Mapping the Innovation Ecosystem of Intermediaries

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Résumé – Des études antérieures ont montré l'émergence du concept d'écosystème d'innovation en tant qu'approche pour étudier l'innovation, :la décrivant comme un effort de collaboration dans un réseau d'acteurs qui mène à la création de valeur. Un de ces acteurs est l'intermédiaire d'innovation, une organisation dont le rôle est de soutenir les processus d'innovation au sein de l'écosystème. Bien que les intermédiaires aient été étudiés dans la littérature, davantage de recherches sont nécessaires pour comprendre leur rôle dans l'innovation collaborative. L'objectif de cet article est d'étudier les activités d'un intermédiaire afin de mieux comprendre son rôle dans un écosystème d'innovation.

Abstract – Previous studies have shown the emergence of an innovation ecosystem as an approach to studying innovation, describing it as a collaborative effort in a network of actors towards value creation. One type of said actor is the intermediary, an organization whose role is to mediate and support the innovation processes. Although previous research has discussed the role of innovation intermediaries, there needs to be more understanding of their role in collaborative innovation. This paper aims to further study an intermediary's activities to understand its role in an innovation ecosystem and extend the literature on this topic.

Mots clés – **Écosystème d'innovation, Intermédiaire, Transfert technologique, Modélisation.**
Keywords – **Innovation Ecosystem, Intermediary, Technology Transfer, Knowledge Transfer, Modeling.**

1 INTRODUCTION

Over the past 15 years, innovation and innovation systems have become popular, with a rapidly growing literature. One of the concepts that have evolved the most is the innovation ecosystem (IE) (Gomes et al., 2018; Dedehayir et al., 2018; Granstrand & Holgersson, 2020). The IE concept has been used with different labels, most prominently: digital innovation ecosystems (e.g., Beltagui et al., 2020), hub ecosystems (e.g., Petänen & Salo, 2022), open innovation ecosystems (e.g., Chesbrough et al., 2014), and platform-based ecosystems (Helfat & Raubitschek, 2018). It is an emerging concept in engineering domains based on sharing technological skills and resources to improve innovation capabilities of firms and market responses (Su et al., 2018; Xu et al., 2020).

The most common definition for IE was proposed by Moore (1996) who described an IE as the collaborative effort of a heterogeneous set of actors towards innovation, who search for a competitive advantage by recognizing the value chain behind the products and services provided to the end customer. Thus, IE offers a systemic approach to innovation, focusing on how a network of actors creates and sustains competitive advantage independently, without hierarchical management, and enabling each agent to leverage its core competencies (de Paula Ferreira et al., 2022a, 2022b).

In that sense, building IE represents a key research area, including the study of decisions, pivot implications, and managing collective uncertainty, which influences more than one actor in the ecosystem (Gomes et al., 2018; Luciani et al., 2021). One such actor in the IE is the intermediary, also known as a technology transfer organization (TTO), an organization whose role is to mediate and support collaboration between actors during the innovation processes (Howells, 2006). Their role is crucial in lessening the challenges the actors encounter and shape the IE knowledge base. However, as highlighted by Xu et al. (2020), more research is needed to understand the real influence of the role of intermediary organizations in structuring IE. Based on this context, this research aims to map an IE from the perspective of an intermediary—a Canadian college centre for technology transfer (CCTT)—identifying the actors and performance indicators that are part of its operational dynamics.

The remainder of this paper is organized as follows: Section 2 provides a background review of the literature on IE; the methodology adopted is described in section 3; Section 4 presents the results; finally, section 5 presents the research conclusions and avenues for future research.

2 THEORETICAL BACKGROUND

2.1 Innovation & Innovation Systems

Innovation is a complex phenomenon involving the production, dissemination, and translation of technical knowledge into new products/services or processes. The innovation process involves interactive relationships between different actors and follows a non-linear path determined by knowledge feedback mechanisms (OECD, 2018).

