From knowledge to business ecosystems: emergence of an entrepreneurial activity during knowledge replication

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Abstract :

Our article emphasizes the relationship between knowledge and business ecosystems. Transformation of a knowledge ecosystem can lead to the emergence of a technological platform embodying a business ecosystem and providing the resources required especially for firm startup. The role of knowledge replication in an innovation ecosystem is identified through exploratory research and a qualitative case study in the technology hotspot of Sophia-Antipolis. Our findings provide evidence of a new technological trajectory in near field communication ecosystems resulting from a radical transformation of traditional knowledge ecosystems. We show that the role of a knowledge filter is reduced by some public actors and universities acting as the "tenant anchor" and accelerating the replication of knowledge, and the resolution of intellectual property rights issues in emergent business ecosystems. We highlight the critical role of a public actor in enabling the emergence and creation of a business ecosystem, and its involvement in this entrepreneurial activity.

Key words. Knowledge ecosystem, entrepreneurial opportunities, technological platform, knowledge replication, academic actor.

JEL CODE: L26, L21, L86, M13, M21, O21, O32.

Introduction

Knowledge is recreated and rebuilt continuously within a dynamic flux. This process ensures competitive advantage, and hence, is a strategic resource for organizations (Bourdon and Bourdil, 2007). Audretsch and Feldman's (1996) seminal work on research and development (R&D) investment underlines the propensity for industrial activity to be spatially clustered to exploit knowledge externalities. However, what is important is not the cluster effect which has been observed over many years, but rather the ability to capture these externalities and to create appropriate business ecosystems for all the partners, whether public or private. Business ecosystems are a form of organization of exchange, a structure or an institutional framework able to manage relationships among several actors committed to a more or less open collective process of innovation. According to Iansiti and Levien (2004:173-175), one of the pillars of business ecosystems is integration which gives rise to tightly knit combinations of assets. Integration underpins business evolution in which the capabilities and technological components delivered by ecosystem participants are recombined to create continuous improvements to product and service offerings. The authors acknowledge that typically knowledge is embedded in the people and systems spread throughout the ecosystem but they do not identify the precise content of this knowledge or the process through which knowledge is recombined.

Arrow’s (1962) notion of a ‘knowledge filter’ constituted a major step towards understanding how knowledge recombination contributes to the birth of a business ecosystem. The knowledge filter controls the transmission of knowledge *via* entrepreneurial activities, and represents the missing link between general knowledge (stock of knowledge) and economically useful knowledge transmitted *via* spill overs (Acs et al., 2003, 2009). This knowledge filter can take the form of entrepreneurial activity such as new firm creation (Braunerhjelm et al., 2010)[1.] There is a huge debate in the entrepreneurship literature over whether opportunities are discovered or created (Alvarez et al., 2013; McKelvey, 2016; Winter, 2016). One thing that has emerged these deliberations is that “*entrepreneurial origins matter*” (Agarwal and Shah, 2014: 1129), as does the process of “*having been and becoming entrepreneurs*” (McKevley, 2016: 787). Indeed, for aspiring entrepreneurs, the process by which knowledge is created within clusters and its potential transformation is determinant for the emergence of a business ecosystem.

[1] “*Entrepreneurship facilitates the spill over of knowledge in the form of starting a new firm*” (Braunerhjelm et al., 2010: 107).

In this paper, we understand a cluster as a knowledge ecosystem (Clarysse et al. 2014), and the business ecosystem as a complex network of actors which create value by combining their skills and assets (Eisenhardt and Galunic, 2000). It has been argued also "*entrepreneurs from different knowledge contexts contribute distinct capabilities to an industry, and may occupy alternative positions within an ecosystem. […]Each source of entrepreneurship plays a critical and irreplaceable role in industry development and evolution. Economic and societal progress may require the presence and of a rich, interwoven knowledge ecosystem*" (Agarwal and Shah, 2014: 1129). Thus, clusters are knowledge ecosystems "*where local universities and public research organizations play a central role in advancing technological innovation within the system*" (Clarysse et al., 2014: 1164). Business ecosystems are characterized by a functional goal to enable technological development and innovation. They comprise two distinct and separate economies: the research economy which is driven by fundamental research, and the commercial economy which is driven by the marketplace (Oh et al., 2016). Although knowledge ecosystems and business ecosystems have different functional goals, they both involve knowledge creation and knowledge management in innovation. While both the knowledge and business ecosystems literatures recognize the role of platforms for facilitating flows of knowledge among members, they differ about the type of platform that is needed. The knowledge ecosystem literature identifies knowledge recombination that may give birth to some knowledge platform and facilitates the implementation of new business models (Lazaric et al., 2008). This knowledge platform takes the form of a digital artefact where knowledge is codified. The strategic management literature, and especially works on platform ecosystems, suggests that the platform consists of a product, service, system or technology (Gawer, 2014) that embodies the business ecosystem (Iansiti and Levien, 2004).

