well connected to those knowledge-producing actors, contributing to the innovation of all actors. Collaborations between different actors are increasingly important for innovations in the domain of emerging technologies (Van Der Valk et al., 2011). The cooperative and interactive activities between actors in an ecosystem not only improve their innovation performance (Song, 2016) but also have a large impact on the future development and advancement of technologies (Van Der Valk et al., 2011). Different types of innovation are influenced by different obstacles (Amara et al., 2016; D'Este et al., 2016), and different actors function differently in the ecosystem (Doloreux & Turkina, 2023). In addition, different types of innovations rely on different types of knowledge, sources, and links (Tödtling et al., 2009; Varis & Littunen, 2010). For example, relationships with upstream actors positively influence innovations in firms (Dong et al., 2023; Song, 2016).

Next, our finding that innovation and collaborations between actors in the ecosystem are positively associated has implications for innovation management. A detailed understanding of the innovations of actors in an ecosystem will provide insights into the nature and scope of innovations and interdependencies between actors in the ecosystem. Such understanding is vital for all actors to take strategies and enhance innovation performance. Our findings are in line with the findings in earlier studies that collaborations between actors in an ecosystem enable them to access complementary knowledge and technologies to overcome internal resource limitations, leading to improving their innovation performance (Adner & Kapoor, 2010; Dong et al., 2023). Generally, the introduction of different types of innovation is positively associated with the performance of firms, but the

association may vary depending on the context (Varis & Littunen, 2010). Following the findings of this study, actors will be able to develop an environment and practices conducive to innovation, which will enable them to develop innovative capacity to effectively deliver innovation outcomes and achieve better innovation performance.

A detailed understanding of the presence of different types of actors and innovations will allow the actors to leverage innovation ecosystems for enhanced innovation performance (Autio & Thomas, 2014). The exploration and retention of knowledge are key elements for improving innovative performance, and innovative performance is associated with the introduction of new products and services as well as the adoption of new processes and strategies (Scaliza et al., 2022). Innovation and performance of an organization depend both on an organization's internal resources and on the knowledge and skills of its collaborators (Filippetti & Guy, 2020). For example, actors benefit from the unique expertise of the researchers and their network as well as the infrastructure through collaborations with universities (Veilleux & Queenton, 2015). The findings will enable actors in the ecosystem to rewire their network of relationships to engender faster information flow and ameliorate innovation performance (Muller & Peres, 2019).

Our findings that innovation and collaboration between actors are positively associated help us to understand the drivers of innovation performance (Robertson et al., 2023). The possession of different types of knowledge and technologies is important for innovation and creativity (Scalera et al., 2018; Turkina & Van Assche, 2018). For example, although healthcare is a controlled sector, a wide range of actors or contributors are involved in a variety of collaborative activities to shape healthcare. Collaborations between diverse actors in healthcare are not limited to the simplistic consideration of doctor-patient collaboration but are more complex and represent an ecosystem (Frow et al., 2016). With a detailed understanding of their internal resources and collaborations in the ecosystem, actors can make strategic decisions to extend

collaborations and improve innovation performance. Above all, a detailed understanding of how the actors are collaborating with different actors and how such collaborations affect different types of innovation will allow us to understand the relational dynamics of emerging technologies (Bailey et al., 2022).

The findings also have implications for the adoption and diffusion of innovation because the innovation ecosystem not only facilitates the transfer of knowledge and technologies but also facilitates the adoption of innovations (Bacon et al., 2019). Although our finding of the general impression of a negative association between age and size of actors implies that innovations in smaller firms may depend on the innovativeness of the entrepreneur(s) instead of the ideas coming from external sources (Varis & Littunen, 2010), the overall finding of the positive association between innovation and collaboration is important given the continuous evolution of innovations and innovation ecosystems. The flow of information and access to resources, facilitated by the recursive interactions between actors, catalyze innovation since innovation rarely happens in isolation. Policymakers need to widen the scope of rules and regulations and take initiatives based on the circumstances of different actors to foster innovations in the ecosystem. The findings will help us to contribute to building necessary infrastructures for inclusive and sustainable development and encourage interdisciplinary and intersectoral innovations.

2.6 Conclusion

In this study, we investigate the relationship between innovation and collaboration using the ecosystem lens. The innovation ecosystem lens makes it easier to understand the dynamic nature of innovation to achieve better innovation outcomes. We explore the AI ecosystem in Quebec focusing on different types of innovations and actors. The types of innovations we focus on are product innovation, process innovation, marketing innovation, and organizational innovation. The types of actors are industry and intermediary. First, we find that the ecosystem is centered around the knowledge-producing actors. Second, we find empirical evidence of the positive association between collaboration and innovation. Of the types of innovation studies, we find that the extent of collaboration between actors in the ecosystem is positively and significantly associated with process innovation and that collaboration with actors from industry is positively associated with marketing innovation and organizational innovation, whereas collaboration with intermediaries is positively associated with process innovation, marketing innovation, and organizational innovation. The absence of a positive association between collaboration and product innovation in both cases is understandable given that the majority of actors in the ecosystem are small and young firms and focused on innovation in healthcare.

The findings corroborate the presence of the characteristics of an innovation ecosystem in the AI ecosystem in Quebec highlighting the specificity of the ecosystem. The most remarkable findings in this study are the dominance of knowledge-producing actors in the ecosystem and the empirical evidence of the association between collaboration and process innovation in terms of both the extent of collaboration and collaboration with intermediaries. The findings contribute to the literature on the innovation ecosystem by providing a detailed understanding of different types of innovations in an innovation ecosystem as well as by providing empirical evidence of the positive association between innovation and collaboration between different types of actors in the ecosystem. The insights

of this study shed light on understanding the debate on innovation performance and improving the innovation performance of actors in different ecosystems (Robertson et al., 2023; Scaliza et al., 2022). Understanding the innovation and collaboration between actors considering different aspects is fundamental to enhancing the value creation through innovations locally, regionally, and globally (Yaghmaie & Vanhaverbeke, 2019). For example, collaboration is particularly important for small and medium-sized firms, and public actors have the means to effectively increase collaboration for innovation by connecting firms, entrepreneurs, and research institutions (Leckel et al., 2020). Equipped with the findings, the policymakers in the ecosystem will be able to take initiatives to support and increase collaboration between actors to foster innovation in the ecosystem.

Nonetheless, this study is subject to some limitations that indicate a need as well as opportunities for future research. There is no unanimously accepted measure for innovation or collaboration. Therefore, we have used the proxies that are most suitable for the context of our research. Given the dynamism of innovation ecosystems, future research can be conducted to investigate the AI ecosystem according to different specializations such as healthcare, video games, transportation, etc. Similarly, studying the innovations of actors according to their size and age to know whether the innovations in smaller or younger firms differ from the innovations in larger or older firms will provide us with a detailed understanding to support the actors in the ecosystem according to their specific contexts. Furthermore, from the organizational studies perspective, it will be interesting to study whether the collaboration styles vary according to different types of actors or technologies.

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Chapter 3

Collaboration for Sustainable Innovation Ecosystem: The Role of Intermediaries

Abstract

Innovation ecosystems have increasingly been studied from various perspectives including connecting innovation ecosystems to sustainable development. Extant studies have found that innovation is important for sustainable development, collaboration is important for innovation, and intermediaries create necessary links and opportunities for the development of relations and cooperation between different actors in an ecosystem. What has been missing, however, is an explicit analysis of the process of collaboration in innovation ecosystems to ensure sustainability and the role of intermediaries in the process. To fill this void, this paper studies six organizations that act as intermediaries, using a multiple-case design approach. It analyzes the process of collaboration in innovation ecosystems and elucidates the role of intermediaries in the development of sustainable ecosystems. The findings indicate that the process of collaboration between actors in innovation ecosystems is an iterative process facilitated by intermediaries. By connecting different actors, intermediaries support the diffusion of innovation that has important implications for building sustainable innovation ecosystems and achieving Sustainable Development Goals (SDGs).

Keywords: Innovation ecosystem; collaboration; intermediaries; sustainable ecosystem; sustainable development

3.1. Introduction

Scholars have studied innovation ecosystems, connected innovation ecosystems to sustainable development, and examined the factors that influence sustainability as well as the role of intermediaries in different ecosystems. In an innovation ecosystem, the focus is usually on the introduction of a new product or service or a new way to create value for customers by introducing a new or changing an existing business model (Yaghmaie & Vanhaverbeke, 2020). Actors in an innovation ecosystem interact and collaborate toward a shared aim of the whole innovation ecosystem. Intermediaries support ecosystem actors in searching for knowledge, monitoring their activities, navigating different interests and avoiding conflicts of interest, and lowering coordination costs (Perkmann & Schildt 2015; Reischauer et al., 2021). Managing innovation ecosystems is not a linear process and requires collaboration between different actors (Szaro et al., 1998). The sustainability of innovation ecosystems relies on collaboration between actors in an open environment as well as knowledge production and transfer (Boyer, 2020). Intermediaries play important roles in this context by facilitating the process of collaboration for innovation leading to sustainability in the ecosystem and by supporting diffusion and implementation of innovation leading to sustainable development. Intermediaries are typical inhabitants of ecosystems that connect diverse actors of an ecosystem (Reischauer et al., 2021; Thomas & Autio, 2020). They can operate both at the network or system level and focus on the bilateral relationship to support individual organizations, and the significance of intermediaries lies in the maintenance, creation, and coordination of networks of interdependent and different actors (van Lente et al, 2003). In other words, intermediaries create the necessary links between actors and create opportunities for the development of relations and cooperation between different actors in an ecosystem.