Innovation has a long conceptual history with many fluid connotations and denotations. The purpose of innovation is to generate a degree of novelty to a product, service or process to increase its usefulness or success, by applying something that is new to the world, a nation, a sector or a company (Godin, 2015; Suominem et al., 2019; Granstrand & Holgersson, 2020). In practical terms, innovation can be defined as an activity that brings about a transformation in the condition of activity of the user (Zarifian, 1999).

The development of innovations emerges in a complex context of interacting stakeholders. The increased process of internationalization, trade liberalization, and data exchange through advances in information, communication, and automation technologies add complexity to the innovation process. The concept of innovation systems emerges from this complex environment; it considers innovation as a social and interactive learning process, where the links between actors—usually represented by knowledge flows—play a crucial role in improving innovation performance, and result from a set of complex relationships between actors (Dahesh et al., 2020; Talmar et al., 2020).

The innovation system is a system that enables innovation-based economic performance pertaining to an interactive learning system focusing on the capacity of individuals, organizations, and regions as part of building capacity to face new challenges. In general, an innovation system is formed not only at a macro level (network of institutions) but also at a micro level (as an organization), and is characterized by hierarchical (regional, national, continental, and global) and structural (economic, financial, technological, infrastructural) dimensions (Steiner, 2017; Steiner, 2018; Satalkina & Steiner, 2020).

2.2 Innovation Ecosystems

The concept of innovation ecosystems was strengthened in the early 2000s with the emergence of the open innovation concept (Chesbrough, 2003), in which organizations make use of non-linear and network-based innovation models to meet the demands of ever-increasing competitive markets (Smorodinskaya et al., 2017).

In fact, use of the IE concept took off after the publication of a Harvard Business review article by Adner (2006), who builds from Moore's (1993) concept of business ecosystems to introduce the concept of an Innovation Ecosystem. Here, an IE is defined as a set of collaborative arrangements through which companies combine their competencies into a consistent solution aimed at adding value to the customer.

Inserted in an IE, companies need to share resources to build a value proposition throughout the ecosystem, which materializes when the individual contributions of different actors are combined, exploring the synergies and network effects arising from the complementarities between the actors (Clarysse et al., 2014; Adner, 2017; de Assis et al., 2021).

No definition includes all the elements that make up an IE in a precise and logically consistent way. Still, three recurring elements stand out in all established purposes: actors, artefacts, institutions, and activities. Actors correspond to organizations that develop collaborative (complementary) and competitive (substitute) relationships with or without a focal company. Artefacts include tangible and intangible, technological and non-technological resources that are used to share competencies among actors. Institutions ensure a set of resources are available to facilitate the innovation process. Activities correspond to rules for structuring the relationship between actors (Granstrand & Holgersson, 2020).

Fig. 1 shows the main components identified for the development of IE. In general, relationships (arrows) occur between different entities that can include complementary and surrogate feedback relationships, as well as transforming relationships and externalities according to the direction of the connections.

Organizations have increasingly innovated by participating in IE, bringing challenges ranging from balancing the breadth and depth that organizations use when seeking knowledge, such as interviews, publications and patents. Another challenge lies in the different orientations between partners (e.g., company-university partnerships). In this regard, intermediary organizations were identified as an important way of dealing with these challenges (Reischauer et al., 2021).

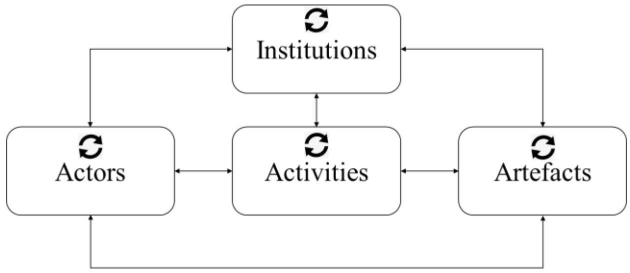

Figure 1. Basic components in an IE.