To contribute to the debate on the role of knowledge filters, and work on the existence of a relation between knowledge and business ecosystems (Clarysse et al., 2014), this paper considers the case of platform ecosystems which are modular structures in which several originally independent components, are interconnected through a key asset: a *technological platform* (Iansiti and Levien, 2004; Baldwin and Woodward, 2009; Koenig, 2013). We investigate the question of how knowledge replication can lead to the birth of a platform ecosystem? We provide empirical evidence of a 'sophipolitan' hotspot within which we observe how academic actors create opportunities and transform their innovative ideas into viable commercial products and services. Our research adopts an *abductiv*e approach involving data collected from active observation and qualitative interviews in order to document the entrepreneurial activity of academic actors and to highlight how a knowledge ecosystem can lead to a business ecosystem. We focused on the commitment to involvement of academic actors to support this dynamic, and on their knowledge replication and recombination activities, and the motivations for enlarging the scope of their activities.

The paper is structured as follows. Section 1 reviews the literature on knowledge recombination and business platforms; section 2 describes the case study and discusses the data gathering methodology. Section 3 presents the empirical findings from the case study. Section 4 discusses the results and the emergence of a business ecosystem. Section 5 offers some conclusions and implications for entrepreneurial activity, and policy makers.

I. Literature review

This section distinguishes the different types of knowledge and knowledge management processes operating in knowledge and business ecosystems, and why entrepreneurship depends on the existence of platforms in both types of ecosystem. It shows that knowledge and its potential recombination and replication is critical for the development of new technologies and platform ecosystems.

1.1. Emergence, potential recombination, and governance of knowledge within a knowledge ecosystem

The basic attributes of knowledge comprise its various externalities and potential openness. Knowledge is distributed among various decentralized units, and needs to be shared and absorbed in the context of innovation. Schumpeter (1934) claimed that knowledge must be combined to produce innovation. This alchemy is far from automatic; a pre-existing opportunity is required for viable interactions to occur (Nahapiet and Ghoshal, 1998). Weitzman (1996: 99) reminds us that recombination refers to the process "*when knowledge is applied, new ideas arise out of existing ideas in some kind of cumulative interactive process that intuitively has a different feel from prospecting for petroleum*". The objective of knowledge recombination is to overcome the traditional obstacles to cooperation, to promote the development of suitable interactions among different sources of technological know-how, to reinforce combinative capabilities, to create viable rules and achieve *transferring* functions.

However, the ability to navigate in diverse innovation spaces in a globalization context, and the ability to create opportunities over time require effort (McKelvey, 2016: 800).

The notion of knowledge base developed by Saviotti (1996) is useful here. Indeed "the *essence of the knowledge base is its collective nature, which confers the basic properties of being a retrieval/interpretative and co-relational structure* "(Antonelli et al., 2010: 52). The generation of new knowledge through knowledge recombination varies with some recombinations more fruitful than others. Saviotti et al. (2005) emphasize that some new technologies are the result of recombination of diverse knowledge and a process which allows the activation of diverse flows of knowledge. Indeed "*in this process core technologies acts as hubs in the collective process of knowledge generation in which all the parties involved act intentionally, within a well identified rent-seeking perspective*" (Antonelli et al., 2010: 52). Thus, motivation is required for beneficial exchanges. Without the engagement of firms and actors, knowledge remains "sticky" and requires a knowledge filter (Szulzanski et al., 2004). However, the real *transfer of knowledge* between firms and institutions can be obstructed by a knowledge filter. The transfer of knowledge requires the actors to become knowledge creators, in turn requiring a shift from closure to disclosure and knowledge sharing (Lazaric et al., 2008: 841)

The literature suggests that some local ecosystems create platforms for sharing and codifying knowledge (Lazaric et al. 2008). If the local social mechanisms at work support these exchanges and combinations, a spirit of entrepreneurship will enable the actors to convert know-how into innovation. The *transferring function* may provide opportunities for new knowledge combinations. In their article on the development and expansion of knowledge ecosystems, Powell et al. (2012) identify the role of tenant anchor as central for enabling the transfer function. Clarysse et al. (2014: 1165) discuss how local universities or public research organizations can act as tenant anchors by '*providing access to subsequent connections and field formation.....these institutions produce basic and applied research and acts as catalysts of technological innovation by transferring this to local industry through R&D collaborations'*. A tenant anchor can reduce the knowledge filter effect by decreasing the role of the traditional gatekeeper and being fully involved in the transfer function. In this paper we focus on ecosystems in general, not just local ones, in order to understand how universities or public research organizations perform (or not) as tenant anchors, and why. We assume that the "knowledge context" is important since "*academic entrepreneurship [is]* *neither a pervasive phenomenon, nor a subject of scholarly attention*" (Agarwal and Shah, 2014: 1114).

Furthermore, although the role of a public actor is to create and transfer knowledge, little work has been done on their role in the creation of business ecosystems which clearly requires additional attributes (Agarwal and Shah, 2014). To analyze this role, it requires investigation of the main attributes of a business ecosystem.