However, how the collaboration between actors in innovation ecosystems comes about and the role of intermediaries in the process has remained relatively underexplored. Although innovation ecosystems can be virtual because of

digitization and globalization, they need some grounded hub as members need to physically meet to interact and co-create, to develop new ideas benefiting from their multidisciplinary skills and competencies (Costa & Matias, 2020; Gamidullaeva, 2018; Jacobides et al., 2019). Scholars find that intermediaries are key facilitators in intra- and inter-ecosystem linkages (Hernandez-Chea et al., 2021; Valkokari et al., 2017). Scholars have also examined the factors that influence sustainability, connected innovation to sustainability, and emphasized collaboration for innovation (Szaro et al., 1998; Zhang et al., 2019) but have rarely explored the process of collaboration from this perspective. Sustainability is not an automatic outcome of innovation activities; obtaining sustainability requires not only resources and capabilities to manage those resources (Zhang et al., 2019) but also the ability to manage relationships and develop partnerships (Liu et al, 2019). The literature still lacks a clear understanding of the collaboration processes in innovation ecosystems and the role of intermediaries in facilitating these processes. Therefore, we aim at answering: what is the process of collaboration between actors in innovation ecosystems? What are the roles of intermediaries in facilitating collaborations in innovation ecosystems and ensuring sustainability?

The purpose of this paper is to move toward a nuanced understanding of the process of collaboration in innovation ecosystems and the role of intermediaries in the process, building on the literature on open innovation and innovation ecosystems. Intermediaries are often identified through the functions they perform including connecting multiple actors, organizing discourse, creating conditions for learning, and transferring knowledge and technologies (Lee et al., 2010; van Lente, 2003). Innovation intermediaries are public or private organizations that support firm-level and system-level innovation in various ways, such as creating knowledge links between organizations, sharing knowledge about particular technologies, providing knowledge-intensive services, and advising policymakers (Howells, 2006; Kivimaa et al., 2019). We adopted a multiple-case design approach and reached out to actors who collaborate with

actors in different ecosystems to obtain a deeper understanding of the phenomenon. Thereby, we set the boundary of our study to the context of innovation in Healthcare in Montreal. At first, we attempt to understand why and how an organization collaborates with another firm to identify the process. Next, we identify the roles of intermediaries in different steps of that process. We find that the process of collaboration between actors in innovation ecosystems is iterative and that intermediaries, being connected to different actors, facilitate the process.

Our findings contribute to the literature on open innovation and innovation ecosystems by demonstrating the process of collaboration in innovation ecosystems and elucidating the role of intermediaries in the process. This paper establishes an interdisciplinary bridge between the different literature and provides an empirical foundation for the role of intermediaries in relational developments in the process of collaboration between actors in different ecosystems. With an understanding of the roles of intermediaries, organizations can make efficient use of their resources, and policymakers can devote resources to fostering ecosystems and developing target sectors. Given that innovation requires integrated collaboration, co-creation, and value-sharing between different actors (Costa & Matias, 2020) and that ecosystem management is generally synonymous with sustainable development (Szaro et al., 1998), the findings will guide actors to create the environment to facilitate collaboration and build collaboration for sustainable development. Sustainability in innovation ecosystems requires not only optimizing internal innovation processes but also optimizing externally through a combination of autonomy and coordination of actors' interests (Fukuda & Watanabe, 2012). Thereby, the findings provide important insights into the scope to integrate services and develop strategic collaborations between firms, intermediaries, and government agencies to increase cooperation around the world and achieve their respective objectives.

The paper is structured as follows: we dedicate the next section to the theoretical background. In the following two sections, we discuss research

methods and report the findings. Next, we discuss the implications of our findings and present a model elucidating the role of intermediaries in facilitating collaboration between actors to ensure the sustainability of ecosystems and sustainable development. Finally, we conclude the paper by providing future research directions.

3.2 Theoretical background

A sustainable innovation ecosystem combines the features of openness and coevolution of actors (Liu et al., 2019). Open innovation provides an environment to exploit the collective and collaborative potentials of individuals and can enhance sustainable innovation ecosystems (Costa & Matias, 2020). Innovation has been widely acknowledged as a key mechanism for addressing sustainable development concerns (Fukuda & Watanabe, 2012; Maier et al., 2020). Interfirm collaboration is central for sustainability purposes (Costa & Matias, 2020). Open innovation has been regarded as an effective way to achieve sustainable innovation through collaboration and stakeholder involvement (Liu et al., 2019). An innovation ecosystem provides an environment for the actors with a wealth of technical expertise, business experience, and access to capital that supports innovation (Granstrand & Holgersson, 2020; Vladut, 2017). Actors must collaborate and select collaboration partners in desired locations to ensure the diffusion and adoption of their innovations (Dahlander et al., 2021). Intermediaries support organizations to identify appropriate collaborative partners, support the process of collaboration, and manage the network of collaborators (Howells, 20006; Li-Ying et al., 2022; Lee et al., 2010; Lopez & Vanhaverbeke, 2009). For example, Appendix E shows how Montreal International can support the development of an actor in Montreal.

The scholarly interest in the role of intermediaries in connecting actors and facilitating innovation has been growing (Lee et al., 2010; Lin et al., 2020; Li-Ying

et al., 2022; Kivimaa et al., 2019). Scholars have studied intermediaries concerning innovation ecosystems in which organizations share technologies, knowledge, or skills and work together to develop new products and services (Cohendet et al., 2020; Gamidullaeva, 2018; Howells, 2006; Thomas & Autio 2020; Vidmar, 2021). Scholars argue that intermediaries are typical inhabitants of an ecosystem and that they broker between diverse actors in the ecosystem by connecting, translating, and facilitating the flow of knowledge (Bramwell & Hepburn, 2019; Brown et al., 2019; Reischauer et al., 2021; van Lente et al., 2003). Intermediaries are often identified through the functions they perform including connecting multiple actors, organizing discourse, creating conditions for learning, and transferring knowledge and technologies (Howells, 2006; Lee et al., 2010; Kivimaa et al., 2003; van Lente, 2003). In this paper, we investigate how intermediaries facilitate the process of collaboration between actors in innovation ecosystems.

In the literature, technology parks, business incubators, knowledge-intensive business services, research, and technology organizations, industry associations, chambers of commerce, university-liaison offices, and regional innovation centers have been considered the prevalent types of intermediaries that play different roles in different ecosystems (Gamidullaeva, 2018; van Lente et al., 2003). Major objectives of innovation intermediaries include promoting ideas and projects; providing external expertise of ideas; exchanging experience and knowledge; supporting partner search, and mobilization of resources needed for project implementation. For example, technology transfer organizations, a type of intermediary organization, operate at the boundary of different communities or fields to transfer technology between organizations (Perkmann, 2017). Innovation intermediaries play important roles in building inter-organizational collaborations by bringing together different actors including firms, governments, and universities to deal with innovation-related challenges (Dalziel, 2010; Rossi et al, 2022).

Although it is not possible to pin down one specific reason for a firm's decision to work with a partner since the decision results from a chain of events, incomplete information, and activities of different actors, such decisions might be a sequential process in which a firm decides to make incremental investments to fortify an already established relationship and specific decisions can be taken at specific circumstances. For example, in joint ventures, the partnering process proceeds through the assessment of the strategic logic for creating the venture, selection of a partner, negotiation of the terms, and implementation and ongoing management of the business (Beamish & Lupton, 2009); partners have important decisions to make in each of these steps. However, although this process identifies partner selection as a separately identifiable phase, it does not explain how to select a partner. Intermediaries play a significant role in this context by providing necessary information (Bramwell & Hepburn, 2019), enhancing relational connections and networks (Brown et al., 2019), and helping actors to adapt to the ecosystem (Schepis, 2020; Williamson & Meyer, 2012). Effective collaborations between actors in innovation ecosystems are paramount for sustainable innovation ecosystems and sustainable development (Costa & Matias, 2020; Dahlander et al., 2021; Manring, 2007).

In the end, while the role of intermediaries has been closely examined within the literature on ecosystems, less attention has been paid to understanding their role in facilitating the process of collaboration in innovation ecosystems. In other words, we know little about how collaborations between different actors in innovation ecosystems come about and the role of intermediaries in the process. Therefore, the question remains: *how do intermediaries facilitate the process of collaboration in innovation ecosystems?* This question and the literature discussed above led us to this research on the process of collaboration in innovation in innovation ecosystems and the role of intermediaries in the process.

3.3 Methods: Multiple case design

We have applied a multiple-case design approach and adopted the purposeful typical case sampling strategy (Martin & Eisenhardt, 2010; Patton, 2002; Yin, 2014). In a multiple-case design approach, a series of cases are treated as a series of experiments in which each case serves to confirm or disconfirm the inferences. The multiple-case design approach is highly iterative and tightly linked to data (Eisenhardt, 1989) and allows a replication logic (Yin, 2014). The logic and power of purposeful typical sampling lie in selecting information-rich cases from which one can study issues that are important to the purpose of the study; purposeful typical sampling provides an in-depth understanding of the cases (Patton, 2002). Since we intend to describe the typical scenario to understand the role of intermediaries in the process of collaboration between actors in innovation ecosystems, purposeful typical sampling is a suitable strategy. In addition, we adopted the snowball strategy to select interviewees since the role of intermediaries in bringing different firms together and forming collaborations stareted to become evident after several interviews. Then, to fortify our observation concerning the role of intermediaries, we prepared a representation of the healthcare ecosystem in Montreal, using the social network analysis approach. Eventually, we focused on intermediaries and reached out to the relevant personnel to learn more about the scenario. The unit of analysis in this study is the organization that is collaborating with different actors since we would like to understand the process of collaboration in innovation ecosystems and the role of intermediaries in the process. Findings from multiple case studies are more likely to be generalizable and robust than the findings of a single case study (Eisenhradt & Graebner, 2007; Yin, 2014).