2.3 Intermediary Organizations

Thomas & Autio (2021) demonstrate that intermediary organizations mediate the relationships between actors in an ecosystem and operate on the cusp of two or more pre-existing communities or fields, such as science and politics, academia and industry. Also known as TTOs, intermediaries represent an open governance mechanism in an IE environment, focusing on shaping the basis of an ecosystem relations through tools that enable a less rigid control of innovation flows and reduce contractual ties between participants. They are incorporated into the ecosystems to promote mutualism, benefiting all involved through the support offered (Reischauer et al., 2021).

Reischauer et al. (2021) argue that there are four domains of activities related to the function of TTOs:

1. Monitoring: establishes representation of each participant and ensures functioning of the IE structure;
2. Membership: defines the rights of each participant and establishes sponsor contributions to the IE;
3. Ownership: assigns tasks among participants, develops contribution agreements, and manages contributions;
4. Knowledge production control: manages technical contributions and disseminates the generated knowledge.

DeSilva et al. (2018) demonstrate that among the various types of involvement of innovation intermediaries, their interaction in collaborative projects represents one of their most complex roles in an IE. Although previous research has discussed the role of innovation intermediaries, there needs to be more understanding of their role in collaborative innovation (Howells, 2006, Knockaert & Spithoven, 2014).

2.4 Ecosystem Mapping

If an organization is to understand the complex dynamics in its ecosystem, it needs to rely on deep knowledge and analysis of the ecosystem by investigating how relationships and dynamics can impact its businesses (Battistella et al., 2013). Multiple academic research papers propose approaches to understanding innovation ecosystems, such as Talmar et al. (2020), with a qualitative strategy tool for mapping, designing, and analyzing innovation ecosystems. Battistella et al. (2013) developed MOBENA, a methodology designed to support the identification and understanding of business ecosystems by providing the criteria to define its structure, and analyze and evaluate the appropriate behaviour. A new perspective is presented by Xu et al. (2020) using network clustering and community identification to analyze strategic roles in an innovation ecosystem.

3 METHODOLOGY

This research adopts the action research method, defined as "an approach in which the action researcher and a client collaborate to diagnose the problem and develop a solution based on the diagnosis" (Bell et al., 2022, p. 5). It seeks to understand a problem using a cyclical process, alternating between action and critical reflection, continually refining data and its interpretations to converge towards a better understanding of the problem. In addition, it is participatory and qualitative (Bradbury et al., 2019; Bell et al., 2022).

The general process of conducting action research is presented as a four-stage procedure, adapted from Bradbury et al. (2019):

1. The planning stage: identifying and narrowing down the topic, defining the need for information;
2. The performance stage: data collection and analysis;
3. The development stage: definition of the action plan activities;
4. The critical analysis stage: sharing and communicating results and reflections on the process.

3.1 Planning Stage

In this project, we are interested in a specific case where we need to describe the IE of an intermediary, in which one of the authors conducted a 6-month internship. The researched CCTT operates in Canada, as one of the pioneers in disseminating Industry 4.0 and the digital transformation concept, helping companies improve their productivity and stimulate innovation. The CCTT was involved in a project to develop a value chain in the context of Industry 4.0, and identified the need to fill operational gaps by mapping the actors and activities involved in the project.

3.2 Performance Stage

For the established ecosystem analysis, we adopted the methodology of business ecosystems network analysis (MOBENA) proposed by Battistella et al. (2013), which is the most consistent with our objectives. It is the most detailed in the search for documentation and information in mapping the ecosystem. The MOBENA methodology aims to identify business news by taking into account the evolution of the actual ecosystems. It can be used as a diagnostic tool to give a quick overview of the state of the ecosystem.

From a dynamic point of view, the methodology can be used to monitor the condition of an ecosystem over time. Additionally, it could be used to compare indices between ecosystems if there is a more extensive data panel. It can also be used to analyze the state of individual potential partners or parts of the ecosystem. The definition of the ecosystem as a complex system focuses on understanding its relationships. The aspect that provides the most information in a system is the relational and understandable challenge. Finally, comprehending the dynamic interactions means integrating foresight methodologies into the analysis. The MOBENA proposal focuses on these essential points: the relational structure and the emotional perspective network (Battistella et al., 2013).

