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Critical Success Factors of Collaboration for Different Types of Industry Convergence

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ABSTRACT

Diverse technological developments and evolving consumer preferences across the telecommunication, information technology and media sectors have altered the industry landscapes considerably. Industry convergence, based on technology and demand drivers, is an apparent trend in the current business environment and plays a significant role in shaping company strategies and operational activities. Industry convergence results in a new set of complementary capabilities and knowledge requirements for companies operating across formerly distinct industries and brings the growing number of collaborative arrangements to the forefront of technology management. From an academic perspective, convergence represents a special case of punctuation into the established equilibrium of innovation systems, and different types of convergence possess distinctive features that place demand on specific collaboration factors depending on the convergence environment. The new convergence context necessitates new operational management concepts and tools that heretofore have not been examined in the literature. The goal of this study is to differentiate types of industry convergence from the collaboration perspective and to identify the most important collaboration success factors for specific convergence contexts.

The theory overview, conducted during the first phase of the study, provides insights into the concepts of industry convergence and inter-company collaboration. Critical success factors, required for effective collaboration in the convergence context, are deduced from the current academic literature. The second phase of the study constitutes the empirical test and validation of the originally deduced factors in the convergence settings of the ICT industry to address the research objective and find the success factors needed for different types of convergence. The current research reveals that different types of convergence bring specific collaboration factors into focus; and a statistical test between all possible pairs of types of convergence shows, in total, 26 statistically significant differences based on the success factors. Technology integration convergence is characterized by the technology push innovation approach and a focus on unique product features. Technology substitution convergence is brought to the market by the advent of radical technological change that threatens to substitute for existing firms' knowledge and capabilities. Firms should monitor new technology trends and constantly assess new technology potential in terms of customer and market needs. In the product substitution convergence case, companies leverage existing technological capabilities to add the complementary functionality required by customers. The key focus of the product complementarity type of convergence is often product interoperability and standards development activities. Such general collaboration success factors as trust, effective communication, clear collaboration roles and objectives should be the focus of managerial attention independent of the type of convergence.

Findings generated from the study have the potential to broaden the understanding of industry convergence and provide valuable insights to managers who are engaged in daily collaboration activities. The success of an organization is based on its ability to anticipate convergence, predict the future direction of technology and market trends and build collaborations to enable successful innovation, new product development and new customer value creation. Understanding collaboration insights as a result of industry boundaries convergence may deepen the knowledge about constant interactions between the firm's

operational activities, strategy and macro environment. Given the overwhelming trend of industry convergence, it is of eminent importance to study the effect of different types of convergence on the governance mechanisms of the collaborations.

Keywords: industry convergence, product convergence, technology convergence, success factors, collaboration, partnerships, ICT

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LIST OF ORIGINAL PUBLICATIONS

1. Rikkiev, A. & Seppänen, M. 2008. Success factors for technology convergence collaborations. In: Abu-Hijleh, B., Arif, M., Khalil, T., Hosni, Y. (eds.) 17th International Conference on Management of Technology, IAMOT, 6th-10th April 2008, Dubai, U.A.E. 19 p.

2. Rikkiev, A. & Mäkinen, S. 2008. Technological and industry convergence types: definitions and empirical assessment. 9th International CINet Conference, Radical Challenges in Innovation Management, Valencia, Spain, 5-9 September 2008. 12 p.

3. Rikkiev, Andrei. 2009. Successful Partnering in convergent Environment: product complements development case. The European Conference on Entrepreneurship and Innovation ECEI 2009 Antwerp/Belgium. 10-11 September 2009. 9 p.

4. Rikkiev Andrei, Seppänen Marko & Mäkinen Saku. 2012. Product convergence perspective on collaboration success factors. International Journal of Business and Systems Research, Vol. 6, Iss. 1, pp. 36-58.

5. Rikkiev, A. & Mäkinen, S. Forthcoming. Technology convergence and intercompany R&D collaboration. International Journal of Innovation and Technology Management. Accepted August 9, 2011.