3.3.1 Description of cases

We explore the context of innovation in healthcare in Montreal in which both local and international organizations are active in healthcare innovation, and therefore, is an opportune context to explore collaborations between actors within

and across ecosystems. The attributes of an innovation ecosystem (Saxenian, 1984) are present in the healthcare ecosystem in Montreal and have been studied by other researchers (Sultana et al., 2023). Diffusion and adoption of innovation in healthcare are crucial because emerging technologies such as artificial intelligence (AI) are challenging the ability to deliver healthcare services in an effective, equitable, and sustainable way (Lee & Yoon, 2021; Russo Spena & Cristina, 2020; Secundo et al., 2019). A significant number of actors in the healthcare ecosystem in Montreal have been using AI technologies. Therefore, organizations that are active in the domain of healthcare and AI were studied. The cases were carefully selected to ensure that they allow the literal replication logic (Yin, 2014).

Six organizations that act as intermediaries and connect different actors in the ecosystem and support innovations in healthcare were studied. Pseudonyms were used to preserve the confidentiality of the organizations studied. The first organization, Alpha, is a transdisciplinary, open collaboration initiative that focuses on the development of innovative medical technologies to meet the needs of the healthcare community. This organization performs intermediary roles by facilitating the implementation of innovation in healthcare through a transdisciplinary approach, in an open innovation ecosystem in partnership with companies and the involvement of users. Another organization, Beta, is a health innovation hub that brings together different actors to build and launch healthcare technologies. This intermediary facilitates the acceleration and adoption of innovation in healthcare by supporting research, innovation, and integration of cutting-edge solutions in the healthcare system in the region. Gamma is a university-affiliated innovative hospital that uses AI to improve and adapt healthcare to the needs of the population. To bridge the gap between healthcare professionals and the AI sector, Gamma collaborates not only with other hospitals and research centers but also with different institutional and private partners. Delta and Zeta support initiatives in AI and healthcare by bringing together the research community, organizations, and institutions. They are collaborating

across sectors to create innovative and effective AI solutions to ensure better healthcare. Theta propels high-potential technological innovation projects stemming from science and engineering, by providing actors of the ecosystem with resources, training, tools, coaching, and contacts to support them. The focus of this intermediary is to encourage innovation activities and projects that are respectful of the environment, society, and people and that are aligned with SDGs.

This study followed rigorous methods in data collection and data analysis given that the credibility of the qualitative inquiry depends on different elements such as rigorous methods, the credibility of the researchers, and the philosophical beliefs in the value of qualitative inquiry (Patton, 2002). Establishing the trustworthiness of the research by ensuring credibility and confirmability was also emphasized (Lincoln & Guba, 1985). The details of data collection and analysis are reported in the following sections.

3.3.2 Data sources

We collected data from both primary and secondary sources: primary sources include interviews and documents provided by the interviewees, and secondary sources include websites of the organizations studied. We have conducted interviews with one to four members of the management team of each organization including CEOs and heads of the relevant streams. We conducted thirty conversational interviews. The interviews were typically from 45 minutes to 75 minutes long. The interview began with a request for a description of the relevant organization's activities and collaborations with other organizations. Each interviewee described his or her area in the organization, the overall activities of the organization, and collaborations with other organizations. With further probing, the interviewees discussed the collaborative activities in detail including how the collaboration started.

Before conducting the interviews, we consulted the organizations' websites to collect information about their activities, the industries, and ecosystems in which they operate, whether they support innovation, whether they collaborate with other organizations, who are the collaborators, what are the reasons for the collaborations, how the collaborations proceeded, and whether and how such collaborations facilitate the diffusion of digital technologies and innovation. Knowing the information beforehand helped us to select suitable cases (Yin, 2014) on the one hand, and to triangulate the data using the information available on company websites and documents and information provided by the interviewees, on the other hand. Triangulation of data sources provides more accurate information and increases the validity of the analysis (Eisenhardt, 1989; Patton, 2002). We consulted the websites of each of these organizations for relevant information available and examined the industry reports and internal documents that are provided by the interviewees. We have also studied relevant news, about the organizations' activities, published online.

3.3.3 Data Analysis

We have used qualitative content analysis (Boreus & Bergstrom, 2017) and narrative analysis strategies (Langley, 1999) to understand how organizations engage in collaborations with other organizations. Qualitative content analysis is appropriate in this context because this approach focuses on interpreting and describing the topics or themes that are evident in the content of the communication. The narrative strategy is also suitable for analyzing data in such circumstances. The narrative strategy enables researchers to analyze data in case studies with high accuracy with the rich contextual information provided and details of the context (Langley, 1999). It is also possible to compare data by using the narrative strategy. Both strategies complement one another in our study since we collected data from multiple organizations. Moreover, these strategies are helpful, on the one hand, to study the changes that unfold over time, and on the other hand, to find patterns in the data (Langley, 1999; Miles et al., 2014).

At first, we organized the qualitative responses of the interviewees in first-order categories to identify the process of collaboration between actors in different ecosystems. To begin with, we analyzed the data within each case to gain familiarity with the data and obtain a preliminary understanding. Next, we analyzed the data across cases to identify the patterns (Eisenhardt, 1989). The steps mentioned by more than one interviewee were included in the process. As mentioned above, after several interviews, we realized that the references to the role of intermediaries in bringing different actors together and forming collaborations were recurrent. Therefore, in the second stage, we cycled between consulting relevant literature and further data analysis; we used the relevant literature to sharpen the insights yielded by the inductive process. We constantly compare the data with the relevant literature to create an increasingly close fit between cases as well as to improve the creativity and reliability of the analysis (Eisenhardt, 2021). After many iterations between data and literature, what emerged was an iterative process of forming a collaborative relationship between actors in different ecosystems and the roles of intermediaries in different steps of the collaboration process. We report the details in the following section.

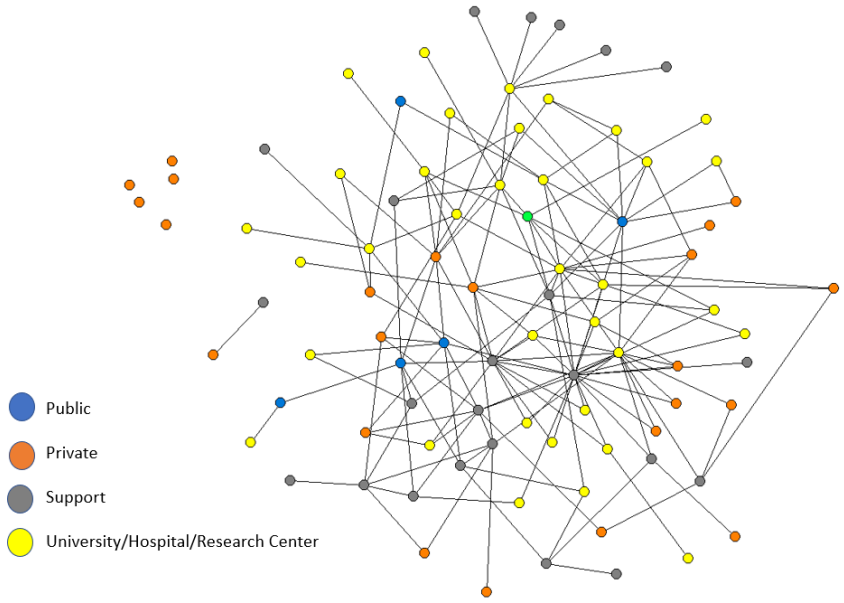
3.4. Analysis and Findings

3.4.1. The Role of Intermediaries in the Collaboration Process

Our study provides a detailed understanding of the process of collaboration in innovation ecosystems and the role of intermediaries in the process. We began by exploring the context of collaboration between actors and found that intermediaries facilitate the collaboration between actors by connecting different actors in the ecosystem. We started to see the role of intermediaries in bringing different firms together and forming collaborations after several interviews. Therefore, to fortify our observation concerning the role of intermediaries, we prepared a representation of the healthcare ecosystem in Montreal using the data

available from Montreal international[11] (Figure 3.1). We built this network model to show the collaborative connections between actors and the role of intermediaries in building such connections.

Figure 3.1: A representation of the healthcare ecosystem in Montreal



With further analysis, we identified that forming a collaborative relationship between actors in an ecosystem involves four steps and that intermediaries play significant roles in three of the steps. Through different events, an organization can learn about local markets and specific customer needs to better identify opportunities for the diffusion of digital technologies and innovation. Therefore, an organization can find an opportunity to collaborate first and plan to expand later. For example, one interviewee from Theta mentioned, *"sometimes, it is the local guy who wants to grow. Then he needs our help to convince the headquarter that here is the right place to be."* We find that intermediaries play significant roles

[11] https://business-map.montrealinternational.com/en/map/?companysearch=%26chk_sector%5B%5D=3%26chk_sector%5B%5D=12%26chk_sector%5B%5D=13%26chk_sector%5B%5D=30%26chk_sector%5B%5D=15%26chk_sector%5B%5D=11%26chk_sector%5B%5D=10%26chk_sector%5B%5D=29%26chk_sector%5B%5D=28

in the meeting, matching, and implementing steps and that the planning step occurs without a significant influence of the intermediaries.

