

# Examining exploration/exploitation along the innovation process in a network: Insights from a case HYGTECH

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## ABSTRACT

Innovations are increasingly developed and commercialized within networks. However, few firms have the capability to manage by themselves throughout the entire innovation process; from visioning and developing to commercializing. Therefore this study analyzes the process of how divergent collaborative organizations explore and exploit their resources along the innovation process comprising visioning, developing and commercializing in order to achieve their goal, a successful innovation. By building a framework for the exploitation/exploration process of visioning, developing and commercializing new innovative solutions in an extensive complex network and by conducting a longitudinal case comprising a network of over 20 firms this study generates contribution to both network and innovation research.

**KEY WORDS:** Innovation, innovation process, network, exploration-exploitation, market visioning, research and development, commercialization

## INTRODUCTION

Innovations are increasingly developed and commercialized within networks. The tendency to innovate within collaborative networks is becoming stronger because of the high complexity and costs, and technological interconnectedness (e.g., Ritter and Gemünden, 2003). Few firms have the capability to manage internally throughout the entire innovation process; from visioning and developing to commercializing (e.g. Håkansson & Waluszewski, 2002; Snow et al. 2011, Story et al., 2009; Aarikka-Stenroos et al. 2014). These sub-processes are partly sequential and also iterative and so continuing research is needed to understand how networks of actors accomplish commercialization of an innovation. The final phase of how new technologies find a place in the network (Medlin & Törnroos 2014) is also a continuing research question. Breakthrough innovations particularly require both development of new and existing technologies and exploration of a future business network (Medlin & Törnroos 2014). However, the more complex the networking for innovation, the more problematic becomes finding a complementarity and a consensus among the network actors and the goals for collaboration (Aarikka-Stenroos & Sandberg, 2012). Also, many elements, such as different industries, technologies, goals, and target markets create greater complexity for the process of innovating in networks. Hence, our research focus is the often cumbersome process of innovating in networks.

The literature suggests manifold definitions of the term innovation (e.g., Garcia & Calantone, 2002) and here we follow the meaning of developing a new product or service that provides economic value, and is aimed to be diffused to other parties beyond the innovator firm, whereas an invention has not passed the production and marketing stages. There are number of issues that arise when researching innovation in a network setting. The conventional innovation and new product development literature tends to rely on an idea that innovating occurs through programmed “phases” or “steps”. In this approach the first step is where a combination of actors focus on a need for a new technology to complement or improve some existing technology (visioning process). In the second step there is a need to develop and attune a new technology to interface with a previously developed one (research and developing process). The third phase involves adapting the new combination of technologies to many heterogeneous contexts (commercializing process). In each of these three innovation elements (i.e. visioning, R&D, and commercializing) the nature of the problems and the required actors to facilitate solutions will change; actors will come and go according to the understanding of the problem. However, recent research (e.g. Aarikka-Stenroos & Lehtimäki, 2014, Prencert 2012) indicates that the activities associated with the three innovation elements overlap and influence each other so that decisions made in one activity sphere often have an unexpected impact on other activities. In other words, the sequence of activities has later implications, and many are unforeseen. Thus, our first research question is: what factors affect the complex interplay of activities required to bring an innovation to commercialization?

A second research issue arising in a network setting is that many actors are involved together in exploring and exploiting (Medlin & Törnroos 2014) within and across the three innovation elements. Each actor exploits their surrounding network to explore and search for new actors to tackle the next technology issues and also multiple actors are exploring the nature of the final commercial solution in a future network (Medlin & Törnroos 2014, Rothaermel & Deeds, 2004). Past research on exploration and exploitation has focused on a single firm having an ambidextrous capability for these activities (March 1991, O’Reilly and Tushman 2008), but a networking perspective of exploring and exploiting provides many more solutions and opportunities and leaves open the question of how the innovation phases are affected by multiple actors heading in sometimes different and the same directions and also towards different goals. In this perspective the possible solutions devolve from many future options (Heger & Rohrbeck 2012), and there are chance events and also unknown options that are attracted to the evolving solution as actors in distant parts of the network undertake their exploring activity. Thus, our second research question is: how does the interlinking of different actors exploring and exploiting activities elaborate and lead to solutions in the unfolding asymmetric innovation process?

In essence innovation in a network is a dynamic process, which can be viewed in at least two time

perspectives: (1) a logical objectivist sequence, and (2) a constructivist process view. In the first view the whole process is grasped and seen from a rearward perspective with the three innovation elements; ideation, R&D and commercialization, spread logically as steps in times path (see Godin, 2006). Next these three elements are linked in either a linear development or in a more messy and iterative set of activities (cf. Aarikka-Stenroos & Lehtimäki, 2014; Prebble et al. 2008; Chesbrough, 2003;). Assumed is a rational goal driven process, where each development period arrives at its named completion. In contrast the second view makes explicit the process nature, by grasping slices inside the forward flow of time. Thus innovation has a problematic beginning leading to the emergence of an under-determined outcome, but always there is some part of a commercial outcome in view, and so different actors are mobilized to resolve specific issues as they emerge. The second perspective displays a sense of flowing time with the actors in a changing present, exploring and exploiting the present network (Medlin & Törnroos 2014). The changing and emerging present is also affected by previous investment, events and processes that forms the base for the sensed present. We surmise that these two perspectives may capture the research gaps within the innovation literature.

*The purpose of our paper is to study how networked organizations explore and exploit their resources along the whole innovation process comprising visioning, developing and commercializing in order to achieve their goal, a successful innovation. This research questions requires a longitudinal research design that follows the interplay of exploring and exploiting activities through the three innovation element phases. The continual changing of actors, their issues and their options, as well as their activities requires a very clear and rich understanding and formulation of the surrounding longitudinal context. In this paper we apply a dynamic network perspective, where firms and other actors are observed in sequential periods designed by the researchers to capture the phases of managerial activity.*

In the empirical part we employ longitudinal case strategy and examine an extensive and constantly developing “HYGTECH” network of over 20 organizations that together aim to develop and commercialize hygiene technology solutions. The case is about collaboration through a network of actors who together aim to innovate a set of hygiene-related offerings what would increase the level of hygiene particularly indoors and lower infections and other diseases. The aim of collaboration was to develop and test antimicrobial products (air, water, and surface related), develop and commercialize a hygiene-technology concept that covers all the indoor environment elements, and also create “hygiene technology market”. As our case is a longitudinal, the case also shows how in the beginning of the case, only a few actors collaborated for hygiene-related offerings, but they did not together provide holistic hygiene technology concepts that could have enabled constructing and maintaining buildings with increased hygiene quality; therefore, the case also presents how along the process the case network expanded as complementary actors joined in to develop and commercialize a holistic hygiene technology concept comprising a complete set of offerings enabling increased indoor hygiene. As construction industry is traditionally quite dispersed into different design and operation areas and technologies (e.g. HVAC (heating, ventilation, air conditioning), electrical, architectural, interior etc.), in order to develop solutions that could really improve indoor hygiene, collaboration across different industries and technologies was crucial for innovating.

We present two key contributions, we firstly show that in collaborative innovation, innovation activities, i.e. visioning, developing, commercializing are interlinked activities that may occur parallel, be overlapping and repeated along the innovation process. Thus the collaborative innovation process is far more complicated, with loops, rewinds, and forwards than the current literature depicts. Second, we present a theoretical way to resolve the issue of relevant time periods for a dynamic analysis of the innovation process, based on key events that bring resources to the focal actor network.

The paper is structured in the following manner. First, the literature on the dynamics of innovation and commercialization are critiqued and an alternate view of innovation by exploring and exploiting with a backdrop of a dynamic context is discussed. Next, we present a framework and research questions. In a third section we describe our research method and present a case study. Next we analyze and discuss the

results of the case, and finish with research and managerial implications.

## LITERATURE REVIEW

### THE THREE ELEMENTS OF INNOVATING AND THEIR DISTINCTIVE OBJECTIVES

Our understanding of the innovation process is undergoing considerable transformation. The conventional innovation model of separate end-to-end linear phases beginning with an idea, proceeding to product development and then ending with a wealth creating product has changed. Recent research has highlighted that many of decisions and activities of the end phase affect decisions to take at the beginning and vice versa (see e.g. Prebble, de Wall &, de Groot, 2008; Prenkert, 2012; Aarikka-Stenroos & Lehtimäki, 2014). For example, early decisions concerning the market and concept strongly influence the success of an innovation when the product is commercialized (Reid & de Brentani, 2012; Markham, 2013, Aarikka-Stenroos & Lehtimäki 2014). The innovation process can also meet technical or market barriers and so new problems and issues arise that call for re-thinking earlier decisions. This more complex view of the innovation process seems to suggest a more iterative nature with decisions and activities seeming to be linked in loops, and certainly not linear. What is apparent is that the logic of innovation, starting from idea to product as the necessary course of decisions and activities is meeting the reality of change flowing towards the actors from across the network. But to comprehend the development, to make sense as managers, we see and impose the logic across the confused reality.