AUTHOR'S CONTRIBUTION TO THE PUBLICATIONS

The author of this thesis was the primary author in all of the publications, responsible for the research question formulation, conception, theoretical review, empirical data collection and analysis, and drafting the paper. Four of the five research publications were written in cooperation with a co-author or two co-authors. The role of the co-authors was mainly in commenting, reviewing, giving valuable feedback and providing overall guidance. In accordance with the Vancouver protocol guidelines (Perry et al., 2003), the current author's contribution to the co-authorship publications in three aspects of authoring is summarized in Table 1.

Table 1. Author's contribution to the co-authorship publications (adopted from Perry et al., 2003).

	Conceptualization and design or analysis and interpretation of data	**Drafting paper or revising it critically for important intellectual content**	**Final approval of the version to be published**
Publication 1	Conceptualization and design, and analysis and interpretation of data	Drafting paper and revising it critically for important intellectual content	Yes
Publication 2	Conceptualization and design, and analysis and interpretation of data	Drafting paper and revising it critically for important intellectual content	Yes
Publication 4	Conceptualization and design, and analysis and interpretation of data	Drafting paper and revising it critically for important intellectual content	Yes
Publication 5	Conceptualization and design, and analysis and interpretation of data	Drafting paper and revising it critically for important intellectual content	Yes

PART 1:

INTRODUCTORY ESSAY

1. INTRODUCTION

1.1 General background and theoretical motivation

During the past few decades, the rate of technological change has accelerated dramatically, and innovations originating in one industry are spreading across different industry sectors. Globalization and other socio-economic developments have induced changes in customer needs and affected product markets with the introduction of new integrated and complementary products and services. Diverse technological developments and changing consumer behavior across the information technology, telecommunication and media industries have affected not only product and services but also the total industry landscape and boundaries. Industries are in an era of tremendous change - industry convergence, when industry boundaries blur and formerly distinct industry sectors merge with each other or overlap to create a new market niches (Curran et al., 2010). Convergence represents a special case of punctuation into the established equilibrium of innovation systems and necessitates new management concepts and tools to apply in the new environment (Hacklin et al., 2010).

Convergence has a transformative effect on industries, business models, technology and innovation, and requires new strategies for companies operating in this environment (Lee et al., 2010). Firms move beyond traditional industry boundaries to create products of increasing complexity by integrating several technologies from adjacent industries (Cunha, 2009). The widening scope of new competencies in the convergence environment requires the companies to make a choice between internal development, buying competencies on the open market or gaining access to the required competencies through collaborative arrangements. Increasing R&D costs, shortening product lifecycles, high technology and market uncertainty and the imperfection of market mechanisms often make collaboration the only available option and an effective means for companies to broaden their existing technology and market base (Borés, 2003; Duysters and Hagedoorn, 1998; Narula and Duysters, 2004).

Convergence forces companies to collaborate with partners outside their own industries and drives cross-sector innovation. Virtually all products and services in the information and communication technology (ICT) industry are created and delivered by collaboration through complex inter-company networked systems (Basole, 2009). Collaborative innovation that goes beyond organizational boundaries and across industries is more crucial than ever, making open innovation models and external collaboration an integral part of a successful organizational culture. However, industry differences may pose managerial challenges to convergence collaborations and bring the issue of successful collaboration implementation in the convergence environment to the research agenda (Bröring, 2010). In addition, different types of industry convergence have endogenous innovation, technology and demand determinants (Stieglitz, 2003), which may bring different requirements for collaboration management competencies.

Intercompany partnering has received significant attention in the academic literature that provides extensive theoretical and empirical foundations. However, developing and maintaining effective cross-industry partnerships in the face of convergence is not yet common knowledge. Despite the growing literature on convergence, few studies have

addressed the practical questions of intercompany collaborations in a convergent environment. Convergence literature refers to collaborations as a means for coping with a changing environment without adequately addressing the details of operational-level processes. Moreover, no review of distinctions between types of convergence is given at the operational level. Literature analysis on convergence shows that most research articles to date focus on the macro level of regulatory and industry implications at the expense of the micro-level perspectives of the firm and end user, and the number of theoretical studies on convergence is double the number of empirical investigations (Kim et al., 2010). Although the academic literature on innovation management, organizational theory and new product development generally describes operational-level interactions, these literature streams do not consider inter-organizational factors in a convergent environment. In addition, the general literature on supply chain management focuses on the challenges of managing upstream materials and downstream distribution, which is not related to the scope of industry convergence.