Table 3.1 The role of intermediaries in the process of collaboration

Steps	**Definition**	**Role of intermediaries**
Planning	The step of evaluating possible resources, opportunities, and requirements to work with actors within the same ecosystem or in different ecosystems.	**Not significant** Example quote, *"Normally, they want to talk to you because they have already started thinking of, for instance, a French company coming to North America …. Then, what you do is accompany them, answer all their questions."*
Meeting	The step of making the acquaintance of potential partners within the same ecosystem or in different ecosystems.	**Yes** Example quote, "*Actually, we are in a position to do a lot of introductions and networking … and, putting different partners together.*"
Matching	The step of obtaining a clear understanding of common visions and objectives of potential partners.	**Yes** Example quote, "*Intermediaries are matching different companies and universities*
Implementing	The step of starting the collaboration and related activities to integrate into an ecosystem.	**Yes** Example quote, *"When they are ready to cut the ribbon, we are there to help them with communication, press release so that people know that they are in town."*

Thereby, we develop a model of the process of collaboration in innovation ecosystems elucidating the role of intermediaries. We present the model in Figure 2. Details of the steps in the collaboration process and the role of intermediaries are presented in Appendix F. Below, we elaborate on our findings.

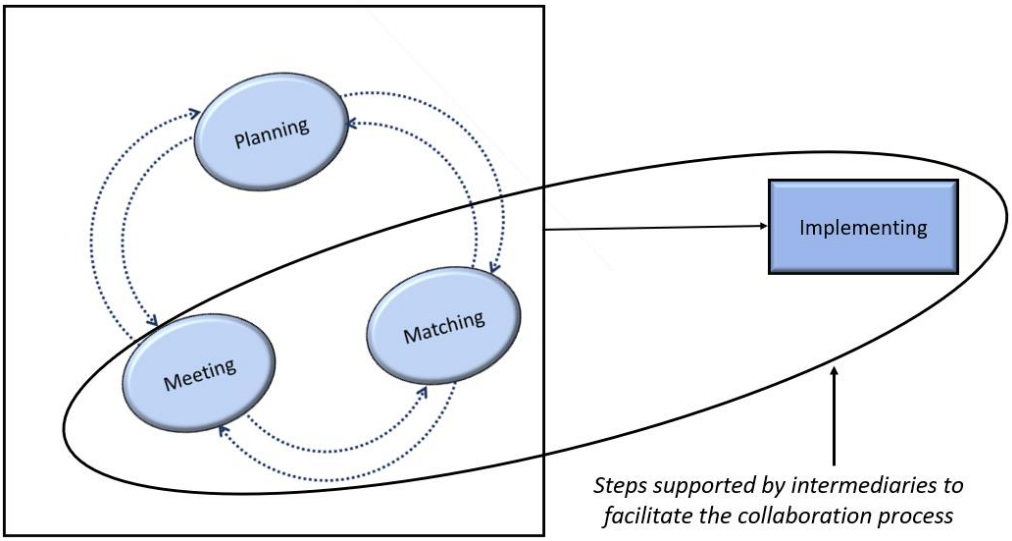
3.4.1.1 The Role of Intermediaries in Planning for Collaboration

In the planning step, an organization evaluates the possible opportunities, resources, or requirements for collaboration with another organization in a different ecosystem. An organization's decision to work with partners is influenced by different factors such as the resources available to the organization and the availability of complementary knowledge or resources with the partners. Before forming a collaborative relationship, a firm needs to assess the strategic logic for working with a partner before selecting a partner (Beamish & Lupton, 2009). For instance, the interviewee from Alpha mentioned, *"we have to focus on our funding, our money, and on what we have a better chance of making a difference with our competitors …. That is how we choose where to invest*." Although it is not possible to pin down the specific reason for a firm's decision to work with a partner, firms are aware of the changes happening in the market and the need to move forward. They are ready to deal with the changes in the local market and expand when possible because the local market may become saturated, or the customer demands may change with time. Therefore, *"if you want to grow, you need to leave*", the interviewee from Beta said, "*that is the organic growth. It is fine, it is okay, but that is going to stop at one moment in time. and we need to be ready when it stops … supplement this with the acquisition."* Often, it is the nature of the organizations that they always work with partners. For example, another interviewee mentioned, "*we systematically worked with foreign partners … by default."*

However, the decision is taken by the firms without any significant involvement of intermediaries (as shown in Figure 3.2). This is evident in the comment of an interviewee from Theta, *"normally, they want to talk to you*

because they have already started thinking of, for instance, a French company coming to North America, but is it within six months? … Within five years? … You never know ... And sometimes, the seed is already a small plant. Then, what you do is accompany them, answer all their questions." Another interviewee mentioned, *"it is not just us selling … as a collaborative place. In fact, we realize that because international players told us that."* In the same line, the interviewee from Alpha said, "*There are times when I talk to people who are … outside Quebec or even outside of Canada for potential … just looking for a set of experts, expert opinions or we just happen to have someone who is interested in what we're doing here*." Therefore, we conclude that an organization's plan to work with partners in different ecosystems depends on its resources and abilities along with other internal factors, and intermediaries can play their roles once the decision is taken.

Figure 3.2: The collaboration process in innovation ecosystems and the role of intermediaries in the process



3.4.1.2 The Role of Intermediaries in Facilitating the Meeting between Potential Partners

> *Proposition 1: Intermediaries facilitate the meeting between potential partners across ecosystems.*

When an organization is ready to move beyond an ecosystem, it searches for opportunities to expand and tries to make the acquaintance of potential partners in different ecosystems. From different industry events and conferences arranged by intermediaries, firms come to know about what is going on in the industry and market, whether there are new products or inventions, what has changed recently, who are the big players, who are the newcomers, etc. Intermediaries often arrange pitching contests and product demonstrations for start-ups to communicate their value offerings to unfamiliar potential collaborators (Schipis, 2020). For example, "*there are, in fact, many different ways to meet them. It can be like, through events and conferences normally*", the interviewee from Beta mentioned. The interviewee from Gamma mentioned, *"they came to our events in Strasburg where we worked with other organizations there to witness the whole thing, and then they started working with us. It's … always a similar pattern."* Intermediaries support new relationship development intentionally by arranging activities such as networking events or unintentionally by providing contexts, due to their affiliation with different actors, to engage potential partners. During these events, firms can learn about local markets and specific customer needs to better identify opportunities for the diffusion of digital technologies and innovation. In formal terms,

Intermediaries create physical or virtual meeting places for potential partners to communicate, which is evident in the statement of the interviewee from Delta, "*actually, we are in a position to do a lot of introductions and networking … and, putting different partners together.*" During these events, potential partners can interact and exchange their ideas leading to innovative projects. The interviewee from Beta said, *"during these conferences, there were*

times when I had opportunities to let people know that I was on the look … I was looking out for companies to acquire …. Then, I met a broker that was specialized in merger and acquisition …. And this broker fed us with many names of the potential companies to acquire … So, yeah, the broker was very useful in that matter, in meeting that organization." Similarly, the interviewee from Gamma said, "*we had got to know through … the conference …. They came to our events … and then started working with us."*

Intermediaries provide opportunities to meet and collect information about potential partners or to meet other intermediaries such as brokers who can facilitate the process of finding a partner in different ecosystems. For example, the interviewee from Beta said, "*this broker fed us with many names of the potential companies to acquire …. So, we finally did this; we looked at six financial acquisitions. The sixth one is the one that materializes. We officially acquired the company, which is our first step in the US market*". Similarly, an interviewee from Theta aptly mentioned, "*If we were not there, for example, for the outreach we do, a lot of companies would not be in here. Or they would not even think about being here." He* said, "*we have clusters and agencies that are putting those players together to create collaboration."* In the end, it is apparent intermediaries play significant roles to bring different actors together.

3.4.1.3 The Role of Intermediaries in Facilitating the Matching of Potential Partners

> *Proposition 2: Intermediaries facilitate the matching of potential partners across ecosystems.*

In this step, organizations try to obtain a clear understanding of the common visions and objectives of potential partners. There are different firm-specific issues that affect a firm's nature of business activities and its decision to collaborate with actors in other ecosystems; depending on the product a firm manufactures or the services it renders, the firm will choose its partners to work

with. For example, the interviewee from Delta pointed out, "*it is really important to have a vision of what you want, how you want this project to go, how you want the partners to look in, and how you actually want to build this entire network and get people on board*." The presence or absence of a similar vision among partners is, therefore, crucial for a successful collaboration. Although each firm is a different entity with specific characteristics, there are other factors in an ecosystem that affect the firm's activities. A firm will look for commonalities in a partner, *"so, what's the big thing I was looking for are the points in common and having a framework that allowed everybody … to kind of have a have role and at the same time having a framework",* the interviewee from Delta mentioned. Firms often look for complementary resources or knowledge in distant locations (Turkina et al., 2018), which can be facilitated by intermediaries. For example, one interviewee mentioned that intermediaries are "*matching different companies and universities".* In formal terms,

Potential partners need to have a clear understanding of the objectives of the collaboration. Firms need to understand whether they share a compatible mission and values to work together. The absence of a clear understanding of the objectives of the investment may lead to the failure of the collaborative projects even though neither partner is at fault. For example, while discussing a failed merger, the interviewee from Beta mentioned *"we sign the agreement and we merge, … I found out that very soon after the official merger that we would not be able to do this".* The partner was looking to serve a different set of target customers, whereas Beta was not at all interested to work with that particular customer segment. As a result, they had to call off the agreement. As an interviewee said, "*we target companies and sectors that we think are the best."* Often, a significant amount of time and resources are required to find a matching partner. As is evident in the comment of an interviewee from Theta, *"sometimes, it is the local guy who wants to grow. Then he needs our help to convince the headquarter that here is the right place to be."* He said, "*so, we meet these*

companies, we try to attract them, and you know, you need to meet a lot of companies to end up finding one that would be like … oh, yeah, that is interesting."