1.2. Conditions of emergence and evolution of a platform ecosystem

The emergence of a platform-ecosystem requires certain conditions (Gawer and Cusumano, 2012; Iansiti and Levien, 2004): identification of a product, a technology or a service which might become the structuring element (the technological platform) of the business ecosystem; a modular architecture of the technical platform; intellectual property rights (IPR) shared among the members of the ecosystem; platform evolution to maintain the "vibrancy" of the business ecosystem. IPR are crucial for the design of a technological platform embodying a business ecosystem (Gawer and Cusumano, 2012). The ability of actors to construct suitable rules of the game and IPR are vital for replication and knowledge transfer. Replication can takes the form of recombination or mutation (Becker and Lazaric, 2003). In *recombination*, the elements of the replicators are unchanged but are arranged in new ways; *mutation* involves a change to the components of the replicators. Thus, the integration and replication of knowledge may be reinforced by sustainable governance of relationships and use of IPR, e.g. patents (Camison and Fores, 2011).

More generally, platform ecosystems are observable at three different levels of analysis and organizational settings: within firms, across supply-chains and across industry ecosystems (Gawer, 2014). A technological platform initially can be an internal platform and then, provided that three conditions are fulfilled, switch to becoming a supply-chain platform and/or an industry platform (Gawer, 2010, p.28). First, external firms can enrich the value of the platform's components. Second, the value for customers is created less by the components assembler than by the actual components. Third, component actors can benefit from different market opportunities.

But whatever the organizational setting, the technology platform architecture includes a set of common components and rules for interaction (Eisenmann et al., 2009). Components are the software and/or service modules which are related via a specific technical architecture (the platform interface) which must be sufficiently open to enable external actors to enrich it through the addition, innovation or development of complementary assets. Rules are defined to coordinate the activities of ecosystem members. These rules are codified knowledge which needs to be shared and communicated (Isckia and Lescop, 2009). They constitute an architecture specifying which modules will be part of the system and what will be their function, interfaces (between the "core" and the "periphery") describing how the modules will interact and communicate, and standards ensuring the module's conformity to other modules (Baldwin and Woodward, 2009). Depending on the organizational setting, the technological interfaces can be closed (in internal platforms), semi-closed (in supply-chain platforms), or open (in industry platforms). In internal platforms, the owner of the platform exercises a high degree of control by incorporating outside innovations and selling the final products to customers. In the supply-chain platform model, the degree of control is lower. The owner of the complementary assets (external actors) build 'on top' of the platform and sell the resulting products to customers (Boudreau and Lakhani, 2009). In industry platforms, external actors have high autonomy. They are free to transact directly with customers as long as they are affiliated to the platform.

However, the platform ecosystem literature mostly considers cases from the telecommunications industry whose members are mostly private actors. The role of public actors in such ecosystems, and particular the question of entrepreneurial opportunities favored by a public actor, has not been studied.

II. Methodology and data collection

The phenomenon described here is knowledge management processes within knowledge and business ecosystems. The objective is to identify how platforms facilitate these processes, and evolve in form such that the birth phase of a business ecosystem occurs within a knowledge ecosystem and contributes to entrepreneurial activity. We employ a case study method because it is used to address how and why type questions applied to contemporary phenomena in real life contexts (Yin, 1989). The case study investigates the birth of near field communication (NFC)[2] ecosystem in Sophia Antipolis. NFC ecosystems are platform ecosystems in which several groups of actors interact: technological actors in the

[2] NFC is a standards-based short-range (less than 3 cm) wireless communication (unlicensed 13.56 MHz radio frequency) technology to enable half or full duplex applications. It offers a general-purpose connection to other wireless devices (Bluetooth, Wi-Fi, GPRS, etc.) and can be used with several other devices (RFID tags, smart cards, etc.) for communication.

telecommunications sector (mobile phone operators, phone manufacturers, etc.), incomers (service providers from transport, banking, etc.) and new businesses such as trusted secure managers[3] (TSM) (Basole, 2009; Pastorelly et al., 2011). A particularity of NFC ecosystems is that in their birth phase no leader has been identified (Attour, 2014). Below we present the case study followed by a description of the data collection and analytical method.