The lack of research in this area also implies that managerial practitioners have limited empirically validated guidelines for operating collaborations in a convergent environment. The motivation for this study is to address this research gap and create the nexus between the fields of industry convergence and collaboration management by defining the most important collaboration success factors needed for companies operating in a convergent environment. Critical success factors (CSFs) are "the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization" (Rockart, 1979). In the context of collaboration, CSFs are those that determine the success or failure of an alliance. The study makes the convergence concept more accessible and actionable by moving it to a firm's operational level and providing practical prescriptions to collaboration managers to focus on the key elements of joint endeavors.

1.2 Research questions and objectives

The research problem, to which resolution the current study attempts to contribute, stems from the influence of the especial convergence context on the companies operating within it. One of the main consequences of convergence is the growing number of collaborative arrangements driven by companies' needs for new competencies and capabilities. However, the percentage of inter-firm collaboration failures and partner dissatisfaction remains high despite a long tradition of collaboration as a practice and the growing number of partnerships. Regardless of the significant influence of convergence on the industry and company level, the convergence phenomenon is ill defined and insufficiently studied. Altogether, managerial implications for operating in blurred industries remain vague, and there are no clear guidelines on the critical success factors required for collaboration in a convergent environment. In addition, industry convergence can be classified as several types, characterized by specific innovation, technology and product attributes, creating potentially different requirements for successful collaboration. To address this research problem of effective collaboration management in different convergence conditions, the thesis is based on the following research question:

RQ: How do inter-company collaboration success factors differ, if at all, between different types of industry convergence?

The sub-questions can be summarized as follows:

1. What are the types of industry convergence?
2. What collaboration critical success factors differentiate types of convergence?
3. What are the most important collaboration critical success factors for each type of convergence?

The goals of the study are to provide a theoretical contribution to the topic of convergence from a collaboration perspective by discovering the differences between the types of convergence identified in the literature and to outline the managerial implications by finding the most important collaboration success factors for each type of convergence. Hence, the research objectives can be outlined as the following:

1. To define industry convergence and identify types of convergence. Discuss the impact of convergence on industry and company operational management
2. To review inter-firm collaboration critical success factors and identify what factors are important in the convergence context
3. To outline important factors needed for successful collaboration in each type of convergence and identify differentiating factors between types of convergence

By answering the research question, this thesis creates a new dimension to the existing knowledge. The originality of the research stems from the new convergence perspective on traditional collaboration management. New insights are added, first, to the concept of convergence, as new practical implications of convergence concept are demonstrated for collaboration management. Second, the new knowledge dimension is open to collaboration theories, as collaboration techniques are applied to a new convergence problem.

1.3 Scope of the research

Based on the research question, the scope of the study is framed by the two main concepts: industry convergence and inter-company collaboration. Industry convergence is investigated from the technology and innovation management perspectives focusing on the operational and partly strategic management domains, and excluding purely technical and engineering developments.

Depending on the company strategy, collaborative arrangements may have different objectives. Defining the scope of the research, the study's primary focus is on technology collaborations. Technology collaboration can be defined as "inter-firm cooperation for which a combined innovative activity or an exchange of technology is at least part of their agreement" (Hagedoorn, 1993). In addition, there is a wide range of organizational modes of alliances reflecting various degrees of interdependence and internalization levels, ranging from wholly owned subsidiaries to spot-market transactions. This study concentrates on non-equity-based agreements, including joint R&D, licensing and technology sharing types.

The information and communication technology (ICT) industry is selected as the focus area due to the apparent effect of technology convergence on this sector as well as the high R&D intensity and high level of technological sophistication. This sector's characteristics are positively correlated with the number of inter-company collaborations (Duysters and Hagedoorn, 1998).

