Ba virtual and inter-organizational evolution: a case study from a EU research project

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Abstract

Purpose – *Taking Nonaka's SECI model as the main reference, this paper aims to offer reflections on the virtual evolution of* ba*, the places for knowledge creation. Indeed, looking at the current scenario, widening the knowledge spiral to the inter-organizational epistemological level is inevitable. To this aim, information technology tools and virtual communities can establish effective interactions to exchange knowledge, making* ba *evolve congruently.*

Design/methodology/approach – *The paper takes the exemplary case of a platform developed during a European research project called "BIVEE: Business Innovation in Virtual Enterprise Environments". The investigative approach chosen is participatory action research (PAR), with two researchers conducting PAR in real time, and two others involved* ex post.

Findings – *The paper shows that the virtual evolution of* ba *can lead the SECI model towards an inter-organizational level. Moreover, through a learning history, it describes how all the phases of the SECI process, even the Socialization one, can take place or be supported in virtual spaces.*

Research limitations/implications – *Taking into account just one single exemplary case study provides a rich, contextualized understanding of phenomena, while allowing only some theoretical generalizations.*

Originality/value – *This paper contextualizes the SECI model within a Web platform for open innovation, to investigate whether the knowledge creation process can take place entirely within a virtual environment linking subjects from different organizations. In so doing, it applies the SECI model to the phases of the innovation process, called waves.*

Keywords *Communities of practice, Open innovation, Knowledge creation, Knowledge management systems, Virtual community*

Paper type *Research paper*

1. Introduction

Nonaka's modern conception of knowledge management has stressed the subjective nature and the relativity of knowledge concept. It depends on individuals that hold and create it, but also on contexts and spaces that hold and frame it (Nonaka and Toyama, 2005; Polanyi, 1967).

In particular, in his numerous works, Nonaka elaborated the SECI (Socialization, Externalization, Combination, Internalization) model of knowledge creation at the level of analysis of a single organization, also providing a categorization of organizational spaces that can host each of the phases of the knowledge creation process (Nonaka and Konno, 2005).

Taking Nonaka's SECI model as the main reference, this paper aims to enquire into the contemporary evolution of places for knowledge creation that, in this theoretical framework, are defined as *ba*. Specifically, the paper focuses on the contribution of the virtual dimension and tools to *ba* evolution, taking into account the example of the development of a virtual platform for knowledge creation.

> **"The BIVEE project developed a methodology showing how virtual spaces can be used to effectively enhance and support all the phases of SECI knowledge creation processes at the inter-organizational level."**

Indeed, looking at the current scenario and taking the cue from Nonaka himself, it appears inevitable that the knowledge spiral should be widened to the inter-organizational epistemological level. To this aim, information technology tools and virtual communities can build the bridge needed to establish effective interactions for the exchange of knowledge (Panahi *et al.*, 2013), and, congruently, they can make *ba* change and evolve (Hessman, 2013).

Nevertheless, the main problem with these kinds of solutions has to do with the Socialization phase, as long as tacit knowledge and contextual knowledge sharing seems to be possible only through *vis-à-vis* interactions (see, for example, Saenz *et al.*, 2012). Moreover, inter-organizational knowledge transfer *per se* also seems to be problematic, involving cultural issues and the need for trust (Tuomi, 1999).

This paper attempts to fill this gap and answer these interrogatives in organizational and knowledge management literature. To this purpose, it also takes into account a European research project called BIVEE – Business Innovation in Virtual Enterprise Environments that was given an "Excellence" rating by the European Union (EU). This is the main reason why we considered it a case study exemplar (Yin, 1994).

Adopting a participatory action research (PAR) approach, the project gave birth to a methodology to develop virtual platforms implementing the open innovation paradigm (Chesbrough, 2006; Chesbrough and Appleyard, 2007) and building up a cyber-physical system. In particular, it broke the innovation process into the main waves that are present in any innovation processes, from idea generation to product engineering, and it applied the SECI model to each of them.

Thus, the aim of the paper is to produce some theoretical insights into the virtual evolution of spaces for knowledge creation and the related advancement of the SECI theoretical model. Nonetheless, this paper can also offer some insights as to how to make organizational practice in knowledge and innovation management more effective using virtual spaces and tools.

In the first section, the paper presents a theoretical and multidisciplinary framework. It then deals with methodological and approach issues, presenting the BIVEE project and contextualizing the SECI spiral model and open innovation approach within the platform design. After that, it presents a real learning history to show and explain the functioning of the platform model, structuring it according to the phases of the SECI model. Finally, it draws and discusses some theoretical and practical conclusions.

2. Theoretical framework

2.1 Nonaka's ba

Looking to the original concept by Japanese philosopher Nishida (Nonaka and Toyama, 2005, p. 428), *ba* has to be considered a shared space representing a foundation for knowledge creation, and thus a platform for advancing individual and organizational knowledge (Nonaka and Konno, 2005) through interaction. Then, what represents the essence of *ba* are the contexts and the meanings created and shared through interactions happening at a specific time and space, rather than the space itself. As a result, managing

organizational knowledge means managing the context and conditions through which knowledge can be created, shared and implemented (Choo and de Alvarenga Neto, 2010). In considering the ontological and the epistemological dimensions of the knowledge creation processes, Nonaka and Konno (2005) identified four different stages (Socialization–Externalization–Combination–Internalization) to build up a spiral model. Moreover, they defined a coherent set of *ba* with different characteristics suitable for hosting and better supporting the processes and dynamics of knowledge that take place during each of the different phases:

- Originating *ba* is a dimension where individuals share emotions and experiences by sympathizing and empathizing with others, removing any psychological barriers. That is the primary *ba* that kicks off the knowledge creation process within the Socialization phase.
- Interacting *ba* is an environment that is constructed more consciously by picking people with specific knowledge and capabilities to integrate. Here, during the Externalization process, tacit knowledge is made explicit through dialogue and metaphorical language.
- Cyber *ba* is a virtual world in which to interact and combine explicit pieces of knowledge. The Combination phase taking place in this space is enhanced by information technology that allows the use of on-line networks, group-ware, documentations and database.
- Exercising *ba* supports the conversion of explicit to tacit knowledge. This phase is called Internalization and consists in the continuous implementation of explicit knowledge in real-life or simulated applications.

