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Jude Onyekachi OZOR

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INNOVATION ECOSYSTEM: ORCHESTRATION OF COMPLEX RELATIONSHIPS AND IMPACT ON ADAPTIVE CAPACITY OF FIRMS

Directed by:

Professor RONDE Patrick	BETA, University of Strasbourg
Dr. BOYER James (co-supervisor)	LEM, HEMiSF4iRE, Catholic University of Lille

Reporters:

Professor VICENTE Jérôme	LEREPS, University of Toulouse
DR MATT Mireille	LISIS, INRAE, University of Marne La Vallée

Other members of the jury:

Professor BOCQUET Rachel	IREGE, University of Savoie Mont Blanc
Professor PENIN Julien	BETA, University of Strasbourg

Dedication

This PhD is dedicated to my son, Henry Chikanyima OZOR

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To GOD be the glory!

Strasbourg, November 2022
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Abstract

Today, regions and industries face increasing shocks arising from technological changes and global phenomena and therefore require adaptation processes. This thesis sheds light on the relevance of the innovation ecosystem as a new conceptual framework for public policies and economic actors in innovation processes that regularly face these shocks and aim to adapt. Innovation ecosystems as complex adaptive systems consider the dynamics of the innovation environment. This thesis studies to what extent ecosystems influence the adaptive capacity of firms and what are the properties and mechanisms of these ecosystems that explain their impact on the adaptive capacity of firms. This thesis explores innovation ecosystems within the Hauts-de-France region, their specificities and the orchestration of complex relationships between heterogeneous actors within the ecosystems. In addition, this thesis analyzes in depth an emblematic ecosystem of this region: the Eurasanté ecosystem (ecosystem around health and biotechnologies). It examines the middleground of the Eurasanté ecosystem to analyze how the relationships between different actors are orchestrated; and empirically tests the impact of the middleground on the technological development of firms. It further analyzes collaborative R&D projects as the most advanced relational component of the middleground to ascertain to what extent the underground influences the involvement of core actors in collaborative R&D projects. The results from econometric models show that firms belonging to local innovation ecosystems are both more innovative and more technologically diversified, and therefore, are more adaptive. The thesis shows that the middleground plays an important role in the orchestration of relations between heterogeneous actors, allows knowledge exchange between formal and informal actors and impacts on the technological development of firms. Finally, the study reveals that beyond the type of project, geographical proximity, the presence of start-ups, actors from the underground, plays a decisive role in the involvement of core actors in collaborative projects. This thesis therefore contributes to a better understanding of the construct or framework of innovation ecosystem that can be adopted to improve the adaptability of firms. Innovation-base policies and the collective strategies of economic actors should focus on promoting the construct of innovation ecosystem in order to stimulate firm adaptation and enhance territorial dynamics. Finally, this thesis fills the gap in the literature, providing empirical evidences on innovation ecosystem and their role in adaptation of firms.

Keywords: Innovation ecosystem; middleground; Hauts-de-France; adaptive capacity

Résumé

Aujourd'hui, les régions et les industries sont confrontées à des chocs croissants découlant des changements technologiques et des phénomènes mondiaux et nécessitent donc des processus d'adaptation. Cette thèse met en lumière la pertinence de l'écosystème d'innovation en tant que nouveau cadre conceptuel pour les politiques publiques et les acteurs économiques engagés dans des processus d’innovation qui font face régulièrement à ces chocs. Les écosystèmes d’innovation en tant que Systèmes Complexes adaptatifs tiennent compte de la dynamique de l'environnement de l'innovation. Cette thèse étudie dans quelle mesure les écosystèmes influence la capacité d’adaptation des entreprises et quelles sont les propriétés et mécanismes de ces écosystèmes qui expliquent leur impact sur la capacité adaptative des entreprises. Cette thèse mobilise les écosystèmes d'innovation au sein de la région Hauts-de-France, leurs spécificités et l’orchestration des relations complexes entre acteurs hétérogènes au sein de ces écosystèmes. De plus, cette thèse analyse de manière plus approfondie un écosystème emblématique de cette région : l’écosystème d’Eurasanté (écosystème autour de la santé et des biotechnologies). Premièrement, elle examine le *middleground* de l'écosystème Eurasanté pour analyser la façon dont les relations entre différents acteurs sont orchestrées ; et teste empiriquement l'impact du *middleground* sur le développement technologique des entreprises. Deuxièmement, elle analyse les projets de R&D collaboratifs en tant que la composante relationnelle la plus avancée du *middleground* pour déterminer les facteurs qui influencent l’implication des *Core actors* dans ces projets de R&D collaboratifs. Les résultats issus de modèles économétriques montrent que les entreprises évoluant au sein des écosystèmes locaux d'innovation sont à la fois plus performantes en termes d’innovation et plus diversifiées sur le plan technologique, et donc ont une plus grande capacité adaptative. Nos analyses montrent que le *middleground* joue un rôle important dans l’orchestration des relations entre acteurs hétérogènes, l'échange de connaissances entre les acteurs formels et informels et le développement technologique des entreprises. Enfin, l'étude révèle qu’au-delà du type de projet, de la proximité géographique, la présence des start-ups, acteurs provenant de l’underground, joue un rôle déterminant dans l’implication des *core actors* dans les projets collaboratifs. Cette thèse contribue donc à une meilleure compréhension de la construction du cadre conceptuel des écosystèmes d'innovation qui peut être adopté pour améliorer l'adaptabilité des entreprises. Les politiques basées sur l'innovation et les stratégies collectives des acteurs économiques devraient se concentrer sur la promotion du concept d'écosystème d'innovation afin de stimuler l'adaptation des entreprises et dynamiser les territoires. Enfin, cette thèse comble un vide dans la littérature, en fournissant des démonstrations empiriques sur les écosystèmes d'innovation et leur rôle dans l'adaptation des entreprises.

Mots-clés : Ecosystème d'innovation ; middleground ; Hauts-de-France ; capacité d'adaptation

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Chapter 1: Introduction

1.1 Background of the study

The constant changes in innovation environment in the past couple of years have challenged economic development models, especially business models and how businesses or firms operate to remain competitive. The Hyper-competition and globalisation entail a decrease in lifecycle of innovation and technologies and high velocity markets. These changes range from technological changes or digital evolution, increased complexity in business environment and changes in climate condition. For example, the transition to digitization of technology and Internet of Things (IoT) require firms to adapt their capability and strategy (Yoo et al., 2010). Similarly, changes in climate conditions are sources of uncertainty, imposing high cost on firms and organizations and require firms to adapt (Linnenluecke et al., 2013; Winn et al., 2011). Firm's inability to adapt to these changes has resulted in dramatic decline in firms expected lifetime and/or huge losses (Dervitsiotis, 2011). Firms lose the competitiveness over time with deep economic crisis or continuous changes. As a result of these challenges, firms face different obstacles and difficulties including sourcing resources to promote innovation. Therefore, in a context of uncertainties and accelerating transformations, it becomes crucial for firms to enhance their adaptive capability to survive.

Adaptation refers to the adjustment in processes, capabilities or strategies in response to ecological, social, economic, technological or market changes. Adaptive capacity of firms implies the capacity of firms to combine capabilities to respond to the effects of these changes to face market dynamics. Adaptation in a resource-based perspective entails the combining of complementary resources to facilitate the development and commercialization of new technology (Barney et al., 2001), and these resources can be sourced internally through acquisition of new human capital or externally through collaborative arrangements (Eggers and Park, 2018). Above of all, innovation has been widely acknowledged as key to driving economic development and the means to adapt to market and technological changes (Geels, 2002; Rothaermel, 2008; Schmitz & Strambach, 2009).

1.1.1 Innovation as driver of adaptation

Drucker (1985) explains that economies are in the era of discontinuity, complexities and uncertainties and identifies innovation as a unique means of survival. Other scholars have noted that innovation is a key competence necessary for adaptation and survival (Hamel, 2007; Gupta et al., 2007). Innovation improves firms' dynamics and enhances their ability to adapt to changes in the competitive environment. Firms require dynamic capabilities not only to enhance competitive advantage but also to adapt to rapid technological changes (Teece, 2007). Dynamic capabilities allow firms to identify and seize opportunities and combine or reconfigure their tangible and intangible assets.

Aside innovation, firm's adaptation has been theorized in different perspective, suggesting strategies for adaptation. For example, transaction cost theory suggests that cost efficiency in both internal and external transactions can enhance firm adaptation (Williamson, 1975). Similarly, resource dependency theory posits that organizational adaptation comes from coalitions to harness resources for survival (Pfeffer and Pfeffer, 1981). In the learning theory, adaptation is an outcome of learning. In this context, learning implies acquisition and application of new knowledge in the organization's routines and decision-making processes (Miller, 1996). However, empirical studies reveal that innovation contributes significantly to the adaptation and survival of firms by offering new growth opportunities (Audretsch, 1995; Archibugi and Pianta, 1996).

Innovation in traditional "Schumpeterian" model takes a linear process, where innovation flows linearly from basic research to applied research and product development (Fischer, 1999; Halvorsen and Lacave, 1998). This model however suffers criticisms with the argument that innovation process does not have to start from the academia but can as well originate from the markets (Halvorsen and Lacave, 1998). Similarly, modern innovation models acknowledge that innovation process is systemic and complex and is best generated in inter-firm relations and interactions (eg. Isckia and Lescop, 2009; Chesbrough, 2003; Baldwin and Von Hippel, 2011)

The changes in innovation environment are systemic and cut across the economy and influence all actors including business firms and organizations and traditional linear model of innovation is limited in providing solutions. The systemic changes pose tremendous challenges to firms and organizations as they strive to manage and cope with them. Similarly, scholars within innovation domain today challenge the traditional, vertically integrated model and the concept of innovation being produced and commercialized within a single firm (Adner and Kapoor, 2010; Fjeldstad, et al., 2012; Iansiti and Levien, 2004; Jacobides, 2005) and favour openness in innovation process, involving many actors (Adner, 2006; Chesbrough, 2003; von Hippel, 2005). The Schumpeter (1948) model of lone organization innovation with its associated benefits is not sufficient to address adaptation to changes in market and technological environment (eg Kolloch and Dellermann, 2018). This has led to openness in innovation process that requires firm to interact with other firms and the firm's environment dynamics (Chesbrough, 2006a; Adner and Kapoor, 2010; Battistella et al., 2013). Increasing studies show that innovation is better created in a network of producers, users, complementors or other heterogenous actors (Adner, 2006; Moore, 1993). This has created opportunities for the development of new interactive models or approaches.

Some scholars also acknowledge the role of knowledge in the innovation process and the importance of collective learning processes in the production and diffusion of knowledge (eg Lundvall, 2007; Jensen et al., 2007). Knowledge that drives innovation goes beyond that which is generated from formal scientific system to include collective learning process, arising from interactions of actors and institutions. This stresses that innovation comes from interactive learning processes. The systemic view arises from the notion that organizational innovation development depends on the quality of the system and the subsystem in which the organization operates (Dosi, 1988; Kline and Rosenberg, 1986; OECD, 1992; Smith, 1994). Inspired by these works, European policy makers adopted RIS3 – Research and Innovation Strategy for Smart Specialization, in line with European Parliament Council Regulation of 2013 (Nunes and Lopes, 2015). This strategy aims at transforming the EU into a smart and sustainable economy.

1.1.2. Adaptation of actors: The need of an Innovation ecosystem approach?

Innovation research abounds that shows how innovation is successfully created and diffused in a strategic and interactive environment, and this has led to different innovation approaches in the recent past. The approaches for example include clusters (Porter, 1998), innovation system (Freeman, 1987; Lundvall, 1992) and innovation ecosystem (Adner, 2006). Clusters and innovation system have been widely adopted in many economies since their introduction.

Clusters as traditional approach, emphasizes on localization economies and competitive advantage derived when related firms are localized in a geographical area. Porter (1998) defines clusters as a geographically agglomeration of related firms who compete and cooperate to improve productivity and innovation. This framework gained importance among scholars in management and innovation studies as it generates positive effects and increases regional competitiveness (McPhillips, 2020). Works on clusters have promoted the development and implementation of cluster policies. For example, the *grappe* *industrielle* in Canada, the Business Clusters in the United States and the United Kingdom and the *Pôles de compétitivités* (Competitiveness clusters) in France.

Freeman (1987) and Lundvall (1992) present innovation system as system of public and private organizations and institutions that interact to generate and diffuse knowledge and produce new technology. Innovation system entails the set of organizations and institutions whose interactions influence innovative performance (Mercan and Goktas, 2011). Two main perspectives coexist in Innovation system literature: a political-administrative perspective and a topological perspective (Touzard et al., 2015). The first refers to institutions, organizations and networks that promote the production of new knowledge and innovation in a sector (sectoral innovation system) (Malerba, 2002) or institutions, organizations and elements common to all sectors within either the same country (National Innovation Systems) (Lundvall, 2010) or the same region (Regional Innovation Systems) (Cooke and Morgan, 1994). The second perspective is more topological and refers to a system built by the interactions between actors or firms around the development of a technology. This is the case of "Technological Systems" which makes it possible to take into account interactions between institutions, organizations and firms beyond the established political-administrative frameworks (Carlsson, 2012).

In the literature, clusters studies have shown the positive effects of clusters on innovation performance of firms (eg Baptista and Swann, 1998; Boix and Galletto, 2009; Beaundry and Breschi, 2003). Arguably, the positive effects of Clusters on firm's innovation performance comes from specialized markets and availability of skill in agglomerations (Boix and Galletto, 2009; Porter, 1998).

However, despite the benefits associated with clusters, ranging from specialization and co-location influence on innovative performance (Hervas-Oliver et al., 2018; Porter, 1990) to economies of scale, low transaction cost and transfer of technologies effect on innovative potentials (Fløysand and Jakobsen, 2001; Molina-Morales and Exposito-Langa, 2012; Porter, 1990), it is argued that during crises and uncertainties, the benefits of clusters are threatened. For example, specialization predisposes clustering to vulnerability to crises and hinders adaptation to economic and technological challenges (Bishop, 2019). Steiner (1998) notes that today's cluster-specialized regions will be the problem areas of tomorrow. This highlights the fact that despite the gains and efficiency in specialization, it faces risks during uncertainties. Specialization locks a region into a specific trajectory and reduces adaptability (Boschma, 2015). In fact, Zucchella (2006) explains that clusters suffer lack of mechanisms to overcome lock-in situation, and institutional and structural rigidity. Traditional clusters approach has been adopted as useful strategy to enhance competitiveness. Empirical and theoretical studies however have failed to explain how existing clusters facilitate sustainable transition and affect firm adaptation when shocks occur (Bergman, 2008; Saxenian, 1996). The decline of clusters indicates that the economic advantages from cluster dynamics are not permanent as cluster lifecycle is related to the respective technological specialization or technological regime (Zucchella, 2006).

Similarly, it is argued that innovation system is a more static structure (Smorodinskaya et al., 2017) and adopts government-centric innovation process, such that government policies determine development of innovation (Schot and Steinmueller, 2016; Amitrano et al., 2018). It is further argued that the static nature of innovation system fails to incorporate the dynamisms in innovation and is unable to stand a strong private-centric economic system (eg; Cooke, 2001; Mercan and Goktas, 2011). Saxenian (1994) explained why Route 128 in Massachusetts declined in the 90s despite similar histories and technologies with Silicon Valley, which flourished, is due to institutional and structural rigidity, independent, self-sufficient and hierarchical corporations. This means that without regeneration mechanisms, lock-in and institutional and structural rigidity could turn into a trap that prevents cluster renewal as well as innovation system dynamics (Boyer, 2020).

One of the main interests of ecosystem research is on how firms cope and adapt (Adner, 2017; Kapoor, 2018). This is of special interest as firms face various shocks and their ability to adapt to these shocks becomes necessary. These shocks could come from changes in technologies and market, regulatory changes or exogenous shocks (such as Covid 19/global shocks).

From a theoretical perspective, the main idea is that innovation ecosystem is seen as a dynamic system characterized by heterogeneous actors with diverse capabilities and complex interactions (Huang et al., 2020; Ritala and Almpanopoulou, 2017). Therefore, embedding in innovation ecosystem, firms tap into the diversity of resources and cross-sectoral structures to recombine resources to chart new paths (eg Maskelll and Malmberg, 1999; Baldwin and Clark, 2000; Ganco, 2013) and enhance both flexibility (eg. Fernández-Esquinas and Ramos-Vielba, 2011; Hassink, 2010; Boschma, 2015) and performance (eg Chesbrough, 2006; Cortright, 2006; Frost, 2001; Rosenfeld, 1997).

From a policy perspective in innovation policies, there is a progressive shift towards innovation ecosystem framework. In France, for instance, the competitiveness clusters (*Pôles de compétitivités)* initiative aims to strengthen competitiveness of economy and foster innovation through synergies between research institutes, firms and organizations within a given geographical space. This initiative evolves in phases. The first phase (2005-2008) targets the structuring of the clusters. At the end, evaluation to ascertain the robustness of the innovation capabilities of the clusters shows however that subsidies on R&D projects discouraged companies' own investment on R&D. Thus, there is lack on knock-on effect of the competitiveness clusters policy on R&D spending (Haithem, 2020).

To avoid lock-in phenomena, the second phase of this policy aims to strengthen the inter-clusters collaboration[1] and to support R&D projects to boost innovative capability and competitiveness of firms. During this phase, the self-financed R&D spending of companies rose, showing a positive leverage effect on private R&D spending.

With the objective to enable clusters drive the future and create synergies around collaborative R&D projects, a new shift becomes imperatives to ensure excellence in high potential sectors for the future and facilitate improved market variables. Public policy actions now aim to orient the region's economic activities towards specific technological fields promoting inter-clusters initiatives.

Similarly, innovation ecosystem concept is gaining ground in France as well as in some innovative countries. For example, US council on competitiveness (2010) advocates for National Innovation Ecosystem in place of National innovation system. Other countries such as China, Finland, Denmark, Korea etc. also base their technology policy on the concept of innovation ecosystem to accelerate innovation and sustainability (Bramwell et al., 2012).

It is against this backdrop that the central objective of this thesis is to assess how innovation ecosystem impact firm's adaptive capability, especially as they face constant shocks.

1 Étude portant sur l'évaluation des pôles de compétitivité », Rapport pour la DGCIS et la DATAR, Erdyn, Technopolis et Bearing Point, 2012

1.2 Research Problem

In the face of shocks, policy makers and economic actors need new tools and methodological frameworks to address the issue of resilience and adaptation. The construct of innovation ecosystems is emerging as an effective way to implement innovation with a view to addressing both competitiveness and adaptability.

Today, there is a growing interest in the construct of innovation ecosystems both within the scientific community in economics and innovation management, and among policy makers and business practitioners (de Vasconcelos Gomes et al., 2018; Kapoor, 2018). Most of the major journals in economics and innovation management have launched calls for papers on innovation ecosystems over the last ten years (eg. Research Policy; Technological forecasting and Social Change; Technovation; Journal of Technology Transfer; Industry and Innovation).

In fact, the notion of innovation ecosystems is now found in the agendas of national and international policies such as the US Council on Competitiveness (2010) which proposed to develop the concept of National Innovation Ecosystem (NIES); the Structure Council industry in Japan, which proposed to switch from a technological policy to innovation policy based on the construct of ecosystem. In Europe, the new European Union program for research and innovation, Horizon Europe which will run from 2021 to 2027, includes a section dedicated to innovation ecosystems. The aim of this section is to connect all the actors - public and private, national and local - in Europe in order to share best practices and resources and to offer the possibility to all European innovators to develop and deploy their products in a level playing ground.

However, despite this enthusiasm for innovation ecosystems, it is imperative to ask if innovation ecosystem really allows firms to better adapt to various market and technological changes?

Some critics have however questioned the usefulness of this concept. For example, some base the criticism on the fact that the promotion of complex relationships and interactions between various actors in innovation processes is not specific to the concept of innovation ecosystems and therefore question the distinctive contribution of innovation ecosystem concept. The second category of criticism concerns the orchestration of these complex relationships. While the work on platform-based ecosystem clearly and very precisely identifies the digital platform as the entity that orchestrates the relationships between the company that owns the platform and the applications and companies that are interwoven or attached to this platform, there is no consensus in the work on ecosystems anchored within territories. Others argue that there is lack of 'meta-level' methodological approach to match the theoretical postulations of ecosystem such as co-evolution and adaptation (e.g. Adner and Kapoor, 2010).

Oh et al. (2016) argue that the innovation ecosystem adds little or no value and does not lead to useful knowledge production. It is however acknowledged that the innovation ecosystem makes a useful contribution to the conceptualisation of innovation and innovation strategy, but instead call for more conceptual and empirical rigour (Ritala and Almpanopoulou, 2017), as it provides a less mechanistic approach necessary for the adaptability and resilience of economies in a context of high uncertainty (OECD, 2015).

The criticisms however form a bedrock for more robust conceptual and theoretical background on the concept and call for a more concrete operationalisation of the concept among scientists in order to better equip policy makers and practitioners in their innovation policies and strategies. In fact, the lack of empirical works and evidences that validate the ontological hypotheses carried by innovation ecosystems creates the biggest gap for this concept.

This thesis therefore provides empirical evidences on innovation ecosystem. First, it highlights the distinct characteristics of innovation ecosystem and tests the impact of local innovation ecosystem on adaptive capacity of firms. The thesis, further provides theoretical and empirical evidence on what makes firms in innovation ecosystem more adaptive than others.

The thesis therefore aims to clarify some of the added-value that the relatively new concept of innovation ecosystem provides to the literature on innovation studies. The findings of the thesis will guide recommendations to both policy makers and other economic actors in their innovation strategies.

1.3 Research Question

Filling all of the gaps in the ecosystem literature as highlighted above is well beyond the scope of a thesis and requires years of work and research.

However, the problematic of this thesis is structured around this following research question:

RQ: To what extent do innovation ecosystems affect the adaptive capacity of firms?

This main question refers to the notion of ecosystems itself as dynamic system characterized by diversity of actors and complexity of interaction (Ritala and Almpanopoulou, 2017; Russel and Smorodinskaya, 2018) and linked to adaptability (Boschma, 2015; Hassink et al., 2010). Consequently, if we consider Innovation Ecosystem as a Complex Adaptive System, this implies that the ecosystem fosters adaptation of actors in order to deal with exogenous or internal shocks.

In line with this view, this thesis aims to test the impact of belonging to innovation ecosystem on adaptive capacity of firms. That means to compare adaptive capacity of firms belonging to Innovation ecosystem and firms that do not belong to innovation ecosystem. However, this demonstration is not sufficient to ascertain the impact of innovation ecosystem on adaptive capacity of firm. It is also important to analyze which mechanisms and features or properties of innovation ecosystem that could explain the positive role of innovation ecosystem on adaptive capacity of firms. This thesis therefore analyzes the organizational structure of innovation ecosystem at regional and local level and the main mechanisms of ecosystem that could explain to what extent the ecosystem impacts the adaptive capacity of firms.

To answer this question, the thesis mobilizes a relevant field of study - the Hauts-de-France region which is confronted with problems of adaptation and resilience, having faced successive declines in its main economic industries, where local innovation ecosystems were instrumental (see chapter 3, section 3.2).

1.4 Organization and Structure of the Thesis

The thesis is organized as follows:

Chapter 1 presents the background and motivation for the research. It identifies the research problem and objectives and outlines the research questions. It also highlights the relevance and importance of the study.

Chapter 2 provides the theoretical background of the study, reviewing the definitions of innovation ecosystem and main streams of ecosystem in the literature. The chapter further reviews the sources of adaptability in relation to innovation ecosystem. It provides the theoretical bases for linking innovation ecosystem to adaptation of the ecosystem actors and specifically position the conceptualization of innovation ecosystem adopted in the thesis.

Chapter 3 introduces the research design and methodology. The chapter presents the local innovation ecosystems in Hauts-de-France region. The research methods adopted in the thesis is presented and finally it describes the data and data sources.

Chapter 4 presents the three papers, which are sub-studies of the thesis.

The first paper (Sub-study 1, published in *Industry and Innovation Journal*) addresses the following research question: *To what extent do innovation ecosystems affect the adaptive capacity of firms?* This paper aims to test whether firms that are part of innovation ecosystem are more adaptive than those that are not and to what extent.

The second paper (sub-study 2) addresses the question about what makes firms more adaptive in ecosystem by focusing on the organizational structure of the local/regional ecosystem based on the upperground, underground and middleground perspective (Cohendet et al., 2020). The specific question discussed in this paper is as follows: *To what extent does the middleground involve in the orchestration of complex relationships within innovation ecosystem and impact technological development of firms?*

The third paper is a working paper, which is an extension of the second level of analysis on what makes firms more adaptive in ecosystem. It focuses rather on one main mechanism: collaborative innovation project. As interaction is mainly studied using collaboration between actors partnering in an inter-organizational network (eg. Bernela and Levy, 2017), collaborative R&D project is one of the mechanisms that facilitate interaction between actors in the innovation ecosystem. While the kind of exchange in collaborative R&D project influences knowledge creation in local innovation ecosystem, the kind of partners could also tell about knowledge sharing and learning mechanisms that drive adaptation processes. Therefore, this third paper addresses the question of the linkages between the project characteristics and the actors' characteristics in order to deduce some specificities of knowledge exchanges and firm's adaptability. As noted, adaptation within the ecosystem depends on the ongoing interactions between actors in the upperground and in the underground (Cohendet et al., 2020). Core actors, the most active among actors in the upperground in collaborative projects with rich connections, tend to absorb the most knowledge in collaborative R&D project. Therefore, the specific research question is as follows: *What explains the involvement of core actors in collaborative innovation project in a local innovation ecosystem*? This sub-study aims to test if the presence of actors in the underground and the geography proximity are among the main factors that motivate the core actors (actor with exploitative capacity) in the ecosystem to involve in collaborative innovation projects.

Chapters 5 presents the discussions and conclusions, and further provides implications of the study and recommendations for future research.

Chapter 2: Literature Review

2.1 Introduction

This chapter presents the extant critical review of literature on innovation ecosystem, reviewing the main approaches to ecosystem and definitions of innovation ecosystem in the literature. The chapter further reviews the sources of adaptation in relation to innovation ecosystem.

Thus, the chapter is divided into two broad areas: the first part critically reviews and presents the main streams of ecosystem and the definitions of innovation ecosystem.

Part two on the other hand, presents the ambidexterity of innovation ecosystem as the source of adaptability and the role of the middleground in local innovation ecosystem. It identifies the characteristics of innovation ecosystem as sources of adaptation capability of innovation ecosystem actors and specifically positions the conceptualization of innovation ecosystem adopted in this thesis.

2.2 The ecosystem approach in economic and management studies

The concept of innovation ecosystem as first introduced by Adner (2006) in a Harvard Business review article takes its foundation from Business ecosystem concept by Moore (1993). In general, the concept of ecosystem in economic and management studies is a metaphor borrowed from the life sciences. It is inspired by the idea of complex relationships within the biocenosis and between it and the biotope. The biocenosis is made up of 'all living beings coexisting and coevolving in a given ecological space'. The biotope corresponds to a biological environment with homogeneous living conditions. The term ecosystem was used for the first time in 1935 by Arthur George Tansley, who defined it as "an ensemble constructed by the relationships between living species (biocenosis) and the physical habitat (biotope) that allows them to develop". (Tansley, 1935, p.299). The concept of ecosystem carries in its DNA the question of complex relationships, interdependence or complementarity, coevolution of actors and the question of adaptation.

Three main streams structure the literature on ecosystems: business ecosystem, entrepreneurial ecosystem and innovation ecosystem.

2.2.1 Business ecosystem

The business ecosystem is the seminal concept proposed by Moore (1993). According to Moore, *'In a business ecosystem, companies coevolve capabilities around a new innovation: they work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations'* (Moore, 1993, p.76). In Moore's view, business ecosystem includes the producers, the customers, the suppliers, the competitors and other stakeholders. Drawing from Moore's definition, Iansiti and Levien (2004) view the business ecosystem as a large number of loosely interconnected participants who rely on one another for their effectiveness and survival and share common fate. Iansiti and Levien (2004) identify the features of business ecosystem to include fragmentation, interconnectedness, cooperation and competition. Ecosystem thrives through adaptation and the internal dynamics that regenerates interaction between the ecosystem actors and the environment (Mercan and Goktas, 2011).

Iansiti and Levien (2004) explain the success mechanisms of business ecosystem. For example, the success of a business ecosystem is centered on its productivity, robustness and ability to create niches. Productivity refers to the ability to efficiently transform technology and other raw materials into a new product or service. Productivity in ecosystem can be measured by three factors – the factor productivity, change in productivity over time and innovation delivery. Robustness on the other hand, indicates the capability to withstand and survive disruptions including unforeseen technological and market changes. Niche creation requires the ability to ensure the growth of new firm variety and product variety.

Discussing the significance of business ecosystem, Iansiti and Levien (2004) identify the roles of different actors. Actors in business ecosystem play different roles ranging from keystone, niche actors, dominators and hub landlords. The keystone actor in a business ecosystem plays a leadership role with strong influence in the co-evolutionary process and constitute small number in the ecosystem. This concept is a metaphor of keystone species in a biological ecosystem. The Niche actors develop specialized capabilities to add value to the ecosystem and represent the large number in the ecosystem. The dominators control a large part of the network and seize larger part of the value and the hub landlords draw as much value as possible from its network without directly controlling it. It is the keystone and the niche players that contribute more to the success and sustainability of business ecosystem (Iansiti and Levien, 2004). Similarly, Gawer and Cusumano (2002) talked about platform in business ecosystem to refer to technologies that provide the foundation upon which users and complementors develop their products or services.

Business ecosystem however is more dedicated to business development for value capture, shaping the commercialization and value chain process. It allows business actors to coordinate various partners and their resources for effective commercialization and delivery of specific products and services. Highlighting the role of focal firm or platform in the orchestration of relationships in business ecosystem, Autio and Thomas (2014) asserts that interconnected organizations center around a focal organization or platform that incorporates different participants that focus on the development of new value through innovation. Ecosystem from the network management perspective focuses on management and coordination within the network. It introduces the notion of focal or hub firm as coordinating firm, providing various control and coordination that ensures performance and value capture in the ecosystem.

Table 1 summarizes the differences and common points between three main streams of the ecosystem in terms of main focus and interest, their network and main actors.

Considering the key features of business ecosystem, the main interest of business ecosystem is value capture through collaboration and competition. It aims to use a strategic collaborative arrangement to create new customer offerings and gain competitive advantage. The large companies (keystone or hub firm) induce or create connections that attract other actors such as customers, suppliers, consumers etc.

The network in business ecosystem is global competition and collaboration and synergy. It depicts 'the global network and ecosystem within which the firm competes' (Zahra and Nambisan, 2012, p. 219).

The main actors or characters in business ecosystem are the leading companies, who create or develop the ecosystem and utilize the external resources through co-opetition. In business ecosystem the actors work or operate around the leader firm or focal firm or are coordinated around a platform.

2.2.2 Entrepreneurial ecosystem

The concept of entrepreneurial ecosystem emerged from the works of Isenberg (2010) and book of Feld (2012) on *start-up communities*. The popularity arises from the growing interest on a more systemic approach to improving entrepreneurial growth; on a more holistic focus on building synergies and aligning priorities (eg Rodriguez-Pose, 2013; Warwick, 2013); and the central idea that local context can have a significant impact on entrepreneurial processes (O'Connor et al., 2018). For Mason and Brown, Entrepreneurial ecosystem refers to '*a set of interconnected entrepreneurial actors that formally and informally coalesce to connect, mediate and govern the performance within the local entrepreneurial environment*' (Mason and Brown, 2013, p5). There are differences and similarities between entrepreneurial ecosystem and business ecosystem concepts (O'Connor et al., 2018). Entrepreneurial ecosystem focuses on the entrepreneurs and the cultures, institutions and networks within a given locality. Entrepreneurial ecosystem approach centers on entrepreneurial individuals, start-ups and entrepreneurs, rather than firms or industries and the role of social and economic context influencing the entrepreneurial processes (Stam and Spigel, 2016; O'Connor et al., 2018). It sees entrepreneurship not only as outcome of a system but also as key actor in the creation and sustenance of the system (Feldman, 2014). Mason and Brown (2013) noted that Entrepreneurial ecosystems are geographically bounded but not confined to a specific geographical scale and can be industry-specific or may evolve to include other industries. Table 1 highlights key features of entrepreneurial ecosystem in relation to other ecosystem streams. The main focus of entrepreneurial ecosystem is to foster the interconnection of entrepreneurial actors to advance new entrepreneurship, high growth firms, rapid job creation and long-term productivity (Isenberg, 2010). The interaction in entrepreneurial ecosystem is local and geographically bounded (Mason and Brown, 2013). The necessary resources for the entrepreneurial success are embedded in a geographical region (Neck et al., 2004) and the stakeholders are likely to be local and embedded to a local area (Mason and Brown, 2013). Region can create conditions for the emergence and survival of entrepreneurial ecosystem. The main actors in entrepreneurial ecosystem include entrepreneurs, start-ups, funding organizations, large firms and infrastructures or environment that foster the actors' interaction. The presence of large companies and collaborative tendencies helps the entrepreneurial ecosystem to flourish (Isenberg, 2013).

Apart from the common feature of collaboration among the three main streams of ecosystem, Entrepreneurial ecosystem and business ecosystem share some other similarities. The large or well-developed companies in Entrepreneurial ecosystem play a similar role of keystone or focal firm in business ecosystem, as they contribute in steering the ecosystem, providing space and resources that enhances the development of start-ups and companies.

2.2.3 The innovation ecosystem concept: Main definition and meaning

The Innovation Ecosystem concept was introduced by Adner (2006) who defines it as 'the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution' (Adner, 2006, p.2). Many definitions of innovation ecosystem concept in the literature draw insight from Adner's and center and revolve around collaborations and interdependences of diverse actors to accelerate technological development and innovation. Among many definitions of innovation ecosystem, Jackson (2011) asserts that Innovation ecosystem models a complex relationship between actors and entities with the functional goal of technology development and innovation. In Mulas et al. (2016), innovation ecosystem is a synergistic relationship between actors/agents that facilitates both the generation of innovative ideas and its commercialization. For Frenkel and Maital (2014), Innovation ecosystem links multiple innovation actors to create a conducive environment for synergy among the innovators. Mercan and Göktaş (2011) include both economic and non-economic agents in their definition. For them, Innovation ecosystem does not only involve interaction between economic agents but also involve non-economic agents such as technology, institutions, cultural and sociological interactions. The actors in innovation ecosystem are diverse and include both the material resources (facilities, equipment) and the human resources (researchers, workers) and their organizations such as the universities, research institutes, firms and other organizations; and comprises two specific entities – the research economy and the commercial economy (Jackson, 2011).

Some scholars view innovation ecosystem with complex system lens and define Innovation ecosystem as a complex adaptive system, characterized by interconnectedness and complex relationship between heterogenous actors with various motivations and capabilities for development of innovation processes and technological development (Huang et al., 2020; Peltoniemi and Vuori, 2004; Ritala and Almpanopoulou, 2017). The heterogenous actors comprise both actors in the upstream and downstream who interact; and with top-down and bottom-up initiatives in the innovation development processes. The evolving set of actors, activities and artifacts and the relations in innovation ecosystem are necessary for innovative performance of participating actors (Granstrand and Holgersson, 2020). Some scholars argue for inclusion of artifacts, such as products and services and technologies; and competition/substitutes in the definition of innovation ecosystem. They assert that these components allow innovation ecosystem to effectively reflect the biological ecosystem which is characterized by different species who compete for resources and upon which innovation ecosystem draws its inspiration (eg Granstrand and Holgerson, 2020; Shaw and Allen, 2018).

Innovative outcomes are best produced through voluntary interaction among the multi-faceted actors. The interaction includes not only collaborating but also competing actors (eg Gawer, 2014; Rohrbeck et al., 2009)

The ecosystem thinking expands the capabilities of a particular actor beyond its boundaries and includes innovation that arises from knowledge transfer in collaboration. Innovation ecosystem becomes a core element in the firms' strategy for innovation performance and growth.

The essence of interaction in driving innovation abound in the literature (Astley, 1984; Lawrence et al., 2002; Powell and Grodal, 2005). For example, firms search for new knowledge both within and outside the organization for effective creation of innovation and competitiveness (Chesbrough, 2003). Collaboration in a network provides the entities with effectiveness in collective creation of innovation (Powell and Grodal, 2005). Collaboration entails interactive participation and exchange of ideas between partnering entities with the collective objective to co-create innovation (WEF, 2013). From value creation perspective, innovation ecosystem emphasizes the non-linearity and iteration process in network, and identifies network externalities and complementarity as mechanism driving value co-creation (Autio and Thomas, 2014). This perspective recognizes the importance of horizontal linkage between actors in the innovation ecosystem.

Through collaboration, the participating entities share and exchange resources, ideas, knowledge, responsibility and risks to be more disposed to collectively face continuous global competition (Astley, 1984; Lawrence et al., 2002). It is however argued that some collaborations fail to produce innovative potentials or generate collective benefits (Gray, 1989; Huxham, 1996; Lawrence et al., 2002), and high interdependence hinders adaptability to changing environments (Levinthal, 1997; Siggelkow, 2002). In response, other scholars argue that it happens only when there is lack of exchange of information and ideas in collaboration (Carlsson and Jacobsson, 1997). Similarly, a well-utilized interdependence enables the firms take advantage and optimize their position and enhance performance (Adner and Kapoor, 2010; Hannah and Eisenhadt, 2018). Others believe that a coevolutionary interactions that are specific, reciprocal and simultaneous in nature necessitates co-creation of value and sustainability (Abatecola et al., 2020; Breslin et al., 2021; Janzen, 1980).

Innovation ecosystem therefore is a form of collaborative network with mutually committed participants and higher level of integration of heterogenous actors in terms of share of information, responsibilities and risks with joint identity, strategy and goal (Russell and Smorodinskaya, 2018). The work of Saxenian (1994) enables innovation ecosystem to be viewed in regional dimension. Saxenian (1994) highlights the key role of geographical proximity and interaction between actors and institutions in the regional performance, and identifies that the core of performance of Silicon Valley over Route 128 comes from their network-based interaction.

The main focus of innovation ecosystem is value co-creation through complex relationships between diversity of actors rather than value capture in business ecosystem (see table 1). In Innovation ecosystem, the collaborative arrangements allow firms to combine their individual offerings into a coherent alignment of assets and resources through joint initiatives to co-create value (Adner, 2017).

Innovation ecosystem integrates the two mechanisms of exploration and exploitation. Thus, the main actors in innovation ecosystem include research organizations, small and large companies, financial organizations and individual actors (communities). Thus, the three ecosystem streams share common features of collaboration and interdependence at varied levels. The interdependence in business and entrepreneurial ecosystems is determined by a given technology or platform and entrepreneurial processes, respectively. In innovation ecosystem, this is not dependent on any hierarchical mechanism.

Our thesis relies on the innovation ecosystem stream, because we believe this stream helps to better address our research problem (see section 2.5).

Innovation ecosystem adds value and addresses some inherent limitations of other traditional concepts. For example, the main characteristics of clusters include – specialization, proximity and synergy. Specialization entails division of labour and proximity encourages the linkage of the related firms to form synergy. Thus, synergy effects of clusters enhance competitiveness of both participants and the territory (Bode et al., 2010; Ketels, 2012).

However, despite the recommendations for clusters approach and adoption in many economic contexts to address competitiveness, it is criticized for being too generic and vogue (eg Martin and Sunley, 2003). From ecological and sustainability perspective, there is lack of cluster-specific mechanisms to avoid both lock-in phenomenon and institutional and structural rigidity (eg. Zucchella, 2006; Liebowitz and Margolis, 2014; Puffert, 2004). The hyper-specialization and lack of regeneration mechanisms prevents clusters renewal and predisposes it risks during shocks.

Some studies however link adaptation to diversity and interaction between exploration and exploitation actors (Grandadam et al., 2013; Cohendet et al., 2018; Avdikos, 2015; Lange & Schüßler, 2018), identifying ambidexterity as useful mechanism.

	Business ecosystem	Innovation ecosystem	Entrepreneurial ecosystem
Main interest	Pivotal organization captures value through orchestration of interaction with other stakeholders	Orchestration of interaction with other stakeholders to co-create value	Fostering the interconnection of entrepreneurial actors to advance the performance within the entrepreneurial environment
Policy objective	Develop innovation platforms around technological fields (exploitation), leverage available resources	Exploration and exploitation to co-create value	Creation of innovative and high-growth new ventures
Actors	Suppliers, customers, including focal player/organization. Focal actor – orchestrates the innovation process and responsible for the ecosystem survival	Research organization and laboratories, financial organization, entrepreneurs, large and small enterprises, talented individual actors, artifacts. Members collaborate and relations are not guided by static rules	Entrepreneurs, start-ups, infrastructures
Network/relationship	Global business network (cooperative and competitive) Digital environment. Collaboration determined by existing common resources accessible to the participants	From local to global network (openness; varied levels of collaboration). Collaboration determined by value creation, not possible with single actor	Geographically bounded but not confined to a specific geographical scale
Governance	Peer-to-peer, top-down	Top-down, bottom-up	Top-down, bottom-up
Baseline/key outcome	Resource exploitation, value capture	Co-creation of innovation/value co-creation	New entrepreneurship Employment, competitive advantage, productivity
Dynamics of collaboration	Coopetition, Co-evolution, Specialization	Collaboration, Co-evolution Co-specialization	Collaboration, absence of direct competition among start-ups
Nature of interdependence	Interdependence determined by a given technology or platform	Interdependence of economic agents not dependent on any market or hierarchical mechanism	Interdependence determined by entrepreneurial processes

Key reference	Moore, 1993; Iansiti and Levien, 2004	Adner, 2006; Adner and Kapoor, 2010, Granstrand and Holgersson, 2020; Tsujimoto et al., 2018; de Vasconcelos Gomes et al., 2018	Isenberg, 2010; Mason and Brown, 2013

Table 1: Main characteristics of the three main streams of the ecosystem

2.3 The Ambidexterity: Source of ecosystem adaptive capability

Ambidexterity as introduced in innovation and management studies refers to both the exploitation and exploration capability (O'Reilly and Tushman, 2013). Exploitation is required for efficiency and control while exploration is required for search and discovery for new innovation. This perspective is in line with studies on Complex Adaptive System. Works on CAS postulates that the adaptive capability of an ecological system relies fundamentally on two main dual forces or functions. The first is the exploitation and stabilization function that ensures growth and leaderships of the system, which maximizes the production process. The second is the regenerative function that ensures renewal, re-organization of the system (Gunderson and Holling, 2002). Similarly, adaptation process of the innovation ecosystem relies fundamentally on the exploitation and stabilization force, which maximizes value creation and value capture function, and the regenerative force that ensures renewal of the ecosystem and the emergence of new structures, which maximizes creativity, invention, and exploration (Moore, 1996, Boyer, 2020). The combination of exploitation and exploration strategies foster the dynamics of the ecosystem and helps the ecosystem to avoid lock-in phenomenon, institutional and structural rigidity that are major problem of business clusters and innovation system dynamics (Saxenian, 1994; Boyer, 2020; Zucchella, 2006, Cohendet et al., 2014; and Lange and Schüßler, 2018).

Innovation ecosystem dynamics center on exploring new ideas and knowledge; and transforming them into formal projects or outputs. Ecosystem study examines both the knowledge generation and value capture (Clarysse et al., 2014).

Ferrary (2011) highlights that ambidexterity can be achieved by interaction of different organizations with both exploration and exploitation capabilities. Kauppila (2007) identified two models of ambidexterity. First, ambidexterity arises when firms specialized in either exploration or exploitation interact in a network. Second, ambidexterity at network level can arise when each firm is ambidextrous such that all the firms specialize and engage in both exploration and exploitation activities.

In the same vein, works on local innovation ecosystem, specifically on creative ecosystem identify three components that are in constant interaction in innovation process (Cohendet et al., 2020; Grandadam et al., 2013; Lange & Schüßler, 2018). They include the creative individuals that form the exploration function and are categorized in the 'underground'. The formal and well-established firms and organizations that form the exploitation function and represents the 'upperground'; and the 'Middleground' that provides the intermediation for interaction of the exploration and the exploitation actors.

The intermediaries such as creative spaces, places, projects and events increase the visibility of the creative individuals and provides firms access to new and creative knowledge that originated from the underground (Grandadam et al., 2013). The adaptive capacity of the ecosystem and the dynamic of innovation ecosystem is said to be dependent on the dual functions of exploration and exploitation. The Middleground made up of places, spaces, projects and events facilitate exploitation of new ideas and new inventions (Pigford et al., 2018; Granstrand and Holgersson, 2020), and enable organic interaction between actors in the upperground and those in the underground. The dynamics in innovation ecosystem arises from continuous transformation of informal ideas and knowledge into formal projects and outputs (eg Cohendet et al., 2009, Cowan and Jonard, 2015). The strength of innovation ecosystem therefore lies in the nature of interaction (formal/informal) and the variety of interacting stakeholders (diversity of actors), reflecting the distinct characteristics of innovation ecosystem. The intensity of the access to shared resources and facilities embedded in interrelationship determines the generativity of the ecosystem. The dynamics of these actors is important in the regeneration and adaptation of innovation ecosystem.

Hou and Shi (2021) proposed a coevolution framework for ecosystem studies and rely on Moore (1993) work and service ecosystem literature (Chandler and Vargo, 2011; Lusch and Vargo, 2014) to explain that "an ecosystem is simultaneously shaped by the downward force from the macro-level institutions for stabilization and the upward force from the micro-level actor-to-actor interactions for the emergence of new structures".

2.4 Innovation ecosystem: Sources of adaptability of actors

In the face of constantly market and technology changes and complex environment, adaptation becomes key driver for firm performance and competitive advantage (eg Hurley and Hult, 1998; Oktemgil and Greenley, 1997). Adaptation in this sense is a continuous capability that a firm develops. Adaptation refers to the ability of a firm to identify and utilize market and technology opportunities and variety of organizational capabilities to respond to changing environment. To adapt, firms modify and align to its environment, and the higher the environmental complexity that is within the control of the firms, the higher the level of its adaptability and long-term survival (Tuominen et al., 2004).

Work on industrial districts emphasizes the role of geographical and relational proximity, complementarity and interdependence of various actors for regional competitiveness (Becattini et al., 2014; Marshal, 2009). Clusters concept developed by Porter in the late 1990s highlights the role of concentration of firms and organizations to form synergy within a particular field

(Porter 1998). Similarly, innovation system developed by evolutionary economists highlights the role of institutions and the interaction between its environment to develop innovation processes (Cooke, 1992; Freeman, 1987; Lundvall, 1992).

On the other hand, Innovation ecosystem from an ecological and strategic perspective of innovation processes, is based mainly on co-evolution and co-adaptation between actors, institutions, artifacts and technologies (Granstrand and Holgersson, 2020; Russell and Smorodinskaya, 2018). The introduction of the concept of innovation ecosystem in innovation studies as a collaborative arrangement through which firms combine their individual offerings into a coherent and customer-facing solution (Adner, 2006), depicts a more sustainable mode of network and reflects diversity and interdependence between independent actors and enhances adaptability. It is in relation to these needs and challenges that the concept of the innovation ecosystem emerges.

Innovation ecosystem is seen as a dynamic system characterized by heterogeneous actors with diversity of qualities, roles and capabilities, co-evolving in a strategic context and the complex interactions between the actors which enable and influence innovation processes and development of technologies (Boyer, 2020; Huang et al., 2020; Ritala and Almpanopoulou, 2017).

First, embedding in innovation ecosystem, firms tap into the diversity of resources and cross-sectoral structures to enhance flexibility (eg. Fernández-Esquinas and Ramos-Vielba, 2011; Hassink, 2010; Boschma, 2015). In the same vein, studies show that the performance of firms is dependent on their ability to tap from knowledge that flows from various external sources (eg. Chesbrough, 2006; Cortright, 2006; Frost 2001; Rosenfeld, 1997). In contrast, scholars argue that high degree of similarity reduces the probability to produce more radical innovation that enhances adaptation to changing market and technology conditions (Turkina et al., 2019). Similarly, complex interactions in innovation ecosystem foster cross-pollination of different knowledge and allow firms to recombine resources to chart new paths (eg. Maskelll and Malmberg, 1999; Baldwin and Clark, 2000; Ganco, 2013).

One of the properties of innovation ecosystem in the lens of a complex system is ‘emergence’, depicting that the interactions between the micro components produce macro-level outcomes, which in turn influence effects in the micro components (eg Russell and Smorodinskaya, 2018). The stakeholders relate with others in complex ways in the innovation process, such that the overall performance of the ecosystem translates to improved individual performance.

As noted in this thesis, the characteristics of innovation ecosystem gives it more explanatory power to explain adaptation of the ecosystem actors compared to other traditional constructs. The adaptation of the ecosystem is however different from the adaptation of the ecosystem actors/components. We believe that, besides internal resources of the firms, adaptive capacity of firm evolving in innovation ecosystem relies on specific characteristics of ecosystems such as diversity or heterogeneity of actors, the complex interaction and the structural composition (upper-middle-underground) in a local/regional perspective of innovation ecosystem.

2.4.1 Ecosystem as source of adaptability of firms: the role of diversity of actors

Innovation includes problem-solving process which requires a search process (Dosi, 1988). It is the search process that produces new knowledge creation, necessitated by recombination of various elements (Fleming, 2001, Nelson, 1982). The diversity of knowledge in the network of firms provides the requisite variety for recombination (Schilling and Phelps, 2007). The heterogeneity of actors in innovation ecosystem provides a source of diverse knowledge necessary for enhanced innovation performance. Indeed, some studies specifically link diversity to adaptability (Iansiti and Levien, 2004; Bristow, 2010). Hassink (2010) clearly asserts that diversity provides a portfolio for guarding against exogenous shock and allows for adaptability and sustainability. Similarly, Boschma (2015) opines that diversity unlocks a regional system from a specific trajectory and enhances adaptability.

The heterogenous actors in innovation ecosystem engage in direct and indirect interaction which provides avenue for exchange of knowledge and information, with each participant acting as both receiver and generator of information and knowledge (see Ahuja, 2000). Empirical evidence shows that both direct and indirect interaction enhances innovation performance (Stuat, 2000, Ahuja, 2000, Owen-Smith and Powell, 2004)

Highlighting the role of heterogeneity, Pinkse et al (2018) and Suire and Vicente (2014) further assert that adaptability and sustainability require heterogeneity and heterogeneity implies openness. Iansiti & Levien (2004) explain that heterogeneity within an innovation ecosystem determines its sustainability. When shocks occur, diversity of actors (firms, organizations), cultural diversity, diversity of skills and knowledge enable the ecosystem to pursue a sustainable transformation. The organizational structure of the innovation ecosystem does not need be embedded within sectoral or industrial boundaries. Ecosystem gather together actors from different sectors or industry and reflects cross-sectoral and cross-industrial innovation processes, coupling sector-specific resources. Innovation, characterized by feedback mechanisms requires cross-sectoral collaborations to produce new combinations of idea, capabilities and resources (Fernández-Esquinas and Ramos-Vielba, 2011). Cross-sectoral structure breeds knowledge diversity and fosters cross-sector fertilisation of activities that are particularly important in generating flexibility and stimulating adaptation.

Today, as business environment experiences constant changes, firms move from technology scale to technology scope, adopting development of new innovation through joint production of several variants of products (Chandler et al., 2009). Thus, the focus is centered on deploying sets of varied technologies. In strategic and innovation studies, diversity is viewed as variety in terms of firm activities such as business diversity (diversification) and organizational heterogeneity.

Study shows that firms operating in a diverse and complex environment with many stakeholders display high probability to adapt during crisis (Desai, 2016). Exposure to diverse and complex environment enhances firm's ability to tap from diverse knowledge. Similarly, with the importance of learning in innovation, learning is facilitated when engaging in environment with diverse stakeholders, and diverse knowledge enhances the capacity to adjust capabilities for adaptation (Desai, 2016; Kim and Lee, 2020).

2.4.2 Ecosystem as source of adaptability of firms: the role of complex interactions

Regarding complex relations in Innovation ecosystem, Russell and Smorodinskaya (2018) identify different forms of relations. First, there is informational and communicational relations that allow actors exchange ideas, new information about technologies, strategies, or new market trends. There is also cooperation and transaction relations through which they devise rules to regulate and guide their relations to achieve a common objective. They highlight collaboration where participants share information, resources, responsibilities, and risks to jointly plan, implement, and evaluate a program of activities for the essence of attaining a common goal. In clusters studies, scholars argue for ties between one cluster and other clusters to avoid lock-in phenomenon; and build a *global pipeline* (Bathelt et al., 2004) which allows access to external sources of knowledge to enhance innovative capacity (Giuliani, 2007; Morrison et al., 2013).

Thus, innovation ecosystem facilitates cross-pollination of different knowledge necessary for innovation development (Maskell and Malmberg, 1999). Collaboration helps actors to source complementary resources and other inputs from the participating actors to maximize value creation. In sum, the participating actors enjoy better benefit of common value when there is high level of linkages and feedback in the collaborative network (Porter, 1990).

Complex interaction requires multiple actors and their relationships. The importance of collaboration in innovation production and business sustainability takes root in open innovation (Chesbrough, 2003; Lopes et al., 2017), in which innovation processes become open to external knowledge and ideas.

Collaboration includes various forms of complex interactions (Russell and Smorodinskaya 2018), where networked actors share a common object, mutual interest and continuously evaluate and negotiate to harmonize activities aimed at achieving a common goal.

Studies give credence to collaboration through which firms embark on collective creation of innovation to sustain competitive advantage (Chesbrough, 2003; Tassey, 2008). In a similar view, Powell and Grodal (2005) opine that innovation is effectively produced in a network interaction of firms with other firms, research organizations and other organizations. In fact, it is noted that the proliferation of networks today arises from the notion that innovation, technology and value can be better created by interactions of actors (Gloor, 2006; Russell et al., 2015; Wessner, 2005).

Evidence abounds in modern economies of the crucial role of interaction in stimulating and influencing innovation (Dangelico et al., 2013; de Medeiros et al., 2014; Ghisetti et al., 2015; Mascarenhas et al., 2018; Vivas & Barge-Gil, 2015).

On the role of interactions in driving adaptive capacity at firm level, studies acknowledge that complex relationships ameliorate the effects of shock. Recent studies assert that ecosystem members pursue a common goal of adaptation and sustainability through collaboration which translates to firm's higher eco-innovation (Behnam et al., 2018; Planko et al., 2019; Wei et al., 2020). Interaction increases the firm's ability to recombine resources and chart new path to enhance adaptation (Baldwin and Clark, 2000; Ganco, 2013; Grant, 1996). It broadens experience to develop new technological trajectories (Burford et al., 2021) and reduces search cost for new solutions (Furr, 2019).

However, some studies analyzed multi-partner interaction and assert that firm that increases partners beyond an optimal level, results in decreasing return in terms of innovation performance (Laursen and Salter, 2006); and increasing number of collaborators increases the complexity and challenges of coping with them (Fu, 2012; Stuermer et al., 2009).

Addressing this contradiction, some studies identify the level of communication in collaboration as key (SFWORK, 2015). If communication is too slow and scanty, it can reduce the gains of interaction. Ample flow of information on the other hand increases the possibility to optimize the gains therein (Sun et al., 2018). Others suggest that interacting with only a supplier can be less innovation-productive than when collaborating with both suppliers and scientific partners (Acebo et al., 2021).

Innovation ecosystem is seen in the literature as means of developing innovative activities through interaction and interrelationships between actors (Eg Mercan and Goktas, 2011), and relies on both formal and informal relationships and intermediary platforms to drive collaboration and innovation (National Research Council 2007). In fact, both direct and indirect interactions in ecosystem creates a mutual benefit among the actors, reflected in co-creation of innovation and thus provides a source of adaptation to the ecosystem firms.

2.4.3 Ecosystem as source of adaptability of firms: the role the organizational structure upper-middle-underground

Works on local innovation ecosystem consider the ambidextrous organizational structure of the innovation ecosystem embedded within territories with the combination of dual forces of exploratory and exploitative capacities necessary for its adaptability and resilience (Grandadam et al., 2013; Cohendet et al., 2010; Lange and Schüßler, 2018). These works identify that actors at the periphery of the ecosystem, often informal collectives (underground), have an exploratory capacity and more formal actors (upperground) have an exploitative capacity.

As highlighted earlier, one of the key characteristics of local innovation ecosystem is the structural composition and its integration. Scholars noted that the integration and interaction of upper-middle-underground structure in local innovation ecosystem fosters cross-sector innovation processes (Grandadam et al., 2013; Cohendet et al., 2014). Works on firm's sustainability-oriented innovation identifies alliance portfolio coordination as positively related to firm sustainable performance (Inigo et al., 2020). The alliance portfolio coordination is similar to intermediary platform (the middleground) that coordinates and integrates many actors with different capabilities and functions in a strategic context, allowing for knowledge generation and exchange (eg Lopes et al., 2017; Wang and Rajagopalan 2015).

This coordination in the context of local innovation ecosystem allows for integration of exploration and exploitation capabilities (Cohendet et al., 2020). Specifically, incremental innovation sustainability strategy requires marginal change to existing patterns and specific technological knowledge (Adams et al., 2016; Holmes and Moir, 2007), the structure of intermediation creates platform that brings together partners whose capabilities and knowledge may be needed. (eg. Inigo and Albareda, 2019).

Similarly, as noted, the structural composition of upper-middle-underground depicts a continuous interaction of actors with different capabilities. Radical sustainability innovation strategy requires a long-term orientation (Bos-Brouwers, 2010) and requires high level of trust (Schaltegger and Wagner, 2011). Continuous relationships build trust and increases the possibility to commit to a long-term process (Inigo et al., 2020). The structural composition of local innovation ecosystem, specifically the intermediation platform of the middleground allows each actor tap into radical sustainable innovation opportunities through incorporation and continuous interaction between many actors with diverse backgrounds.

In these studies, the middleground is likened to digital platforms that facilitate complex and dynamic interactions, automated transactions between a diversity of actors (customers, developers, users and suppliers) in a platform-based ecosystem (Cusumano and Gawer, 2002; Gawer and Cusumano, 2008).

2.5 Conceptualization of innovation ecosystem in this thesis

Our conceptualization of innovation ecosystem in this thesis is based on evolutionary and ecological perspective of innovation process. Complex system perspective emphasizes diversity of actors and complex interactions and adaptation. In this thesis, we view innovation ecosystem as a dynamic system characterized by a network of interdependent and diverse actors that interact to collectively create value and enhance innovative performance and adaptation of actors.

Specifically, local innovation ecosystem adopted in this thesis draws insight from the work of Saxenian (1994) on Silicon Valley, emphasizing territorial dimensions that form the basis for innovation dynamics in an ecosystem. The interactions/relations include formal and informal relations that foster exploration and exploitation necessary for innovation development and adaptation.

Local innovation ecosystem as a complex and interactive system integrates two major sub-systems – one sub-system responsible for the generation of knowledge or ideas and the other responsible for the application and commercialization of innovation (Eg Lazarenko et al., 2020). In addition, there is information and communication sub-system that form part of local innovation ecosystem. This can be in the form platforms or channels that facilitate connections. As noted in the previous sections, innovation ecosystem is characterized by complex interactions between diversity of actors, with upper-middle-underground organizational structures.

These features allow innovation ecosystem to address adaptation through the notion of ambidexterity. Ambidexterity is guaranteed at the system level by the interaction of firms that explore and exploit through the upper-middle-underground structure.

As we posit in this thesis, the local or regional ecosystem based on a upperground-middleground-underground structure explains adaptation process and what makes firms in innovation ecosystem more adaptive than others (see figure 1). The upperground provides the exploitation and stabilization functions while the underground provides the regeneration function. The middleground is key for developing complex interactions between the upperground and the underground within the innovation ecosystem.

As shown in figure 1, while events, places and spaces are very important in the middleground, we assume that collaborative innovative projects are the most advanced relational component of the middleground. Coevolution between actors in the upperground and the underground within collaborative projects are key to improve adaptive capacity of firms and an indicator of the ecosystem ambidexterity as well.