The logical and conventional view of innovation development is seen as three distinct elements each with its own implied objectives. The naming of the elements is logical on the basis of the objective in each stage. We briefly outline the three innovation elements to make this point clear.

- Front end/ideation/envisioning: Market visioning includes initial ideas and decisions on which concepts to pursue (idea of the concept) and who could be potential users (idea of customer segments/markets), and it can also imply novel business models (how to make money with the innovation) (see O'Connor & Rice 2013, Reid & de Brentani 2012. There are two key objectives: *firstly to ideate/vision the final potential users, and secondly to identify business opportunities for the innovation.*
- Research and development/technical development: R&D activities include basic research, fundamental research, technology development, advanced development, concept development, new product development, process development, and prototyping (e.g. Lynn, et al. 1996). The objective of R&D activities is *to develop the workable product/service.*
- Commercialization: This element includes market strategy planning (including targeting, segmentation, and positioning and the identification of competitors) and subsequent marketing tactics implementation (including pricing, developing the “whole product” configuration, launch and market introduction, establishing the distribution channels, communicating the innovation’s benefits in a context relevant to customers, and building awareness for the novelty) (e.g., Aarikka-Stenroos & Lehtimäki, 2014; Chiesa & Frattini, 2011, Crawford & Di Benedetto, 2006; Koen et al., 2001; O'Connor et al., 2008; Story et al., 2011). For commercialization the objective is *to disseminate the innovation, to initiate and develop sales, to find the matching product/market fit and thus to convert a new product or service into a profit-making position in the marketplace* (Aarikka-Stenroos & Lehtimäki, 2014, Siegel et al., 1995).

Implied in the conventional three element innovation model is a necessary re-configuration of the actor network and application of different resources and activities, as each stage of the development is

achieved. For example, during ideation the innovator firms can explore and exploit the resources of their diverse network relations with suppliers, distributors, and customers to advance the innovation success. These actors can support innovating in various ways. (see Aarikka-Stenroos and Sandberg, 2012; Partanen et al. 2011; Perks & Moxey, 2011, Story et al. 2009; Story et al., 2011; Snow et al. 2011; Coviello & Joseph, 2012; Aarikka-Stenroos et al. 2014). However, during commercialization these same and new actors can enhance demand and sales by communicating with end-users, accessing and developing market and customer information, and accelerating adoption among users, complementors, and intermediaries (Harrison and Waluszewski, 2008, Story et al. 2009, Aarikka-Stenroos et al. 2014). Not only, however, is a change in the resources required by innovation stages, the nature and dynamics of the firm network also change.

The first approach to noting the reality of change flowing through the network of firms is to see the logic of the innovation elements, in iterative linked hierarchical steps and then noting that each different example of innovation follows an undetermined and idiosyncratic path from beginning to end (see Figure 1). Note, however, that the assumption of a three element logical path for innovation development remains to guide interpretation of unique events, some occurring by chance and others imposed from elsewhere in the network. Also the three element logic notes the forward and backward ramification of decisions and activities inside an innovation process. Thus, even though the innovation process follows a unique path the direction of development is given by the logic of categories: beginning-middle-end. This suggests research should continue to acknowledge the order of an innovation development and search for new ways to envisage and capture the under-determined nature of innovation.

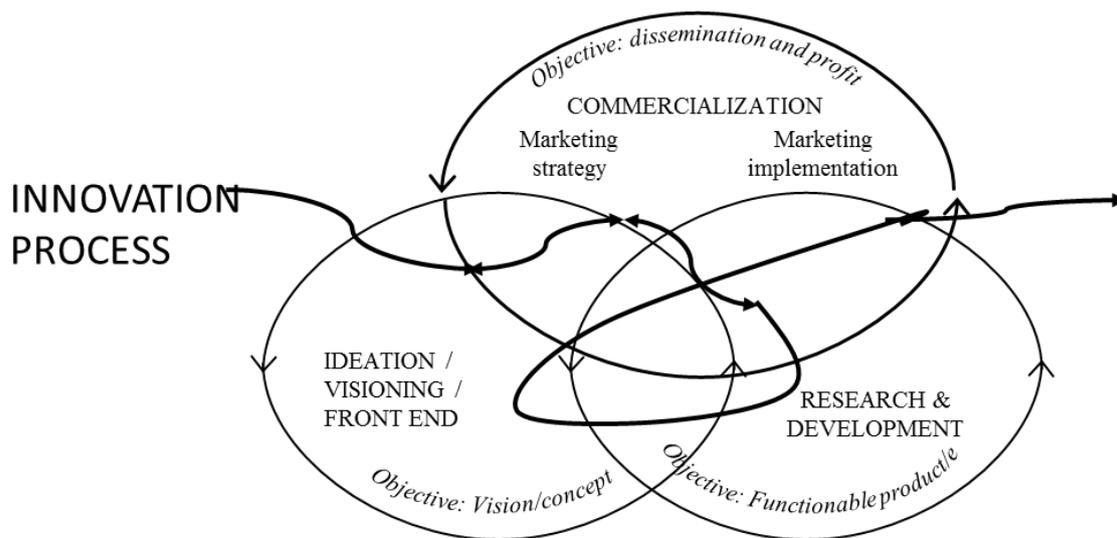
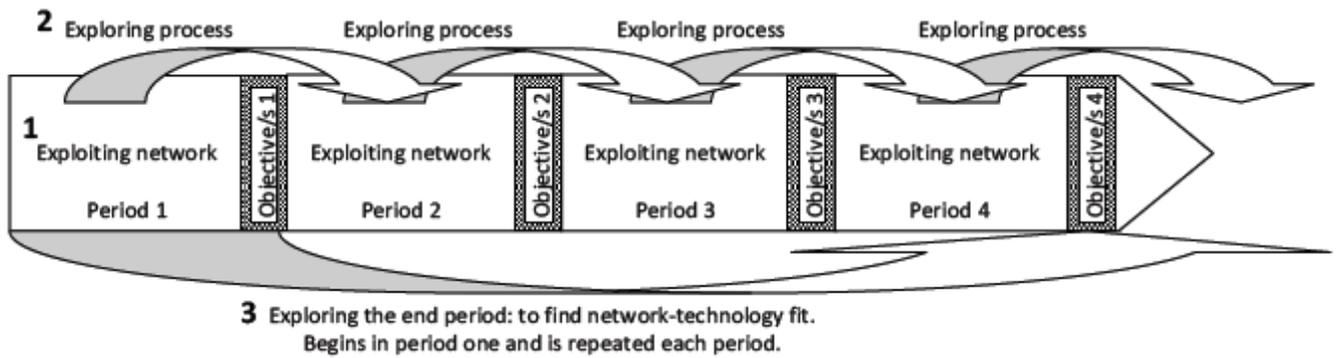


Figure 1 Innovation process as a dynamic nonlinear process (Modified from Aarikka-Stenroos & Lehtimäki, 2014)

#### EXPLORING AND EXPLOITING TO INNOVATE

Recently Medlin and Törnroos (2014) approached the innovation development process by taking a different time perspective, where managers face reality in slices of the ongoing present. These slices of time are considered as periods with goal/s where the outcome defines the theoretical periods of development. In each period managers face three required processes (see Figure 2). They must (1) exploit the network to achieve the technology development objective/s of the period, (2) explore the next period to find the actors, resource access and activities needed to achieve the still developing objective/s of that next step, and (3) explore the end period of commercialization, a future network, to find a technology-network fit.