This *ba* categorization appears to be not only functional but necessary to successfully support knowledge creation in its different phases. However, it is important to know that an organization's *ba* does not consist in the mere accumulation of information or documents, but rather, that it has to be interpreted as a continuous dynamic cycle of converting tacit into explicit knowledge and vice versa (Table I).

Focusing the literature review on Nonaka's original papers on *ba* is a conscious choice. Indeed, despite the possible limitations of considering just one author's work, the decision was dictated by the choice to focus on original sources.

Now, what stands out in this model overview is the great importance explicitly accorded to physical proximity and *vis-à-vis* interaction. They represent the key to conversion and transfer of tacit knowledge and, thus, are the triggers for the whole knowledge creation process. Indeed, according to this model, new knowledge always begins with an individual directly sharing tacit knowledge with another (Nonaka, 1991). On the contrary, virtual spaces, namely, Cyber *ba*, are mostly limited to the combination phase. Here, explicit knowledge is generated and systematized, thus merging information and diffusing it throughout the organization. Obviously, information technology is essential for providing the collaborative environments able to support this phase of the SECI model (Nonaka, 1991). Nevertheless, virtual spaces and information and communications technology (ICT) are mainly considered accessory tools only to be used once implicit knowledge has been converted into explicit knowledge, and then, to merge or store it.

Table I Categorization of *ba* within the SECI model

Ba	*Phase*	*Epistemological level*	*Ontological level*	*Knowledge created*	*Needed tools*
Originating *Ba*	Socialization	Tacit–Tacit	Individual/Individual	Empathic knowledge	Direct interaction
Interacting *Ba*	Externalization	Tacit–Explicit	Individual/Group	Theoretical knowledge	Metaphors
Cyber *Ba*	Combination	Explicit–Explicit	Group/Organization	Systematic knowledge	Information technology
Exercising *Ba*	Internalization	Explicit– Tacit	Organization/Individual	Operational knowledge	Learning by doing

2.2 Inter-organizational knowledge creation

Nowadays, social media or virtual platforms, ICT devices or applications are all able to enhance and support social relationships and knowledge sharing or transfer (Panahi *et al.*, 2013; Siebdrat *et al.*, 2009) and, consequently, they could be considered essential elements for building up a proper space for knowledge creation or innovation. Taking into account the evolution of organizational space itself, it seems necessary to re-discuss and reconsider the spatial aspects of knowledge-related processes. Contemporary organizations merge the physical dimension with the virtual one and work spaces with data flows. They often represent cyber-physical systems, interconnecting webs of information and production (Hessman, 2013).

The interface between electronic communication and physical interaction, the combination of networks and places (Castells, 2005), shape and deeply transform the knowledge creation processes, particularly at the inter-organizational epistemological level, where these considerations acquire significance and relevance.

Moreover, the open innovation paradigm (Chesbrough *et al.*, 2006; Chesbrough and Appleyard, 2007) and the constitution of networks and communities of people and of organizations in the current scenario raise questions about the functioning of the model in cross-cultural organizations. Tuomi (1999) and Šarkiūnaitė and Krikščiūnienė (2005) outlined how the SECI model was developed from the viewpoint of inner action of one single organization and how culture and language are taken for granted without paying any attention to their respective differences. Indeed, one of the main unexplored questions regards how the model functions in a network of many different organizations – or members of those organizations – where cross-culturalism can cause problems due to diverse organizational cultures (Kostiainen, 2002).

More in depth, the essential precondition for Originating *ba* to rise is a strong sense of belonging and a strong commitment of the network members, to make them perceive tacit knowledge transfer as the core purpose of the network itself. To this end, the trigger for the Socialization process is a field in which to interact and share experiences so that it is possible to deeply understand and empathize with others' *modus cogitandi* and mental models (Takeuchi and Nonaka, 2004).

2.3 Communities of practice

Communities of practice (CoPs) have proven to be an important and effective field for socialization and knowledge sharing and creation. By their very nature, CoPs provide a platform upon which to share knowledge, discuss and learn more about a particular topic (Yang and Wei, 2010). They are defined as informal groups of people interacting on a regular basis, discussing problems and sharing knowledge (Lave and Wenger, 1991; Wenger and Snyder, 2000; Wenger *et al.*, 2002).

Consequently, the performance of the CoP relies heavily on the individuals' willingness to share the knowledge they own, on their active collaboration and participation (Yang and Wei, 2010).

For this reason, CoPs obviously rely on physical proximity and face-to-face interaction. Nevertheless, in the past few years, several scholarly contributors to this topic have started to enlarge their interest to virtual interaction. The main studies have taken a look at multinational organizations in which CoPs are focused on the inter-organizational level

"Knowledge management is a key competence for virtual enterprises (VEs) dealing with innovation goals."

> **"Virtual space should not be considered just a tool to collect information or an instrument to ease communication."**

despite having geographically dispersed members and cultural and linguistic barriers (Li, 2010) to deal with. Other studies have taken into account online formats that are paired with an existing face-to-face community and, in these cases, the online environment works merely as a complement to knowledge exchange (Wenger, 1998, p. 45; Hislop, 2002).

Nevertheless, a virtual community of practice (VCoP) is a network of individuals, not necessarily belonging to the same organization, who share a domain of interest about which they communicate online.

To this purpose, high-fidelity communication media (McLuhan and Fiore, 1967; Panahi *et al.*, 2013) are very useful, as they are able to send complete messages, convey plenty of tacit and contextual components and require little extra interpretation. However, Socialization in an online environment is still challenging and, considering the importance accorded to the Socialization phase, the consensus is that it should always include a face-to-face component (Siebdrat *et al.*, 2009; Saenz *et al.*, 2012).