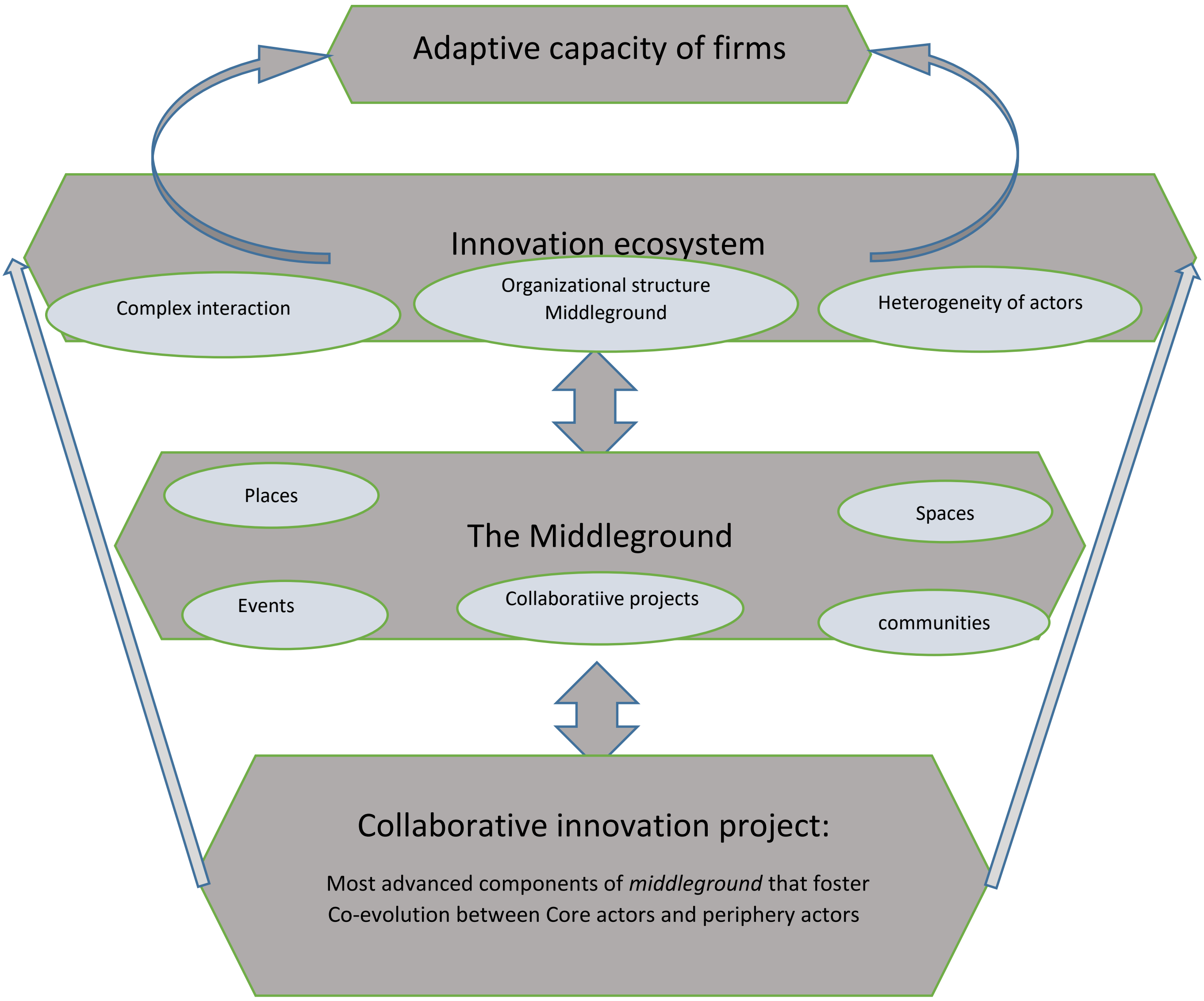

Figure 1 : The general research framework for the thesis

Chapter 3: Research design and methodology

3.1 Introduction

This chapter presents the research design and methodological approach and general reflections on the choice of methods and description of data and main variables. Further methodological aspects are discussed in more details in the empirical chapters.

First, as we explained in the theoretical background, this thesis fits into the innovation ecosystem stream, particularly into the Complex System perspectives, in which the components adapt continuously in order to respond to changes, environment dynamics and internal disturbances (Gunderson and Holling, 2001).

We aim to test one of the main hypotheses of innovation ecosystem view as complex adaptive system. Consequently, if we consider Innovation Ecosystem as a Complex Adaptive System, this implies that the ecosystem fosters adaptability of actors in order to deal with exogenous or internal shocks. Adaptation implies the co-evolution of actors, institutions, networks, and knowledge (Boyer 2020). In fact, coevolutionary dynamics that occur within the innovation ecosystem is one of the main characteristics of innovation ecosystem that distinguishes it from other traditional constructs such as cluster (Gawer and Cusumano, 2014; Moore, 1993; Rong et al., 2015; Teece, 2012; Heaton et al., 2019).

In accordance with this view, this thesis aims to test the impact of belonging to innovation ecosystem on adaptive capacity of firms. We compare firms that are part of Innovation ecosystem and those that are not, to examine if being part of an innovation ecosystem improve adaptive capacity of firms. However, this demonstration is not sufficient to ascertain the impact of innovation ecosystem on adaptive capacity of firm. It is also important to examine what makes firms in innovation ecosystem more adaptive than others. In others words, which features or mechanisms of innovation ecosystem could explain the positive role of innovation ecosystem on adaptive capacity of firms.

As developed in the theoretical framework, the structural organization of local or regional ecosystem based on an upperground-middleground-underground structure is key to understand adaptation process and what makes firms in innovation ecosystem more adaptive than others. The exploitation or stabilization function is provided by the upperground actors, while the generativity function is provided by the underground actors. We point out the role of the *middleground* as essential for developing complex relationship within the innovation ecosystem that enables companies to develop strategic action in order to adapt to new technological paradigms (Cohendet et al., 2009; Cohendet et al., 2014; Cohendet et al., 2020). The *middleground* provides an intermediation role, bringing together talented, creative and outlying elements (*underground*) and actors who have standardization capacity (*upperground*) in order to develop and exploit new paths for growth. The middleground connects continuously the actors of the upperground and the underground and facilitate coevolution and adaptation process (Cohendet et al., 2020). Companies that are evolving within the ecosystem benefit therefore from the ambidexterity of the ecosystem and become more adaptive (Faridian and Neubaum, 2021; Xie and Wang, 2021). Therefore, in order to examine what makes firms in innovation ecosystem more adaptive than others, we focus our analysis on the role of *middleground*. We examine, through empirical analysis the role of *middleground* on the orchestration of complex relationships within the innovation ecosystem and on technological development of firms. Finally, with collaborative R&D projects as the most advanced relational components of middleground, we focus on these projects to ascertain the extent the kind of partner, for which kind of project influences knowledge sharing and learning mechanisms that drive adaptation processes.

The thesis mobilizes a relevant field of study: the Hauts-de-France region which faces the challenges of adaptation and resilience due to failure of its main economic industries and has developed local innovation ecosystem to facilitate transition.

3.2 The region of Hauts-de-France and the development of Local Innovation Ecosystems

The region of Hauts-de-France is a new region created by the territorial reform of 2014, from a unification of two former regions of France Picardie and Nord-Pas-de-Calais. The Hauts-de-France region covers about 31,806 km^2 and is subdivided into five departments:[2] Aisne, Nord, Oise, Pas-de-Calais and Somme. While Nord-Pas-de-Calais has an industrial past, Picardie was specialized in agriculture and agro-industry. Nord-Pas-de Calais was considered a declining region in the 1970s due to the failure of its main economic industries – textiles, metallurgy, and coal. The Hauts-de-France region constitutes a relevant region for studying adaptation at regional level as well as firms' level, because it has been confronted for several decades with economic, social and environmental shocks which have led to a profound reconversion of its economic fabrics. The relevance of this region for our study is also justified by the fact that the reconversion of its economic fabric was based on a set of innovation ecosystems that have

2 The French departments correspond to the European NUTS 3 regional level.

developed around what the actors call *Poles of Excellence* and *Innovation Parks* to stimulate transition and adaptation. It becomes relevant to study the innovation ecosystem in relation to the adaptation of its component actors in line with the objectives of the region to move from a declining region to adaptive and resilient region. The thesis therefore takes a micro-level perspective to evaluate the ecosystem actors' adaptive capacity. Notably, the ability of micro sectors or actors to adapt to technological and market changes and market opportunities can translate to a long-run success of the macro-level effect - economies (Simmie and Martin, 2010), and the adaptation and resilience of the regional economy (macro-level) is threatened when the actors within the economy (micro-level) fail to enhance their adaptive capabilities (eg Evenhuis, 2017; Ramos and Royuela, 2021).

3.2.1 The region of Hauts-de-France: From a Declining Region to a Region in Transition

Since the 16th century, the region of Nord-pas-de-Calais, the northern area of the Hauts-de-France region, has been the engine of French industry with the textile, metallurgy and coal industries. The first industrial revolution accentuated the role of textiles in the socio-economic fabric by the mechanization of the production chain. The textile industry in the Nord-Pas-de-Calais was in 1954 the first main regional activity, with more than 171,000 jobs. This industry represented approximately 12.8% of regional employment and 26.5% of the national textile industry (Pierrard, 1991). The other impact of the industrial revolution on the territory of the region is the development of steel, metallurgy and chemistry. Indeed, mechanical transformation of metallurgy is rapidly becoming a flagship of the regional economy. In 1930, heavy and textile industry in the Nord-Pas-de-Calais region, was at its peak, employing 60% of the working population and the region was called the "France's factory".

The process of deindustrialization known in France in general has struck the heart of the productive fabric of the region. From 1960, textile employment began to collapses in a few years and factory closures and layoffs followed one after another.

The region of Hauts-de-France as a declining region due to the failure of its main economic industries - textile, metallurgy and coal industries, records unemployment rate and GDP below the national average. The impact of this industrial change ranges from increased unemployment, poverty, deindustrialization, low attractiveness and poor health and education indicator performance (OECD, 2018).

Hauts-de-France region faces industrial transition. OECD (2018) asserts that the region records high employment in job categories at high risk of automation. In 2017, most jobs in demand were low-skilled (OECD, 2018). The trend poses both challenges and opportunities for cross-industry cooperation for adaptation to future labour market challenges. Industrial transition challenges require three main strategic interventions – the promotion of entrepreneurship culture and collaboration, fight against territorial disparities and support for change in leading sectors (Hauts-de-France, 2018)

The 2000's marks the beginning of a reconversion of this region following the successive declines. Four stages can be distinguished in the dynamics of the Hauts-de-France region since the beginning of the 2000s.

1. **Awareness phase** for a reconversion of the productive fabric (1998-2004). This phase was characterized by a desire to build a genuine regional innovation strategy to reverse the declining regional dynamic. This step started in Lille and was then called the 'Metropolitan bifurcation' (Paris and Stevens, 2000), which corresponds to the process of reconversion of its productive fabric and re-composition of its economic, social and cultural structures. Reflections were conducted to answer key questions such as the treatment of industrial wastelands, the requalification of housing, the development of innovation process and sustainable development. It was in the early 2000s that the main strategic orientations were specified and confirmed in the Master Plan (SDUL, 2002). This master plan identified emerging sectors (digital, image-culture-media and eco-activities) and priority sectors (biology-health, transport) on which to base the redevelopment of Lille.

2 **The repositioning phase** (2004-2010). This phase aimed to initiate the transformation of the region through the development of innovation processes in new specialisations. The 'Contrat Plan Etat-region' (CPER 2007-2013), designed Technological Innovation Programmes and the development of Territorial Innovation Plans for four major territories: Metropole, Littoral, Artois and Hainaut-Cambrésis. This includes the recruitment of local innovation advisors who are to work with socio-economic and academic actors to build up clusters of economic excellence called "Pôle d'excellence", reinforcing the national policies for the development of "competitiveness clusters". Eleven areas have been identified as being able to stimulate innovation in the region

3 **Confirmation phase** (2010-2014). This phase corresponds to the launch of the activities of the various poles of excellence. The poles of excellence bring together on the same site or district, companies, research structures, innovation intermediaries, incubators and business accelerators. These centres of excellence are classified into three categories, those specialising in high-performance sectors (Health, Transport, Trade of the Future), those

specialising in sectors undergoing change (Automotive, Biosourced Materials, Composite Textiles, Building and Eco-construction), and those specialising in emerging sectors (Energy and Power Electronics, Waste Treatment, Imaging and Digital Creation, and E-health). The main ‘sites of excellence’ set up are: Euratechnologies, Plaine Images, Ceti, Eurasanté, and Haute-Borne.

4 **Specialisation phase** (2014-2020). This phase corresponds to the implementation of the SRI-SI (Regional Innovation Strategy - Intelligent Specialisation) and the SRDEII (Regional Economic Development, Innovation and Internationalisation Plan) which aim to orient the region's economic activities towards specific technological fields. Public policy actions for the development of innovation target the specialisation of the Region in six strategic areas of activity: Health and Food; Ubiquity and the Internet of Things; Chemicals/Materials and Recycling; Digital Images and Creative Industries; Energy; and Transport and Ecomobility.

The region's smart specialisation strategy focuses on strengthening and improving regional innovation capacities. As part of the strategy to foster the adaptation and transformation of the region, local authorities, through collective action and public policy guidelines, have created poles of excellence or sites of excellence that constitute the main components of local innovation ecosystems, centered around innovation parks, with heterogeneous actors and complex relationships for innovation development.

Many data explain that today the region of Hauts-de-France is following a good transition path. In 2017[3], the region of Hauts-de-France set a new record in terms of job creation which is almost twice as much as in 2016: 150,000 job creations (+ 8%), compared to just over 50,000 job losses (-35%), a net job creation of nearly 100,000 against 50,000 in 2016. The region was on the lead of industrial job creation in 2017, ahead of New Aquitaine and Auvergne-Rhône-Alpes. The number of creation of companies rose (+ 5.2%) at the same time.

The Lille Metropolis becomes one of the most creative metropolises (Liefooghe, 2017), and according to the magazine ‘L'Expansion’, it occupies the second place of cities most favorable to companies (excluding Paris) and behind Lyon. In October 2017, the MEL, former stronghold of the steel industry and the textile industry was elected World Capital of Design 2020 by the World Organization of Design (WDO).

3 http://hauts-de-france.direccte.gouv.fr/Bilan-economique-2017-des-Hauts-de-France-la-repise-se-generalise

As we explained, beyond the political will, the transformation of this territory relies on the development of Local Innovation Ecosystems build around *Poles of Excellence* or *Innovation Parks*

3.2.2 Local Innovation Ecosystems in the Hauts-de-France Region

This thesis focused on local innovation ecosystems[4] in Hauts-de-France. These local innovation ecosystems in Hauts-de-France are very specific and are based on Innovation Parks. Innovation Parks, comparable to technopoles or science parks concept, are institutional and organizational arrangement that bring together heterogeneous agents like research laboratories, technological structures, finance organization, brokers, start-ups and companies and third-places (fablabs, coworking space, living labs) within an interacting and strategic context. Innovation Parks have a spatial dimension (they bring together in the same area or district a group of heterogeneous players) associated to a strategic dimension in the sense that they enable development of complex relationships between heterogeneous actors both in the Hauts-de-France territory and national, European or international. Innovation Parks agency (team manager) have two major objectives: to promote the development and growth of new high-tech companies through incubation activities; and to stimulate regional economic development and growth through innovation and technological development. Each local innovation ecosystem in Hauts-de-France is associated at least to an Innovation Park or Sites of excellence. For example, the digital and Internet of Things (IoT) ecosystem centered around EuraTechnologies park*;* the health and nutrition ecosystem around Eurasanté park*;* transport and mobility ecosystem around Transalley Park, the Green chemistry and Agro-Sourced Materials around Haute Borne Park, the fashion and textile ecosystem centered around CETI / Uptex park[5].

Beside the Innovation Parks, three other actors structure these local ecosystems: an innovation hub which hosts a business incubator and accelerator; a Pole of Competitiveness agency or a regional equivalent and a business cluster.

The business incubator or start-up accelerator is involved in the support for business creation projects. The incubator can provide support with accommodation, training, advice and financing, during the first stages of the life of the start-ups. They foster relationships between start-ups, between start-ups and research organizations, large companies etc…

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4 The innovation ecosystems in Hauts-de-France region are well located in the region but are not restricted to only members within the geographical area. In fact, the ecosystems have members who are not resident in the geographical areas. As noted in table 1, the network of innovation ecosystem extends from local to global coverage.
5 Since February 2019, CETI and Haute Borne have merged to give birth to Euramaterials

Pole of competitiveness[6] promotes relationships between actors (University, research organization and companies) mainly through innovative project and animation or creation of network. They contribute to find relevant partners (inside or outside of Innovation Park), labeling and financing of collaborative innovative project. They work with research valorization structure of universities and Research laboratories in order to develop R&D project or techno-push innovation. For example, the Pole of Competitiveness NSL (Eurasanté) from 2006, labelled 248 R&D projects and animate a network of 150 companies, 47 academic and research structures[7].

Business clusters are association of main companies that evolve within the innovation ecosystem and are, in the context of innovation park in Hauts-de-France, more oriented Market-pull innovation. Each innovation park has a business cluster. The main role of Business clusters is to foster relationship between companies in order to expand their business to new markets. They offer companies and other actors adapted tools to make technological watch. They develop depth studies on specific themes or in strategic areas. They make daily monitoring and send periodically newsletter on network life. They develop collaborative platform that allows members to interact with each other and monitor network projects. Finally, they organize expert meetings in order to allow share of best practices. We have for example, the IoT cluster for the IoT and digital ecosystem, Clubtex for the textile and fashion ecosystem, ARIA for the transport and mobility ecosystem.

In sum, these local ecosystems foster strong relationships (formal and informal) and fertilisation between a diversity of actors and companies in one or more technology fields. They support the development and management of knowledge by bringing together research laboratories, technological structures, financial organizations, brokers and companies in a strategic and interactive context. The presence of these actors promotes the integration of scientific, technological and business dimensions within local ecosystems.

3.2.3 Main Local innovation ecosystems in Hauts-de-France and characterization

Local innovation ecosystems in Hauts-de-France refer more likely to multi-actor network ecosystem (see Tsujimoto et al., 2018). As explained above, these local innovation ecosystems

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6 All local innovation ecosystems do not have a Pole of competitiveness, but majority of the parks do have, at least a representative structure of pole of competitiveness or equivalent at regional level. Moreover, members of Pole of competitiveness could as well be inside or outside of the Innovation Park.

7 https://pole-nsl.org/le-pole-nsl/chiffres-cles/#1482160916642-b5952d7e-2e1c

are centered on Innovation Parks. Besides actors and companies located in the Innovation parks, the local innovation ecosystems in Hauts-de-France are composed of three main networks of actors whose focal organizations are located in the innovation parks. A network around the Pole of Competitiveness, a Business Clusters network and an Innovation hub network. *Therefore, the local innovation ecosystems include companies or organizations that are either located in the innovation park, members of the three main networks, or interact with these actors through at least two collaborative innovation projects*. The main local innovation ecosystem in the Hauts-de-France region are the Health and biotechnologies Ecosystem, the Digital and IoT innovation ecosystem, the green chemistry and agro-industry ecosystem, the fashion and textiles ecosystem, the video game and imaging ecosystem and the transport and mobility ecosystem [8](see table 2).

The Health and nutrition Ecosystem

The Health and nutrition Ecosystem, or *Eurasanté* Innovation Ecosystem is specialized on Biotechnologies, Healthcare and Nutrition. The main actors that structure the main networks of actors in the ecosystem are the University Hospital Center (CHU) of Lille, the Pole of Competitiveness *Nutrition Health Longevity (Clubster-NSL)*[9] and the *Eurasanté* Innovation Park, which houses two business incubators and start-up accelerators (bio-incubator, bio-accelerator, ageing incubator)[10]. CHU is a public regional hospital focusing on healthcare services, teaching and research (clinical, basic and applied research). The governance and the animation of the *Eurasanté* Innovation ecosystem is provided by the *Eurasanté* Agency, an Economic Interest Group (GIE[11]), which is an emanation of CHU Lille, Clubster NSL, and the organization managing the *Eurasanté* Innovation Park. Eurasanté innovation park houses 170 companies, 3100 employees, 8 hospitals, 4 faculties, 50 research labs and 20,000 students, a center of valorization and collaboration with research, a competitiveness cluster NSL, specialized in nutrition, health, longevity, a business cluster 'Clubster-Santé. However, 661 companies and organizations are officially involved within the *Eurasanté* Ecosystem, thus generating a multi-actor- network.

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8 In the paper 1 we presented a sample of 4 innovation ecosystem in order to explain networks characteristics, however the econometric analyses were performed on data of the 6 ecosystems

9 The Clubster-NSL is from a recent fusion between the former Pole of Competitiveness NSL and the business Cluster Clubster Santé

10 In this study we did not associate the Euralimentaire Innovation Park as main actors of the Eurasanté Ecosystem, because we consider that Euralimentaire are main actor of another ecosystem more specialized on agriculture and Food industry

11 In France, the GIE is a group of legal persons whose objective is to facilitate the economic development of businesses by pooling resources, material and competencies.

The Digital and IoT innovation ecosystem

The Digital and IoT innovation ecosystem is centered around Euratechnologies. Euratechnologies is the first business incubator and accelerator of start-ups in France. Euratechnologies is also an innovation Park. It currently houses 270 companies, ranging from ultra-innovative TPE technology to world-renowned IT leaders, such as IBM. There is concentration of laboratories in Euratechnologies innovation Parks offering combination of tools, technological equipment and skills dedicated to innovation. These include INRIA (French National Institute for computer science and applied mathematics), Cea Tec (specialized in smart digital systems micro and nanotechnologies and their integration into systems and nanomaterials). The Digital and IoT innovation ecosystem include also the IoT cluster managed by the CITC (Center for Technology Resources and Expertise of Internet of Things Technologies) and the Pole of Competitiveness Picom by Cap Digital dedicated to E-commerce and E-business. There are 500 companies and organizations officially involved in the Digital and IoT innovation ecosystem centered around Euratechnologies.

Transport and Mobility ecosystem

The Transport and Mobility ecosystem is historically animated by the Pole of Competitiveness I-Trans. Four main sectors are represented: The Railway Sector, the Automotive Sector, the Aeronautic Sector and the logistic sector. However, recently as for the other local ecosystem, an Innovation Park, Transalley was established. Transalley innovation park brings together companies, research labs/organizations and training establishments to develop mobility and industry of the future. Located in 34 hectares, Transalley is a strategic location connected to the Université Polytechnique Hauts-de-France and the main research laboratories and research centers dedicated to transport and mobility ecosystem such as LAMIH, IEMN, Railenium. Transalley offers a conducive environment for business development in automotive, rail, aeronautics and other mobility. Transalley offers unique services and facilities such as business incubators, business hotels, equipment and shared spaces. Transalley provides and offers spaces for professionals and support project leaders, companies and start-ups in the development of their activities. Transalley houses 51 companies, 6 laboratories and 9 associations and institutions of transport/mobility sector. As Innovation Hub, Transalley houses also a business incubator, a start-up accelerator named GAMMA, and business center. The business cluster for the transport and mobility ecosystem is the ARIA association, which brings collective action to the service of competitiveness of SMEs and large companies in mainly the automotive sector. There are 750 companies and organizations officially involved in the transport and mobility innovation ecosystem. The region Hauts-de-France is the first French automotive region and a leading territory in Europe.

The Textiles and Fashion ecosystem

This ecosystem is built around a "Site of Excellence[12]", which hosts 125 companies. It is made up of a business incubator and accelerator (Innotex) and an R&D center dedicated to fashion and textile - CETI (European Center for Innovative Textiles). CETI provides services to companies, accelerating their growth and innovation processes. It is a place to design, experiment, prototype and industrialize new products, materials and processes adapted to the needs of the global sector. CETI sets to bring transformation and sustainable development of textile sector. We find also a component of the Pole of competitiveness Euramaterials[13]. CETI and Euramaterials collaborate with diverse actors including producers, distributors of fashion, sports, luxury and technical textiles. Astier (2021) distinguishes two branches that structure this ecosystem: clothing and furnishings, and technical textiles. The clothing branch includes fashion, manufacturing and distribution and is headed by the business cluster of Fashion Green Hub (FGH). The technical textiles branch which presents various textiles for technical uses (medical, mechanical, etc.) and it is headed by the business cluster ClubTex.

The Green chemistry and Agro-Sourced Materials ecosystem

The Green chemistry and agro-sourced materials ecosystem is centered on Site of Excellence - Haute-Borne Park. The Haute-Borne Park was inaugurated in 2003, but its vocation was affirmed since 1988. It is dedicated to innovative agro-sourced materials and brings together in the same area:

- 148 companies of all sizes.
- A center for industrial applications of innovative agro-sourced materials (CREPIB).
- Technological demonstrators.
- Research organizations and higher education establishments, particularly on the Cité Scientifique campus in Villeneuve-d'Ascq, such as the University of Lille 1, the National School of Chemistry of Lille and the Institute of Molecules and condensed

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12 Sites of Excellence and innovation Park are synonymous in substance. However, Innovation Park is a label from the regional council, while Site of excellence is a label of Lille Metropolis council. Sometime a Site of Excellence have the regional label of Innovation Park such as Euratechnologies, Eurasanté. Sometimes a Site of Excellence does not have the regional label of the regional council, as is the case of Uptex/Ceti and Haute Borne.

13 Euramaterials is a new Pole of Competitiveness from the fusion of two Pole of competitiveness: Uptex dedicated to textile and Matikem dedicated to new materials.

matter in Lille, UCCS, IEMN Lille, INRA Lille, Polytech'Lille and Télécom Lille, Ecole Centrale de Lille, IFSTTAR, IFMAS, IEED

Since 2005 the Pole of competitiveness, Matikem was the main organization that animated the ecosystem dedicated to green chemistry, eco-materials and vegetable plastics. However, recently in 2020, Matikem decided to fusion with the pole of competitiveness UP-TEX and the GMTH association (Grouping of textile and clothing resources), to give birth to the Pole of competitiveness EuraMaterials. There are 450 companies and organizations officially involved in the Green chemistry and agro-sourced materials ecosystem**.**

The video game and imaging ecosystem

The video game and imaging ecosystem is different at several levels of the other local innovation ecosystem in Hauts-de-France. First, this ecosystem includes two innovation parks Plaines images and Serre Numerique. Plaine Images is located at Roubaix-Tourcoing, houses 125 companies with two schools: the Fresnoy (national studio of contemporary arts) and Pole IIID. It hosts the Visual Sciences and Cultures research program and a technological platform (EquipEX, 2011), in collaboration with the Universities of Lille 1, Lille 3 and the CNRS. We find also Pictanovo, a business cluster and innovation platform that offers a watch and strategic analysis service for businesses and all professional players. Serre Numerique is located at Valenciennes and connected to the Université Polytechnique Hauts-de-France and the main research laboratory dedicated to videos and imaging in Valenciennes Devizu (Design Visuel et Urbain) associated to LARSH. At Plaines Images as well at Serre Numerique, there are business incubator and start-ups accelerators. The video game and imaging ecosystem does not have a specific dedicated pole of competitiveness. However, we find a business cluster: Pictanovo, which promotes the creation, production, distribution and innovation in cinema, television, video games, animation, computer graphics, new writing, performing arts and musical production within the Hauts-de-France region. There are 350 companies and organizations are officially involved in the video game and imaging ecosystem.

The upperground-middleground-underground structure of local innovation ecosystems in Hauts-de France

The local innovation ecosystems, as described above have a clear organizational structure made up of an upperground, a middleground and an underground. The upperground refers to stable actors with exploitative capacity. We can cite research laboratories, well established companies (PME, larges companies etc), business clusters and at some regards the pole of competitiveness in their formal function (labelling of projects for example). The middleground of these local ecosystems refers fundamentally to the Innovation Park or Site of Excellence. The parks are the emblematic places were complex relationships (formal as well informal) are promoted. These places house main actors whose functions are to connect actors of the ecosystem, particularly start-ups, informal communities with more established actors, companies and organization.

Innovation Parks or Sites of excellences house a large range of spaces of creativity, co-creation of knowledge, open innovation and codesign in order to reinforce collective intelligence, creativity and agility among the complex actors' system. Specifically, we can highlight:

- **Imaginarium** at Plaine Images as a coworking and open innovation space, and the **IrDIVE technological Living Lab**, dedicated to image perception and interactions with digital visual environments.
- **Girovia** located at Transalley, which is an open space instrumented, equipped and designed to safely simulate traffic scenarios in an urban environment, to present and promote connected, automated or autonomous vehicles. It is equipped with maneuverability paths for wheelchairs as well as a cycle section to study the coexistence of modes of transport.
- The **Atrium** at Euratechnologies, a large coworking room in the heart of the building, an innovation lab and a demonstration technology platform.
- The **Saga Concept Room** at Eurasnaté, a Living Lab bringing together designers and users to co-design tomorrow's health products and services, and cutting-edge creative prototypes.

Events are considered as one of the forms of middleground. Events provide an avenue for connection between talented and periphery actors to well-established structures and organization. Main events organized by Innovation Parks are hackathon (co-design, collaborative, creative events that have sometimes an artistic or hacking dimension) and speed dating (event that uses method of finding a partner for innovation project through short conversation). Others include after-work (event that allows people to meet together, after work, and discuss with others about new ideas, new projects and new experimentation), start-up weekend (event that allows 'start-uppers' to share their ideas, business model etc with others 'start-uppers' and financing actors or experienced businessmen).

Beyond these generic events, there are events specifically organized by each Innovation Park. Managers of Euratechnologies explain that about 500 events take place in a year at this innovation Park, which include Euratech day and Euratechkids. For Eurasanté, we have Ageingfit, Medfit, Biofit and Nutrievent. For Plaine Images there are Game-all-over, *Matinale de la Plaine images etc*. For Haute-Borne we have Haute Borne Business Lunch, Scientific and technological day and Haute Borne Xmas Meeting. These events provide a meeting point for various categories of actors.

One of the main characteristics of Innovation Park in Hauts-de-France is incubation of new project and acceleration of start-up or SMEs. Each innovation Park offers spaces, skills and support for the development of new start-up. Annually, about 200 innovation projects are supported by the business incubators, which are located in the Innovation Parks or Sites of Excellence. Moreover, acceleration structure within Innovation Parks boosts new start-up and SMEs already created or in activity, intrapreneurship to get the most out of their development path. With incubation and acceleration activities, actors within the underground can benefit from Innovation Parks, including talented students, entrepreneurs, hacker community, research entrepreneurs, artists and engineers.

The composition of the underground of the local innovation ecosystem in Hauts-de-France are different. In Euratechnologies, we found mainly communities of hackers/makers, such as Catalyst/Anis (collective of makers on digital and social innovation), and some computer engineers or ICT entrepreneurs. There are artists and gamer communities in Plaine Images. In Eurasanté, we find mainly talented researchers and students, doctors, innovators and some people working on the use of ICT in medical field. Finally, in Haute-Borne we find talented students and researchers, and talented people who work on sustainable development. There is a high presence of universities, research laboratories and students in Eurasanté and Haute Borne. Their innovation projects are more science-based than Euratechnologies and Plaine Images. The technological domains of Euratechnologies and Plaine Images are more attractive to communities of makers and hackers. Plaine Images, due to its thematic around images and videos, artists are likely more interested in its environment. Table 2 presents the characteristics of the six main local innovation ecosystems described above.

Upperground

Middleground

Underground

Local Innovation Ecosystem	Digital, IOT	Health nutrition	Green chemistry and Agro-Sourced Materials	Fashion and textile	Transport and ecomobility	Videos, images
Estimation of numbers of companies	500	700	450	300	750	350
Number of companies hosted in the Innovation Park	270	170	148	125	51	180
Research centers or laboratories	Inria, CITC…	Laboratoires de recherche du CHRU de Lille…	INRA, INRIA, CNRS, IEMN….	ENSAIT…	IEMN, LAMIH, IRT Railenium, PRIMOH, SwiTlab	Devizu, Pole IIID
Technological transfer organization	SATT-Nord	SATT-Nord	SATT-Nord	SATT-Nord	SATT-Nord	SATT-Nord
Business cluster	CITC-IOTcluster	Clubster Santé	Matikem	Clubtex/ Nord Crea	ARIA, AIF	Pictanovo
Pole of Competitiveness	Si-Lab (Picom)	NSL	Euramaterials (Formerly Matikem)	Euramaterials (Formerly Uptex)	I-Trans	--
Innovation Park/Site of Excellence	Euratechnologies	Eurasanté	Haute Borne	Ceti	Transalley	Serre Numerique/ Plaines Images
Incubators	Euratech 80 projects incubated per /years	Bioincubateur 20 projects incubated per /years	Cré'Innove 15 projects incubated per /years	Innotex 20 projects incubated per /years	Transalley 10 projects incubated in 2020	Serre Numerique incubator Plaines Images incubator 30 projects/year
Accelerators	Scale by Euratech	Hibster	Hub innovation	Innotex	GAMMA	Take Off - Plaine Images Serre Numerique accelerator
Third places, creativity space	Atrium/ Adicode/ techshop Leroy Merlin	Saga Concept Room (living lab)	Coworking spaces Lilliad	Plateforme Textile & Fashion Design 4.0 Plateau Fertile	Build; Mobilium GYROVIA, IMD	Imaginarium IrDIVE technological Living Lab
Events	Euratecdays, Hackaton speed dating	Ageingfit, Medfit, Biofit, Nutrievent	Hackaton speed datin	Fashion green day	Eurêka, Technopolis, Instant T	Game-all-over, Matinale de la Plaine images
Talented actors/informal group	Hakers/makers communities (catalyst, Roumics)	Research-entrepreneurs, doctors, entrepreneurs, Talented students	Talented researchers and students, talented people who work on sustainable development	Fashion green community	Research-entrepreneurs, doctors, entrepreneurs, Talented students	Gamers community (Lille - Meltdown

Table 2: Characteristics of the main local Innovation ecosystems in Hauts-de-France

3.3 Overview of the sub-studies: Choice of methods and main variables

This thesis is structured into three sub-studies, presented in three scientific papers, to address three research sub-questions. Figure 2 presents the sub-studies, research sub-questions and the unit of analysis.

The first paper (published in *Industry and Innovation Journal*) addresses the following research question: *To what extent do innovation ecosystems affect the adaptive capacity of firms?* This paper aims to test whether firms that are part of innovation ecosystem are more adaptive than those that are not and to what extent. This paper uses a sample of 431companies located in the region of Hauts-de-France, with 131 companies which belong officially to Local innovation ecosystems and 300 companies which do not belong to innovation ecosystem (see section 3.4.1 and Article 1 for further details about constitution of the sample and characterisation of local ecosystem in the region of Hauts-de-France).

The second paper (to be submitted to *Technological Forecasting and Social Change*) addresses the following research question: *To what extent does the middleground involve in the orchestration of complex relationships within innovation ecosystem and impact technological development of firms?* This paper is related to the second level of analysis of this thesis, which tests why and what makes ecosystem firms more adaptive than others. Thus, it aims to determine to what extent the ecosystem influences firms in the ecosystem to become more adaptive than others. In other words, to find out main mechanisms or components of the Innovation Ecosystem that enable companies to develop strategic action in order to adapt to new technological paradigms, and to deal with market and institutional changes, this study posits that the middleground is the main components of the innovation ecosystem that foster complex and dynamic relationships between heterogenous actors and enable adaptability of actors. In this perspective, this paper aims to test the role of *middleground* in the orchestration of complex relationships between heterogenous actors and its impact on technological development of firms. As this analysis needs deeper examination, we decided to focus on an emblematic ecosystem of Hauts-de-France: The Eurasanté ecosystem dedicated to healthcare and biotechnologies. Through qualitative analyses, we described the role of middleground of this ecosystem in the orchestration of complex relationships between the actors evolving in this ecosystem. Second, the study used two components of middleground: project and event that allow us to take into account both formal and informal relationships, in order to test empirically using econometric models, the role of these components on technological performance of firms that are part of this ecosystem (see section 3.4.2 and Article 2).

The third paper is a working paper, which is an extension of the second level of analysis. This paper explores the collaborative innovation project as the most advanced relational component of the middleground to identify the determinants of core firm involvement in collaborative R&D projects. This paper addresses this following research question: *What explains the involvement of core actors in collaborative innovative project in a local innovation ecosystem*? This study focused again on the Eurasanté ecosystem. We analyzed main collaborative innovation projects that bring together actors and identify the determinants of firm's core participation in these collaborative R&D projects (see section 3.4.2 and Article 3)

Driven by the objectives of the study, the core of the research method is rooted in the quantitative approach, adopting the use of econometric models to test the hypotheses. However, we used qualitative approach as complement in order to describe the innovation ecosystem, the main components and key actors.

Considering the research objectives and sub-questions, the adoption of different research methods becomes important. The nature of the sub-question guides the choice of analytical methods adopted in the empirical chapters.

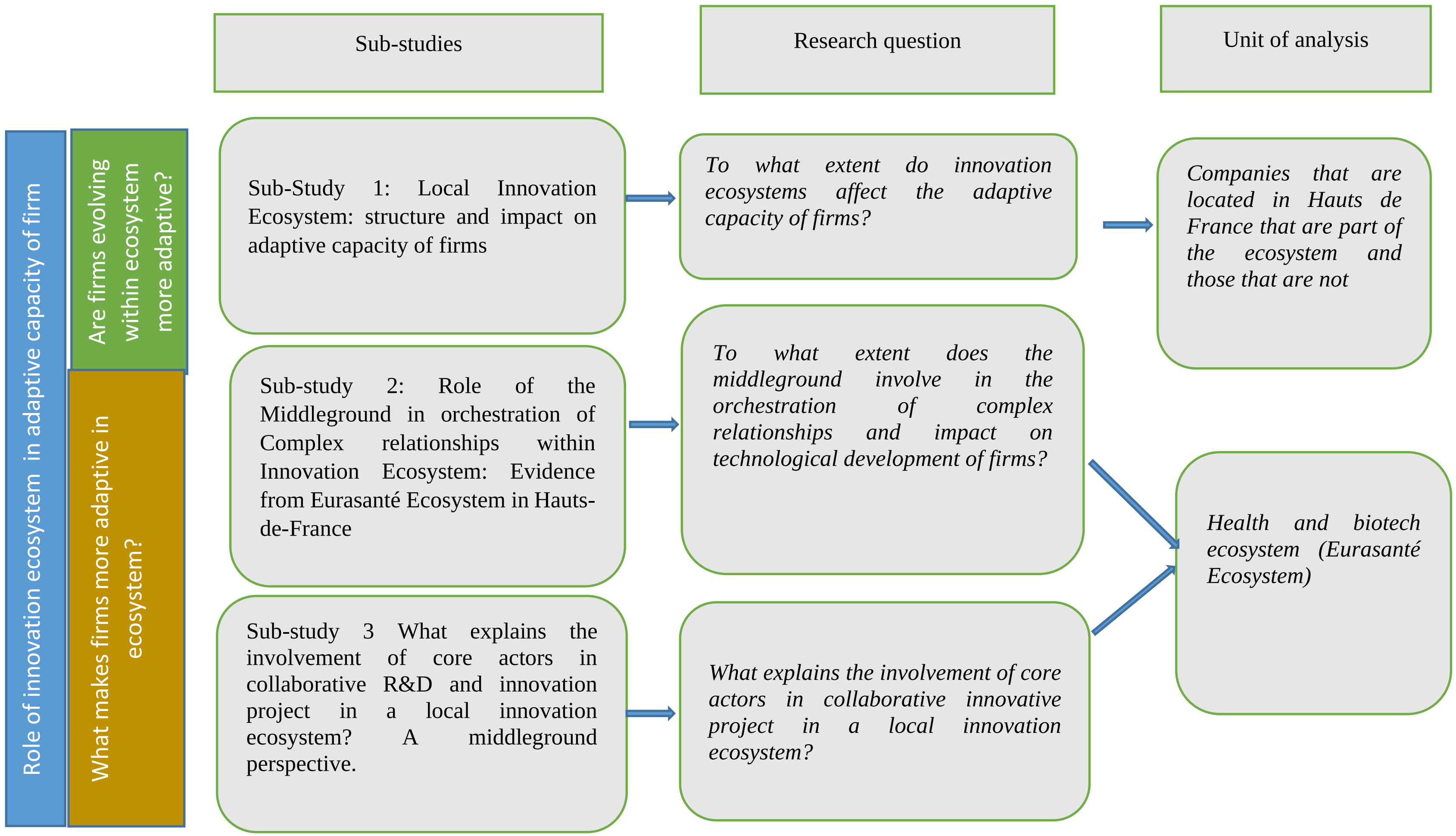

Figure 2: The relation between the sub-studies and the research question

3.3.1 Sub-study one: Impact of innovation ecosystems on the adaptive capacity of firms

First, the sub-study aims to explore the innovation ecosystem construct, providing new insights and empirical evidence on the impact of innovation ecosystem on adaptive capacity of firms.

With theoretical studies emphasizing adaptation as one of the main dimensions of the innovation ecosystem (eg. de Vasconcelos Gomes et al., 2018), this study specifically analyzes the impact of innovation ecosystems on the adaptive capacity of firms, testing if firms belonging to innovation ecosystem are more adaptive than others.

To do this, the study uses two variables – innovative performance and technological diversity to proxy adaptive capacity of firms. To adapt to technological and market changes, firms require exploration and exploitation strategies and change their innovation behaviour (eg. Cohendet et al., 2014; Lange and Schüßler, 2018). Similarly, diversity is linked to adaptation. Diversity provides the portfolio to respond and adapt to technological and market changes (eg Hassink, 2010; Boschma, 2015).

The choice of these indicators is motivated by the fact that adaptive capacity refers to the degree to which firms apply and adopt variety of organizational capabilities (Sanchez and Mahoney, 1996), reflecting in the ability to produce new innovation development. Firm adaptive capacity reflects in the ability to identify and exploit emerging market and technological opportunities, through adjusting their strategic position (Oktemgil and Greenley, 1997).

Similarly, drawing from evolutionary theory and organizational learning, (Dosi, 1982; Nelson and Winter, 1982), technological diversification influences exploratory and exploitative inventions and enhances innovation capacity. Diversification allows firms or organizations to develop diverse R&D portfolio necessary for adapting to new technologies. Technological diversity predisposes firms to combine and recombine their stock of existing knowledge with new ones that bring new breakthroughs (Quintana-Garcia and Benavides-Velasco, 2008). Firms that focus on a particular class of technology, for example, stand to be rendered obsolete if technology advances and moves away from the specific class of technology. Firms that are technological diversified, on the other hand, exploit more opportunities and technical possibilities with changing technologies.

To measure innovative performance, the study uses *Innoscope* score as proxy. This proxy is adopted by HDFID (the regional Innovation Agency)[14], INSEE and European commission

14 https://www.hautsdefrance-id.fr/

(Marmuse and Godest, 2008) to measure firm innovation potentials using two broad series of measures – the exploitation of innovation potential (performance perspective) and the creation of innovation potential (growth perspective). Performance perspective is based on seven ratios which measure the performance of the companies (productivity of labour, productivity of capital, value added rate, the return on equity, the rate of self-financing capacity, the rate of gross operating profit, and the overall performance of the company). The growth perspective is based on six ratios: elasticity of turnover, elasticity of gross operating profit, elasticity of net fixed assets, elasticity of added value, workforce elasticity, and operating cash profit. The *Innoscope score* shows four distinct states - N*on-innovative*, *Creative*, *Efficient*, and *Innovative*. The assessment is biennial, with the possibility of firm moving from one *Innoscope* state to another. The study compares the *Innoscope* scores of two different years (2013 and 2017) and used dummy variable, 1 to represent moving from a lower score to a higher score or maintaining a higher score, and 0 otherwise (see section 4.1.1 in Article 1).

In order to measure technological diversity, the study follows Gkotsis et al. (2018) to classify firms in terms of technological diversity, using the number of IPC4-digit codes in the firms' patent portfolios. The IPC code shows the technological classification of a patent which describes the technical content and the IPC4-digit shows the specific technological domain. It is believed that a more technologically diversified firm incorporates a greater number of IPC4-digit in its patent portfolio, indicating its capacity to belong to a more technological field. Firms were however categorized based on the number of IPC4-digit into – low, medium, and high (see section 4.1.2 in Article 1 for details).

Measures of Independent variables.

The main explanatory variable of interest in our study is *InP*, which indicates belonging to the local innovation ecosystem that centres around the innovation parks (see section 3.2.2 in Article 1). This variable measures the contribution of the local innovation ecosystem to the innovative performance and technological diversity of firms as proxies for firm adaptive capacity. *InP* is a binary: 1 if a firm is a member of local innovation ecosystem centered around the innovation parks; and 0 otherwise. We use other control variables which include the level of regional support received; relational effect, using the network centrality measures and the effect of external market exposure using export. We control for firms' characteristics such as size, age, location and sector.

Figure 3 presents the framework for the first sub-study. Innovation ecosystem is characterized by diversity of actors, artifacts and institutions that interact and co-evolve to develop innovation and adapt to continuous market and technological changes.

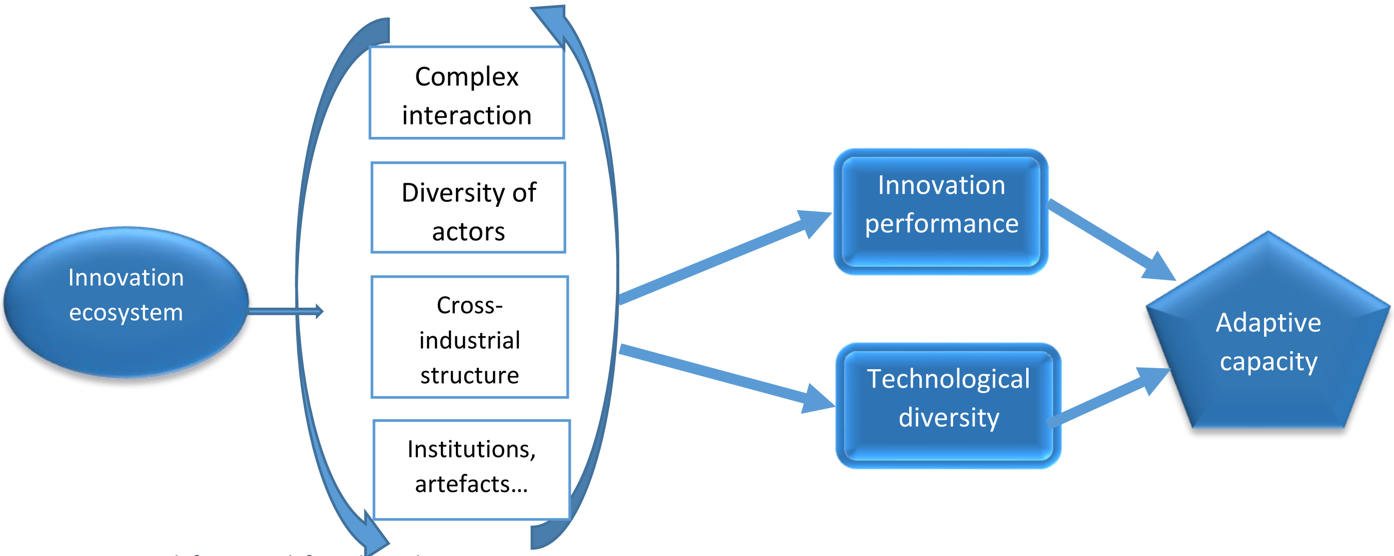

Figure 3: Research framework for sub-study one

3.3.2 Sub-study two: Orchestration of Complex relationship in Innovation Ecosystem: the role of the middleground

Having ascertained the positive impact of innovation ecosystem on adaptive capacity of firms in terms of innovative performance and technological diversity, it becomes important to ascertain why and how firms belonging to innovation ecosystem are more adaptive than others.

Theoretically, the middleground as introduced in local innovation ecosystem stream (eg. Cohendet et al., 2014; Cohendet et al., 2020) is in the form of places, spaces, project and event, and intermediary platform that orchestrates complex relationship, connecting the actors in the upperground (formal actors) and the underground (informal actors).

This platform, similar to digital platform in platform-based ecosystem stream, allows emerging creative ideas and knowledge to be absorbed, experienced and developed within a collaborative context and commercialized in the marketplace. The quality and the extent of interaction in the middleground determines the performance in the innovation ecosystem (Amin & Cohendet, 2004; Coe & Bunnell, 2003; Cohendet et al., 2010; Saxenian 1996; Boyer, 2020).

Therefore, considering the second research objective to ascertain the extent the middleground orchestrates complex relationships and enhance technological development, the second sub-study focused on Eurasanté healthcare ecosystem, the most developed ecosystem in Hauts-de-France as a unit of analysis.

To measure technological development, the study used number of patents by each firm in the innovation ecosystem as proxy. Patent is seen as a good indicator of firms' technological performance (Ernst, 2003; Breschi et al., 2014).

Our choice of technological development is driven by the fact that Eurasanté ecosystem centers around healthcare and biotechnology and are more scientific, where patenting is relevant measure of innovation.

We identify the number of patents of firms which are part of the Eurasanté Innovation Ecosystem for the last five years (from 2016 to 2020).

To test the hypotheses, the study specified three econometric models and adopted the use of zero-inflated negative binomial (Zinb) model in the estimations (see section 4.1 in Article 2 for details).

Measure of independent variables

For availability of data, the study focused on two components of middleground – project and events in the analysis.

Events: allows for informal relationships among actors, foster idea generation, connecting ecosystem actors with external knowledge, information, technological updates (inside or outside the Ecosystem), and in turn make them receptive to new external influences (Cohendet et al., 2020). The study uses the number of participations of each firm (through their representation) in events organized by Eurasanté innovation park or by the Eurasanté agency, which is in charge of animation of the Eurasanté innovation ecosystem; and its Competitiveness Cluster, NSL. We extracted this information from 2009 to 2015, since available data firm participation in events from ASTRIDE database starts from 2009. We categorized the firm's participation in events to capture effects of different levels of participation (see section 4.1.2 in Article 2).

Project: this data represents the collaborative R&D projects supported by Eurasanté and its Competitiveness Cluster. Collaborative R&D projects indicate formal relations that officially engage actors within the innovation ecosystem to work together through a given project. To measure the participation in collaborative R&D projects, we used the dummy variable

PROJECT. This variable indicates 1 if a firm has been officially involved in collaborative R&D projects with other firms within the *Eurasanté* Ecosystem in the period 2009-2015 and 0, otherwise. We tested then if participating in collaborative projects at a given period *t* affects the technological performance of firms at *t+1*. We control for firms' characteristics such as size, age and regional support received (see section 4.1.2 in Article 2).

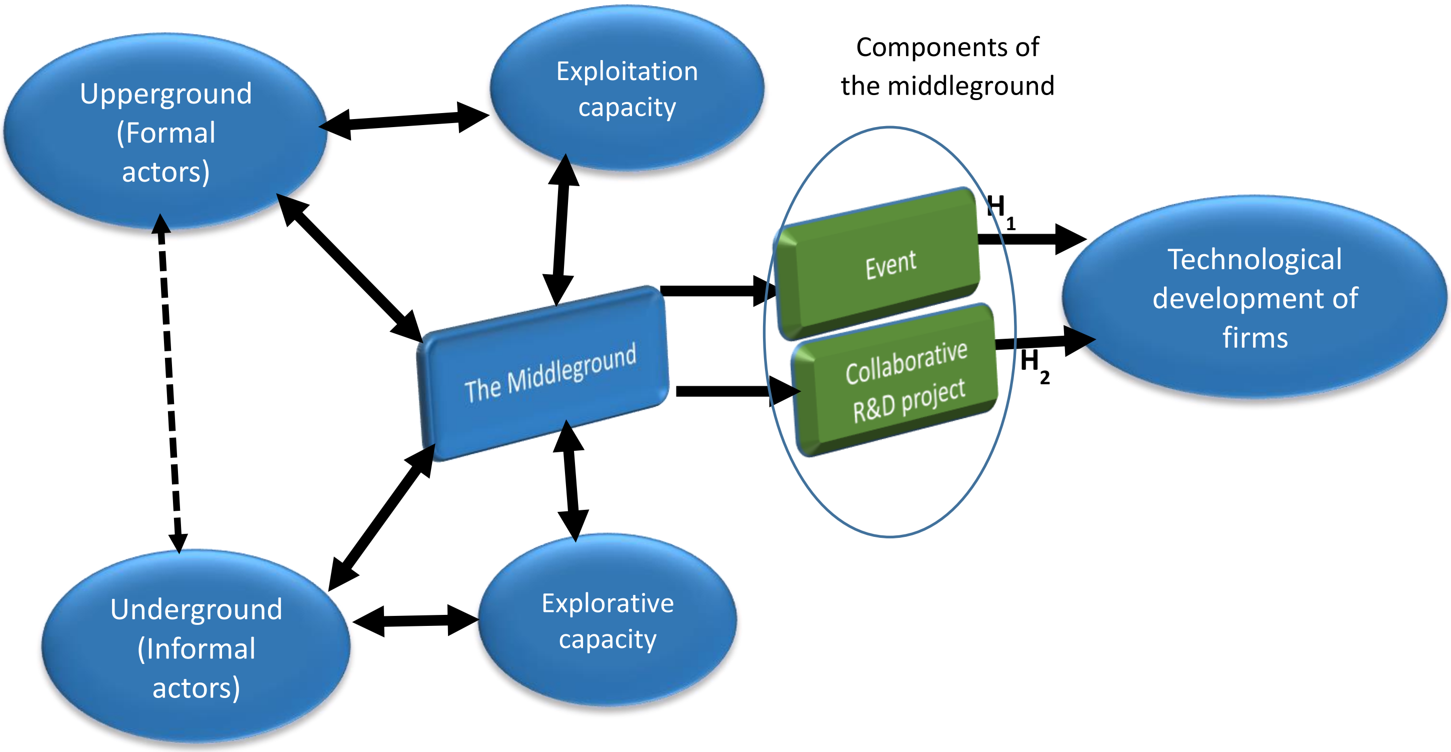

Figure 4: Research framework for sub-study two

3.3.3 Sub-study three: What explains the involvement of core actors in collaborative R&D and innovation project in a local innovation ecosystem? A middleground perspective.

As an extension of the second sub-study, the third sub-study on the other hand analyzes the most advanced relational component of middleground – collaborative R&D projects – to ascertain what kind of project, for what kind of exchange drives learning mechanism and adaptation.

With innovation ecosystem characterized by complex relationships between heterogeneous actors and with the organizational structure that allows interactions between different levels of actors, collaborative R&D project advances and has become success factor that drives interaction and knowledge exchanges. Adaptation is linked to acquisition of external knowledge through collaboration, and collaboration is mainly studied using interaction between actors/organizations, partnering in an inter-organizational project (eg. Bernela and Levy 2017).

Collaboration in R&D project as a form of middleground, facilitates interactive learning for knowledge creation and diffusion. Adaptation within the ecosystem depends on the ongoing interactions between actors in the upperground and in the underground (Cohendet et al., 2020).

Our previous study clearly points out the importance of collaborative project in orchestrating interactions between different levels of actors, and in enhancing innovative performance and adaptation.

Despite the role of collaborative projects in driving knowledge exchange and learning process among partners, little is known about the specificities linked to both the kind of projects and the kind of exchange in the learning mechanisms that drive adaptation.

However, if adaptation is linked to acquisition of external knowledge in collaboration, core actors with rich connections absorb the most knowledge in collaborative R&D project and exhibit the greatest power of adaptation. Considering that the peripheral actors or underground actors involved in the collaborative project are driven by the motives to benefit from resources that are beyond their scope, factors driving the involvement of 'core' actors engagement in collaborative R&D or innovation projects are still under-developed.

Therefore, the specific research question is as follows: *What explains the involvement of core actors in collaborative innovation project in a local innovation ecosystem*?

In the first step, we constructed and analyzed the network of R&D collaboration in Eurasanté ecosystems to identify the core actors, the type of partners or exchange and the kind of project. The study therefore adopted the fractional logistic model, using the proportion of 'core' actors as outcome variable to test particularly if the the kind of exchange/partners and the kind of project drive core actor involvement in collaborative R&D projects (see Article 3 for details).

Table 3 links the research questions with the sub-studies, the main data sources and econometric models adopted for each of the three sub-studies.

S/N	Articles/sub-studies	Research Questions	Main Data source	Content	Data analysis and econometric model
1	Local Innovation Ecosystem: structure and impact on adaptive capacity of firms	*To what extent do innovation ecosystems affect the adaptive capacity of firms i.e firms' innovativeness and firms' technological diversification?*	ASTRIDE; INPI	Empirical investigation of impact of Innovation ecosystem on adaptive capacity of firms	*i. Structural network analysis* *ii. Entropy analysis* *iii. Logit model* iv. *Ordered logit model*
2	Role of the middleground in the orchestration of Complex relationship in Innovation Ecosystem: Evidence from Eurasanté Ecosystem	*To what extent does the middleground involve in the orchestration of complex relationships and impact on technological development of firms?*	ASTRIDE; INPI, Eurasanté/NSL Clubster database	Empirical examination of *middleground* in the orchestration of complex relationships and impact on technological development of firms	*i. Zero-inflated Negative Binomial model* ii. *Structural equation model*
3	What explains the involvement of core actors in collaborative R&D and innovation project in a local innovation ecosystem? A middleground perspective.	*What explains the involvement of core actors in collaborative innovative project in a local innovation ecosystem?*	Eurasanté Agency website; ASTRIDE	Empirical investigation to determine if underground enhances the likelihood of 'core' actor involvement in collaborative R&D projects	*i. Network analysis* *ii. Fractional logistic econometric model*

Table 3:The main data and econometric models for each of the sub-studies

3.4 Data source

The empirical analyzes in this thesis are based on set of economic, innovation and relational indicators. Thus, economic, innovative activities/performance and relational variables are included in the database. The construction of database, the sample selection and the description of the datasets are discussed in the sub-sections below.

3.4.1 Construction of the database

Driven by the research objectives to provide empirical evidences, the thesis sourced secondary data from ASTRIDE Hauts-de-France Innovation Development database, INPI (National Institute of Industrial Property database) and official websites of Eurasanté Agency.

Hauts-de-France Innovation Development (HDFID) is the regional innovation agency in the region. It is in charge of leading and coordinating the support system for innovation processes, the creation and acceleration of innovative companies, the research and innovation networks, assistance in setting up innovative and performance projects, assistance in the design and the implementation of regional innovation, economic development and research strategies and policies.

The ASTRIDE[15] database is a collaborative information system, designed and managed by Hauts-de-France Innovation Development Agency (HDFID), providing a large range of data on almost the quasi-totality of companies in Hauts-de-France and updated yearly - about all sectors and innovation parks in the Hauts-de-France Region. For instance, in 2017 the Astride database contained data on 243,215 companies out of 281,038 companies identified by INSEE (87%)[16]. ASTRIDE provides database for the network of regional innovation stakeholders, providing information and data on firms/organizations including high potential SMEs in the region. Other information and data on regional firms provided by ASTRIDE include:

- Information on the activities (visits, services) carried out by the support organizations
- Company's financial data and intellectual property
- Company's participation in regional/national innovation initiatives/activities
- Company's innovative potentials assessed by the *Innoscope* methodology
- Platform for collaborative work (project management, partnership etc)

For instance, it provides information about economic and structural characteristics of companies and organizations, their collaborative projects, their innovation potential, their

15 https://ssl.astride.fr/acl_users/credentials_cookie_auth/require_login?came_from=https%3A//ssl.astride.fr/
16 https://www.insee.fr/fr/statistiques/4197529/?geo=REG-32

collaborations with other actors within and outside the region and public support they receive. Collection of the data, which feed the Astride database is ensured by all the research innovation networks and organizations involved in the animation of network actors, orchestration of relations between actors, technology transfer and support for innovation process. We can cite Poles of competitiveness, SATT, Innovation Parks agencies, business incubators and accelerators agencies, universities, business clusters agencies etc, which provide data about their activities and their members' activities related to innovation and economic activities. Information could be provided directly by the firms or organizations through their account in the regional website. Astride database source some data from INSEE about economic characteristics of companies and financial data about their annual activities; and from INPI about patents and IP activities.

Finally, the official website of Eurasanté Agency provides data on collaborative R&D project. This data represents the collaborative R&D projects supported by Eurasanté and its Competitiveness Cluster. We found data for European project, ANR projects (National research Agency) and FUI projects (Fonds unique interministériel). Collaborative R&D projects indicate formal relations that officially engage actors within the innovation ecosystem to work together through a given project.

INPI on the other hand, is a public institution under the administrative supervision of the ministry of industry in France, with the responsibility to keep information concerning industrial property such as patents and trademarks of innovators and companies. The INPI database provides data about firm patents. Patent data were used in the thesis to access not only the number of patent but also the technological diversity. The number of IPC4-digit in the patent portfolio is used to proxy technological diversification.