**Figure 2: Exploring and exploiting processes for technological development by period**

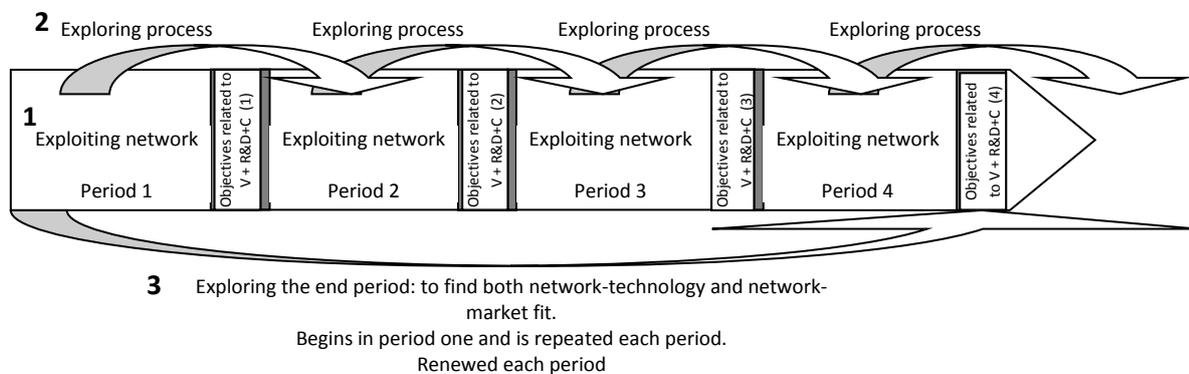


Source: Medlin & Törnroos (2014)

The exploring processes include the “activities of searching, seeking, risking, experimenting, playing, being flexible, discovering and innovating; while exploiting includes the activities of refining, choosing, selecting, implementing and executing and so producing efficiently.” (Medlin & Törnroos 2014) In figure 2, there are exploring processes (number 3) directed at understanding the end of the innovation process, so as to find a network-technology fit. There are also exploring processes directed at understanding the network configuration for the next period (number 2). Also in figure 2 there are exploiting processes, which are “activities of searching, seeking, risking, experimenting, playing, being flexible, discovering and innovating; while exploiting includes the activities of refining, choosing, selecting, implementing and executing and so producing efficiently.” (March 1991, Medlin & Törnroos 2014) These processes of exploring and exploiting lead firms to find and feed resources into developing and commercializing an innovation. Necessarily exploring and exploiting processes are dynamically bound (Ritala, Hurmelinna-Laukkanen, and Nätti 2012), but what is evident here is that there are three distinct processes directed towards achieving managerial objectives. Thus there is the potential to apply the flowing present perspective of Medlin and Törnroos (2014) with the logic of the three innovation elements and so seek to understand better the dynamics of the process.

#### INTEGRATING THEORETICAL ASPECTS INTO A FRAMEWORK

We start with the framework developed by Medlin and Törnroos (2014) and elaborate it by adding the particular objectives of the three innovation elements (see Figure 3).



**Figure 3** The process of exploring and exploiting for network actors' resources in order to vision, develop and commercialize by period

In figure three each period is constructed by the researcher to include three exploring and exploiting processes based on a defined objective which has implied within it the three elements of innovation relevant to that objective. Thus, we rely - in contrast to a linear stage approach – on interactive affects between the front end, R&D, and commercialization. We expect that activities towards the exploring and exploiting processes for commercialization should vary in resource use at the beginning as compared to the end. Table one provides a comparison of the activity intensity towards the three exploring and exploiting processes that compares the beginning and end phases of innovation development.

<b>Exploring/Exploiting processes</b>	<b>Beginning</b>	<b>End</b>
Exploiting the network	Visualization – intense R&D – focused intensity Commercialization - minimal	Visualization – minimal R&D – intense Commercialization – intense Networking, intense
Exploring the next period network	Visualization – intense R&D – minimal Commercialization - minimal	Visualization – minimal R&D – medium Commercialization - intense
Exploring the technology-network fit of the future	Visualization – intense R&D – minimal Commercialization - medium	Visualization – minimal R&D – minimal Commercialization - medium

**Table 1: Variation in activity intensity by two contrasting innovation development periods and by the three exploring and exploiting processes**

There are, however, two unresolved issues in the theoretical framework proposed. First, the nature of the beginning and end of innovation remain problematic, and secondly the nature of a period is underdetermined. To deal with these issues we note that a constructivist and process approach provides some resolutions. Here, we observe that the innovation process is a human construction understood as “a sequence of individual and collective events, actions, and activities unfolding over time in a context.” (Pettigrew 1997, 338). In a network perspective there are always preceding activities and on-going activities, so that innovation continues onwards along new paths; accordingly in reality there is no beginning or ending of the innovation process. In this understanding time proceeds in a relational manner (through the continuous existence of past-present-future along the unfolding of the process) in conjunction with the asymmetric nature of this process (Halinen et al. 2012, Adam 2000). However, periods of change and innovation lead eventually to a dynamic stability where there is a commercialized solution (Garcia & Calantone, 2002). Thus, the apprehension of the beginning and the end of the innovation development are researcher and social constructions.

The solution to the first issue also notes the way to resolve the issue of underdetermined periods. Since innovation development brings resources together in new ways, there is necessarily a growing set of resources and activities attracted and applied according to the success of the three exploring and exploiting processes on the path to commercialization. Thus, there are social and collective events that mark the introduction of new resources to the innovation development process. In other words there are points in time flow where new resource constellations and activity patterns are realized and these occur after, or when, a resource goal or objective is achieved. For example, the gaining a research grant (i.e. an objective) can mark the beginning of a new period of innovation development (see Medlin and Törnroos 2014). Here, within a constructivist perspective, the time and timing of the actors is critical for a researcher or observer to apprehend and interpret the periods that configure innovation development. The timing is inherent within the development network, just as the timing of maturity for a pea plant is given by the number of growth nodes (Ackoff and Emery 1972; Thornthwaite 1953). Thus, to observe empirically innovation development a researcher or observer must decide a starting point, and from there two criteria determine the end and/or beginning of a period of development: (1) each objective/goal is noted when new resources join the path, and (2) the change in resources allows a new set of activities

heading for a new objective/goal. These two criteria have meaning only within the concept of a process of development and change according to a network of actors.

## METHOD

### RESEARCH STRATEGY AND DESIGN

To conduct an empirical analysis, we chose a longitudinal, focused single case-study strategy since it facilitates a holistic understanding of complex phenomena that are not easily separable from their context (Halinen and Törnroos, 2005, Yin 2004). The research methodology follows an interpretive and constructivist approach, where the process is considered as unique and contextually embedded and developed (Polkinghorne 1995, Järvensivu & Törnroos 2010). The case follows a longitudinal processual approach.

The unit of analysis in this study consists of a connected and emerging network of innovating organizations. We have followed an extensive network of firms and other organizations aiming to vision, develop, and commercialize “a HYGTECH concept”, both at a general level and especially concerning individual hygiene technology solutions. The approach also highlights key events (Hedaa & Törnroos 2008), sequences (Perks & Roberts, 2013) and unfolding trajectories of processual phenomena (Pettigrew 1997, Van de Ven & Poole 1995) in order to get a rich and thick description of the process under scrutiny in its setting. In this manner the research shares closely the characteristics of naturalistic inquiry; with a focus on trustworthiness, relevance and richness of data (Lincoln & Guba 1985). Data access has been excellent and rich due to the closeness and open attitude of the firms and informants related to the process. The key informants and the detection of key events in the innovation process and network development have been followed in parallel.

### DATA GATHERING AND CASE FOLLOW UP

The case named HYGTECH has been closely followed from 2012 to the beginning of 2015. During this period, the case network has had a turbulent period of change. Our study relied on retrospective and real-time data collection and multiple sources of data. To capture the innovating in networks empirically (see Hoholm & Araujo, 2011), the researchers followed the process during which the innovation and the emerging innovation network evolved. The researchers participated in the innovation activities as observers giving an ethnographic dimension to the research. The researchers observed communications, the firms' products, their installation, use, and related research results during the project. In detail, our longitudinal follow-ups are based on the following data sets:

- Interviews: 17 face-to-face semi-structured interviews with firms and key research organizations
- Group discussions with multiple firm representatives
- Meetings and collaboration workshops (observations and memos), e.g. two spin-off net meetings and 11 project group meetings.
- Applications for funding (revealing the goals of projects, involved actors etc.)
- Scientific publications (e.g. publications on hygiene technology, infections etc.)
- Media material (on products, firms, collaboration, projects etc.)
- Marketing material (e.g. brochures)
- Administrative documents related to projects (HYGTECH1&2, HYGLI); e.g. meeting minutes
- Delphi survey

The diverse datasets consolidated the intention to follow closely and longitudinally. Such detailed, longitudinal research designs are still rare in innovation research (Perks & Roberts, 2013). By collecting different types of data along the process and from different network actors, we increased data triangulation (e.g. Flick, 2004). Temporally the unfolding of the process relates to the idea of flow-time and the presented past developments and final future prospects as well as specific situational issues (i.e. tackling the unfolding of contextual problems and events along the way). The data also gives a rich and thick data frame for analyzing the specific phases in the process in relation to exploration-exploitation processes.