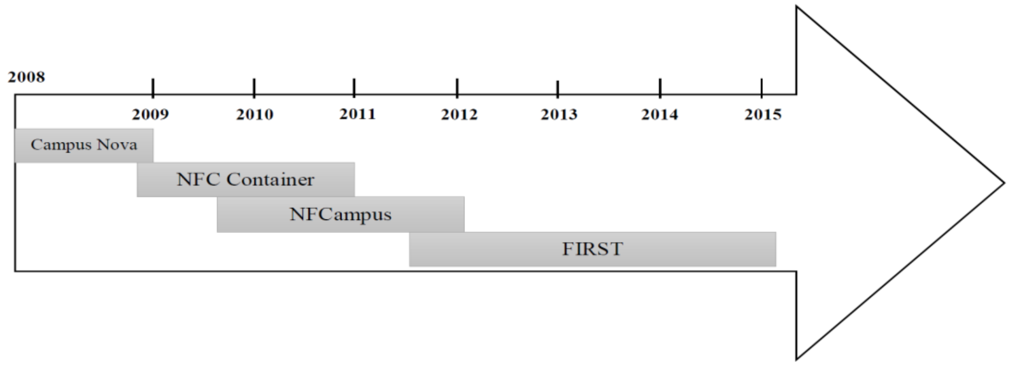
2.1. Case study

Our research focuses on the case of the "*Mobiquité, Bases de Données et integration de Systèmes*" (MBDS) team of project managers led by Professor Serge Miranda who in 1992, launched a graduate computer science degree course at the University of Nice Sophia Antipolis (UNS). The team offers specialized courses based on their experience, and especially experience in projects with national and international private and public partners. The MBDS team is located in Sophia-Antipolis, and since 2004 has been conducting research on mobile services using the NFC standard. Innovative proof-of-concept and pilot projects based on the NFC standard have been developed in the MBDS Sophia-Antipolis laboratory within partnerships and other contracts with industry, the French Ministry of Industry, the Southern Regional government Provence-Alpes-Côte d'Azur, the Indo-French Centre for the Promotion of Advanced Research (CEFRIPA), etc.

The NFC know-how acquired by Professor Miranda and his MBDS team led the UNS hosting ambitious pilot NFC projects (e.g. Campus Nova, NFC Container, NFCampus, FIRST) with large consortiums of firms/organizations (Crédit Agricole bank, Docapost, Orange Labs, Gemalto, Tata Consultancy Services (TCS), etc.) and start-ups (Cassis International, Mobile Distillery, etc.) either located in or with a subsidiary in Sophia-Antipolis. Figure 2 depicts the chronology of these projects.

[3] TSM is NFC ecosystem, a neutral broker that sets up business agreements and technical connections with mobile network operators, phone manufacturers and other entities controlling the secure element on mobile phones. TSM enables service providers to distribute and manage their contactless applications remotely by allowing access to the secure element in NFC-enabled handsets.

Figure 2. NFC projects carried out by UNS from 2008 to 2015.



The Campus Nova project was implemented in France in 2008 with UNS (MBDS), Crédit Agricole bank and Nokia. The objective was to develop a NFC platform that allows students to pay using their mobile phones for transactions in five stores in the city of Nice and the university restaurant, exchange cash via virtual wallets based on a peer-to-peer connection and use their mobile phones to access university classrooms (Miranda et al., 2011).

NFC Container ran between 2009 and 2011. The project was carried out by a consortium of major firms and phone operators (Orange Labs, Gemalto, Docapost, and others[4]) and research institutes (Telecom Paristech, UNS (MBDS), University of Caen Basse-Normandie). The objective was to define a mobile application which would store data securely and enable their transfer via a NFC reader. Within this project, UNS developed a technical architecture which has given service providers a set of tools allowing them to develop NFC applications for services delivered via mobile phones.

The Nice Futur Campus (NFCampus**)** project began in September 2009 and ran till February 2012. It involved UNS (MBDS), Docapost, BMS, Cassis International, ASK, Mobile Distillery and Orange Labs in the design of a multiservice and multimodal student card accessible via a NFC, or a NFC compatible mobile phone. The multiservice student card is a technological platform combining two service types - 'student life' and 'daily life' - in order to facilitate interactions between two user groups: UNS students, and Nice storekeepers.

[4] Several others companies are official project participants: Ardis, CEV Group, Constructive Card, Digital Airways, Monext, High Co, Netinf, NXP, Oberthur T. In this research we interviewed only project partners which are stakeholders in the work package related to the development of a mobile application for secure data storage and transfer over a NFC reader and in which UNS was an active player.

The project **FIRST** (**F**inancial **I**nclusion based upon **R**ural mobiquitous **S**ervices **T**echnological) ran from September 2012 to December 2015. FIRST actors included Tata Consultancy Services (TCS), the Indian Institute of Science of Bangalore (IISc), UNS and Gemalto. Technologically, FIRST aimed to ensure interoperability between two solutions based on different industry infrastructures (banking and telecoms) via a financial TSM developed by TCS and a TSM-Over-The-AIR (TSM-OTA) developed by Gemalto. The financial TSM is a virtual bank account. TSM-OTA guarantees personal data exchange (user identification, users' rights, etc.) between FIRST components and users.

2.2.Data collection and analysis

One of the authors of this paper acted as researcher-observer and was known to the actors in two (NFCampus and FIRST) of the four projects studied. The co-author had an operational role although it was not dedicated specifically to the objective of the present research but provided access to longitudinal data particularly important for an analysis of the innovation processes (Van de Ven and Huber, 1990). It enabled collection of rich primary data via participation in various meetings (face-to-face, telephone or video-conference, brainstorming sessions), enabling us to follow how the MBDS's NFC projects and ecosystem were set up and evolved through the various phases of development. Some of the interviews were conducted by the co-author as part of her business models study. To obtain further information, we conducted additional interviews (see table 1). The questionnaire for these additional interviews which were semi-structured, was based on our theoretical framework. Interviews lasted around 90 minutes and involved actors from the projects studied.