The study also used some documentary data to trace the history and development trajectory of innovation ecosystem of Hauts-de-France region and critically examine the role of regional policy in its development. The study explores three Regional Innovation Strategy documents during the period 2005-2020 of the former Nord-Pas-de-Calais region and master plans of the Lille Metropolis. The thesis also explores annual activity reports of Innovation parks executive committee and the annual activity reports of regional innovation agency (HDFID). For the documentary research, the thesis also uses information from research programs such as the POPSU (Project Observation Platform and Urban Strategies) that have observed the evolution of the region for the last decade. The documentaries provide us with information about the adaptation processes of Hauts-de-France region, its industrial past and repositioning relating to the development of the Innovation ecosystems, centering around the innovation parks, and their missions. They also allow us to understand the number or nature of new technological domain that these innovation parks develop and how the specification of the region evolved since 2004. They further allow us to identify the technological specialization of innovation parks and how the specialization of the region evolved since the early 2000's.

3.4.2 Sample and data collection

We draw on different databases, Astride and INPI and official website of Eurasanté Agency, for the construction of our dataset. The first sub-study used a cross-section data on n = 431 firms drawn from Astride and INPI databases. Aware of particular challenge of selections bias, the dataset includes both companies that belong to the ecosystem and those that do not. Firstly, we focus only on companies that publish patents during the period of 2000-2017 and are located in the Hauts-de-France region. We found about 1,233 have complete data on INPI database, mainly data about IPC Code. Second, we cross the data from INPI with the Astride database. We consider firms in the region that are part of two Innoscope evaluations: the 2013 and 2017 Innoscope evaluations (see Article 1). Astride database provides data about *Innoscope score,* an indicator assigned to firm's innovative performance by Hauts-de-France Innovation Development Agency (HDFID) and sometimes used by the National Institute of Statistics and Economic Studies (INSEE) and the European Commission. We deleted firms that no longer exist and excluded firms that have incomplete data on other firm main characteristics. The final sample of 431 firms were used for the empirical analysis in the first sub-study[17]. Our test shows no significant difference between our sample and the rest of the data (see appendix D1).

The second sub-study focused on Eurasanté healthcare ecosystem. Eurasanté ecosystem is the most developed ecosystem in Hauts-de-France with information concerning their collaborative projects, their innovation potential, their participating in events, their collaborations with other actors within and outside the region and the economic and structural characteristics of companies and organizations. We found 661 actors involved in the *Eurasanté* ecosystem (including actors outside France). These companies and organizations are either located in the innovation park, members of the three main networks, or interact with other actors through innovative projects (since 2009). Crossing these data with ASTRIDE database, we found a sample of 277 actors with complete data on other firm characteristics, including participation

17 Missing values reduces sample size. If missing values are not systematically created, that is, they are random, then the representativeness should not be affected (Sun et al., 2020)

in events for the analysis. There is no significant difference between our sample mean (see appendix D2). The discussion on what constitutes a sufficient sample size for regression analysis continues in the literature. However, the commonly accepted rule is at least 10 samples for each independent variable. Thus, our sample size is sufficient considering the number of our variables.

To examine if underground influences 'core' involvement in collaborative project, the third study focused on Eurasanté ecosystem and identified about 70 R&D projects labelled between 2009 and 2020. The 70 projects have 409 actors/participants (who collaborated in R&D projects) which include both firms and research organizations/universities.

Chapter 4: Empirical Sub-Studies

Article 1. Local Innovation Ecosystem: structure and impact on adaptive capacity of firms

Abstract

Focusing on the Local Innovation Ecosystem in Hauts-de-France region (France), the aim of this paper is to analyze how the ecosystems affect the adaptive capacity. First, we show these local innovation ecosystems are based on *Innovation Parks*. They promote knowledge development and innovation processes by bringing together heterogeneous agents such as research laboratories, technological structures, finance organizations, brokers, start-ups, and companies within a complex interacting and strategic context. Second, we use econometric models to test the impact of these local innovation ecosystems on the innovativeness and technological diversity of firms viewed as components of adaptive capacity. Our results show that firms belonging to local innovation ecosystems centered on innovation parks are both more innovative and more technologically diversified than others. Our study suggests further empirical research in order to specify links between the most relevant characteristics of the innovation ecosystem and the firm's adaptive capacity.

1. Introduction

Our paper aims at analyzing the ecosystem's impact on firm's adaptive capacity since, in our opinion, it is precisely this linkage that gives the concept of innovation ecosystem a greater scope compared to other concepts such as clusters. In fact, recent decades have witnessed a general trend towards the development of cluster-based innovation policies (Borras and Tsagdis, 2008; Lucena-Piquero and Vicente, 2019; Menu, 2012). The main objective of these policies has been to sustain regional competitiveness through the development of innovation capabilities (Teece 1986) in order to create regional dynamics that would provide growth and wealth in different territories. The French 'Pôle de Compétitivité' policy can be seen as a reflection of the European promotion of clustering, reinforced by the communication of the European Commission on European industrial policy in 2010. The European Cluster Observatory, Cluster Excellence, Cluster Internationalization, Cluster and Emerging Industries are tools provided at the European level in order to support regional policies regarding the promotion of clusters. One of the assumptions underlying these policies is that, by favoring connections between economic agents, they would encourage the emergence of clusters – a cluster being the artefact of a successful regional innovation dynamics. In fact, these policies often take the shape of state-supported cluster initiatives (Fromhold-Eisebith and Eisebith, 2005; Kowalski and Marcinkowski, 2014) defined as 'public-private initiatives set up and financed to strengthen clusters' (Lindqvist et al., 2003). Although most policies promote collective dynamics of innovation and complementary asset-building through the development of cooperation among different actors (see e.g., Porter 1998; Newlands 2003), they can vary in their results and successes.

As a matter of fact, declining clusters indicate that the economic advantages from cluster dynamics are not permanent as cluster lifecycle is related to the respective technological specialization or technological regime (Zucchella, 2006). During shocks, clusters do not provide sufficient mechanisms to lead adaptation processes at firm and regional levels. Moreover, empirical and theoretical studies have failed to explain how existing clusters facilitate sustainable transition and affect regional and firm adaptation when shocks occur (Bergman, 2008; Saxenian, 1996). Therefore, policy makers and economic actors need new tools and new frameworks to address transition and adaptation issues. In fact, an important question to ask of regional policies is how could those policies be able to overcome shocks and provide economic resilience? Resilience is the capability of a region to resist, recover, reorient, and renew itself following a shock (Martin, 2011).

The concept of an innovation ecosystem, derived from biological science and adopted into business studies by Moore (1993), is undoubtedly viewed by many authors – and politicians – as a corner-stone of the renewal of regional policies in order to provide economic resilience (e.g., Philips and Ritala, 2019).

The term, 'innovation ecosystem' refers to adaptation processes that are considered crucial for sustainable transition and transformation of regions. Therefore, recent regional innovation-based growth policies favor the ecosystem approach (eg Warwick, 2013; Robaczewska et al., 2019). An 'innovation ecosystem' could be defined as a complex adaptive and dynamic system characterized by interactions among heterogeneous agents in order to foster the development of new products and services (Moore, 1996; Porter, 2000; Russell and Smorodinskaya, 2018). Hence, beyond this strategic role of facilitating the emergence and development of new technologies and innovation processes, works on innovation ecosystems put the focus on coevolution and adaptation of actors and institutions (Schaffers et al., 2012). Adaptation process and coevolution of actors in a complex and dynamic environment are often pointed out as one of the main elements that legitimize the innovation ecosystem framework and its specificities over the more conventional clusters framework (Iansiti and Levien, 2004; Ritala and Almpanopoulou, 2017). Moreover, it is the ability of the innovation ecosystem to resist and/or to overcome shocks through actors' processes of adaptation and evolution that gives it its greatest explanatory power compared to other related theories such as regional innovation systems, clusters or networks.

But, while theoretical studies emphasize adaptation as one of the main dimensions of the innovation ecosystem (de Vasconcelos Gomes et al., 2018), we have not found empirical studies that specifically highlight the question of how innovation ecosystems foster adaptation of firms. Our study is a first attempt to fill this gap and focus on the relation between the innovation ecosystem and the adaptive capacity of firms. As a firm's adaptive capacity implies its ambidexterity (Lange and Schüßler, 2018), it could be theoretically linked to innovativeness and diversity (c.f. supra). Thus, the main research question we address is: *do innovation ecosystems really affect firms' innovativeness and diversity?*

Therefore, in this paper, we develop an econometric model that estimates the ecosystem's impact on the firm's adaptive capacity. The remainder of the paper is organized as follows: In section 2, we position our contribution in the literature on innovation ecosystems and develop the hypotheses we wish to test. In section 3, we present the case study and the data, and we explain why we focus on innovation ecosystems in Hauts-de-France. In section 4, we detail the variables and econometric models and discuss the empirical results. Our principal contributions are summarized in the conclusion.

2. Theoretical Backgrounds

2.1 Innovation ecosystem: a new framework beyond networks?

The concept of the innovation ecosystem, first adopted into business studies (Business Ecosystem) in the early 1990s by Moore (1993) and further integrated into innovation studies by Adner (2006), has today become part of innovation policy (Kapoor, 2018). The literature on innovation ecosystems contains many definitions of this concept but all of them highlight collaborations and interdependence among diverse actors to accelerate technological development and innovation (de Vasconcelos Gomes et al., 2018). The regional/local innovation ecosystem approach is an extension of the work of Saxenian (1994), highlighting the territorial dimension in the dynamics of innovation ecosystems. Therefore, this approach has its roots in clustering theories and regional innovation systems (Porter, 1990, Cooke, 1992), which explains the central role of geographical proximity and interactions between actors, networks and institutions in the development of innovation process. But, despite a growing interest in Moore's work (1993, 1996) and the 'ecosystem' metaphor in the last decade (Audretsch et al., 2018), the literature criticizes the inconsistent use of the term 'ecosystem' and its vague definition that adds no additional value to the scholarly discourse compared to existing concepts like 'cluster initiatives', 'triple-helix initiatives' or 'network analysis' (Brown and Mason 2017).

But the innovation ecosystem characterized by interconnected and evolving agents, and top-down and bottom-up initiatives for developing innovations (Schaffers et al., 2012), goes beyond strategic relationships and interactions in clusters (Autio and Thomas, 2014). Indeed, the innovation ecosystem integrates an evolutionary and ecological dimension, emphasizing co-evolution and adaptation of actors, institutions, and knowledge base. One of the most important aspects of an innovation ecosystem is its sustainability capacity i.e., the capacity to produce change in its structure, create new or efficient methods, or generate new contents and values in response to different shocks (Bristow and Hearly, 2015). It is the sustainability characteristic of the innovation ecosystem that gives this concept a better explanatory power compared to more traditional concepts of clusters (Boyer, 2020). In order to integrate these dimensions, the characteristics of the innovation ecosystem need to be considered.

2.2 Innovation ecosystem characteristics and sustainability

With the goal to go into the black box of innovation ecosystem sustainability, a first characteristic of innovation ecosystem pointed out by several studies (Russell and Smorodinskaya, 2018; Tsujimoto et al., 2018) is that it includes more relationships between diverse agents with different attributes, behaviors, and strategies. Indeed, in regional studies, diversity has specifically been linked to sustainability (Bristow, 2010; Iansiti and Levin, 2004). A more diversified system becomes more flexible to respond to shocks, providing a portfolio against shocks (Hassink, 2010). Diversity unlocks a region from a specific trajectory and enhances adaptability (Boschma, 2015). At firm level, diversity entails flexibility in responding to market changes (Kreiser et al., 2013), and diversification into a varied technological portfolio provides firms with the capacity to mitigate path dependencies (Quintana-García and Benavides-Velasco, 2008). Sustainability comes from the opportunity that diversification provides through a mix of resources for a new growth trajectory. As pointed out by Pinkse et al. (2018) and Suire and Vicente (2014), sustainability comes from continuity and adaptation and requires homogeneity and heterogeneity. Homogeneity ensures stability and growth.

Heterogeneity implies openness and diversity for adaptation and sustainability of any cluster. Moreover, the necessity to mobilize a heterogeneous group of local actors for sustainability transitions is pointed out in several urban studies (Essletzbichler, 2012).

Looking at innovation ecosystem characteristics, a second aspect is pointed out by Russell and Smorodinskaya (2018) who focus on the complexity of relationships between actors in innovation ecosystem. They identify informational and communicational relations through which actors exchange ideas, novel information about new technologies, strategies, and new market trends. They also highlight 'cooperation and transaction relations' between autonomous actors, during which they create common rules to regulate their interactions and fields of activity or tackle common issues cohesively. They highlight collaboration where participants share information, resources, responsibilities and risks to jointly plan, implement, and evaluate a program of activities aimed at achieving a common goal. Indeed, in clustering theories, a number of studies argue that in order to respond to the complexity of the environment, clusters have to develop complex relationships with other actors. For example, we know that in order to avoid the lock-in phenomenon in existing clusters, regional policies implement new instruments and prompt clusters to engage in inter-clustering, that is, to develop ties with other clusters and build *global pipelines* (Bathelt et al., 2004). Indeed, global pipelines are presented as a way to tap into external sources of knowledge (Giuliani, 2007; Morrison et al., 2013), thus enhancing the innovative capacity of firms (Fitjar and Rodriguez-Pose, 2011) and the upgrading of clusters (Giuliani, 2011). In the same view, complex relationships (for example, relationships with agents characterized by social distance) in clusters are very important for sustainability, as pointed out by Boschma (2010), with his example of spinoffs that outperform regular start-ups. To sum up, complex inter-organizational relations are of central importance for sustainability transitions (Truffer and Coenen, 2012).

A third important characteristics of innovation ecosystem is found in research on new forms of organization. Indeed, the organizational structure of innovation ecosystem does not need to be embedded within sectoral or industrial boundaries. Innovation ecosystems promote cross-sectoral and cross-industrial innovation processes. Moreover, most of the works in business ecosystems and innovation ecosystems emphasize new forms of relationship based on digital platforms where networks with strong complementarities are created between heterogeneous actors from different sectors (Jacobides et al., 2018; Tsujimoto et al., 2018). Many works adopted the layered structure (core–periphery structure, triple-layer structure, triple-layer core–

periphery structure) to represent the business ecosystem or innovation ecosystem (Iansiti and Levien, 2004). Keystone firms, leaders and the main stakeholders of the innovation ecosystem are located at the core of the innovation ecosystem, where interactions are more complex and intense. An important contribution in this vein comes from works that focus on the relationship between formal and informal entities; on exploration and creativity as well as on exploitation and development which constitute the ambidexterity of the innovation ecosystem (Cohendet et al., 2014; Grandadam et al., 2013; Lange and Schüßler, 2018). According to these works, the innovation ecosystem has three main components (the upperground, middleground, and underground) that are in organic interaction. The underground of the innovation ecosystem refers to smaller players, the talented individuals, artists, informal collectives where new ideas and new trends originate, constituting the exploratory capacity. The upperground contains elements and actors who have standardization capacity in order to develop and exploit new paths of growth. The middleground takes the form of places, spaces, events or projects, and serves as a platform where talents and ideas are developed and transmitted to the marketplace (Coe and Bunnell, 2003; Hakason, 2005). The middleground provides an intermediation role, bringing together talented and creative actors and well-established actors. The performance and the sustainability of the innovation ecosystem depends on the quality of the middleground or the quality of the organic relationship between the formal and informal entities that foster coevolution and adaptive strategic context for innovation development (Coe and Bunnell, 2003; Cohendet et al., 2010). Moreover, studies in institutional economic geography emphasize the central role of formal and informal institutions in promoting sustainability transitions in local areas (Hansen and Coenen, 2015).

To sum up, the diversity and heterogeneity of agents, the complexity of relationships, and new forms of organization (underground, middleground, and upperground) are the main characteristics of innovation ecosystems, in contrast to more traditional concepts like clusters or networks. The strength of the innovation ecosystem in terms of sustainability is explained more effectively by these characteristics than by classical clustering analysis.

2.3 Innovation ecosystem sustainability and firms' adaptive capacity

But, if the three main characteristics of innovation ecosystem contribute to the sustainability of the system, how does it work at firm level? What are the transmission mechanisms? Our main idea is that the sustainability of the ecosystem is the result of firms' adaptive capacity. In fact, the innovation ecosystem provides mechanisms that enable actors to adjust their behaviors and strategies in order to deal with market and technological changes. Hence, our proposition:

Innovation ecosystems affect the adaptive capacity of firms.

The adaptive capacity of firms is linked to their ambidexterity (Cohendet et al.. 2014; Lange and Schüßler, 2018). Indeed, the sustainability of innovation ecosystem comes from both the continuous increase in value creation and the firm's ability to reorganize and adapt to market and technological changes (Boyer, 2020). Thus, the innovation ecosystem requires both exploitation and exploration capability to remain sustainable.

Concerning exploitations, we know that in innovation systems, market and technological uncertainty are lower and appropriability as well as perceived opportunities are better (Dosi, 1988). Moreover, knowledge externalities in a phase of exploitation of a technological domain stimulate R&D expenditures (Rondé, 2001) and the competitive cooperation of actors reduces transaction costs and increases efficiency in the ecosystem. As a result of lower transaction costs, lower uncertainty and better perception of opportunities, we expected that firms are more innovative in Innovation Ecosystem than outside. But in order to avoid lock-in phenomenon when the technological trajectory becomes mature, firms have to combine exploitation strategies with exploration strategies (Cohendet et al., 2014; Lange and Schüßler, 2018), that require co-creation, regeneration and restructuring of innovation ecosystem. Therefore, firms also have to innovate outside the boundaries of a technological trajectory. As firm's adaptive capacity is linked to both strategies, what is relevant is not only that firms are able to innovate or even that it innovates a lot, but that they are able to change their innovation behaviors. What is relevant to explain adaptive capacity of firms is the firms' aptitude to combine and move from exploitative innovations to creative innovations i.e. to change their innovation behavior. Hence, our first hypothesis:

Hypothesis 1: The innovation ecosystem positively affects firms' innovation processes.

Concerning more especially exploration strategies, this phase highlights the importance of creative class (Florida 2002) and diversity in the ecosystem. Individuals or collective actions of exploration of ideas and experimentation in a varied and uncertain environment are essential. Companies and organizations venture and explore new opportunities to cope with the external variability and prevailing conditions. Therefore, diversity and variety in innovations are essential for firms in innovation ecosystem in order to explore new trajectories (Saviotti, 1995).

Innovation Ecosystems provide efficient conditions for exploring opportunities for at least two reasons:

- Due to their specific characteristics (diversity of agents and complexity of relationships), they are able to bring new ideas and knowledge to the firms belonging to the system;
- Due to the special organization of ecosystems, agents in the upperground could tap into the underground's tank of ideas, creativity, and knowledge and transform it into new technological domains and market opportunities, thanks to the middleground intermediation. This process could, for example, take the form of spinoffs or start up creations.

Hence, our second hypothesis:

Hypothesis 2: The innovation ecosystem positively affects firms' diversity of innovation.

In order to go further, our research design is as follows:

- In the first step, we identify the main characteristics that confer to the innovation ecosystems more sustainability power compared to traditional clustering analysis and check for these characteristics in our case study.
- In the second step, as sustainability is linked to a firm's ambidexterity which implies being more innovative and diverse, we propose an econometric analysis to measure the innovation ecosystems' impact on these two variables.

In the next section, we present our materials in order to test these two hypotheses.

3. The Hauts-de-France ecosystem of innovation

3.1 Presentation and data sources

The region of Hauts-de-France (France) is a new French region created in 2016, from the merger of the Nord-Pas-de-Calais and Picardy regions. The Hauts-de-France region covers about 31,806 km^2 and is subdivided into five departments:[18] Aisne, Nord, Oise, Pas-de-Calais and Somme. Nord-Pas-de Calais was considered a declining region in the 1970s due to the failure

18 The French departments correspond to the European NUTS 3 regional level.

of its main economic industries – textiles, metallurgy, and coal. From 2000, efforts have been made to develop new tools in order to activate sustainable transition based on innovation. One of the main innovative initiatives was to co-construct ‘innovation parks’ (or *sites of excellence*) through public–private collaborations in order to support the regional transition and the dynamism of new industrial specializations. The innovation parks have two major objectives: to stimulate development and growth of new and high-tech firms; and to promote regional economic development and growth through innovation and technological development. As things progress, innovation parks have become the core of the local innovation ecosystems in Hauts-de-France. For example, the digital and Internet of Things ecosystem centered around EuraTechnologies park*;* the health and nutrition ecosystem centered around Eurasanté park*;* the green chemistry and agro-industry ecosystem centered around Haute Borne park; and the fashion and textile ecosystem centered around CETI / Uptex park.[19]

The local innovation ecosystems centering around innovation parks in the Hauts-de-France region are the result of more than 20 years of collective action (bottom-up initiatives) and public policy orientations to foster transformation of the region. They bring together heterogeneous agents like research laboratories, technological structures, finance organizations, brokers, start-ups, companies, and third places (fablabs, coworking spaces, living labs) within an interacting and strategic context (see section 4.1).

Hence, in this study, we describe the main properties of the local innovation ecosystems elaborated around innovation parks. To do this, we use data based on documentary research and a regional database.

First, we carried out documentary research. We identified three regional innovation strategy documents for the period 2005–2019, from the former Nord-Pas-de-Calais region and master plans of the Lille Metropolis (2001). We also analyzed the annual activity reports of innovation parks’ executive committees and the annual activity reports of the regional innovation agency. These documents give relevant information about the emergence of the local innovation ecosystems around the innovation parks, their structure and their main components. They also allow us to identify the new technological specializations carried by the innovation parks and how the specialization of the region evolved since 2004.

19 Since February 2019, CETI and Haute Borne have merged to give birth to Euramaterials

Second, we use an original database (ASTRIDE). This database is the collaborative information system designed and managed by Hauts-de-France Innovation Development (HDFID), the regional innovation agency. This database contains data for more than 200,000 companies and organizations, and contains information about all innovation parks, innovation networks, and collaborative projects for more than 20 years.

3.2 Diversity, complex relationships, and new forms of organization within local innovation ecosystems in Hauts-de-France

As pointed out in section *2.2*, innovation ecosystems – unlike the more traditional concepts of clusters or networks – are characterized by the diversity of agents, complexity of relationships, and new forms of organizations.

3.2.1 Diversity of agents and complexity of relationships

The local innovation ecosystems in Hauts-de-France promote strong and complex relationships (formal and informal), feedback, interactions, and fertilization between a diversity of actors and companies within one or more technological fields. They uphold knowledge development and management by bringing together heterogeneous agents from different sectors, like research laboratories, technological structures, finance organization, brokers, start-ups, and companies. Table 2 presents the main characteristics of the ecosystem diversity.

Three main networks whose focal organizations are located in the innovation parks could be found. A network around Pole of Competitiveness, a Business Clusters network and an Innovation hub network.

First, the innovation parks house the executive committees and team managers of the Pole of Competitiveness.[20] The Pole of Competitiveness promotes relationships between actors (university, research organizations, and companies) mainly through innovative or R&D projects, facilitation or creation of networks (inside or outside of the innovation park), and the labelling and financing of collaborative innovative projects. In our case, we found NSL for Eurasanté, Picom for EuraTechnologies, Euramaterials for both Ceti and Haute-Borne (formerly Uptex for Ceti and MatiKem for Haute-borne). For example, the Pole of Competitiveness NSL (Eurasanté) from 2006 has labelled 248 R&D projects and run a network of about 150 companies and 47 academic and research structures.[21] These projects most times foster *triple helix interactions* that ensure acceleration of knowledge generation, knowledge transfer, and innovation development.

Second, the innovation parks house the 'Business clusters' that in the context of the local innovation ecosystem in Hauts-de-France are more oriented towards market-push innovation. We can cite, for example, Clubster Santé at Eurasanté park, CITC-IOT cluster at EuraTechnologies park, and Clubtex at Ceti / Uptex park: they focus mainly on business-to-business relations and value capture. These relations could be supplier and customer relations, and informational relations (technology intelligence, competitive intelligence). They also develop collaborative platforms in order to share knowledge, information, and best practices, and to develop complementary products.

Third, each innovation park houses an innovation hub which has three components: the business incubator, the business accelerators and business centres. The innovation hubs foster relationships manly between start-ups, large companies, financial organizations, and R&D organizations. Innovation parks in Hauts-de-France are mainly based on incubation and acceleration of companies to support creation and acceleration of innovative companies and renew existing business clusters.

3.2.2 Sectoral diversity and new forms of organization

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20 Not all the innovation parks house a Pole of Competitiveness executive committee, but the majority of parks do, or at least have a representative structure of competitiveness cluster. Moreover, members of Pole of competitiveness could be inside or outside of the innovation park

21 https://pole-nsl.org/le-pole-nsl/chiffres-cles/#1482160916642-b5952d7e-2e1c

We use the ASRTIDE database to identify companies and organizations involved officially in the local innovation ecosystem centering around the innovation parks (companies or organizations that are either located in the innovation park, members of the three main networks, or interact with these actors through innovative projects); and to characterize the sectoral diversity of these innovation ecosystems.

To do this, we use measures of sectoral diversity and perform a structural network analysis for the four main local innovation ecosystems (the digital and IoT ecosystem around EuraTechnologies park, the health and nutrition ecosystem around Eurasanté park; the green chemistry and agro materials ecosystem around Haute Borne park; the fashion and textile ecosystem around CETI park).

To measure sectoral diversity, we use Code NAF700, which is currently used in France to identify the main sectors, and we propose two indicators:

The Shannon Index Entropy = $-\sum_{i=1}^{n}(P_i)\ ln\ (\frac{1}{P_i})$

where P_i is the proportion of firms in the local innovation ecosystem that belong to *ith* sector

The Modified Herfindahl Index = 1 - $\sum_{\mathrm{i}=0}^{\mathrm{n}} S_{\mathrm{i}}^2$

where S_i is the share of possible sectors in the local innovation ecosystems.

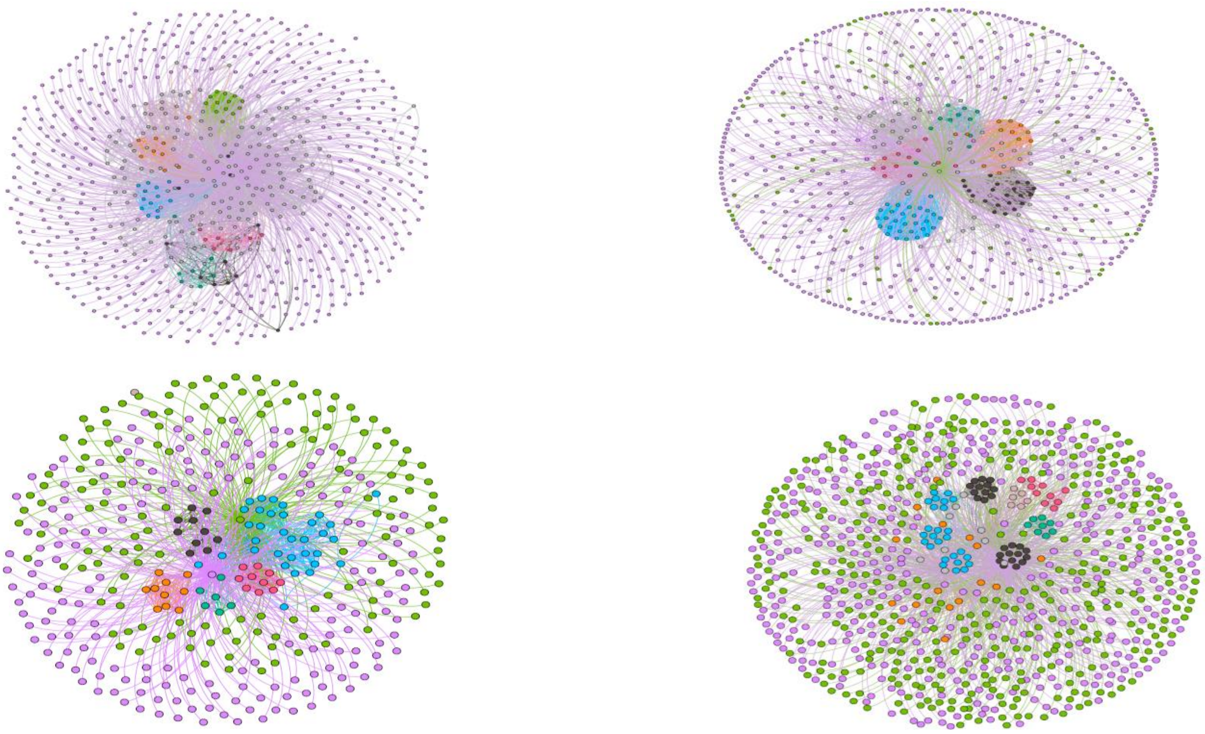
To perform a structural network analysis for the four main local innovation ecosystems for new forms of organization, we use data from Astride database about collaborations between companies and/or organizations through patents, innovation projects, business cluster relations, pole of competitiveness interactions. We also use the Gephy software and the Fruchterman Reingold algorithm, which allow us to move the elements of the network from core to periphery according to the centrality of these elements. We stop the execution of this algorithm when it is possible to identify clearly the core and the periphery of the structural network.

The local innovation ecosystems in Hauts-de-France host a sectoral diversity of actors (Table 4). Indeed, in all the ecosystems, the Shannon Index Entropy and the Modified Herfindahl Index show over 50% of the maximum value and indicate a high sectoral diversity. For instance, all 10 sectors in the INSEE classification are represented in the health and nutrition ecosystem (around Eurasanté park) and the green chemistry and new materials ecosystem (around Haute Borne park) with the maximum Modified Herfindahl Index of 0.9. Thus, the MHI of 0.80 and 0.84, respectively indicate a high level of sectoral diversity in these Innovation Ecosystems. For the digital and IoT ecosystem (EuraTechnologies park) and the fashion and textile ecosystem (CETI park), we found a Modified Herfindahl Index of about 0.64 and 0.69 for a maximum value 0.88 and 0.89, respectively.

A core-periphery perspective result of structural network analysis, using the Fruchterman Reingold algorithm from Gephy, allows us to confirm that innovation parks are the core of the local innovation ecosystem in Hauts-de-France (Fig 5, Table 5). Most of the companies or organizations with a strong centrality are located in the innovation park or are members of the three main networks whose focal organizations are located in the innovation parks.
The statistics about the structural characteristics of the social networks (degree centrality, betweenness centrality, closeness centrality) within the local innovation ecosystems show very dense networks and point to complex relationships between actors involved in these innovation ecosystems (table 5). However, we found strong variability (standard deviation) that indicates there are companies or organizations that are in the core of the ecosystems and others at the periphery (core-periphery layered structure).

Health and Nutrition Ecosystem (Eurasanté Park)

Green chemistry and agro-sourced material ecosystem (Haute Borne Park)



Fashion and textile ecosystem (Ceti/ Uptex Park)

Digital and IoT Ecosystem (Euratechnologies Park)

Figure 5: Structural Network of Local Innovation Ecosystem (core-periphery structure)

A middleground (made up of spaces, places, communities, and events) that connects the upperground and the underground could be found in the local innovation ecosystems in Hauts-de-France (table 2). For the upperground, there are research laboratories, technological structures, finance organizations, and companies.

The components of the middleground of the local innovation ecosystem in Hauts-de-France are mainly found in the innovation park. Innovation parks are clearly the emblematic places for the local innovation ecosystem in Hauts-de-France. They house openlabs, fablabs, makerspaces, coworking spaces (for example, Atrium for EuraTechnologies, the Saga Concept Room for Eurasanté). These spaces or places foster open innovation and informal interactions between actors in the local innovation ecosystem.

Many events are organized within the innovation park to reinforce coherence, a shared vision, and above all, develop new business opportunities between the diversity of actors. The main events organized in the innovation parks include conferences, hackathon (co-design, collaborative, creative events that sometimes have an artistic or hacking dimension) and speed dating (event that uses method of finding a partner for innovation project through short conversation). Others include after-work (event that allows people to meet together, after work, to discuss with others about new ideas, new projects and new experimentation), start-up weekend (event that allows 'start-uppers' to share their ideas, business models etc. with other 'start-uppers' and financing actors or experienced businessmen). Within EuraTechnologies, for example, about 500 events take place in a year.

Finally, several different communities evolve around innovation parks. For example, communities of hackers/makers, such as *Catalyst / Anis* (collective of makers in digital and social innovation); communities dedicated to transition and sustainable development (*Transition 2030*), and *fashion green* communities dedicated to new fashion design and technical textiles.

	Health and Nutrition Ecosystem (Eurasanté Park)			Digital and IoT Ecosystem (Euratechnologies Park)			Fashion and textile (CETI/Uptex Park)			Green chemistry and agro-sourced material ecosystem (Haute Borne Park)		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Sectoral Diversity (Shannon Index Entropy)	1.86	0	2.30	1.32	0	2.08	1.54	0	2.20	1.98	0	2.30
Sectoral Diversity (Modified Herfindahl Index)	0.80	0	0.9	0.64	0	0.88	0.69	0	0.89	0.84	0	0.9
Sector represented within each Local Innovation ecosystem	• Agriculture, forestry and fisheries • Construction • Financial and insurance activities • Information and Communication • Manufacturing, mining and quarrying and others • Professional, scientific and technical activities and administrative • Public administration, education, Human health • Real estate activities • Wholesale and retail trade, transport, accommodation and food services • Other service activities			• Financial and insurance activities • Information and Communication • Manufacturing, mining and quarrying and others • Professional, scientific and technical activities and administrative • Public administration, education, Human health • Real estate activities • Wholesale and retail trade, transport, accommodation and food services • Other service activities			• Construction • Financial and insurance activities • Information and Communication • Manufacturing, mining and quarrying and others • Professional, scientific and technical activities and administrative • Public administration, education, Human health • Real estate activities • Wholesale and retail trade, transport, accommodation and food service • Other service activities			• Agriculture, forestry and fisheries • Construction • Financial and insurance activities • Information and Communication • Manufacturing, mining and quarrying and others • Professional, scientific and technical activities and administrative • Public administration, education, Human health • Real estate activities • Wholesale and retail trade, transport, accommodation and food services • Other service activities		

Table 4: Summary and statistics of the sectoral diversity within Local Innovation Ecosystem in Hauts-de-France

	Health and Nutrition Ecosystem (Eurasanté)	Digital and IoT Ecosystem (Euratechnologies)	Green chemistry and agro-sourced material ecosystem (Haute Borne)	Fashion and textile ecosystem (Ceti/ Uptex)
Number of companies	661	479	419	234
Number of ties	3618	1714	3166	1124
Average degree centrality (St. dev)	5.47 (15.11)	3.59 (14.14)	7.56 (15.69)	4.78 (11.47)
Average betweenness, centrality (St. dev.)	599.26 (6483.65)	403.95 (4995.72)	180.69 (3222.28)	174.16 (1537.04)
Average closeness centrality (St. dev.)	0.36 (0.04)	0.38 (0.04)	0.32 (0.03)	0.41 (0.04)
Clustering coefficient/Cliquishness (St. dev.)	0.34 (0.45)	0.20 (0.40)	0.33 (0.46)	0.32 (0.46)

Table 5: Structural characteristics of the social networks within the Local Innovation Ecosystem

4. Empirical analysis

For the econometric model we use the INPI database (National Institute of Industrial Property) to identify all companies in Hauts-de-France that obtained patents from 2000. We found 1233 companies. We deleted all companies that no longer exist. We cross-referenced the results from the INPI database with the Astride database. In the end, we found 431 companies that have complete data for our analysis.

4.1 Econometric model

The main objective of the study is to assess the impact of the local innovation ecosystem on the adaptive capacity of the regional firms. To do this, we propose two models to test our two hypotheses. We use innovative performance and technology diversity as proxies for adaptive capacity.

First, we use a Logistic model to assess the role of the innovation ecosystem on firms' innovation performance. The choice of logistic model is inspired by the binary nature of our dependent variable. In the second model, we employed an Ordered Logistic model to assess the impact of the innovation ecosystem on firms' technological diversity. Again, our dependent model is categorized and ordered in three categories, hence the Ordered Logistic model.

Specification of the model:

The first is a logistic model and can be written in the following mathematical form

(1) $Y_i = ln(\frac{P_i}{1-P_i}) = \alpha + \beta X$

where Y_i is a measure of the capacity of firm *i* to innovate, and *X* the vector of independent variables.

Dependent Variables: Innovation performance and diversity of innovation

In Hauts-de-France *Innoscope* scores are used as a proxy to assess firms on their *innovation potentials* (or innovation performance) (Marmuse and Godest, 2008). This proxy is used by HDFID (Regional Innovation Agency), INSEE (National Institute of Statistics and Economic Studies), and the European Commission.[22] The scores help to grade firms into four innovation states – *non-innovative* (low innovation performance), *creative*, *efficient*, and *innovative* (high innovation performance). To assess the innovation performance of companies, the *Innoscope* uses two series of measures. Firstly, the exploitation of the innovation potential (performance perspective) that is based on seven ratios which measure the performance of the companies (productivity of labour, productivity of capital, value added rate, the return on equity, the rate of self-financing capacity, the rate of gross operating profit, and the overall performance of the company). Secondly the creation of innovation potential (growth perspective). The ability to create potential is, for its part, represented by elasticity ratios related to the speed of growth of the companies. This measure allows a given company to be referenced with data about other companies from the sector to which it belongs. Six ratios are used: elasticity of turnover, elasticity of gross operating profit, elasticity of net fixed assets, elasticity of added value, workforce elasticity, and operating cash profit.

According to these two main axes, exploitation of the innovation potential and creation of innovation potential, the companies are regrouped into four categories: Non-innovative, Creative, Efficient and Innovative states.

The firms' evaluations are biennial, and firms can move from one *Innoscope* state to another in subsequent evaluation. For example, a creative firm can move to an innovative state and a non-innovative firm has the possibility to move either to an efficient or a creative state in subsequent assessment. Firms however, have the possibility to move to a lower *Innoscope* status. In this study, we compare the *Innoscope* scores of two different years (2013 and 2017, the latest evaluation available). We posit that maintaining a higher *Innoscope* score or moving from a

22https://www.ideum.de/download/KNOWHUB_Handbook_Challenges_for_Smart_Specialisation.pdf
http://www.epsilon.insee.fr/jspui/bitstream/1/20598/1/P13_144.pdf

lower status to a higher status indicates firm innovativeness. The four-year period allows the firms to adjust their strategy and capability.

Measuring firm diversity of innovation (technological diversity)

To measure technological diversity, we follow Gkotsis et al., (2018) in classifying firms in terms of technological diversity, using the number of IPC4-digit codes in the firms' portfolios. The IPC code shows the technological classification of a patent which describes the technical content. The highest level of IPC classification (IPC1-digit) shows the eight main sections of the classification (A-H) while the IPC4-digit shows the specific technological domain. It is believed that a more technologically diversified firm incorporates a greater number of IPC4-digit patents in its patent portfolio, indicating its capacity to belong to a more technological field. Some studies, however, have used the probability of including other technological fields in their core technology to measure technological diversification (Breschi et al., 2003).

In our first model, *INNOV* takes the value 1 if a given firm moves from a lower *Innoscope* score to a higher *Innoscope* score or has maintained a higher *Innoscope* score, and 0 otherwise.

We denote *P* = P(INNOV= 1) the probability that a given firm moves from a lower score to a higher score or has maintained a higher *Innoscope* score.

We assume a linear relationship between the predictor variables and the log-odds of the event that INNOV = 1.

Our model 1 becomes:

$$Y_i = \ln\left(\frac{Pi}{1-Pi}\right) = \alpha_0 + \beta_1 InP + \beta_2 Age + \beta_3 Aid\_region + \beta_4 Export + \beta_5 Loc + \beta_6 Size + \beta_7 Sector + \varepsilon_i$$

InP is a binary, 1 being an official member of the local innovation ecosystem around the innovation parks; and 0, otherwise. *Age* refers to age of the firm; *Aid region* refers to the level of regional support received by a firm; *Export* refers to the share of exportation in the turnover of the firm; *Size* refers to firm size, *Loc* refers to the firm's location; and *Sector* refers to the sector to which the firm belongs.

For the second model, to ascertain the effect of our explanatory variables on different levels of technological diversity, we categorize firms according to the number of IPC4-digit patents in their portfolios: we classify the firms into three categories to show the levels of technological diversity – low, medium and high. These categories are built by transforming a continuous variable (*N_IPC4*) to a categorical variable (*Techdiv*) depending on its distribution (see appendix A1 and A2). The categories of Techdiv are built as follows:

Techdiv low: Number of IPC4-digit ranging from 1 to 2

Techdiv medium: Number of IPC4-digit ranging from 3 to 6

Techdiv high: Number of IPC4-digit above 6

Finally, we use the Ordered Logistic regression to estimate our second model. Hence, the Ordered logit model is employed to estimate the probability of each category outcome, where the log-odds of the outcomes are modelled as a linear combination of the explanatory variables.

The ordered logit model is specified as:

$$Z = \beta^{\tau} X_i + \epsilon_i$$

where Z is the unobservable variable, β is a vector of estimable coefficients, X is a vector of explanatory variables, and ϵ_i is the error term.

Each of the observed ordinal variable of levels of technological diversity can be obtained as:

$S = 1 \; if \; Z \leq \mu_0$ (Low diversity)

$S = 2 \; if \; \mu_0 < Z \leq \mu_1$ (Medium diversity)

$S = 3 \; if \; \mu_1 < Z$ (High diversity)

where S is the observed variable reflecting the levels of technological diversity, and μ_i are the thresholds or estimable parameters that define the levels of technological diversity.

Justification and Measures of Independent variables.

The main explanatory variable in our study is *InP*, which indicates belonging to the local innovation ecosystem that centers around the innovation parks (see section 3.2.2). This variable measures the contribution of the local innovation ecosystem to the innovation performance and technological diversity of firms as proxies for firm adaptive capacity. Collaboration in network entails knowledge creation and exchange and technological innovation rarely discards the importance of this. Innovation network arrangement is said to play key role in innovation processes (eg Powell and Grodal, 2005; Pavitt, 2005). We include the network closeness centrality in the model.

We understand that there are firm-specific characteristics (size, age, internationalization), locations and sectoral specificities that are capable of affecting a firm's innovative performance and its technological diversity (Gaussens and Movahedi, 2016; Love and Ropper, 1999; Shefer and Frenkel, 2005).

InP is a binary: 1 if a firm is a member of local innovation ecosystem centered around the innovation parks; and 0 otherwise. *Size* refers to firm size. In order to emphasis on specific effects when firms belong to specific categories (micro, small, medium or large), we use two measures for Size: a continuous variable *(SIZE)* as well as a categorial variable *(T_SIZE)* (INSEE[23] classification). *Age* is a continuous variable that refers to firm age. Finally, *Loc* and *Sector* are dummy variables in order to control for location and sectoral heterogeneity. We use INSEE classification for the sector to which a firm belongs and the five departments of the region to control for firm location in the study (appendix A1).

We are aware that public support is often critical in fostering firms' innovative activities (Doh and Kim, 2014). We use an indicator *Aid_Region*[24] from the regional Innovation Agency (HDFID) of Hauts-de-France region, which shows the level of regional support received by a given company/firm for innovative activities. This is a scale variable 0 to 5, with 0 if the company does not receive regional support and 5 the highest level of support (appendix A2). These supports are not linked only to financial assistance, but also to technical support. Another variable, *Export* represents the ratio of a firm's exports to their turnover. This variable captures the effect of external market exposure on the adaptive capacity of firms.

We test for relational effect on the adaptive capacity of firms. To account for this, we characterize the network identifying the centrality measures. We identify the position of actors within the network, using the centrality measures (degree, closeness, betweenness, eigencentrality). Degree centrality indicates the number of ties that link one node to other nodes with the network. Closeness centrality shows the distance between a node and other network

23 The National Institute of Statistics and Economic (INSEE) is the main French organism that studies collects, analyzes and disseminates information on the French economy and society.

24 Aid_Region is used to account for the influence of external aid on the adaptive capacity of firms. Moreover, Aid_Region is correlated with firms R&D expenditures and probably Human Capital because regions only grant aid if firms are already engaged in an R&D process. Furthermore, the level (1-5) of Aid_region depends on the R&D investment of companies. For instance, the score 5 of Aid_region is intended to companies that received both finance and technical support for developing R&D project with European or global scope. The variable Aid_region partially reduces the problem of some omitted variables that our work suffers like R&D expenditures and Human Capital.

nodes. Betweenness centrality shows the intermediary position of an actor. Betweenness centrality shows how much control an actor has in the information flow in the entire network (Wasserman and Faust, 1994). Eigen centrality on the other hand extends the degree centrality to include how well a node is and how many links their connections have within the network. Clustering coefficient shows the proportion of existing links in the number of all possible links in the direct neighborhood (Watts and Strogatz, 1008). Clustering facilitates information exchange and increases information exchange capacity in the network (Schilling and Phelps, 2007).

To avoid multicollinearity problem, we include the closeness centrality normalized, degree centrality normalized at the firm level and the average betweenness centrality at the cluster level in the models.

4.2 Results and discussions

Based on the first model (table 6, model 1), the econometric results show that belonging to local innovation ecosystems around innovation parks positively impacts the probability that a given firm moves from a lower *Innoscope* status to a higher status or has maintained a higher *Innoscope* score. Thus, being part of the local innovation ecosystem increases the likelihood of a firm's innovative performance. These results are in line with other studies on innovation ecosystems which associate the innovation performance of firms with their involvement within a given innovation ecosystem (Adner and Kapoor, 2010). In addition, when the network centrality variables are included in the model (table 6, model 3), significant effects are found for the variables describing the position of firms in the networks i.e. closeness centrality and degree centrality. Hence, having access to various sources of knowledge enhances innovation as previously founded by Uzzi and Spiro (2005) and Shilling and Phelps (2007). But, what's interesting in our case is that the sources of knowledge affect innovation behaviours i.e. firm's capacities to adapt innovation strategies and not just the number of patents.
Therefore, ***hypothesis 1 is validated.***
Similarly, we found regional support to be positive and statistically significant in our model. This shows that regional support increases the probability of moving to a higher *Innoscope* score. Thus, regional support increases the likelihood of innovative performance of regional firms.

In terms of firm size, our results show that the SMEs are likely to be more innovative than larger firms. Our results are in line with studies that show specific firm sizes – ETI or SMEs – are often more favourable for innovative performance (Agarwal, 1998; Chabaud and Messeghem, 2014).

The departments of Nord and Pas-de-Calais are statistically significant in our result. This implies that firms that belong to Nord department have a greater probability of moving to a higher innovation score. These two departments refer to the former region of Nord-Pas-de-Calais. In fact, our results show that more firms located in this part of the Hauts-de-France region move to a higher innovation score than those located in the former region of Picardie. Here we find evidence of the impact of geographic proximity (Rallet and Torre, 2001). In fact, most of the elements (even the main components) of the regional innovation ecosystem of the Hauts-de-France region are located in these two departments. Some public actors highlight even a disparity between the north of this region (ex-Nord-Pas-de-Calais) and the south (ex-Picardie). Export is not statistically significant in our model. This may be because exposure to the external market increases incentives to improve innovation and at the same time reduces the innovation performance of less productive firms as a result of the associated exposure to higher competition (e.g., Aghion et al., 2018).

Finally, we do not find any relevant statistical evidence about the sectoral effect on the firms' innovative performance.

	Model 1 (Innov)		**Model 2 (Techdiv)**		**Model 3 (Innov)**	**Model 4 (Techdiv)**
	Model 1 (with variable T_Size)	**Model 1 (with variable Size)**	**Model 2 (with variable T_Size)**	**Model 2 (with variable Size)**	**Model 3 (with Network and centrality measures)**	**(Model 4 with Network and centrality measures)**
CC					14.265** (14.88)	8.690** (7.254)
InP	2.190*** (0.642)	2.090*** (0.586)	2.845**** (0.668)	2.919*** (0.671)		
Age	1.010 (0.007)	1.013* (0.007)	0.989* (0.006)	0.988* (0.006)	1.013* (0.007)	0.988* (0.006)
Aid_Region	1.223** (0.096)	1.199** (0.092)	1.155** (0.081)	1.167** (0.081)	1.209** (0.094)	1.143* (0.080)
Export	1.007 (0.005)	1.009* (0.005)	1.009** (0.004)	1.009** (0.004)	1.010* (0.005)	1.009** (0.004)
Location						
Loc_Aisne						
Loc_Nord	3.097** (1.460)	3.164** (1.482)	0.842 (0.369)	0.839 (0.368)	3.210** (1.507)	0.808 (0.354)
Loc_Oise	1.555 (0.778)	1.657 (0;822)	1.530 (0.706)	1.607 (0.704)	1.658 (0.825)	1.577 (0.726)
Loc_Pas-de-Calais	5.336*** (2.870)	5.416*** (2.891)	0.725 (0.355)	0.731 (0.357)	5.506*** (2.949)	0.751 (0.367)

Loc_Somme	2.421* (1.280)	2.453* (1.288)	2.919** (1.420)	2.738** (1.328)	2.432* (1.280)	2.766** (1.339)
Size		1.011 (0.058)		1.171*** (0.060)	1.014 (0.058)	1.173*** (0.061)
Micro	5.120* (4.842)					
Small	7.560** (6.990)		1.769** (0.447)			
Medium	8.114** (8.032)		2.960*** (1.222)			
Large			5.666** (4.795)			
Sector						
Agriculture, forestry and fishery	0.076* (0.110)	0.082* (0.119)			0.095 (0.142)	
Construction	1.168 (0.946)	1.114 (0.883)			1.085 (0.867)	
Financial and insurance activities	0.366 (0.251)	0.321* (0.215)			0.330 (0.221)	
Information and Communication	0.166 (0.197)	0.148 (0.174)			0.147 (0.174)	
Manufacturing, mining and quarrying						
Other service activities	4.264 (5.635)	3.953 (5.155)			4.024 (5.257)	
Professional, scientific and technical activities	0.740 (0.238)	0.698 (0.222)			0.798 (0.228)	
Public administration, education, Human health	0.521 (0.689)	0.506 (0.663)			0.838 (1.176)	
Wholesale and retail trade, transport, accommodation	1.039 (0.320)	0.928 (0.279)			0.921 (0.280)	
DC					0.975* (0.016)	1.010 (0.013)
ClusterBC					0.999 (0.001)	1.001* (0.001)
_cons	0.036*** (0.039)	0.184* (0.165)			0.170** (0.153)	
/cut 1			1.119 (0.437)	3.086 (0.799)		3.044 (0.806)
/cut 2			2.938 (0.459)	4.903 (0.824)		4.890 (0.831)
Number of obs	430	430	431	431	430	431
LR chi2(19)	85,09	78.89	85,51	85,23	79.81	91.56
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.1472	0.1365	0.1024	0.1020	0.1381	0.1096

Table 6: Results of econometrics models (Article 1)

Notes: All results are odds ratios. Standard errors are shown in parentheses.

*Significant at 0.1 level; **significant at 0.05 level; ***significant at 0.01 level.

From the second model (table 6), our econometric results show that belonging officially to a local innovation ecosystem positively impacts a firm's technological diversity. A firm in the local innovation ecosystem is more likely to be in the higher category of technological diversity. These results highlight the fact that the innovation ecosystem not only affects the innovative performance of firms, but also the flexibility of firms, measured by their capacity to be involved in several technological domains. Moreover, the closeness centrality of firms as well as the betweenness centrality of the network positively impact firm's technological diversity. Interesting is the fact that if firm's position in networks impact both innovativeness and diversity, structural properties of clusters (cluster betweenness centrality in our case) only affect innovation diversity. This is an important result for both firms and territorial authorities because – as pointed out in §2 – diversity has been linked to adaptability (Bristow 2010; Evenhuis, 2017). Diversity unlocks a region from a specific trajectory, enhances adaptability (Boschma, 2015), and helps mitigate path dependencies (Quintana-García and Benavides-Velasco, 2008). Hence, in order to avoid lock-in phenomenon, territorial authorities must promote not only the adhesion of firms to networks but also a particular structuration of the networks in terms of betweenness likely to favour the diversity of the exchanged knowledge.

Interestingly, the results concerning marginal effects (appendix A3) further support the above findings. From the marginal effects results, companies which are part of a local innovation ecosystem are about 26% less likely to have low technological diversity; about 15% more likely to be in the medium category of technological diversity; and about 11% more likely to be highly technologically diversified.

Hence, ***hypothesis 2 is validated***.

Our results show that, as the share of exportation in a firm's turnover increases, the firm is more likely to be in the higher category of technological diversity. Again, considering the effect of firm size, the small, medium, and large firms – compared to micro firms – have higher odds of being in the high technological diversity category. This positive effect of firm size can be explained by the fact that the larger the companies are, the more they could have sufficient financial resources or have access to financial markets to finance diversification of R&D activities, considering that such activities are short-term and independent of the company's production.

Our results show that regional support is statistically significant and a unit increase in regional support results in greater probability of being in the category of high technological diversity. We found that increased exposure to the external market increases the likelihood of becoming more technologically diversified. This result is in line with the findings of Badwin and Gu

(2004) that the increased diversity of technologies among Canadian plants is influenced by their exposure to the external market.

Finally, we found a territorial effect. Unlike previous results on improving the innovation score, there is no correlation between firms located in the Nord department and the firm's technological diversity. However, in other territories, like Somme, firms are more diversified than those located in Aisne. The results from models 1 and 2 tend to show that in Aisne department, effort should be made to enhance innovative performance and economic diversification at territorial and firm level.

According to the results from model 1 and model 2, our work provides empirical evidence that the innovation ecosystem has a positive impact on the adaptive capacity of firms which is linked to a firm's ambidexterity (Quintana-García and Benavides-Velasco, 2008). We show that being part of an innovation ecosystem could affect the capacity of the firm to increase in terms of value creation and in terms of its technological diversity, which enable the firm to reorganize and adapt to market and technological changes (Kreiser et al., 2013).

5. Conclusion

At the end of this study, two main results emerge.

First, from a methodological point of view, the concept of an innovation ecosystem seems relevant and provides interesting findings. Indeed, in the theoretical part of the paper, we identified three main characteristics that give the notion of an innovation ecosystem more explanatory power in terms of adaptability and sustainability compared to traditional analysis, like clusters. Then, we performed a case study analysis in the Hauts-de-France region and checked that the innovation ecosystems in this region exhibit the main characteristics of an ecosystem in terms of structure and organization, diversity of actors and sectors, and complexity of interactions.

Second, as a consequence of the innovation ecosystem's characteristics, we have deduced two testable hypotheses about the adaptive capacities of firms in the Hauts-de-France region. A primary result is that firms in the Hauts-de-France region are significantly more innovative when they are part of the innovation ecosystem. What is very interesting in these results is that our dependent variable measures change in firm's innovative behaviors and not only a quantitative measure of innovation. Therefore, belonging to an innovation ecosystem impacts adaptive capacities of firms. A second result is that firms in the ecosystem of innovation are also more diverse in terms of innovation. Finally, this study highlighted both the impact of the position of firms in their networks and the overall structure of alliances on their innovation behavior.

Therefore, in terms of regional policy, our analysis shows that the various instruments (the creation of innovation parks and public financial support) implemented by the region certainly contribute to making it more adaptable, and, certainly, more resistant to shocks.

However, our analysis could and must be improved before giving clear recommendations in terms of regional policy. Indeed, for the moment our modelling only proves that firms are more innovative and diverse when they are part of the ecosystem. But we do not prove that any specific organization, diversity, and complexity are necessary and sufficient conditions for that. Based on these findings, further empirical research should aim at specifying the various links between the most relevant characteristics of the innovation ecosystem and the firm's adaptive capacity.

Moreover, given that our contribution focuses only on patenting firms in the ecosystems, other studies are also needed before any generalization can be made. As a matter of fact, in line with previous contributions (Hansen and Coenen, 2015), our paper emphasizes that place-specificity matters and exhibits some characteristics of the place in terms of organization, diversity, and complexity. Some papers, however, highlight the importance of other place characteristics like norms and values (Späth and Rohracher, 2012), local natural resource endowments (Murphy and Smith 2013) or local market formation (Binz et al., 2012). Besides this, a theoretical paper on evolutionary framework (Crespo et al., 2014) suggests that it is some specific characteristics of clusters (hierarchy and assortative) that give firm's ability to perform and avoid negative lock-in.

Hence, much work is needed in order to provide a theoretical and testable framework of firm's adaptive capacities and place sustainability conditions. Our finding is that the concept of an innovation ecosystem is certainly an interesting basis for this further study.

References

Adner, R. 2006. “Match your Innovation Strategy to your Innovation Ecosystem.” *Harvard Business Review* 84 (4): 98-107

Adner, R., and R. Kapoor. 2010. “Value Creation in Innovation Ecosystems: How the Structure of Technological Interdependence Affects Firm Performance in New Technology Generations.” *Strategic Management Journal* 31: 306–333.

Agarwal, R. 1998. “Small Firm Survival and Technological Activity.” *Small Business Economics* 11: 215–224.

Aghion, P., A. Bergeaud, M. Lequien, and M.J. Melitz. 2018. “The Impact of Exports on Innovation: Theory and Evidence.” *Banque de France Working Paper* No. 678. Available at SSRN: https://ssrn.com/abstract=3171084 or http://dx.doi.org/10.2139/ssrn.3171084

Audretsch, D., C. Mason, M.P. Miles, and A. O’Connor. 2018. “The Dynamics of Entrepreneurial Ecosystems.” Entrepreneurship & Regional Development, 30:3-4, 471-474, DOI: 10.1080/08985626.2018.1436035

Autio, E., and L. Thomas. 2014. “Innovation Ecosystems.” *The Oxford Handbook of Innovation Management*: 204–288.

Baldwin, J. R., and W. Gu. 2004. “Trade liberalization: Export-market participation, Productivity Growth, and Innovation.” *Oxford Review of Economic Policy* 20 (3): 372–392.

Bathelt, H., A. Malmberg, and P. Maskell. 2004. “Clusters and knowledge: Local Buzz, Global Pipelines and the process of Knowledge Creation.” *Progress in Human Geography* 28 (1): 31–56.

Bergman, E. 2008. “Cluster life-cycles: An Emerging Synthesis.” *Handbook of Research on Cluster Theory* 1: 114–132.

Binz, C., B. Truffer, L. Li, Y. Shi, and Y. Lu. 2012. “Conceptualizing leapfrogging with spatially coupled Innovation Systems: The case of onsite wastewater treatment in China.” *Technological Forecasting and Social Change* 79 (1): 155–171.

Borrás, S., and D. Tsagdis. 2008. *Cluster Policies in Europe: firms, institution and governance*. Cheltenhem: Edward Elgar Publishing.

Boschma, R. 2015. “Towards an Evolutionary Perspective on Regional Resilience.” *Regional Studies* 49 (5): 733–751.

Boyer, J. 2020. “Toward an Evolutionary and Sustainability Perspective of the Innovation Ecosystem: Revisiting the Panarchy Model.” *Sustainability* 12 (8): 3232.

Breschi, S., F. Lissoni, and F. Malerba. 2003. “Knowledge-relatedness in firm Technological Diversification.” *Research Policy* 32 (1): 69–87.

Bristow G., and A. Healy. 2015. “Crisis response, Choice and Resilience: insights from Complexity Thinking.” *Cambridge Journal of Regions, Economy and Society* 8 (2): 241–256.

Bristow, G. 2010. “Resilient Regions: Re-‘place'ing Regional Competitiveness.” *Cambridge Journal of Regions, Economy and Society* 3 (1): 153–167.

Brown, R., and C. Mason. 2017. “Looking inside the spiky bits: A Critical Review and Conceptualisation of Entrepreneurial Ecosystems.” *Small Business Economics* 49 (1): 11–30.

Chabaud, D., and K. Messeghem. 2014. “Mid-size Companies, Myth and / or Reality?” *Management* 36 (198): 11–126.

Coe, N. M., and T. G. Bunnell. 2003. “‘Spatializing’ Knowledge Communities: towards a Conceptualization of Transnational Innovation Networks.” *Global Networks* 3 (4): 437–456.

Cohen, W. M., and S. Klepper. 1996. “Firm size and the Nature of Innovation within Industries: the case of process and product R&D.” *The review of Economics and Statistics* 232–243.

Cohendet, P., D. Grandadam, and L. Simon. 2010. “The anatomy of the creative city.” *Industry and Innovation* 17 (1): 91–111.

Cohendet, P., D. Grandadam, L. Simon, and I. Capdevila. 2014. “Epistemic Communities, localization and the Dynamics of Knowledge Creation.” *Journal of Economic Geography* 14 (5): 929–954.