**Table 1.** The involved firms and organizations and data sources of the case

<i>Actor</i>	<i>Size</i>	<i>Industry</i>	<i>Type of the actor</i>	<i>Involvement</i>	<i>Data type and informants</i>
Faucet Ltd	1400	faucet manufacturing	firm	H 1&2	group discussion & 2 workshops - Manager, Technical Sales Support & Customized products supervisor
Tube Ltd	200	copper tube manufacturing	firm	H 1&2	interview - Sales and Marketing Director workshop - Communications Manager
Copper Ltd	390	copper manufacturing	firm	H 1&2	interview – Head Company Physician 2 workshops - Product and Chemical Stewardship Specialist
Association	<5	organizational activities	other organization	H 1&2	group discussion, 2 workshops & 2 net meetings – Director
Handle Ltd	850	manufacturing of locks and hinges	firm	H 1&2	interview, 2 workshops & 2 net meetings – Industrial Designer
OnLine Ltd	<5	technical services	firm	H 1	interview - Founder, Chief Technologist
Sheet Ltd	200	copper sheets and strips manufacturing	firm	H 1&2	interview, 2 workshops & 2 net meetings - Application Engineer, Architectural Products
DisinfectionLtd	<5	wholesale of machinery, equipment and supplies	firm	H 1&2	interview – Sales Director
Air Ltd	430	manufacturing of machinery and equipment	firm	H 2	group discussion – R&D Manager & Product Manager
Equipment Ltd	<20	agents involved in the sale of machinery and industrial equipment	firm	H 2	interview – Managing Director
Maintenance Ltd	5800	conglomerate; waste collection, treatment and disposal activities; materials recovery	firm	H 2	interview – Development Manager 2 workshops & 1 net meeting – Service Administration Manager, Facility Services
Wearable Ltd	<20	manufacturing of clothing	firm	H 2	interview, workshop - R&D Engineer, Electronics
SalesLtd	22	wholesale of other machinery and equipment	firm	H 2	interview – Director, Sales
Computer Ltd	80	computer programming, consultancy and related activities	firm	S	2 interviews – Technical Director
Furniture Ltd	460	manufacturing of furniture	firm	S	I group discussion & 2 net meetings – Development Manager (3), Director, International Development Projects (2), Director, occupational health care services (
Medical Ltd	130	manufacturing of medical instruments	firm	S	2 net meetings - CTO & Global Business Director (2), Product Development Manager (1)

Services Ltd	<5	Professional, scientific and technical activities	firm	S	1 net meeting – Managing Director
Metal Ltd	20	manufacturing of other fabricated metal products	firm	S	1 net meeting – Managing Director
LLab1		technology center	users and other stakeholders	H 1&2	living lab research results
LLab2		sheltered accommodation	users and other stakeholders	H 1&2	living lab research results
LLab3		education	users and other stakeholders	H 2	living lab research results
LLab4		day care	users and other stakeholders	H1&2	living lab research results
LLab5		health care	users and other stakeholders	H2	living lab research results
Applied		education and research (technology)	other organization	H 1&2	project workshops and other project material
Water		research and development (water)	other organization	H 1&2	project workshops and other project material interview – project manager
Technology		education and research (technology)	other organization	H 2	project workshops and other project material
Business		education and research (business)	other organization	H 2	project workshops and other project material

H1 = project Hygtech1, H2 = project Hygtech2, S=Stakeholder

Our main data-collecting method was semi-structured interviewing, which provides formality for analyzing complex phenomena and allows unexpected issues to emerge (see Wengraf, 2001). The interviews were conducted face-to-face at the firms' head offices or on the university premises. The length of an interview varied from 1 to 2 hours. All interviews were recorded and transcribed. The first interview round was conducted from October to December 2013. All the firms were interviewed or involved in-group discussions. The respondents included CEOs, sales and product managers, technical directors, external experts, and consultants representing the firms and other organizations involved in the R&D and commercialization activities having good access to the process.

## DATA ANALYSIS

The first step of the analysis was to create an overview by developing a general sense of the processes of the case from all data sets. Since we are analyzing a process comprising several periods, it is important to explain how we structured the case. The process is specific in its spatio-temporal context as it unfolds and changes through the activities, acts and interactions between network counterparts. Medlin and Törnroos (2014, 1101) note that “An important part of the processual method, case analysis and interpretation is the decision to impose time units; events as moments or periods and processes as phases or periods.” In the case presented here, researchers structured the process with 5 periods that were determined by events, of which some were critical. The beginnings of a period comprise a critical incident/event that push the involved actors to consider and reconsider the forthcoming objectives. Endings of a period are often a “closing of accounts” or turning points when a project phase ends and organizations need to evaluate how they have reached their objectives and how to proceed from that point in another manner than previously.

We identified and ordered events and managerial phases of development and then constructed researcher periods. This view we want to extend by also analyzing periods that extend a more strict view of how objectives achieved exert an impact on the process. Here Adams' (2000) notion of asymmetric time comes into play, where processes travel at different tempos, intensity and length before they come to a turning point and start another phase of development. These periods also rest on our interpretation of the events of the innovation and networking process in the HyghTech case. Figure 4 shows distinct periods at play denoting one way to address a continuing progress of development in a time-flow with certain change-forces starting new periods of exploration and exploitation to emerge. The start-up period is forming a first reconstruction of the events that initiated the innovation idea and how it came about. Following the start-up each period is given by an outcome achieved. Also noted in Figure 2 are: (1) how the future network-technology fit changes as the case unfolds; (2) how the present situation is affected at different periods of the development of the innovation, and (3) how actor connections proceed and are affected by the past and future dimensions (Halinen & Törnroos 1995).

The next step dealt with a more detailed analysis with the data presented as processes through the period framework (Table 1). We organized and interpreted the data through specific themes consisting of innovation activities, goals, exploration and exploitation themes. This final analysis is clearly interpretive in a constructivist manner (Polkinghorne 1995, Järvensivu & Törnroos 2010). The final analysis of the data sort to understand the processes of exploration, exploitation and the ambidextrous moments at play in developing and finding a network technology fit for commercialization. The storyline shows the process, emerged objectives, and their consequences along the unfolding flow and periods/phases leading to new goals and exploration/exploitation rounds.

**Table 1 The case storyline and analysis: The exploiting and exploring processes in the Hygtech network in order to innovate hygiene technology solutions**

STORYLINE OF THE CASE PROCESS	ANALYSIS OF THE CASE PROCESS <small>Numbers 1-3 indicate the exploration/exploitation process in the framework</small>
<p><i>The story starts with three separated prologues that will integrate later &gt; together they build PERIOD 0 that sets the ground for the process. (Ancient times &gt; 2007 &gt; 2010)</i></p> <ul style="list-style-type: none"> <li>• Prologue 1 (with the focus on R&amp;D and visioning): There has been prolonged knowledge on the antimicrobial property of copper. Early Egyptians knew this feature on some level. Some Finnish organizations, e.g. a large mining and multi-metal company and Copper Association had initial collaborations around copper materials in order to extend and promote the use of copper due to its diverse features, including its antimicrobial feature. They had started to investigate the business potential of antimicrobial copper at the beginning of the 2000's and later in 2007 they initiated R&amp;D collaboration and prototype testing.</li> <li>• Prologue 2 (with the focus on visioning): Dr. Jane Average expert in Biochemistry and Molecular Biology was conducting research in Universities in Finland and UK, she had history on being at the “<i>cross-roads of disciplines and divergent experts</i>”. During the years, gradually an idea and vision of an extensive concept of indoor hygiene technology started to develop in her mind.</li> <li>• Prologue 3 (with the focus on market): The story of the market is that these days people spend over 90 % of their lives indoors, which exposes them to different kinds of health problems, such as infections. For example nosocomial infections in hospitals are among the most significant septicity problems in developed countries. In hospitals in the United States alone health-care-associated infections account for an estimated 1.7 million infections and 99,000 associated deaths each year. Hygiene problems cause extra costs for welfare and the health sector, and therefore a proactive perspective i.e. preventing hygiene problems through hygiene technology solutions would offer savings.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Starting point of the period 0:</b> a blurred, long era and three separated “paths” that together launch the process to innovate a hygiene technology business.</li> <li>• <b>1 Exploiting for network to reach the objective of the period 0:</b> <ul style="list-style-type: none"> <li>• <b>Visioning:</b> Copper firms with long technological and business expertise shared and integrated their visions to identify if the antimicrobial features of copper provide any market potential. Also a key person started to develop a vision of indoor hygiene technology business.</li> <li>• <b>R&amp;D:</b> Copper firms and the researcher developed technological knowledge on the antimicrobial features of copper; firms developed some functionable prototypes and tested them.</li> <li>• <b>Commercialization:</b> Copper firms developed the early commercialization ideas; they aimed to extend the sales of the copper material by emphasizing its antimicrobial features.</li> </ul> </li> <li>• <b>2 Exploring the next period:</b> Actors in different prologues devised the potential of hygiene-related features of copper and other technologies; firms particularly realized an opportunity to increase their business with antimicrobial features of copper. The prologues suggest that this would require integrating diverse hygiene-technology related expertise, development and testing relevant in the next periods.</li> <li>• <b>3 Exploring the end period:</b> In looking at commercial features the copper firms looked at how to fit profitable materials and products into the building trade network and adding the hygiene-aspect to sales arguments.</li> <li>• <b>The end of the period 0:</b> the groundings for hygiene-</li> </ul>