A graphic representation of the ecosystem is produced in Gephi with visualization and exploration software for all types of graphs and networks. Based on this representation, it is possible to introduce phase 3, the ecosystem analysis. We will test the model and measure key performance indicators, such as the ones listed below, with the company team to proceed with the ecosystem analysis.

1. Degree centrality: measures the number of ties an individual has with others;
2. Degree: measures the number of connections an individual has with others;
3. Betweenness centrality: measures the number of pairs of nodes that an individual connects (acting as an intermediary);
4. Proximity centrality: measures the number of links between an individual and other people, that is, the degree of accessibility of an entity to other people;
5. Self-centrality: measures the influence of a node in a network based on the degree of centrality.

3.3 Development Stage

Based on MOBENA, a social network analysis methodology is needed to identify links and know how to interpret them. After reviewing the literature on methods and theories of analyzing collaborations and networks, we agreed on the selection of the Social Network Analysis (SNA), as it is the method applied by many ecosystem models and the one used in the reference articles identified during the first literature review.

SNA is an approach that focuses on the relational structures of the systems within existing entities. It is a method of studying the interactions and relationships between agents, which can be different entities, such as people, companies, universities, governments, etc. It provides both visual and quantitative analysis for the interpretation of human associations. Not only does SNA examine the structure of relationships between individuals, but it also studies the natural mechanisms that occur within them (Alarcon et al., 2017).

For the mapping part, the three-tier model is relevant to us, a model close to University, Industry and Government but more adapted to the scale of the intermediary. As an intermediary that establishes a connection between university and industry, we find a tripartite model here. It is, therefore, necessary to adapt the entities to the scale of the study and identify the relationships that may correspond to the model's logic.

3.4 Critical Analysis

This step consists in analyzing the results obtained in the previous step and comparing them with state-of-the-art concepts from the existent literature. The findings of the critical analysis are the results obtained and described in the next topic.

4 RESULTS

The first action following the MOBENA method was to define the actors' meaning and the studied ecosystem's limits (ecosystem perimeter, elements and relationships). Next, initial data mining was carried out to identify the leading players in the ecosystem. This allowed developing a questioning process and producing critical questions required to continue the methodology.

After implementing the data on the Gephi software, an innovation ecosystem mapping of the company was developed, as well as the measures of key SNA parameters of the network. Figure 2 shows the representation proposed by Gephi. Through clustering and modularity, the graph indicated a significant community structure, i.e., the appearance of groups of nodes in a network that is more densely connected internally than with the rest of the network, affecting the density of the network.