And yet, the open innovation paradigm (Chesbrough *et al.*, 2006) has highlighted the importance of grasping ideas *intra* and *extra moenia* to make organizations reach markets faster, meet their needs more quickly and make their competencies evolve accordingly. In this regard, ICT solutions can meet the need for weak ties to expose individuals to new ideas that can trigger new knowledge creation (Alavi and Leidner, 2001).

2.4 ICT and Cyber ba

Nowadays, various communities have already taken advantage of the Web to facilitate communication and information flows inside and outside of the community (Bugshan *et al.*, 2015; Siebdrat *et al.*, 2009). However, it is evident that cultural barriers to knowledge sharing and transfer cannot be effectively reduced or eliminated just through ICT applications (Panahi *et al.*, 2013; Li, 2010). Moreover, new knowledge creation processes and innovation itself depend not just on the free flow of information in general, but on the recombination of non-obvious knowledge to trigger innovative solutions to complex problems. The human factor is the essential one when it comes to knowledge and knowledge creation processes, in which technology can still represent a useful tool.

A key-concept of VCoPs is the management of knowledge acquired or developed within the community. That is to say, that the knowledge needs to be indexed and stored to be easily retrieved. However, VCoPs should not be seen as a technical environment alone. Indeed, while online communities are cyber-spaces with computer-mediated communication that enable knowledge sharing (Zhang and Watts, 2008), VCoPs are virtual contexts in which knowledge creation takes place.

In Nonaka's SECI model, ICT is contextualized within Cyber *ba*. This *ba* can be considered a place of monologue, in which new explicit knowledge is combined with existing knowledge. However, considering the flexibility of modern IT, other forms or features of organizational *ba* and the corresponding phases of knowledge creation can be enhanced through several kinds of information systems (Alavi and Leidner, 2001), especially considering the inter-organizational epistemological level.

3. Methodology

This paper pursues its aim of inquiring into the virtual evolution of spaces for knowledge creation, contextualizing the SECI model within a Web platform for open innovation.

More specifically, the paper uses the example of a platform developed during a three-year project financed by the EU that received an "Excellence" rating for the final outcome. The R&D project is called "BIVEE: Business Innovation in Virtual Enterprise Environments" and is part of the Factories of the Future FP7 project, sub-program area: FoF-ICT-2011.7.3 – Virtual Factories and enterprises (http://cordis.europa.eu/project/rcn/100275_en.html). It engaged nine different European partners until December 2014 and was dedicated to the creation of an ICT environment for managing innovation. The fact that the project was financed and then given an "Excellence" rating by the EU is the main reason why it was chosen as an exemplar case study (Patton, 1990; Yin, 1994; Eisenhardt, 1989; Eisenhardt and Graebner, 2007) for this paper.

3.1 Approach

Given that this is a research-for-development project, aimed at linking theory and practice through research, the approach chosen is PAR.

In spite of the difficulty and scepticism linked to the supposed lack of scientific rigour and discipline in action research and the difficulty of generalizing results from these kinds of studies (McKay and Marshall, 2001), this approach appears to strongly fit the analysed case and the studied phenomena.

The success of applying this research approach to this paper can be retrieved in Lewin's thought that causal inferences about the behaviour of human beings are more likely to be valid and enactable when the human beings in question participate in building and testing them (Ragsdell, 2009; Brydon-Miller *et al.*, 2003; Gummesson, 2000).

In this research, two of the researchers were end-users of the project and agents of change, actively promoting and participating in the BIVEE European Project (de Guerre, 2002). They indicated the requirements, participated in the platform's design according to open innovation principles and organized innovation processes, aware of the SECI phases and dynamics. That means that they had a certain degree of familiarity with knowledge management in general and with the SECI model in particular. Not only did they acknowledge the importance of the epistemological shifts between implicit and explicit knowledge and vice versa to be taken into account for the building up of effective data storage and retrieval systems, but they were also aware of the importance of the ontological dimension, choosing to design the Web platform putting individuals and their relationships at the centre, while constantly operating at an inter-organizational epistemological level.

Consequently, the two researchers conducted PAR in real time, while the other two were involved *ex post* (Leonard-Barton, 1990; Eisenhardt and Graebner, 2007). In this way, it was possible to have a different point of view that could help re-elaborate facts in a traditional case study written in retrospect to have a "learning history" that could be used as an intervention to promote reflection and learning in the organizations (Gummesson, 2000). The methodology related to this second part is further described in Section 5 of this paper.

3.2 The BIVEE project

The underlying approach of the project appears to be of particular interest to this paper, as it was aimed at putting people in the centre, with their creativity and competencies, providing a nurturing environment where open thinking and free interaction are more important than formal processes and stringent control (http://bivee.eu/). Indeed, the BIVEE Platform heavily relies on the collaboration of different skilled actors to successfully conduct an innovation venture. The adoption of an open innovation approach further enforces this aspect, envisioning the participation of different stakeholders also belonging to the surrounding business ecosystem or even to the "external world".

Due to the high heterogeneity of networked organizations, a primary issue is the need for knowledge sharing, efficient access to knowledge resources and interoperability

technologies. To this extent, the BIVEE project considers the virtual enterprise (VE) environment, a temporary alliance of businesses that come together to share skills or core competencies and resources to better respond to a single project or business opportunity, and whose cooperation is supported by computer networks (Chesbrough, 2006).

The BIVEE project also takes into account and splits into two different spatial dimensions: the value production space (VPS) and the business innovation space (BIS). While ideas for production improvement are mainly created and elaborated in the VPS, pure or radical innovations emerge from the BIS. This corresponds to the idea of the coexistence of material and abstract components within the organizational innovation process and stresses the difference between improvement and innovation concepts and dynamics (Smith *et al.*, 2013).