The first and second sources of primary data were complemented by data from technical documents provided by practitioners, project annual reports and online information on similar projects in which one or more actors in our case study had participated (see table 1).

Table 1. Methodological issues of data gathering

Data source	NFC projects carried out by MBDS from 2008 to 2015 studied in our research			
	Campus Nova	**NFC Container**	**Nice Futur Campus**	**F**inancial **I**nclusion based upon **R**ural mobiquitous **S**ervices **T**echnological
Primary data	-	-	Continuous observation during 12 meetings and 3 brainstorming sessions	Continuous observation during 8 meetings and 1 brainstorming session
	2 interviews	3 interviews	8 interviews during the project 3 interviews during the project	5 interviews during the project 3 interviews in the downstream phase of the project
Secondary data	Documents available online		Product requirement documents Researches on similar projects, etc.	
			Consortium agreement	

A set of analytical categories enriched by field visits and comparison with theory, was developed to analyze the data collected. The categories relate to the type of technological platform (internal, supply-chain or industry) developed by the studied NFC projects, the technologies or functionalities mobilized and resulting from the projects, the knowledge associated to the technologies (knowledge shared or partly shared, generated and replicated in NFC platforms), and the projects' entrepreneurial resources (what are they, did they emerge before, during or after the project)[5].

[5]These categories required coding technologies or functionalities used at the beginning of the projects and resulting from innovation (cf. Appendix 1 table 3). The codes allowed us to identify knowledge that was combined and replicated from one project to the next (cf. table 2 and appendix 1 table 3).

We formulated our hypotheses based on an analysis of the literature on platform ecosystem foundations and knowledge platforms, and tested them against the literature and in the field in which the co-author was immersed. This allowed identification of patterns related to how knowledge is replicated, combined and/or recombined through and within the NFC platform, by actors in the upstream and life phases of the studied ecosystem. The analytical categories facilitated the testing of our hypotheses.

III. Results

All four projects studied were aimed at developing an NFC platform which integrated several components into a system that constituted its architecture (Eisenmann et al., 2009). However, the organizational settings differed. The aim of both Campus Nova and NFContainer was to develop a supply-chain platform while the aim of NFCampus and FIRST was to design an industry platform. The role of knowledge recombination was a key factor in all these cases.

3.1. From knowledge to technological platform : the role of knowledge replication

The ecosystem members were actors from Campus Nova and NFContainer in which the technical architecture developed by UNS - NFC mobile applications architecture which we describe as T2 (see Appendix 1 table 3) – acted as the assembler of the ecosystem. It constituted the technical support for the components deployed and added by the other members, respectively Crédit Agricole and Gemalto. However, the technology T2 is the same; its elements were arranged in new ways in each project resulting in different innovation results. Within NFContainer for example, UNS and Gemalto developed distinct Application Programming Interfaces (API), respectively T6 and T7, by recombining two of their technologies - Gemalto's TSM-OTA T5 and UNS's architecture of NFC mobile applications T2. In the case of NFCampus and FIRST projects, replication takes the form of recombination and mutation of T3, T4 and/or T6 technologies that have been generated from prior innovations during Campus Nova and NFContainer (see table 2 below).

Table 2. Knowledge generated and replicated by UNS*

NFC project	Technology generated	Technology recombined and/or changed
Campus Nova	T3, T4	T2
NFContainer	T6, T7**	T2, T3, T4
NFCampus	T15	T3, T4, T6
FIRST	T17, T18	T6, T15

**See annex 1 table 3 for a description of all the items (T) indicating a technology or a functionality developed by members of the NFC projects in our case study; **Technology (T7) was developed jointly by UNS and Gemalto.*