*A critical event triggers the next period 1 (in 2011) that is about agreeing on a business opportunity and potentiality of a new business field, and seeking complementary partners with resources to realize the opportunity.*

- Dr. Jane Average needed to constantly build up research projects around her research area and for research organizations Satakunta University of Applied Sciences (SUAS) and Nordic Water Institute (WANDER). In 2011 she was attending an event where the potential submissions for ERDF projects were presented. When seeing the proposals and their “sales pitches” she thought “*that they all were really lousy*” and that “*I need to seize this opportunity as we are able to build better project proposals*”. Even though the deadline was already coming close, she realized that her earlier ideas on developing hygiene solutions via cross-industry and cross-disciplinary collaboration could be “*the one that could win the race of proposals*”.
- As Dr. Jane Average already had some initial relations with firms and experts, she started to look for firms and other actors who could join in the project. Dr. Jane Average exploited her social and organizational networks to gather up an impressive and diverse set of firms with some link to hygiene business/technology, most of them from copper and water business. Since ERDF funding aims to develop and enhance business in some particular areas, Dr. Jane Average gathered firms and organization particularly from Satakunta area (located in Western Finland). She started drafting the application and the initial project goals and suggested applying funding together; she started to lead the planning.
- Several firms agreed on nascent but promising markets related to hygiene products and that divergent hygiene related offerings could offer new business opportunities and growth potential for all of them. Also Copper Association was involved as it has a good reputation, good relationships and contacts to diverse industries and research and business expertise.
- One ground-building aspect behind the emerging collaboration concerned global market opportunities: In domestic Finland markets –a tiny market - the hygiene standards and e.g. water quality are originally on high-level, but in emerging markets and other areas hygiene standards were developing and their relevance was increasing, so there

business are built

- **The start of the period 1:** Critical event of the key person identifying an opportunity and “a time frame” for advancing the hygiene business development.
- **1 Exploiting for network to reach the objective of the period 1:** i.e. identification of relevant firms and offerings and initiation of collaborations in order to develop a set of hygiene-related solutions and thus generate a business field around hygiene-business.
  - **Visioning:** Collaborators started to envision and refine the idea of hygiene-related markets; since the original vision and the initial R&D was based on copper, firms and offerings from copper business dominated visions.
  - **R&D:** Firms and the key person started to develop hygiene-related features of copper technologies and test existing products.
  - **Commercialization:** In the early process, firms aimed to develop plans how to make business with hygiene, gain early evidence of the benefits that particularly copper technologies could create and also to get funding from the ERDF i.e. European Regional Development Fund to cover the costs of developing new markets.
- **2 Exploring the next period:** Since hygiene-related business was emergent, there was a need to explore what actors and offerings, and resources were still needed to develop the vision on markets further, develop relevant technologies and commercialization plans realizing the holistic hygiene technology concept comprising a complete set of offerings. Involved actors altogether did not yet provide a holistic hygiene technology concept that could have enabled constructing and maintaining buildings with increased hygiene quality; further explorations on completing firms and offerings were needed.
- **3 Exploring the end period:** Now firms aimed to develop

<p>was a vast market potential on global markets.</p> <ul style="list-style-type: none"> <li>• SUAS together with WANDER started to coordinate collaboration and applied funding for the project, and seven firms: faucet manufacturing, copper tube manufacturing, copper manufacturing, manufacturing of locks and hinges, technical services, copper sheets and strips manufacturing, wholesale of machinery, equipment and supplies and the copper association joined in.</li> </ul>	<p>and/or build up from their existing materials, technologies and products a solution that improved the hygiene-level of environments in order to make profitable business with related technologies.</p> <ul style="list-style-type: none"> <li>• <b>The end of the period:</b> Firms applied funding together and their visions and product development of hygiene technology were mostly relying on copper, i.e. copper was dominating and shaping collaboration.</li> </ul>
<p><i>The period 2 (2011-2012) is about focusing on developing and testing of identified products of involved firms and seeking further resources to continue realizing the market vision. The focus was on basic research and testing of the hygiene features of products and materials in different contexts.</i></p> <ul style="list-style-type: none"> <li>• ERDF gave a positive decision for HYGTECH project funding but split the funding into two sections: in the first phase (Hygtech 1) the firms could focus on testing the hygiene technology and prototyping antimicrobial products but after that in phase “Hygtech2”, collaborators needed to gain resources and actors related to commercialization of developed hygiene technology.</li> <li>• Firms and SAMK&amp;WANDER deepened their collaboration around prototype building and Living Lab testing. In order to get credibility for hygiene products, co-operation with universities and research centers was a way to build up a reliable scientific foundation and proof that antimicrobial products do what they are promised to do.</li> <li>• Potential markets were ideated in project meetings: now markets were defined based on the level of hygiene requirements; high (e.g. hospitals), advanced (day care centers) and basic (e.g. office buildings). The most interesting key target group for hygiene solutions was identified to be the public sector (e.g. constructing and maintaining hospitals, day care centers, etc.) but no actual market related analyses were done.</li> <li>• Based on these early decisions, living lab partners were recruited: the antimicrobial effects of the products were tested in a technology center, a day care center, and a detached house through the Living Labs. Research offered new knowledge both about the technical issues of the products and their real use in real context and they provided also the life cycle point of view. The products of several firms were</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Starting point of the period 2:</b> The collaborators succeeded to get funding and “Hygtech 1” was launched.</li> <li>• <b>1 Exploiting for network to reach the objective of the period 2,</b> i.e. particularly to develop and test the hygiene-related offerings by involved firms. <ul style="list-style-type: none"> <li>• <b>Visioning:</b> Firms started to refine the vision of the hygiene market and decide which markets to pursue, so that development would match the market. Now the vision was based on the extensive use of copper, i.e. “to copper-blade everything” for hygiene and markets where masses of people travel, live and work.</li> <li>• <b>R&amp;D:</b> Firms tested the developed technology based on copper, brass and antimicrobial coating on surfaces and water quality monitoring solutions, in living labs, and in the real use contexts to learn user perspectives and lifecycle aspects. Microbiology knowledge and on how to test hygiene technology were critical resources used during the period.</li> <li>• <b>Commercialization:</b> Firms were pondering the target markets widely and early decisions on commercialization were made, as they started to be directed toward public markets. Interest was also in global market potential.</li> </ul> </li> <li>• <b>2 Exploring the next period:</b> The vision needed to be extended but it was still dependent on the available partners and technological solutions. Therefore new technologies and firms were scanned constantly. New</li> </ul>

<p>tested.</p> <ul style="list-style-type: none"> <li>• Even though the idea of hygiene-technology concept was a holistic one, visions, technologies and plans for commercialization were still quite unclear and there were still “holes” in the value network hindering any offering. The firms and research organizations were still seeking novel partners that would extend the offerings and fulfill the gaps. For example, services and the air-dimension were missing but in order to create a holistic concept of hygiene technology they were needed: consequently firms such as Maintenance Ltd and Air Ltd were recruited.</li> <li>• Copper firms were looking for visionary sub-contractors willing to switch from their conventional raw material (stainless steel, plastic, cast iron) to copper or brass in products that have been found to be high risk targets (door handles, trolley, railings etc.).</li> <li>• Furthermore, the business perspective was becoming more relevant and also ERDF required that the project organizations extend their resources to cover commercialization; therefore researchers with business-related knowledge from Turku School of Economics were invited in. To cover also the life-cycle perspective and related services, indoor monitoring researchers from Tampere University of Technology were invited in.</li> </ul>	<p>expert resources also in commercialization were mapped to support developing commercialization plans, and new customer and subcontracting firms that were willing to switch to the technology provided by firms were sought.</p> <ul style="list-style-type: none"> <li>• <b>3 Exploring the end period:</b> Collaborators start to realize that there must be even more extensive set of firms, offerings and technologies in order to create true holistic indoor environments.</li> </ul> <p>- <b>The end of the period 2:</b> The Hygtech 1 where R&amp;D elements had been strong ended, but the need to fortify commercialization elements became stronger: Thus resources expanded from technological basic research and testing also to business knowhow.</p> <p>Noteworthy is that already at this period, firms’ hygiene technology related offerings were at different stage of development. For example, Faucet Ltd had an established technology and market position and mature products with touchless faucets, whereas some other firms were still struggling with prototypes.</p>
<p><i>The period 3 (2013) is about expanding and elaborating the core idea of whole hygiene technology business; a new project phase, Hygtech 2 starts and new collaborators with new resources and ideas come in.</i></p> <ul style="list-style-type: none"> <li>• The network gained five new firm members and two new research partners (Turku School of Economics and Tampere University of Technology). One of the new comers, HVAC manufacturer shifted the focus also to air. Also a concrete alteration towards life cycle concept was made by bringing in service perspective and knowledge on maintenance (e.g. the cleanability and serviceability of the products) by Maintenance Ltd. Two other new firms were manufacturers (Wearable Ltd, Equipment Ltd) and one was an agent involved in the sale of machinery and industrial equipment (Sales Ltd).</li> <li>• Thus, the range of firms with different offerings started to extend to different technologies and products and services, and consequently also original visions started to extend from copper-centric and</li> </ul>	<ul style="list-style-type: none"> <li>• <b>The start of the period 3:</b> The new project Hygtech 2 is launched and new collaborators join in.</li> <li>• <b>1 Exploiting the network to reach the objective of the period 3:</b> i.e. refine vision and commercialization decisions in order to identify suitable markets and to make initial plans on how to reach these later, also to fortify R&amp;D to provide benefits for these chosen markets. <ul style="list-style-type: none"> <li>• <b>Visioning:</b> Firms aimed to check the vision: potential users’, customers’ and stakeholders’ perspectives were used to analyze if there really could be users and a business opportunity</li> <li>• <b>Development:</b> Firms were again testing products and developing prototypes, increasingly also other technologies than copper, and developing related technological expertise.</li> </ul> </li> </ul>

technology-centric towards a more holistic “hygiene technology” concept and business.