Concretely, the BIVEE project develops a distributed and collaborative platform of ICT services with two well-differentiated scopes: enterprise innovation management and production processes improvement. Indeed, the BIVEE environment is based on:

- a *Mission Control Room*, for monitoring VEs value production activities;
- a *Virtual Innovation Factory*, for managing the entire cycle of innovation ideas development; and
- a *Production and Innovation Knowledge Repository* (PIKR), for providing a unified access point to heterogeneous knowledge resources (e.g. business processes, documents, technology, business domains, competitors).

Thus, the BIVEE environment is a complete knowledge management system to pursue innovative solutions or products and, consequently, new knowledge. That means that the whole system is finalized towards knowledge creation, and thus towards supporting and hosting the SECI model.

4. The knowledge creation process within BIVEE

The knowledge circle establishes the knowledge exchange interface between the BIS and the VPS and also describes how ideas are enabled as long as knowledge is advanced iteratively (Rossi *et al.*, 2012, p. 14). It is based on Nonaka's SECI model, the process coming from Socialization, Internalization, Combination and Externalization carried out in both spaces.

However, implementing an open innovation approach means bringing about an important evolution in the SECI spiral model. Indeed, the BIVEE platform takes into account the inter-organizational dimension from the very beginning. The inter-organizational level does not come as an incremental ontological shift succeeding the organizational one (Wu *et al.*, 2010). So, when considering knowledge creation phases, the BIVEE platform does not consider individuals or groups belonging to the same organization, but rather it involves individuals, groups and organizations acting in the same virtual space.

Nevertheless, while aiming to describe the main mechanics, the knowledge circle is not meant to be a deterministic model. The BIVEE approach with respect to innovation tries to find a compromise between guidance and freedom.

To give some guidance to the innovation space, the BIVEE project divides and organizes the innovation process in four main waves (Knoke, 2012). The underlying concept of waves in the BIVEE project strongly characterizes it and differentiates it from linear phase models (Whitehead, 1926; Birkinshaw and Mol, 2006). Indeed, the concept of "wave" is not rigid and can support the variability and the recursiveness of the innovation process. Consequently, this implies that the innovation process within the BIVEE project is rendered by four distinct moments that are not linearly subsequent and consecutive, but that can also overlap (Knoke, 2012, p. 21).

Moreover, the main steps considered in this model are generally acknowledged in innovation management and, despite different nomenclatures and classifications, they are a constant within any innovation project *lato sensu*:

- *Creativity*: Starts with an innovation idea or a problem to be solved, providing a first sketchy idea to be developed. It mainly refers to creative activities and initial connections.
- *Feasibility*: Justifies the actual undertaking and the further development of the original idea in economic and operational terms by collecting and providing the necessary information.
- *Prototyping*: Produces a first implementation of the initial idea in the form of a prototype. The idea is drawn into the real world for the first time.
- *Engineering*: Contains testing and overhaul procedures. The original idea transformed into a prototype is attentively analysed to generate production and engineering plans (Taglino *et al.*, 2012).

Now, each of these waves can be seen as giving birth to different but interrelated SECI spiral processes, that intertwine information flows with production ones, space of flows with space of places. Once the SECI spiral within a wave is accomplished, resulting in knowledge creation, it leads to the next wave, corresponding to the next step of the innovation process that finally results in the manufacturing process.

5. Learning history: the Flumen innovation project

To understand how the platform works and how the waves can be contextualized within the SECI model, an example of an innovation project is described hereafter. This is a project developed in a realistic industrial scenario and conducted through the BIVEE environment.

The learning history goes back over the steps of the development of the innovation project, describing it throughout the waves that eventually lead to the manufacturing.

The wave partition is macroscopic and quite neat. Indeed, the waves were easily identified *in itinere,* while activities and relative documents were taking place or were being recorded on the Web platform.

The four SECI phases within each wave were identified *ex post* and the learning history was elaborated using qualitative criteria. In fact, the identification mainly relied on the researchers' knowledge of SECI model theory and their ability to collocate each action in the corresponding SECI phase. In doing so, the researchers used Nonaka (1991) and his major example of Matsushita Electric Company and its home bread-making machine as a guiding light. They summarized the different characteristics of each of the phases that were outlined in Nonaka's example and then further described in some of his later works (Nonaka, 1991; Nonaka and Takeuchi, 1995; Nonaka *et al.*, 2000).

The criteria are the key elements shown in Table I, i.e. the two dimensions of the SECI model (the epistemological and the ontological levels), the kind of knowledge created and the needed tools. Once adapted to the virtual environment within which the innovation process took place, these characteristics helped researchers in their evaluation. The considered criteria are reported at the end of the corresponding learning history phase, along with the exact literature reference.

Additionally, the identification process was conducted separately by two researchers – one who dealt with the learning history and one who participated in designing the BIVEE platform and carried out the Flumen project within the virtual environment. The two versions were compared and discussed and then reviewed by the other researcher dealing with the learning history. In this way, although the criteria are qualitative and linked to subjective evaluation, eventual bias risks were minimized.

The project at the centre of the learning history is called Flumen and is supported by the Loccioni Group, a medium-sized Italian company that is one of the BIVEE partners and an end-user of the platform. Flumen is a project aimed at developing a system for real-time monitoring of bridge piers for scour risk during floods.

As the Loccioni headquarters are located next to the Esino river and the Scisciano bridge connects two of the main buildings of the Group, there was a need to develop a robust and reliable system for objective monitoring, replacing decision processes based on the subjective experience of technicians. The project led to the development and set up of a monitoring system targeted to controlling the phenomenon of pier scouring, a sedimeter called BLESS+ (Bed Level Seeking System) (Figure 1).

5.1 Creativity wave

5.1.1 Socialization. The project started with a specific request from Loccioni's top management during an internal meeting with the Research for Innovation team (the Loccioni internal team tasked with developing long-term research projects and innovation). The team was asked to develop a monitoring system able to check for seismic vulnerability of the nearby bridge.