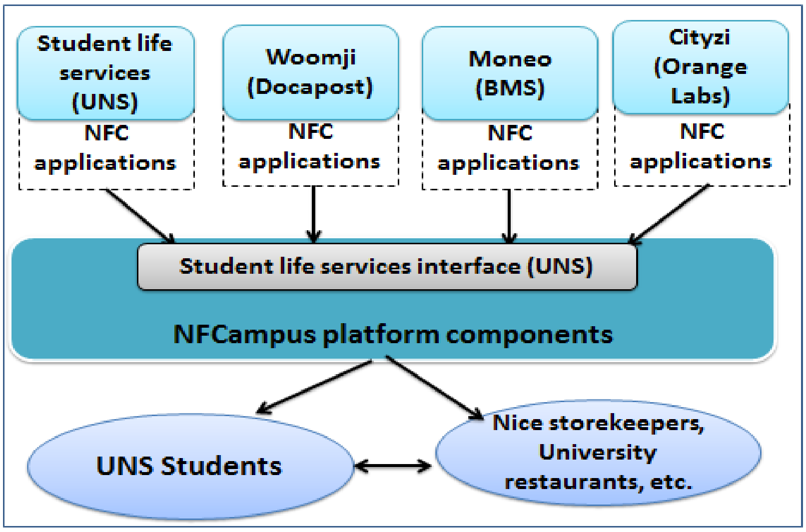
Technologies T15 and T17 generated by UNS within respectively NFCampus and FIRST are technological interfaces facilitating interaction between the core and peripheral elements of the ecosystems (Baldwin and Woodward, 2009). T15 allows interconnection between UNS's components (student life services) and complementary assets (daily life services) which enriched the value proposition of the NFCampus platform (Attour, 2014). In FIRST ecosystem, T17 created an exchange area between TCS and Gemalto components (Attour and Della Peruta, 2014). In that case, T2 identified as a critical knowledge platform, will become the replicator developed by students and project managers in the development of the three next projects studied. It facilitates the sharing of knowledge between students and project managers engaged in Campus Nova, and members of NFContainer, NFCampus and FIRST. The four projects were conducted successively but had different student and project manager involvement. Knowledge codified in T2 and recombined during the four projects allowed UNS to develop a technical architecture for each platform ecosystem. Each architecture results from replication (i.e. in our terminology not only recombination of knowledge but also mutation of its content) of codified UNS knowledge with external knowledge (from UNS's project partners) from previous projects (see table 2) (Becker and Lazaric 2003). Appendix 1 (see table 3) shows that this process of replication resulted from recombination and mutation of technologies.

NFC platforms depend on recombination and mutation of platform T2. Technologies resulting from this replication are digital artefacts (technological architecture) structuring the organizational setting of their ecosystems. They take the form of a standard (set of norms) which describes system functioning rules, links and possible interactions among components (Isckia and Lescop, 2009).

3.2. Evolution of supply-chain platform to industry platform: knowledge replication as a solution for IPR management

Campus Nova and NFContainer are two cases of a supply chain platform composed of a NFC architecture and mobile applications. Within these ecosystems the assembler is the owner of the NFC mobile architecture, and the suppliers are the providers of mobile services. In NFCampus and FIRST the role of the technical architecture seems to be more complex. In NFCampus, a core component of the platform is the UNS 'student life' services offer which is enriched by complementary actors (Attour, 2014): the 'daily life' services offer is an original combination of already existing value propositions, initially adopted and used by UNS students in the form of independent plastic cards (Moneo[6] plastic card and student transport plastic card). The student life services interface was identified as the starting point for ecosystem members' asset developments (cf. figure 3 below).

Figure3. NFCampus two-sided platform



[6] To be precise, the plastic UNS student card includes a micro-payment function for use in the university canteen. This offer is the result of a partnership between Moneo, UNS and the Centre Régional des Oeuvres Universitaires (CROUS).

Source: Our research

The 'daily life' services offer does not involve complementary components integrated into the 'student life' services information system; rather they are connected, in the sense of Boudreau and Lakhani (2009), '*on top of*' it via UNS's technical architecture for its 'student life' services, and enable interoperability among all NFCampus services. This technical architecture is the core element of NFCampus in the sense of Gawer and Cusumano (2012). However, since development of interoperability among external services requires the sharing of explicit knowledge (and consequently its associated IPR), UNS changed the degree of openness of T2 from a semi-closed model to an open model. Indeed, the NFCampus collaborative agreement states that "*all background IPR of a party shall remain the sole and exclusive property of such party*" and that "f*or any joint IPR made under this agreement, the parties (...) shall jointly own such IPR*". Consequently, visible design rules for the technical architecture of the 'student life' services were defined such that external actors could relate directly to end users, and could retain the residual rights to their assets. While the role of UNS as an assembler was crucial in the upstream phase of NFCampus, during NFCampus experimentation, 'daily life' services created more value for students than the 'student life' services (Attour, 2014). All the conditions required for the evolution of a supply-chain platform to an industry platform were fulfilled (Gawer, 2010) based on recombination and mutation of T2, T3 and T4.

In the case of FIRST, since the roles of Financial-TSM (TCS) and TSM-OTA (Gemalto) were symmetric, the interconnection between their components was facilitated by the UNS technical architecture. Both actors wanted to retain the IPR of their TSM and share the foreground IPR, which required a neutral technical architecture (an application and extension of NFC Container to the FIRST case) interconnecting the two TSMs. It was deployed in UNS (T17) and took the form of a platform with a modular technical architecture designed as a standard including functioning rules, links and definition of how the two TSMs would interact, while allowing the actors to retain the IPR on their components (Baldwin and Woodward, 2009). The aim of the FIRST project was to integrate the UNS architecture with the Financial-TSM to allow TCS to provide Gemalto's component without sharing its IPR. In this initial stage, FIRST can be characterized as a supply-chain platform in which the assembler is UNS's neutral architecture. In the next step, the objective was to develop a technological NFC platform to address the low penetration of banking services and financial exclusion problem in India. TCS wanted to use T17 to develop secure banking services via mobile phones (bank account, credits, savings, and payments). Potential market activities and innovation trajectories, essential conditions for an industrial platform design according Gawer (2010), were identified by TCS. They enabled the FIRST ecosystem to open, and to enrich its value proposition and be deployed in markets other than the market for which the supply-chain platform initially had been designed. The financial TSM became the core element in the industry version of the FIRST platform which enables external firms to enrich the platform's value proposition and makes UNS's role as assembler less important than the value created by the TCS component (Attour and Della Peruta, 2014). The initial version of the FIRST platform took the form of a supply-chain platform incorporating technologies based on knowledge replication. It evolved to become an industry platform thanks to the identification of new market opportunities and the fruitful replication of prior knowledge.