3.4.1.4 The Role of Intermediaries in Implementing Collaborations

> *Proposition 3: Intermediaries facilitate the implementation of collaborations across ecosystems.*

In the final step, an organization starts collaborating with an organization in a new ecosystem. However, although an organization finds a matching partner in a different ecosystem, the role of intermediaries in the cross-ecosystem collaboration is not over. One interviewee from Theta aptly pointed out, "*it would be fun if they decide to come and my job is over, and there is nothing else to do. Well, that is not the case … now the real work starts*." Tasks related to starting a business or moving to a new location include preparing the new setups, moving employees or hiring new employees, and adapting to the new environment. All these are challenging and require considerable effort from all involved. It is important for the local actors to know the possible opportunities and positive impacts of the incoming business so as to establish a reliable and mutually beneficial network. For example, the interviewee from Alpha said, *"then, we all work together in order to agree… what are the rules for the certification process ... that's a collaborative work."* The interviewee from Theta mentioned, *"we help them with immigration, we accompany them through the immigration process*", and he said, *"when they are ready to cut the ribbon, we are there to help them with communication, press release so that people know that they are in town."* In formal terms,

Ecosystems comprise many stakeholders, including suppliers and producers from the private sector, customers as innovators, and government and regulatory bodies from the public sector (Jacobides et al., 2019). For example, the interviewee from Delta mentioned, "*we have partnerships, and we fund things … I can think of some examples like …. So, there are companies that we work*

with that have offices in Quebec … that are not based in Quebec." She said, "*so, we have ongoing discussions with them*." Therefore, to succeed in a new ecosystem, it is critical for an actor to know other actors in the new ecosystem such as local businesses, financial institutions, and government officials who can aid the actor to acclimatize in the new ecosystem. Intermediaries play important role in this context as one interviewee from Theta pointed out, "*we are creating connections … we are putting foreign companies in relationships with all the different people that they need to talk to in order to set up shops here."* Another interviewee mentioned, "*once they are in, we keep accompanying them. That means two, three, or four years of time. Later on, … they say, you know what …the project is going so well that we are thinking of growing. Ok. Then, the process starts all over again*."

3.4.2 The Role of Intermediaries in the Diffusion of Innovation

> *Proposition 4: Intermediaries support the diffusion of innovation by facilitating collaboration between actors across ecosystems.*

Intermediaries play crucial roles in the diffusion of digital technologies and innovation because they have access to information that is not publicly available; they *"have the capacity internally to provide that information, make benchmark and analysis*" as one interviewee from an intermediary organization mentioned. After analyzing and coding the data – the conversation and information available in the sources mentioned in the methodology section – we have identified a four-step process to form a collaborative relationship between actors in different ecosystems. The four steps of the collaboration process include planning, meeting, matching, and implementing. However, the process is not necessarily a sequential one.

Innovation intermediaries can expedite the diffusion of digital technologies and innovation by being informed of the market demands and conveying those demands to the innovators. For example, intermediaries can put "*more weight in*

the purchasing power through innovation than just the lowest bidder" mentioned one interviewee while discussing the purchase of scientific equipment in healthcare organizations. He also mentioned the government and the intermediaries " *are playing an excellent role to stimulate innovation and trying to make the healthcare system more efficient in terms of outcome.*" Having collaboration with innovation intermediaries drives innovation in organizations not only to deal with the current innovation challenges but also to be prepared for the future because being affiliated with intermediaries " *inherently gives you the mandate to drive innovation, it could drive research, and it could also drive the creation and generation of next-generation healthcare professionals."* One interviewee mentioned that *"our ultimate goal is to include innovation in the continuum of the healthcare system. If it does not happen then the innovation has not occurred. For something to be considered innovation, it really has to be in use."* This particular intermediary brings together clinicians and end-users with entrepreneurs and innovators to build and launch technologies that improve people's lives.

By supporting the diffusion of digital technologies and innovation, innovation intermediaries also facilitate digital transformations in organizations. One organization in we studied is working towards the goal of "*transforming the experience of healthcare through an integrated model of research, innovation, and implementation that is patient-centric and informed by large-scale data science."* Organizations need to work with actors who have credibility in their field to successfully diffuse an innovation, and intermediaries can connect organizations to those influential actors to enhance the credibility of innovations. For example, *"if you develop a cardio product, you need cardiologists around that can validate and assess that your product is good … to have the support from key opinion leaders helps for the next step … we work with research centers … organizations in the pipeline."* Innovation intermediaries actively connect the supply and demand sides of the market by forging links between innovation seekers and innovation providers. An innovation intermediary "*identifies, inspires,*

and accelerates innovation" by mobilizing "*external public and private partnerships*" and by helping the *"industry partners to understand the innovation and navigate requirements of a system*" to integrate the innovation in the system.

Eventually, the collaborative relationships pave the way for actors to access complementary knowledge and adopt innovation in different ecosystems. It is not always easy for an organization to find information about organizations in different ecosystems on their own. Intermediaries can arrange face-to-face meetings with potential collaborators by arranging events such as meetings, conferences, shows, etc. For example, an organization may not have a clear idea of with whom to work in a new location; the decision can be influenced by other actors in the network and can be taken at any time that is convenient to all parties involved.

To sum up, we find that intermediaries facilitate collaborations between actors across ecosystems and that they play significant roles by supporting actors in their meeting with potential collaborators, in finding collaborators with matching interests, and in implementing collaborations as long as necessary. Below, we discuss the implications of our findings and propose a model for sustainable innovation ecosystems.

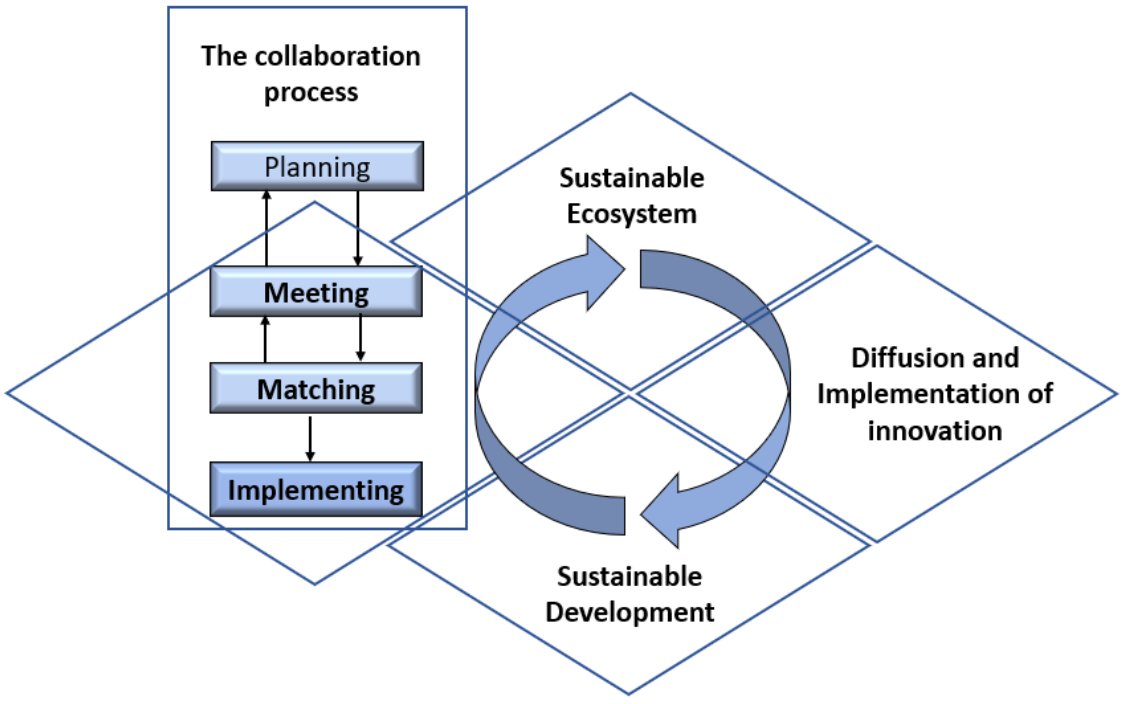
3.5. Discussion

In this study, we attempt to understand the process of collaboration in innovation ecosystems and the roles of intermediaries in the process. Conducting multiple case studies, we find that the process of collaboration between actors in innovation ecosystems is an iterative process with four steps and that intermediaries facilitate collaboration between actors across ecosystems. Our findings highlight three steps in which intermediaries can play roles to facilitate the collaboration between actors in different ecosystems to support the diffusion of innovation. First, by having connections with different actors, intermediaries

can provide information about potential partners and arrange different events to meet individuals from different organizations. Second, intermediaries can collect and provide specific information about an organization or find an organization to match the innovation interest of another organization. Finally, intermediaries facilitate the integration of the incoming organization into an ecosystem. This study highlights the relational development roles of intermediaries, in which they support actors to access knowledge, technologies, and other resources for innovation.