One of the Research for Innovation engineers had an intuition: the vulnerability of the bridge could be caused by hydrogeological risk. She logged into the BIVEE platform to insert the idea in the Virtual Innovation Factory and shared it with other engineers in the "innovation team".

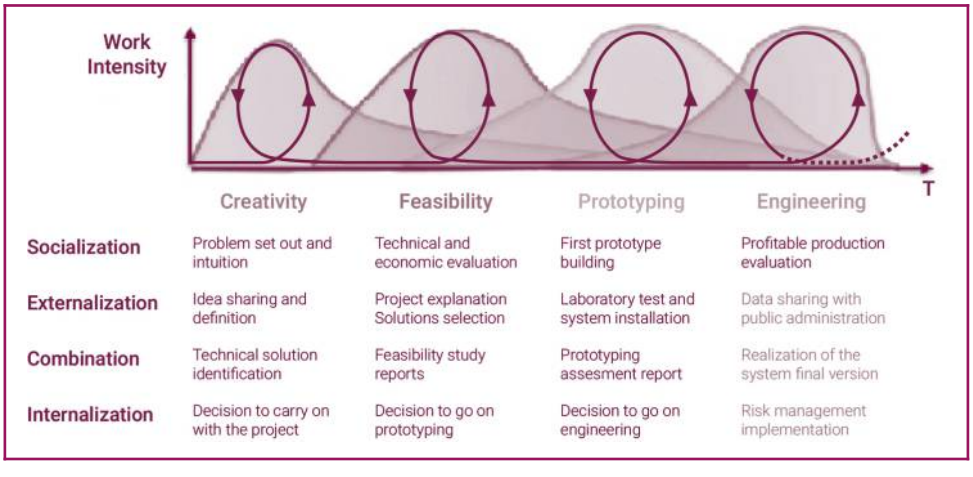
Criteria: personal insight coming from the researcher's competencies applied to a new exigency (Nonaka, 1991, p. 97).

5.1.2 Externalization. The Loccioni engineer acknowledged that the Scisciano bridge had partially collapsed during a flood of the Esino river in the 90s, so she collected information about the causes. In the Loccioni Group's internal database, she found the technical report stating that the bridge had collapsed because of pier scouring problems. She shared the collected documents, selected possible required competencies for this idea and found matching domain specialists among BIVEE users.

Criteria: idea sharing (Nonaka, 1991, p. 99; Nonaka *et al.*, 2000, p. 9); abductive thinking (Nonaka *et al.*, 2000, p. 11), i.e. analogies with historical events; competencies' selection (Nonaka *et al.*, 2000, p. 17).

5.1.3 Combination. The Innovation Team uploaded documents and added comments in the Idea Wizard (a kind of remote desktop where each member can modify, add, share

Figure 1 The SECI model applied to the four main waves of the Flumen innovation project



documents and interact). As a result, they found two different technologies that could be used to measure the pier scour, based on sonar and fiber Bragg grating.

As all the requested fields were completed and a lot of documents uploaded, the idea was considered suitable for turning into an innovation project. At this point, both of the technical solutions were evaluated, in light of the existing literature, and the conclusion was reached that the second solution (the BLESS system, developed and patented by an Italian Polytechnic University) would be much more reliable in case of flooding. After having checked out the marketing report and chosen the key performance indicators (KPIs) to take into account, the Innovation Team submitted the Innovation Report to Loccioni management.

Criteria: document collection; production of a systematic set of knowledge (Nonaka *et al.*, 2000, p. 9), i.e. the Innovation Report.

5.1.4 Internalization. Loccioni management decided to go ahead with the feasibility wave of the project and the decision was announced via mail. At this moment, the project switched to the feasibility wave.

Criteria: explicit knowledge embodiment (Nonaka *et al.*, 2000, p. 10); action triggering (Nonaka *et al.*, 2000, p. 17).

5.2 Feasibility wave

5.2.1 Socialization. Researchers and business people worked in cooperation to understand the technical and economic feasibility of the project. The technical solution proposed by the Innovation Team had to be improved and simplified to be engineered so as to obtain a high-performing and reliable system.

Criteria: interaction between individuals (Nonaka *et al.*, 2000, p. 16); experience sharing (Nonaka and Takeuchi, 1995, p. 62).

5.2.2 Externalization. The project and the sub-projects were explained, specifying again the members of the Innovation Team and the required competencies.

First of all, the Innovation Team chose the suppliers for components, looking for the best solution in terms of cost and performance. Once found, the solutions were shared through the BIVEE platform and suppliers became partners of the Loccioni VE and members of the Innovation Team. At this point, different components were tested and a satisfactory solution was found.

Criteria: project articulation and sharing (Nonaka, 1991, p. 99); selection of individuals (Nonaka *et al.* 2000, p. 17).

5.2.3 Combination. The Feasibility Study Report was prepared and uploaded to the platform. The document included the state of art, the sub-projects, the risk and the cost–benefit analysis along with some recommendations for the realization phases. Once the last technical aspects were discussed, the Innovation Team was ready to build the first prototype.

Criteria: data gathering and processing; production of a systematic set of knowledge (Nonaka *et al.* 2000, p. 9), i.e. the Feasibility Study Report.

5.2.4 Internalization. Loccioni top management had to evaluate again the state of art of the project through KPIs and documents. They understood that although there were high risks, the project faced an actual and crucial problem, which could involve both public and private aspects, and they decided to go on to the prototyping wave.

Criteria: explicit knowledge embodiment (Nonaka *et al.*, 2000, p. 10); reflection through action (Nonaka *et al.*, 2000, p. 17).

5.3 Prototyping wave

5.3.1 Socialization. The Innovation Team started to build the first prototype, respecting the tight constraints on the budget while trying to maximize the reliability of the BLESS system. Five sub-projects were identified: Bless system, civil project, electrical project, mechanical project and external heating circuit.