In both cases, the evolution from supply-chain to industrial platform was enabled by the key role of UNS and its technical architecture which facilitates IPR management. This resulted from the recombination and mutation of knowledge associated to the technologies codified in T2. This replication in several consecutive projects generated new knowledge and technologies significant for the emergence of technology platforms.

3.3. Emergence of the tenant anchor's entrepreneurial resources during the creation of NFCampus and FIRST platforms

Technically, we observed that while in Campus Nova and NFC Container there was background knowledge sharing among all the actors, in the NFCampus and FIRST cases the transfer function was enabled by UNS which can be described as tenant anchor *à la* Powell et al. (2012) and Clarysse et al. (2014). In NFCampus, the transfer function did not lead to full articulation of the knowledge[7]. This was achieved between UNS and Docapost through the recruitment and supervision of part-time students from UNS by Docapost for the deployment of Woomji. At the end of their Master's degree, the part-time students founded a joint start-up specialized in the development of the NFC application.

In the case of FIRST, UNS and Gemalto jointly developed two components of FIRST (the Wolf platform, an extension of NFC Container). This collaboration was formalized through

[7]With other NFCampus members, knowledge sharing was within a collaborative arrangement specifying that members should provide temporary access through a free license (limited to the duration of the project) to all the patented technologies (see annex 1 table 3).

the recruitment during the project of two part-time UNS students, and a PhD student from Gemalto. At the end of their contracts, the two UNS students were hired by Gemalto. They were supervised during their contract period by two project managers (former MBDS students) who had been recruited for project FIRST. These two project managers were co-founders of a start-up - Tokidev- established in 2011 at the beginning of FIRST. Since then, collaborations between the UNS MBDS team and Tokidev have occurred in several other projects carried out by the team. This is a "*win-win collaboration*" (Prof. Miranda) which allows the UNS MBDS team to benefit from entrepreneurs' experience, and exploit this learning in projects and for Master's degree courses, and allows "*access to a land of opportunities where we can bring and develop our know-how in the technological fields of our activity*" (Co-founder of Tokidev).

Working on the Wolf platform and the M-PDS proof-of-concept in the Sophia-Antipolis ecosystem provided a supportive environment to generate new knowledge not related to the FIRST project but which led UNS and Gemalto to apply for a joint patent, and for the PHD student to apply for a separate patent in a new but related field: "*the patent I had applied for is absolutely not related to the project FIRST, but its ecosystem enabled me to identify the idea I documented in the 'potential' patent*" (PHD student UNS-Gemalto)

To conclude, it seems that in the NFCampus and FIRST projects, the transfer function was enabled by the industry partners' recruitment of UNS part-time students. This provided training in entrepreneurship and resulted in the emergence of economic activities such as industrial platforms (in the FIRST case) and the generation of new knowledge codified in a patent.

IV. Discussion

Our results show the critical role played by public organizations (here, UNS through the research activities of Prof. Miranda and his MBDS team) to implement a transfer function in the sophipolitan hotspot which played a key role in the birth of a business ecosystem. This role was supported by a digital artefact, a technological platform with a technical architecture resulting from a long innovation and entrepreneurial process. During this period, UNS replicated, combined and recombined knowledge related to the realization of this technical architecture by the MBDS team and its partners. The delicate task of introducing modularity, and enabling knowledge replication (Tsvetkova and Gustafsson, 2012; Zahra and Nambisan,

2012) among the members of an ecosystem who were both partners and competitors, was achieved via a digital platform developed by a public organization (UNS). As Clarysse et al. (2014) underline, the tenant anchor (in our case UNS) is critical for building partnerships and generating knowledge among the partners. This public actor was not disinterested, and was keen to develop its own activities through the emergence of a business ecosystem to accelerate knowledge valorization including potential replication of knowledge. This key actor created a knowledge ecosystem to enrich its knowledge base and include many resources to protect its innovation and to transform innovative ideas into viable products and services. The tenant anchor was critical for both knowledge generation and construction of the knowledge ecosystem, and implementing appropriate rules favoring the birth of a business ecosystem.