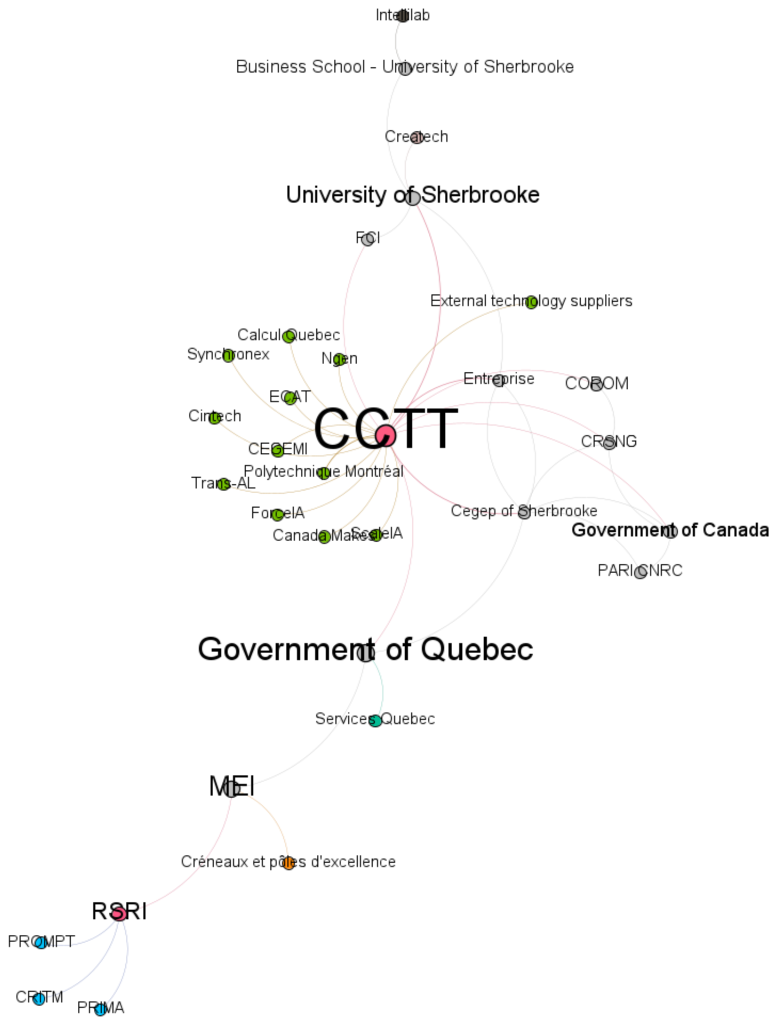

Figure 2. Mapping the innovation ecosystem.

We must take these results lightly because they depend on our goals: whether we want to improve this density because actors are more interconnected across the network or whether we wish to strengthen the intermediate position of the CCTT. In this case, the density will not increase; however, the degree, modularity, and proximity centrality will increase for the CCTT.

As previously stated, we can visually identify the links with the most weight in the network and the so-called dominant nodes. Using the Force Atlas 2 algorithm, a layout of the nodes and a length of links specific to the data entered is obtained. With this mapping, the company can quickly identify the actors as the connections between each actor in its network.

To facilitate the reading of the map, it was decided to represent only the most exciting links for the project based on the connection matrix. The results at the individual level for the main actors of the network are found in table 1.

The CCTT is at the top of the rankings, with all network analysis parameters at the highest point. According to the definitions previously given for each parameter, the researched CCTT has the highest degree of importance in the network, which shows that it is the actor that best establishes links with the other actors in the network. We can identify dominant actors in the network, such as the University, the government, and the companies that CCTT collaborates with for the project. As previously stated, these actors emerged from the network in the current mapping. The results here depend directly on the number of nodes and links inserted into the mapping but mainly on the number of connections between the actors.

Actor	Key performance indicators			
	Degree	Betweenness centrality	Proximity Centrality	Self-centrality
CCTT	20	0.61	377	1
University	5	0.42	86.5	0.35
Government	4	0.48	174	0.33
Enterprises	4	0.41	4.67	0.46

Table 1- Results of the main actors of the network at the individual level.

After technical visits to partners, it was possible to identify a set of performance indicators for the CCTT to manage the activities carried out among the EI actors studied. Figure 3 demonstrates a UML use case diagram that highlights the timeline of a project implementation, making it possible to identify performance indicators that are consistent with this timeline. These indicators will enable the CCTT to evaluate its performance at different levels, tracking the progress of the projects to make decisions for future implementation of the technology project. The selected performance indicators are indicated in Table 2.