Criteria: observation and practice (Nonaka, 1991, p. 99); tacit knowledge: a craft or profession, a particular technology or the activities of a work group (Nonaka, 1991, p. 98).

5.3.2 Externalization. The first tests conducted in the laboratory proved that the solution was really robust, flexible and reliable. All the sub-project reports were completed to continue with the installation. Then, when the system was installed on the Esino riverbed, close to a bridge pier, technical problems occurred. As a result, there was a positive deviation from the planned cost, but the results were nevertheless considered successful because the levels of risk and uncertainly were very high.

Criteria: dialogue and cooperation (Nonaka *et al.*, 2000, p. 11) among sub-projects; knowledge crystallized in data (from the tests); product specification (Nonaka *et al.*, 2000, p. 9).

5.3.3 Combination. The BIVEE Prototyping Assessment Report was completed, including comments and feedback, based on reports and KPI analysis to take into account during the engineering wave.

Criteria: information and data gathering; production of a systematic set of knowledge (Nonaka *et al.*, 2000, p. 9), i.e. the BIVEE Prototyping Assessment Report.

5.3.4 Internalization. After a long and detailed measuring campaign, the Innovation Team established that the improvements suggested for the system made it ready for the engineering wave.

Criteria: explicit knowledge embodiment (Nonaka *et al.*, 2000, p. 10); action triggering (p. 17).

5.4 Engineering wave

5.4.1 Socialization. Loccioni's top management required a careful analysis of all the components to guarantee a cost-effective selection of components for the profitable production of several units of the system. The results obtained from the prototyping wave showed that the cost of the components of this first prototype was too high. However, by also analysing the strategic factors and market opportunities, the cost was considered acceptable in relation to the innovative potential of the system. Therefore, Loccioni management decided to go forward with the engineered version of the BLESS+ system.

Criteria: new tacit knowledge through shared experiences (Nonaka and Takeuchi, 1995, p. 62); intuitions guided by technical and managerial knowledge, i.e. intuitive sense of market trends (Nonaka, 1991, p. 97).

5.4.2 Externalization. At the moment, the project is still in the Engineering wave, waiting to complete the final version of the BLESS+ system for a new customer. It is worth noting that these data will be used to manage hydrogeological risk and will be shared with public administrations for damage evaluation and alert management. In other words, the project is still on-going and the engineering wave is about to be concluded.

Criteria: articulating the foundations of an individual's tacit knowledge and sharing it with others (Nonaka, 1991, p. 99).

6. Discussion

Nonaka's SECI model is the cornerstone of the modern knowledge management. It moved the emphasis onto individuals and their tacit and implicit knowledge. Nevertheless, the numerous contributions by Nonaka stop at an intra-organizational level of analysis; little do

they analyse about inter-organizational epistemological, and even less do they take into account the modalities of the implied interactions.

Consequently, there is room for drawing some interesting insights about the evolution of *ba*, taking into account the open innovation paradigm and considering organizations as cyber-physical systems.

This paper was built around the BIVEE project, which was aimed at developing a methodology to build a platform for sustaining and managing innovation linking different organizations in a virtual environment. According to the PAR approach, the design of the structure of the platform itself was influenced *ex ante* by the willingness to concretely apply the open innovation paradigm and the SECI spiral model for creating new knowledge.

6.1 BIVEE methodology

Knowledge management is a key competence for VEs dealing with innovation goals. Their distributed structure can be both a thread and an opportunity, giving access to a wide spread of inter-disciplinary knowledge, or leading to the diffusion of knowledge and ideas.

What came out of the BIVEE research project is first of all a methodology to develop structured and functioning platforms involving a network of different organizations and making them share and mutually grasp knowledge efficiently. Moreover, the BIVEE project also developed a methodology to manage an innovation project completely at the inter-organizational level.

Specifically, the BIVEE methodological approach to innovation management is related to:

- *Repository function*: BIVEE follows a centralized approach, storing the knowledge from the VPS and the BIS in a set of ontologies that are organized in the PIKR. The framework is built around two basic sets: a standard library which allows companies to set up environments for collaboration and process alignment, and a set of standardized semantically defined metrics, which makes it possible to quantify and benchmark processes from a strategic point of view (Rossi *et al.*, 2012).
- *Efficient management of innovation and production processes*: BIVEE splits the innovation process into four waves. This partition makes for easier tracking and management of the processes (Rossi *et al.*, 2012). To this extent, BIVEE adopts a "document-based" approach, focused on the documents exchanged during the improvement and innovation activities within a VE (Taglino *et al.*, 2012). That is to say, a specific innovation project moves through the waves producing a number of documents for each wave and, more specifically, for each activity of each wave (Rossi *et al.*, 2012).
- *Effective monitoring and measuring activities*: BIVEE methodology also includes a Monitoring Framework aimed at achieving a constant and effective monitoring of the industrial reality where BIVEE is adopted. To this extent, KPIs are intended as virtualization instruments that enable the monitoring of physical production in a digital environment such as BIVEE (Rossi *et al.*, 2012). Indeed, one of the objectives of the BIVEE Framework is to support and connect Innovation space and Production space to create an integrated meta-space through a continuous flow of ideas and information.

These components have given birth to a virtual platform model that could encompass and host all the knowledge creation phases at an inter-organizational level. Indeed, along with the storage of knowledge, BIVEE encompasses the creation of knowledge as well. Specifically, knowledge-creating activities within the BIVEE environment follow the SECI model and adopt a human-centric approach.

6.2 The SECI virtual evolution

The Socialization phase in this kind of platform does not strictly require a physical interaction, but it is possible thanks also to ICT tools provided by the platform. *Vis-à-vis*

interaction can be effectively replaced or supported by virtual interaction provided by rich media (McLuhan and Fiore, 1967; Panahi *et al.*, 2013).