The tenant anchor needs to identify precisely the knowledge that constitutes its core activity (the template) and to replicate parts of it while protecting and preserving its knowledge base. Universities and public research organizations fulfilled these critical roles supporting knowledge recombination and its mutation, and favoring the establishment of business ecosystems - particularly in their early phases. Indeed, without a clear IPR policy, the knowledge ecosystem can suffer from abusive appropriability of innovations, and experience difficulties to expand. Gawer and Cusumano (2012) show that a common background makes IPR crucial for the design of a technological platform that embodies a business ecosystem. This condition is especially important in the upstream phase of business ecosystem emergence when the strategic positioning of members is unclear (as happened in FIRST), and there is no identifiable leader.

In contrast to the literature on knowledge filters which points to the significant role of private actors, our findings show that public organizations are critical for the development of technological platforms to extend their initial activity. The conversion of opportunities into innovations and products was enabled by the entrepreneurial role of the director of the MBDS team combined with the innovation process exploiting the replication of knowledge. Winter (2016) claims that the exploitation of new knowledge by actors is not automatic. In our case study, it depended on the entrepreneurial skills of key actors who during each of the NFC projects identified and initiated opportunities to extend the scope of the innovation. In addition to its transfer role, the public actor was able to create the appropriate conditions for the development of new firms (Braunerhjelm *et al.* 2010), such as the start-up Tokidev or the one founded by NFCampus part-time students. Thus, the birth and development of these start-ups are a good illustration of academic spinouts associated to the birth of diverse business ecosystems.

V. Conclusion

This paper discussed the birth of an entrepreneurial activity performed by a public actor enabled by the replication of its initial knowledge base. This process occurred in Sophia Antipolis, a geographical hotspot in southern France, and a traditional knowledge ecosystem characterized by local universities and a public research organization (Lazaric et al., 2008). Exploratory research on the birth of business ecosystems, such as near field communication (NFC) platform ecosystems, shows that companies contributing to this hotspot come from different business ecosystems. However, Sophia Antipolis, by spurring knowledge creation and its diffusion in the region had been shown to be a suitable environment favoring the birth of business ecosystems based on the critical role of a tenant anchor to enable the development of technological platforms. These platforms are the result of the replication of knowledge and resolution of classical IPR management issues related to complex systems such as NFC ecosystems. Our findings show that although implementing new business models is not natural or neutral for knowledge ecosystems (Clarysse et al. 2014), it is a necessary condition for the expansion of activities. We demonstrated the need for a public actor to enable both the birth of diverse business ecosystems and the performance of entrepreneurial activity during knowledge recombination and its mutation. We highlighted that its role goes beyond the traditional knowledge transfer function to include the creation of Schumpeterian opportunities for supporting and participating in the creation a business ecosystem, notably for finding components of the replicator and to implement the replication process. Indeed, this entrepreneurial activity and its contribution to the emergence of this business ecosystem is generally not assumed by a public actor (see Agarwal and Shah, 2014).

This research has some limitations; for instance, we consider only one knowledge ecosystem (Sophia-Antipolis) and only one business ecosystem category (notably a platform ecosystem). Future research could observe diverse knowledge ecosystems in different hotspots characterized by various public and private actors in the upstream phase, in order to identify multiple entrepreneurial contexts.

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Appendix 1.

Table 3. Technologies recombined and changed during the NFC projects.

NFC platform	Technology recombined and/or changed	Results of the innovation
Campus Nova	**CA**: A digital wallet **(T1)** **UNS:** Architecture of NFC mobile applications **(T2)**	A contactless mobile applications proof-of-concept (using RFID/NFC standards) for mobile payment services, access control to classrooms **(T3)** A contactless mobile applications proof-of-concept (using RFID/NFC standards) for deploying a ticketing-couponing mobile services **(T4)**
NFC Container	**Gemalto** : TSM-OTA **(T5)** **UNS** : **(T2)**	**UNS** : a generic API inspired by a SQL approach **(T6)** **UNS and Gemalto:** NFC container Data management API **(T7)**
NFCampus	**UNS** : **(T3), (T4), (T6)** **Docapost :** web solution for ticketing couponing (without midlet but with cardlet) **(T8)** **Moneo : 2nd** generation of a French contactless card of payment **(T9)** **Orange Labs :** artefact for NFC application management **(T10),** a Sim-Centric card **(T11),** access to Citizy application **(T12)** **Cassis International :** TSM-OTA **(T13)** **Mobile Distillery :** Solution for non NFC mobile to be compatible NFC **(T14)**	**UNS** : NFCampus' technical architecture and 'student life' services; the NFC application of Woomji **(T15)** **Docapost :** Woomji **Moneo :** Cardlet and Midlet of Moneo **Orange Labs :** incremental innovation on **(T11)** **Cassis International :** operational and secure solution OTA
FIRST	**UNS** : **(T6)** **Gemalto : (T5)** **UNS and Gemalto: (T7)** **TCS:** TSM-Financial **(16)**	**UNS** : Wolf platform **(T17)** **UNS and Gemalto** : proof-of-concept of M-PDS; extension of **(T7)** with the formalization of SE-QL **Gemalto :** UICC[8] with the formalization of SE-QL **(T18)** **TCS:** Financial inclusion service

[8] Universal Integrated Circuit Card (UICC) is a secure element.