Our findings contribute to the literature on innovation ecosystems by providing a detailed understanding of the process of collaboration in innovation ecosystems as well as providing an empirical foundation for the roles of intermediaries in relational developments across ecosystems. In figure 3, we present a model to illustrate the role of intermediaries in innovation ecosystems: from facilitating collaboration to supporting sustainable development to sustainable development.

Figure 3.3: Sustainable innovation ecosystems and the role of intermediaries



Understanding the process of collaboration in innovation ecosystems and the role of intermediaries in the process has multiple implications for theory and practice. First, the findings will guide actors towards efficient collaboration to obtain sustainable innovation ecosystems. Second, intermediaries support the diffusion of innovation by connecting different actors in innovation ecosystems. Third, a sustainable innovation ecosystem and timely diffusion and implementation of innovation will ensure sustainable development. Below, we elaborate on the implications of our findings.

We find that intermediaries play a very powerful role in cross-ecosystem connections by alleviating information asymmetries, connecting firms with other actors and experts, and developing mutual understanding between potential partners (Brown et al., 2019; Howells, 2006). Intermediaries facilitate the collaboration process by arranging for potential partners to meet and discuss possible collaborations in innovative projects, providing necessary information to find a matching opportunity, and supporting the incoming organization in implementing the decision in a new ecosystem. Given the barriers to entry in different markets and the lack of an existing network, intermediaries can provide a premise for interaction between potential collaborators. Intermediaries often have sectoral specialization and varying degrees of international connection and provide essential support for internationalization to occur and facilitate negotiations with prospective partners (Schepis, 2020).

Collaboration is essential to reach the necessary scale of research efforts, production, and distribution of digital technologies and innovation (Dahlander et al., 2021). From the relevant literature, we know that intermediaries play important roles in connecting different actors, navigating different interests, and lowering coordination costs in ecosystems. For example, innovation intermediaries support the diffusion of innovation in various ways which include but are not limited to creating knowledge links between organizations, processing, and brokering of information and knowledge, sharing knowledge about specific technologies, providing knowledge-intensive services, and advising policymakers (Howells,

2006; Kivimaa et al., 2019). Therefore, maintaining an ongoing and deeper collaboration is essential to advance knowledge and technologies and digital transition (Dahlander et al., 2021; Rossi et al., 2022). By building cross-ecosystem connections, innovation intermediaries can support the diffusion and adoption of digital technologies and innovation to bridge the gap between actors in different ecosystems, improve their innovation performance, and enhance growth in target sectors.

Intermediary activities are typically considered internally oriented within local ecosystems. However, we find that based on their connection with actors in different local and international ecosystems, intermediaries can provide significant support to both incoming and outgoing firms in overcoming challenges in new environments. Our findings conform to the activities of innovation intermediaries noted by Schepis (2020) that innovation intermediaries facilitate relationship development between start-ups and partners in new markets. Actors may not always rely on formal networks but access valuable information and connection through informal connections. In an ecosystem, partners can collaborate flexibly through loosely coordinated development and experimentation and deal effectively with uncertainties (Williamson & Meyer, 2012). Intermediaries, being embedded in different networks and ecosystems, support firms to access new information, complementary capabilities, resources, and trusted referrals as well as reducing the time to access required information and develop relationships (Bramwell & Meyer, 2019; Gamidullaeva, 2018; Lee et al., 2010; Schepis, 2020).

Ecosystems enable firms to set up bilateral and multilateral alliances and enhance competitive advantages. The interaction between firms in an ecosystem can be collaborative and competitive at the same time, and it goes beyond available opportunities and constraints (Adner & Kapoor, 2016; Granstrand & Holgresson, 2020). Ecosystems differ in their scope, structure, and nature of relationships on which they are built (Williamson & Meyer, 2012). For instance, actors within an ecosystem perform complementary activities such that the

activities of one actor are more valuable for another actor than for other actors (Jacobides et al., 2018). Increased global integration may also lead firms to build an integrated global ecosystem by attracting actors from different countries to maximize network effects. We found evidence in our study that both local and international firms, across different ecosystems, are active in healthcare innovation and that innovation intermediaries are supporting them in all possible ways to facilitate the diffusion of digital technologies and innovation. With an understanding of the roles of innovation intermediaries, firms can make efficient use of their resources, and policymakers can devote resources to building and maintaining ecosystems and target sectors to foster innovation. A globally integrated ecosystem will widen the scope and opportunities for all actors to diffuse and adopt innovation. The findings will be helpful in ecosystem governance by elucidating the role of intermediaries in coordinating the activities of ecosystem actors.

Our findings also have implications for achieving sustainable innovation ecosystems and sustainable development goals (SDGs). There has been a growing mandate among actors from diverse backgrounds to become collaborative stakeholders in dialogues about the sustainable management of ecosystems (Manring, 2007). Scholars have explored the connection between innovation and sustainability (Costa & Matias, 2020; Fukuda & Watanabe, 2012; Gu et al., 2021; Liu et al., 2019; Maier et al., 2020). Sustainable development is a big challenge for all innovation ecosystems (Fukuda & Watanabe, 2012). We find that intermediaries increase relational proximity between actors in different ecosystems and enable them to pursue opportunities in distant locations efficiently and in a more agile manner. The sustainability of innovation ecosystems depends on the ability to continuously adapt to the changes in the external environment to maintain productivity and efficiency (Boyer, 2020; Costa & Matias, 2020; Fukuda & Watanabe, 2012). Therefore, regulations and policies should be adapted to the transition and transformation taking place in the

environment to strengthen collaboration between actors, better manage the innovation ecosystem, and remain sustainable.

To sum up, this study identifies three relationship-enhancing activities by intermediaries that facilitate the process of collaboration between actors in innovation ecosystems and support the diffusion of innovation. Integrating these activities into policies will increase the resilience and generativity in local innovation ecosystems leading to sustainable management of innovation ecosystems (Boyer, 2020; Manring, 2007). It is often difficult for new businesses to initiate communication with larger businesses because of their relative inexperience in the industry. Intermediaries play a critical role in shaping collaboration in ecosystems through their different roles of brokering, facilitating, and configuring to mobilize resources between actors (Hernandez-Chea et al., 2021). Innovation intermediaries support the diffusion of innovation by creating knowledge links between organizations, processing and brokering information and knowledge, sharing knowledge about specific technologies, providing knowledge-intensive services, and advising policymakers (Howells, 2006; Kivimaa et al., 2019). Therefore, there are scopes to integrate services and develop strategic partnerships between firms, intermediaries, and government agencies to achieve their respective objectives. The findings will also help policymakers to acknowledge the roles of intermediaries and both individual firms and intermediaries to increase cooperation around the world.

3.6. Conclusion

This study offers a nuanced understanding of the roles of intermediaries in the process of collaboration in innovation ecosystems and in supporting the diffusion of innovation. We begin by investigating how the process of collaboration in innovation ecosystems unfolds and find that the process of collaboration in innovation ecosystems is iterative. The process includes four steps: planning to work with partners, meeting with potential partners from different ecosystems, finding a matching partner for potential collaboration, and implementing

collaborations across ecosystems. Actors can iterate over the first three steps many times before implementing the collaborations. Our findings highlight that intermediaries play significant roles in the last three steps to facilitate the process of collaboration between actors in different ecosystems. First, by having connections with different actors, intermediaries provide information about potential partners and arrange different events to meet individuals from different organizations. Second, intermediaries collect and provide specific information about an organization or find an organization to match the interest of another organization. Finally, intermediaries facilitate the integration of the incoming organization into the new ecosystem.

We also find that by facilitating collaboration between actors within and across ecosystems, intermediaries support the diffusion of innovation. The findings have important implications for building sustainable innovation ecosystems and achieving sustainable development goals. For example, inclusive action is needed to balance the efforts for solving SDGs by using AI (Nasir et al., 2022). Effective and sustainable ecosystem management is emerging as a vital societal issue for two reasons: diverse actors and interests & sustainable economic development (Manring, 2007). Our study highlights the relational development roles of intermediaries that facilitate an organization to access information, connect to potential partners, and integrate into local ecosystems. Future studies may benefit from a deeper investigation into differentiating the direct and indirect role of intermediaries in the diffusion of innovation and the process of collaboration between actors from different ecosystems. It will also be interesting to understand whether the process of collaboration and the roles of intermediaries are different in different types of ecosystems.

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Conclusion

In this thesis, we investigate the Artificial Intelligence (AI) ecosystem in Quebec to obtain a detailed understanding of innovation ecosystems from different perspectives. An innovation ecosystem provides an environment for the actors with a wealth of technical expertise, business experience, and access to capital that supports innovation (Vladut, 2017). Actors in innovation ecosystems interact and collaborate toward a shared aim of the whole innovation ecosystem (Su et al., 2018). However, less is known about how ecosystems emerge, who the actors are, and how the actors in innovation ecosystems collaborate. We also lack empirical evidence on whether such collaboration between actors makes a difference in their innovation, and an explicit analysis of the process of collaboration in innovation ecosystems to ensure sustainability and the role of intermediaries in the process.