Cooke, P. 1992. “Regional Innovation Systems – Competitive regulation in the new Europe.” *Geoforum,* 23 (3): 365–382.

de Vasconcelos Gomes, L. A., A. L. F. Facin, M. S. Salerno, and R. K. Ikenami. 2018. “Unpacking the Innovation Ecosystem construct: Evolution, Gaps and Trends.” *Technological Forecasting and Social Change* 136: 30–48.

Doh, S., and B. Kim. 2014. “Government support for SME Innovations in the Regional Industries: The Case of Government Financial Support Program in South Korea.” *Research Policy* 43 (9): 1557–1569.

Dosi, G. 1988. “Sources, Procedures, and Microeconomic effects of Innovation.” *Journal of Economic Literature*: 1120–1171.

Essletzbichler, J. 2012. “Evolutionary Economic Geographies.” In *The Wiley-Blackwell companion to Economic Geography,* edited by Barnes, T., J. Peck, and E. Sheppard, 183–198. Chichester: Wiley-Blackwell

Fitjar, R. D., and A. Rodríguez-Pose. 2011. “Innovating in the Periphery: Firms, Values and Innovation in Southwest Norway.” *European Planning Studies* 19 (4): 555–574.

Florida, R. 2002. *The Rise of the Creative Class–and how it’s transforming Work, Leisure, Community and everyday Life*. New York: Basic Books.

Fromhold-Eisebith, M., and G. Eisebith. 2005. “How to institutionalize Innovative Clusters? Comparing Explicit top-down and Implicit bottom-up Approaches.” *Research Policy* 34 (8): 1250–1268.

Gaussens, O., and M. Movahedi. 2016. “Les effets de l’exportation sur l’innovation et la productivité : le rôle clé de l’apprentissage par l’exportation : analyse empirique sur un échantillon de PMI.” *Revue internationale PME* 29 (1): 101–141.

Giuliani, E. 2007. “The selective nature of Knowledge Networks in Clusters: Evidence from the Wine Industry.” *Journal of Economic Geography* 7: 139–168

Gkotsis, P., E. Pugliese, and A. Vezzani. 2018. “A Technology-Based Classification of Firms: Can We Learn Something Looking Beyond Industry Classifications?” *Entropy* 20 (11): 887.

Grandadam, D., P. Cohendet, and L. Simon. 2013. “Places, Spaces and the Dynamics of Creativity: The video game Industry in Montreal.” *Regional Studies* 47 (10): 1701–1714.

Håkanson, L. 2005. “Epistemic communities and Cluster Dynamics: on the role of Knowledge in Industrial Districts.” *Industry and Innovation* 12 (4): 433–463.

Hansen, T., and L. Coenen. 2015. “The Geography of Sustainability Transitions: Review, synthesis and reflections on an emergent Research Field.” *Environmental Innovation and Societal Transitions* 17: 92–109.

Hassink, R. 2010. “Regional Resilience: a promising Concept to explain differences in Regional Economic Adaptability?” *Cambridge Journal of Regions, Economy and Society* 3 (1): 45–58.

Iansiti, M., and R. Levien. 2004. “Strategy as Ecology”. Harvard Business Review 82 53): 68-81.

Jacobides, M. G., C. Cennamo, and A. Gawer. 2018. “Towards a theory of Ecosystems.” *Strategic Management Journal* 39 (8): 2255–2276.

Kapoor, R. 2018. “Ecosystems: broadening the locus of Value Creation.” *Journal of Organization Design* 7 (1): 12.

Kowalski, A. M., and A. Marcinkowski. 2014. “Clusters versus Cluster initiatives, with Focus on the ICT Sector in Poland.” *European Planning Studies* 22 (1): 20–45.

Kreiser, P. M., L. D. Marino, D. F. Kuratko, and K. M. Weaver. 2013. “Disaggregating entrepreneurial orientation: the non-linear impact of innovativeness, proactiveness and risk-taking on SME performance.” *Small Business Economics* 40 (2): 273–291.

Lange, B., and E. Schüßler. 2018. “Unpacking the middleground of creative cities: spatiotemporal dynamics in the configuration of the Berlin design field.” *Regional Studies* 52 (11): 1548–1558.

Lindqvist, G., C. Ketels, and Ö. Sölvell. 2013. *The Cluster Initiative Greenbook 2.0.* Stockholm: Ivory Tower Publishers.

Love, J.H. and S. Roper. 1999. “The Determinants of Innovation: R & D, Technology Transfer and Networking Effects.” *Review of Industrial Organization* 15: 43–64.

Lucena-Piquero, D., and J. Vicente. 2019. “The visible hand of cluster policy makers: An analysis of Aerospace Valley (2006–2015) using a place-based network methodology.”. *Research Policy* 48 (3): 830–842.

Marmuse, C., and J.C. Godest 2008. “La détection des Entreprises Potentiellement Innovantes Modélisation d’une approche de score pour l’accompagnement des Entreprises à potentiel Innovateur.” XVIIème Conférence Internationale de Management Stratégique, Nice 2008.

Martin, R. 2011. “Regional Economic Resilience, Hysteresis and Recessionary Shocks.” *Journal of Economic Geography* 12 (1): 1–32.

Menu, S. 2012. “The role of Cluster Policy on Leadership: Evidence from two Pôles de Compétitivité.” *Environment and Planning C: Government and Policy* 30 (5): 816–834.

Moore, J. 1996. *The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems*. New York: Harper Collins.

Moore, J. F. 1993. “Predators and prey: a new Ecology of Competition.” *Harvard Business Review* 71 (3): 75–86.

Morrison A., R. Rabellotti, and L. Zirulia . 2013. “When do Global Pipelines enhance the Diffusion of Knowledge in Clusters?” *Economic Geography* 89: 77–96. doi:10.1111/j.1944-8287.2012.01167.x

Murphy, J., and A. Smith. 2013. “Understanding Transition—Periphery dynamics: Renewable Energy in the Highlands and Islands of Scotland.” *Environment and Planning A* 45 (3): 691–709.

Newlands, D. 2003. “Competition and Cooperation in Industrial Clusters: The Implications for Public Policy.” *European Planning Studies* 11 (5): 521–532.

Pavitt, K., 2005. *Innovation Process,* in: Fagerberg, J., D. C. Mowery, and R. Nelson. (Eds), The Oxford Handbook of Innovation 86-114, Oxford: Oxford University Press.

Phillips, M.A., and P. Ritala. 2019. “A Complex Adaptive Systems agenda for Ecosystem Research Methodology.” *Technological Forecasting and Social Change* 148: 119739.

Pinkse, J., A. L. Vernay, and B. D’Ippolito. 2018. “An Organizational Perspective on the Cluster Paradox: Exploring how members of a Cluster manage the Tension between Continuity and Renewal.” *Research Policy* 47 (3): 674–685.

Porter, M. 1990. *The Competitiveness Advantage of Nations*. New York: The Free Press.

Porter, M. E. 1998. “*Clusters and the New Economics of Competition*.” *Harvard Business Review* 76 (6): 77–90.

Porter, M. E., and M. R. Kramer. 2006. “The link between Competitive Advantage and Corporate Social Responsibility.” *Harvard Business Review* 84 (12): 78–92.

Powell, W. W., and S. Grodal. 2005. *Networks of innovators*. in: Fagerberg, J., D. C. Mowery, and R. Nelson. (Eds), The Oxford Handbook of Innovation 56-85, Oxford: Oxford University Press.

Quintana-García, C., and C. A. Benavides-Velasco. 2008. “Innovative Competence, Exploration and Exploitation: The Influence of Technological Diversification.” *Research Policy* 37 (3): 492–507.

Rallet, A., & Torre, A. (2001). Proximité géographique ou proximité organisationnelle? Une analyse spatiale des coopérations technologiques dans les réseaux localisés d'innovation.

Ritala, P., and A. Almpanopoulou. 2017. “In defense of ‘eco’ in Innovation Eecosystem.” *Technovation* 60: 39–42.

Robaczewska, J., W. Vanhaverbeke, and A. Lorenz. 2019. “Applying open innovation strategies in the context of a regional innovation ecosystem: The case of Janssen Pharmaceuticals”. *Global Transitions* 1: 120-131.

Ronde, P. 2001. “Inertie : un comportement optimal en fin de trajectoire technologique.” *Economie Appliquée*, tome LIV (1): 201–224.

Russell, M. G., and N. V. Smorodinskaya. 2018. “Leveraging Complexity for Ecosystemic Innovation.” *Technological Forecasting and Social Change* 136: 114–131.

Sarazin, B., L. Simon, and P. Cohendet. 2017. Les communautés D’innovation: De la Liberté Créatrice à L’innovation Organisé. Caen, France: Editions EMS.

Saxenian, A. 1994. *Regional Networks: industrial Adaptation in Silicon Valley and route 128*. Cambridge: Harvard University Press

Saxenian, A. 1996. “Inside-out: Regional Networks and Industrial Adaptation in Silicon Valley and Route 128.” *Cityscape* : *A journal of Policy Development and Research* 2(2): 41–60.

Saviotti, P. 1995. “Renouveau des politiques industrielles : le point de vue des théorie évolutionnistes”. *Revue d'Economie Industrielle*, 71, (1) : 1999-212.

Schaffers, H., N. Komninos, M. Pallot, M. Aguas, E. Almirall, T. Bakici, J. Barroca et al.. 2012. "Smart Cities as Innovation Ecosystems sustained by the future Internet." available at : https://hal.inria.fr/hal-00769635/file/FIREBALL-White-Paper-Final2.pdf

Schilling, M. A., and C. C. Phelps. 2007. "Interfirm Collaboration Networks: The Impact of Large-Scale Network Structure on Firm Innovation" *Management Science* 53 (7): 1113-1126.

Shefer, D., and A. Frenkel. 2005. "R&D, Firm Size and Innovation: An Empirical Analysis." *Technovation* 25 (1): 25–32.

Späth, P., and H. Rohracher. 2012. "Local demonstrations for Global Transitions—Dynamics across Governance levels fostering Socio-technical Regime change towards Sustainability." *European Planning Studies* 20 (3): 461–479.

Suire, R., J. Vicente. 2014. "Clusters for Life or Life Cycles of Clusters: in search of the Critical Factors of Clusters' Resilience." *Entrepreneurship and Regional Development* 26 (1-2): 142–164.

Teece, D. J. 1986. "Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy." *Research Policy* 15(6):285-305

Truffer, B., and L. Coenen. 2012. "Environmental Innovation and Sustainability Transitions in Regional Studies." *Regional Studies* 46 (1): 1–21.

Tsujimoto, M., Y. Kajikawa, J. Tomita, and Y. Matsumoto. 2018. "A review of the Ecosystem Concept—Towards Coherent Ecosystem Design." *Technological Forecasting and Social Change* 136: 49–58.

Uzzi, B., and J. Spiro. 2005. "Collaboration and creativity: The small world problem". *Amer. J. Sociol*. 111: 447–504.

Watts, D. J., and S. H. Strogatz. 1998. "Collective dynamics of "small-world" networks." *Nature* 393(6684): 440–442.

Wasserman, S., and K. Faust. 1994. *Social Network Analysis—Methods and Applications*. Cambridge: Cambridge University Press.

Warwick, K., 2013. *Beyond Industrial Policy: Emerging Issues and New Trends.* OECD Science, Technology and Industry Policy Papers, No. 2. Paris: OECD Publishing

Yin, R. 2009. *Case Study Research: Design and Methods.* 4th ed. USA: Sage

Zucchella, A. 2006. "Local Cluster Dynamics: Trajectories of mature Industrial Districts between decline and multiple Embeddedness." *Journal of Institutional Economics* 2 (1): 21–44.

Appendices

Appendix A1: Summary statistics for binary and categorical variables

Variables	**Label**	**Variables type**	**Variables /Categories**	**Freq.**	**Percent**
INNOV	Moving from a lower status to a higher status or maintaining a highest Innoscope score (2013-2017)	Binary variable	No	172	40%
			Yes	259	60 %
Techdiv	The Level of technological diversity of firms	Scale variable	Low	239	55%
			Medium	129	30%
			High	63	15%
InP	Belonging officially to Local Innovation Ecosystem.	Binary variable	No	300	70%
			Yes	131	30 %
T_Size	Size of the firms using categories of INSEE	Categorical variable that is split into 4 dummies variables	Micro	155	36%
			SME	231	54%
			ETI (Medium-sized)	39	9%
			Large compagnies	6	1%
Loc	Location of the firms	Categorical variable that is split into 5 dummies variables	Loc_Aisne	31	7%
			Loc_Nord	229	53%
			Loc_Oise	62	14%
			Loc_Pas-de-Calais	64	15%
			Loc_Somme	45	10%
Sector	Sectors in which the firms belong	Categorical variable that is split into 10 dummies variables	Agriculture. forestry and fisheries	4	1%
			Construction	8	2%
			Financial and insurance activities	14	3%
			Information and Communication	6	1%
			Manufacturing. mining and quarrying and	242	56%
			Other service activities	3	1%
			Professional. scientific and technical	70	16%
			Public administration. education. Human	3	1%
			Real estate activities	1	0,2%
			Wholesale and retail trade. transport.	80	19%

Appendix A2: Summary statistics for continuous and scale variables

Descriptive Statistics						
Variable	**Label**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Aid_Region	The level of regional support received by a given firm for innovative activities (0-5)	431	1.986079	1.673262	0	5
Age	The age of the firms	431	31.02784	17.82053	8	122
Size	Firms size	431	15.25592	2.449052	6.214608	23.27009
N_IPC4	Number of IPC4-digit	431	3.714617	4.429263	1	44
CC	ClosenessCentrality	431	0.1138107	.1735995	0	0.508867
DC	DegreeCentrality	431	2.048533	8.517163	0	57
ClusterBC	Cluster Average BetweennessCentrality	431	339.52	203,47	174.16	599.26
Export	Part of the exportations in the turnover of the firm	431	16.68149	24.87326	0	100
Techdiv	The level of technological diversity of firms	431	1.591647	0.731564	1	3
Size	Firms size	431	15.25592	2.449052	6.214608	23.27009

Appendix A3: The Impact of the explanatory variables on the response variable (Marginal effects)

	Pr(Techdiv==1). predict (outcome (1- Low)			Pr(Techdiv==2). predict(outcome(2-Medium)			Pr(Techdiv==3). predict (outcome (3-High)		
	With variable T_Size	**With variable Size**	**With centrality measure**	**With variable T_Size**	**With variable Size**	**With centrality measure**	**With variable T_Size**	**With variable Size**	**With centrality measure**
CC			-0.534** (0.206)			0.317** (0.127)			0.217** (0.086)
InP	-0.258*** (0.058)	-0.265*** (0.057)		0.151*** (0.037)	0.155*** (0037)		0.107*** (0.025)	0.110*** (0.025)	
Age	0.002* (0.001)	0.003* (0.002)	0.003* (0.002)	-0.001 (0.001)	-0.002* (0.001)	-0.002* (0.001)	-0.001* (0.001)	-0.001* (0.001)	-0.001* (0.001)
Aid_Region	-0.035** (0.017)	-0.038** (0.017)	-0.033* (0.017)	0.021** (0.010)	0.001** (0.010)	0.020* (0.010)	0.015** (0.007)	0.016** (0.007)	0.013* (0.007)
Export	-0.002** (0.001)	-0.002** (0.001)	-0.002** (0.001)	0.001** (0.001)	0.001** (0.001)	0.001** (0.001)	0.001** (0.000)	0.001** (0.000)	0.001** (0.000)
Location									
Nord	0.041 (0.107)	0.042 (0.107)	0.052 (0.108)	-0.025 (0.064)	-0.026 (0.065)	-0.033 (0.065)	-0.016 (0.043)	-0.016 (0.043)	-0.019 (0.043)
Oise	-0.106 (0.114)	-0.118 (0.113)	-0.113 (0.114)	0.0566 (0.063)	0.061 (0.063)	0.060 (0.064)	0.049 (0.051)	0.057 (0.052)	0.054 (0.052)
Pas-de-Calais	0.076 (0.118)	0.075 (0.118)	0.069 (0.118)	-0.048 (0.073)	-0.047 (0.073)	_0.044 (0.073)	-0.028 (0.045)	-0.028 (0.046)	-0.025 (0.046)
Somme	-0.256** (0.114)	-0.243** (0.115)	-0.244** (0.114)	0.099* (0.059)	0.098 (0.060)	0.098 (0.060)	0.157** (0.069)	0.145** (0.067)	0.146** (0.067)
Size		-0.039*** (0.013)	-0.040*** (0.013)		0.023*** (0.008)	0.024*** 0.008)		0.016*** (0.005)	0.016*** 0.005)
Small	-0.137** (0.059)			0.085** (0.038)			0.052*** (0.022)		
Medium	-0.2642*** (0.097)			0.141*** (0.044)			0.123*** (0.057)		
Large	-0.404** (0.161)			0.156**** (0.042)			0.247 (0.179)		
DC			-0.002 (0.003)			0.001 (0.002)			0.001 (0.001)
ClusterBC			-0.001* (0.001)			0.000 (0.001)			0.001* (0.000)

Appendix A4: Correlation Matrix shows the relationship among explanatory variables using Pearson's Correlation coefficient method

	InP	age	Aid_Region	Export	size	Nord	Oise	Pas-de-calais	Somme	Agriculture	Construction	Financial	Information and communication	Others	Scientific	Administration	Realestate	Wholesale
InP	1.0000																	
Age	0.1373	1.0000																
Aid_Region	0.2741	0.0348	1.0000															
Export	0.2455	0.1213	0.1580	1.0000														
Size	0.3579	0.4354	0.0947	0.3520	1.0000													
Nord	0.0950	-0.0633	0.3399	0.0156	-0.0219	1.0000												
Oise	-0.0840	0.0358	-0.2616	0.0053	-0.0056	-0.4364	1.0000											
Pas-de-calais	0.0645	-0.0252	0.1206	0.0259	0.0244	-0.4446	-0.1712	1.0000										
Somme	-0.0112	0.0476	-0.1742	0.0030	0.0503	-0.3635	-0.1400	-0.1426	1.0000									
Agriculture, forestry and fishery	0.0413	-0.0219	0.0153	0.0275	-0.0129	-0.0546	0.0293	0.0276	-0.0330	1.0000								
Construction	-0.0161	-0.0244	-0.0194	-0.0885	-0.0406	0.0603	-0.0074	-0.0091	-0.0470	-0.0133	1.0000							
Financial and insurance activities	-0.0642	-0.0870	-0.0768	-0.0761	-0.1539	-0.0115	-0.0005	-0.0397	0.0658	-0.0177	-0.0252	1.0000						
Information and Communication	0.0076	-0.1237	0.0247	-0.0798	-0.1753	-0.0075	0.1206	-0.0496	-0.0406	-0.0115	-0.0163	-0.0218	1.0000					
Other service activities	-0.0553	-0.0613	-0.0661	-0.0562	-0.0085	-0.0332	0.0452	-0.0350	-0.0286	-0.0081	-0.0115	-0.0153	-0.0099	1.0000				
Professional, scientific and technical activities	0.0236	-0.2050	-0.0152	-0.0559	-0.2244	0.0480	0.0167	0.0107	-0.0475	-0.0426	-0.0606	-0.0807	-0.0523	-0.0369	1.0000			

Public administration, education, Human health	0.1267	0.0986	-0.0494	0.0168	0.1076	0.0786	-0.0343	-0.0350	-0.0286	-0.0081	-0.0115	-0.0153	-0.0099	-0.0070	-0.0369	1.0000		
Real estate activities	-0.0319	0.0351	0.0004	-0.0201	-0.0363	0.0453	-0.0198	-0.0201	-0.0165	-0.0047	-0.0066	-0.0088	-0.0057	-0.0040	-0.0212	-0.0040	1.0000	
Wholesale and retail trade	-0.0819	-0.0889	-0.0639	-0.1756	-0.0020	0.1733	-0.1107	-0.0651	-0.0654	-0.0462	-0.0657	-0.0875	-0.0567	-0.0400	-0.2102	-0.0400	-0.0230	1.0000

Appendix A5: Correlation Matrix shows the relationship among explanatory variables using Pearson's Correlation coefficient method (with Network and centrality measures)

	CC	Age	Aid_Re~n	Export	Size	Nord	Oise	Pas-de-calais	Somme	Agriculture	Construction	Financial	Information and communication	Others	Scientific	Administration	Realestate	Wholesale	DC	Cluster BC
CC	1.0000																			
Age	0.1451	1.0000																		
Aid_Region	0.2812	0.0348	1.0000																	
Export	0.2530	0.1213	0.1580	1.0000																
Size	0.3621	0.4354	0.0947	0.3520	1.0000															
Nord	0.1066	-0.0633	0.3399	0.0156	-0.0219	1.0000														
Oise	-0.0913	0.0358	-0.2616	0.0053	-0.0056	-0.4364	1.0000													
Pas-de-calais	0.0649	-0.0252	0.1206	0.0259	0.0244	-0.4446	-0.1712	1.0000												
Somme	-0.0203	0.0476	-0.1742	0.0030	0.0503	-0.3635	-0.1400	-0.1426	1.0000											
Agriculture, forestry and fishery	0.0376	-0.0219	0.0153	0.0275	-0.0129	-0.0546	0.0293	0.0276	-0.0330	1.0000										

Construction	-0.0180	-0.0244	-0.0194	-0.0885	-0.0406	0.0603	-0.0074	-0.0091	-0.0470	-0.0133	1.0000									
Financial and insurance activities	-0.0701	-0.0870	-0.0768	-0.0761	-0.1539	-0.0115	-0.0005	-0.0397	0.0658	-0.0177	-0.0252	1.0000								
Information and Communication	0.0138	-0.1237	0.0247	-0.0798	-0.1753	-0.0075	0.1206	-0.0496	-0.0406	-0.0115	-0.0163	-0.0218	1.0000							
Other service activities	-0.0550	-0.0613	-0.0661	-0.0562	-0.0085	-0.0332	0.0452	-0.0350	-0.0286	-0.0081	-0.0115	-0.0153	-0.0099	1.0000						
Professional, scientific and technical activities	0.0123	-0.2050	-0.0152	-0.0559	-0.2244	0.0480	0.0167	0.0107	-0.0475	-0.0426	-0.0606	-0.0807	-0.0523	-0.0369	1.0000					
Public administration, education, Human health	0.1518	0.0986	-0.0494	0.0168	0.1076	0.0786	-0.0343	-0.0350	-0.0286	-0.0081	-0.0115	-0.0153	-0.0099	-0.0070	-0.0369	1.0000				
Real estate activities	-0.0317	0.0351	0.0004	-0.0201	-0.0363	0.0453	-0.0198	-0.0201	-0.0165	-0.0047	-0.0066	-0.0088	-0.0057	-0.0040	-0.0212	-0.0040	1.0000			
Wholesale and retail trade	-0.0866	-0.0889	-0.0639	-0.1756	-0.0020	0.1733	-0.1107	-0.0651	-0.0654	-0.0462	-0.0657	-0.0875	-0.0567	-0.0400	-0.2102	-0.0400	-0.0230	1.0000		
DC	0.4785	0.1254	0.1360	0.1144	0.2040	0.0548	-0.0806	0.0946	-0.0545	-0.0176	-0.0186	-0.0410	-0.0240	-0.0202	-0.0551	0.2442	-0.0116	-0.0770	1.0000	
ClusterBC	0.5959	0.0996	0.2694	0.2051	0.1921	0.1312	-0.0363	-0.0354	-0.0370	0.1470	-0.0552	-0.0206	0.0549	-0.0336	0.0871	0.1458	-0.0193	-0.0457	0.1317	1.0000

Appendix A6: Multicollinearity statistics of different explanatory factors

Variable	VIF	1/VIF	Variable	VIF	1/VIF
InP	1.30	0.768034	CC	2.31	0.432586
Age	1.32	0.755382	Age	1.33	0.751068
Aid_Region	1.43	0.70124	Aid_Region	1.46	0.684905
Export	1.25	0.802218	Export	1.26	0.795247
Size	1.65	0.60629	Size	1.65	0.606741
Location			Location		
Nord	4.72	0.21172	Nord	4.73	0.211552
Oise	2.65	0.377433	Oise	2.65	0.377219
Pas-de-Calais	2.94	0.339634	Pas-de-Calais	2.96	0.337952
Somme	2.27	0.439633	Somme	2.28	0.439317
Sector			Sector		
Agriculture, forestry and fishery	1.02	0.978935	Agriculture, forestry and fishery	1.05	0.950291
Construction	1.05	0.954736	Construction	1.05	0.953324
Financial and insurance activities	1.09	0.92082	Financial and insurance activities	1.09	0.917240
Information and Communication	1.10	0.909189	Information and Communication	1.11	0.902903
Other service activities	1.03	0.969309	Other service activities	1.03	0.968738
Professional, scientific and technical activities	1.25	0.802844	Professional, scientific and technical activities	1.27	0.787116
Public administration, education, Human health	1.05	0.948608	Public administration, education, Human health	1.12	0.891952
Real estate activities	1.01	0.989067	Real estate activities	1.01	0.989009
Wholesale and retail trade	1.25	0.801727	Wholesale and retail trade	1.26	0.794590
Mean VIF	1.63		DC	1.45	0.688173
			ClusterBC	1.80	0.554918
			Mean VIF	1.69	

Article 2: Orchestration of Complex relationship in Innovation Ecosystem: Do project and event impact on technological development of firms? Evidence of Eurasanté Ecosystem in Hauts-de-France

Abstract

This paper examines the role of middleground in terms of project and event in orchestrating complex relationships in innovation ecosystem and the impact on technological development of firms. Recent works on local innovation ecosystem theoretically identify middleground in the form of places, spaces, projects and events, as intermediary platform that orchestrates complex relationship. The middleground as intermediary platform connects the actors in the upperground (formal actors) and the underground (informal actors). We analyzed the middleground of Eurasanté ecosystem specialized in healthcare and nutrition in Hauts-de-France region. We used data from INPI, Astride database and Eurasanté agency and employed econometric analysis to empirically determine the impact of middleground (in terms of project and event) on the technological development of firms. Our network statistics show that Eurasanté ecosystem is densely connected. Our Zinb and SEM econometric results reveal that collaboration in project and participation in event generally impact on technological development. All frequency levels of participation in event positively affect technological development. This study fills the gap in the literature, providing empirical evidence of intermediation role of middleground that enables complex interaction and its impact on innovation performance of firms.

1 Introduction

Innovation requires collaboration as knowledge creation centers on collective processes (Kline and Rosenberg, 1986). The Innovation Ecosystems concept has been widespread over the last few decades in managerial and economic science and has become a new field in the Innovation Studies literature (Moore, 1993; Kapoor, 2018; Tsujimoto et al., 2018; Fagerberg and Vespargen, 2009). Innovation-based growth policy favors ecosystem approach, emphasizing complex interactions, open innovation, collaboration in a network, co-evolution of actors and institutions and knowledge exchange (Moore, 1996, Porter, 2006; Russell and Smorodinskaya, 2018).

Literature acknowledges that innovation is a localized process and cooperation and competition improve productivity and innovation (Porter, 1998). This highlights the essence of network and spatial proximity in knowledge transfer (Audretsch and Feldman, 1996; Fritsch and Slavtchev, 2007, Boschma, 2005). Innovation ecosystem is characterized by heterogenous actor with both formal and informal interactions to generate innovation. Local Innovation Ecosystems are described in terms of their features, characteristics and roles. First, they promote strong relationship, feedback, interactions and fertilization between a diversity of actors and organizations within one or more technological fields. Second, they uphold knowledge development and management by bringing together research laboratories, technological structures, finance organization, brokers and companies within an interacting and strategic context. Similarly, Innovation ecosystem concept is likened to biological ecosystem where species interact, co-evolve with their environment and need to develop perpetual adaptive behaviors in order to survive (Mercan & Göktas, 2011). In innovation ecosystem, actors interact and co-evolve to develop innovation and adapt to continuous market and technological changes. The challenge for firms is therefore to develop strategies, based on both firms' characteristics (resources and competences), external innovators and the ecosystem in which they evolve, in order to create and capture value and get competitive advantage (Adner, 2006). Therefore, collaboration process and networking capabilities within the ecosystem enhance innovation opportunities. Moreover, network of actors in innovation process can be fostered by specific innovation platforms. The key features of a healthy and successful network include proximity, stable and lasting relations, equal participation of partners and the ability to see each partner as key in the business strategy (Gamidualleva, 2018). The new form of organizing economic or innovation activities in a network enhances both availability and access of diversity of resources. Individuals, firms or institutions share a mutual responsibility and benefits; and engage in activities that produce better results.

Works on platform-based ecosystem identify digital platforms as the tools that orchestrate complex relationships between actors under the leadership of a focal actor (Gawer & Cusumano, 2014, Jacobides et al., 2016). Platforms maintain and coordinate the network of interdependent actors (van Lente et al., 2003), creating interaction between formal and informal actors in innovation ecosystem. In a regional/local innovation ecosystem, works on creative cities and localized innovation ecosystem argue for the middleground as another form of common intermediary platform that orchestrates complex relationships between actors in the ecosystem (Cohendet et al., 2020; Boyer et al., 2021). These works identify three interacting components of local innovation ecosystem – the upperground, the middleground and the underground. The upperground represents the formal and well-established actors that possess the exploitation capacity (such as: companies, universities, innovation agencies, public institutions, etc). The underground represents the informal actors, talented individuals, entrepreneurs, artists that generate new ideas with exploration capacity; and the middleground represents the common platform that facilitates the connection and interaction of the actors in the upperground and the underground. The *middleground* is in the form of places, spaces, events or projects which brings together communities and connects continuously the actors of the upperground and the underground (Cohendet et al., 2020). It allows emerging creative ideas and knowledge to be absorbed, experienced and developed within a collaborative context and commercialized in the marketplace. Similarly, scholars assert that the quality and the extent of interaction in the middleground determines the performance of the innovation ecosystem (Amin & Cohendet, 2004; Coe & Bunnell, 2003; Cohendet et al., 2010; Saxenian, 1996; Boyer, 2020).

With this theoretical evidence upon which to consider middleground as intermediary platform that orchestrates complex interaction in a local innovation ecosystem, there is dearth of empirical work to support and confirm the role of middleground in the innovation process in innovation ecosystem. This study aims to address this gap in the scientific literature, analyzing the Eurasanté ecosystem centered around health and nutrition domain in Hauts-de-France region (France).

The study therefore aims to ascertain the role of middleground in orchestrating complex relationship and its impact on technological development within the local innovation ecosystem. The study tends to provide answer to the following research question:

Does middleground of innovation ecosystem impact on technological development?

The remainder of the paper is structured as follows: In section 2, we review the literature and position our contribution on the essence of middleground in local innovation ecosystem and develop our testable hypotheses. We present our case study, methodology and data in section 3. Our empirical results and discussions are presented in section 4 and finally, we summarize our contribution and conclusion in section 5.

2. Theoretical Background

The objective of this section is to penetrate the black box of innovation ecosystems in order to better understand the determinants of their effectiveness in innovation. Indeed, if the success of innovation ecosystems depends on the exchange and sharing of diverse and complex knowledge, it is not yet clear how these exchanges are orchestrated. For example, although interactions between agents can generate common knowledge, there is nothing to say that knowledge is necessarily exchanged during interactions, nor that this will lead to common innovations. Therefore, it seems important to us to understand the determinants of the allocative efficiency (in terms of knowledge) of innovation ecosystems and to infer testable indicators of this efficiency.

2.1 Complex relations within ecosystem: From business to innovation ecosystem

The basis of innovation ecosystem is drawn from the business ecosystem concept proposed by Moore in the early 1990's. He defined business ecosystem as set of actors that work cooperatively and competitively to support new product/services and satisfy customer needs (Moore, 1993).

Other scholars draw insights from Moore's view in their definitions. For example, Iansiti and Levien (2004) defined business ecosystem as large interconnected business actors who share common fate and rely on one another for effectiveness and survival. The business actors interact with other actors such as suppliers, manufacturers, competitors, customers; and whose interaction leads to co-evolution process. Iansiti and Levien (2004) introduced the concept of keystone player in business ecosystem. The keystone player is the key organization or company that coordinates the relationship between other actors in the business ecosystem. The co-evolution of actors is materialized by the alignment of these actors around a focal firm and on the added value, through a collective innovation process. For Adner, alignment structure is the extent to which there is mutual agreement among members regarding positions and flows in the whole ecosystem (Adner, 2017). The business ecosystem approach positions the company at the heart of its environment. In this approach, the business ecosystem represents the environment with which the firm must interact to develop dynamic and adaptive capabilities in order to build a sustainable competitive advantage (Teece, 2007). Business ecosystem therefore is best applied in a platform-based ecosystem where the digital platform structures the integration of multilateral set of partners that interact around a focal firm for value proposition and capture (eg Gawer and Cusumano, 2014). The digital platform serves as the main artefact that structures, around the focal firm, the alignment of the multilateral set of partners that must interact for a focal value proposition to materialize.

Debate still exists on the clarity of business ecosystem and innovation ecosystem. Scholars most times use the terms interchangeably without a clear-cut distinction (e.g. Gawer and Cusumano, 2014; Nambisan and Baron, 2013; Granstrand and Holgersson, 2020). Attempt for a clear distinction highlights that key focus of business ecosystem is value capture while innovation ecosystem focuses on value creation (de Vasconcelos Gomes et al., 2018). Value capture centers on how firms exploit the market opportunities to achieve competitive advantage and reap the accrued benefits. Value creation emphasizes collaborative processes targeted at creating value for both customers and stakeholders (Ritala and Almpanopoulou, 2017). Thus, business ecosystem targets exploitation process and competitive advantage while innovation ecosystem focus on exploration and exploitation processes to jointly create value (Cohendet et al., 2020; Valkokari, 2015). This unique difference in the goal of business ecosystem and innovation ecosystem is reflected in the level of analysis in terms of their organizational settings; For example, the study interest of business ecosystem focuses on the role of the anchor firms and how they orchestrate interaction between other stakeholders to capture value. Whereas in the analysis of innovation ecosystem, the interest is focused on how a structure of heterogeneous actors (companies, diverse organizations, informal collectives, and individuals) commonly linked in an innovation process act on its environment and co-create value (Cohendet et al., 2020; Boyer, 2020). Similarly, knowledge production and the flows of knowledge is unilateral (to the anchor firm) in business ecosystem, while in innovation ecosystem, production of knowledge and flow is rather multidirectional. Thus, the latter affirms that actors are more heterogenous and relationships more complex in innovation ecosystems than business ecosystem.

Innovation ecosystem therefore is characterized by heterogeneity of actors and complex interaction between the actors in a strategic context to co-create innovation. Valkokari (2015) explains that innovation ecosystem thrives and survives with the understanding that different forms of interaction are necessary and required. The literature highlights the essence of interaction and relationships in ecosystem, ranging from the ability to enhance adaptability to ability to co-create new innovation. The interaction between diverse actors in ecosystem enhances adaptability and sustainability (eg Roundy et al., 2018). de Vasconcelos Gomes et al. (2018) suggests that innovation ecosystem co-creation of value relies on the interaction between interdependent actors. Similarly, Luo (2018) asserts that interaction between diversity of actors enhances the ability of the system to produce or generate new innovation. The intensity of the access to shared resources and facilities embedded in interrelationship determines the generation of innovation. The generation of innovation is centered on network embeddedness, creating access to information, resources and technology (Nosella and Petroni, 2007). Network creates economies of scale for participating actors, resulting from lower transaction cost and risks sharing (Gulati et al., 2000; Rabinovich et al., 2007).

Highlighting the complexity of relationships between actors in innovation ecosystem, Russell and Smorodinskaya (2018) explain the key differences between collaboration, cooperation, coordination and networking.

Collaboration is the most advanced form of interaction where common objectives, strategies, identity and responsibility reflect in joint activities for co-creation. Cooperation is a loose of coordination of the activities of individual identities for the achievement of compatible goals. Coordination is an alignment of activities for the purpose of achieving mutual benefit and the achievement of complementary goals. Finally, networking is simply the communication and exchange of information. Collaboration is in essence explained by network relationships where mutually committed participants share information, resources, responsibilities and risks to jointly plan, implement and evaluate a program of activities to achieve a common goal.

In innovation ecosystems, interactions are key elements that facilitate the co-creation of value. Such complex interactions between heterogeneous actors raise the question on how those relationships are orchestrated or how to bring those relationships into existence or facilitate them. Similarly, if these interactions exist and orchestrated in innovation ecosystem, further question arises as to what extent does the orchestration of interaction contribute to innovation performance.

2.2 Orchestration of complex relationships within ecosystem: From Digital platform to Middleground

Most of the works on business ecosystem emphasize new forms of relationship based on digital platform where networks with strong complementarities are created between different actors (Tsujimoto et al., 2018; Gawer, 2014; Jacobides et al., 2018). The platform-based ecosystem highlights the role of digital platforms on which the actors build a complementary product or services.

In the innovation ecosystem stream, recent works identify the role of middleground as a new form of platform that foster orchestration of complex relationships in innovation ecosystem (Cohendet et al., 2010; Boyer et al., 2021; Cohendet et al., 2021).

Middleground is discussed in other works on creative cities (eg Capdevila, 2015, Capron et al., 2020, Lange and Schüßler, 2018) as intermediary platform that brings together different actors within a complex interacting context to facilitate creation and exchange of knowledge. The relevance of middleground concept relies on the emphasis on the importance of organic relationship between the formal and informal entities in innovation ecosystem, as actors tend to co-evolve in a symbiotic relationship environment (Coe and Bunnell 2003; Cohendet et al., 2020, Iansiti and Levien, 2004, Ritala et al., 2013).

Local innovation ecosystem approach draws insight from the work of Saxenian (1994), highlighting the key role of interaction between formal and informal actors to facilitate sustainability dynamics. The work explains that Silicon Valley draws its strength from integrating network between firms, external companies and more importantly, the diverse communities (engineers, IT experts, business managers etc). Similarly, other works explain the importance of informal relationship, specifically within epistemic communities (Cohendet et al., 2001; Sarazin et al., 2017). Cohendet et al. (2010) and Grandadam et al. (2013) further explain that the main mechanism that affects adaptive capacity and the autopoiesis process of the innovation ecosystem is the permanent and organic interaction between three components of the Innovation ecosystem – the underground, the middleground and the upperground.

The underground of innovation ecosystem refers to smaller players, the talented individuals, artists, informal collective where new ideas and new trends originate, constituting the exploratory capacity. The upperground contains elements and actors who have standardization capacity to develop and exploit new path of growth (firms, R&D organizations, public organizations. The middleground provides intermediation role, bringing together both talented, creative and outlying elements with exploration capacity and standardized actors with exploitation capacity for interaction in innovation process (Cohendet et al., 2010; Cohendet et al., 2020). The middleground takes the form of creative places, spaces, events and projects (Grandadam et al., 2013) – and serves as platform where talents and ideas are nurtured, developed and strengthened and provides the collaboration for new creative ideas to be transmitted to the market place. The innovation intermediaries create opportunity and condition for development of innovation. Bell (2014) admits that events and collaboration spaces such as meetups, co-working spaces, accelerators or incubators are part of networking assets of innovation ecosystem. He referred to these spaces and places as innovation cultivators that support the generation of ideas and growth of entrepreneurs. Innovation intermediation provides public-private collaboration producing benefits for the territory and accelerate innovation process in terms of developing new technology, product and services (Gamidullaeva, 2018). The performance of the Innovation Ecosystem depends on the quality of the middleground or the quality of the organic relationship between the formal and informal entities (Amin & Cohendet, 2004; Coe & Bunnell, 2003; Cohendet et al., 2010; Saxenian, 1996; Boyer, 2020). Nishimura and Okamuro (2011) similarly in their empirical study, highlight direct and indirect effect of networking and identify positive effect of indirect support measures on networking.

The concept of 'middleground' in innovation ecosystem studies as developed by Cohendet (2010) depicts a platform that plays an intermediary role of bringing together well-established and innovative firm with exploitation capacities and creative individuals with exploration capacity for interaction in the innovation process. In this view, middleground takes the form of creative places, spaces, projects and events (Grandadam et al., 2013)

Places are physical locations where formal and informal interaction takes place. They provide face-to-face interaction of different agents to create innovation dynamics. Places include restaurants, bars, café, recreation centres where people of diverse backgrounds interact and exchange knowledge and information (Rantisi and Leslie, 2010).

Spaces are related to places but spaces have cognitive meaning to physical places (Capedavila, 2015). Spaces depict cognitive environment where individuals interact and share knowledge and information (Amin and Cohendet, 2004). Spaces require cognitive proximity that enables individuals understand, interpret and exploit new knowledge (Cohen and Levinthal, 1990). Spaces represent cognitive proximity and complement places with geographical proximity, both of which enhance innovation (eg Boschma, 2005).

Events provide avenue for participation and interaction of both close and distant actors, enhancing the creation and dissemination of tacit knowledge (Bathelt et al., 2004; Maskell et al., 2006). Events enable local actors exchange knowledge and innovation with diversity of external actors.

Projects on the other hand allow coordination and integration of diverse knowledge bases (Capdevila, 2015). Projects are evidence collaborative activities in the innovation process. They integrate talents and diversity to develop exploration and exploitation of innovation. Projects allow geographically and cognitively distant actors integrate and exchange heterogeneous knowledge. For Gilsing (2000) and Maskell (2001), common innovative projects can contribute to ambidexterity, developing existing competencies within the ecosystem or developing new competencies to explore future possibilities. Collaborative projects provide the participant the opportunity to engage in collaborative activities for innovation dynamics. The participants include both firms and organizations within the innovation ecosystem and external actors, with diverse capabilities, facilitating exploration and exploitation.

Thus, structured interactions provide the actors with the opportunity to engage in knowledge generation and exchange processes (Bathelt et al., 2004). Similarly, Saxenian (1996) asserts that the strength of an ecosystem lies in the complex network of interaction among firms and between firms and institutions. Innovation intermediary such as middleground supports innovation creation through interaction, generation and commercialization of ideas (eg Inkinen and Suorsa, 2010). The intermediary structures include technical assistance centres, vocational training centres (Bocquet and Mothe, 2015), incubators and accelerators, spaces, such as coworking spaces, places, projects and events (Grandadam et al., 2013; Cohendet et al., 2010). These intermediaries are critical in knowledge transfers and can be formal or informal structures that focus on promotion of networking of actors.

The middleground of innovation ecosystem provides the platforms for the interaction of firms with both exploration and exploitation capabilities. Therefore, to assess the impact of middleground of innovation ecosystem on the technological development, we develop two hypotheses:

Hypothesis 1*: Participation in event in period t positively affects technological development of firms in period t+1*

Hypothesis 2*: Collaboration in project in period t positively affects technological development of firms in period t+1*

Hypothesis 3*: Participation in event and collaboration in project in period t positively affect technological development of firms in period t+1*

3. Hauts-de-France Innovation Ecosystem

3.1 Presentation of Eurasanté ecosystem

The region of Hauts-de-France (France) emerged from the merger of the Nord-Pas-de-Calais and Picardy regions in 2016 and covers about 31,806 km2 and is subdivided into five departments1 Aisne, Nord, Oise, Pas- de-Calais and Somme. In the 1970’s, the Nord-Pas-de Calais was considered a declining region as a result of the failure of its main economic industries – textiles, metallurgy and coal. However, since 2000, the region has made efforts to develop new tools in order to activate sustainable transition based on innovation.

The SRI-SI and SRDEII (Regional Innovation Policy of Hauts-de-France Region) target the specialization of Hauts-de-France region on specific technological fields and centers around a specific local innovation ecosystem as follows: Biotechnology, Health and nutrition ecosystem; ICT and internet of things ecosystem; the green chemistry and agro-industry ecosystem and the fashion and textile ecosystem; digital images and creative industries ecosystem; Energy; and Transport and mobility ecosystem (Boyer et al., 2021).

Eurasanté Innovation ecosystem is one of the local innovation ecosystems of Hauts-de-France region and specializes on biotechnology, health and nutrition.

Eurasanté Innovation ecosystem is built around the public regional university hospital in Lille (CHRU Lille) created in 1958 and university and health research center (CNRS). They have three fundamental responsibilities: healthcare, teaching and research (both fundamental and applied research).

Eurasanté Innovation Ecosystem was created out of both the national policies of Pole of competitiveness and regional policies of innovation parks.

The Innovation Park as the core of innovation ecosystem, is a place where located artefact and the main organizations whose role are the animation of the ecosystems and the promotion of the regional economic development and growth through innovation and technological development.

It promotes strong relationship (formal and informal), feedback, interactions and fertilization between a diversity of actors and companies within one or more technological fields. They

uphold knowledge development and management by bringing together research laboratories, technological structures, finance organization, brokers and companies within an interacting and strategic context. The Presence of such actors fosters the integration of scientific, technological and business dimensions (eg. Jackson, 2011).
Eurasanté ecosystem (Health Nutrition Ecosystem) has approximately 700 companies (with some outside of the Hauts-de-France region), and about 170 companies located in the Eurasanté. It has a Competitiveness Cluster (NSL) specialized in nutrition, health, longevity; and a business cluster (Clubster-Sante; now Clubster-NSL). The Eurasanté Innovation Ecosystem (Biotechnology, Healthcare and Nutrition) emerged from public–private collaborations in order to support the regional transition and the dynamic of new industrial specializations.

Pole of Competitiveness or Competitiveness clusters policies are aimed to develop within a given geographic area, a competitiveness clusters on a given innovation and technology domain with a diversity of actors such as small, medium or large companies, research laboratories and training establishments that interact through R&D collaborative project (Retour, 2008). The *Nutrition Health Longevity* (NSL since 2005, now Clubster-NSL since 2019) is the Pole of Competitiveness of Eurasanté and is one of the main components of the Eurasanté Innovation Ecosystem.

Eurasanté Innovation ecosystem emerged also from the establishment of the Site of Excellence and Innovation Park resulting from the Lille European Metropolis[25] and Hauts-de-France regional policies. Innovation parks are labels specific to the Hauts-de France region and refer to organizational arrangements that bring together a diversity of actors (companies, research centers, R&D organization, fablabs, co-working space, living laboratories…) within a technological field to foster complex interactions between these actors (Boyer et al., 2021). The Eurasanté Park is one of the Innovation Parks in the Hauts-de-France region whose mission is to ensure the governance and animation of Hauts-de-France Innovation Ecosystems at regional level, to stimulate the development and growth of new and high-tech companies through the role of incubation and to promote regional economic development and growth.

25 Master plans of the Lille European Metropolis (2001).

Finally, the governance and animation of the Eurasanté Innovation ecosystem is provided by the Eurasanté Agency, a GIE (Economic Interest Group)[26] which is an emanation of CHU Lille, Clubster NSL, and the organizations that manage the Eurasanté Innovation Park.

The Eurasanté Innovation Ecosystem emerged from public–private collaborations in order to support the regional transition and the dynamic of new industrial specializations. Biotechnology, Healthcare and Nutrition represent one of the main industrial specializations in Hauts-de-France.

3.2 Research design and data sources

In this study, we combine a case study approach with quantitative data analysis.

The case study approach allows us to describe the Eurasanté Ecosystem in Lille (France), its structure and main characteristics. We also describe the middleground of Eurasanté Ecosystem and the main components.

For quantitative analysis, we use both structural network analysis to identify the strategic nodes, the core-periphery actors in the ecosystem and use econometric analysis to test our hypotheses.

The network analysis is built with data from three main sources. First, Astride database managed by HDFID (the Hauts-de-France Innovation Development Agency), data from Eurasanté website and the INPI (National Institute of Industrial Property) database. We used Astride and Eurasanté database to identify companies and organizations participating in Eurasanté innovation ecosystem. We find 661 actors in the Eurasanté ecosystem. These actors are either located in the innovation park or members of the three main networks, or interact with these actors through innovative R&D projects labelled since 2009.

For the econometric analysis, we triangulate the Astride database, the Eurasanté agency database and INPI database to obtain complete data for 277 actors to test our hypotheses. We used patent data to measure the level of firm's technological performance from 2016 -2020. We used Astride database to identify the number of participations in events organized by Eurasanté and its Competitiveness Cluster; and collaboration in R&D projects supported by Eurasanté and its Competitiveness Cluster from 2009 - 2015. We control for regional supports and firm characteristics such as firm size and location in the innovation park (see section 4.1).

26 In France, the GIE is a group of legal persons whose objective is to facilitate the economic development of businesses by pooling resources, material and competencies

For our econometric analysis, we identified 277 firms that are official members of Eurasanté ecosystem, with complete data in Astride.

3.3 Middleground and Complex relationships in Eurasanté Ecosystem

The middleground orchestrates complex interaction between diversity of actors in innovation ecosystem. It provides a common platform that serve as a generator of new ideas and shared knowledge and facilitates talent development and entrepreneurial initiatives by blending the formal and the material components with the informal and the intangible components. Our documentary research confirms that Eurasanté innovation ecosystem has a formidable middleground with the four main components – places, spaces, projects and events

3.3.1 Place within Eurasanté Ecosystem

The place of the middleground of Eurasanté Ecosystem refers to the Eurasanté Innovation Park. The Innovation Park as the core of the Eurasanté innovation ecosystem, is the emblematic place where main artefact and organizations are located whose role are the animation of the ecosystems and the promotion of the technological development and growth in the Biotechnologies, Healthcare and nutrition industry in Hauts-de-France region. This specific place houses the three main actors that structure the whole ecosystem and manage the innovation networks within this ecosystem.

First, the Eurasanté Innovation Park houses the CHU Lille (University Hospital of Lille) the main actor around which the ecosystem is built. CHU Lille is the main actors that are involved in knowledge production within the Eurasanté Ecosystem. More than 50 research laboratories are associate to the CHU Lille and it is involved in knowledge transfer mainly through the Health Technologies Expertise Unit (CETS), which is a multidisciplinary platform coordinated by the Research and Innovation Department of the CHU. Furthermore, CHU Lille is associated with many R&D projects with companies and start-ups.

Second, Eurasanté Innovation park houses the Innovation Hub of Eurasanté. The role of the Innovation Hub is mainly incubation and acceleration of companies. The innovation hub has three main components: the business incubator (Bio-incubateur), the business accelerator (Innov-hub, Bio-accelerateur) and business center where about 170 companies are located. The innovation hub of Eurasanté fosters relationships between start-ups on the one hand and on the other hand, relationships between start-ups, large companies, financial organizations, the CHU of Lille and R&D organizations. The innovation Hub supports the creation and acceleration of innovative companies and contributes to renew existing business clusters and the evolution and dynamics of the Eurasanté Innovation Ecosystem.

Third, the Eurasanté Innovation Park houses the executive committees and team managers of NSL-Clubster, the Competitiveness cluster. Clubster-NSL is involved in animating a network with over 300 actors and facilitates relationships for techno-push innovation and market-push innovation The Clubster-NSL promotes *triple helix relationships* (university and research organizations, companies and public organizations) mainly through innovative or R&D projects. The Competitiveness clusters contribute to find relevant partners and financing for co-elaboration and development of R&D projects. For example, the Clubster-NSL from 2006, labelled 250 private or collaborative R&D projects. Interview with managers of Clubster-NSL shows one of the main roles of the Competitiveness cluster is to foster relationship between companies in order to expand their business to new markets. They offer to companies and other actors adapted tools to make technological watch. They develop depth studies on specific themes or in strategic areas. They make regular monitoring and send periodically newsletter to members of the business network. They develop collaborative platform that allows members to interact with each other and monitor network projects. Finally, they organize expert meetings to share knowledge and best practices.

Presence of such actors fosters the integration of scientific, technological and business dimensions within the Eurasanté Innovation Ecosystem (eg. Jackson, 2011).

3.3.2 Spaces within Eurasanté Ecosystem

Spaces as component of the middelground provide the cognitive platforms to unite different communities of actors, and to exchange, translate new ideas, and create new innovative initiatives. Since 2010, the Eurasanté Agency has fostered the emergence of Openlabs, Fablabs, makerspace in the Eurasanté Innovation Ecosystem. The Eurasanté innovation park houses many spaces of creativity, co-creation of knowledge, open innovation and codesign in order to reinforce collective intelligence, creativity and agility among the complex actor’s system. For instance, since 2012, the Saga Concept Room at Eurasanté, a Living Lab, brings together researchers, medical practitioners, entrepreneurs, designers and users to co-design and develop prototypes of future health products, biotechnologies and services. Inspired by the famous "concept cars", these creative and pioneering prototypes highlight the know-how of regional health industries and aim to improve the well-being of patients, nurses and medical practitioners. Since its creation, the Concept Room has given rise to 5 co-elaborative and creative and futurist projects. Among them are: (i) a full-scale prototype of a hospital room of the future (2012); (ii) the optimized ambulatory care service (2013); (iii) the Silver concept, the EHPAD (establishment for dependent elderly people) of future (2015); (iv) the Hospihome concept, connected home health (2016); and (v) the Emergencies and unscheduled care (2020). Furthermore, the Eurasanté Innovation Hub offers spaces, skills and support for the development of new start-up. Every year more than 20 start-up projects are supported by the Bio-incubator of Eurasanté.

3.3.3 Events within Eurasanté Ecosystem

Events are considered one of the forms of middleground. Event provides an avenue for connection between talented and periphery actors to well-established structures and organization. Events are organized with the objective to exchange ideas and knowledge for development of innovation. Events allow face-to-face interaction for social relations and provide a global pipeline for new knowledge (Bathelt et al., 2004). Main events organized by Innovation Park include conferences, hackathon (co-design, collaborative, creative events that have sometimes an artistic or harking dimension) and speed dating (events that use method of finding a partner for innovation project through short conversation). Others include after-work (events that allows people to meet together after work and discuss with others about new ideas, new projects and new experimentation), start-up weekend (events that allow 'start-uppers' to challenge their ideas, business model etc with other 'start-uppers' and financing actors or experienced businessmen).

Beyond these generic events, there are events such as trade fairs and conferences specifically organized by Eurasanté innovation park. For example, we have Ageingfit (event on Silver economy), Medfit (event on medical and diagnostic technologies), Biofit (event on technology transfer, academia-industry collaboration, early-stage innovation and seed capital investment in the field of Life Sciences) and Nutrievent (event on partnership innovation in nutrition, food and health).

Events such as trade fairs are temporary clusters (Maskell et al., 2006; Torre, 2008) that bring together actors from different technological field and locations for a short period of time.

3.3.4 Projects within Eurasanté Ecosystem

Projects are one of the main components that foster formal relationships between actors and co-evolution within the Eurasanté Innovation Ecosystem. More than 250 R&D projects have been realized from 2006 to 2020 supported by the Eurasanté Agency.

These R&D projects take many forms. They could be fundamental and applied research projects led by the CHU 's research laboratories but which associates industrial firms. For example, there are research projects financed by the French National Research Agency (ANR) and project European Regional Development Fund (ERDF) dedicated to research, technological development and innovation for regional competitiveness. They are also collaborative projects supported by the NSL-Clubster organization or competitiveness clusters financed by the Interministerial Fund (or FUI) intended to support applied research, development and commercialization of new products and services. These projects incorporate large companies, SMEs and laboratories assisted by competitiveness clusters.

One the other hand, R&D collaborative project in Eurasanté Innovation Ecosystem can emerge from creatives ideas developed during events or codesign workshops. For example, the Hibster events where new ideas are challenged and developed through open innovation and collective intelligence. There are about 5 projects initiated by the Saga Concept Room.

Finally, the main function of the Eurasanté innovation Hub is the incubation of new project and acceleration of start-up or SMEs. The Bio-incubator that boosts health business projects that require innovative solutions.

In conclusion, the *middleground* of Eurasanté serves as a relevant platform that facilitates orchestration of complex relationships between actors. The components of this middelground (places, spaces, events, projects) are involved in several forms of relationships : i) contractual and customer-supplier relationships; ii) learning relationship (seminar, professional training, workshop); iii) formal network relations; iv) relationship through innovative project; v) informal relationship (ad hoc mutual support, ad hoc and informal advice, participation in an epistemic community); and vi) informational relationship (information sharing, trade fairs, technology watch).

3.4 Network structure of Eurasanté Innovation Ecosystem

The structural network analysis of Eurasanté Innovation Ecosystem shows very dense networks and highlights complex relationships between actors involved in this innovation ecosystems (see figure 6). Statistics about degree centrality, betweenness centrality, closeness centrality, cliquishness that measure the structural characteristics of the social networks within the Eurasanté Innovation Ecosystem show both dense interactions between actors but also strong variability (standard deviation) (Table 7). These results highlight the fact that there are companies or organizations that are in the core of the ecosystems like CHU Lille and others at the periphery. Degree centrality indicates the number of ties that link one node to other nodes within the network. Closeness centrality shows the distance between a node and other network nodes. Betweenness centrality shows the intermediary position of an actor. Betweenness centrality shows how much control an actor has in the information flow in the entire network (Wasserman and Faust, 1994). Eigen centrality on the other hand extends the degree centrality to include how well a node is and how many links their connections have within the network. Clustering coefficient shows the proportion of existing links in the number of all possible links in the direct neighborhood (Watts and Strogatz, 1998).

However, our structural network analysis shows only formal interactions between actors. Our empirical analysis uses proxies to capture the importance of informal interactions within the Eurasanté Innovation Ecosystem.

	Health and Nutrition Ecosystem (Eurasanté)
Number of companies	661
Number of ties	3618
Average degree centrality (St. dev)	5.47 (15.11)
Average betweenness, centrality (St. dev.)	599.26 (6483.65)
Average closeness centrality (St. dev.)	0.36 (0.04)
Clustering coefficient/Cliquishness (St. dev.)	0.34 (0.45)

Table 7: Structural characteristics of the social networks within Eurasanté Innovation Ecosystem

	Health and Nutrition Ecosystem (Eurasanté Ecosystem)		
	Mean	Min	Max
Sectoral Diversity (Shannon Index Entropy)	1.86	0	2.30
Sectoral Diversity (Modified Herfindahl Index)	0.80	0	0.9
	• Agriculture, forestry and fisheries • Construction • Financial and insurance activities		

Sector represented within the Eurasanté Innovation ecosystem	• Information and Communication • Manufacturing, mining and quarrying and others • Professional, scientific and technical activities and administrative • Public administration, education, Human health • Real estate activities • Wholesale and retail trade, transport, accommodation and food services • Other service activities

Table 8: Heterogeneity and Sectoral Diversity within Eurasanté Innovation Ecosystem

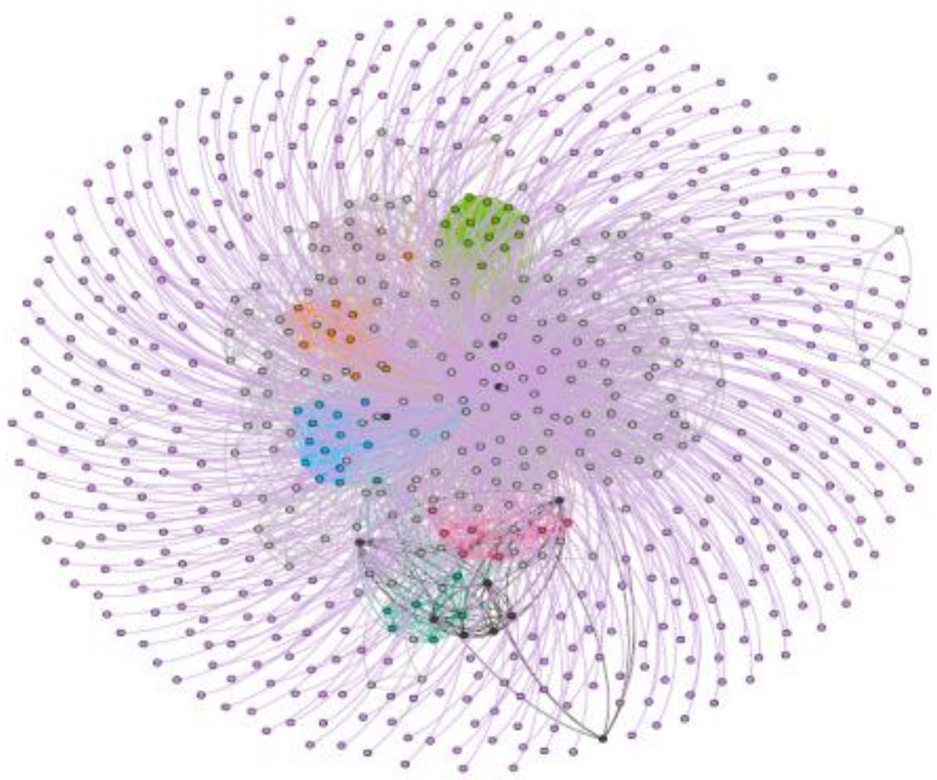


Figure 6: Structural Network of Eurasanté Innovation Ecosystem (core-periphery structure)

Note: *E*ach color represents group of firms that are most related to each other, or are part of the same sub-network. (the links have the color of the node)

4. Empirical Analysis

Based on the objective of the study, the empirical analysis aims to determine the impact of the middleground in technological development within the Eurasanté innovation ecosystem.