- The firms started to discuss in more detail how to make business with hygiene technology products: for example potential business models were examined and discussed jointly. The collaborators identified several parallel paths to make business with hygiene-technology offerings. Firms could:
  - create a joint venture, a start-up
  - collaborate tightly to provide a holistic set of divergent offerings of hygiene technology
  - aim to create a certification and use that to control a new business field
  - complete loose marketing collaboration in hygiene technology.
- New commercialization related activities were induced: collaborators started to gather some user experiences and accumulated information on markets, potential clients etc. and the firms began to share and elaborate this information through joint workshops to develop understanding of potential of the market. Commercialization planning started: market information was gathered and developed; target markets were re-evaluated; a Delphi-survey among key stakeholders was conducted to capture firm and customer perspectives so as to analyze the future market potential of hygiene technology concept and the challenges of commercialization.
- Firms also started to more clearly explore each other’s resources in terms of making the market. Sense making increased on “what resources we do have, what we should have, what is still needed and what gaps related to products/offerings and knowledge there are and how to gain such resources”.
- Collaborators were still doing extensively R&D work: three new Living Labs joined in (sheltered home, hospital ward and school). Especially the hospital ward was a challenging research place and the research permission for installing firm products required several negotiations.
- The link between the R&D and commercialization started to be more obvious. Clearer elaboration of technical and customer benefits facilitated further commercialization for different products: for example in “surface” products it was quite easy to test and show the benefits of hygiene technology, and small improvements of products

- **Commercialization:** Firms developed ideas on business models and required commercialization efforts that would enable reaching the chosen target markets, the public sector and particularly hospitals. The firms had some existing market information and user experiences and this knowledge was exploited to develop the ideas on commercialization and business model.

- **2 Exploring the next period:** The firms aimed to identify more collaborators that complete the existing hygiene related value network constellations and to figure out the potential business models in order to make profitable business. The firms explored what different hygiene-related technologies could be useful, but it was still uncertain, who were the relevant collaborators and with what technologies.

- **3 Exploring the end period:** Final objective here is to build up a value network constellation from the complete set of firms, technologies and offerings that together enable realizing the hygiene-level of environments

- **The end of the period 3:** The Hygtech 2 ended: it had advanced innovating in both R&D and commercialization elements, but the need to develop a set of interoperable offerings, technologies and firms became stronger.

Noteworthy is that at this stage of collaboration, the “readiness” of offerings started to differ even more: some mature firms with established business had ready products and market knowledge, whereas some actors were just developing and testing their products. The particular products’ development paces were different (e.g. due to different technologies/industries) and this also set challenges to development of a common hygiene technology concept.

<p>offered clear savings for customer, while scientific test results increased the credibility of benefits and proposed value. E.g. there was much evidence on how facet products' hygiene technology related features created savings. To give an opposite example, in the HVAC business it would be more laborious and time-taking to evidence the benefits of innovative hygiene technology products.</p> <ul style="list-style-type: none"> <li>• At this time the cumbersome innovation journey started to make some of the collaborators tired. The basic mindset among the firms was that “someone” should take the leading role and solve all unanswered questions. They “were waiting for the Messiah to come”. Furthermore, some actors withdrew or neglected collaboration, since they considered that the technologies of relevant network actors were in conflict or not compatible or there were conflicting individual and common goals (e.g. pursued target markets).</li> <li>• Novel potential collaborators around hygiene technology business were constantly scanned. A researcher in SUAS realized that Furniture Ltd had collaborated with the Association and therefore contacted this firm. Furniture Ltd showed a green light and was willing to negotiate.</li> </ul>	
<p><i>Period 4 is split into two exploration/exploitation paths. PATH A (2014) is an emergent one and brings in a new market vision and collaborator constellation whereas PATH B continues the original path among collaborators.</i></p> <ul style="list-style-type: none"> <li>• The period 4A starts when Hygtech project researchers visited one of living labs (the occupational health care center pilot) and met a representative from Furniture Ltd (a large international player manufacturing furniture and providing interior solutions for public and private sector). This was a critical incident as the representative of the Furniture Ltd became attracted with the idea of collaborating for hygiene-technology business and started to elaborate the idea further.</li> <li>• Furniture Ltd expressed clearly its interest toward hygiene related solutions: it has an established global business in providing turnkey office facilities in hospitals, but it wanted to extend its business into to other facilities in hospitals as well and hygiene technology aspect would give a competitive advantage. Their turnkey solutions required integrating hygienic fabrics, metals, etc. Furniture Ltd was interested in exploring the business potential of antimicrobial surfaces with the</li> </ul>	<ul style="list-style-type: none"> <li>• <b>The start of the period 4A:</b> The Furniture Ltd becomes attracted to the vision of hygiene-technology and actively induces new collaborations, with the modified goal.</li> <li>• <b>1 Exploiting for network to reach the objective of the period 4A:</b> The modified and narrowed objective was to develop and commercialize Indoor hygiene <b>surface</b> products for <b>international markets</b>; particularly to launch and commercialize a product family around hygiene technology <ul style="list-style-type: none"> <li>• <b>Visioning:</b> The collaborators were keen to grab and capitalize the idea of hygiene-technology business, but with the narrower focus. The existing ideas and visions were used to facilitate ideation of new markets.</li> <li>• <b>Development:</b> Firms relied on the developed surface-related technological expertise and products. The testing and prototyping was focused</li> </ul> </li> </ul>

<p>existing collaborators.</p> <ul style="list-style-type: none"> <li>• The other firms welcomed Furniture Ltd to join: it operated in such a business area that it wasn't in competitive position with other Hygtech network firms, quite the contrary, and several actors agreed on having a win-win situation. The copper firms have searched for a firm that would take the lead and operate as a leading partner that could provide more resources and channels for commercialization of novel products and solutions. Furniture Ltd was already operating as a hub firm in its own business area and it started actively calling together other firms with products that would complement the network.</li> <li>• Furniture Ltd was active and invited some Hygtech firms into tighter collaboration (a new net emerged). Almost twenty firms were invited, but eight firms presented - four new firms (however with earlier relations with each other thereby increasing trust) and four Hygtech network firms were present. Some of the invited collaborators filled gaps in offerings and knowledge: an important novel collaborator was a Medical Ltd, which manufactures and markets operating room equipment and integration systems, surgical tables, medical lights, trolleys and hospital beds and makes business in 120 countries.</li> <li>• Firms agreed on shared goals: exploring the business potential and particularly creating prototypes and showrooms together for hygiene "surface" products. Furniture Ltd offered its good experience in branding and building showrooms that could now be used in commercializing the hygiene technology products.</li> <li>• Consequently, two collaborators with mature hygiene-related products Faucet Ltd and Handle Ltd together with Medical Ltd and Furniture Ltd (who rapidly created small series products based on prototypes), extremely rapidly in couple of months developed a shared commercialization plan: a branded product family around hygiene technology. Firms had also decided on creating three showrooms. All the other Hygtech firms were also welcome to join in and be a part of a collective offering presented in showrooms that facilitated commercialization of HYGTECH solutions.</li> <li>• Noteworthy is that this collaboration does not rely directly on any project, and collaborators do not get monetary support at this stage.</li> </ul>	<p>on surface solutions.</p> <ul style="list-style-type: none"> <li>• Commercialization: Firms accelerated commercialization: they built a brand that highlighted the hygiene dimension of existing surface products, gathered them under the "hygiene category", and increased awareness among customers and soreached the chosen target markets. Because Furniture Ltd has a long experience in being a hub position and integrating divergent competences and products into solutions, it could easily take this hub role and mobilize firms and advance commercialization efforts.</li> <li>• <b>2 Exploring the next period:</b> New materials, products and technologies related to particularly "surface" hygiene needed to be identified, developed and tested, and Furniture Ltd lead these explorations. The best practices to commercialize the concept were scanned and shared to realize the international markets.</li> <li>• <b>3 Exploring the end period: the modified final objective</b> of 4A is to make global business with "surface" products that increase indoor hygiene.</li> </ul> <p><b>The end of the period:</b> The collaborators with surface hygiene technologies had clarified short-time and long-time goals and plans to capitalize the business potential.</p>
<p><i>PATH 4B (2014 -) the collaborators including both original collaborators but also the novel ones continue the original path by building up a new project</i></p>	<ul style="list-style-type: none"> <li>• <b>The start of the period 4B:</b> The large set of collaborators induces new collaborations, with a refined goal and</li> </ul>