Indeed, the BIVEE platform has implemented several virtual tools to enable effective speed and collaboration throughout the innovation process. One of the most important is the Idea Wizard, where documents can be uploaded and comments posted about the innovation idea. Another interesting function is the Observatory of Open Innovation, through which the platform can automatically retrieve other innovation ideas, knowledge and documents related to the inserted idea.

Along with the Wizard, there are several other virtual tools like the chat-room, the forum and, the most important one, the meeting room. In this virtual space, individuals on the Innovation Team can brainstorm and meet together to discuss the content presented in the Wizard and can also see each other.

For instance, in the learning history of the Flumen project, these rich media tools provided important support for socialization in the prototyping wave. Indeed, besides involving geographically dispersed individuals belonging to different organizations, the project was so complex and innovative that it was split into several sub-projects, depending on the specific technical issues involved. For this reason, the platform and its tools were fundamental and very useful for managing all the steps, sharing knowledge and monitoring the KPIs related to each step. Moreover, they allowed different know-how and technical expertise to be shared, and also team work and social knowledge to be built (Nonaka *et al.*, 2000).

Consequently, it no longer seems appropriate to speak about Cyber *ba* just to contextualize the Combination phase. Hence, this work suggests exclusively adopting the nomenclature Systemizing *ba* that Nonaka (Nonaka *et al.*, 2000) used in one of his works to indicate the *ba* that hosts the combination phase. In fact, all of the SECI phases can take place totally or partially in virtual spaces; consequently, all kinds of *ba* can be both physical and virtual.

Moreover, the virtual environment makes it possible to overcome the single organization barriers from the very beginning. Implementing the open innovation approach, individuals look for useful knowledge from outside the company and for individuals, groups or organizations that own this knowledge. Concretely, this results in a re-framing of the SECI model itself.

If Nonaka's SECI model describes an incremental and gradual process from the epistemological point of view, starting with individuals, spreading to groups of the same organization and eventually involving the whole organization (Nonaka, 1994), here things are different because they involve inter-organizational interactions from the very beginning. Individuals and groups do not necessarily belong to the same organization, but are interacting thanks to ICT tools in the same virtual environment.

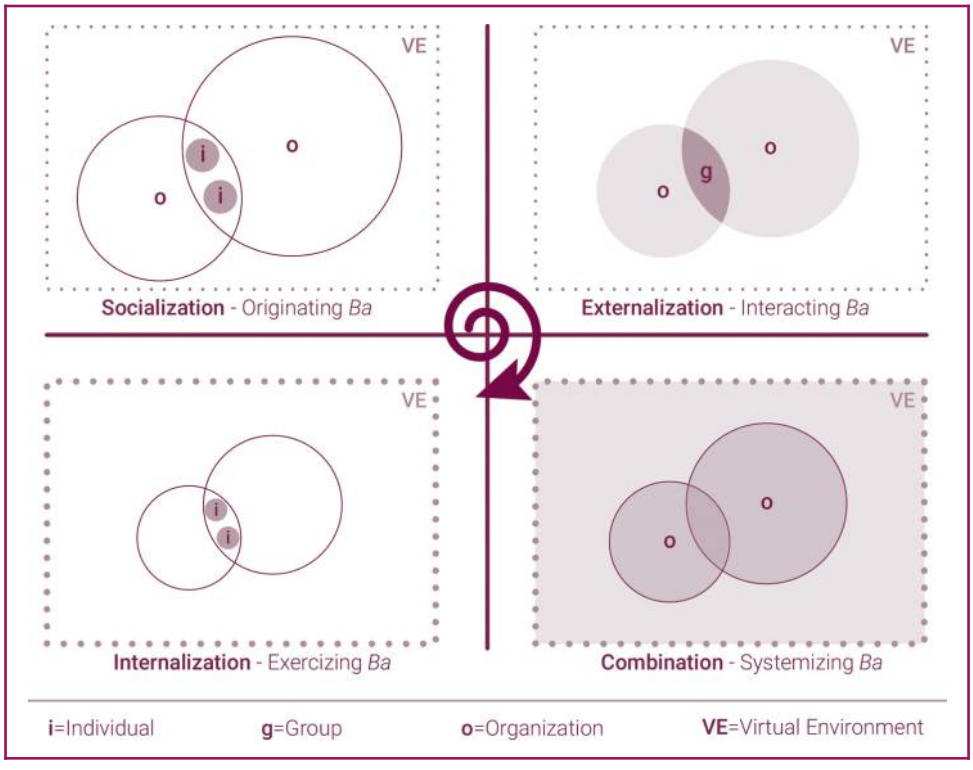
Consequently, in this paper, the inter-organizational level is not considered a shift (Wu *et al.*, 2010). It is a constant, rather than an incremental ontological level (Figure 2).

Moreover, within the BIVEE environment, inter-organization is not just an ontological level in the knowledge creation process. It starts from knowledge sharing, implying a certain level of interaction through the use of the BIVEE platform, and eventually and most relevantly for the sake of the project, it results in an inter-organizational implementation and realization of the innovative solution. So, while the SECI model shows how the interaction takes place at the inter-organizational level for knowledge creation, the wave partition shows how the interaction takes place horizontally up to the production.

6.3 Virtual enterprise and virtual community of practice

It can be said that the BIVEE platform builds up a proper VCoP. Indeed, the active participation of the different actors is sustained by a strong commitment and an explicit

Figure 2 Re-elaboration of Nonaka's SECI model to fit inter-organizational ontological level within a virtual environment



purpose. Being involved in the same research project or in the development of an innovative idea is the key factor to building up a common ground to enact interaction.

Certainly, the fact that subjects belong to a common technical and technological background supports the creation of the network and the rise of the needed trust (Takeuchi and Nonaka, 2004). The sharing of practices establishes one shared context that helps overcome other contextual differences (Gammelgaard and Ritter, 2008). Nonetheless, a great heterogeneity of the network should be acknowledged, including, for example, both private companies and universities from different countries and integrating different fields of knowledge and expertise.