We empirically test the effects of participating in collaborative R&D projects and events (two components of middleground) on technological development of firms within the Eurasanté innovation ecosystem. These two components of middleground capture both formal and informal dimensions of the middleground. Furthermore, we have complete data from Astride database to measure these components for the Eurasanté Innovation Ecosystem.

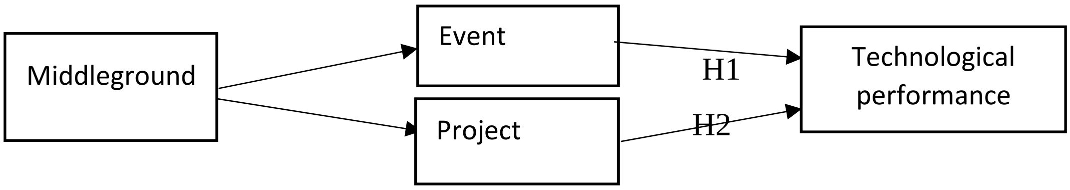


Figure 7: Theoretical framework and hypotheses

4.1 Econometric model

To determine the impact of middleground on the technological development, we develop two models to test our two hypotheses, employing a count regression model.

Specifically, we use Zero-inflated Negative Binomial (Zinb) regression. Zinb is a modified Poisson regression model that deals with issues associated with Poisson regression such as overdispersion and excess zero (Greene 1994). Poisson distribution assumes that its variance is equal to its mean. But count data most times shows overdispersion such that the variance is larger than the mean. Overdispersion can be caused by unobserved heterogeneity and/or excess zeros in the data and Zinb is used to model count data with excess zeros. Due to many zeros in the dependent count variable, we adopt Zinb model in our estimation. Zinb also accounts for the probability of excess zeros using logit model (binary).

The dependent variable contains excess zeros as there are two categories of firms with zeros. Firms with zero patents are treated as having no technological development. However, firms with zero patents are likely to arise from two different processes of data generation: (a) firms that do not innovate at all and do not have patent; (b) firms that attempt to innovate but fail to produce patents.

Zinb model was designed to account for excessive zero in the data. It presents a structure of mixture of Negative binomial distribution and a logit function as presented below:

$$Pr(Y_{it} = y_{it}) = \begin{cases} P_{it} + (1 - p_{it})\, f(0), y_{it} = 0 \\ (1 - p_{it})\, f(y_{it}), y_{it} > 0 \end{cases} \quad (1)$$

Where, $f(0)$ is the logistic function and $f(y_{it})$ is the negative binomial distribution.

Y_{it} is the response variable, i.e the number of patents. When firms do not innovate and do not produce innovation at all (certain zero group), the binary process takes 0 with the probability of p_{it}, and when firms attempt to produce, patent takes values 0, 1, 2…, and the binary takes value 1 with the probability of equal to 1- p_{it}. The negative binomial distribution is as below

$$f(y_{it}) = Pr(Y_{it} = y_{it}|\lambda_{it}, \alpha) = \left(\frac{1}{1+\alpha\lambda_{it}}\right)^{1/\alpha} \frac{\Gamma[1/\alpha + y_{it}]}{\Gamma(1/\alpha) y_{it}!]} \left(\frac{\alpha\lambda_{it}}{1+\alpha\lambda_{it}}\right)^{y_{it}}$$

Where, λ_{it} is the mean parameter and α is the overdispersion parameter.

Following above model, we use the following variables in our models.

Model 1:

$lnPat = \beta_0 + \beta_1 Eve + \beta_2 Aid\_Region + \beta_3 Size + \beta_4 Loc + \beta_5 CC + \varepsilon$ i

Model 2

$lnPat = \beta_0 + \beta_1 Pro + \beta_2 Aid\_Region + \beta_3 Size + \beta_4 Loc + \beta_5 CC + \varepsilon$ ii

Model 3

$lnPat = \beta_0 + \beta_1 Pro + \beta_2 Eve + \beta_3 Aid\_Region + \beta_4 Size + \beta_5 Loc + \beta_6 CC + \varepsilon$ iii

Where:

Pat = Number of patents as a proxy for technological development (2016 -2020)

Pro = Dummy, 1 to indicate participation in R&D innovative projects (2009-2015)

Eve = Number of participations in events (2009-2015)

β_3*Aid_Region* = level of regional support received by firms

Size = firm size

Loc = 1 if a firm is officially located in the innovation park; and 0 otherwise

CC = Closeness centrality measure

To further validate our results and capture the simultaneous effect of event and project, rather than their separate effects, structural equation modelling (SEM) technique is employed. Structural equation modelling is used to investigate complex relationships between variables and to resolve the endogeneity problem between variables. SEM assumes response variables are continuous. In this study we use generalized structural equation modeling (GSEM). GSEM generally accommodates both continuous and other forms of data such as binary, ordinal and categorical data and allows multilevel models. Figure 8 presents the conceptual model structure, showing the effect of event and project on technological development.

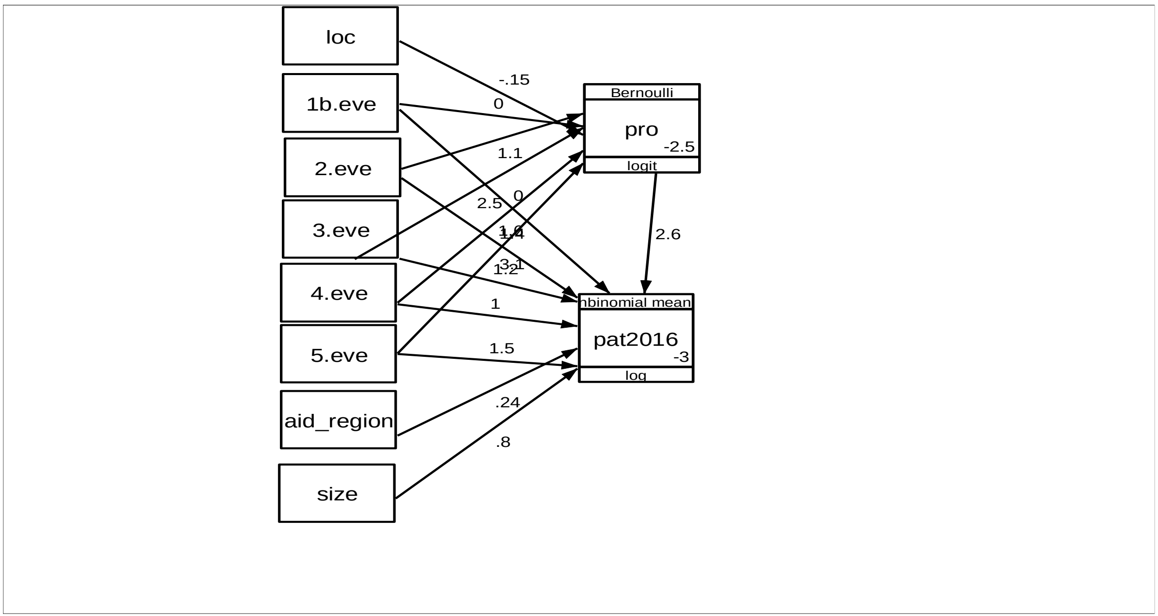


Figure 8: Conceptual model structure and the effect of event and project

4.1.1 Dependent variable: Technological Development

To measure technological development, we use number of patents by each firm in the innovation ecosystem as proxy. Patent application is seen as a good indicator of firms' technological performance (Ernst, 2003; Breschi et al., 2013). We identify the number of patents of firms which are part of the Eurasanté Innovation Ecosystem for the last five years (from 2016 to 2020). We used the INPI database to obtain data on the number of invention patents granted for each firm evolving within the Eurasanté innovation ecosystem.

4.1.2 Measures of independent variables

We have two main variables of interest as proxy for 'middleground' namely – Events and collaborative R&D Projects. The justification of these two components of middleground comes from the fact that they capture both formal and informal relationship that are orchestrated in the ecosystem.

Collaborative R&D projects are related to formal relations that engage official actors within the Innovation Ecosystem to work together through a given project.

On the other hand, *Event* accounts for informal relationships, foster idea generation and connects ecosystem actors with external knowledge, information, technological updates and allows them to be receptive to new external influences.

To measure *Event*, we use the number of participations by each firm (through their representation) in events organized within the Eurasanté Innovation park or organized by Eurasanté agency, main actors in charge of the animation of the Innovation ecosystem; and its Competitiveness Cluster, NSL. We extracted this data from 2009 to 2015, since available data firm participation in events from ASTRIDE database starts from 2009.

The Astride database has data and information about participation of firms in events organized in the region since 2009. We classify the firms into five categories to show the regularity with which a given firm participate in events through its representatives within Eurasanté, Innovation Hub or organized by main actors in charge of the animation of the Eurasanté Innovation Ecosystem. These categories are built by transforming a count variable to a scale variable depending on its distribution (see Appendix B1). The categories are built as follows:

Category 1: Firms that never participate in ecosystem events

Category 2: Firms that participate in ecosystem events rarely

Category 3: Firms that participate in ecosystem events sometimes

Category 4: Firms that participate in ecosystem events often

Category 5: Firms that participate in ecosystem events very often

Project represents the collaborative R&D projects supported by Eurasanté and its Competitiveness Cluster

To measure project, we use a dummy variable *PROJECT*. The variable takes 1 if a given firm has been involved officially in collaborative R&D projects with other firms within the Eurasanté Ecosystem for the same period 2009- 2015 and 0, otherwise.

We use *Aid_region* to control for public support received by firms as public support tends to influence innovative activities (Doh and Kim, 2014). *Aid_Region* indicates support (financial and technical) for innovational activities from the Regional Innovation Agency (HDFID). This variable is a scale variable 0 to 5, with 0 if the company does not receive regional support and 5 the highest level of support (see appendix B2). We consider firm-specific characteristics such as size that can influence technological development. We use INSEE classification of firm size (micro, small, medium or large). We control for firm located in Eurasanté Innovation Park. *Loc* takes binary, 1 for firms located in the innovation park and 0, otherwise.

To test the effect of the position of actors within the network on technological development of firms, we use the centrality measures (degree, closeness, betweenness, eigencentrality, Cliquishness). In fact, while the Eurasanté Innovation Ecosystem is a multi-network ecosystem built around a focal structure (CHU of Lille), network position of actors is still important in the innovation ecosystem, because clustering facilitates information exchange and increases information exchange capacity in the network (Schilling and Phelps, 2007). To avoid multicollinearity, we include the closeness centrality in our models.

4.2 Empirical Results

Poisson model is generally used to model count data. In this study, we estimated Poisson model but 'Goodness of fit' test and LR test of Alpha equals zero were very statistically significant, allowing us to employ Negative Binomial regression. However, the vuong statistic test for the excess zeros was found to be positive and statistically significant, indicating that Zero-inflated model (Zinb) is preferred to standard Negative Binomial. The statistically significance of Alpha coefficient at 1% level indicated overdispersion in the data. Thus, our choice for Zinb model is validated.

A positive/negative estimated value of β coefficients of explanatory variables in the count model of Zinb indicates that an increase in the variable leads to a higher/lower expected count of the dependent variable, holding other factors constant. Similarly, a negative/positive value of γ in the 'inflate' model indicates that the variable reduces/increases the log odds ratio of zero occurrence.

The regression results of Zero-inflated negative Binomial and generalized structural equation estimations are reported in table 9. Both results show event participation and collaboration in project are statistically significant and exert positive impact on technological development.

From table 9, model 1 shows that among firms within non-zero group, participation in events exhibits a higher propensity for technological development. The results show that all the frequency level of participation exerts positive impact on the technological development. Similarly, model 2 shows that collaboration in projects exhibits higher effect on the technological development among the non-zero group. Results of model 3 show that both variables are statistically significant and positively impact on technological development for non-zero group. In the results, firm size has positive effect on firm technological development, except for model 1. Larger firms exhibit a higher effect on technological development. Regional support is found to be negative in model 1. This indicates a negative effect on technological development and contrary to apriori expectation. However, it is not statistically significant in models 2 and 3. The result shows that the position of firms in the network (Closeness centrality) is statistically significant in models 1.

On the other hand, for firms within zero group, the result of the 'inflate' model shows that regional support and firm size are negative and statistically significant. If regional support increases, the odds of being in the zero group would decrease. Thus, the higher the regional support the less likely the firms to produce no technological development. Similarly, the larger the firm size the less likely the firm to produce no technological development.

The Structural equation model estimations further validate the results above, capturing the simultaneous effect of both event and project on technological development. Table 9 column 7 shows that the higher the participation in event, the more likely to collaborate in project; and interestingly, Column 8 reveals that both participation in event (all the frequency levels) and collaboration in project have positive impact on technological development. Table 10 presents the results of Negative Binomial estimations.

Appendix B3 presents the zero inflated Negative binomial and Structural equation models with different levels of event as a reference variable.

	Zero-inflated Negative Binomial						**Structural equation model**	
	Model 1		***Model 2***		***Model 3***		**Pro (Logit model)**	**Technological development (Negative Binomial model)**
	Count model (1)	*Inflated model (2)*	*Count model (3)*	*Inflated model (4)*	*Count model (5)*	*Inflated model (6)*	*(7)*	*(8)*
Variable	*β (Coeff)*	*β (Coeff*	*β (Coeff*	*β (Coeff*	*β (Coeff*	*β (Coeff*	*β (Coeff*	*β (Coeff*
Event								
Never								
Rarely	1.381*** (0.423)				1.440*** (0.375)		1.120** (0.511)	1.606*** (0.401)
Sometimes	1.524*** (0.480)				1.111*** (0.424)		2.541*** (0.487)	1.179** (0.459)
Often	1.000* (0.522)				0.937** (0.470)		1.356** (0.592)	1.010** (0.499)
More often	2.610*** (0.731)				1.891*** (0.683)		3.132*** (0.628)	1.510** (0.681)
Pro			1.978*** (0.368)		1.910*** (0.351)			2.613*** (0.360)
Aid_Region	-0.289** (0.103)	-1.420*** (0.432)	0.065 (0.105)	-1.858** (0.981)	-0.041 (0.102)	-1.757** (0.817)		0.243*** (0.091)
Size	0.471 (0.221)	-1.401*** (0.382)	1.053*** (0.177)	-1.129*** (0.410)	0.711*** (0.230)	-1.102** (0.463)		0.801*** (0.210)
Loc	-0.542 (0.345)		-0.343 (0.318)		-0.403 (0.315)		-0.145 (0.392)	
CC	10.590** (3.918)		0.877 (4.823)		0.691 (4.328)			
_cons	-3.155** (1.279)	4.729*** (0.921)	-1.780 (1.525)	4.114*** (1.119)	-1.577 (1.352)	4.095*** (1.091)	-2.502*** (0.311)	-2.955*** (0.417)
Number of obs	277		277		277		277	
LR chi2	71.44		85.63		103.50			
Prob > chi2	0.0000		0.0000		0.0000			
Vuong statistic	3.88***		2.69***		2.47***			
lnalpha	4.02***		3.36***		3.35***		7.52***	

Table 9: Results of econometrics models (Article 2)

Notes: Standard errors are shown in parentheses.
*Significant at 0.1 level; **significant at 0.05 level; ***significant at 0.01 level.

	Model 1	*Model 2*	*Model 3*
Variable	*β (Coeff)*	*β (Coeff)*	*β (Coeff)*
Event			
Never			
Rarely	1.699*** (0.505)		1.596*** (0.398)
Sometimes	1.969*** (0.591)		1.282*** (0.463)
Often	1.564* (0.664)		1.303** (0.525)
More often	2.647*** (0.857)		1.610** (0.693)
Pro		2.707*** (0.360)	2.312*** (0.346)
Aid_Region	0.096* (0.110)	0.419*** (0.090)	0.286*** (0.093)
Size	0.630 (0.245)	1.170*** (0.196)	0.836*** (0.220)
Loc	-0.939** (0.418)	-0.451 (0.335)	-0.573 (0.347)
CC	3.471 (4.407)	-4.236 (5.199)	-4.012 (4.589)
_cons	-2.529 (1.427)	-1.632 (1.712)	-1.552 (1.518)
Number of obs	277	277	277
LR chi2	81.13	123.86	144.28
Prob > chi2	0.0000	0.0000	0.0000
PseudoR2	0.09	0.14	0.16

Table 10: Results of Negative Binomial model

5. Discussion of findings

Our results highlight the difference between two groups of firms: the firms that produce technological development and those that did not.

For the non-zero group, our results reveal that event generally impact on technological development, no matter the frequency level of event participation. This validates our hypothesis 1 and confirms that middleground in the form of event contributes to the technological development of firms. This is consistent with other studies that conclude that event provides the participating firms the platform at which they systematically acquire information on new technological trend that influences their technological performance (eg Maskell et al., 2006).

From the second model (table 9), our result for the firms that produce technological development reveals that project positively affect technological development. This validates our hypothesis 2 and confirms that middleground in the form of project contributes to the technological development of firms.

Similarly, from table 9, our results clearly show (model 3, columns 7 & 8) that participation in event and collaboration in project together impact on technological development of firms. This validates our hypothesis 3 and confirms that middleground in the form of event and project simultaneously contribute to the technological development of firms.

In the same vein, the negative and significant impact of zero-participation in event ('Never' category) on technological development of firms (appendix B3) further confirms the above results.

Furthermore, our results show that firm size affects firm technological performance within the *Eurasanté* Ecosystem. The size of the company can be an indicator of capacity to have access to the financial market to source fund to finance the development of technologies. This is also in line with other findings that firms size provides some advantages including technological capabilities and competitive advantage (Damanpour, 1992).

The firm's position in the network impacts its innovativeness. Indeed, while the *Eurasanté* Innovation Ecosystem is a multi-actor ecosystem built around a focal structure (CHU of Lille), positions of actors within the network play a role in the innovation ecosystem, because of the degree of information exchange (Schilling and Phelps, 2007).

For the certain zero group, we found that firm size and regional support reduces the probability of producing no technological development. This imply that firm size not only enhances technological development but also reduces the probability of belonging to 'no technological development' group.

However, regional support has a negative effect on technological development in model 1 which is contrary to apriori expectation. This negative relationship could be explained by the fact that although this support aims to improve their innovation performance, the application of this support in their innovative activities may not have effectively taken place. Again, it could depend on the firm's technological strategy. A firm that focuses and utilizes the support on improving existing technologies may be less likely to appropriate new innovation in terms of patent as our proxy for technological development (Eg. Beneito, 2006; Huang and Cheng, 2015). Thus, it calls for evaluation of firm's technological strategy to ensure this support reflects in the firm's technological performance.

6. Conclusion

This study produces interesting results. First, in the theoretical part we examined the orchestration of complex interaction in innovation ecosystem and identified the middleground as intermediary platform that facilitates interaction between actors in the upperground with exploitation capacity and actors in the underground with exploration capacity, necessary for performance and adaptability of innovation ecosystem. We identified the middleground in Eurasanté innovation ecosystem in Hauts-de-France region. Second, we developed three hypotheses and used data on firms that belong to Eurasanté innovation ecosystem to test the impact of middleground on firm's technological development. Our research therefore empirically confirms that middleground contributes to the technological performance of firms.

This research fills the gap in the literature by providing empirical evidence on the impact of middleground on firm's innovation performance.

Similarly, this study makes a remarkable contribution by using a regression model (Zinb) that differentiates the behaviors of two zero-patent groups of firms – firms that do not innovate at all and do not have patent and those that attempt to innovate but fail to produce patents.

In terms of implication for regional policy makers and managers, our findings highlight the need for intermediary platforms that enable interaction and knowledge exchange between heterogeneous actors. For business practitioners, this research indicates the need to evaluate and identify the best technological strategies that meet their specific need for new innovation performance.

However, this study presents some limitations. First, we use patent application to proxy technological development. Some technological and innovation performances are not reflected in patenting. Thus, further research should consider other measures of technological development to measure non-patentable activities. Again, we focused on events and projects as measures of middleground. Further research can account for other forms of middleground as identified in the literature.

References

Adner, R. (2006). Match your innovation strategy to your innovation ecosystem. *Harvard business review*, *84*(4), 98.

Adner, R. (2017). Ecosystem as structure: An actionable construct for strategy. *Journal of management*, *43*(1), 39-58.

Amin, A., & Cohendet, P. (2004). *Architectures of knowledge: Firms, capabilities, and communities*. Oxford University Press on Demand.

Audretsch, D.B. & Feldman, M.P. (1996). R&D spillovers and the geography of innovation and production. *Am Econ Rev 86(3)*:630–640

Bathelt, H., Malmberg, A., & Maskell, P. (2004). Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in human geography*, *28*(1), 31-56.

Bell, Thatcher. 2014. "Elements of an Innovation Ecosystem." http://thatcherbell.vc/elements-of-an-innovation-ecosystem/.

Beneito, P. (2006). The innovative performance of in-house and contracted R&D in terms of patents and utility models. *research Policy*, *35*(4), 502-517.

Bocquet, R., & Mothe, C. (2015). Can a governance structure foster cluster ambidexterity through knowledge management? An empirical study of two French SME clusters. *Knowledge Management Research & Practice*, *13* (3), 329-343.

Boschma, R. (2005). Proximity and innovation: A critical assessment. *Regional Studies* 39: 61–74

Boschma, R. (2015). "Towards an evolutionary perspective on regional resilience". *Regional Studies* 49(5): 733-751.

Boyer, J. (2020). Toward an evolutionary and sustainability perspective of the innovation ecosystem: Revisiting the panarchy model. *Sustainability*, *12*(8), 3232.

Boyer, J., Ozor, J., & Rondé, P. (2021). Local innovation ecosystem: structure and impact on adaptive capacity of firms. *Industry and Innovation*, 1-31.

Breschi, S., Lissoni, F., & Malerba, F. (2003). Knowledge-relatedness in firm technological diversification. *Research policy*, *32*(1), 69-87.

Capdevila, I. (2015). Co-working spaces and the localised dynamics of innovation in Barcelona. *International Journal of Innovation Management*, *19*(03), 1540004.

Capron, E., Sagot-Duvouroux, D., & Suire, R. (2020). Anatomy of a techno-creative community–the role of places and events in the emergence of videomapping in Nantes. *Available at SSRN 3636403*.

Coe, N. M., & Bunnell, T. G. (2003). 'Spatializing'knowledge communities: towards a conceptualization of transnational innovation networks. *Global networks*, *3*(4), 437-456.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative science quarterly*, *35*(1), 128-152.

Cohendet, P., Creplet, F., & Dupouet, O. (2001). Organizational innovation, communities of practice and epistemic communities: the case of Linux. In *Economics with heterogeneous interacting agents* 303-326. Springer, Berlin, Heidelberg.

Cohendet, P., Grandadam, D., & Simon, L. (2010). The anatomy of the creative city. *Industry and innovation*, *17*(1), 91-111.

Cohendet, P., Grandadam, D., & Suire, R. (2021). Reconsidering the dynamics of local knowledge creation: Middlegrounds and local innovation commons in the case of FabLabs. *Zeitschrift für Wirtschaftsgeographie* , *65* (1), 1-11.

Cohendet, P., Simon, L., & Mehouachi, C. (2020). From business ecosystems to ecosystems of innovation: the case of the video game industry in Montreal. *Industry and Innovation*, 1-31.

Damanpour, F. (1992). Organizational size and innovation. *Organization studies*, *13*(3), 375-402.

de Vasconcelos Gomes, L. A., Facin, A. L. F., Salerno, M. S., & Ikenami, R. K. (2018). Unpacking the innovation ecosystem construct: Evolution, gaps and trends. *Technological Forecasting and Social Change*, *136*, 30-48.

Doh, S., & Kim, B. (2014). Government support for SME innovations in the regional industries: The case of government financial support program in South Korea. *Research policy*, *43*(9), 1557-1569.

Ernst, H. (2003). Patent information for strategic technology management. *World patent information*, *25*(3), 233-242.

Fagerberg, J., & Verspagen, B. (2009). Innovation studies—The emerging structure of a new scientific field. *Research policy*, *38*(2), 218-233.

Faridian, P. H., & Neubaum, D. O. (2021). Ambidexterity in the age of asset sharing: Development of dynamic capabilities in open source ecosystems. *Technovation*, *99*, 102125.

Fritsch, M. & Slavtchev, V. (2007). Universities and innovation in space. *Ind Innov 14(2):*201–218

Gamidullaeva, L. (2018). Towards combining the innovation ecosystem concept with intermediary approach to regional innovation development. In *MATEC Web of Conferences* (Vol. 212, p. 09017). EDP Sciences

Gawer, A. (2014). Bridging differing perspectives on technological platforms: Toward an integrative framework. *Research policy*, *43*(7), 1239-1249.

Gawer, A.; Cusumano, M.A. (2004). Industry Platforms and Ecosystem Innovation. J. Prod. Innov. Manag., 31, 417–433. [CrossRef]

Grandadam, D., Cohendet, P., & Simon, L. (2013). Places, spaces and the dynamics of creativity: The video game industry in Montreal. *Regional studies*, *47*(10), 1701-1714.

Greene, W. H. (1994). Accounting for excess zeros and sample selection in Poisson and negative binomial regression models.

Gulati, R., Nohria, N., & Zaheer, A. (2000). Strategic networks. *Strategic management journal*, *21*(3), 203-215.

Hassink, R. (2010). Regional resilience: a promising concept to explain differences in regional economic adaptability? *Cambridge journal of regions, economy and society*, *3*(1), 45-58.

Huang, K. F., & Cheng, T. C. (2015). Determinants of firms' patenting or not patenting behaviors. *Journal of Engineering and Technology Management*, *36*, 52-77.

Iansiti, M., & Levien, R. (2004). Strategy as ecology. *Harvard business review*, *82*(3), 68-81.

Inkinen, T., & Suorsa, K. (2010). Intermediaries in regional innovation systems: high-technology enterprise survey from Northern Finland. *European Planning Studies*, *18*(2), 169-187.

Jackson, D. J. (2011). What is an innovation ecosystem. *National Science Foundation*, *1*(2), 1-13 available at: http://www.erc-assoc.org/docs/innovation_ecosystem.pdf

Jacobides, M. G., Cennamo, C., & Gawer, A. (2018). Towards a theory of ecosystems. *Strategic management journal*, *39*(8), 2255-2276.

Jacobides, M. G., MacDuffie, J. P., & Tae, C. J. (2016). Agency, structure, and the dominance of OEMs: Change and stability in the automotive sector. *Strategic Management Journal*, *37*(9), 1942-1967.

Kapoor, R. (2018). Ecosystems: broadening the locus of value creation. *Journal of Organization Design*, *7*(1), 1-16.

Kline, S. and N. Rosenberg (1986). An overview of innovation, in R. Landau and N. Rosenberg (eds), *The Positive Sum Strategy*, Washington, DC: National Academics Press, pp. 275–305.

Lange, B., & Schüßler, E. (2018). Unpacking the middleground of creative cities: spatiotemporal dynamics in the configuration of the Berlin design field. *Regional Studies*, *52* (11), 1548-1558.

Luo, J. (2018). Architecture and evolvability of innovation ecosystems. *Technological Forecasting and Social Change*, *136*, 132-144.

Maskell, P. (2001). Towards a knowledge-based theory of the geographical cluster. *Industrial and corporate change*, *10*(4), 921-943.

Maskell, P., Bathelt, H., & Malmberg, A. (2006). Building global knowledge pipelines: The role of temporary clusters. *European planning studies*, *14*(8), 997-1013.

Mercan, B., & Goktas, D. (2011). Components of innovation ecosystems: a cross-country study. *International research journal of finance and economics*, *76*(16), 102-112.

Moore, J. (1996). *The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems*. Harper Collins: NY.

Moore, J. F. (1993). Predators and prey: a new ecology of competition. *Harvard business review*, *71*(3), 75-86.

Nambisan, S., & Baron, R. A. (2013). Entrepreneurship in innovation ecosystems: Entrepreneurs' self–regulatory processes and their implications for new venture success. *Entrepreneurship theory and practice*, *37*(5), 1071-1097.

Nishimura, J., & Okamuro, H. (2011). Subsidy and networking: The effects of direct and indirect support programs of the cluster policy. *Research Policy*, *40*(5), 714-727.

Nosella, A., & Petroni, G. (2007). Multiple network leadership as a strategic asset: The Carlo Gavazzi Space case. *Long Range Planning*, *40*(2), 178-201.

Porter, M. E. (1998). *Clusters and the new economics of competition* (Vol. 76, No. 6, pp. 77-90). Boston: Harvard Business Review.

Porter, M. E., & Kramer, M. R. (2006). The link between competitive advantage and corporate social responsibility. *Harvard business review*, *84*(12), 78-92.

Rabinovich, E., Knemeyer, A. M., & Mayer, C. M. (2007). Why do Internet commerce firms incorporate logistics service providers in their distribution channels?: The role of transaction costs and network strength. *Journal of Operations Management*, *25*(3), 661-681.

Rantisi, N. M., & Leslie, D. (2010). Materiality and creative production: the case of the Mile End neighborhood in Montréal. *Environment and Planning A*, *42*(12), 2824-2841.

Retour, D. (2008). Pôles de compétitivité, propos d'étape. *Revue française de gestion*, (10), 93-99.

Ritala, P., Agouridas, V., Assimakopoulos, D., & Gies, O. (2013). Value creation and capture mechanisms in innovation ecosystems: a comparative case study. *International Journal of Technology Management*, *63*(3-4), 244-267.

Ritala, P., & Almpanopoulou, A. (2017). In defense of 'eco'in innovation ecosystem. *Technovation*, *60*, 39-42.

Roundy, P., Bradshaw, M., & Brockman, B. (2018). The emergence of entrepreneurial ecosystems: A complex adaptive systems approach. *Journal of Business Research, 86,* 1-10.

Russell, M. G., & Smorodinskaya, N. V. (2018). Leveraging complexity for ecosystemic innovation. *Technological Forecasting and Social Change*, *136*, 114-131.

Sarazin, B., Cohendet, P., & Simon, L. (2017). *Les communautés d'innovation: de la liberté créatrice à l'innovation organisée*. Éditions EMS.

Saxenian, A. (1994). Regional networks: industrial adaptation in Silicon Valley and route 128.

Saxenian, A. (1996). Inside-out: regional networks and industrial adaptation in Silicon Valley and Route 128. *Cityscape*, 41-60.

Teece, DJ (2007). Explaining dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic management journal*, *28* (13), 1319-1350.

Torre, A. (2008). First steps towards a critical appraisal of clusters. *The Economics of Regional Clusters, Networks, Technology and Policy*, 29-40.

Tsujimoto, M., Kajikawa, Y., Tomita, J., & Matsumoto, Y. (2018). A review of the ecosystem concept—Towards coherent ecosystem design. *Technological Forecasting and Social Change*, *136*, 49-58.

Valkokari, K. (2015). Business, innovation, and knowledge ecosystems: How they differ and how to survive and thrive within them. *Technology Innovation Management Review*, *5*(8).

van Lente, H., Hekkert, M., Smits, R., & Van Waveren, B. A. S. (2003). Roles of systemic intermediaries in transition processes. *International journal of Innovation management*, *7*(03), 247-279.

Watts, D. J., & Strogatz, S. H. (1998). Collective dynamics of 'small-world'networks. *nature*, *393*(6684), 440-442.

Appendices

Appendix B1: Summary statistics for binary and categorical variables

Variables	**Label**	**Variable type**	**Variable /Categories**	**Freq.**	**Percent**
Eve	Level of participation in events of each firm (frequency)	Scale variable	Never (0)	179	65
			Rarely (1-4)	36	13
			Sometimes (5-10)	26	9
			Often (11-20)	22	8

			More often (More than 20)	14	5
Loc	Belonging officially to Innovation park	Dummy variable	No	186	67
			Yes	91	33
Pro	Participation of a given company to collaborative project during the period 2009-2015	Dummy variable	No	230	83
			Yes	47	17

Appendix B2: Summary statistics for other variables

Variable	**Label**	**Variables type**	**Mean/freq**	**Std. Dev.**	**Min**	**Max**
Pat	The number of patents owned by each firm	Count variable	5.10	29.09	0	437
CC	Closeness Centrality	Continuous variable	0.36	0.03	0.25	0.51
Aid_region	The level of regional support received by a given firm for innovative activities (0-5)	Ordinal variable	1.86	1.66	0	5
Size	The size of the companies	Ordinal variable	1.66	0.72	1	4

Appendix B3: Econometric results with different level of event as reference variable

	Zero-inflated Negative Binomial				**Structural equation model *(with ref variable 'Rarely')***	
	Model 1 (with ref variable 'Rarely')		***Model 3 (with ref variable 'Rarely')***		**Pro (Logit model)**	**Technological development (Negative Binomial model)**
	Count model (3)	*Inflated model (4)*	*Count model (9)*	*Inflated model (10)*	*(13)*	*(14)*
Variable	*β (Coeff*	*β (Coeff*	*β (Coeff*	*β (Coeff*	*β (Coeff*	*β (Coeff*
Event						
Never	-1.381*** (0.423)		-1.440*** (0.375)		-1.120** (0.511)	-1.606*** (0.401)
Rarely	Ref		ref		ref	ref
Sometimes	0.143 (0.482)		-0.329 (0.453)		1.421** (0.576)	-0.428 (0.521)
Often	-0.381 (0.524)		-0.503 (0.493)		0.236 (0.669)	-0.596 (0.553)
More often	1.229* (0.682)		0.451 (0.673)		2.012*** (0.699)	-0.096 (0.699)
Pro			1.910*** (0.351)			2.613*** (0.343)
Aid_Region	-0.289*** (0.103)	-1.420*** (0.432)	-0.041 (0.102)	-1.836** (0.859)		

Size	0.471** (0.221)	-1.402*** (0.382)	0.711*** (0.230)	-1.178*** (0.436)		
Loc	-0.542 (0.345)		-0.403 (0.315)		-0.145 (0.392)	
CC	10.590*** (3.918)		0.691 (4.328)			
_cons	-1.774 (1.336)	4.729*** (0.921)	-0.137 (1.399)	4.124*** (1.117)	-1.382*** (0.433)	-1.348** (0.558)
Number of obs	277		277		277	
LR chi2	71.44		103.50			
Prob > chi2	0.0000		0.0000			
Vuong statistic	3.88***		2.47***			
lnalpha	4.02***		3.35***		7.52***	

Notes: Standard errors are shown in parentheses.
*Significant at 0.1 level; **significant at 0.05 level; ***significant at 0.01 level

Appendix B4: Correlation Matrix

	Pat	Eve	Pro	Aid_region	Size	Loc	CC
Pat	1.0000						
Eve	0.3080	1.0000					
Pro	0.2939	0.3858	1.0000				
Aid_region	0.1630	0.3248	0.2115	1.0000			
Size	0.3416	0.3731	0.2545	0.0764	1.0000		
Loc	-0.0444	0.0447	-0.0295	0.0672	-0.1408	1.0000	
CC	0.2678	0.1954	0.2953	0.1427	0.1758	0.1989	1.0000

Appendix B5: Multicollinearity statistics of different explanatory factors

Variable	VIF	1/VIF
Eve	1.42	0.705451

PRO	1.28	0.779900
Size	1.24	0.807462
Aid_region	1.18	0.847471
CC	1.14	0.876636
Loc	1.09	0.915425
Mean VIF	1.23	

Article 3: What explains the involvement of core actors in collaborative R&D and innovation project in a local innovation ecosystem? A middleground perspective

Abstract

Studies assert that local/regional innovation ecosystem is characterized by complex interactions between heterogenous actors, with upper-middle-underground organizational structure. One of the adaptation mechanisms comes from the interaction between actors that explore and actors that exploit and this interaction is orchestrated by the middleground. Linking adaptation to acquisition of external knowledge through collaboration suggests that core actors with rich connections absorb the most knowledge in collaborative R&D project and exhibit the greatest power of adaptation. This paper analyzes collaborative R&D projects as a form of middleground, with the objective to ascertain to what extent the underground influences the involvement of core actor in collaborative R&D projects. Using econometric model and focusing on Eurasanté innovation ecosystem dedicated to healthcare, nutrition and biotechnology in Hauts-de-France region, the study confirms that the exchanges with the exploratory actors from the underground enhance the core actor involvement in collaborative R&D project and thus, confirms that the interactions between the actors in the upperground and actors in the underground are necessary to stimulate adaptation. Similarly, the study shows that specificities of the projects matter. For instance, it shows the importance of project funding type in influencing core actor involvement in collaborative R&D project. There is evidence of geographical effect in influencing core actor involvement in collaborative R&D project. Our study therefore contributes to the literature, providing new insight and empirical evidence on the role of middleground in orchestrating interactions, with particular reference to the importance of exchanges with exploratory actors in driving learning mechanisms and adaptation in local innovation ecosystem.

1. Introduction

Knowledge creation and innovation rarely occur in isolation but rather requires collaboration of actors from both industry, science and government (Pavitt, 2005). Today, it is widely believed that organizations do not rely exclusively on their internal R&D activities to maintain competitiveness or adapt to technological changes (eg. Powell and Grodal, 2005; Malerba and Vonortas, 2009). They rather require interorganizational alliances and collaboration to explore and exploit new knowledge necessary to enhance development (Kline and Rosenberg, 1986; Spanos et al., 2015). It is argued that random collisions and interactions fail to produce desired business development (Traitler et al., 2011). The idea however focuses on formal partnerships that are key for cross-pollination and synergy.

In innovation studies, collaboration is mainly studied using interaction between actors/organizations, partnering in an inter-organizational network (eg Bernela and Levy, 2017).

In economics, one of the underlying motives for collaboration is joint knowledge production and exchange for improving performance in a modern knowledge-based economy. Collaborations for value co-creation are fundamental for innovative firms and are in perfect line for the innovation ecosystem construct.

Collaborative projects allow actors to build relationship that advances and shapes their future outcome (eg. Cattani and Ferriani, 2008; Uzzi and Spiro, 2005), and allow for contribution and input of other co-participants that produce positive results, as evident in increased co-authorship and joint research project (Barabasi, 2005).

In collaborative project, participants interact and expand their social network and work together for mutual adjustment and communication (Cattani and Ferriani, 2008; Jones et al., 1997).

Despite the role of collaborative projects in driving knowledge exchange and learning process among partners, little is known about the specificities linked to both projects and actors in driving the learning processes. Studies on the specificities of projects and partners in determining the forms of learning and knowledge exchange in collaborative innovation projects are still scarce. Thus, it is important to know what kind of project and for which kind of exchange drive knowledge sharing and learning mechanisms that drive adaptation. Miotti and Sachwald (2003) opine that the central focus of R&D network analysis tends to go beyond analyzing the characteristics of the network, to ascertaining the determinants of network formation. Similarly, Arranz and Fernandez de Arroyabe (2008) noted that exploring the determinants for partners choice require empirical attention.

In innovation ecosystem studies, collaborative projects could be seen as a form of middleground that connect underground actors, with high exploration capacity, and upperground actors, with high exploitation capacity, and have become key element in driving research and technology development (Cohendet et al., 2020). The linkages in collaborative R&D projects facilitate interactive learning for knowledge creation and diffusion within an ecosystem (Adner, 2006; Adner and Feiller, 2019). Therefore, within a network generated by multiple collaborative R&D projects in an ecosystem, we can find core actors, which refers mainly to actors in the upperground and periphery actors that could be part of the underground.

Indeed, actors in social network occupy various positions. For example, using social network analysis and complex network methodologies, Breschi and Cusumano (2004) find existence of dense and hierarchical network; and core actors with strong centrality and connectivity.

The concept of network core and periphery exits in different fields such as in social network, in scientific citation a or in economy-centric networks. A core/periphery networks represents two classes of nodes, a cohesive subgroup which is well-linked core; and periphery actors that are loosely connected to each other and to the core (Borgatti and Everett, 1999; Csermely et al., 2013). Core actors are highly central in the network and is characterized by high density of interrelations in contrast to periphery actors that are loosely connected. Arguably, the actors in the core are the relatively small number of well-established actors with necessary resources, politic and social connections to enforce their central role in the network (Fraiberger et al., 2018). This position comes with legitimacy, experience and credibility (Clauset et al., 2015). Core actors have rich connection which provide multiple network flow options and allow degeneration processes (Csermely et al., 2013). The core has less fluctuations and their integrative function is key to the development of network robustness and stability (Bustos et al., 2012; Csermely et al., 2013). Finally, linking adaptation to acquisition of external knowledge through collaboration suggests that core actors with rich connections absorb the most knowledge in collaborative R&D project and exhibit the greatest power of adaptation.

In the periphery are however the variety of actors with less constrained social relations (Cattani and Ferriani, 2014). It is emphasized that in order the succeed and enhance performance, peripheral actors need visibility and to introduce their image and voice through strategic collaboration on new projects with the core (Cattani and Ferriani, 2008; Hurlbert et al., 2000). Thus, they need to legitimize their ideas in the community through collaboration with the core.

If we consider that the motivations of peripheral actors or underground actors to involve in the collaborative project are to benefit from resources that are beyond their scope, factors driving core actors' engagement in collaborative R&D or innovation projects are still under-developed.

Therefore, linking the general question that this study addresses - what kind of project, for what kind of partners drives knowledge sharing and creation in innovation ecosystem, this study aims to provide answer to the following specific research question: *What explains the involvement of core actors in collaborative innovative project in a local innovation ecosystem?*

This study mobilizes a middleground perspectives of local innovation ecosystem to explore this question and uses a case study of the Eurasanté Ecosystem (Hauts-de-France region) dedicated to health Nutrition and biotechnology. We analyzed 70 collaborative R&D projects for a period of ten years in order to see, through econometric model, what explain the involvement of core actors in those collaborative projects.

The remainder of the paper is organized as follows: The next section focuses on the theoretical background on upper-middle-underground structure of innovation ecosystem in relation to collaboration in R&D projects. Section three focuses on the data and empirical models. Section four presents the results and discusses the findings and section five finally presents the conclusions.

2. Theoretical background

2.1 Core actors in innovation ecosystem: new insight beyond focal actors

In the business ecosystem, Iansiti and Levien (2004) introduced the concept of keystone player or focal actor. The keystone refers to the key organization or company that coordinates the relationships between other actors in the business ecosystem. Business ecosystem is in this perspective best applied in a platform-based ecosystem, where digital platforms coordinate the interactions of multilateral set of partners, around a focal or keystone actor for effective value proposition and capture. (eg Gawer and Cusumano, 2014). Platform-based ecosystem centres around a digital platform that coordinates complex interactions and enables value proposition (Adner 2006; Iansiti and Levien, 2004). The platform provides governance structures for interactions within the business ecosystem. The platform is governed and maintained by a focal actor, who conceives and controls what, how and for whom value is created. In a platform-based ecosystem, the focal actor is pivotal and controls the structure of governance and interactions, that is, controls the activities of actors in the ecosystem and how the ecosystem actors benefit from the value (Adner, 2006; Iansiti and Levien, 2004; Selander et al., 2013).

To ensure the growth of the ecosystem, the focal actor is charged with the responsibility to create network effect. This is achieved by devising mechanisms and strategies to expand and increase the number of actors that participate and benefit from the value (Economides, 1996).

Although, business ecosystem and innovation ecosystem are used interchangeably in the literature (eg Nambisan and Baron, 2013; Granstrand and Holgerson, 2020), it is argued that clear distinction somewhat exists. Business ecosystem targets exploitation of market opportunities to capture value (de Vasconcelos Gomes et al., 2018). Similarly, the interest of business ecosystem centres on the role of focal firm or keystone and how it orchestrates and controls interactions to capture value.

On the other hand, innovation ecosystem rather focuses on exploration and exploitation innovation process to co-create value (Cohendet et al., 2020; Boyer, 2020). The interest of innovation ecosystem revolves around how the structure of diverse actors are commonly linked in innovation process for the purpose of value co-creation (Cohendet et al., 2020).

Thus, innovation ecosystem is characterized by heterogeneity of actors and complex interactions in a strategic context for value co-creation. In this context, there may not be a focal actor who exerts control in the innovation ecosystem, specifically in regional/local innovation ecosystem stream. As noted, Sun et al (2019) affirms that innovation process can emerge in a self-coordinated bottom-up condition, other than being coordinated by a single focal actor in a top-down condition. Similarly, innovation ecosystem can be eco-centric, operating around a group of few innovation leaders (Klimas and Czakon, 2022), other than ego-centric, operating under a single most powerful focal actor (Beliaeva et al., 2019; Dąbrowska et al., 2019).

Most of the time, rather to have a focal actor, these are well-developed actors that occupy 'core' position, connecting with more actors within the ecosystem. This position comes with legitimacy, experience and credibility (Clauset et al., 2015).

These are referred to as core actors in opposition to "periphery actors". Indeed, in R&D collaborative project, core-periphery network structure represents a subgroup of core actors who are deeply rooted in the social system and are more likely to share vast ideas and information, and a subgroup of periphery actors who are loosely linked and scarcely connected to each other and are not as visible as core actors in the network (Cattani and Ferriani, 2008).

In the context of regional/local innovation ecosystem, the 'core' roles are considered across different areas of operation but are assigned to some type of actors (Su et al., 2018). The actors have the capacity to develop human capital and transfer existing know-how and can come from the universities and research centres. They as well have the capacity to bring new technology to the market and can come from well-developed firms. The core position in the ecosystem allows them to link and connect with other non-core actors.

Core actors however need the diverse access to new or disruptive ideas that often originate from the non-core or peripheral actors. Recent empirical study reveals that core actors increases their probability to advance in innovation performance when they broker between the periphery (Juhász et al., 2020). They have rich connections which provide multiple network flow options and allow degeneration processes (Csermely et al., 2013). The core has less fluctuations and their integrative function is key to the development of network robustness and stability (Bustos et al., 2012; Csermely et al., 2013). The relatively small number of well-established actors therefore have the necessary resources, political and social connections to absorb the most knowledge and greater exploitation capacity to enforce a central role in the ecosystem.

2.2 Collaborative projects in Innovation ecosystem: a middleground perspective

Innovation ecosystem, characterized by complex relationships between diversity of actors emphasized on upper-middle and underground structural organization.

The upperground represents the formal and well-established actors that possess the exploitation capacity. The underground represents the informal actors, talented individuals, entrepreneurs and small actors with exploration capacity; and the middleground represents the common platform that facilitates the connection and interaction of the actors in the upperground and the underground and allows coevolution and adaptation processes.

The middleground offers a potential cognitive tools or platforms for interaction for the process of knowledge production, providing mechanisms for coordinating the interaction of diverse actors and their knowledge-bases in order to commercialize ideas (Cohendet et al., 2018). The interaction between the diverse actors involved allows for generation and diffusion of new knowledge and technology in the innovation process. The middleground represents the intermediary platform that links the knowledge production activities of the formal exploitation of the upperground and informal exploration of the underground (Cohendet et al., 2010; Gradandam et al., 2013; Avdikos, 2015; Lange and SchuBler, 2018).

As noted in the literature, collaborative R&D projects are the most advanced relational component of the middleground that integrates talents and diversity to develop exploration and exploitation of innovation; and contribute to ambidexterity (eg. Grandadam et al., 2013; Gilsing, 2000; Maskell, 2001).

Collaborative R&D project allows coordination and integration of diverse knowledge-bases (Capdevila, 2015). Particularly, projects provide intermediary platforms for geographically and cognitively distant actors to integrate and exchange heterogeneous knowledge; and help to develop existing competencies within the ecosystem or developing new competencies to explore future possibilities. The participants collaborate to foster interactive leaning, providing mechanism for knowledge exchange. The interaction between the diverse actors involved allows for generation and diffusion of new knowledge and technology for innovation and adaptation processes.

2.3 Core actors and R&D collaborative projects in Innovation ecosystem

Regarding drivers of R&D collaboration, the recent literature identifies new aspects beyond traditional individual characteristics. These new dimensions of determinants include network effect, that is, the actors' position in the network and prior acquaintances (Jackson and Wolinsky, 1996; Bala and Goyal, 2000; Autant-Bernard et al., 2007).

Indeed, our main proposition in this study is that core actors need the diverse access to new or disruptive ideas that often originate from the non-core or peripheral actors. This proposition is in perfect line with our middleground perspective of the ecosystem. The role of the middleground is to connect actors in the upperground, including core actors, with the actors in the underground with more exploration capacity (new and disruptive ideas). This ongoing connection facilitate therefore co-evolution between those actors and foster adaptive capacity of firms.

Considering the fact that the firms that participate in many projects (core actors) are those that theoretically best learn and absorb the most knowledge through interactions (allocative efficiency of the ecosystem), we seek to know the key factors driving core actor involvement in collaborative R&D projects.

Therefore, our main proposition is as follows:

In innovation ecosystem context, involvement of core actors in collaborative R&D and innovation projects depends on the presence of actors of the underground or coming from the underground.

To be testable, this proposition needs to be transformed into hypotheses. Therefore, this study focuses on a category of actors who most of the time are in or come from the underground: the start-ups. Start-ups refer to newly created innovative companies or new businesses based on disruptive innovation that intend to grow, due to their very strong innovative potentials.

Start-ups play important role in exploration of new technological areas and rely on other firms for technological development (Almeida and Kogut, 1997). Highlighting the comparative success of Silicon Valley over Route 128, Saxenian (1994) noted the role of inter-firm knowledge exchanges between large firms and informal actors, including start-ups. Similarly, start-ups allow large companies gain systematic access to new trends and new innovative fields through their exploration disposition (Freytag, 2019).

Similarly, drawing from upper-middle-underground perspective that shows adaptation capacity arises from interactions and exchanges between actors who explore and actors who exploit, we therefore develop our first hypothesis

H_1: In a local innovation ecosystem context, involvement of core actors in collaborative R&D and innovation projects depends on the presence of actors of the underground.

Beyond this ‘Middleground perspective’, various works have considered different forms of proximity in driving collaboration in patenting (Hussler and Ronde, 2007; Breschi and Lissoni, 2009), in scientific collaboration (Hoekman et al., 2010; Ponds et al., 2007; Fritsch and Kauffeld-Monz, 2010) and in collaboration in European Programs (Autant-Bernard et al., 2007). Non-spatial proximity including the similarity between firms’ attributes, reflected in cognitive proximity matters especially in knowledge transfer (Boschma, 2005). Cognitive proximity explains the extent to which two organizations share the same knowledge. Firms tend to partner with more cognitive proximate firms. Thus, homophily firms i.e. firms with a high level of cognitive proximity share similar preferences, backgrounds and social status and are more attracted to each other (Mcpherson et al., 2001). A particular form of cognitive proximity is sectoral proximity because entities of the same sector of activity are likely to exploit and rely on the same or similar pieces of information and knowledge (Nooteboom, 2000; Knoben and Oerlemans, 2006). Thus, sectoral proximity might prompt mutual learning and should be decisive when selecting an innovative partner. At the same time, excess of sectoral proximity might be detrimental to collaboration due to a higher risk of unplanned and unwanted knowledge spillovers (Suire and Vicente, 2009). This may limit their willingness to collaborate with partners which are too similar from an industrial viewpoint.

Therefore, our second hypothesis addresses the issue of homophily through sectoral diversity.

H_2: In a local innovation ecosystem context, involvement of core actors in collaborative R&D and innovation projects depends on the sectoral diversity.

Works on regional and innovation studies argue that knowledge is bound to a geographical location and it evolves with time based on the existing knowledge base (Boschma, 2005; Zucker et al., 1998). Literature notes the role and importance of collaborative networks and proximity in knowledge production and diffusion (Audretsch and Feldman, 1996; Fritsch and Slavtchev, 2007; Boschma, 2005), as innovation is said to be localized process, occurring within a geographical space (eg. Porter, 1998). As collaborative networks are inter-sectoral, inter-organizational and inter-national (Wagner and Leydesdorff, 2005; Roijakkers and Hugedoorn, 2006), spatial proximity with reference to geographical proximity becomes important driving factor. Moreover, recent studies confirm the positive impact of geographical proximity on the likelihood to collaborate in R&D projects; thus, geographical distance reduces the possibility of partners to collaborate or interact (Scherngell and Barber, 2009; Paier and Scherngell, 2011; Maggioni and Uberti, 2009).

Hence, our third hypothesis draws from the role of spatial proximity in driving collaboration in local innovation ecosystem. Thus,

H_3: In a local innovation ecosystem context, involvement of core actors in collaborative R&D and innovation projects depends on the geographical proximity.

In terms of project characteristics, empirical studies identify project size as a determinant for frequency of interaction in collaborative project (Bernela and Levy, 2017) and the likelihood to collaborate (Broekel et al., 2015). Other characteristics of project considered in the literature include project funding type and period of labelling.

Similarly, motivated by the fact that the kind of project informs us about the collaboration and learning mechanisms, we develop our fourth hypothesis:

H_4: In a local innovation ecosystem context, involvement of core actors in collaborative R&D and innovation projects depends on the kind of project.

Lastly, characteristics of firms such as size, age and ownership structure (Laursen et al., 2011; Huynh and Rotondi, 2009) are traditionally identified in the literature as driving factor for R&D collaboration.

This study explores the research question, using a case study of the Eurasanté Ecosystem (Hauts-de-France region) dedicated to healthcare and biotechnology.

3. Empirical analysis

3.1 The Eurasanté Ecosystem

This study focuses on collaborative R&D projects labelled in Eurasanté ecosystem of Hauts-de-France region as a form of middleground.

The region of Hauts-de-France (France) emerged from the merger of the Nord-Pas-de-Calais and Picardy regions in 2016 and is subdivided into five departments - Aisne, Nord, Oise, Pas-de-Calais and Somme. The economic development of Nord-Pas-de Calais was threatened in the 1970's as a result of the failure of its main economic industries – textiles, metallurgy and coal. In the past two decades, efforts have been made to activate and stimulate adaptation process based on innovation.

Thus, the SRI-SI and SRDEII (Regional Innovation Policy of Hauts-de-France Region) target the specialization of Hauts-de-France region on specific technological fields and centers around a specific local innovation ecosystem. Eurasanté Innovation ecosystem is one of the local innovation ecosystems of Hauts-de-France region and specializes on biotechnology, healthcare and nutrition, built around the public regional university hospital in Lille (CHRU Lille) and university and health research center (CNRS). The Eurasanté Innovation Ecosystem emerged from public–private collaborations in order to support the regional transition and the dynamic of new industrial specializations. Biotechnology, Healthcare and Nutrition represent one of the main industrial specializations in Hauts-de-France.

It has three fundamental responsibilities: healthcare, teaching and research (both fundamental and applied research). Eurasanté Innovation Ecosystem was created out of both the national policies of Pole of competitiveness and regional policies of innovation parks. The governance and animation of the Eurasanté Innovation ecosystem is provided by the Eurasanté Agency, a GIE (Economic Interest Group)27 which is an emanation of CHU Lille, Clubster NSL, and the organizations that manage the Eurasanté Innovation Park.

The innovation park becomes the core of the innovation ecosystem, with artefact and the main organizations whose roles are the animation of the ecosystem and the promotion of the regional economic development and growth through innovation and technological development. Eurasanté ecosystem has approximately 700 companies (with some outside of the Hauts-de-France region), and about 170 companies located in the Eurasanté innovation park. It has a

27 In France, the GIE is a group of legal persons whose objective is to facilitate the economic development of businesses by pooling resources, material and competencies

Competitiveness Cluster (Clubster-NSL) specialized in nutrition, health and longevity. Clubster-NSL is the Competitiveness Cluster of Eurasanté and is one of the main components of the Eurasanté Innovation Ecosystem.

Competitiveness clusters (*Pôle de Compétitivité*) policies aimed to develop within a given geographical area a competitiveness clusters on a given innovation and technology domain with diversity of actors such as small, medium or large companies, research laboratories and training establishments that interact through R&D collaborative project (Retour, 2008). It can be seen as a reflection of the European promotion of clustering, reinforced by the communication of the European Commission on European industrial policy in 2010. The European Cluster Observatory, Cluster Excellence, Cluster Internationalization, Cluster and Emerging Industries are tools provided at the European level in order to support regional policies regarding the promotion of clusters. In fact, one of the objectives is to promote interaction between economic agents that would influence the emergence of clusters, which in turn become artefacts of successful regional innovation dynamics.

The Competitiveness clusters contribute to find relevant partners and financing for collaboration and development of R&D projects. Clubster-NSL is involved in the animation of a network with more than 300 actors and facilitates relationship between cluster members and others even outside the cluster location.

These collaborative R&D projects take many forms. They could be fundamental and applied research projects led by the CHU's research laboratories but which associate industrial firms. For example, there are research projects financed by the French National Research Agency (ANR), established in 2005 for project-based funding in France; and European Regional Development Fund (ERDF) dedicated to research, technological development and innovation for regional competitiveness. There are also collaborative projects supported by the NSL-Clubster organization or competitiveness clusters financed by the Interministerial Fund (FUI) intended to support applied research, development and commercialization of new products and services. These projects incorporate large companies, SMEs and laboratories assisted by competitiveness clusters.

3.1.1 Collaborative R&D projects in Eurasanté ecosystem

Collaboration network is generally discussed in the form of affiliation network (Anderson et al., 1998; Newman, 2001; Onel et al., 2011; Ortega and Aguillo, 2010).

Affiliation network represents network of participation or membership in which 2-mode data shows sets of relations that connect 'actors' and 'events'. The affiliation network makes it possible to determine network links between actors through events, thus, allowing to know which actors participated in which event; with dual perspective on network relationships between actors an event.

In this study, the 'actors' represents the firms/organizations and 'events' represents collaborative R&D projects. Collaborative R&D projects allow for interorganizational interactions in the innovation process.

From the official website of Eurasanté agency and its competitiveness cluster (Clubster-NSL), we identified about 70 collaborative R&D projects labelled between 2009 and 2020 that the details were accessible and have at least two partners, to meet our aim to study collaboration. We use the data to construct affiliation network, a 2-mode network with two subjects of nodes and edges between two sets. The data links each project with the partners.

With the objective of the study in mind to ascertain if the presence of the underground enhances the chances of core actor involvement in collaborative R&D project and further test what drives core actors involvement in collaborative R&D project, the 2-mode network was analyzed using the projects and partners.

The 70 projects have 409 actors/participants which include both firms and research organizations and universities (see table 11).

3.1.2 Construction of R&D networks

We constructed a 2-mode network of R&D cooperation. 2-modes (ie. bipartite) networks are made of two different sets of nodes. In the following (figures 9,10,11), blue nodes represent collaborative R&D projects while red nodes represent organizations. Links only connect a given project with organizations having taken part to it. 2-mode networks allow to represent on the same graph collaborative R&D projects and organizations and to possibly conduct analyses on two distinct 1-mode (ie. relational) networks: networks of organizations and networks of projects. In this type of network representation, a tie forms when an organization is involved in a project (cf. figure). Switching from 2-mode to 1 mode networks consists in "projecting" 2-mode networks in the "relational space" of one of the types of nodes, collaborative R&D projects or organizations. This procedure is commonly used because many (and the most popular), analysis methods and measures (eg. for analyzing network or node properties) have been developed for relational networks (Borgatti and Everett, 1997). However, projecting 2-mode into relational networks raises two types of issues. First, as for all projections, it causes a loss in information that may possibly cause misinterpretations of obtained results because, in most network analyses in social sciences, relationships between any two nodes stems from external factors (eg. joint participation to events or projects, joint membership to an organization…) (Vernet et al., 2014). Second, and more importantly when it comes to a quantitative analysis of node positions in a network, reducing 2-mode into 1-mode network may bias individual measures because, underlying in the reduction process is the "complete graph" hypothesis (Breschi and Cusmano, 2004; Autant-Bernard et al., 2007). According to this hypothesis, all members in a project are assumed to have interacted with each other. However, this hypothesis is often not empirically observed, especially in projects involving numerous organizations (Bernela and Levy, 2017). Taking those observations into account, we retain a 2-mode representation of networks in our quantitative analysis.