*HygLi but the rules of the game start to change.*

- The firms and researchers start to develop a new project around the development of hygiene-technology business and apply for funding. However, Furniture Ltd starts to question the constellation of collaborators strongly. Furniture Ltd wanted to utilize their existing network and relationships and introduce their partners in project. Most of the firms accept this; Furniture Ltd seem to be “the Messiah” that has been desired.
- The collaborators wanted to develop the hygiene concept based on a wider vision and they focus first in new construction in public sector (e.g. hospitals). They also start to create a “credibility record” for their offerings and to prove the effectiveness of hygiene technology. The collaborators realized that they need to probe potential business models. The firms also ponder how they can create markets by shaping regulations and instructions that would support hygiene technology solutions, for example in public bidding processes/contests. Several new collaborators with different resources and perspectives were pursued and several joined in.
  - First, the municipality actor, the city of Rauma joined in; it provides more information on the logics of public sector buying, i.e. how the public sector buys, what kind of sales arguments and procedures work for this kind of sector.
  - The collaborators realized that hygiene-related solutions need to be included in early construction planning, if sales were to occur. They accept a new entrant that develops and provides HVAC engineering software Computer Ltd (now hygiene technology could be added into the engineering software). Also Consultant Ltd (a leading real estate and business facility company in Finland, providing services in over 50 countries) entered in collaboration.
  - Some of the firms were very keen to continue innovating, as new objectives started to take a shape: The active members in the network (also mentioned in period 4A) wanted to continue collaborations and actively invited their partner firms: e.g. a manufacturer that develops unobstructed bathroom solutions to join the group. Also an environmental products manufacturer joined the group.

seeks funding for collaborations through the HygLi project, to advance the market development.

- **1 Exploiting for network to reach the objective of the period 4B: i.e.** to refine the plans to reach the chosen markets, public construction (hospitals, schools, sheltered homes etc.)
  - **Visioning:** The existing knowledge and relations were used to understand the logic of the envisioned market.
  - **R&D:** New elements on value network constellations were developed. New collaborators, Computer Ltd and Consultant Ltd were recruited to develop the planning service element.
  - **Commercialization:** As the market was chosen, the existing knowledge and relational resources were employed to capture the perspective of a potential customer to refine commercialization plans, sales arguments and evidence on benefits and savings to be used in customers’ investment decisions.
- **2 Exploring the next period:** Firms realized that in the near future they needed to influence construction regulations and standards and to build “the ecosystem” around the hygiene technology business in Finland. The firms investigate in more detail how to sell hygiene technology offerings to the public sector in Finland and solve how to win this market.
- **3 Exploring the end period:** Final objective of 4B is to realize the original vision of extensive Hygiene technology concept and solutions and to make business in national markets, with welfare focus standards.
- **The end of the period:** As the firms realized that they still have many unanswered questions to be solved in innovating, they applied for funding and were successful and thus they could continue pursuing the ultimate objective.

## SUMMING UP RESULTS AND DISCUSSION

After presenting the extensive case and applying the framework of exploration/exploitation in network, we can summarize the key results and discuss what we can learn.

We captured and depicted the complex features of process through which firms explore the potential decisions for innovation and routes to the final objective, i.e. network technology fit for commercialization. Our case also shows how there can be potential multiple paths towards the ultimate objective and each path requires different innovation activities and exploitation/exploration rounds. From a network perspective the process is also a struggle in finding actors that could join and align needed resource interdependencies and joint value mechanisms.

As our framework assumed that the process of exploration/exploitation touches all three elements of innovating, our case shows that along the process, the visioning, research and development and commercialization efforts are continuous but asymmetric by nature. Exploration/exploitation phases in the network towards the final objective, making a profitable business with holistic indoor hygiene concept often triggered new efforts in visioning, development and commercialization planning. Thus the innovating elements do not build a linear process, such as vision>develop>commercialize, instead, these elements are interlinked, concurrent and overlapping and may also create wholly new paths to other innovations.

Our analysis shows that each period of the case contained some visioning, some development and some commercialization even though their role and relevance changed. For example, even though the story of “innovating hygiene business” strongly started from copper technology, the focus of innovating later started to shift from copper-technology-based offerings towards more holistic indoor hygiene solutions, as new network actors joined in collaboration with other technologies (e.g. touchless faucets with high-tech) and services. This change in collaborator composition triggered refinements in the final objective: the objective changed from “making new business with copper due to its antimicrobial features” to “making business with more holistic indoor hygiene solutions. Consequently, such change in objectives and in the ultimate objective triggered changes in innovating elements:

- changes in market visioning: vision on markets shifted from copper markets to more extensive indoor hygiene markets;
- changes in research and development: the focus of developing shifted from testing the features and benefits of copper to analyzing how different technologies should be integrated and how used technologies should be maintained in their use along their life-time, and
- changes in commercialization plans: the focus of commercialization planning moved from “selling more copper” to “selling indoor hygiene solutions”.
- Continuous changes in network actors connections, emergence and unfolding in finding a relevant innovation and network technology fit for making a capable joint structure and resource base.

Noteworthy is however, that even though the visioning was done in an extensive collaboration between networked firms, the actual development actions are centered on these smaller nets, comprising only some key actors.

Our results also show that network exploration towards agreed objectives can be challenging due to different circumstances and due to unclear roles, positions of the actors, and different statuses of relevant technologies. In the case, collaborators have aimed to develop “a holistic comprehensive concept” basing on hygiene technology on all involved actors and sharing market knowledge, envisioning markets, developing the concept together; learning on market potential together, however at the same time the concept comprises the use of different technologies (copper, water and touchless, smart technologies in faucets) that are isolated in different technological systems and in different R&D phases. This complicated considerably reaching the agreed objectives.

Exploration/exploitation in networks resulted in the many possible outcomes of the case. In terms of exploitation in networks, knowledge on markets, marketing, target groups, best practices in marketing was shared between collaborators. The Living Lab research enabled the individual firms to get knowledge of their products real use and test prototype products, which opened new business possibilities that then again triggered exploration of visions and commercialization. Exploration for visions/development/commercialization generated learning and extended perspectives of involved firms. By exploring together and through collaborative market visions, firms identified new business opportunities that they could choose and target with novel products and services, but they also identified new business opportunities to their existing products by applying and employing the hygiene feature.

However, a more significant effect of exploration and exploitation in networks was the development of a multi-industry and multi-technology hygiene business, which was seen as something new that crosses the traditional industry boundaries and enables creating new markets and business fields. Thus the process seemed to induce the change in mind-set; instead of visioning, doing R&D and making business planning in silos, firms were pushed to innovate with larger perspectives and to admire the wide view and the landscape of hygiene business markets, a new business field (see e.g. Möller & Svahn, 2009). This broadening of view inspired the firms to reconsider their future markets and potentials.

But our exploration/exploitation case is also a story of stepping on each other's toes, as one actors also took over and gained leading roles and started to develop their own exploration and exploitation processes in collaboration with their own network of relationships (e.g. the actors Furniture Ltd, Handle Ltd, Faucet Ltd and Medical Ltd capitalized some potential; or Furniture Ltd pushed some collaborators out). This is similar to the case of The Manor in Munksgaard and Medlin (2014), where one actor is able to access the resources of the network to pursue their own objectives. In effect a new objective attracts firms to undertake an innovation path now available, but most interesting is how the resources of the network are re-applied.

The case presents that it is not only about “finding” the technology-fit but also “making” the fit. On the one hand, through explorations and exploitations in network, *firms aimed to innovate holistic hygiene-indoor solutions*, by visioning market potential, by developing and testing products, services and use contexts, and by probing how to make business with solutions. On the other hand, *firms also needed identify and match the network to the innovative offering; they needed to find partners and collaborators that together enable realizing and delivering such holistic solution*. This however was not a simple task, as due to explorations/exploitations for the vision, R&D and commercialization, the relevance/role of different technologies evolved and the focus changed from copper technologies and “copper firms” to more diverse technologies and different firms comprising “a value constellation” (see Adner & Kapoor, 2010), i.e. ecosystem-like network of firms and organizations that could build and deliver indoor hygiene solutions and maintain them along their life-cycle.