This interaction is possible even if there is a lack of physical proximity, because communication happens in cyberspace. In this sense, the online communities that arise around the platforms not only offer the possibility for information exchange but they also enable people to socialize (Gammelgaard and Ritter, 2008). Obviously, strong links among individuals or organizations can be a prerequisite for the success of this Socialization, that is to say, of tacit knowledge sharing in a virtual environment. However, interactions in virtual environments can be useful to establish weak links (Alavi and Leidner, 2001) or to strengthen the existing ones.

Indeed, modern ICT tools and platforms are useful not just to store and retrieve documents or information, separating it from the owners, but to bring individuals and social interaction back to the centre of knowledge sharing and transfer, according to Nonaka's conception of knowledge management. They represent a step beyond ICT implementation, moving from information management to proper knowledge management, from online communities to VCoP implementation and from knowledge sharing to knowledge creation.

Actually, in this model, the VCoP concept is entwined with the VE one. Indeed, while the VCoP is linked to knowledge management and knowledge flows, referring to innovation

space, the VE is linked to engineering and manufacturing processes, referring to production space.

Thus, it can be stated that in the BIVEE project, VCoP and VE concepts are combined to encompass both the knowledge creation aim of this kind of platform, and the pragmatic and industrial nature of the context. In this way, knowledge creation and the SECI spiral can be applied and contextualized up to the production processes, and they constantly relate to the inter-organizational ontological level.

7. Conclusions

The BIVEE project developed a methodology showing how virtual spaces can be used to effectively enhance and support all the phases of SECI knowledge creation processes at the inter-organizational level. Specifically, the project shows that the socialization phase can also be supported by rich media in virtual spaces.

Through the wave partition for innovation management, it is possible to consider the SECI spiral at a different level of analysis. Entering the manufacturing and engineering processes, the SECI model goes all the way to the production process, while through a virtual platform, it is possible to implement an open innovation approach based on inter-organizational knowledge sharing. For this reason, the VCoP concept could be taken into account along with the VE one.

Finally, virtual space should not be considered just a tool to collect information or an instrument to ease communication. It is not merely Cyber *ba*, in which only explicit knowledge can be contemplated. It is about the whole SECI spiral. When speaking about VCoP, it is not just about a technical environment that is used to enable knowledge sharing, but it is about relationships and interactions creating knowledge.

7.1 Limitations

Of course, the limitations of having taken into account a single case study are evident. However, the choice to use a case study as an exemplar allows some theoretical generalization (Yin, 1994). Moreover, having considered a widespread partition in innovation management confers to the case study some general value.

Also, the methodology behind the identification of the SECI phases in the learning history strongly relies on the individual's interpretation and expertise. However, some theoretical guidelines were extrapolated and summarized from Nonaka's past works and followed, to give consistency and reliability to their interpretations, and a validation process was carried out.

Finally, the innovation project described in the learning history is still in progress. In this case, the production time was not compatible with the research time of the European project (that lasted three years). Nonetheless, the main steps and the main interactions that are not yet completed were already identified and collocated in the relative SECI phase. However, for the interests of this paper, the focus should stay on the platform rather than on the innovative product or the solution realized through it.

7.2 Implications for practitioners

Open innovation management is crucial, not just for grasping knowledge and information from the outside, but also for creating new knowledge through collaborations. Effectively building and managing inter-organizational relationships and interactions represent a key point for today's organizations.

This paper shows that Web platforms can represent a way to successfully carry out an innovation project involving individuals who are geographically dispersed and who belong to different organizations. The Web-platform model the article takes into account consists of an advanced knowledge repository (PIKR). Nevertheless, modern ICT platforms should

not just be made up of a knowledge repository to store and retrieve digitalized explicit knowledge. They should be developed with the underlying awareness that there is a part of the knowledge, often referred to as tacit knowledge, that remains concealed in the heads of people (Taglino *et al.*, 2012, p. 10).

For this reason, the Web-platform model taken into account here also consists of a Mission Control Room and a Virtual Innovation Factory, that attempt to manage people's presence and interactions while involving a certain degree of tacitness of the knowledge that is exchanged and used to find solutions, take decisions and assess value (Šarkiūnaitė and Krikščiūnienė, 2005).

The methodology behind the Web platform construction along with the wave partition model provide a way to effectively manage and monitor innovation processes within industrial contexts.

7.3 Implications for researchers

It can be stated that if we consider the open innovation paradigm and organizations to be cyber-physical systems, then Nonaka's *ba* categorizations need to be updated:

- The SECI spiral itself should be reviewed to take into account the inter-organizational ontological level being a constant rather than an incremental shift.
- It seems no longer appropriate to speak about Cyber *ba* just to contextualize the Combination phase. Thus, this work suggests exclusively adopting the nomenclature Systemizing *ba*.
- Face-to-face interactions and physical proximity are no longer *sine qua non* elements crucial to building up an Originating *ba* and thus to having a socialization process. Indeed, within a virtual environment, socialization is possible, thanks also to reach communication tools.
- The SECI model can be applied to and contextualized in industrial processes at different levels of analysis.

Virtual evolution of the spaces for knowledge creation also affects CoP:

- Thanks to a virtual environment and tools, a VCoP can reach an inter-organizational level, involving individuals who are geographically dispersed and who belong to different organizations.
- The VCoP concept can intertwine with the VE one to encompass the whole innovation process. This combination describes a virtual community sharing competencies and creating knowledge with the goal to collaboratively produce an innovative solution or product.

7.4 Future research

Future research works should go on exploring the virtual evolution of *ba*. There are many methods and tools to take into account and many others will come. The BIVEE project, for instance, has also hypothesized social network integration in the Web platform, but it has not implemented the idea in the developed platform, yet.

Additionally, research should validate the results of this paper, presenting other cases using the same BIVEE platform, or comparing the methodologies and findings of other Web platforms.

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