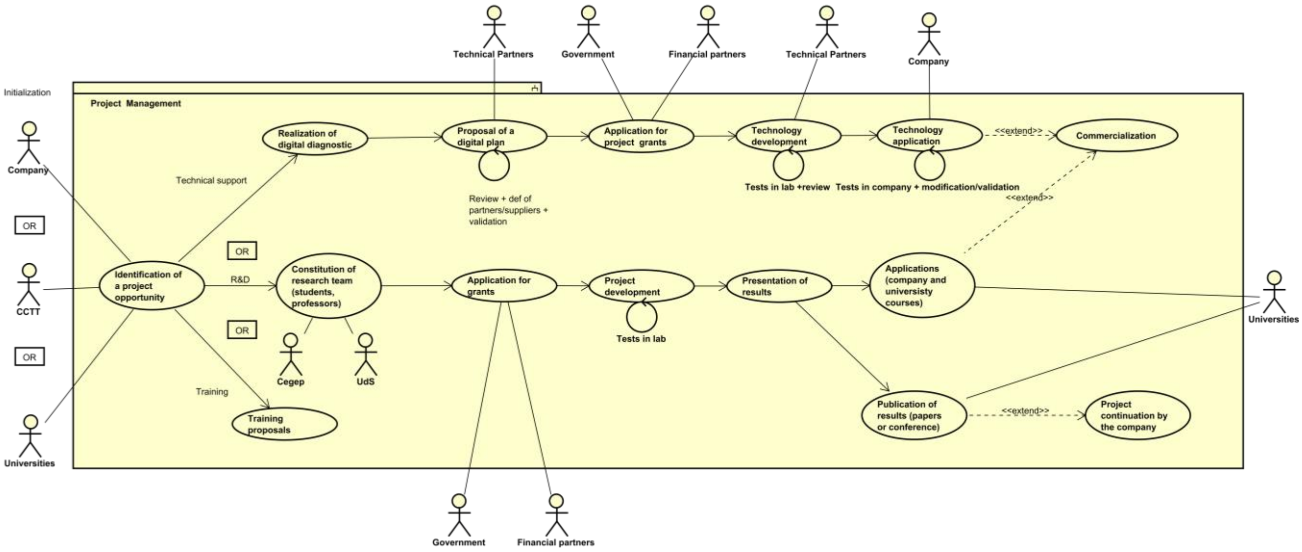

Figure 3. Use case Diagram.

KPI	Description
1	Number of full-time staff (professor-researchers in research projects)
2	Number of different people who are involved in the projects (full-time, part-time, intern, student, etc.)
3	Number of people from CCTT who are assigned to projects
4	Number of unpaid students (PFE)
5	Number of paid students (interns)
6	Number of university courses that integrate search results
7	Number of new university courses resulting from research results
8	Number of awareness events
10	Number of internal processes improved through innovation
11	Number of service offerings that were created thanks to innovation
12	Number of research grants (in monetary value)
13	Number of companies that have improved their processes through innovation
14	Number of documents generated internally during projects
15	Level of satisfaction of users of the documents produced on the projects
16	Number of documents produced for projects reused in other projects
17	Number of equipment involved in innovation projects
18	Quality level of the equipment implemented for the projects
19	Number of companies that have improved their processes through innovation

Table 2- Selected key performance indicators (KPI).

The results were presented to the legal guardians of the researched CCTT, who validated the information. From this, the project would proceed with new activities linked to modelling and simulation.

5 CONCLUSION

Understanding the operation of an IE is a topic of extreme importance. By developing a study that aims to identify the organizational specificities of TTOs, we offer insights on how to align the design of TTOs with the companies that make up the IE. This approach is a step towards a more comprehensive understanding of ecosystem governance and provides a point of view on collaborative enterprise network design.

The contribution of the research is centered on the approach applied in the study based on action research. An effective benchmarking was created, making it possible to explore the various layers of information on the role of the intermediary company in an IE. At the end of the development stage, it was possible to advance in the mapping of actors and operational management activities for an IE. By identifying the relationship between the actors, the operational proximity between the agents was established, as well as the set of KPIs that can help in the decision-making process.

Future work is expected to explore IE from the perspective of agent-based modelling and simulation, as it provides a way to design social systems consisting of agents interacting and influencing one another, learning from their experiences and adapting their behaviour accordingly. An agent-based model of an IE can adequately represent the emergent behaviour of innovation entities working in an innovation environment. Another possible approach would be to explore IE from the perspective of Systems Dynamics.

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