Regarding the processes observed in the innovation elements, our results present several time-related aspects. The intensity and pace of change varied across the periods. For example, there was a long prologue of idea generation, followed by a period of accelerated change, which lead to a period of slower change and finally as one firm took a leader position change again accelerated. These changes in pace are also reflected in the diversity of development phases of individual firms. Some firms were doing R&D with their products, some were testing, some already had established products to re-launch and re-commercialize as “hygiene technology products”. Thus, the exploring and exploiting also included the requirement to speed development or wait for developments in the overall innovation of hygiene technology. No firm acts alone.

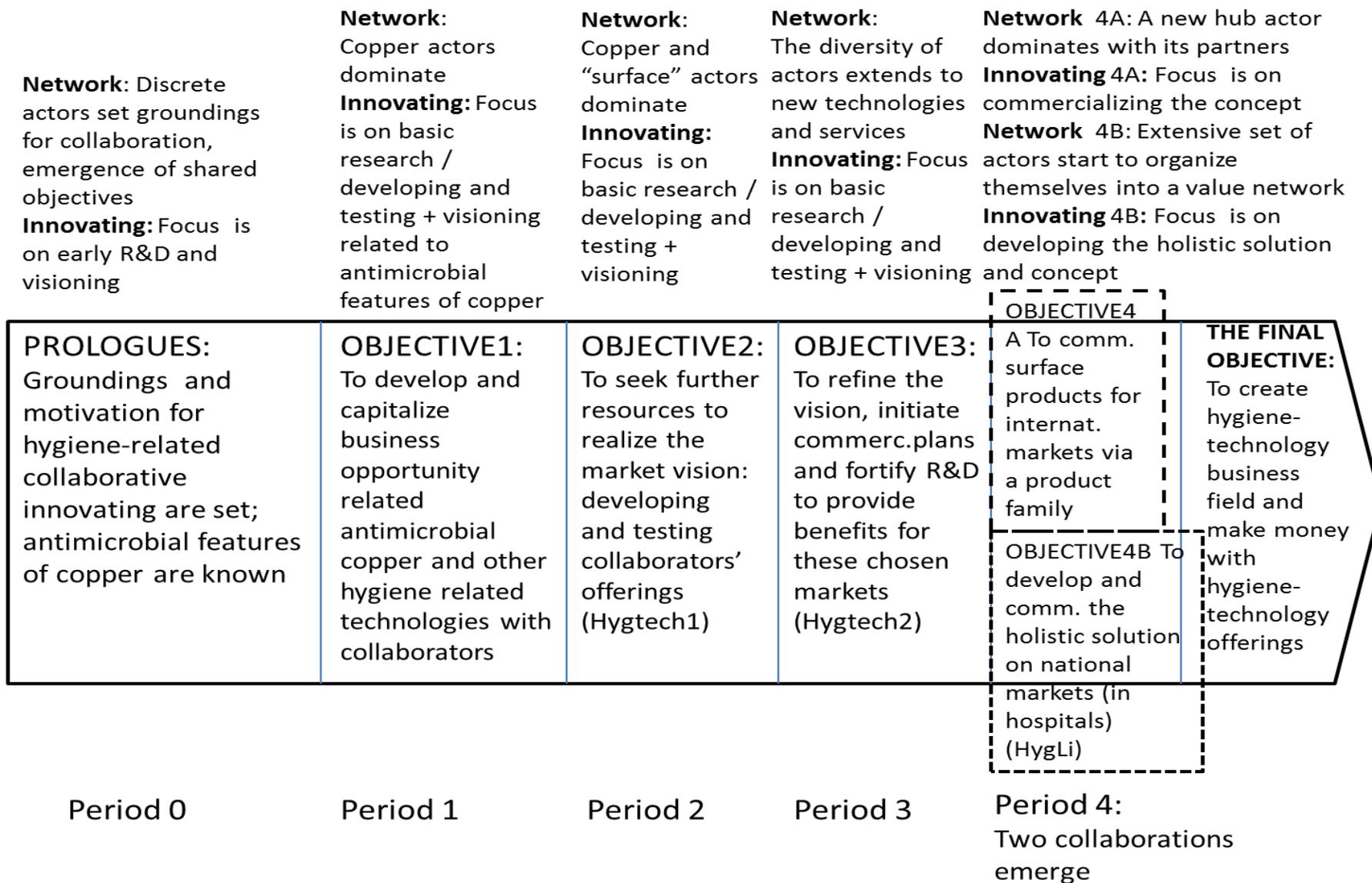


Figure 4 The process of exploring and exploiting in network in order to vision, develop and commercialize and achieve related objectives by periods

## CONCLUSIONS

### THEORETICAL CONTRIBUTIONS AND MANAGERIAL IMPLICATIONS

As so much research has focused on exploration/exploitation in a single firm or one phase of an innovation process, this study focused on the whole process of innovating in networks through exploration/exploitation. Our study brings in three major contributions.

First, our results show how exploration/exploitation rounds in a network lead to evolving objectives for visioning, R&D and commercialization. Firms continually define and refine the ultimate innovation objectives, and sub-objectives, for visioning, R&D and commercialization. As we analyzed how this happened through networks, we contribute to research by extending the single firm view of ambidextrous capability (March 1991, O'Reilly and Tushman 2008) to include a collaborative approach for exploration and exploitation.

Second, our findings on how collaborators together explore and exploit existing resources and shape further goals of innovating reveal the positive and negative dynamics between collaborators. There is also evident how collaboration leads to new outcomes, and how resources in the network are directed into new outcomes, thus we contribute to the literature streams on innovation networks, collaboration for innovation and open innovation (e.g. Snow et al. 2014; Story et al. 2011). Our contribution to innovation research is in the dynamics between ideation, R&D and commercialization along the exploitation and exploration; this is apparent as there is no one firm shaping the objectives for innovating but several organizations in the network. Different industries, technologies, goals, and target markets between the collaborators on the one hand created new business opportunities along the process; on the other hand they complicated networking and hindered reaching some objectives and further innovating.

Third, our case analysis show the continuous and embedded process of innovating, where visioning, R&D and commercialization do not follow each other in a certain order, instead they evolve along multiple paths in flows of relational and asymmetric processes of time. We also analyzed these time aspects in the process by mapping events and periods that constructed and shaped the whole innovation process. These insights contribute to increasing literature that has challenged the conventional model of innovation process (Chesbrough, 2003; Aarikka-Stenroos & Lehtimäki 2014, Prencert 2012).

Thus, due to our longitudinal approach, we captured the interlinked elements along the innovating process through exploration/exploitation rounds and deepened the current knowledge on both innovation process and the process of exploration/exploitation. This is relevant aspect, as in innovation research longitudinal research designs has been rare (Perks & Roberts, 2013). We mapped in detail the cumbersome process of innovating in networks by following the process per se and the actor's intentions and mind-set's closely along the process closely. This exercise is limited by being an embedded single case study. It can give guidelines for further inquiry, however.

### LIMITATIONS AND FURTHER RESEARCH

Our findings stem from the exploration/exploitation process comprising of an extensive network of collaborative firms and organizations in an European context. Therefore studies on different industries and business contexts might yield different answers. Nevertheless, we believe that our findings are likely to be applicable to divergent situations where firms aim to seek and integrate their resources through networks, as single firms are seldom able to vision, develop and commercialize and create markets and larger ecosystems alone.

Suggestions for research include firstly, to seek a deeper understand of the dynamics between the three elements of innovation and how decisions made in one often impact other activities; this requires more longitudinal research designs that follow such interplay along the innovation process.

Second, our results indicated that network exploration towards agreed objectives can be an exhausting task, due to unclear roles and positions, a lack of commitment, adaptability needs and issues with financial capabilities, but we did not analyze these issues in this research. Therefore such barriers and obstacles that hinder innovating in collaboration through exploration/exploitation should be taken to the focus in further inquiries.

Third, further research needs to be made concerning the role of investments into relationships and finding right resource-technology fits in conjunction with the networking process in enabling the commercialization process to be a reality.

Fourthly, our study showed that cross-industry and cross-technology collaboration tend to face challenges. At the same time the tendency of innovating in multi-industry networks is just increasing (Rampersad et al. 2010) and complexities originate not only from different technologies but different values and logics of involved network actors and stakeholders (Driessen & Hillebrand, 2013; Markard & Truffer 2008). Therefore we encourage researchers to investigate the process of cross-industry/technology innovating in more detail.

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