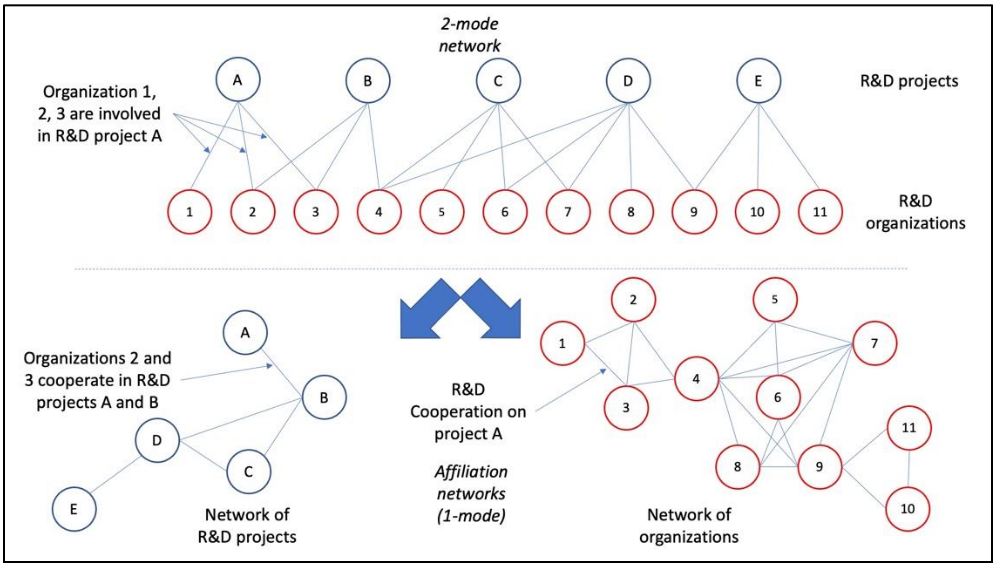


Figure 9: 2-mode and corresponding 1-mode / relational networks

In a first step, we constructed the network of R&D collaboration of the Eurasanté ecosystems (figure 10): organizations (represented in circles) of the ecosystem are linked to collaborative R&D projects (represented in blue squares) they are involved in. This graph is highly polarized, with only a few organizations being involved in many collaborative R&D projects, while most of them are only involved in a 1 or 2 projects (figure 11). We then extracted those core actors. In so doing, we set the cut-off value for four projects, corresponding to fifteen organizations. Indeed, those fifteen organizations are all members of the Eurasante ecosystem. The main aim of this paper is to test the influence of underground in determining the core actors' involvement in collaborative project in local innovation ecosystem.

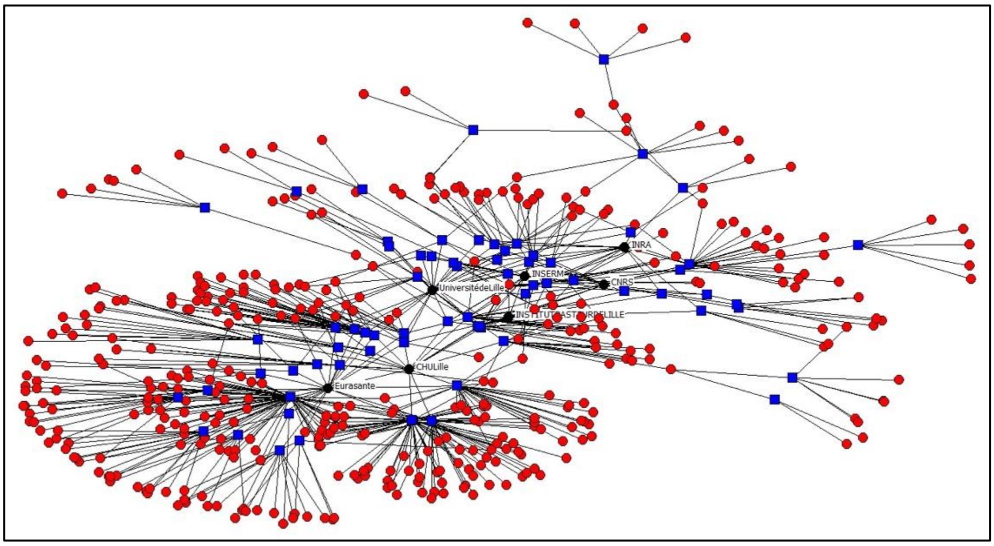


Figure 10: 2-mode network representation of the Eurasanté R&D network.

Note: Blue squares stand for collaborative R&D projects. Circles stand for organizations: "core actors" are in black and "non-core actors" are in red.

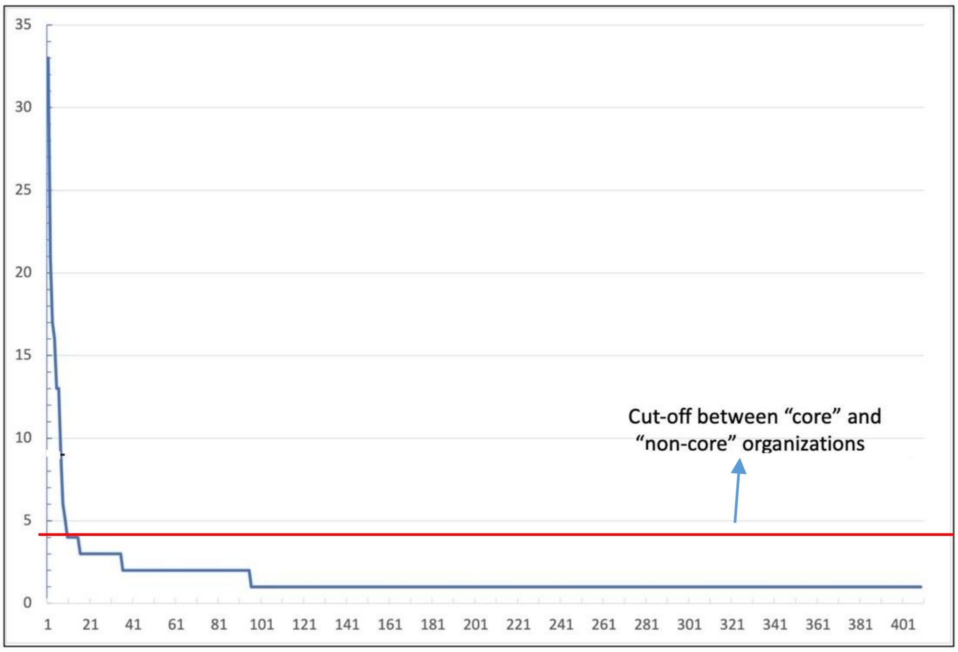


Figure 11: Distribution of organizations along the number of projects they are involved in (in ordinate)

The projects comprise of core actors participating in most of the projects. These actors participated in at least 4 projects, with at least one core actor participating in 89 percent of the projects (62 projects). In fact, one actor participated in as many as 33 projects (see figure 9).

These actors are well-established organizations with the capacity to develop connections and equally act as knowledge and information leaders. They are higher education/R&D and companies. On the average, these actors have existed for over 30 years and are mostly located in Nord department of Hauts-de-France region.

Number of Project	No of partners	No of core partners	Proportion of core actor in the total number of partners
70	409	15	3.7%

Table 11: Summary of projects and partners

3.2 Econometric Model

The objective of the study is to test if the presence of the underground enhances the chances of core actor involvement in a collaborative R&D project.

To do this, we develop econometric model, employing fractional logistic estimation with proportion outcome variable. Fractional logit model allows dependent variable to take on the boundaries between 0 and 1 with positive probability, different from other methods that models proportions. Thus, it becomes appropriate for our estimation as our dependent variable ranges from 0 to 1.

Thus, we specify our model as follows:

$$\Pr(y \mid x') = \frac{\exp(X^{i}\, ij\beta)}{1 - \exp(X^{i}\, ij\beta)} \qquad i$$

Where, β = vector of estimation regression parameters, Y = dependent variable, Xi = vector of explanatory variable that determine outcome

3.2.1 Dependent variable

Our dependent variable represents the proportion of core actors in each project. We posit that the core firms learn best through interactions and exhibit the greatest power of knowledge acquisition.

Each sample project has at least 2 partners and 89 percent of the projects have at least one core partner in participation.

3.2.2 Measures of independent variables

Based on the objective of the study, we consider the *underground*, project type, *Geographical proximity* and sectoral diversity as our main independent variables.

To measure the *presence of underground in the projects* we use the proportion of start-ups in each project. As we explained in the theoretical section, start-ups could represent actors in or coming from the *underground*. We examined the year of creation of each partner and posit that innovative firms established within five years before the launch of the projects are start-ups.

Considering the kind of project, we characterize the projects by funding type. We identify three funding types which include: National Research Agency (ANR), Interministerial Fund (FUI) and European funding. Project funding type *Fundt* – a categorical variable, showing 1 for *FUI*; 2 for *ANR*; and 3 for *European funding* (see table 12).

In terms of the role of proximity in driving collaboration, we test the effect of spatial proximity, using *Geo_prox* variable to represent geographical proximity.

To measure *Geo_prox*, we use location of partners in each project. Since Eurasanté is located in Nord department (NUTS 3 classification) of France, we calculate the proportion of partners within the same neighbouring location of Nord. Thus, *Geo_Prox* takes a binary value of 1 if proportional value is 0.5 and above; and 0 if below 0.5 (see table 12).

We further characterize the project by size. Project size is represented by the number of partners involved in the project. The projects each has between 2 and 73 partners, with a mean of 9. Thus, we use this to categorize the project into two sizes to simplify our analysis. Small projects have maximum of 9 partners and large projects have above 9 partners.

We categorize the project size *P_Size* using binary, 1 for large project and 0 for small projects.

To test homophily effect, we use Shannon entropy index to calculate the sectoral diversity in each project. This variable is expected to be negative to confirm that firms with similar attributes are attractive to each other.

We also account for the project period using the duration of the project (in months).

Variables	**Label**	**Variable type**	**Variable /Categories**	**Freq.**	**Per cent**
Fundt	Funding types	Scale variable	ANR_pro	28	40.00
			FUI_pro	24	34.29
			European_pro	18	25.71
P_Size	Project size	Dummy variable	≤9	50	71.43
			>9	20	28.57
Geo_Prox	Geographical proximity	Dummy variable	No	32	45.71
			Yes	38	54.29

Table 12: Summary statistics for binary and categorical variables

Variable	**Label**	**Mean/freq**	**Std. Dev./percent**	**Min**	**Max**
P_Start-ups	Proportion of startups	0.15	0.18	0	1
NP	Number of partners	9.30	12.13	2	73
Prop_core_actor	Proportion of core actors	0.35	0.28	0	1
Div	Sectoral diversity	0.82	0.20	0	1
Pro_period	Project duration (months)	52.19	31.89	5	164

Table 13:Summary statistics for variables

4. Results and Discussion of findings

In this section, we present the results of our econometric model (see table 14).

First, the table shows that the proportion of start-ups is positive and statistically significant in our model.

This implies that the *presence of the underground* significantly influences the core actor involvement in collaborative R&D projects. Therefore, hypothesis 1 is validated.

Similarly, our result shows a positive and significant impact of geographical proximity in the likelihood to core actor involvement in collaborative R&D projects. Thus, hypothesis 3 is validated.

In the same vein, ANR and European Fund variables are positive and statistically significant. Thus, we observe a positive and significant influence of ANR and European Fund on core actor participation in collaborative R&D projects. This implies that the kind of project for which collaboration takes place explains the core actor involvement in collaborative R&D projects. Hence, hypothesis 4 is validated.

On project size, we find a negative impact of project size in explaining core actor participation in collaborative R&D projects.

Finally, our result shows negative and significant effect of sectoral diversity in determining the core actor participation in collaborative R&D project.

	(Prop_core_actor)
Variable	*β (Coeff)*
P_start-ups	2.410***(0.738)
Fundt	
FUI	ref
ANR_pro	1.130*** (0.321)
European_pro	0.934*** (0.312)
Div	-1.890*** (0.700)
1.P_Size	-1.025*** (0.224)
Pro_period	0.001 (0.003)
1.Geo_Prox	0.537** (0.257)
_cons	-0.292 (0.622)
Number of obs	70

Table 14: Results of econometric model (Article 3)

Notes: Standard errors are shown in parentheses.
*Significant at 0.1 level; **significant at 0.05 level; ***significant at 0.01 level.

As noted, core actors have the capacity to connect with most actors and acquire diverse knowledge.

Our econometric results reveal interesting empirical insights and contribution to the literature on the upper-middle-underground structure of local innovation ecosystem.

The study is unique and novel as it confirms the role of middleground in orchestrating interaction between the upperground and the underground. Using collaborative R&D project as a form of middleground, our results show that the well-developed and well-embedded or core actors in local innovation ecosystem need the small and informal actors from the underground.

Specifically, the proportion of start-ups reflects the presence of underground and enhances the likelihood of core actors to acquire diverse knowledge in local innovation ecosystem.

This finding is in line with theoretical studies that affirm the underground plays a key role in innovation process, providing the upperground new and disruptive ideas and opportunities to develop new business models (eg Cohendet et al., 2018; Avdikos, 2015; Lange and SchuBler, 2018).

In the same vein, this study reveals that kind of project for which exchange takes place is significant in influencing acquisition of diverse knowledge in local innovation ecosystem.

Collaborative projects funded by ANR and European funds exert more influence than FUI in influencing core actor involvement in several collaborative R&D projects. A similar study on existence of interaction and frequency of interaction rather shows European projects exert less effect (Bernela and Levy, 2017). In fact, this can be associated with the nature and domain of collaborative R&D project. For example, ANR dedicates more funds for fundamental projects (61%) than applied projects (de Finance et al., 2008).

Interestingly, this study confirms that the geographical proximity significantly influences the likelihood of core actor participation in collaborative R&D project. This implies that geographical distance between partners reduces the possibility to collaborate. This result is in line with other previous studies on the frequency of face-to-face interaction in R&D project (Bernela and Levy, 2017).

Relating to size of project, this study highlights that small project increase the likelihood of to engage in many project collaborations in local innovation ecosystem. Thus, exchanges in smaller projects are more intense and learning processes are more facilitated.

The negative and significant effect of diversity rather confirms hypothesis 2 and homophily effect. Project attracts firms that share similar attribute or social status rather than diverse firms. This result however underlines the ongoing tension that exists between exploitation and exploration, or stabilization forces and exploration forces in an ecosystem. The negative effect of the sectoral diversity and the positive effect of the proportion of start-ups are a wonderful illustration about this tension and paradox. It is obvious that core actors are more likely to exploit existing technological trajectory and are more comfortable in that. But the role of the ecosystem is to promote interactions between them and actors from the underground. This study therefore shows, beyond the fact that core actors tend to be more attracted by project with sectoral homogeneity of actors, they are aware about added value that start-ups can bring into a collaborative project in terms of new ideas, knowledge and competences or in exploring new fields.

5. Conclusion

The main focus of this study is to provide empirical evidence on the notion of upper-middle-underground structure of local innovation ecosystem. This notion posits that the middleground serves as intermediary platform that orchestrates interaction between formal actors in the upperground, with exploitative capacity and informal actor in the underground with explorative capacity for effective and efficient development and commercialization of innovation.

First, we confirm that the collaborative R&D project as one of the mechanisms of middleground, brings together both well-developed and large organizations who are well-linked and small firms who are scarcely linked to each other. This finding is line with Cattani and Ferriani (2008) that evaluated core/periphery structure of film industry and reveals that creative outcome and performance is enhanced with the interaction with both actors in the core and actors in the periphery.

Second, this study confirms that the upperground requires the underground through interaction.

Specifically, we find that the presence of underground in collaborative R&D projects enhances core actor involvement in several project and thus, enhances diverse knowledge acquisition.

Again, we show evidence that kind of project, for which exchange takes place in terms of funding type is important in driving core actor involvement in collaborative R&D project. ANR project and European funds are more attractive than FUI. ANR project for example, brings flexibility and competitiveness and aims to stimulate both fundamental and applied research projects and complements recurrent funding of research organization based on the merits of projects.

Considering the geographical effect, our finding shows that the likelihood of core actor engagement in collaborative R&D project is significantly influenced by geographical proximity. Organizations are more likely to collaborate in many projects when they are close to each other in a geographical space. This finding is in line with other related studies on the determinant of collaboration (Paeir and Scherngell, 2011; Bernela and Levy, 2017).

However, homophily leads to poor circulation of new information and knowledge necessary for innovation. To overcome this therefore, may require different financing procedures.

This study therefore contributes to the literature, providing new insights and empirical evidence on the role of middleground in orchestrating interaction between the upperground and the underground, with particular reference to the importance of exchanges with exploratory actors that belong to the underground in driving knowledge acquisition and adaptation in local innovation ecosystem.

References

Adner, R. (2006). Match your innovation strategy to your innovation ecosystem. *Harvard business review*, *84*(4), 98-107.

Adner, R., & Feiler, D. (2019). Interdependence, perception, and investment choices: An experimental approach to decision making in innovation ecosystems. *Organization science*, *30*(1), 109-125.

Almeida, P., & Kogut, B. (1997). The exploration of technological diversity and geographic localization in innovation: Start-up firms in the semiconductor industry. *Small Business Economics*, *9*(1), 21-31.

Anderson, H., Havila, V., Andersen, P., & Halinen, A. (1998). Position and role-conceptualizing dynamics in business networks. *Scandinavian Journal of Management*, *14*(3), 167-186.

Arranz, N., & de Arroyabe, J. C. F. (2008). The choice of partners in R&D cooperation: An empirical analysis of Spanish firms. *Technovation*, *28*(1-2), 88-100.

Audretsch D, Feldman M (1996) R&D spillovers and the geography of innovation and production. *The American Economic Review* 86: 630–640

Autant-Bernard, C., Billand, P., Frachisse, D., & Massard, N. (2007). Social distance versus spatial distance in R&D cooperation: Empirical evidence from European collaboration choices in micro and nanotechnologies. *Papers in regional Science*, *86*(3), 495-519.

Avdikos, V. (2015). Processes of creation and commodification of local collective symbolic capital; a tale of gentrification from Athens. *City, Culture and Society*, *6*(4), 117-123.

Bala, V., & Goyal, S. (2000). A noncooperative model of network formation. *Econometrica*, *68*(5), 1181-1229.

Barabási, A. L. (2005). Network theory--the emergence of the creative enterprise. *Science*, *308*(5722), 639-641.

Beliaeva, T., Ferasso, M., Kraus, S., & Damke, E. J. (2019). Dynamics of digital entrepreneurship and the innovation ecosystem: A multilevel perspective. *International Journal of Entrepreneurial Behavior & Research*.

Bernela, B., & Levy, R. (2017). Collaboration networks within a French cluster: Do partners really interact with each other? *Papers in Regional Science*, *96*(1), 115-138.

Borgatti, S. P., & Everett, M. G. (1999). Models of core/periphery structures. *Social networks*, *21*(4), 375-395.

Borgatti, SP, & Everett, MG (1997). Network analysis of 2-mode data. *Social networks*, *19* (3), 243-269.

Boschma, R (2005) Proximity and innovation: A critical assessment. *Regional Studies* 39: 61–74

Boyer, J. (2020). Toward an evolutionary and sustainability perspective of the innovation ecosystem: Revisiting the panarchy model. *Sustainability*, *12*(8), 3232.

Breschi S, Cusmano L (2004) Unveiling the texture of a European research area: Emergence of oligarchic networks under EU framework programmes. *International Journal of Technology Management* 27: 747–772

Breschi, S., & Lissoni, F. (2009). Mobility of skilled workers and co-invention networks: an anatomy of localized knowledge flows. *Journal of economic geography*, *9*(4), 439-468.

Broekel, T., Fornahl, D., & Morrison, A. (2015). Another cluster premium: Innovation subsidies and R&D collaboration networks. *Research policy*, *44*(8), 1431-1444.

Bustos, S., Gomez, C., Hausmann, R., & Hidalgo, C. A. (2012). The dynamics of nestedness predicts the evolution of industrial ecosystems. *PloS one*, *7*(11), e49393.

Capdevila, I. (2015). Co-working spaces and the localised dynamics of innovation in Barcelona. *International Journal of Innovation Management*, *19*(03), 1540004.

Cattani, G., & Ferriani, S. (2008). A core/periphery perspective on individual creative performance: Social networks and cinematic achievements in the Hollywood film industry. *Organization science*, *19*(6), 824-844.

Cattani, G., Ferriani, S., & Allison, P. D. (2014). Insiders, outsiders, and the struggle for consecration in cultural fields: A core-periphery perspective. *American Sociological Review*, *79*(2), 258-281.

Clauset, A., Arbesman, S., & Larremore, D. B. (2015). Systematic inequality and hierarchy in faculty hiring networks. *Science advances*, *1*(1), e1400005.

Cohendet, P., Grandadam, D., & Simon, L. (2010). The anatomy of the creative city. *Industry and innovation*, *17*(1), 91-111.

Cohendet, P., Grandadam, D., Mehouachi, C., & Simon, L. (2018). The local, the global and the industry common: the case of the video game industry. *Journal of Economic Geography*, *18*(5), 1045-1068.

Cohendet, P., Simon, L., & Mehouachi, C. (2020). From business ecosystems to ecosystems of innovation: the case of the video game industry in Montréal. *Industry and Innovation*, *28*(8), 1046-1076.

Csermely, P., London, A., Wu, L. Y., & Uzzi, B. (2013). Structure and dynamics of core/periphery networks. *Journal of Complex Networks*, *1*(2), 93-123.

Dąbrowska, J., Lopez-Vega, H., & Ritala, P. (2019). Waking the sleeping beauty: Swarovski's open innovation journey. *R&D Management*, *49*(5), 775-788.

de FINANCE, X., de LATTRE-GASQUET, M., & ISABELLE, M. Which companies participate in subsidised R&D projects with public labs? Evidence from the French ANR collaborative programme.

de Vasconcelos Gomes, L. A., Facin, A. L. F., Salerno, M. S., & Ikenami, R. K. (2018). Unpacking the innovation ecosystem construct: Evolution, gaps and trends. *Technological forecasting and social change*, *136*, 30-48.

Economides, N. (1996). The economics of networks. *International journal of industrial organization*, *14*(6), 673-699.

Fraiberger, S. P., Sinatra, R., Resch, M., Riedl, C., & Barabási, A. L. (2018). Quantifying reputation and success in art. *Science*, *362*(6416), 825-829.

Freytag, R. (2019). On a growth track with startups: how established companies can pursue innovation. *Strategy & Leadership*.

Fritsch, M. & Slavtchev, V. (2007). Universities and innovation in space. *Ind Innov 14(2):*201–218

Fritsch, M., & Kauffeld-Monz, M. (2010). The impact of network structure on knowledge transfer: an application of social network analysis in the context of regional innovation networks. *The Annals of Regional Science, 44*(1), 21-38.

Gawer, A., & Cusumano, M. A. (2014). Industry platforms and ecosystem innovation. *Journal of product innovation management*, *31*(3), 417-433.

Gilsing, V. (2000). Cluster Governance: How Cluster Can Adapt and Renew Over Time. In *paper prepared for DRUID PhD-conference, Copenhagen, 2000*.

Grandadam, D., Cohendet, P., & Simon, L. (2013). Places, spaces and the dynamics of creativity: The video game industry in Montreal. *Regional studies, 47*(10), 1701-1714.

Granstrand, O., & Holgersson, M. (2020). Innovation ecosystems: A conceptual review and a new definition. *Technovation, 90,* 102098.

Hoekman, J., Frenken, K., & Tijssen, R. J. (2010). Research collaboration at a distance: Changing spatial patterns of scientific collaboration within Europe. *Research policy, 39*(5), 662-673.

Hurlbert, J. S., Haines, V. A., & Beggs, J. J. (2000). Core networks and tie activation: What kinds of routine networks allocate resources in nonroutine situations? *American Sociological Review*, 598-618.

Hussler, C., & Ronde, P. (2007). Explaining the geography of co-patenting in the scientific community: a social network analysis. *Annales d'Economie et de Statistique*, 351-372.

Huynh, K. P., & Rotondi, Z. (2009). R&D spending and knowledge spillovers. *Available at SSRN 968666*.

Iansiti, M., & Levien, R. (2004). Strategy as ecology. *Harvard business review*, *82*(3), 68-78.

Jackson, M. O., & Wolinsky, A. (1996). A strategic model of social and economic networks. *Journal of economic theory*, *71*(1), 44-74.

Jones, C., Hesterly, W. S., & Borgatti, S. P. (1997). A general theory of network governance: Exchange conditions and social mechanisms. *Academy of management review*, *22*(4), 911-945.

Juhász, S., Tóth, G., & Lengyel, B. (2020). Brokering the core and the periphery: Creative success and collaboration networks in the film industry. *PloS one*, *15*(2), e0229436.

Klimas, P., & Czakon, W. (2022). Gaming innovation ecosystem: actors, roles and co-innovation processes. *Review of Managerial Science*, 1-47.

Kline, S. and N. Rosenberg (1986). An overview of innovation, in R. Landau and N. Rosenberg (eds), *The Positive Sum Strategy*, Washington, DC: National Academics Press, pp. 275–305.

Knoben, J., & Oerlemans, L. A. (2006). Proximity and inter-organizational collaboration: A literature review. *international Journal of management reviews*, *8*(2), 71-89.

Lange, B., & Schüßler, E. (2018). Unpacking the middleground of creative cities: spatiotemporal dynamics in the configuration of the Berlin design field. *Regional Studies*, *52* (11), 1548-1558.

Laursen, K., Reichstein, T., & Salter, A. (2011). Exploring the effect of geographical proximity and university quality on university–industry collaboration in the United Kingdom. *Regional studies*, *45*(4), 507-523.

Maggioni M, Uberti T (2009) Knowledge networks across Europe: Which distance matters? *The Annals of Regional Science* 43: 691–720

Malerba, F., & Vonortas, N. S. (Eds.). (2009). *Innovation networks in industries*. Edward Elgar Publishing.

Maskell, P. (2001). Towards a knowledge-based theory of the geographical cluster. *Industrial and corporate change*, *10*(4), 921-943.

McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a feather: Homophily in social networks. *Annual review of sociology*, *27*(1), 415-444.

Miotti, L., & Sachwald, F. (2003). Co-operative R&D: why and with whom? An integrated framework of analysis. *Research policy*, *32*(8), 1481-1499.

Nambisan, S., & Baron, R. A. (2013). Entrepreneurship in innovation ecosystems: Entrepreneurs' self–regulatory processes and their implications for new venture success. *Entrepreneurship theory and practice*, *37*(5), 1071-1097.

Newman, M. E. (2001). Scientific collaboration networks. I. Network construction and fundamental results. *Physical review E*, *64*(1), 016131.

Nooteboom, B. (2000). Learning by interaction: absorptive capacity, cognitive distance and governance. *Journal of management and governance*, *4*(1), 69-92.

Onel, S., Zeid, A., & Kamarthi, S. (2011). The structure and analysis of nanotechnology co-author and citation networks. *Scientometrics*, *89*(1), 119-138.

Ortega, J., & Aguillo, I. (2010). Network collaboration in the 6th Framework Programmes: country participation in the health thematic area. *Scientometrics*, *84*(3), 835-844.

Paier M, and Scherngell T (2011) Determinants of collaboration in European R&D networks: Empirical evidence from a discrete choice model. *Industry and innovation* 18: 89–104

Pavitt, K. (2005), 'Innovation processes', in J. Fagerberg, D.C. Mowery and R.R. Nelson (eds.), *The Oxford Handbook of Innovation*, Oxford: Oxford University Press, 86-114.

Ponds, R., Van Oort, F., & Frenken, K. (2007). The geographical and institutional proximity of research collaboration. *Papers in regional science*, *86*(3), 423-443.

Porter, M. E. (1998). *Clusters and the New Economics of Competition*. Harvard Business Review 76 (6): 77–90.

Powell, W.W. and S. Grodal (2005), 'Networks of innovators', in J. Fagerberg, D.C. Mowery and R.R. Nelson (eds.), *The Oxford Handbook of Innovation*, Oxford: Oxford University Press, 56-85.

Roijakkers N, Hagedoorn J (2006) Inter-firm R&D partnering in pharmaceutical biotechnology since 1975: Trends, patterns, and networks. *Research Policy* 33: 1153–1165

Saxenian, A. (1994). *Regional Networks: industrial Adaptation in Silicon Valley and route 128*. Cambridge: Harvard University Press

Scherngell, T., & Barber, M. J. (2009). Spatial interaction modelling of cross-region R&D collaborations: Empirical evidence from the 5th EU framework programme. *Papers in Regional Science*, *88*(3), 531-546.

Selander, L., Henfridsson, O., & Svahn, F. (2013). Capability search and redeem across digital ecosystems. *Journal of information technology*, *28*(3), 183-197.

Spanos, Y. E., Vonortas, N. S., & Voudouris, I. (2015). Antecedents of innovation impacts in publicly funded collaborative R&D projects. *Technovation*, *36*, 53-64.

Su, Y. S., Zheng, Z. X., & Chen, J. (2018). A multi-platform collaboration innovation ecosystem: the case of China. *Management Decision*.

Suire, R., & Vicente, J. (2009). Why do some places succeed when others decline? A social interaction model of cluster viability. *Journal of Economic Geography*, *9*(3), 381-404.

Sun, S. L., Zhang, Y., Cao, Y., Dong, J., & Cantwell, J. (2019). Enriching innovation ecosystems: The role of government in a university science park. *Global Transitions*, *1*, 104-119.

Traitler, H., Watzke, H. J., & Saguy, I. S. (2011). Reinventing R&D in an open innovation ecosystem. *Journal of food science*, *76*(2), R62-R68.

Uzzi, B., & Spiro, J. (2005). Collaboration and creativity: The small world problem. *American journal of sociology*, *111*(2), 447-504.

Vernet, A., Kilduff, M., & Salter, A. (2014). The two-pipe problem: Analysing and theorizing about 2-mode networks. In *Contemporary Perspectives on Organizational Social Networks*. Emerald Group Publishing Limited.

Wagner CS, Leydesdorff L (2005) Network structure, self-organisation, and the growth of international collaboration in science. *Research Policy* 34: 1608–1618

Zucker, L. G., Darby, M. R., & Armstrong, J. (1998). Geographically localized knowledge: spillovers or markets?. *Economic Inquiry*, *36*(1), 65-86.

Appendices

Appendix C1: Correlation Matrix

	Prop_core	Prop_startups	Fundt	Div	P_Size	Pro_Period	Geo_Prox
Prop_core	1.0000						
Prop_startups	0.3839	1.0000					
Fundt	-0.4100	-0.1232	1.0000				
Div	-0.2474	0.2719	0.0828	1.0000			
P_Size	-0.4326	-0.1511	0.3510	0.0196	1.0000		
Pro_period	0.0904	-0.0285	-0.3868	0.0830	0.1012	1.0000	
Geo_Prox	0.4898	0.3429	-0.4877	-0.1328	-0.3083	-0.0381	1.0000

Appendix C2: Multicollinearity statistics of different explanatory variables

Variable	VIF	1/VIF
Fundt		
1	1.98	0.504081
3	1.53	0.652881
Div	1.19	0.843251
1.P_Size	1.25	0.797743

Prop_start-ups	1.30	0.768274
Pro_period	1.53	0.652161
Geo_Prox	1.65	0.605406
Mean VIF	1.49	

Chapter 5: General Discussions and Conclusions

5.1 Introduction

This chapter discusses and summarizes the key findings and theoretical contributions of the thesis to innovation studies and related fields. The chapter further discusses the policy implications and recommendations and finally concludes with suggestions for future research.

5.2 Theoretical contributions

The successive failure of the main economic industries of Hauts-de-France region in the late 1970's has particularly led to the policy to reconvert its economic fabrics based on a set of innovation ecosystems that develop around the *pole of excellence* or Innovation parks, to stimulate and facilitate adaptation and resilience. This thesis adopted empirical approaches to analyze the local innovation ecosystem of Hauts-de-France region to ascertain its contribution to adaptability of firm.

First, this thesis makes relevant theoretical contributions on innovation ecosystem, in relation to the conceptualization of local innovation ecosystem adopted. Drawing from the work of

Saxenian (1994), the thesis theoretically integrates territorial dimension in the conceptualization of innovation ecosystem as a place-base community of interacting actors. Second, the thesis practically identifies all the structures that participate in the ecosystem.

The innovation parks in Hauts-de-France created to facilitate regional adaptation and resilience depicts local innovation ecosystems that bring together heterogenous actors such as research organizations/labs, finance organizations, companies, brokers, start-ups, third-places, technological structures etc and characterized by complex relationships for innovation development. This conceptualization highlights territorial and spatial dimensions in innovation process. Innovation parks enable development of complex relationships between diverse actors within a strategic context. Although, ecosystem can have a global coverage, it is usually rooted in a given locality or emerges at a local level.

Besides innovation parks, the thesis identifies other structures that form the local innovation ecosystem which include innovation hubs such as business incubators and accelerators that foster relationships between the Start-ups, large companies, financial organization and R&D organizations. The thesis finds also the Competitiveness clusters that facilitate relationships between actors (universities, research organizations, companies etc) through innovative projects. Business clusters in the same vein foster relationships between companies to facilitate development of new markets. They develop collaborative platform that allows actors interact, share best practices to expand their businesses.

Similarly, this thesis makes theoretical contribution as it specifically identifies the key characteristics or attributes and the structure of innovation ecosystem that distinguishes it and predisposes it to better address adaptation at firm level.

As noted, the continuous disruption of economic activities calls for tools to navigate through the challenges. It is in this regard that the rising interest of policy makers and business practitioners moves from competitiveness to adaptation.

5.2.1 What explains firm adaptive capacity in innovation ecosystem

Drawing from the characteristics or attributes of innovation ecosystem such as heterogeneity of actors, complex interactions and the structural composition, innovation ecosystem provides the environment and predisposes the actors for enhanced adaptive capacity. In fact, the three main distinct characteristics or attributes and the structure of local innovation ecosystem give it more explanatory power to address adaptation at firms' level compared to other traditional constructs. First, as posited in this thesis, there are heterogenous agents/actors with different motivations, abilities and strategies. The actors include the organizations such as the universities, research institutes and firms and the human resources (researchers, workers) and in the view of Jackson (2011), comprises two specific entities – the research economy and the commercial economy. As noted in regional studies, diversity is linked to adaptation and sustainable transition as diversity provides the flexibility to respond to shocks. Similarly, the diversity provides the ability to unlock from a specific trajectory to chart new paths.

Second, the relationships between actors in the innovation ecosystem are dense and complex and involve continuous interactions among interdependent actors. It is argued that the complexity of interaction generates more dynamics, efficiency and innovation.

In fact, to avoid a lock-in situation and enhance sustainability, there is need to develop complex relationships and build *global pipeline*, taking advantage of external sources of knowledge. The complexity of interaction provides the flexibility to respond to complexity of environment. Therefore, diversity of actors and complex inter-organizational relations are pivotal to adaptation of ecosystem firms.

The third characteristic is however centered on the organizational structure. The thesis opines that the organization structure is unique for co-evolution in local innovation ecosystem. It explains ambidexterity in innovation ecosystem, integrating two dimensions that drive innovation and adaptation processes of firms and organizations: exploration and exploitation, allowing a synergistic relationship between actors/agents that facilitates both the generation of innovative ideas and its commercialization.

Structuring the local innovation ecosystem into upper-middle-underground, the thesis clearly identifies the formal and well-developed actors in the upperground, the informal and small actors in the underground and the middleground as platform that integrates the other two in interacting context. As shown in the thesis, the middleground explains firm co-evolution in the ecosystem and influences firm innovative performance. The structural composition of the upper-middle-underground allows for the interaction of dual forces of exploration and exploitation capabilities and fosters knowledge generation and exchange and cross-pollination of different knowledge that facilitates adaptation. The innovation ecosystem reflects cross-sector structures and fosters cross-sector innovation processes.

5.2.2 The middleground perspective of local innovation ecosystem

Having found the positive impact of innovation ecosystem on adaptive capacity of firms, it is also important to examine what makes firms in innovation ecosystem more adaptive than others.

In others words, what mechanism or feature of innovation ecosystem could explain the positive role of innovation ecosystem on adaptive capacity of firms.

In this regard, the literature on localized innovation ecosystem emphasizes the importance of interaction between informal communities/talented professionals and innovative firms in the localized innovation processes.

In the regional/local innovation ecosystem perspective, this thesis posits that the *middleground* is a form of common intermediary platform that orchestrates complex relationships between heterogenous actors.

Considering the middleground and the orchestration function, this thesis shows first, the middleground orchestrates complex interactions that necessitate adaptation processes. Second, the middleground fosters co-evolution between the underground and the upperground within the innovation ecosystem.

As innovation depends not only on internal knowledge-base but also on external sources from other co-located firms, formal and informal interactions can be of great value for learning about new market opportunities and new technologies. The middleground necessitates the interactions, providing brokerage for knowledge flows between different levels of firm.

The interacting components – the upperground and the underground reflect the ambidexterity of exploitation and exploration capacity that enhances innovation performance and adaptation.

In this perspective, the *middleground* comprises places, spaces, collaborative innovative projects and events as platforms that facilitate interactions between informal communities in the underground and well-established firms in the upperground, to tap from the local external sources of innovation.

The bases of innovation are not exclusively centered on firms but on the complex relationships between the firms and other actors at different levels.

In fact, a wide range of literature highlights the role of technological and digital platforms as orchestrators of interaction in business ecosystem. While the interest of business ecosystem centers on how the focal or pivotal organization captures value with interaction of stakeholders in a digital or technological platform, innovation ecosystem stream rather focuses on how various structures of heterogenous actors interact and engage in processes of knowledge production and exchange to develop new solution and co-create value. Thus, the construct of innovation ecosystem adds a distinct insight as it includes and highlights the importance of the complementarity of both informal and formal/well-developed actors.

Drawing from the findings, this thesis concludes that the middleground of innovation ecosystem, represented by the innovation park and its competitiveness clusters responsible for labeling collaborative projects and organizing various events, is involved in orchestration of a large range of relationships between actors: formal interactions as well as informal interactions. They foster *triple helix relations*, relationships between start-ups on the one hand, and the relationships between start-ups, large companies, financial organizations, and R&D organizations on the other hand. There is info-communicational relationship, relations through innovative project and informal relations through events, meetings etc. in the ecosystem.

As shown, the organizational arrangement of innovation ecosystem is one factor that explains the adaptation of the ecosystem actors. It has a structural agility that is explained by the diversity and complementary actors and innovative places and a multitude of events that generate innovation process. These actors include researchers, students, business angels, managers of competitiveness clusters, entrepreneurs, companies (SMEs, subsidiaries of large groups), Start-ups, makers and artists. In terms of places, there are research laboratories, business hotels, accelerators, incubators and spaces for creativity. Annually, more than a thousand of events that foster connections, interactions and collaborations between actors as well as international forums take place within the innovation ecosystem.

The presence of research laboratories, companies, start-ups and creative places on the same technological field within the local innovation ecosystem facilitates collective learning and technological proximity. The competitiveness clusters facilitate the cooperation and collaboration of the research laboratory and companies through innovative projects. Networking events are boosters for informal relationships. New forms of science-industry relations are emerging within the innovation ecosystem. For example, there are researchers and business developers who unite to create start-ups; or companies and start-ups that are housed in the premises of research labs; or the case of companies that have access to research laboratory facilities within the innovation ecosystem.

5.2.3 The importance of core actors in Innovation Ecosystem

Using collaborative innovation projects as the most advanced relational component of middleground, we identify various interacting actors including a relatively small number of well-established core actors with necessary resources, political and social connections and greater exploitation capacity to enforce a central role in the ecosystem. First, the core actors have the capacity to develop human capital and transfer existing know-how and come from the universities and research centres. Second, they have the capacity to bring new technology to the market and come from well-developed firms. This position however requires the interaction with the non-core or peripheral actors. For example, core actors require the access to new or innovative ideas that can emanate from the non-core or peripheral actors. The thesis reveals that the position of core actors that develop central positions with many links and connections in the ecosystem need interaction with the non-core or peripheral actors, especially the ones coming from the underground. This finding is in line with the theoretical works on local innovation ecosystem linking adaptation to co-evolution between the actors in the upperground and actors in the underground.

The business ecosystem stream especially the platform-based ecosystem identifies a focal or keystone actor as key to providing coordination and control. On the contrary, Innovation ecosystem characterized by heterogeneity of actors and complex interactions can be viewed as a multi-actor network and can emerge in a self-coordinated bottom-up approach. Thus, innovation ecosystem can be eco-centric and operates around a set of few core actors, and not under a single most powerful focal actor.

We show that geographical space fosters interactions and symbiotic relationships that facilitate knowledge diffusion among firms and organizations.

5.3 Empirical and methodological contributions

The thesis developed and tested hypotheses and empirically confirms the positive impact of innovation ecosystem on adaptive capacity of firms.

This implies that firms in innovation ecosystem tap into various resources necessitated by the structural organization in the ecosystem to enhance their adaptive capacity.

In fact, one of the main hypotheses of innovation ecosystem conceptualized in complex adaptive system perspective is adaptability. The thesis rather took a micro-level view to analyze the innovation ecosystem with respect to impact on adaptive capacity of firms.

Innovation ecosystem concept has been widely theorized in the scientific literature and is widely adopted in many economies. Despite the wide theoretical justifications, there is dearth of empirical studies to lend credence to the widely-adopted concept to clearly justify its operationalization. In fact, one of the criticisms of innovation ecosystem lies on its distinctive contribution (Oh et al., 2016). Thus, it is argued that it rather requires more empirical rigour, as innovation ecosystem provides a useful tool to address adaptation in the context of high uncertainty.

This thesis therefore addresses this main literature gaps about innovation ecosystem, providing demonstration and empirical evidences of the impact of innovation ecosystem on adaptive capacity of firms and the role of *middleground* in the orchestration of complex relationships and impact on technological development of firms.

This thesis makes empirical contribution arising from the measures of adaptive capacity adopted in the thesis.

First, this thesis developed two measures to proxy adaptive capacity of firms – innovation performance and technological diversity. This thesis posits that adaptive capacity of firms depends not only on the ability to innovate but also on the ability to diversify. As noted, innovation improves firm dynamics and offers new growth opportunities necessary to enhance adaptive capacity. Similarly, technological diversification provides firms the portfolio to respond to market and technological changes and mitigate path dependencies. This thesis links innovation ecosystem to adaptive capacity of firms.

Second, in order to ascertain what makes firms in innovation ecosystem more adaptive than others, the thesis empirically confirms the key role of complex relationships necessitated by the middleground. The thesis confirms that the various forms of intermediary platforms such as collaborative projects or events orchestrate complex relationships and fosters co-evolution between the upperground and the underground and enhances the innovation performance of ecosystem firms.

Similarly, local innovation ecosystem is characterized by complex interaction between diversity of actor. Using the most advanced form of middleground responsible for bringing together diversity of actors within an interactive context, this thesis ascertains different actors interacting in collaborative R&D project, including the core actors, start-ups or young innovative firms. This implies that the core actors require the interaction of non-core actors. In fact, the study shows that the start-up positively increases the possibility of core actor involvement in collaborative R&D projects. Thus, this again lends credence to the important roles of the underground in innovation ecosystem. As shown in the third article, the core actors are more exploitative and tend to align more to sectoral homogenous actors and thus do not explore new trajectories. However, aligning or interacting with exploratory start-ups reinforces their exploratory opportunity and the capacity to chart new technological paths.

In terms of methodological contributions, this thesis adds to the way to operationalize the concept of innovation ecosystem with the perspective of dynamic system, characterized by complex relationships between heterogenous actors and adaptive capacity. The thesis interestingly conceptualized innovation ecosystem with territorial dimension and tested one of the main hypotheses of innovation ecosystem in complex adaptive system perspective –

adaptability. In fact, it is the ability to address adaptability that distinguishes innovation ecosystem from other traditional constructs.

Again, with innovation ecosystem characterized by diverse actors, the thesis adopted the use of entropy analysis to ascertain the sectoral diversity in innovation ecosystem. Using Shannon entropy index and modified Herfindahl index and considering the sectors of actors in the innovation ecosystem, the thesis confirms high sectoral diversity in the innovation ecosystem.

In the same vein, the thesis adopted structural network analysis for new forms of organization and the density of relations using collaborations between companies and/or organizations through patents, innovation projects, business cluster relations and interactions in competitiveness clusters.

The thesis adopted the use econometric analysis to provide empirical evidences on the tested hypotheses.

First, using econometric analysis we ascertain positive impact of innovation ecosystem on adaptive capacity of firms.

This implies that firm who are part of innovation ecosystem are more adaptive than others. This result is interesting but however requires to further ascertain what makes firms in innovation ecosystem more adaptive. Driven by this objective, the thesis focused on the structural organization, as one of the key features of innovation ecosystem.

Using econometric analysis, the thesis confirms that the middleground fosters co-evolution and facilitates knowledge generation and exchange and allows actors tap into external sources of knowledge for effective and efficient innovative performance and adaptation. Co-evolution between actors in the upperground and the underground are key to improve adaptive capacity of firms. Considering collaborative innovative projects as the most advanced relational component of the middleground, the thesis shows that the linkages in collaborative innovative projects facilitate interactive learning for knowledge creation and diffusion. Thus, adaptive capacity of firms is drawn from interactions and co-evolution of different actors in innovation ecosystem.

Above all, this thesis reinforces the Complex System perspective of the innovation ecosystem concept in relation to adaptability, as most of the works use only a strategic view of innovation ecosystem.

Finally, this thesis fills the gap in the literature, providing the first empirical study, to the best of my knowledge, on innovation ecosystem and adaptation of firms.

5.4 Policy implications and recommendations

In fact, this thesis generally provides indications and guidelines for policymakers that aspire to create or invest in innovation ecosystem, especially to stimulate adaption processes. Innovation ecosystem offers conceptual and operational tools that address both competitiveness and adaptation and therefore becomes relevant. This thesis sheds light on the insight for new framework for innovation policy that considers the dynamics of innovation environment to enhance adaptability. It contributes to the wider understanding of innovation ecosystem construct that can be adopted to enhance adaptation at firms level.

Innovation policy in the past couple of decades focused on competitiveness of firms and regions. Today, regions and industries face increasing shocks arising from technological changes and global phenomena. As noted, adaptation is key for any firm or organization, especially in the face of various market and technological changes. Thus, the interest is rather on relevant tools or frameworks that stimulate both competitiveness and adaptation.

We hope that the findings of this thesis raise useful and relevant policy implications especially at the time economies face continuous shocks and policy agendas of many economies focus on the appropriate instruments or frameworks to enhance not only competitiveness but also adaptation.

From the perspective of innovation policy, this thesis shows that innovation ecosystem provides a viable tool for adaptive dynamic capability of firms. The study provides a new theoretical perspective based on empirical evidence linking innovation ecosystem and firms' adaptive capacity. Thus, the study contributes to both theory, practice and policy of innovation ecosystem, which has become central to the innovation and economic development agenda of many emerging economies. It provides some empirical evidence to both business practitioners and policy makers who aim to exploit innovation and adaptation through an ecosystem.

Specifically, in terms of implications for business practitioners, this study highlights that in order to pursue adaptability, there is need for firms to focus not only on innovative activities but also on ensuring diversification and most especially tap into the unique structures that allows cross-pollination of new ideas to chart new paths in the event of shocks.

Similarly, this thesis allows the business practitioners to understand in concrete terms, the specific features of innovation ecosystem as well as the strategic interactions through event and R&D project that can be pivotal for stimulating creative or new ideas and creation of successful innovation. Particularly, this study reveals that being part of innovation ecosystem avails firms the opportunity to interact with diverse knowledge, ideas and information sources to tap new knowledge capable of advancing their innovativeness and adaptation. Conversely, as noted by some scholars, collective identity and homogeneity in clusters breeds cohesion but hinders the requisite variety needed to avoid lock-in phenomenon and adapt to disruptive changes (Pinkse et al., 2018; Menzel and Fornahl, 2010).

Clearly, we show that both formal and informal interactions are effective in driving innovative performance and adaptation.

Interestingly, this thesis rather contributes to the discussion with somewhat different perspective from business ecosystem, identifying the *middleground* as a unique platform in local innovation ecosystem that orchestrates complex interaction between different levels of actors for innovation co-creation. The study shed new light on the orchestration logic in innovation ecosystem with empirical evidence.

The thesis also contributes to the knowledge and theory related to collaborative projects. Using the collaborative R&D projects as a form of middleground and source of interactions, this study interestingly shows that actors occupy varied positions, the non-core or peripheral actors with the capacity to offer innovative ideas and the core actors with capacity to develop and commercialize innovation. It further reveals that the core actors with exploitation capacity need interactions with the non-core with exploration capacity to enhance adaptation.

As shown in this study (article 1), the negative marginal effect of firm age on diversification is in line with the notion that start-ups are needed to strengthen diversity. The positive effect of start-ups on proportion of core therefore implies that interaction with start-ups in a collaborative project predisposes the core actors to new ideas, knowledge and, maybe, exploration opportunities. But the negative effect of sectoral diversity on the proportion of core actors explain that core actors are more attracted to homogenous actors and are more disposed to exploiting existing technological trajectory, rather than exploration.

In terms of policy implications, a new perspective calls for policy makers to create opportunities for more interactive environment that motivates firms to exploit heterogeneity to unlock potentials towards adaptation, rather than locked into homogeneity-dominated clusters. In fact, innovation-base policies and the collective strategies of economic actors should focus on promoting the construct of innovation ecosystem in order to promote interaction between exploratory and exploitation actors to stimulate adaptation.

As shown, the core actors that are mainly organizations and well-developed companies. The success of the core actors in innovation dynamics in the local innovation ecosystem depends on how they integrate or interact with non-core actors in the periphery. Policies should also gear towards advancing small actors such as start-ups. Particularly, policies should be favourable and supportive to small actors such as start-ups, providing technical and monetary supports to boost their capacity to exploit their exploration. Thus, innovation policies targeting innovation performance and adaptability should provide support and opportunities to stimulate formal and informal technical exchanges. A healthy and successful ecosystem requires both healthy central actors and innovative start-ups.

Again, in order to ensure a formidable innovation ecosystem, various forms of middleground need to be support by policy in a way that they form strong pillars upon which collaborations breed.

The top-down approach of government policy and various supports have contributed and led to creation and coordination of local innovation ecosystem. Efforts need to integrate bottom-up approach, developing incentives and mechanisms to recognize and allow for diversity of actor to form meaningful symbiotic relationships through exploratory and exploitative interactions.

As a matter of fact, this study provides evidence that innovation ecosystem serves as a unique construct or mechanism for policymakers that wish to invest in regional adaptation. This thesis tends to prove that the various instruments implemented by Hauts-de-France region certainly contribute to adaptation of firms and can translate to the regional adaptation and resilience. As noted in the literature, the ability of micro sectors or actors to adapt to technological and market changes and market opportunities can translate to a long-run success of the macro sector (Simmie and Martin, 2010). Similarly, some scholars posit that the adaptation of the regional economy is threatened when the actors within the economy fail to enhance their adaptive capabilities (eg Evenhuis, 2017; Ramos and Royuela, 2021).

As policy implementation requires different assets and resources, policymakers as well as managers should appreciate the critical need for successful implementation of ecosystem-based policies not only to enhance firm's adaptive capacity but also to ensure structural transformation. Policymakers should consider innovation parks not just as spaces or location that offer shared facilities for firms but more importantly, as a form of network that breeds knowledge diffusion among different levels of actors through interaction that proves to be the most significant contribution in explaining innovation performance and adaptation of firms.

Policymakers that wish to stimulate adaptation to continuous shocks should develop and encourage mechanisms that foster complex interactions between diversity of actors. This would foster new knowledge generation and diffusion that enhances innovation and technological diversification.

Although some scholars have challenged and questioned the usefulness and contribution of innovation ecosystem, this studies specifically points out the significance of innovation ecosystem in driving adaptation of firms through its main characteristics and structural organization.

Finally, we posit that innovation ecosystem is a relevant concept compared to other traditional approaches such as clusters, in addressing adaptation in times of uncertainty. However, despite the ambition of adaptability, there is risk that this can be hampered if the core actors are not diversified and/or are surrounded with homogenous actors.

5.5 Limitation of the study and Recommendations for future research

This thesis brings insightful perspective to innovation ecosystem construct. With the methodological and empirical insights offered by this thesis, some limitations need to be noted. First, the study faced the challenge of unavailability of data. Particularly, with the unavailability of data on other forms of middleground, the study focused on collaborative projects and events for the analysis. Second, the study only assessed innovation ecosystem in Hauts-de-France with the objective to ascertain its contribution in driving adaptive capacity of firms.

This study however is only a trigger for more research on this relatively new but increasingly interesting construct. Certainly, it is only a first step aiming to trigger some future research opportunities.

Current discussions in the literature on the importance and usefulness of innovation ecosystem extend beyond the borders of a particular region and require empirical investigation across nations. Based on the limitations of this study, a number of recommendations for future studies are hereby made.

First, it is recommended that other studies should expand the scope of the study, looking at the entire regions or various countries, or compare one with another. This will give a broader coverage and further lend credence to the effectiveness and usefulness of innovation ecosystem for policy and practice. Second, future studies can explore other choices of more complex adaptability indicators such as related and non-related innovations.

Again, this thesis took a micro-level analysis, looking at firm’s adaptive capacity in ecosystem. It will be interesting for future studies to focus on other analytical levels (meso or macro). In other words, future studies can test if the ecosystem is adapting and if the adaptation of ecosystem leads to regional or national adaptation.

Finally, with rising theoretical evidences on the role of middleground in local innovation ecosystem and the need for empirical justification, future studies should go beyond the limitations of this study, to include other forms of middleground in the analysis.

References

Abatecola, G., Breslin, D., & Kask, J. (2020). Do organizations really co-evolve? Problematizing co-evolutionary change in management and organization studies. *Technological Forecasting and Social Change*, 155, 119964.

Acebo, E., Miguel-Dávila, J. Á., & Nieto, M. (2021). External stakeholder engagement: Complementary and substitutive effects on firms' eco-innovation. *Business Strategy and the Environment*, *30*(5), 2671-2687.

Adams, R., Jeanrenaud, S., Bessant, J., Denyer, D., & Overy, P. (2016). Sustainability-oriented innovation: A systematic review. *International Journal of Management Reviews*, *18*(2), 180-205.

Adner, R. (2006). Match your innovation strategy to your innovation ecosystem. *Harvard business review*, *84*(4), 98-107.

Adner, R. (2017). Ecosystem as structure: An actionable construct for strategy. *Journal of management*, *43*(1), 39-58.

Adner, R., & Kapoor, R. (2010). Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations. *Strategic management journal*, *31*(3), 306-333.

Ahuja, G. (2000). The duality of collaboration: Inducements and opportunities in the formation of interfirm linkages. *Strategic management journal*, *21*(3), 317-343.

Amin, A., & Cohendet, P. (2004). *Architectures of knowledge: Firms, capabilities, and communities*. Oxford University Press on Demand.

Amitrano, C. C., Tregua, M., Russo Spena, T., & Bifulco, F. (2018). On technology in innovation systems and innovation-ecosystem perspectives: A cross-linking analysis. *Sustainability*, *10*(10), 3744.

Archibugi, D., & Pianta, M. (1996). Innovation surveys and patents as technology indicators: the state of the art.

Astier, B. (2021). *Ecosystème d'innovation et processus info-communicationnels: enjeux du textile dans les Hauts-de-France* (Doctoral dissertation, Université Polytechnique Hauts-de-France; Institut national des sciences appliquées Hauts-de-France).

Astley, W. G. (1984). Toward an appreciation of collective strategy. *Academy of Management Review*, 9: 526–535.

Audretsch, D. B. (1995). *Innovation and industry evolution*. MIT press.

Autio, E., & Thomas, L. (2014). *Innovation ecosystems*. The Oxford handbook of innovation management, 204–288.

Avdikos, V. (2015). Processes of creation and commodification of local collective symbolic capital; a tale of gentrification from Athens. *City, Culture and Society*, *6*(4), 117-123.

Baldwin, C. Y., & Clark, K. B. (2000). Design rules: The power of modularity. Cambridge, MA: MIT Press.

Baldwin, C., & Von Hippel, E. (2011). Modeling a paradigm shift: From producer innovation to user and open collaborative innovation. *Organization science*, *22*(6), 1399-1417.

Baptista, R., & Swann, P. (1998). Do firms in clusters innovate more?. *Research policy*, *27*(5), 525-540.

Barney, J., Wright, M., & Ketchen Jr, D. J. (2001). The resource-based view of the firm: Ten years after 1991. *Journal of management*, *27*(6), 625-641.

Bathelt, H., Malmberg, A., & Maskell, P. (2004). Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in human geography*, *28*(1), 31-56.

Battistella, C., Colucci, K., De Toni, A. F., & Nonino, F. (2013). Methodology of business ecosystems network analysis: A case study in Telecom Italia Future Centre. *Technological Forecasting and Social Change*, *80*(6), 1194-1210.

Beaudry, C., & Breschi, S. (2003). Are firms in clusters really more innovative?. *Economics of innovation and new technology*, *12*(4), 325-342.

Becattini, G., Bellandi, M., & De Propris, L. (Eds.). (2014). *A handbook of industrial districts*. Edward Elgar Publishing.

Behnam, S., Cagliano, R., & Grijalvo, M. (2018). How should firms reconcile their open innovation capabilities for incorporating external actors in innovations aimed at sustainable development?. *Journal of Cleaner Production*, *170*, 950-965.

Bergman, E. M. (2008). Cluster life-cycles: an emerging synthesis. *Handbook of research on cluster theory*, *1*, 114-132.

Bernela, B., & Levy, R. (2017). Collaboration networks within a F rench cluster: Do partners really interact with each other? *Papers in Regional Science*, *96*(1), 115-138.

Bishop, P. (2019). Knowledge diversity and entrepreneurship following an economic crisis: an empirical study of regional resilience in Great Britain. *Entrepreneurship & Regional Development*, *31*(5-6), 496-515.

Bode, A., Talmon l'Armee, T. B., & Alig, S. (2010). Research note: clusters vs. networks–a literature-based approach towards an integrated concept. *International Journal of Globalisation and Small Business*, *4*(1), 92-110.

Boix, R., & Galletto, V. (2009). Innovation and industrial districts: a first approach to the measurement and determinants of the I-district effect. *Regional Studies*, *43*(9), 1117-1133.

Bos-Brouwers, H. E. J. (2010). Corporate sustainability and innovation in SMEs: evidence of themes and activities in practice. *Business strategy and the environment*, *19*(7), 417-435.

Boschma, R. (2015). Towards an evolutionary perspective on regional resilience. *Regional Studies*, *49*(5), 733-751.

Boyer, J. (2020). Toward an evolutionary and sustainability perspective of the innovation ecosystem: Revisiting the panarchy model. *Sustainability*, *12*(8), 3232.

Bramwell, A., Hepburn, N., & Wolfe, D. A. (2012). Growing innovation ecosystems: university-industry knowledge transfer and regional economic development in Canada. *Final Report to the Social Sciences and Humanities Research Council of Canada*, *62*.

Breschi, S., Lissoni, F., & Tarasconi, G. (2014). *Inventor data for research on migration and innovation: a survey and a pilot* (Vol. 17). WIPO.

Breslin, D., Kask, J., Schlaile, M., & Abatecola, G. (2021). Developing a coevolutionary account of innovation ecosystems. *Industrial Marketing Management*, *98*, 59-68.

Bristow, G. (2010). Resilient regions: re-‘place'ing regional competitiveness. *Cambridge Journal of Regions, Economy and Society*, *3*(1), 153-167.

Burford, N., Shipilov, A. V., & Furr, N. R. (2021). How ecosystem structure affects firm performance in response to a negative shock to interdependencies. *Strategic Management Journal*, *43*(1), 30-57.

Carlsson, B. (Ed.). (2012). *Technological systems and economic performance: the case of factory automation* (Vol. 5). Springer Science & Business Media.

Carlsson, B., & Jacobsson, S. (1997). Diversity creation and technological systems: a technology policy perspective. *Systems of innovation: Technologies, institutions and organizations, London, Pinter Publishers*, *7*.

Chandler, A. D., Hikino, T., & Chandler, A. D. (2009). *Scale and scope: The dynamics of industrial capitalism*. Harvard University Press.

Chandler, J. D., & Vargo, S. L. (2011). Contextualization and value-in-context: How context frames exchange. *Marketing theory*, *11*(1), 35-49.

Chesbrough, H. (2006a). Open innovation: a new paradigm for understanding industrial innovation. *Open innovation: Researching a new paradigm*, *400*, 0-19

Chesbrough, H. (2006). *Open business models: How to thrive in the new innovation landscape*. Harvard Business Press.

Chesbrough, H.W., (2003). Open Innovation: The New Imperative for Creating and Profiting from Technology. Harvard Business School Press, Boston, MA.

Clarysse, B., Wright, M., Bruneel, J., & Mahajan, A. (2014). Creating value in ecosystems: Crossing the chasm between knowledge and business ecosystems. *Research Policy*, *43*(7), 1164-1176.