First, we find that the mechanism underlying the emergence of the AI innovation ecosystem in Montreal is the articulation of innovation commons by *commoners*. *Commoners* are the key actors who facilitate the articulation of a series of "innovation commons" (Allen and Potts, 2015) that enable knowledge to be progressively revealed, enhanced, nurtured, interpreted, and enacted collectively, leading to the emergence of innovation ecosystems. Based on the actions of *commoners* in different steps of the development of the ecosystem, we identified three sub-mechanisms: orchestration of social commons, orchestration of symbolic commons, and orchestration of knowledge commons. At first, *commoner*s orchestrate social commons by connecting actors from diverse backgrounds. Next, the decentralized structure of the community of actors leads to the orchestration of symbolic commons. Finally, the orchestration of knowledge commons occurs due to the collaboration between actors across boundaries and their attendant knowledge.

Next, we find that the AI ecosystem is centered around the knowledge-producing actors. The higher presence of the universities and research

institutions in the center of the ecosystem confirms the presence of the attributes of an innovation ecosystem in the AI ecosystem in Quebec and signals the strength of the ecosystem (Saxenian 2018). We have also proposed and found empirical evidence of the positive association between collaboration and innovation. Of the types of innovation studied, we find that the extent of collaboration between actors in the ecosystem is positively and significantly associated with process innovation and that collaboration with actors from industry is positively associated with marketing innovation and organizational innovation, whereas collaboration with intermediaries is positively associated with process innovation, marketing innovation, and organizational innovation.

Finally, we find that the process of collaboration between actors in innovation ecosystems is an iterative process with four steps and that intermediaries facilitate collaboration between actors across ecosystems. Our findings highlight three steps in which intermediaries can play roles to facilitate the collaboration between actors in different ecosystems to support the diffusion of innovation. First, by having connections with different actors, intermediaries can provide information about potential partners and arrange different events to meet individuals from different organizations. Second, intermediaries can collect and provide specific information about an organization or find an organization to match the innovation interest of another organization. Finally, intermediaries facilitate the integration of the incoming organization into an ecosystem.

The findings of this thesis provide a detailed understanding of the initiatives of *commoners* and the mechanisms underlying the emergence of innovation ecosystems and complement the literature on ecosystems by shedding light on the structure of an innovation ecosystem and the factors related to the innovations of actors. First, our observation of the bottom-up approaches in the emergence of the AI innovation ecosystem in Montreal sheds light on the challenges in innovation ecosystems at the beginning and during evolution. Finding the higher presence of the universities and research institutions in the center of the

ecosystem confirms the presence of the attributes of an innovation ecosystem in the AI ecosystem in Quebec as well as signaling the strength of the ecosystem (Saxenian 2018). Second, our findings provide a detailed understanding of different types of innovations in innovation ecosystems as well as by providing empirical evidence of the positive association between collaboration and innovation in innovation ecosystems. Third, our findings provide an explicit analysis of the process of collaboration in innovation ecosystems as well as providing an empirical foundation for the roles of intermediaries in relational developments across ecosystems.

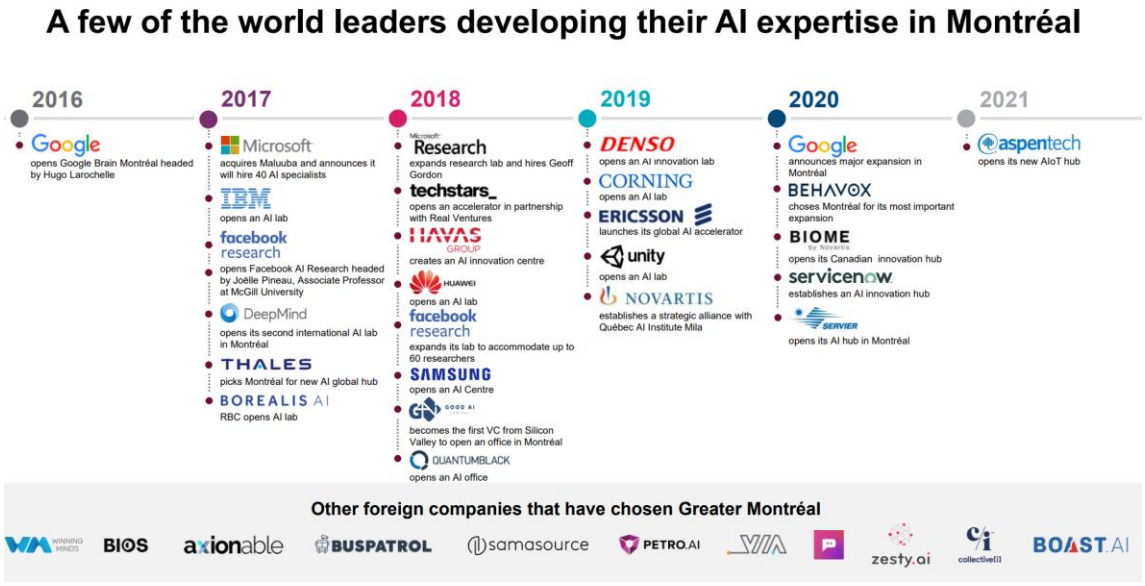
It is important to understand connections between actors in innovation ecosystems to facilitate innovation, create shared knowledge, and obtain sustainability (Ketonen-Oksi & Valkokari, 2019). The findings contribute to our understanding of how to facilitate the creation of a successful ecosystem of innovation and formulate favorable innovation policies. With an understanding of the roles of intermediaries, organizations can make efficient use of their resources, and policymakers can devote resources to fostering innovations in the ecosystems and developing target sectors while considering the specific circumstances of different actors. Given that innovation requires integrated collaboration, co-creation, and value-sharing between different actors (Costa & Matias, 2020) and that ecosystem management is generally synonymous with sustainable development (Szaro et al., 1998), the findings will guide actors toward efficient collaboration to obtain sustainable innovation ecosystems and ensure sustainable development.

Nonetheless, this study is subject to some limitations that indicate a need as well as opportunities for future research. We acknowledge that ecosystems may require a combination of top-down and bottom-up initiatives. The top-down approach makes sense when the necessary information is available at the top level, and there exists a supportive system to communicate strategies and plans from top to down (Colombo et al., 2019). We also acknowledge that we did not compare the dynamics of AI in Montréal to that of other innovative territories.

Another aspect is that in the case of Montreal, we concentrate on the successful application of AI in the domain of health. In Montreal, the application of AI in health is particularly strong, but it is important to investigate the deployment of AI in other domains. In the absence of a unanimously accepted measure for innovation or collaboration, we used the proxies that are most suitable for the context of our research. Given the dynamism of innovation ecosystems, future research can be conducted to investigate the AI ecosystem according to different specializations such as healthcare, video games, transportation, etc. Similarly, studying the innovations of actors according to their size and age to know whether the innovations in smaller or younger firms differ from the innovations in larger or older firms will provide us with a detailed understanding to support the actors in the ecosystem according to their specific contexts.

Given that the AI ecosystem in Montreal is flourishing, it would be opportune to study innovation by integrating insights from different regional and national contexts and by comparing different ecosystems. The perspective on Global Innovation Systems (GIS) might be used to integrate insights from regional, national, sectoral, and technological innovation systems research (Binz & Truffer, 2017). We can explore whether these ecosystems have emerged the same way, whether there are similar challenges or opportunities, whether the actors in different ecosystems collaborate differently, and whether the style of collaboration has different impacts on different types of innovation in different ecosystems, etc. In the thesis, we did not focus specifically on innovation intermediaries, but on intermediaries in general. It would be interesting to study specifically the innovation intermediaries and their role in the innovation ecosystem in Montreal and elsewhere. Future studies may also benefit from a deeper investigation into differentiating the direct and indirect role of intermediaries in the diffusion of innovation and the process of collaboration between actors from different ecosystems. Furthermore, from the organizational studies perspective, it will be interesting to study whether the collaboration styles vary according to different types of actors or technologies.

Appendix A: World leaders developing AI expertise in Montreal.



Appendix B: Data sources

https://www.thecanadianencyclopedia.ca/en/article/artificial-intelligence

https://www.forbes.com/sites/peterhigh/2017/11/06/why-montreal-has-emerged-as-an-artificial-intelligence-powerhouse/?sh=fcaa2a823bd4

http://www.canada.ai/timeline

http://www.montrealintechnology.com/ai-leaders-in-montreal-launch-ai-startup-factory/

https://medium.com/real-ventures/canadas-artificial-intelligence-ecosystem-4798b0517016

https://ormuco.com/blog/canada-pioneers-ai-research-policy#:~:text=Most%20prominent%20of%20Montrealais%20AI,co%2Dfounder%20of%20Element%20AI.

https://www.forbes.com/sites/peterhigh/2017/11/06/why-montreal-has-emerged-as-an-artificial-intelligence-powerhouse/?sh=7fd4f97a23bd

https://www.concordia.ca/jmsb/news/magazine/issue-2/the-reality-of-ai-in-montreal.html

https://www.montrealinternational.com/en/news/lintelligence-artificielle-au-service-de-la-sante/