Coe, N. M., and T. G. Bunnell. 2003. “Spatializing’knowledge communities: towards a conceptualization of transnational innovation networks”. *Global networks* 3(4): 437-456.

Cohendet, P., Grandadam, D., & Simon, L. (2009). Economics and the ecology of creativity: evidence from the popular music industry. *International Review of Applied Economics*, *23*(6), 709-722.

Cohendet, P., Grandadam, D., & Simon, L. (2010). The anatomy of the creative city. *Industry and innovation*, *17*(1), 91-111.

Cohendet, P., Grandadam, D., Mehouachi, C., & Simon, L. (2018). The local, the global and the industry common: the case of the video game industry. *Journal of Economic Geography, 18*(5), 1045-1068.

Cohendet, P., Grandadam, D., Simon, L., & Capdevila, I. (2014). Epistemic communities, localization and the dynamics of knowledge creation. *Journal of economic geography, 14* (5), 929-954.

Cohendet, P., Simon, L., & Mehouachi, C. (2020). From business ecosystems to ecosystems of innovation: the case of the video game industry in Montreal. *Industry and Innovation*, 1-31.

Cooke, P. (1992). Regional innovation systems: competitive regulation in the new Europe. *Geoforum*, *23*(3), 365-382.

Cooke, P. (2001). Regional innovation systems, clusters, and the knowledge economy. *Industrial and corporate change*, *10*(4), 945-974.

Cooke, P., & Morgan, K. (1994). The regional innovation system in Baden–Wurttemberg. *International journal of technology management*, *9*(3-4), 394-429.

Cortright, J. (2006). Making sense of clusters: Regional competitiveness and economic development (Discussion Paper). Washington, DC: Brookings Institution Metropolitan Policy Program

Cowan, R., & Jonard, N. (2015). Organization, Emotion and Performance: Interactions between Formal and Informal Structures.

Cusumano, M. A., & Gawer, A. (2002). The elements of platform leadership. *MIT Sloan Management Review*, 43: 1-8.

Dangelico, R. M., Pontrandolfo, P., & Pujari, D. (2013). Developing sustainable new products in the textile and upholstered furniture industries: Role of external integrative capabilities. *Journal of Product Innovation Management*, *30*(4), 642-658.

De Medeiros, J. F., Ribeiro, J. L. D., & Cortimiglia, M. N. (2014). Success factors for environmentally sustainable product innovation: a systematic literature review. *Journal of cleaner production*, *65*, 76-86.

de Vasconcelos Gomes, L. A., Facin, A. L. F., Salerno, M. S., & Ikenami, R. K. (2018). Unpacking the innovation ecosystem construct: Evolution, gaps and trends. *Technological Forecasting and Social Change*, *136*, 30-48.

Dervitsiotis, K. N. (2011). The challenge of adaptation through innovation based on the quality of the innovation process. *Total Quality Management & Business Excellence*, *22*(5), 553-566.

Desai, V. (2016). Learning to learn from failures: the impact of operating experience on railroad accident responses. *Industrial and Corporate Change*, *25*(2), 199-226.

Dosi, G. (1982). Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change. *Research policy*, *11*(3), 147-162.

Dosi, G. (1988). Sources, procedures, and microeconomic effects of innovation. *Journal of economic literature*, 1120-1171.

Drucker, P. F. (1985). The discipline of innovation. *Harvard business review*, *63*(3), 67-72.

Eggers, J. P., & Park, K. F. (2018). Incumbent adaptation to technological change: The past, present, and future of research on heterogeneous incumbent response. *Academy of Management Annals*, *12*(1), 357-389.

Ernst, H. (2003). Patent information for strategic technology management. *World patent information*, *25*(3), 233-242.

Evenhuis, E. (2017). New directions in researching regional economic resilience and adaptation. *Geography Compass 11*(11): e12333.

Faridian, P. H., & Neubaum, D. O. (2021). Ambidexterity in the age of asset sharing: Development of dynamic capabilities in open source ecosystems. *Technovation*, *99*, 102125.

Feld, B. (2012). *Startup communities: Building an entrepreneurial ecosystem in your city*. Hoboken, New Jersey: John Wiley & Sons.

Feldman, M. P. (2014). The character of innovative places: entrepreneurial strategy, economic development, and prosperity. *Small Business Economics*, *43*(1), 9-20.

Fernández-Esquinas, M., & Ramos-Vielba, I. (2011). Emerging forms of cross-sector collaboration in the Spanish innovation system. *Science and Public Policy, 38*(2), 135-146.

Ferrary, M. (2011). Specialized organizations and ambidextrous clusters in the open innovation paradigm. *European management journal*, *29*(3), 181-192.

Fischer, M. M. (1999). The innovation process and network activities of manufacturing firms. In *Innovation, networks and localities* (pp. 11-27). Springer, Berlin, Heidelberg.

Fjeldstad, Ø. D., Snow, C. C., Miles, R. E., & Lettl, C. (2012). The architecture of collaboration. *Strategic management journal*, *33*(6), 734-750.

Fleming, L. (2001). Recombinant uncertainty in technological search. *Management science*, *47*(1), 117-132.

Fløysand, A., & Jakobsen, S. E. (2001). Clusters, social fields, and capabilities: rules and restructuring in norwegian fish-processing clusters. *International Studies of Management & Organization*, *31*(4), 35-55.

Freeman, C., (1987). Technology Policy and Economic Performance: Lessons from Japan. Frances Pinter, London

Frenkel, A., & Maital, S. (2014). Mapping national innovation ecosystems: Foundations for policy consensus. Cheltenham: Edward Elgar.

Frost, T. S. (2001). The geographic sources of foreign subsidiaries' innovations. *Strategic management journal*, *22*(2), 101-123.

Fu, X. (2012). How does openness affect the importance of incentives for innovation?. *Research Policy*, *41*(3), 512-523.

Furr, N. R. (2019). Product adaptation during new industry emergence: The role of start-up team preentry experience. *Organization Science, 30*(5), 1076-1096.

Ganco, M. (2013). Cutting the Gordian knot: The effect of knowledge complexity on employee mobility and entrepreneurship. *Strategic Management Journal*, *34*(6), 666-686.

Gawer, A. (2014). Bridging differing perspectives on technological platforms: Toward an integrative framework. *Research policy*, *43*(7), 1239-1249.

Gawer, A. and Cusumano, M.A. (2008). How companies become platform leaders. *MIT Sloan Management Review*, 49 (2), 28–35

Gawer, A., & Cusumano, M. A. (2002). *Platform leadership: How Intel, Microsoft, and Cisco drive industry innovation* (Vol. 5, pp. 29-30). Boston, MA: Harvard Business School Press.

Gawer, A., & Cusumano, M. A. (2014). Industry platforms and ecosystem innovation. *Journal of product innovation management*, *31*(3), 417-433.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research policy*, *31*(8-9), 1257-1274.

Ghisetti, C., Marzucchi, A., & Montresor, S. (2015). The open eco-innovation mode. An empirical investigation of eleven European countries. *Research Policy*, *44*(5), 1080-1093.

Giuliani, E. (2007). The selective nature of knowledge networks in clusters: evidence from the wine industry. *Journal of economic geography*, *7*(2), 139-168.

Gkotsis, P., Pugliese, E., & Vezzani, A. (2018). A technology-based classification of firms: can we learn something looking beyond industry classifications? *Entropy*, *20*(11), 887.

Gloor, P. A. (2006). *Swarm creativity: Competitive advantage through collaborative innovation networks*. Oxford University Press.

Grandadam, D., Cohendet, P., & Simon, L. (2013). Places, spaces and the dynamics of creativity: The video game industry in Montreal. *Regional studies*, *47*(10), 1701-1714.

Granstrand, O., & Holgersson, M. (2020). Innovation ecosystems: A conceptual review and a new definition. *Technovation*, *90*, 102098.

Grant, R. M. (1996). Toward a knowledge-based theory of the firm. *Strategic management journal*, *17*(S2), 109-122.

Gray, B. (1989). *Collaborating: Finding common ground for multiparty problems.* San Francisco: Jossey-Bass.

Gunderson, L. H., & Holling, C. S. (Eds.). (2002). *Panarchy: understanding transformations in human and natural systems*. Island press.

Gupta, A. K., Tesluk, P. E., & Taylor, M. S. (2007). Innovation at and across multiple levels of analysis. *Organization science*, *18*(6), 885-897.

Haithem, H. B. (2020, August). *Competitiveness clusters: what outcomes since 2005?* Retrieved May 27, 2022, from https://www.strategie.gouv.fr/sites/strategie.gouv.fr/files/atoms/files/note_de_synthese_-_pole_de_competitivite_-_en.pdf

Halvorsen, K., & Lacave, M. (1998). Innovation systems in urban areas. *Norwegian Institute for Urban and Regional Research (NIBR) Working Paper*, *110*.

Hamel, G. (2007). The future of management. Boston: Harvard University Press.

Hannah, D. P., & Eisenhardt, K. M. (2018). How firms navigate cooperation and competition in nascent ecosystems. Strategic Management Journal, 39(12), 3163–3192.

Hassink, R. (2010). Regional resilience: a promising concept to explain differences in regional economic adaptability? *Cambridge journal of regions, economy and society*, *3*(1), 45-58.

Hauts-de-France Region (2018, unpublished), “Hauts-de-France” PowerPoint Presentation for the Peer Learning in Industrial Transition Regions Workshop: Preparing Jobs of the *Future*, 8-9 March, 2018, Brussels, Belgium.

Heaton, S., Siegel, D. S., & Teece, D. J. (2019). Universities and innovation ecosystems: a dynamic capabilities perspective. *Industrial and Corporate Change*, *28*(4), 921-939.

Hervas-Oliver, J. L., Sempere-Ripoll, F., Rojas Alvarado, R., & Estelles-Miguel, S. (2018). Agglomerations and firm performance: Who benefits and how much? Regional Studies, 52(3), 338–349.

Holmes, S., & Moir, L. (2007). Developing a conceptual framework to identify corporate innovations through engagement with non-profit stakeholders. *Corporate Governance: The international journal of business in society*.

Hou, H., & Shi, Y. (2021). Ecosystem-as-structure and ecosystem-as-coevolution: A constructive examination. *Technovation*, *100*, 102193.

Huang, J., Wang, H., Wu, J., Yang, Z., Hu, X., & Bao, M. (2020). Exploring the key driving forces of the sustainable intergenerational evolution of the industrial alliance innovation ecosystem: Evidence from a case study of China's TDIA. *Sustainability*, *12*(4), 1320.

Hurley, R. F., & Hult, G. T. M. (1998). Innovation, market orientation, and organizational learning: an integration and empirical examination. *Journal of marketing*, *62*(3), 42-54.

Huxham, C. (Ed.). (1996). *Creating collaborative advantage.* London: Sage.

Iansiti, M., & Levien, R. (2004). Strategy as ecology. *Harvard business review*, *82*(3), 68-78.

Inigo, E. A., & Albareda, L. (2019). Sustainability oriented innovation dynamics: Levels of dynamic capabilities and their path-dependent and self-reinforcing logics. *Technological Forecasting and Social Change*, *139*, 334-351.

Inigo, E. A., Ritala, P., & Albareda, L. (2020). Networking for sustainability: Alliance capabilities and sustainability-oriented innovation. *Industrial Marketing Management*, *89*, 550-565.

Isckia,T., & Lescop, D. (2009). Open innovation within business ecosystems: a tale from Amazon. com. *Communications & stratégies*, (74), 37.

Isenberg, D. (2013). *Worthless, impossible and stupid: How contrarian entrepreneurs create and capture extraordinary value*. Harvard Business Review Press.

Isenberg, D. J. (2010). How to start an entrepreneurial revolution. *Harvard business review*, *88*(6), 40-50.

Jackson, D. J. (2011). What is an innovation ecosystem. *National Science Foundation*, *1*(2), 1-13. available at: http://www.erc-assoc.org/docs/innovation_ecosystem.pdf

Jacobides, M. G. (2005). Industry change through vertical disintegration: How and why markets emerged in mortgage banking. *Academy of Management Journal*, *48*(3), 465-498.

Janzen, D. H. (1980). When is it coevolution? *Evolution*, *34*(3), 611–612. Kallis, G., & Norgaard, R. B. (2010). Coevolutionary ecological economics. *Ecological Economics*, *69*(4), 690–699.

Jensen, M. B., Johnson, B., Lorenz, E., Lundvall, B. Å., & Lundvall, B. A. (2007). Forms of knowledge and modes of innovation. *The learning economy and the economics of hope*, *155*.

Kapoor, R. (2018). Ecosystems: broadening the locus of value creation. *Journal of Organization Design*, *7*(1), 1-16.

Kauppila, O. (2007). Towards a network model of ambidexterity (No. W-429) (p. 429). Helsinki School of Economics Working Papers.

Ketels, C.H.M. (2012). The impact of clusters and networks of firms on EU competitiveness. In: Final Report. WIFO Specific Contract no. 605748.

Kim, N., & Lee, J. (2020). Who is leaping through failure? The influence of innovation characteristics on learning from failure. *Industry and Innovation*, *27*(9), 1014-1039.

Kline, SJ, & Rosenberg, N. (1986). An overview of innovation. The positive sum strategy: Harnessing technology for economic growth. *The National Academy of Science, USA , 35* , 36.

Kolloch, M., & Dellermann, D. (2018). Digital innovation in the energy industry: The impact of controversies on the evolution of innovation ecosystems. *Technological Forecasting and Social Change*, *136*, 254-264.

Lange, B., & Schüßler, E. (2018). Unpacking the middleground of creative cities: spatiotemporal dynamics in the configuration of the Berlin design field. *Regional Studies*, *52* (11), 1548-1558.

Laursen, K., & Salter, A. (2006). Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms. *Strategic management journal*, *27*(2), 131-150.

Lawrence, T. B., Hardy, C., & Phillips, N. (2002). Institutional effects of interorganizational collaboration: The emergence of proto-institutions. *Academy of Management Journal,* 45: 281–290.

Lazarenko, Y., Garafonova, O., Marhasova, V., Tkalenko, N., & Grigashkina, S. (2020). Exploring Strategic Directions for the Local Innovation Ecosystem Development in the Mining Industry. In *E3S Web of Conferences* (Vol. 174, p. 02001). EDP Sciences.

Levinthal, D. A. (1997). Adaptation on rugged landscapes. *Management science*, *43*(7), 934-950.

Liebowitz, S., & Margolis, S. E. (2014). *Path dependence and lock-in*. Edward Elgar Publishing.

Liefooghe, C. (2017). *Lille, métropole créative?: Nouveaux liens, nouveaux lieux, nouveaux territoires*. Presses universitaires du Septentrion.

Linnenluecke, M. K., Griffiths, A., & Winn, M. I. (2013). Firm and industry adaptation to climate change: a review of climate adaptation studies in the business and management field. *Wiley Interdisciplinary Reviews: Climate Change*, *4*(5), 397-416.

Lopes, C. M., Scavarda, A., Hofmeister, L. F., Thomé, A. M. T., & Vaccaro, G. L. R. (2017). An analysis of the interplay between organizational sustainability, knowledge management, and open innovation. *Journal of cleaner production*, *142*, 476-488.

Lundvall, B. Å. (2007). National innovation systems—analytical concept and development tool. *Industry and innovation*, *14*(1), 95-119.

Lundvall, B. A. (2010). National Systems of Innovation: Toward a Theory of Innovation and Interactive Learning, Anthem Press. *London, UK*.

Lundvall, B.-Å. (Ed.), (1992). National Systems of Innovation: Toward a Theory of Innovation and Interactive Learning. Pinter, London.

Lusch, R. F., & Vargo, S. L. (2014). *Service-dominant logic: Premises, perspectives, possibilities*. Cambridge University Press.

Malerba, F. (2002). Sectoral systems of innovation and production. *Research policy*, *31*(2), 247-264.

Marmuse, C., & Godest, J. C. (2008, May). La détection des Entreprises Potentiellement Innovantes Modélisation d'une approche de score pour l'accompagnement des Entreprises à potentiel Innovateur. In *Conférence Internationale de Management Stratétgique, Nice–Sophia Antipolis* (pp. 28-31).

Marshall,, A. (2009). *Principles of economics: unabridged eighth edition*. Cosimo, Inc.

Martin, R., & Sunley, P. (2003). Deconstructing clusters: chaotic concept or policy panacea? *Journal of economic geography*, *3*(1), 5-35.

Mascarenhas, C., Ferreira, J. J., & Marques, C. (2018). University–industry cooperation: A systematic literature review and research agenda. *Science and Public Policy*, *45*(5), 708-718.

Maskell, P., & Malmberg, A. (1999). The Competitiveness of Firms and Regions: 'Ubiquitification'and the Importance of Localized Learning. *European urban and regional studies*, *6*(1), 9-25.

Mason, C., & Brown, R. (2013). Entrepreneurial ecosystems and growth-oriented entrepreneurship. *Final report to OECD, Paris*, *30*(1), 77-102.

McPhillips, M. (2020). Innovation by proxy–clusters as ecosystems facilitating open innovation. *Journal of Entrepreneurship, Management and Innovation*, *16*(3), 101-128.

Menzel, M. P., & Fornahl, D. (2010). Cluster life cycles—dimensions and rationales of cluster evolution. *Industrial and corporate change*, *19*(1), 205-238.

Mercan, B., & Goktas, D. (2011). Components of innovation ecosystems: a cross-country study. *International research journal of finance and economics*, *76*(16), 102-112.

Miller, D. (1996). Configurations revisited. *Strategic management journal*, *17*(7), 505-512.

Molina-Morales, F. X., & Expósito-Langa, M. (2012). The impact of cluster connectedness on firm innovation: R&D effort and outcomes in the textile industry. *Entrepreneurship & Regional Development*, *24*(7-8), 685-704.

Moore, J. (1996). *The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems*. Harper Collins: NY.

Moore, J. F. (1993). Predators and prey: a new ecology of competition. *Harvard business review*, *71*(3), 75-86.

Morrison, A., Rabellotti, R., & Zirulia, L. (2013). When do global pipelines enhance the diffusion of knowledge in clusters?. *Economic geography*, *89*(1), 77-96.

Mulas, V., Minges, M., & Applebaum, H. (2016). Boosting tech innovation: Ecosystems in cities: A framework for growth and sustainability of urban tech innovation ecosystems. *Innovations: Technology, Governance, Globalization*, *11*(1-2), 98-125.

National Research Council. (2007). *Innovation policies for the 21st century: Report of a symposium*. National Academies Press. , Washington, DC.

Neck, H. M., Meyer, G. D., Cohen, B., & Corbett, A. C. (2004). An entrepreneurial system view of new venture creation. *Journal of small business management*, *42*(2), 190-208.

Nelson, R. R. (1982). The role of knowledge in R&D efficiency. *The quarterly journal of economics*, *97*(3), 453-470.

Nelson, R. R., & Winter, S. G. (1982). The Schumpeterian tradeoff revisited. *The American Economic Review*, *72*(1), 114-132.

Nunes, S., & Lopes, R. (2015). Firm performance, innovation modes and territorial embeddedness. *European Planning Studies*, *23*(9), 1796-1826.

O'Connor, A., Stam, E., Sussan, F., & Audretsch, D. B. (2018). Entrepreneurial ecosystems: The foundations of place-based renewal. In *Entrepreneurial ecosystems* (pp. 1-21). Springer, Cham.

OECD (2018–unpublished), "Jobs at Risk of Automation", PowerPoint Presentation for the Peer Learning in Industrial Transition Regions Workshop: *Preparing Jobs of the Future*, presented by David Bartolini, 8-9 March, 2018, Brussels, Belgium.

OECD, (2015). System Innovation: Synthesis Report. OECD Publishing, Paris.

OECD. (1992). Technology and the economy: The key relationships. Paris: OECD

Oh, D. S., Phillips, F., Park, S., & Lee, E. (2016). Innovation ecosystems: A critical examination. *Technovation*, *54*, 1-6.

Oktemgil, M., & Greenley, G. (1997). Consequences of high and low adaptive capability in UK companies. *European Journal of Marketing*.

O'Reilly III, C. A., & Tushman, M. L. (2013). Organizational ambidexterity: Past, present, and future. *Academy of management Perspectives*, *27*(4), 324-338.

Owen-Smith, J., & Powell, W. W. (2004). Knowledge networks as channels and conduits: The effects of spillovers in the Boston biotechnology community. *Organization science*, *15*(1), 5-21.

Peltoniemi, M., & Vuori, E. (2004, September). Business ecosystem as the new approach to complex adaptive business environments. In *Proceedings of eBusiness research forum* (Vol. 2, No. 22, pp. 267-281).

Pfeffer, J., & Pfeffer, J. (1981). *Power in organizations* (Vol. 33). Marshfield, MA: Pitman.

Pierrard, P., (1991), *La vie ouvrière à Lille sous le Second Empire*. Éditions Charles Corlet

Pigford, A. A. E., Hickey, G. M., & Klerkx, L. (2018). Beyond agricultural innovation systems? Exploring an agricultural innovation ecosystems approach for niche design and development in sustainability transitions. *Agricultural Systems*, *164*, 116-121.

Pinkse, J., Vernay, A. L., & D'Ippolito, B. (2018). An organizational perspective on the cluster paradox: Exploring how members of a cluster manage the tension between continuity and renewal. *Research Policy*, *47*(3), 674-685.

Planko, J., Chappin, M. M., Cramer, J., & Hekkert, M. P. (2019). Coping with coopetition—Facing dilemmas in cooperation for sustainable development: The case of the Dutch smart grid industry. *Business strategy and the environment*, *28*(5), 665-674.

Porter, M. (1990). *The Competitiveness Advantage of Nations*. New York: The Free Press.

Porter, M. E. (1998). *Clusters and the New Economics of Competition*. Harvard Business Review 76 (6): 77–90.

Powell, W. W., & Grodal, S. (2005). *Networks of innovators*. in: Fagerberg, J., D. C. Mowery, and R. Nelson. (Eds), The Oxford Handbook of Innovation 56-85, Oxford: Oxford University Press.

Puffert, D. J. (2004). Path dependence, network form and technological change. *History Matters: Essays on Economic Growth, Technology, and Demographic Change, Stanford University Press, Stanford*.

Quintana-García, C., & Benavides-Velasco, C. A. (2008). Innovative competence, exploration and exploitation: The influence of technological diversification. *Research policy*, *37*(3), 492-507.

Ramos, R., & Royuela, V. (2021). Introduction to the Special Issue on "Territorial Resilience: Mitigation and Firms' Adaptation".

Ritala, P., & Almpanopoulou, A. (2017). In defense of 'eco'in innovation ecosystem. *Technovation*, *60*, 39-42.

Rodríguez-Pose, A. (2013). Do institutions matter for regional development? *Regional studies*, *47*(7), 1034-1047.

Rohrbeck, R., Hölzle, K., & Gemünden, H. G. (2009). Opening up for competitive advantage–How Deutsche Telekom creates an open innovation ecosystem. *R&d Management*, *39*(4), 420-430.

Rong, K., Wu, J., Shi, Y., & Guo, L. (2015). Nurturing business ecosystems for growth in a foreign market: Incubating, identifying and integrating stakeholders. *Journal of International Management*, *21*(4), 293-308.

Rosenfeld, S. A. (1997). Bringing business clusters into the mainstream of economic development. *European planning studies*, *5*(1), 3-23.

Rothaermel, F. T. (2008). Competitive advantage in technology intensive industries. In *Technological innovation: Generating economic results*. Emerald Group Publishing Limited.

Russell, M. G., & Smorodinskaya, N. V. (2018). Leveraging complexity for ecosystemic innovation. *Technological Forecasting and Social Change*, *136*, 114-131.

Russell, M. G., Huhtamäki, J., Still, K., Rubens, N., & Basole, R. C. (2015). Relational capital for shared vision in innovation ecosystems. *Triple Helix*, *2*(1), 1-36.

Sanchez, R., & Mahoney, J. T. (1996). Modularity, flexibility, and knowledge management in product and organization design. *Strategic management journal*, *17*(S2), 63-76

.Saxenian, A. (1994). *Regional Networks: industrial Adaptation in Silicon Valley and route 128*. Cambridge: Harvard University Press

Saxenian, A. (1996). Inside-out: Regional Networks and Industrial Adaptation in Silicon Valley and Route 128. *Cityscape*: *A journal of Policy Development and Research* 2(2): 41–60.

Schaltegger, S., & Wagner, M. (2011). Sustainable entrepreneurship and sustainability innovation: categories and interactions. *Business strategy and the environment*, *20*(4), 222-237.

Schilling, M. A., & Phelps, C. C. (2007). Interfirm collaboration networks: The impact of large-scale network structure on firm innovation. *Management science*, *53*(7), 1113-1126.

Schmitz, H., & Strambach, S. (2009). The organizational decomposition of innovation and global distribution of innovative activities: insights and research agenda. *International Journal of Technological Learning, Innovation and Development*, *2*(4), 231-249.

Schot, J., & Steinmueller, W. E. (2016). Framing innovation policy for transformative change: Innovation policy 3.0. *SPRU Science Policy Research Unit, University of Sussex: Brighton, UK*.

Schumpeter, J. A. (1948). Irving Fisher's econometrics. *Econometrica: Journal of the Econometric Society*, 219-231.

SFWORK (2015). Complexity science and management: What's in it for business? Available at http://sfwork.com/ complexity-science-and-management

Shaw, D. R., & Allen, T. (2018). Studying innovation ecosystems using ecology theory. *Technological Forecasting and Social Change*, *136*, 88-102.

Siggelkow, N. (2002). Evolution toward fit. *Administrative science quarterly*, *47*(1), 125-159.

Smith, K., (1994). New directions in research and technology policy: indentifying the key issues, STEP Report R-01, STEP Group, Oslo, ISSN 0804-8185.

Smorodinskaya, N., Russell, M., Katukov, D., & Still, K. (2017). Innovation ecosystems vs. innovation systems in terms of collaboration and co-creation of value. In *Proceedings of the 50th Hawaii international conference on system sciences*.

Stam, F. C., & Spigel, B. (2016). Entrepreneurial ecosystems. *USE Discussion paper series, 16*(13).

Steiner, M. (1998) (Ed.) Clusters and Regional Specialisation: On Geography, Technology and Networks, London: Pion

Stuart, T. E. (2000). Interorganizational alliances and the performance of firms: a study of growth and innovation rates in a high-technology industry. *Strategic management journal*, *21*(8), 791-811.

Stuermer, M., Spaeth, S., & Von Krogh, G. (2009). Extending private-collective innovation: a case study. *R&d Management*, *39*(2), 170-191.

Suire, R., & Vicente, J. (2014). Clusters for life or life cycles of clusters: in search of the critical factors of clusters' resilience. *Entrepreneurship & Regional Development*, *26*(1-2), 142-164.

Sun, J., Wu, S., & Yang, K. (2018). An ecosystemic framework for business sustainability. *Business Horizons*, *61*(1), 59-72.

Tansley, A. G. (1935). The use and abuse of vegetational concepts and terms. *Ecology*, *16*(3), 284-307.

Tassey, G. (2008). Globalization of technology-based growth: the policy imperative. *The Journal of Technology Transfer*, *33*(6), 560-578.

Teece, D. J. (2007). Explicating dynamic capabilities: the nature and micro foundations of (sustainable) enterprise performance. *Strategic management journal*, *28*(13), 1319-1350.

Teece, D. J. (2012). Dynamic capabilities: Routines versus entrepreneurial action. *Journal of management studies*, *49*(8), 1395-1401.

Touzard, J. M., Temple, L., Faure, G., & Triomphe, B. (2015). Innovation systems and knowledge communities in the agriculture and agrifood sector: a literature review. *Journal of Innovation Economics Management*, (2), 117-142.

Tsujimoto, M., Kajikawa, Y., Tomita, J., & Matsumoto, Y. (2018). A review of the ecosystem concept—Towards coherent ecosystem design. *Technological Forecasting and Social Change*, *136*, 49-58.

Tuominen, M., Rajala, A., & Möller, K. (2004). How does adaptability drive firm innovativeness? *Journal of Business research*, *57*(5), 495-506.

Turkina, E., Oreshkin, B., & Kali, R. (2019). Regional innovation clusters and firm innovation performance: An interactionist approach. *Regional Studies*, *53*(8), 1193-1206.

US Council on Competitiveness. (2005, octobre). *Measuring regional innovation: A guidebook for conducting regional innovation assessments*. Retrieved July 10, 2020, from https://compete.secure.nonprofitsoapbox.com/storage/images/uploads/File/PDF%20Files/Regional_Innovation_Guidebook.pdf

Vivas, C., & Barge-Gil, A. (2015). Impact on firms of the use of knowledge external sources: A systematic review of the literature. *Journal of Economic Surveys*, *29*(5), 943-964.

von Hippel, E. (2005). Democratizing Innovation. MIT Press, Cambridge, MA.

Wang, Y., & Rajagopalan, N. (2015). Alliance capabilities: Review and research agenda. *Journal of management*, *41*(1), 236-260.

Warwick, K., (2013). *Beyond Industrial Policy: Emerging Issues and New Trends.* OECD Science, Technology and Industry Policy Papers, No. 2. Paris: OECD Publishing

Wei, F., Feng, N., Yang, S., & Zhao, Q. (2020). A conceptual framework of two-stage partner selection in platform-based innovation ecosystems for servitization. *Journal of Cleaner Production*, *262*, 121431.

Wessner, C. W. (2005). Entrepreneurship and the innovation ecosystem policy lessons from the United States. In *Local Heroes in the Global Village* (pp. 67-89). Springer, Boston, MA.

Williamson, O. E. (1975). Markets and hierarchies: analysis and antitrust implications: a study in the economics of internal organization. *University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship*.

Winn, M., Kirchgeorg, M., Griffiths, A., Linnenluecke, M. K., & Günther, E. (2011). Impacts from climate change on organizations: a conceptual foundation. *Business strategy and the environment*, *20*(3), 157-173.

World Economic Forum (2013). Entrepreneurial Ecosystems Around the Globe and Company Growth Dynamics. Davos: World Economic Forum.

Xie, X., & Wang, H. (2020). How can open innovation ecosystem modes push product innovation forward? An fsQCA analysis. *Journal of Business Research*, *108*, 29-41.

Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). Research commentary—the new organizing logic of digital innovation: an agenda for information systems research. *Information systems research*, *21*(4), 724-735.

Zahra, S. A., & Nambisan, S. (2012). Entrepreneurship and strategic thinking in business ecosystems. *Business horizons*, *55*(3), 219-229.

Zucchella, A. (2006). Local cluster dynamics: trajectories of mature industrial districts between decline and multiple embeddedness. *Journal of Institutional Economics*, *2*(1), 21-44.

Appendices

Appendix D1

Summary statistics for variables

			Population =1233	Sample used n=431	Incomplete data n=802	t-test/z-test
				proportion	mean	p-value
Size	Size of the firms using categories of INSEE	Micro		36,00%	17,60%	0.000
		Small		53,60%	52,90%	0,612
		Medium		9,50%	10,20%	0,553
		Large		0,90%	19,30%	0.000
locat	Location of the firms	Aisne		7,20%	6,40%	0,574
		Nord		53,10%	54,20%	0,521
		Oise		14,40%	12,30%	0,250
		Pas-de-Calais		14,80%	18,00%	0,048
		Somme		10,40%	9,10%	0,541

Appendix D2

Summary statistics for variables (Eurasante)

			Population =661	Sample used n=277	Incomplete data n=384	t-test/z-test
				Mean/proportion	Mean/Proportion	p-value
Pat	The number of patents owned by each firm			5.097	14.054	0.176
Size	Size of the firms using categories of INSEE	Micro		46,60%	22,90%	0.000
		Small		42,60%	49,90%	0.171
		Medium		9,00%	12,30%	0.284
		Large		1,80%	14,90%	0.000

Jude Onyekachi OZOR

INNOVATION ECOSYSTEM: ORCHESTRATION OF COMPLEX RELATIONSHIPS AND IMPACT ON ADAPTIVE CAPACITY OF FIRMS

Abstract

Today, regions and industries face increasing shocks arising from technological changes and global phenomena and therefore require adaptation processes. This thesis sheds light on the relevance of the innovation ecosystem as a new conceptual framework for public policies and economic actors in innovation processes that regularly face these shocks and aim to adapt. Innovation ecosystems as complex adaptive systems consider the dynamics of the innovation environment. This thesis studies to what extent ecosystems influence the adaptive capacity of firms and what are the properties and mechanisms of these ecosystems that explain their impact on the adaptive capacity of firms. This thesis explores innovation ecosystems within the Hauts-de-France region, their specificities and the orchestration of complex relationships between heterogeneous actors within the ecosystems. In addition, this thesis analyzes in depth an emblematic ecosystem of this region: the Eurasanté ecosystem (ecosystem around health and biotechnologies). It examines the middleground of the Eurasanté ecosystem to analyze how the relationships between different actors are orchestrated; and empirically tests the impact of the middleground on the technological development of firms. It further analyzes collaborative R&D projects as the most advanced relational component of the middleground to ascertain to what extent the underground influences the involvement of core actors in collaborative R&D projects. The results from econometric models show that firms belonging to local innovation ecosystems are both more innovative and more technologically diversified, and therefore, are more adaptive. The thesis shows that the middleground plays an important role in the orchestration of relations between heterogeneous actors, allows knowledge exchange between formal and informal actors and impacts on the technological development of firms. Finally, the study reveals that beyond the type of project, geographical proximity, the presence of start-ups, actors from the underground, plays a decisive role in the involvement of core actors in collaborative projects. This thesis therefore contributes to a better understanding of the construct or framework of innovation ecosystem that can be adopted to improve the adaptability of firms. Innovation-base policies and the collective strategies of economic actors should focus on promoting the construct of innovation ecosystem in order to stimulate firm adaptation and enhance territorial dynamics. Finally, this thesis fills the gap in the literature, providing empirical evidences on innovation ecosystem and their role in adaptation of firms.

Keywords: Innovation ecosystem; middleground; Hauts-de-France; adaptive capacit

Résumé

Aujourd'hui, les régions et les industries sont confrontées à des chocs croissants découlant des changements technologiques et des phénomènes mondiaux et nécessitent donc des processus d'adaptation. Cette thèse met en lumière la pertinence de l'écosystème d'innovation en tant que nouveau cadre conceptuel pour les politiques publiques et les acteurs économiques engagés dans des processus d'innovation qui font face régulièrement à ces chocs. Les écosystèmes d'innovation en tant que Systèmes Complexes adaptatifs tiennent compte de la dynamique de l'environnement de l'innovation. Cette thèse étudie dans quelle mesure les écosystèmes influence la capacité d'adaptation des entreprises et quelles sont les propriétés et mécanismes de ces écosystèmes qui expliquent leur impact sur la capacité adaptative des entreprises. Cette thèse mobilise les écosystèmes d'innovation au sein de la région Hauts-de-France, leurs spécificités et l'orchestration des relations complexes entre acteurs hétérogènes au sein de ces écosystèmes. De plus, cette thèse analyse de manière plus approfondie un écosystème emblématique de cette région : l'écosystème d'Eurasanté (écosystème autour de la santé et des biotechnologies). Premièrement, elle examine le *middleground* de l'écosystème Eurasanté pour analyser la façon dont les relations entre différents acteurs sont orchestrées ; et teste empiriquement l'impact du *middleground* sur le développement technologique des entreprises. Deuxièmement, elle analyse les projets de R&D collaboratifs en tant que la composante relationnelle la plus avancée du *middleground* pour déterminer les facteurs qui influencent l'implication des *Core actors* dans ces projets de R&D collaboratifs. Les résultats issus de modèles économétriques montrent que les entreprises évoluant au sein des écosystèmes locaux d'innovation sont à la fois plus performantes en termes d'innovation et plus diversifiées sur le plan technologique, et donc ont une plus grande capacité adaptative. Nos analyses montrent que le *middleground* joue un rôle important dans l'orchestration des relations entre acteurs hétérogènes, l'échange de connaissances entre les acteurs formels et informels et le développement technologique des entreprises. Enfin, l'étude révèle qu'au-delà du type de projet, de la proximité géographique, la présence des start-ups, acteurs provenant de l'underground, joue un rôle déterminant dans l'implication des *core actors* dans les projets collaboratifs. Cette thèse contribue donc à une meilleure compréhension de la construction du cadre conceptuel des écosystèmes d'innovation qui peut être adopté pour améliorer l'adaptabilité des entreprises. Les politiques basées sur l'innovation et les stratégies collectives des acteurs économiques devraient se concentrer sur la promotion du concept d'écosystème d'innovation afin de stimuler l'adaptation des entreprises et dynamiser les territoires. Enfin, cette thèse comble un vide dans la littérature, en fournissant des démonstrations empiriques sur les écosystèmes d'innovation et leur rôle dans l'adaptation des entreprises.

Mots-clés : Ecosystème d'innovation ; middleground ; Hauts-de-France ; capacité d'adaptation

UNIVERSITÉ DE STRASBOURG

ÉCOLE DOCTORALE AUGUSTIN COURNOT

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Préparée par:

Jude Onyekachi OZOR

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ÉCOSYSTÈME D'INNOVATION: ORCHESTRATION DES RELATIONS COMPLEXES ET IMPACT SUR LA CAPACITÉ ADAPTATIVE DES ENTREPRISES

Résumé en Français

Directeur de thèse :

Professeur RONDE Patrick	BETA, Université de Strasbourg
Dr. BOYER James (co-supervisor)	LEM, HEMiSF4iRE, Catholic University of Lille

Rapporteurs:

Professeur VICENTE Jérôme	LEREPS, Université de Toulouse
DR MATT Mireille	LISIS, INRAE, Université de Marne La Vallée

Autres Membres du Jury:

Professeur BOCQUET Rachel	IREGE, Université de Savoie Mont Blanc
Professeur PENIN Julien	BETA, Université de Strasbourg

Partie 1

Introduction

1.1 Contexte de l'étude

Les changements constants dans l'environnement de l'innovation au cours des dernières années remettent en question les modèles de développement économique, les modèles d'affaires et les stratégies des entreprises pour rester compétitives. Ces changements vont des changements technologiques liés à l'évolution numérique aux changements de conditions climatiques ou encore de la complexité accrue de l'environnement commercial à l'hyper-concurrence. Par exemple, la transformation numérique et le développement de l'Internet des Objets (IoT) obligent les entreprises à s'adapter (Yoo et al., 2010). De même, les changements climatiques induisent de l'incertitude dans l'environnement économique et imposent aux agents économiques de développer des stratégies d'adaptation (Linnenluecke et al., 2013 ; Winn et al., 2012).

L'adaptation désigne l'ajustement des processus, des capacités ou des stratégies en réponse à des changements qu'ils soient écologiques, sociaux, économiques, technologiques ou concurrentiels. La capacité d'adaptation des entreprises renvoie à la propension des entreprises à combiner les ressources et les compétences pour répondre aux évolutions de l'environnement économique. L'adaptation des entreprises a été théorisée dans différentes perspectives. La théorie des coûts de transaction suggère que l'efficacité des coûts de transactions (informations sur les nouvelles opportunités et les signaux faibles, flexibilité des contrats, coopération) peut améliorer la capacité d'adaptation des entreprises (Williamson, 1975). De même, la théorie de la dépendance en ressources (*Resource Dependency Theory*) postule que l'adaptation organisationnelle provient de coalitions visant à exploiter les ressources critiques pour survivre (Pferffer et Pferffer, 1981). L'adaptation implique donc la combinaison de ressources complémentaires pour répondre aux chocs d'ordre technologiques, institutionnels ou pour faire face à la dynamique du marché (Barney et al., 2001). Dans la théorie de l'apprentissage, l'adaptation est un résultat de l'apprentissage. Dans ce contexte, l'apprentissage implique l'acquisition et l'application de nouvelles connaissances dans les processus décisionnels de l'organisation (Miller, 1996).

Par ailleurs, l'innovation est largement reconnue comme un élément clé des stratégies d'adaptation (Geels, 2002 ; Rothaermel, 2008 ; Schmitz et Strambach, 2009). Drucker (1985) explique que les économies sont à l'ère de la discontinuité, de la complexité et des incertitudes et identifie l'innovation comme un moyen indispensable à la survie des entreprises (Hamel, 2007 ; Gupta et al., 2007). L'innovation est à la fois source de performance économique et de résilience (Boschma 2015 ; Tan et al., 2017 ; Giannakis and Bruggeman, 2017). Elle permet de générer des gains de productivité, améliore la dynamique des entreprises et renforce leur capacité à faire face aux changements de l'environnement concurrentiel et aux changements technologiques. Les études empiriques révèlent que l'innovation contribue de manière significative à l'adaptation et à la survie des entreprises en offrant de nouvelles opportunités de croissance (Audretsch, 1995 ; Archibugi et Pianta, 1996).

L'innovation dans le modèle traditionnel dit "Schumpétérien" suit un processus linéaire, où l'innovation découle de la recherche fondamentale, puis de la recherche appliquée au développement de produits et services (Fischer, 1999 ; Halvorsen et Lacave, 1998). Ce modèle est toutefois critiqué pour son argumentaire car les innovations peuvent aussi provenir d'ailleurs et pas nécessairement des résultats provenant du milieu académique (Halvorsen et Lacave, 1998). De même, les chercheurs dans le domaine de l'innovation remettent aujourd'hui en question le modèle traditionnel intégré verticalement et le concept d'innovation produite et commercialisée au sein d'une seule entreprise (Adner et Kapoor, 2010 ; Fjeldstad, et al., 2012 ; Iansiti et Levien, 2004 ; Jacobides, 2005). Ils plaident plutôt pour des processus d'innovation ouverts impliquant de nombreux acteurs (Adner, 2006 ; Chesbrough, 2003 ; von Hippel, 2005). Les modèles d'innovation modernes reconnaissent que les processus d'innovation sont systémiques et complexes nécessitant des relations et interactions entre des acteurs hétérogènes (Isckia et Lescop, 2009 ; Chesbrough, 2003 ; Baldwin et Von Hippel, 2011). Le modèle de Schumpeter (1948) de l'innovation en organisation solitaire, avec les avantages qui y sont associés, n'est donc pas suffisant pour aborder l'adaptation aux changements du marché et de l'environnement technologique vu leur complexité et les incertitudes associées, tels que observés de nos jours (Kolloch et Dellermann, 2018). De plus en plus d'études montrent que l'innovation réussit mieux lorsque qu'elle est réalisée, au moins en partie, dans un contexte interactif impliquant un réseau d'acteurs hétérogènes interdépendants et complémentaires (Adner, 2006 ; Moore, 1993).

Certains chercheurs reconnaissent également le rôle de la connaissance dans le processus d'innovation et l'importance des processus d'apprentissage collectif dans la production et la diffusion des connaissances (Lundvall, 2007 ; Jensen et al., 2007). Les connaissances à l'origine de l'innovation vont au-delà de celles qui sont générées par le système scientifique formel et incluent le processus d'apprentissage collectif qui résulte des interactions entre les acteurs et les institutions. Cela souligne que l'innovation provient de processus d'apprentissage interactifs et certaine fois itératifs. La vision systémique découle l'hypothèse ontologique selon laquelle le développement de l'innovation dépend de la qualité du système d'innovation dans lequel l'organisation fonctionne (Dosi, 1988 ; Kline et Rosenberg, 1986 ; OCDE, 1992 ; Smith, 1994).

Les changements systémiques liés à l'innovation ouverte qui exigent que l'entreprise interagissent avec un ensemble d'acteurs hétérogène posent d'énormes défis aux entreprises et aux organisations qui s'efforcent de gérer ou manager ces complexités liées à la nature même de ces processus d'innovation pour faire face aux évolutions constantes dans l'environnement économique.

1.1.2 L'adaptation des acteurs : La nécessité d'une approche de l'écosystème de l'innovation ?

Les recherches sur l'innovation abondent et montrent comment l'innovation est réalisée et diffusée avec succès dans un environnement stratégique et interactif, ce qui a conduit à différentes approches de l'innovation dans un passé récent. Ces approches comprennent par exemple les Clusters (Porter, 1998), les Systèmes d'Innovation (Freeman, 1987 ; Lundvall, 1992) et plus récemment les Ecosystèmes d'Innovation (Moore 1993, Adner, 2006). Les clusters et le système d'innovation ont été largement adoptés dans de nombreuses économies depuis leur introduction.

Les clusters, en tant qu'approche traditionnelle, mettent l'accent sur les économies de localisation et l'avantage compétitif dérivé lorsque des entreprises spécialisées sur un domaine technologique ou une industrie sont localisées dans une zone géographique. Porter (1998) définit les clusters comme une agglomération géographique d'entreprises liées qui se font concurrence et coopèrent pour améliorer la productivité et l'innovation. Ce cadre a gagné en importance parmi les chercheurs en économie et management de l'innovation car il génère des effets positifs et augmente la compétitivité régionale (McPhillips, 2020). Les travaux sur les clusters ont favorisé le développement et la mise en œuvre de politiques de clusters. Par exemple, la grappe industrielle au Canada, les Business Clusters aux États-Unis et au Royaume-Uni et les Pôles de compétitivités en France.

Freeman (1987) et Lundvall (1992) ont proposé le concept de système d'innovation en soulignant le rôle clé des institutions dans le développement de l'innovation. Un système d'innovation se définit comme un ensemble d'organisations et entreprises et d'institutions qui interagissent pour générer et diffuser des connaissances et produire de nouvelles technologies.

Le système d'innovation englobe l'ensemble des organisations et institutions dont les interactions influencent les performances en matière d'innovation (Mercan et Gotkas, 2011). Deux perspectives principales coexistent dans la littérature sur les systèmes d'innovation : une perspective politico-administrative et une perspective topologique (Touzard, 2015). La première fait référence aux institutions, organisations et réseaux qui favorisent la production de nouvelles connaissances et de l'innovation dans un secteur (système d'innovation sectoriel) (Malerba, 2002) ou aux institutions, organisations et éléments communs à tous les secteurs au sein soit d'un même pays (systèmes d'innovation nationaux) (Lundvall, 2010) ou d'une même région (systèmes d'innovation régionaux) (Cooke et Morgan, 1994). La seconde vision est plus topologique et fait référence à un système construit par les interactions entre acteurs ou firmes autour du développement d'une technologie. C'est le cas des " Systèmes Technologiques " qui permettent de prendre en compte les interactions entre institutions, organisations et firmes au-delà des cadres politico-administratifs établis (Carlsson, 2012). Inspirés par ces travaux, les décideurs européens ont adopté la RIS3 - Stratégie de recherche et d'innovation pour une spécialisation intelligente, conformément au règlement du Conseil du Parlement européen de 2013 (Nunes et Lopes, 2015). Cette stratégie vise à transformer l'UE en une économie intelligente et durable.

Dans la littérature, les études sur les clusters ont montré les effets positifs des clusters sur la performance des entreprises en matière d'innovation (Baptista et Swann, 1998 ; Boix et Galletto, 2009 ; Beaundry et Breschi, 2003). On peut soutenir que les effets positifs des clusters sur la performance d'innovation des entreprises proviennent des marchés spécialisés et de la disponibilité des compétences dans les agglomérations (Boix et Galletto, 2009 ; Porter, 1998).

Cependant, malgré les avantages associés aux clusters, allant de l'influence de la spécialisation et de la colocalisation sur la performance d'innovation (Hervas-Oliver et al., 2018 ; Porter, 1990), passant par les externalités régionales, à la diminution des coûts de transaction et à l'effet du transfert de technologies sur les potentiels d'innovation (Fløysand et Jakobsen, 2001 ; Molina-Morales et Exposito-Langa, 2012 ; Porter, 1990), il est avancé que pendant les crises et les incertitudes, les avantages des clusters sont menacés. Par exemple, la spécialisation prédispose les clusters à la vulnérabilité face aux crises liées à l'émergence de nouveaux paradigmes technologiques, et entrave l'adaptation aux défis économiques et technologiques (Bishop, 2019). Steiner (1998) note que les régions avec des clusters spécialisés d'aujourd'hui seront les zones à problèmes de demain. Cela met en évidence le fait que malgré les gains et l'efficacité de la spécialisation, celle-ci est confrontée à des risques induits par l'évolution technologique ou des marchés. La spécialisation enferme les entreprises au sein d'un cluster dans une trajectoire spécifique (*lock-in, path-dependency*) et réduit leur capacité d'adaptation (Boschma, 2015). En fait, Zucchella (2006) explique que les clusters souffrent d'un manque de mécanismes pour surmonter les situations de verrouillage technologique (lock-in) et la rigidité institutionnelle et structurelle. L'approche traditionnelle des clusters a été adoptée comme une stratégie utile pour améliorer la compétitivité. Les études empiriques et théoriques n'ont cependant pas réussi à expliquer comment les clusters existants facilitent la résilience, la transition durable et affectent l'adaptation des entreprises lorsque des chocs se produisent (Bergman, 2008 ; Saxenian, 1996). Le déclin des clusters indique que les avantages économiques de la dynamique des clusters ne sont pas permanents car le cycle de vie des clusters est lié à la spécialisation technologique ou au régime technologique respectif (Zucchella, 2006).

De même, il est avancé que le système d'innovation est une structure plus statique dû à la stabilité des institutions qui déterminent le développement de l'innovation (Schot et Steinmueller, 2016 ; Amitrano et al., 2018 ; Smorodinskaya et al., 2017). La nature statique du système d'innovation ne parvient pas ontologiquement à intégrer les dynamiques de l'innovation sans mobiliser d'autres cadres complémentaires en lien avec le management de la transition (Geels 2002 ; Cooke, 2001 ; Mercan et Goktas, 2011). Par exemple, Saxenian (1994) a expliqué pourquoi la Route 128 dans le Massachusetts a décliné dans les années 90 malgré des histoires et des technologies similaires à celles de la Silicon Valley, qui a prospéré, est due à une rigidité institutionnelle et structurelle, à des sociétés indépendantes, autosuffisantes et hiérarchisées. Cela signifie que sans mécanismes de régénération, l'enfermement et la rigidité institutionnelle et structurelle pourraient se transformer en un piège qui empêche le renouvellement des clusters ainsi que la dynamique du système d'innovation (Boyer, 2020).

L'un des principaux intérêts de la recherche sur les écosystèmes concerne la question de coévolution et coadaptation des entreprises (Adner, 2017 ; Gratacap et al 2017 ; Kapoor, 2018). Cela présente un intérêt particulier car les entreprises sont confrontées à divers chocs et leur capacité à s'adapter à ces chocs devient nécessaire. Ces chocs peuvent provenir de changements dans les technologies et le marché, de changements réglementaires ou de chocs exogènes (tels que les chocs Covid 19/mondiaux).

D'un point de vue théorique, l'idée principale est que l'écosystème d'innovation est considéré comme un système dynamique caractérisé par des acteurs hétérogènes aux capacités diverses et aux interactions complexes (Huang et al., 2020; Ritala et Almpanopoulou, 2017). Par conséquent, en s'intégrant dans l'écosystème d'innovation, les entreprises exploitent la diversité des ressources et des structures intersectorielles pour recombiner les ressources afin de tracer de nouvelles voies de création de valeur (Maskelll et Malmberg, 1999 ; Baldwin et Clark, 2000; Ganco, 2013) et d'améliorer à la fois la résilience (Fernández-Esquinas et Ramos-Vielba, 2011; Hassink, 2010 ; Boschma, 2015) et la performance (Chesbrough, 2006b ; Cortright, 2006; Frost, 2001; Rosenfeld, 1997).

Dans une perspective en termes de politiques publiques, de nos jours on assiste à un changement progressif vers des politiques d'innovation en faveur des écosystèmes d'innovation. En France, par exemple, l'initiative des pôles de compétitivité (Pôles de compétitivités) lancée en 2005, vise à renforcer la compétitivité de l'économie et à favoriser l'innovation grâce à des synergies entre les instituts de recherche, les entreprises et les organisations dans un espace géographique donné. Cette initiative évolue par phases. La première phase (2005-2008) visait la structuration des clusters. À la fin, l'évaluation de la solidité des capacités d'innovation des clusters montre cependant que les subventions aux projets de R&D ont découragé les entreprises d'investir elles-mêmes dans la recherche et le développement. Il y a donc un manque d'effet d'entraînement de la politique des pôles de compétitivité sur les dépenses de R&D (Haithem, 2020). Pour éviter les phénomènes de lock-in, depuis la deuxième phase de cette politique de pôle de compétitivité, le renforcement des collaborations inter-pôles pour plus de diversités en termes de ressources et de compétences a été mis en avant afin de stimuler la capacité d'innovation et la compétitivité des entreprises. Durant cette phase, les dépenses de R&D autofinancées des entreprises ont augmenté, montrant un effet de levier positif sur les dépenses de R&D privées.

Les actions de politique publique relatif aux pôles de compétitivités visent désormais à orienter les activités économiques des régions vers des domaines technologiques à fort potentiels en encourageant les initiatives inter-clusters.

De même, le concept d'écosystème d'innovation gagne du terrain en France ainsi que dans certains pays innovants. Par exemple, le Conseil américain sur la compétitivité (2010) préconise un écosystème national d'innovation à la place du système national d'innovation. D'autres pays comme la Chine, la Finlande, le Danemark, la Corée du Sud, etc. fondent également leur politique technologique sur le concept d'écosystème d'innovation pour accélérer l'innovation et la durabilité (Bramwell et al., 2012).

C'est dans ce contexte que l'objectif central de cette thèse est d'évaluer l'impact de l'écosystème d'innovation sur la capacité d'adaptation des entreprises, en particulier lorsqu'elles sont confrontées à des chocs constants.

1.2 Problématique de recherche

Face aux chocs, les décideurs politiques et les acteurs économiques ont besoin de nouveaux outils et cadres méthodologiques pour aborder la question de la résilience et de l'adaptation. Le concept d'écosystèmes d'innovation apparaît comme un moyen efficace de mettre en œuvre l'innovation dans le but d'aborder à la fois la compétitivité et l'adaptabilité.

Aujourd'hui, le concept d'écosystème d'innovation suscite un intérêt croissant tant au sein de la communauté scientifique en économie et en management de l'innovation que parmi les décideurs politiques et les praticiens du monde des affaires (de Vasconcelos Gomes et al., 2018 ; Kapoor, 2018). La plupart des grandes revues en économie et en management de l'innovation ont lancé des appels à articles sur les écosystèmes d'innovation au cours des dix dernières années (par exemple, Research Policy ; Technological forecasting and Social Change ; Technovation ; Journal of Technology Transfer ; Industry and Innovation).

En fait, comme souligné plus haut, la notion d'écosystème d'innovation se retrouve maintenant dans les agendas des politiques nationales et internationales telles que le Conseil américain sur la compétitivité (2010) qui a proposé de développer le concept d'écosystème national d'innovation (NIES) ; le Conseil de Structure de l'Industrie au Japon, qui a proposé de passer d'une politique technologique à une politique d'innovation basée sur le concept d'écosystème. En Europe, le nouveau programme de l'Union européenne pour la recherche et l'innovation, Horizon Europe, qui s'étendra de 2021 à 2027, comprend une section consacrée aux écosystèmes d'innovation. L'objectif de cette section est de connecter tous les acteurs - publics et privés, nationaux et locaux - en Europe afin de partager les meilleures pratiques et ressources et d'offrir la possibilité à tous les innovateurs européens de développer et de déployer leurs produits sur un pied d'égalité.

Toutefois, malgré cet enthousiasme pour les écosystèmes d'innovation, un certain nombre de questions se posent notamment si ce cadre fournit réellement aux entreprises des outils et un environnement qui leur permettent de mieux s'adapter aux divers changements technologiques ou dans l’environnement concurrentiel. D’ailleurs, certains critiques ont remis en question l'utilité même de ce concept. Par exemple, certains font valoir que la promotion de relations et d'interactions complexes entre les différents acteurs qui s’impliquent dans les processus d'innovation n'est pas spécifique au concept d'écosystème d'innovation et remettant de ce fait en question la contribution distinctive du concept d'écosystème d'innovation. La deuxième catégorie de critiques concerne l'orchestration de ces relations complexes. Alors que les travaux sur les écosystèmes basés sur des plateformes identifient clairement et très précisément la plateforme numérique comme l'entité autour de laquelle les relations complexes entre acteurs hétérogènes s’orchestrent ou s’organisent, que ce soient les relations entre l'entreprise propriétaire de la plateforme et les entreprises propriétaires d’applications ou de contenus rattachées à cette plateforme, il n'y a pas de consensus dans les travaux sur les écosystèmes ancrés au sein des territoires. D'autres affirment qu'il n'existe pas d'approche méthodologique de "méta-niveau" correspondant aux postulats théoriques de l'écosystème tels que la coévolution et l'adaptation (Adner et Kapoor, 2010).

Oh et al. (2016) soutiennent que l'écosystème d'innovation n'apporte que peu ou pas de valeur ajoutée et ne conduit pas à une production de connaissances utiles. Si d’autres chercheurs admettent que l'écosystème d'innovation apporte une contribution utile à la conceptualisation et la stratégie de l'innovation, ils appellent toutefois à plus de rigueur conceptuelle et méthodologique et à plus d’évidences empiriques (Ritala et Almpanopoulou, 2017).

Ces critiques appellent donc à un socle pour un fond conceptuel et théorique plus robuste sur le concept et appellent à une opérationnalisation plus concrète du concept parmi les scientifiques afin de mieux équiper les décideurs politiques et les praticiens dans leurs politiques et stratégies d'innovation. En fait, le manque de travaux et de démonstrations empiriques qui valident les hypothèses ontologiques portées par les écosystèmes d'innovation crée la plus grande lacune pour ce concept.

Cette thèse fournit donc des preuves empiriques sur les écosystèmes d'innovation. Tout d'abord, elle met en évidence de manière théorique les caractéristiques distinctes des écosystèmes d'innovation et teste l'impact des écosystèmes d'innovation locaux sur la capacité d'adaptation des entreprises. La thèse fournit également des preuves théoriques et empiriques sur ce qui rend les entreprises de l'écosystème d'innovation plus adaptatives que les autres.

La thèse vise donc à clarifier une partie de la valeur ajoutée que le concept relativement nouveau d'écosystème d'innovation apporte à la littérature sur les études de l'innovation. Les résultats de la thèse guideront les recommandations faites aux décideurs politiques et aux autres acteurs économiques dans leurs stratégies d'innovation.

1.3 Question de recherche

Combler toutes les lacunes de la littérature sur les écosystèmes comme souligné ci-dessus dépasse largement le cadre d'une thèse et nécessite des années de travail et de recherche.

Cependant, la problématique de cette thèse s'articule autour de la question de recherche suivante :

RQ : Dans quelle mesure les écosystèmes d'innovation affectent-ils la capacité d'adaptation des entreprises ?

Cette question principale renvoie à conceptualisation de la notion d'écosystèmes elle-même en tant que système dynamique caractérisé par une diversité d'acteurs, la complexité des interactions qui favorise la capacité d'adaptation des acteurs (Ritala et Almpanopoulou, 2017 ; Russel et Smorodinskaya, 2018 ; Boschma, 2015 ; Hassink et al., 2010). Par conséquent, si nous considérons l'écosystème d'innovation comme un système adaptatif complexe, cela implique que l'écosystème favorise l'adaptation des acteurs afin de faire face aux chocs exogènes ou internes.

En accord avec cette vision, cette thèse vise à tester l'impact de l'appartenance à un écosystème d'innovation sur la capacité d'adaptation des entreprises. C'est-à-dire de comparer la capacité d'adaptation des entreprises appartenant à des écosystèmes d'innovation et des entreprises qui n'y appartiennent pas. Cependant, cette démonstration n'est pas suffisante pour établir l'impact de l'écosystème d'innovation sur la capacité d'adaptation des entreprises. Il est également important d'analyser les mécanismes et les caractéristiques ou les propriétés de l'écosystème d'innovation qui pourraient expliquer le rôle positif de l'écosystème d'innovation sur la capacité d'adaptation des entreprises. Cette thèse analyse donc la structure organisationnelle de l'écosystème d'innovation au niveau régional et local et les principaux mécanismes de l'écosystème qui pourraient expliquer dans quelle mesure l'écosystème a un impact sur la capacité d'adaptation des entreprises.

Cette thèse mobilise un terrain d'étude pertinent : la région Hauts-de-France qui est confrontée à des problèmes d'adaptation et de résilience – ayant connu des déclins successifs dans ses principales industries économiques- où les écosystèmes d'innovation locaux ont été déterminant dans la restructuration de l'environnement économique (voir chapitre 3, section 3.2 dans le document de thèse principal).

1.4 Organisation et structuration de la thèse

La thèse est organisée comme suit :

Le chapitre 1 présente le contexte et la motivation de la recherche. Il identifie le problème et les objectifs de la recherche et expose les questions de recherche. Il souligne également la pertinence et l'importance de l'étude.

Le chapitre 2 fournit le contexte théorique de l'étude, en passant en revue les définitions de l'écosystème d'innovation et les principaux courants de l'écosystème dans la littérature en économie et management de l'innovation. Il fournit les bases théoriques permettant de lier le concept de l'écosystème d'innovation à la question de l'adaptation des acteurs. Ce chapitre positionne notre étude spécifiquement dans la conceptualisation de l'écosystème d'innovation en termes de Système Complexe Adaptatif.

Le chapitre 3 présente la méthodologie de recherche y compris les outils et les sources de données mobilisées dans ce travail. Ce chapitre présente aussi les écosystèmes d'innovation locaux de la région Hauts-de-France.

Le chapitre 4 présente les trois articles, qui sont des sous-études de la thèse.

Le premier article (Sub-study 1, publié dans la revue Industry and Innovation) répond à la question de recherche suivante : Dans quelle mesure les écosystèmes d'innovation affectent-ils la capacité d'adaptation des entreprises ? Cet article vise à vérifier si les entreprises qui font partie d'un écosystème d'innovation sont plus adaptatives que celles qui n'en font pas partie et dans quelle mesure.

Le deuxième article (sous-étude 2) aborde la question des propriétés des écosystèmes d'innovation qui permettent d'expliquer le fait que, toute chose étant égale par ailleurs, les entreprises évoluant dans un écosystème sont plus adaptatives que celles qui ne le sont pas. Cet article se focalise sur la structure organisationnelle de l'écosystème local/régional, à travers une perspective *upperground*, *underground* et *middleground* (Cohendet et al., 2020). La question spécifique abordée dans cet article est la suivante : Dans quelle mesure le *middleground* intervient-il dans l'orchestration des relations complexes au sein d'un écosystème d'innovation et comment il affecte sur le développement technologique des entreprises ?

Le troisième article est un *working paper*, qui constitue une extension du deuxième niveau d'analyse. Ce travail explore les projets d'innovation collaboratifs en tant que composante relationnelle la plus avancée du *middleground* afin d'identifier les déterminants de l'implication des entreprises principales dans les projets de R&D collaborative. Ce document aborde la question de recherche suivante : Qu'est-ce qui explique l'implication des acteurs centraux (core actors) dans les projets d'innovation collaboratifs dans un écosystème d'innovation régional ? Cette étude se concentre à nouveau sur l'écosystème Eurasanté. Nous avons analysé les principaux projets d'innovation collaboratifs qui rassemblent les acteurs et identifié les déterminants de la participation des core acteurs à ces projets de R&D collaboratifs.

Le chapitre 5 présente les discussions et les conclusions, et fournit également les implications de l'étude et les recommandations pour les recherches futures.

Remarque : Ce document ne présente pas la thèse entière. Il est une synthèse de la thèse. Il est composé donc d’une première partie introductive, des résumés longs des trois papiers et une partie conclusive avec les principales contributions de la thèse

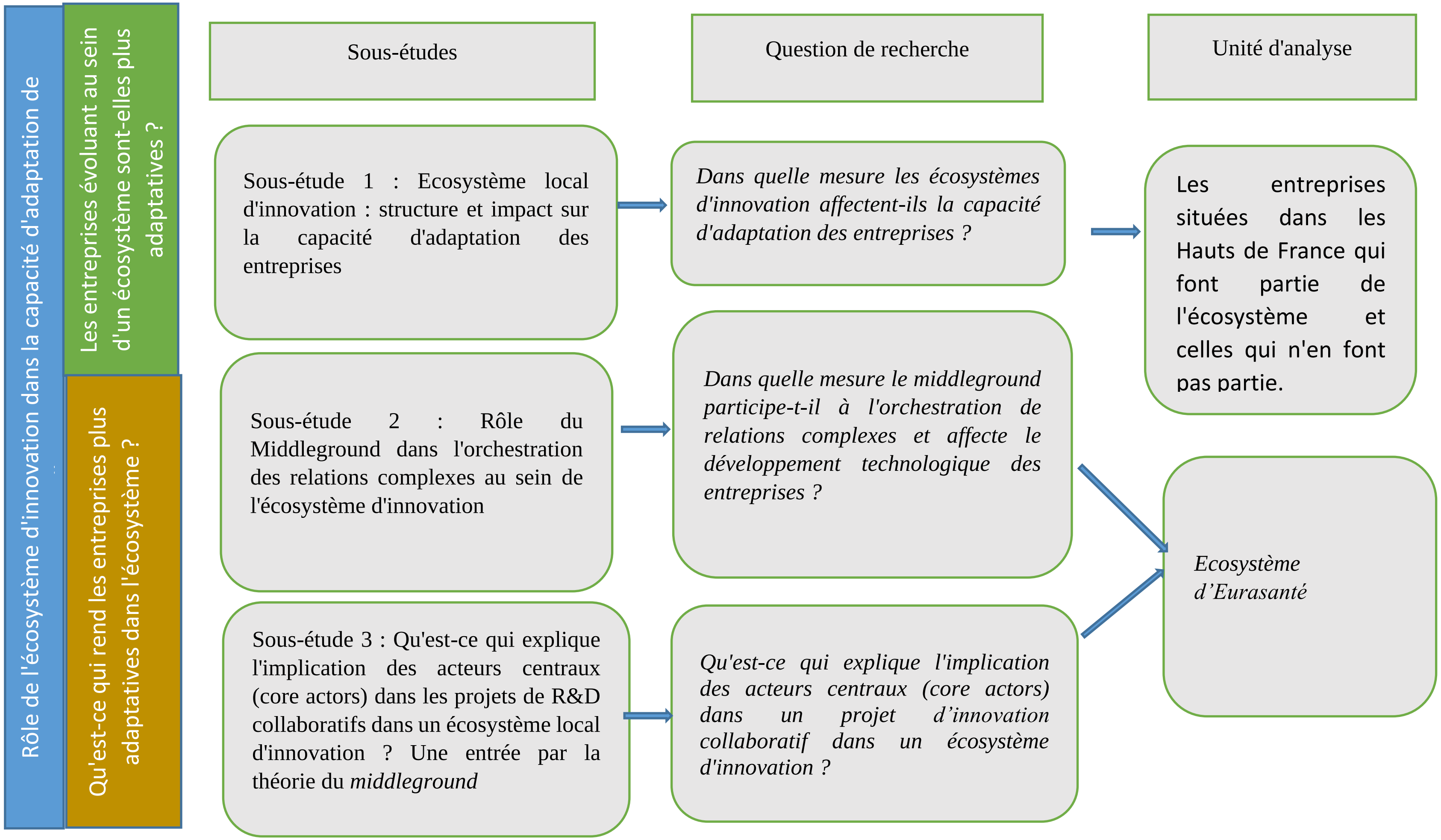

Figure 1 : La relation entre les sous-études et la question de recherche.

1.5 Terrain d'étude

1.5.1 Hauts-de-France : de la région en déclin à la région en transition

La région Hauts-de-France est une nouvelle région créée par la réforme territoriale de 2014, à partir d'une unification de deux anciennes régions de France : la Picardie et le Nord-Pas-de-Calais. Alors que le Nord-Pas-de-Calais a un passé industriel, la Picardie était spécialisée dans l'agriculture et l'agro-industrie. Les années 2000 marquent le début d'une reconversion de cette région, particulièrement le Nord-Pas-de-Calais, suite aux déclins successifs des anciennes industries - le textile, la métallurgie et le charbon - sur lesquelles reposait son tissu socio-économique.

Quatre étapes ont pu être distinguées dans la dynamique de la région des Hauts-de France depuis le début des années 2020.

1) Phase de prise de conscience pour une reconversion du tissu productif (1998-2004). Cette phase se caractérise par une volonté de construire une véritable stratégie régionale d'innovation pour inverser la dynamique régionale en déclin. Cette étape a débuté à Lille et a été appelée la « bifurcation métropolitaine » (Paris et Stevens, 2000), qui correspond au processus de reconversion de son tissu productif et de recomposition de ses structures économiques, sociales et culturelles. C'est au début des années 2000 que les grandes orientations stratégiques ont été précisées et confirmées dans le schéma directeur (SDUL, 2002). Ce schéma directeur a identifié des secteurs émergents (numérique, image-culture-média et éco-activités) et des secteurs prioritaires (biologie-santé, transports) sur lesquels s'appuyer pour le redéveloppement de La métropole lilloise.

2) La phase de repositionnement (2004-2010). Cette phase visait à amorcer la transformation de la région par le développement de processus d'innovation sur de nouvelles spécialisations. Le Contrat Plan Etat-région (CPER 2007-2013) a conçu des programmes d'innovation technologique et des plans territoriaux d'innovation pour quatre territoires majeurs : Métropole de Lille, le Littoral, Artois et Hainaut-Cambrésis. Cela comprend le recrutement de conseillers locaux en innovation qui devaient travailler avec les acteurs socio-économiques et universitaires pour construire des pôles d'excellence économique appelés « Pôle d'excellence », en renforcement des politiques nationales de développement des « pôles de compétitivité ». Onze domaines ont été identifiés comme pouvant stimuler l'innovation dans la région

3) la phase de confirmation (2010-2014). Cette phase correspond au lancement des activités des différents pôles d'excellence. Les pôles d'excellence rassemblent sur un

même site ou quartier, des entreprises, des structures de recherche, des intermédiaires d'innovation, des incubateurs et accélérateurs d'entreprises. Ces pôles d'excellence sont classés en trois catégories, ceux qui sont spécialisés sur les secteurs performants (Santé, Transport, Commerce du futur), ceux qui sont spécialisés sur les secteurs en mutation (Automobile, Matériaux biosourcés, textiles composites, bâtiment et écoconstruction), et ceux qui sont spécialisés sur les secteurs émergents (énergie, électronique de puissance, traitement des déchets, imagerie et création numérique et e-santé). Les principaux pôles d'excellence mis en place sont : Euratechnologies, Plaine Images, Ceti, Euralille, Eurasanté, et Haute-Borne.

4) la phase de spécialisation (2014-2020). Cette phase correspond à la mise en place de la SRI-SI (Stratégie Régionale d'Innovation - Spécialisation Intelligente) et le SRDEII (Schéma Régional de Développement Economique d'Innovation et d'Internationalisation) qui visent à orienter les activités économiques de la région sur des domaines technologiques spécifiques. Les actions de politiques publiques de développement de l'innovation ciblent la spécialisation de la région Hauts-de-France sur six domaines d'activités stratégiques : Santé et alimentation ; ubiquité et internet des objets ; chimie/matériaux et recyclage ; images numériques et industries créatives ; Énergie ; et Transports et écomobilité.

Les deux dernières décennies marquent le processus de reconversion de la région Hauts-de-France suite aux déclins successifs des anciennes industries - le textile, la métallurgie et le charbon sur lesquelles reposait son tissu socio-économique jusqu'aux années 1970. La stratégie de spécialisation intelligente de la région est axée sur le renforcement et l'amélioration des capacités d'innovation régionales. Dans le cadre de la stratégie visant à favoriser l'adaptation et la transformation de la région, les autorités locales, par le biais d'une action collective et d'orientations de politiques publiques, ont créé des pôles d'excellence, des sites d'excellences qui constituent les principales composantes des écosystèmes locaux d'innovation impliquant des acteurs hétérogènes et des relations complexes pour le développement de l'innovation.

1.5.2 Les écosystèmes locaux d'innovation de la région Hauts-de-France

Les écosystèmes locaux d'innovation dans les Hauts-de-France se réfèrent plutôt à des écosystèmes de réseaux multi-acteurs (voir Tsujimoto et al., 2018). Les écosystèmes locaux d'innovation en Hauts-de-France s'articulent autour des parcs d'innovation. Les Parcs d’innovation (extension de la politique régionale des pôles d’excellence) sont des concepts proches des technopoles ou des parcs scientifiques qui rassemblent dans un même espace ou quartier un ensemble d’acteurs hétérogènes (entreprises, start-ups, laboratoires de recherche, openlabs, …) sur une ou plusieurs spécialisations technologiques. Deux autres acteurs structurent ces écosystèmes locaux, un Hub d’innovation qui héberge un incubateur et accélérateur d’entreprises et un hôtel d’entreprise, et une agence de pôle de compétitivité ou un équivalent régional. Les parcs d’innovation ont pour objectifs majeurs : promouvoir le développement et la croissance de nouvelles entreprises de hautes technologies et stimuler le développement et la croissance économique régionale.

Ces écosystèmes favorisent les relations fortes (formelles et informelles) et la fertilisation entre une diversité d'acteurs et d'entreprises dans un ou plusieurs domaines technologiques. Ils soutiennent le développement et la gestion des connaissances en réunissant des laboratoires de recherche, des structures technologiques, des organisations financières, des brokers et des entreprises dans un contexte stratégique et interactif. La présence de ces acteurs favorise l'intégration des dimensions scientifiques, technologiques et commerciales au sein de ces écosystèmes d’innovation localisés.

Les principaux écosystèmes locaux d'innovation de la région Hauts-de-France sont l'écosystème Santé et biotechnologies, l'écosystème d'innovation Digital et IoT, l'écosystème chimie verte et agro-industrie, l'écosystème mode et textile, l'écosystème jeu vidéo et imagerie et l’écosystème des transports et de la mobilité.

1.6 Méthodes de recherche et sources de données

Sur la base des objectifs de l'étude, le cœur de la méthode de recherche est ancré dans une approche quantitative, adoptant l'utilisation de modèles économétriques pour tester les hypothèses de l’étude. La thèse a été divisée en trois sous-études. Cependant, nous avons utilisé une approche qualitative en complément afin de décrire les écosystèmes d'innovation, leurs principales composantes et leurs acteurs clés.

Poussée par les objectifs de recherche visant à fournir des preuves empiriques, la thèse s'est appuyée sur des données secondaires provenant de la base de données ASTRIDE (base de données sur le développement de l'innovation dans les Hauts-de-France), de l'INPI (base de données de l'Institut National de la Propriété Industrielle) et des sites officiels des pôles de compétitivités, des agences de gestion des parcs d’innovation. La base de données ASTRIDE est un système d'information collaboratif conçu et géré par l'Agence pour le développement de l'innovation en Hauts-de-France (HDFID). Elle fournit un large éventail de données - concernant plus de 200 000 entreprises et organisations et mises à jour chaque année - sur tous les secteurs de la région Hauts-de-France. Elle fournit par exemple des informations sur les caractéristiques économiques, technologiques et structurelles des entreprises et organisations, les projets collaboratifs dans lesquels elles s'impliquent, leur potentiel d'innovation, leurs collaborations avec d'autres acteurs, les aides publiques dont elles bénéficient...

La base de données de l'INPI fournit des données sur les brevets des entreprises. Les données sur les brevets ont été utilisées dans la thèse pour accéder non seulement au nombre de brevets mais aussi à la diversité technologique des entreprises. Le nombre d'IPC4-digit dans le portefeuille de brevets est utilisé comme indicateur de la diversité technologique.

Enfin, nous utilisons les données des sites officiels des pôles de compétitivités en région et des agences de gestion de parcs d'innovation. Par exemple nous avons exploité de manière approfondi les données de l'agence Eurasanté et du pôle de compétitivité NSL. On y trouve les données sur les projets de R&D collaboratifs soutenus par Eurasanté et son pôle de compétitivité. Nous avons trouvé des données sur les projets européens, les projets ANR (Agence nationale de la recherche) et les projets FUI (Fonds unique interministériel). Les projets de R&D collaboratifs indiquent des relations formelles qui engagent officiellement les acteurs de l'écosystème de l'innovation à travailler ensemble dans le cadre d'un projet donné.

L'étude a également utilisé certaines données documentaires pour retracer l'histoire et la trajectoire de développement des écosystèmes d'innovation de la région Hauts-de-France et examiner le rôle de la politique régionale dans son développement. L'étude explore trois documents de stratégie régionale d'innovation au cours de la période 2005-2020 de l'ancienne région Nord-Pas-de-Calais et les schémas directeurs de la métropole lilloise. Pour la recherche documentaire, la thèse utilise également des informations provenant de programmes de recherche, tels que le POPSU (Project Observation Platform and Urban Stratégies), qui ont observé l'évolution de la région au cours de la dernière décennie. Les documents nous renseignent sur les processus d'adaptation de la région Hauts-de-France, son passé industriel et son repositionnement par rapport au développement des écosystèmes d'innovation, autour des parcs d'innovation. Ils nous permettent également d'identifier la spécialisation technologique des parcs d'innovation et l'évolution de la spécialisation de la région depuis le début des années 2000. Ces éléments sont synthétisés dans le tableau 1.

S/N	Articles/etudes	Questions de recherche	Source de données	Data analysis and econometric model
1	Ecosystème local d'innovation : structure et impact sur la capacité d'adaptation des entreprises	*Dans quelle mesure les écosystèmes d'innovation affectent-ils la capacité d'adaptation des entreprises, c'est-à-dire leur capacité d'innovation et leur diversification technologique ?*	ASTRIDE; INPI	*v. Structural Network analysis* *vi. Analyse de l'entropie* *vii. Logit model* viii. *Ordered logit model*
2	Rôle du Middleground dans l'orchestration des relations complexes au sein de l'écosystème d'innovation : Evidence de l'écosystème Eurasanté dans les Hauts-de-France	*Dans quelle mesure le middleground participe-t-il à l'orchestration de relations complexes et à l'impact sur le développement technologique des entreprises ?*	ASTRIDE ; INPI, base de données Eurasanté/NSL Clubster	*iii. Zero-inflated Negative Binomial model* iv. *Structural equation model*
3	Qu'est-ce qui explique l'implication des acteurs centraux (core actors) dans les projets de R&D collaboratifs dans un écosystème local d'innovation ? Une entrée par la théorie du *middleground*	*Qu'est-ce qui explique l'implication des principaux acteurs dans un projet innovant collaboratif dans un écosystème local d'innovation ?*	Site web de l'Agence Eurasanté ; ASTRIDE	*iii. Network analysis* *iv. Fractional logistic econometric model*

Table 1 : Les principales données et modèles économétriques pour chacune des sous-étude

Partie 2

Article 1

Les écosystème locaux d'innovation : Structuration et Impact sur la capacité d'Adaptation des Entreprises[28]

Contexte et objectifs

Les dernières décennies ont été marquées par une tendance générale au développement de politiques d'innovation basées sur les clusters (Borras et Tsagdis, 2008 ; Menu, 2012 ; Lucena-Piquero et Vicente, 2019). Cependant, les études empiriques et théoriques n'ont pas réussi à expliquer comment les clusters existants facilitent la transition durable et affectent l'adaptation des entreprises lorsque des chocs se produisent (Saxenian 1996 ; Bergman 2007). Les décideurs politiques et les acteurs économiques ont donc besoin de nouveaux outils et de nouveaux cadres pour aborder les questions de la transition et d'adaptation. Le concept d'écosystème d'innovation, dérivé de la science biologique et adopté dans les études en économie et management, est considéré par de nombreux auteurs – managers et responsables publics - comme une pierre angulaire du renouvellement des stratégies des entreprises et des politiques régionales afin d'assurer la compétitivité et la résilience économique (Moore, 1993 ; Philips et Ritala, 2019).

Un écosystème d'innovation se défini comme un système complexe adaptatif ou dynamique caractérisé par des interactions entre des agents hétérogènes afin de favoriser le développement de nouveaux produits et services (Moore, 1996 ; Porter, 2006 ; Russell et Smorodinskaya, 2018). Dès lors, au-delà de ce rôle stratégique de facilitation des processus d'innovation, les travaux sur les écosystèmes d'innovation mettent l'accent sur la coévolution et l'adaptation des acteurs et des institutions (Schaeffer et al., 2012). Le processus d'adaptation et la coévolution des acteurs dans un environnement complexe et dynamique sont souvent pointés comme l'un des principaux éléments qui légitiment le cadre des écosystèmes d'innovation et ses spécificités par rapport au cadre plus classique des clusters (Iansiti et Levien, 2004 ; Ritala et Almpanopoulou, 2017). Il en découle donc la question de recherche suivante :

28 Boyer, J., Ozor, J., & Rondé, P. (2021). Local innovation ecosystem: structure and impact on adaptive capacity of firms. *Industry and Innovation*, *28*(5), 620-650.

Dans quelle mesure les écosystèmes d'innovation affectent-ils la capacité d'adaptation des entreprises ?

Cette étude vise donc à explorer le concept d'écosystème d'innovation, en apportant de nouvelles perspectives et en fournissant des preuves empiriques de l'impact des écosystèmes d'innovation sur la capacité d'adaptation des entreprises.

Cadrage théorique et méthodologique

En effet, dans la partie théorique de l'article, nous avons identifié trois caractéristiques principales qui donnent à la notion d'écosystème d'innovation plus de pouvoir explicatif en termes d'adaptabilité et de durabilité par rapport aux analyses traditionnelles, comme les clusters. Pour résumer, la diversité et l'hétérogénéité des agents, la complexité des relations et la structure organisationnelle (*upstream*, *middlestream* et *downstream* pour les écosystèmes de plateformes ; et *Upper-Middle-Underground* pour les écosystèmes régionaux) sont les principales caractéristiques des écosystèmes d'innovation, contrairement aux concepts plus traditionnels tels que les clusters ou les réseaux. Cette structure organisationnelle ambidextre composée des acteurs plutôt stables (avec de fortes capacités d'exploitation) qui constituent l'*Upperground* ou l'*Upstream*, et des acteurs ayant plutôt de fortes capacités d'exploration qui constituent l'*Underground* ou le *Downstream* (Tiwana, 2014 **;** Cohendet et al. 2020). Le middleground (dans le cas des écosystèmes régionaux) ou la plateforme digitale constitue donc l'entité intermédiaire qui favorisent les relations complexes entre les acteurs hétérogènes, la coévolution entre les acteurs et le renforcement des capacités adaptatives des acteurs à travers la connexion permanente entre l'*Upperground* ou *Upstream* et l'*Underground* ou *Downstream*. La capacité adaptative des acteurs est expliquée plus efficacement par ces caractéristiques de l'écosystème que par l'analyse classique des clusters. L'écosystème d'innovation fournit donc des mécanismes qui permettent aux acteurs d'ajuster leurs comportements et leurs stratégies afin de faire face aux changements du marché et des technologies.

Cette étude analyse spécifiquement l'impact des écosystèmes d'innovation sur la capacité d'adaptation des entreprises, en testant si les entreprises évoluant au sein des écosystèmes d'innovation sont plus adaptatives que les autres.

Pour ce faire, l'étude utilise deux variables - la performance d'innovation et la diversité technologique - pour évaluer la capacité d'adaptation des entreprises. De même que l'innovation, la diversité est liée à l'adaptation. La diversité technologique fournit un portefeuille nécessaire pour répondre et s'adapter aux changements technologiques et de marché (Hassink, 2010 ; Boschma, 2015). Pour s'adapter aux changements technologiques et de marché, les entreprises ont besoin des stratégies d'exploration et d'exploitation et des ressources dédiées qui peuvent être internes à l'entreprise ou fournies par l'écosystème d'innovation (Cohendet et al., 2014 ; Lange et Schüßler, 2018).

La capacité d'adaptation des entreprises se traduit par l'aptitude à identifier et à exploiter les opportunités technologiques et de marché émergentes, en ajustant leur position stratégique (Oktemgil et Greenley, 1997).

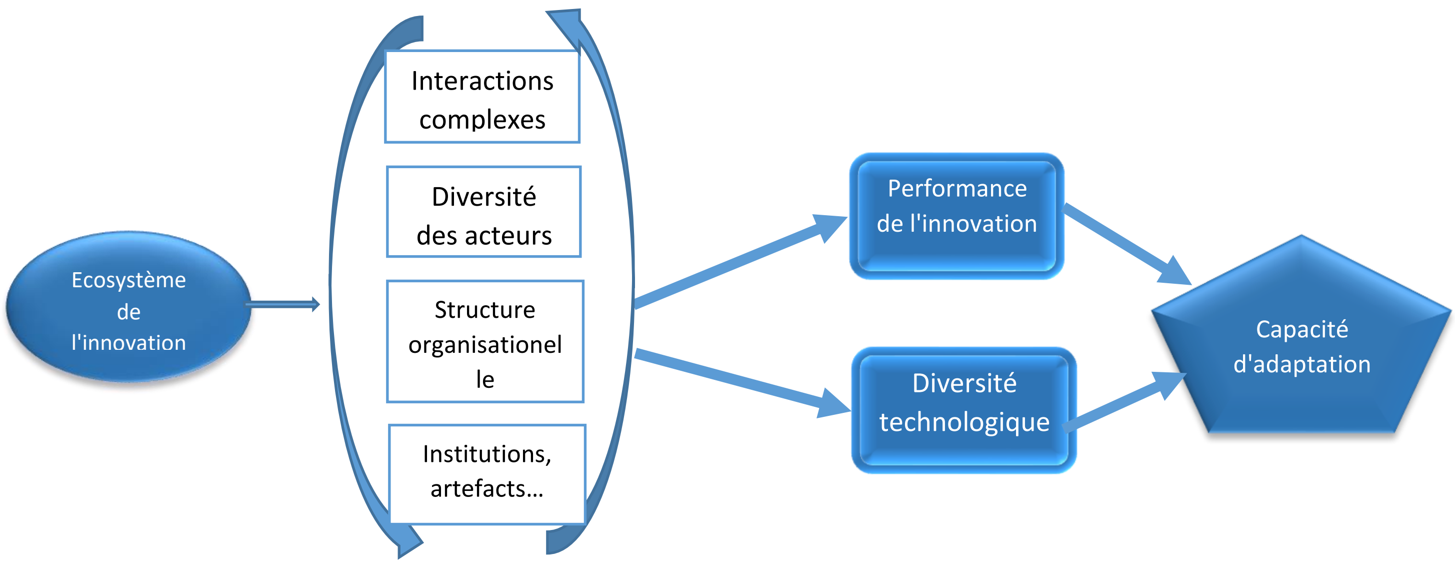

Figure 2 : Cadre conceptuel reliant l'écosystème avec la capacité adaptative des entreprises

Notre méthodologie repose sur un échantillon de 431 entreprises qui ont obtenu des brevets à partir des années 2000. Comme expliqué, nous avons décomposé la capacité adaptative en deux composantes : la performance d'innovation et la diversification technologique de l'entreprise. Nous avons utilisé deux proxys pour mesurer ces deux composantes. Un indicateur régional dénommé Innoscope utilisé par l'agence régional d'innovation (HDFID)(Marmuse et Godest, 2008) avec comme postulat : le maintien d'un score Innoscope plus élevé ou le passage d'un statut inférieur à un statut supérieur correspondent à des trajectoires de performance d'innovation. Nous avons utilisé un modèle économétrique de type logistique pour déterminer les facteurs qui affectent la probabilité pour une entreprise de maintenir un score de performance d'innovation élevée ou passer d'un statut inférieur à un statut supérieur pour une période donnée (2011-2017)

Nous avons utilisé comme proxy le nombre d'IPC4-digit dans le portefeuille de brevets d'une entreprise donnée pour mesurer la diversification technologique. Après avoir classé les entreprises en trois catégories pour montrer les niveaux de diversité technologique : faible, moyen et élevé, nous avons donc utilisé le modèle logistique ordonné pour cette analyse.

Pour les variables indépendantes, nous avons utilisés des variables qui font référence aux caractéristiques spécifiques des entreprises (taille, âge, internationalisation), à la localisation des entreprises, au soutien public reçu par les entreprises et aux spécificités sectorielles de celles-ci. De plus, nous avons utilisé une variable binaire qui prend la valeur de 1 si l'entreprise appartient officiellement à un l'écosystème d'innovation localisé, et 0 dans le cas contraire.

Principaux résultats et contributions

Nos résultats montrent que les entreprises sont significativement plus innovantes lorsqu'elles font partie d'un écosystème d'innovation localisé. De même, nos résultats montrent que les entreprises faisant partie d'un écosystème d'innovation localisé sont également plus diversifiées technologiquement. Par conséquent, l'appartenance à un écosystème d'innovation a un impact sur la capacité d'adaptation des entreprises.

D'autre part, notre étude a mis en évidence l'impact de la position des entreprises dans les réseaux d'acteurs au sein des écosystèmes localisés comme un autre élément important expliquant la performance d'innovation et la diversification technologique. En effet, plus les entreprises ont un niveau de centralité élevé (closeness centrality, betwenness centrality), plus elles ont une plus grande performance d'innovation ou sont technologiquement plus diversifiées.

Nous avons trouvé aussi un effet positif des soutiens publics, de la localisation des entreprises, dans la capacité d'adaptation des entreprises. Enfin, nos résultats montrent que les PME et ETI ont une plus grande capacité d'adaptation que les autres (sont significativement à la fois plus innovantes et technologiquement plus diversifiées que les autres).

Cet article fournit des preuves empiriques de l'impact de l'écosystème d'innovation sur la capacité d'adaptation des entreprises. L'article contribue également au débat sur les écosystèmes d'innovation en tant que cadre pouvant jouer dans les processus d'adaptation des entreprises. En termes de politique régionale, notre analyse montre que différents instruments peuvent être mobilisés pour développer ou consolider des écosystèmes localisés (création de parcs d'innovation, soutien financier public, incubateurs, pôle de compétitivité) et contribuer à renforcer la capacité adaptative des entreprises, comme rendre les entreprises plus innovantes et technologiquement plus diversifiées.

Enfin, cet article jette les bases d'une recherche empirique plus approfondie visant à spécifier les liens entre les caractéristiques pertinentes de l'écosystème d'innovation et la capacité d'adaptation des entreprises.

Article2

Orchestration de relations complexes dans l'écosystème d'innovation : Les projets et les événements ont-ils un impact sur le développement technologique des entreprises ? L'exemple de l'écosystème Eurasanté en Hauts-de-France29

Contexte et objectifs

Après avoir établi l'impact positif de l'écosystème d'innovation sur la capacité d'adaptation des entreprises en termes de performance d'innovation et de diversité technologique, il devient important de déterminer pourquoi les entreprises appartenant à l'écosystème d'innovation sont plus adaptatives que les autres.

Les écosystèmes d'innovation locaux sont décrits en fonction de leurs caractéristiques, de leurs particularités et de leurs rôles. Tout d'abord, ils favorisent les relations fortes, le partage d'informations et de connaissances, les interactions et la fertilisation entre une diversité d'acteurs et d'organisations dans un ou plusieurs domaines technologiques. Dans un écosystème d'innovation, les acteurs interagissent et co-évoluent pour développer l'innovation. Par conséquent, le processus de collaboration et les capacités de mise en réseau au sein de l'écosystème renforcent les possibilités d'innovation. Se pose alors la question de l'orchestration des relations complexes entre les acteurs hétérogènes. Comme cette orchestration est réalisée ? Qui s'en charge ? De quelle manière cette orchestration de relations complexes favorise la coévolution et l'adaptation des acteurs ? Les travaux sur les écosystèmes basés sur des plateformes identifient les plateformes numériques comme l'entité d'orchestration des relations complexes entre les acteurs sous la gouvernance d'un acteur focal, propriétaire de la plateforme (Gawer et Cusumano, 2014, Jacobides et al., 2016). Pour les écosystèmes d'innovation localisés, de récents travaux inspirés des travaux sur les villes créatives plaident pour le *middleground* comme une forme de plateforme intermédiaire pouvant jouer un rôle important dans l'orchestration des relations complexes entre les acteurs de l'écosystème (Cohendet et al., 2020 ; Boyer, 2020). Ces travaux identifient trois composantes interactives des écosystèmes d'innovation localisés. L'*upperground* qui regroupe des acteurs stables de l'écosystème d'innovation (entreprises, organismes de recherche, structures publiques…), l'*underground* qui regroupe des acteurs talentueux, périphériques et des communautés informelles, et le

29 Article finalisé, à soumettre

middleground qui permet de connecter les acteurs de l'*upperground* et ceux de l'*underground.* Le *middleground* se présente sous la forme de lieux, d'espaces, d'événements ou de projets qui rassemblent les communautés et relient en permanence les acteurs de l'écosystème (Cohendet et al., 2020). Cette connexion favorise le couplage des forces d'exploitation et d'exploration dans l'écosystème indispensable aux processus de coévolution et d'adaptation pour les acteurs.

S'il existe des démonstrations théoriques qui pourraient permettre de considérer le *middleground* comme une entité orchestratrice de relations complexes dans un écosystème d'innovation localisé, cette hypothèse souffre d'un manque de travaux empiriques confirmant le rôle du *middleground* dans les processus d'innovation au sein des écosystèmes d'innovation. Notre travail vise à combler cette lacune dans la littérature scientifique en mobilisant une étude de cas d'un écosystème d'innovation localisé : l'écosystème Eurasanté dédié aux soins- santé-nutrition au niveau de la région des Hauts-de-France (France)

Méthodologie

Une méthodologie mixte mobilisant une approche en termes d'étude de cas, complétée par des analyses structurelles de réseaux et des études économétriques, est utilisée dans cette étude.

L'écosystème d'Eurasanté est un écosystème d'innovation dédié aux biotechnologies, à la santé et à la nutrition construit autour d'un lieu symbolique : le Parc d'innovation d'Eurasanté, et autour d'un acteur emblématique le CHU de Lille.

Pour cette étude, nous avons utilisé des données primaires et secondaires. Les entretiens avec les acteurs locaux impliqués dans l'écosystème sont triangulés avec une base de données de l'agence régionale de l'innovation (HDFID, Hauts-de-France Innovation Développement) ainsi qu'avec certaines recherches documentaires basées sur trois rapports de Stratégie Régionale d'Innovation sur la période 2005-2020. Nous avons également utilisé les rapports d'activités annuels de l'équipe de direction de l'agence d'Eurasanté. Nous avons triangulé ces données avec celles d'entretiens avec des représentants exécutifs d'Eurasanté.

Nous avons croisé les données d'une base de données régionale (ASTRIDE), de l'INPI et du site internet d'Eurasanté sur les projets collaboratifs et les partenaires sur un échantillon de 277 acteurs.

Nous avons développé 3 hypothèses en lien avec deux composantes du *middleground* à savoir les projets collaboratifs et les évènements.

Hypothèse 1 : La fréquence de participation à des événements dédiés à l'innovation (organisés par l'agence d'Eurasanté et/ou au sein des locaux du parc d'innovation d'Eurasanté) à une période t affecte positivement le développement technologique des entreprises à la période t+1

Hypothèse 2 : La collaboration dans des projets de R&D collaboratifs à une période t affecte positivement le développement technologique des entreprises à la période t+1

Hypothèse 3 : La fréquence de participation à des événements dédiés à l'innovation et la collaboration à des projets de R&D collaboratifs en période t affectent positivement le développement technologique des entreprises en période t+1

Nous avons utilisé un modèle économétrique Zero inflated binomial négatif et un modèle d'équation structurelle pour tester les composantes du *middleground.* Nous avons utilisé le nombre de brevets (2016-2020) comme indicateur de l'innovation de l'entreprise comme variable dépendante. Nous avons utilisé comme variables indépendantes : la participation aux projets de R&D collaboratif (2010-2015), la participation à des événements de recherche-innovation, la localisation des entreprises et des variables de contrôle comme la taille, l'âge des entreprises, le niveau d'aide public dédiée à l'innovation dont bénéficie une entreprise donnée.

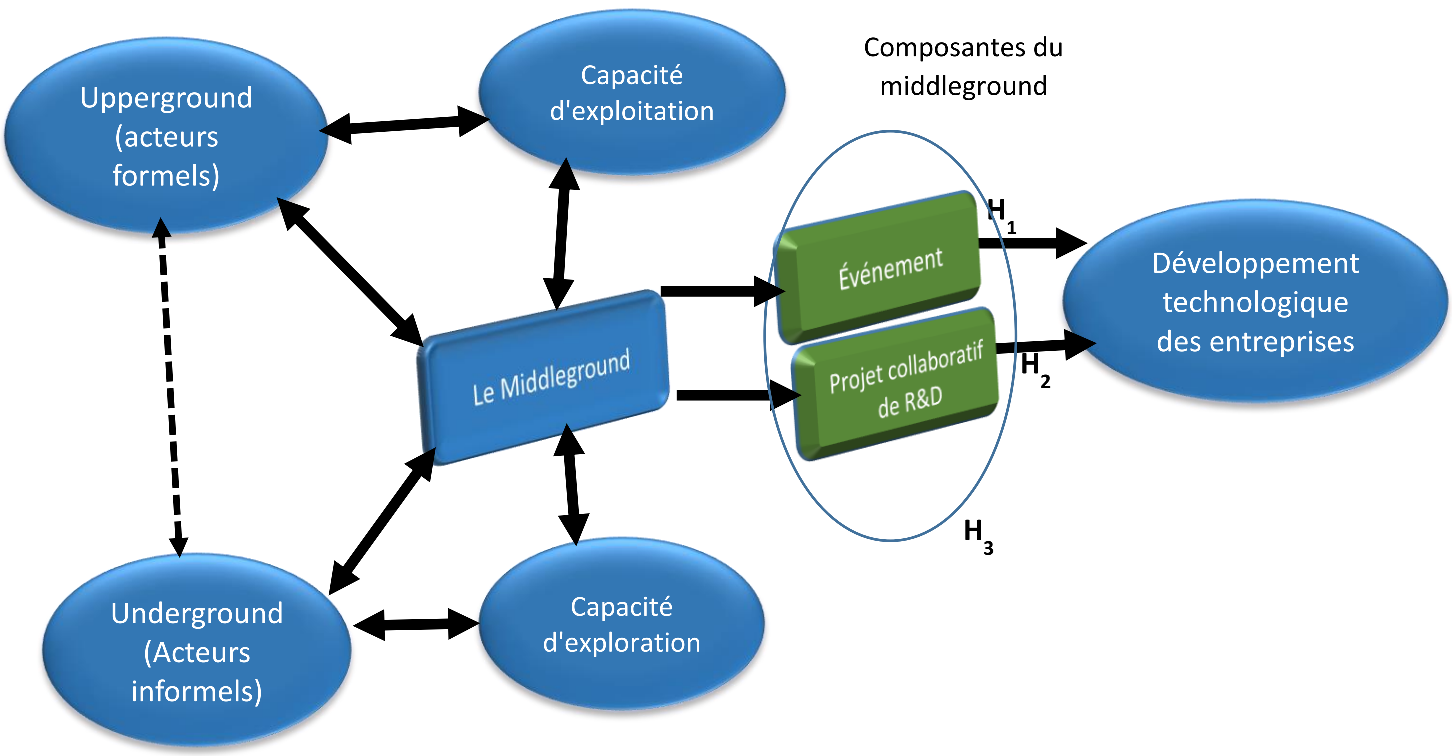

Figure 12: Cadre de recherche de la deuxième sous-étude

Principaux résultats et contributions

L'écosystème Eurasanté est un écosystème Innovation construit autour du CHU de Lille (Centre Hospitalier Universitaire) et du Parc Eurasanté qui regroupe des agents hétérogènes. Cet écosystème abrite plus de 700 entreprises, 50 laboratoires de recherche et organismes de R&D et de transfert de technologies, un pôle de Compétitivité (NSL-Clubster-Santé), un incubateur et accélérateur d'entreprises, des organismes de financement, des start-ups et des openlabs dans un contexte interactif et stratégique autour des biotechnologies, du secteur de la santé et de la nutrition.

Concernant le *middleground* qui joue un rôle clé dans l'orchestration de l'écosystème d'innovation d'Eurasanté, nous avons identifié le parc de l'innovation comme le lieu emblématique qui abrite i) le Pôle de compétitivité (NSL-Clubster-Santé), ii) un Hub d'innovation qui comporte trois composantes : un incubateur, un accélérateur et un hôtel d'entreprises où sont implantées 170 entreprises. Deuxièmement, de 2006 à 2020, plus de 250 projets collaboratifs de R&D ont été réalisés entre des entreprises, des centres de recherche et d'autres acteurs. Enfin, plus de 100 événements par an sont organisés et se déroulent principalement dans les locaux du parc d'innovation d'Eurasanté dont des hackathons, speed dating, afterwork et start-up week-end. Au-delà de ces évènements génériques, nous pouvons identifier des événements plus spécifiques et emblématiques comme le Hibster (dédié aux projets innovants des étudiants), Ageingfit (dédié aux technologies de la Silver économie), Medfit (dédié aux technologies médicales), Biofit (dédié aux biotechnologies, innovation niches, et investissement en capital d'amorçage) et Nutrievent (événement sur l'innovation partenariale en nutrition, alimentation et santé)

Les statistiques sur les caractéristiques structurelles des réseaux sociaux (degré de centralité, Betwenness, Closeness) au sein de l'écosystème d'innovation d'Eurasanté montrent des réseaux très denses et mettent en évidence des relations complexes.
Les résultats économétriques permettent de valider nos hypothèses. En effet, le fait de participer à des projets collaboratifs dans la période T affecte le développement technologique des entreprises en période T+1. Il en est de même pour la fréquence de participation dans les évènements. De plus, la position dans le réseau (closeness centralité, betwenness centrality) affecte positivement le développement technologique des entreprises. Cependant, nos résultats montrent que le fait d'être situé dans le parc d'innovation n'affecte pas le développement technologique des entreprises pour la période 2016-2020, ni les soutiens publics.

Cette étude comble un vide dans la littérature en fournissant des preuves empiriques de l'impact du *middleground* sur la performance des entreprises en matière d'innovation.

En termes d'implication pour les décideurs publics au niveau des territoires, nos résultats soulignent le besoin de plateformes intermédiaires qui permettent l'orchestration des relations complexes et les échanges de connaissances entre des acteurs hétérogènes.

Ainsi, les recherches futures devraient envisager d'autres mesures du développement technologique pour mesurer les activités non brevetables. De même, nous avons utilisé les événements et les projets comme proxy du *middleground*. Les recherches futures peuvent prendre en compte d'autres formes du *middleground* identifiées dans la littérature.

Article 3
Qu'est-ce qui explique l'implication des *core* acteurs dans des projets collaboratifs de R&D et d'innovation dans un écosystème local d'innovation ? Une entrée par la théorie du *middleground*.

Contexte et objectifs

Dans le prolongement de la deuxième sous-étude, la troisième sous-étude analyse la composante relationnelle la plus avancée de l'environnement intermédiaire - les projets de R&D

collaboratifs - afin de déterminer quel type de projet, pour quel type d'échange, entraîne un mécanisme d'apprentissage et d'adaptation.

L'écosystème d'innovation étant caractérisé par des relations complexes entre des acteurs hétérogènes et par une structure organisationnelle qui permet des interactions entre différents niveaux d'acteurs, les projets de R&D collaboratifs progressent et sont devenus des facteurs de réussite qui stimulent l'interaction et les échanges de connaissances. L'adaptation est liée à l'acquisition de connaissances externes par la collaboration, et la collaboration est principalement étudiée en utilisant l'interaction entre les acteurs/organisations, le partenariat dans un projet inter-organisationnel (par exemple, Bernela et Levy 2017).

La collaboration dans le cadre de projet de R&D, qui constitue une forme de *middleground*, facilite l'apprentissage interactif pour la création et la diffusion de connaissances. L'adaptation au sein de l'écosystème dépend des interactions continues entre les acteurs de la *upperground* et de la *underground* (Cohendet et al., 2020).

Notre étude précédente met clairement en évidence l'importance du projet collaboratif dans l'orchestration des interactions entre les différents niveaux d'acteurs, et dans l'amélioration des performances d'innovation et d'adaptation.

Malgré le rôle des projets collaboratifs dans l'échange de connaissances et le processus d'apprentissage entre les partenaires, on sait peu de choses sur les spécificités liées à la fois au type de projet et au type d'échange dans les mécanismes d'apprentissage qui favorisent l'adaptation.

Cependant, si l'adaptation est liée à l'acquisition de connaissances externes dans le cadre de la collaboration, les acteurs principaux ayant de riches connexions absorbent le plus de connaissances dans les projets de R&D collaboratifs et font preuve du plus grand pouvoir d'adaptation. Si l'on considère que les acteurs périphériques ou les acteurs clandestins qui participent à un projet de collaboration sont motivés par la volonté de bénéficier de ressources qui dépassent leur champ d'action, les facteurs qui déterminent l'engagement des acteurs centraux ou *core* acteurs dans les projets de R&D ou d'innovation en collaboration sont encore peu développés. Les *core* acteurs ou acteurs centraux de l'écosystèmes sont les acteurs les plus actifs parmi les acteurs de l'upperground dans les projets de collaboration avec des connexions riches. Ils ont tendance à absorber le plus de connaissances dans les projets de R&D collaboratifs.

Par conséquent, la question de recherche spécifique est la suivante : Qu'est-ce qui explique l'implication des acteurs principaux dans les projets d'innovation collaborative dans un écosystème d'innovation local ?

Nous avons développé trois hypothèses

H_1 : Dans un écosystème d’innovation territorialisé, l’implication des core acteurs dans les projets de R&D collaboratifs dépend de la présence des acteurs du ou provenant de l’underground (des startups).
H_2 : Dans un écosystème d’innovation territorialisé, l’implication des core acteurs dans les projets de R&D collaboratifs dépend de la diversité sectorielle des acteurs impliqué dans le projet.
H_3 : Dans un écosystème d’innovation territorialisé, l’implication des core acteurs dans les projets de R&D collaboratifs dépend de la proximité géographique avec les autres acteurs.
H_4 : Dans un écosystème d’innovation territorialisé, l’implication des core acteurs dans les projets de R&D collaboratifs dépend du type de projet.

Méthodologie

Dans un premier temps, nous avons construit et analysé le réseau de collaboration en R&D dans l’écosystèmes d'Eurasanté afin d'identifier les acteurs principaux, le type de partenaires ou d'échanges et le type de projet.

Nous avons utilisé une approche en termes de réseau d’affiliation. Le réseau d'affiliation représente un réseau de participation ou d'adhésion dans lequel les données à 2 modes montrent des ensembles de relations qui relient les « acteurs » et les « événements ». Le réseau d'affiliation permet de déterminer les liens de réseau entre les acteurs à travers les événements, permettant ainsi de savoir quels acteurs ont participé à quel événement ; avec un double regard sur les relations de réseau entre les acteurs d'un événement. Dans cette étude, les « acteurs » représentent les entreprises/organisations et les « événements » représentent les projets de R&D collaboratifs. Les projets de R&D collaboratifs permettent des interactions inter-organisationnelles dans les processus d'innovation.

Ces projets collaboratifs de R&D prennent plusieurs formes. Il peut s'agir de projets de recherche fondamentale et appliquée portés par les laboratoires de recherche du CHU mais associant des industriels. Citons par exemple les projets de recherche financés par l'Agence nationale de la recherche (ANR), les projets des Fonds Européen de Développement Régional (FEDER) dédié à la recherche, des projets collaboratifs des pôles de compétitivité financés par le Fonds Interministériel (FUI) destinés à soutenir la recherche appliquée, le développement et la commercialisation de nouveaux produits et services.

Nous avons utilisé la période 2009-2020 comme période de référence et identifié 70 projets de R&D collaboratifs impliquant 409 acteurs ou participants y compris les entreprises les laboratoires ou centres de recherches et les universités. Nous avons trouvé après des analyses de réseaux 15 acteurs qu'on peut considérer comme core acteurs de par leur position dans le réseau.

L'étude a donc adopté le modèle logistique fractionnel, en utilisant la proportion d'acteurs "centraux" comme variable à expliquer. Nous avons testé en particulier si le type d'échange/partenaires et le type de projet déterminent l'implication des acteurs centraux ou *core actors* dans les projets de R&D collaboratifs, y compris la proximité géographique.

Principaux résultats et contributions

Nos résultats montrent que la présence des startups (acteurs de ou provenant de l''underground influence significativement l'implication des acteurs centraux dans les projets de R&D collaboratifs. L'hypothèse 1 est donc validée.

De même, notre résultat montre un impact positif et significatif de la proximité géographique sur la probabilité d'implication des acteurs centraux dans des projets de R&D collaboratifs. Ainsi, l'hypothèse 3 est validée.

Dans le même ordre d'idées, les variables ANR et Fonds Européen sont positives et statistiquement significatives. Ainsi, on observe une influence positive et significative de l'ANR et du Fonds Européen sur la participation des acteurs centraux aux projets de R&D collaboratifs. Cela implique que le type de projet pour lequel la collaboration a lieu explique l'implication des acteurs centraux dans les projets de R&D collaboratifs. L'hypothèse 4 est donc validée.

Enfin, notre résultat montre un effet négatif et significatif de la diversité sectorielle dans la détermination de la participation des acteurs centraux dans le projet de R&D collaborative. L'hypothèse 2 n'est pas validée

Nos résultats soulignent une tension permanente qui existe entre les forces d'exploitation les forces de stabilisation et les forces d'exploration dans un écosystème. L'effet négatif de la diversité sectorielle et l'effet positif de la proportion de startups sont une belle illustration de cette tension et de ce paradoxe. Il est évident que les acteurs centraux sont plus susceptibles d'exploiter les trajectoires technologiques existantes et sont plus à l'aise avec cela. Mais le rôle de l'écosystème est de favoriser les interactions entre eux et les acteurs de l'underground. Cette étude montre donc, au-delà du fait que les acteurs centraux ont tendance à être plus attirés par les projets avec une homogénéité sectorielle des acteurs, ils sont conscients de la valeur ajoutée que les startups peuvent apporter à un projet collaboratif en termes d'idées nouvelles, de connaissances et de compétences ou en termes d'exploration de nouveaux champs.

En résumé, ce travail confirme que les projets de R&D collaboratifs, en tant que l'une des composantes du *middleground*, rassemble à la fois des core acteurs évoluant dans l'Upperground et des start-ups bien souvent issues de *l'underground*. Cette constatation est conforme à celle de Cattani et Ferriani (2008) qui ont évalué la structure centre/périphérie de l'industrie cinématographique et révèlent que les résultats créatifs et les performances sont améliorés par l'interaction avec les acteurs centraux et les acteurs de la périphérie.

Plus précisément, nous constatons que la présence des éléments de l'underground dans les projets de R&D collaboratifs influence l'implication des acteurs centraux dans plusieurs projets et, par conséquent, améliore le partage et l'acquisition de connaissances diverses.

Cependant, l'homophilie conduit à une mauvaise circulation de connaissances nouvelles nécessaires à l'innovation de rupture. Par conséquent, pour surmonter cela, des procédures de financement différentes peuvent être nécessaires de la part des financeurs publics.

Notre étude contribue donc à la littérature en fournissant de nouvelles perspectives et des preuves empiriques sur le rôle du *middleground* dans l'orchestration de l'interaction entre *l'upperground* et l'underground, précisément sur l'importance des échanges de connaissances et le partage des compétences dans le cadre des projets collaboratifs.

Partie 3

Discussions générales et conclusions

Cette partie discute et résume les principaux résultats de la thèse et les contributions théoriques. Elle discute ensuite des implications en termes de politiques publiques.

Cette thèse apporte des **contributions théoriques** pertinentes sur l'écosystème d'innovation, en relation avec la conceptualisation de l'écosystème local d'innovation adoptée. S'inspirant des travaux de Saxenian (1994), la thèse intègre théoriquement la dimension territoriale dans la conceptualisation de l'écosystème d'innovation en tant que communauté d'acteurs en interaction, basée majoritairement sur un territoire. Bien que l'écosystème puisse avoir une portée mondiale, il est généralement enraciné dans un territoire.

Cette thèse apporte une contribution théorique car elle identifie spécifiquement les caractéristiques ou attributs clés et la structure de l'écosystème d'innovation qui le distingue et le prédispose à mieux aborder l'adaptation au niveau de l'entreprise.

À partir des caractéristiques ou attributs de l'écosystème d'innovation, tels que l'hétérogénéité des acteurs, les interactions complexes et la composition structurelle, l'écosystème d'innovation fournit un environnement propice et prédispose les acteurs à une capacité d'adaptation accrue. En fait, les trois principales caractéristiques ou attributs distincts lui confèrent un pouvoir explicatif plus important pour aborder l'adaptation au niveau des entreprises que d'autres constructions traditionnelles tels que les clusters et les réseaux. Premièrement, comme le postule cette thèse, il existe des agents/acteurs hétérogènes avec des motivations, des capacités et des stratégies différentes. Les acteurs comprennent des organisations telles que les universités, les instituts de recherche et les entreprises (provenant souvent de secteurs différents), etc. Comme indiqué dans les études régionales, la diversité est liée à l'adaptation et à la transition durable, car la diversité offre la flexibilité nécessaire pour répondre aux chocs. De même, la diversité offre la capacité de débloquer d'une trajectoire spécifique pour tracer de nouvelles voies.

Deuxièmement, les relations entre les acteurs de l'écosystème d'innovation sont denses et complexes et impliquent des interactions continues entre des acteurs interdépendants. Il est avancé que la complexité des interactions génère plus de dynamisme, d'efficacité et d'innovation.

En fait, pour éviter une situation de verrouillage et améliorer la durabilité, il est nécessaire de développer des relations complexes et de construire un pipeline mondial, en tirant parti des sources de connaissances externes. La complexité de l'interaction offre la flexibilité nécessaire pour répondre à la complexité de l'environnement. Par conséquent, la diversité des acteurs et les relations inter-organisationnelles complexes sont essentielles à l'adaptation des entreprises de l'écosystème.

La troisième caractéristique est cependant centrée sur la structure organisationnelle. La thèse postule que la structure organisationnelle favorisant la coévolution des acteurs doit être nécessairement ambidextre. L'ambidextrie de l'écosystème d'innovation (exploration et l'exploitation) permettant une relation synergique entre les acteurs/agents facilitant la génération d'idées innovantes et d’autres qui facilitent leur standardisation et leur commercialisation.

Comme le montre la thèse, le *middleground* explique la coévolution des entreprises dans l'écosystème et influence le développement technologique des entreprises. Il permet l'interaction entre des acteurs avec les capacités d'exploration et ceux avec la capacité d'exploitation et favorise la production et l'échange de connaissances ainsi que la pollinisation croisée de différentes connaissances qui facilitent l'adaptation.

En considérant le *Middleground* et la fonction d'orchestration et de connexion entre l'*Underground* et l'*Upperground* , cette thèse montre d'abord que celui-ci joue un rôle pivot dans les interactions complexes que nécessitent les processus d'adaptation.

Une autre contribution théorique de notre thèse est l'importance des core acteurs. Si la littérature sur les écosystèmes met l'emphase sur l'acteur pivot ou Keystone autour duquel se construit l'écosystème, ces théories ne permettent pas d'expliquer des écosystèmes avec des modes de gouvernance décentralisées qui sont souvent le cas pour les écosystèmes ancrés sur les territoires. Les core acteurs peuvent mieux expliquer ces types d'écosystèmes, les caractéristiques et leurs dynamiques. En utilisant les projets d'innovation collaborative comme composante relationnelle de l'écosystème, nous avons identifié divers acteurs en interaction, dont un nombre relativement restreint d'acteurs centraux bien établis disposant des ressources, des connexions politiques et sociales nécessaires et d'une plus grande capacité d'exploitation pour imposer un rôle central dans l'écosystème. Premièrement, les acteurs centraux ont la capacité de développer le capital humain et d'accéder aux connaissances issues des universités et des centres de recherche. Deuxièmement, ils ont la capacité d'introduire de nouvelles technologies sur le marché. Cette capacité nécessite toutefois une interaction avec les acteurs périphériques ou issus de l'underground. Par exemple, les acteurs centraux ont besoin d'accéder à des idées nouvelles qui peuvent émaner ou porter par des start-ups. Notre thèse révèle que, dans un contexte d'écosystème d'innovation, l'implication des acteurs centraux dans un projet collaboratif dépend de la présence des start-ups qui, dans une certaine mesure viennent de l'underground. Cette conclusion est en accord avec les travaux théoriques sur l'écosystème local d'innovation liant l'adaptation à des interactions dynamiques entre les acteurs de l'upperground et les acteurs de l'underground.

En termes **de contributions empiriques**, cette thèse aborde une des principales lacunes de la littérature sur l'écosystème d'innovation, en fournissant des démonstrations et des preuves empiriques de l'impact de l'écosystème d'innovation sur la capacité d'adaptation des entreprises. Afin de déterminer ce qui rend les entreprises de l'écosystème d'innovation plus adaptatives que les autres, la thèse confirme empiriquement le rôle clé des relations complexes rendues possibles par le middleground. La thèse confirme que les différentes composantes du middleground, tels que les projets de collaboratif ou les événements favorisent la coévolution entre l'upperground et l'underground et améliorent les performances d'innovation des entreprises de l'écosystème. En utilisant une analyse économétrique, la thèse confirme que le *middleground* facilite la génération et l'échange de connaissances entre une diversité d'acteurs qui peuvent provenir de secteurs ou d'industries différents et permet donc aux acteurs de puiser dans des sources de connaissances externes et diversifiées. De plus, en isolant les projets collaboratifs, comme composante du middleground, notre étude montre à travers des tests économétriques que la présence des start-ups augmente positivement la possibilité d'implication des acteurs centraux dans les projets de R&D collaboratifs. Ainsi, cela confirme une fois de plus l'importance du rôle de l'underground dans l'écosystème de l'innovation.

En termes **de contributions méthodologiques**, cette thèse ajoute des éléments dans la littérature sur la manière d'opérationnaliser le concept d'écosystème d'innovation. La thèse a conceptualisé de manière intéressante l'écosystème d'innovation avec une dimension territoriale. Notre travail croise des analyses structurelles de réseaux et les tests d'Entropie de Shannon et l'indice d'Herfindahl modifié pour valider empiriquement des cas d'écosystèmes localisés en tenant compte des relations denses et complexes et des acteurs hétérogènes. Ces analyses confirment une forte densité relationnelle entre les acteurs et confirme une grande diversité sectorielle dans les écosystèmes d'innovation de cette étude.

En termes **d'implications pour les praticiens** du monde des affaires, cette étude souligne que pour poursuivre l'adaptabilité, il est nécessaire que les entreprises se concentrent non seulement sur les activités innovantes, mais aussi sur la diversification et surtout exploiter les opportunités qu'offre les écosystèmes d'innovation

Les interactions stratégiques à travers des événements et les projets de R&D peuvent être essentiels pour stimuler les idées créatives ou nouvelles et la création d'une innovation réussie. En particulier, cette étude révèle que le fait de faire partie d'un écosystème d'innovation offre aux entreprises la possibilité d'interagir avec diverses sources de connaissances, d'idées et d'informations afin d'exploiter de nouvelles connaissances capables de faire progresser leur capacité d'innovation et d'adaptation. Clairement, nous montrons que les interactions formelles et informelles sont efficaces pour stimuler la performance innovante et l'adaptation. Enfin, le succès à moyen et long terme des acteurs centraux dans la dynamique d'innovation de l'écosystème local d'innovation dépend de la manière dont ils s'intègrent ou interagissent avec les acteurs de la périphérie ou de l'underground particulièrement les start-ups.

En termes **d'implications politiques**, cette thèse appelle les décideurs politiques à créer des opportunités pour un environnement plus interactif qui motive les entreprises à exploiter l'hétérogénéité pour libérer les potentiels d'adaptation, plutôt que de s'enfermer dans des clusters dominés par l'homogénéité. En fait, les politiques fondées sur l'innovation et les stratégies collectives des acteurs économiques devraient se concentrer sur la promotion de la construction d'un écosystème d'innovation afin de favoriser l'interaction entre les acteurs d'exploration et d'exploitation pour stimuler l'adaptation.

Comme on le voit, les acteurs principaux sont principalement des organisations et des entreprises bien développées. Les politiques devraient également viser à promouvoir les jeunes entreprises innovantes ou les start-ups. En particulier, les politiques devraient inciter le développement des projets collaboratifs qui allient les acteurs centraux et les start-ups. Un écosystème performant nécessite à la fois des acteurs centraux et des start-ups innovantes.

Étant donné que la mise en œuvre d'une politique nécessite différents actifs et ressources, les décideurs publics doivent être conscients de la nécessité de réussir la mise en œuvre de politiques basées sur les écosystèmes, non seulement pour améliorer la capacité d'adaptation des entreprises, mais aussi pour assurer la transformation des territoires. Les décideurs politiques devraient aussi promouvoir des lieux emblématiques d'interactions ou de véritable *middleground*. De ce fait, il est indispensable de considérer les parcs d'innovation (ou mêmes les Technopole ou parc Scientifique) non seulement comme des espaces ou des lieux offrant des installations partagées aux entreprises, mais surtout comme une forme de réseau qui favorise la diffusion des connaissances entre les différents niveaux d'acteurs par le biais d'interactions formelles et informelles.