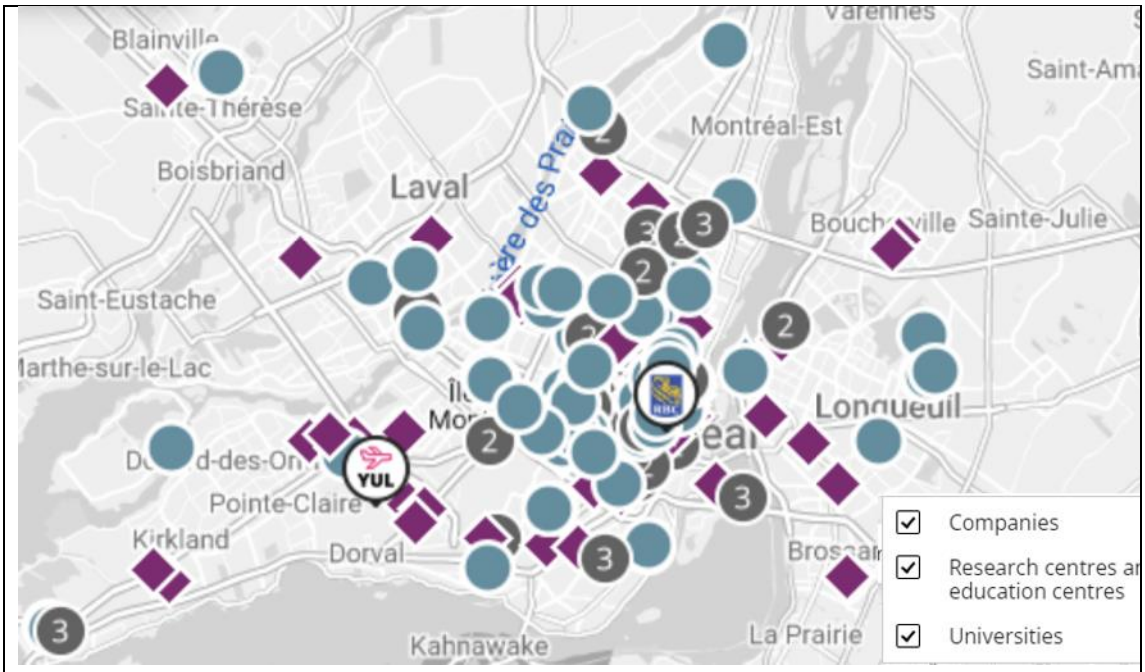
https://www.montrealinternational.com/en/news/life-sciences-and-health-technology-the-compelling-attraction-of-montreal/

https://ici.radio-canada.ca/nouvelle/1926656/yoshua-bengio-palmares-scientifiques-plus-influent-monde-ia

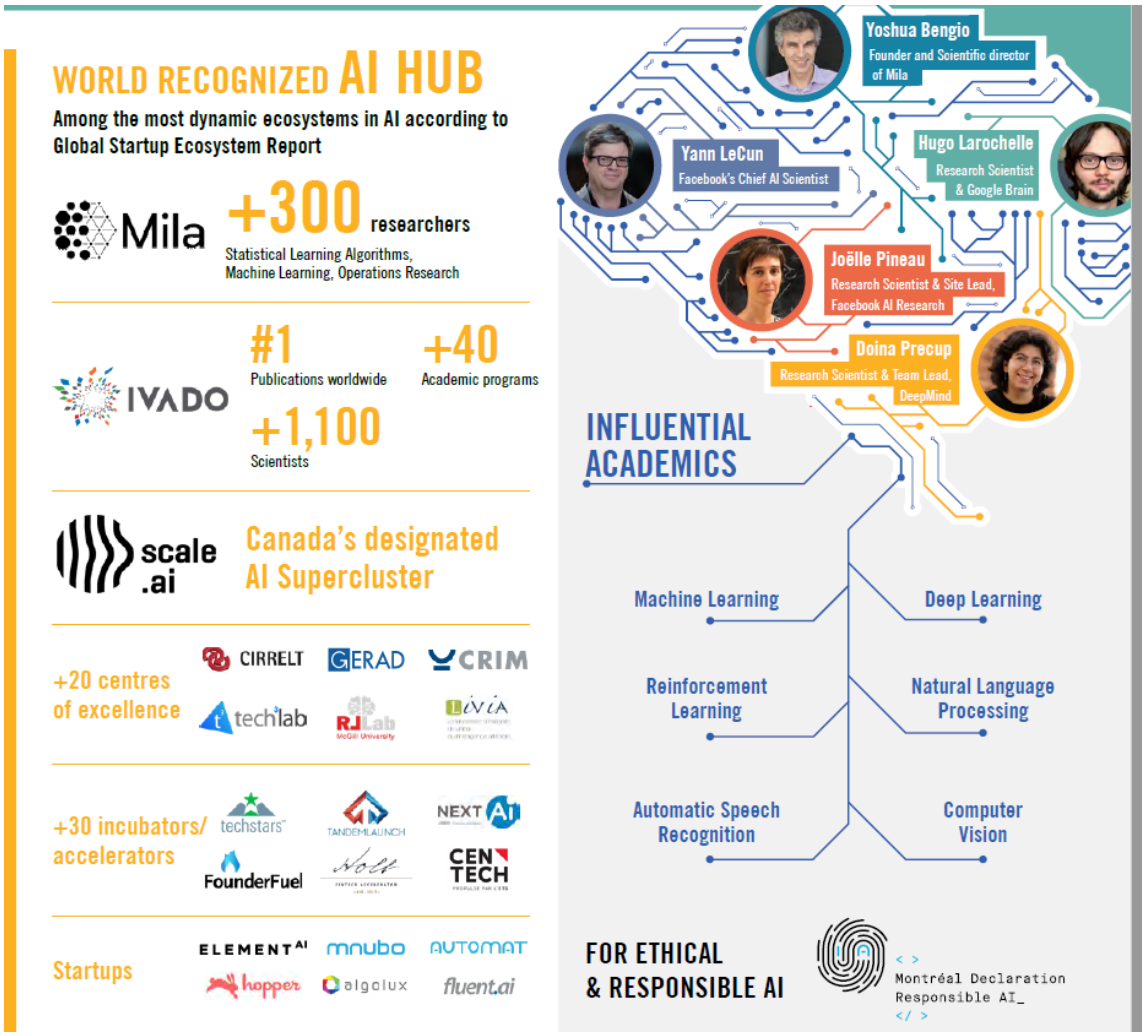
https://www.montrealinternational.com/en/publications/greater-montreal-an-artificial-intelligence-hub/

https://www.canada.ca/en/innovation-science-economic-development/news/2019/09/government-of-canada-and-government-of-quebec-announce-the-creation-of-an-international-centre-of-expertise-in-montreal-for-the-advancement-of-arti.html

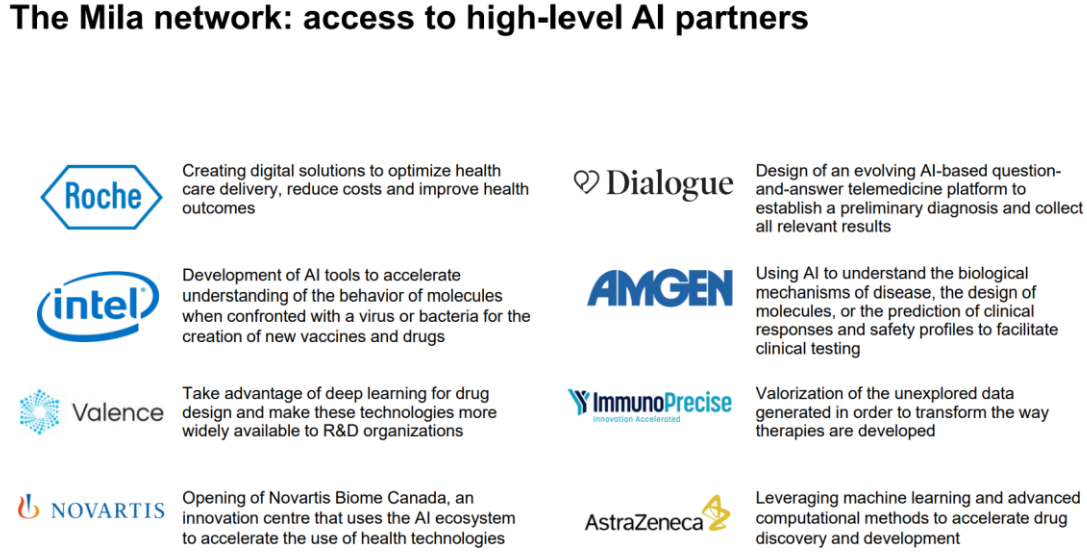
https://business-map.montrealinternational.com/en/map/?companysearch=&chk_sector%5B%5D=3&chk_sector%5B%5D=12&chk_sector%5B%5D=13&chk_sector%5B%5D=30&chk_sector%5B%5D=15&chk_sector%5B%5D=11&chk_sector%5B%5D=10&chk_sector%5B%5D=29&chk_sector%5B%5D=28


Blainville
Sainte-Thérèse
Boisbriand
Laval
Montréal-Est
Saint-Eustache
Sainte-Julie
Longueuil
Pointe-Claire
Kirkland
Dorval
Kahnawake
La Prairie
YUL
Companies
Research centres a
education centres
Universities

Appendix C: Some of the actors in the AI ecosystem in Montreal



Appendix D: Some of the partners in the MILA network



Appendix E: The role of intermediaries in the development of an actor in an ecosystem

Appendix F: The role of intermediaries in the process of collaboration

Steps	Definition	Role of intermediaries
Planning	The step of evaluating the possible resources, opportunities, and requirements to work with actors in different ecosystems	Not significant
Meeting	The step of making the acquaintance of potential partners in different ecosystems	Yes
Matching	The step of obtaining a clear understanding of the common visions and objectives of potential partners.	Yes
Implementing	The step of starting the collaboration and related activities to integrate into a different ecosystem.	Yes