1.4 Structure of the thesis

The study consists of two main parts. Part 1 provides an extended introduction for the research subject and brings additional input to the study by comparing all four types of industry convergence and providing a complete answer to the research question. Part 2 comprises five complementary peer-reviewed research publications, which follow a logical sequence and explore the research topic by comparing two pairs of types of convergence. To provide a holistic answer to the research question, the introductory essay part and the publications part are required. Table 2 summarizes the relationships between the research phases, introductory part and publications.

Table 2. Structure of the thesis.

Research Phase	Part 1	Part 2
Research gap identification, defining the scope, setting research objectives and question	Chapter 1	Paper 1
Research methodology formulation, research methods selection	Chapter 3	
Theory overview and conceptualization of convergence and types of convergence	Chapter 2	Paper 2
Theory overview and conceptualization of inter-company collaborations and collaboration success factors	Chapter 2	Paper 1
Theoretical deductive proposition of success factors, important in convergence context	Chapter 2	Paper 1
Empirical identification of critical success factors importance for each type of convergence	Chapter 4	Papers 3, 4, 5
Analysis of critical success factors differences between all types of convergence	Chapter 4	
Conclusion, assessment and contribution of the research	Chapter 5	

Part 1 is further divided into the following five chapters. Chapter 1 provides a general introduction to the dissertation, outlining the theoretical motivation, identifying the research gap and setting the objectives and research question. Chapter 2 reviews the theoretical background for industry convergence and inter-company collaboration areas, and develops the theoretical proposition for the collaboration success factors required in the convergence context. Chapter 3 outlines the background research philosophy and the research design and methodology. Chapter 4 presents the study results by summarizing the findings of the original publications and comparing the importance of the collaboration success factors across four convergence contexts. Finally, Chapter 5 concludes the research, highlighting the contribution to theory and managerial practice, gives an assessment of the research and provides further research suggestions.

Part 2 consists of five complementary research papers. The first two publications deal with the conceptual model of convergence. The main objective of Paper 1 is to introduce the entire study framework and set the research scope. This theoretical exploratory paper presents a literature review in two areas: industry convergence and inter-firm collaboration success factors. The conceptual framework is selected to define different types of convergence. Using a logical deduction process, the initial list of collaboration success factors, relevant in the convergent context, is outlined, and propositions are made to match various collaboration success factors to different types of convergence.

Paper 2 builds on empirical data to develop the exploratory pre-test phase of research with the main objective to confirm conceptual definitions of different types of convergence. Industry convergence is sub-classified into four types, which are conceptualized in terms of innovation, technology and demand parameters. The convergence framework is tested to verify differences in the convergence context to align collaboration success factors with different types of convergence and build the theoretical and managerial implications in the subsequent research phase.

The three subsequent publications contribute to the research on convergence from an empirical perspective. Paper 3 reflects the context of the product complements type of industry convergence and constitutes an empirically based study of the collaboration success factors critical in this context. Product complementarity is a significant trend in the current business environment and is reflected in inter-company collaborations and ecosystem networks. The importance of the collaboration success factors is ranked in accordance with the data received during the interview process with collaboration managers at an international IT company.

Paper 4, using a survey as the research method, contributes to the existing body of knowledge on convergence and intercompany collaboration from an operational management–level point of view by determining and comparing the main success factors needed for partnering under product types of convergence. The paper outlines the context of product convergence and defines whether the importance of collaboration success factors differs between product substitution and product complementarity types.

The aim of the empirically based Paper 5 is to define whether the importance of collaboration success factors differs between two technology-based industry types of convergence:

technology substitution and technology integration types. The paper highlights the differences in convergence contexts and tests the initial propositions outlined in the theoretical part of the research about possible differences in collaboration success ingredients.

2. THEORETICAL FRAMEWORK

2.1 Industry convergence

The theme of convergence emerged in the literature in the late 1970s. Technological convergence is first mentioned in Rosenberg's (1976) study that relates industries based on commonly used technologies. Farber and Baran (1977) identified the merger of computing and telecommunication systems, and similarly, in 1997, Japan's NEC Corporation formulated a vision of the convergence of communication networks and distributed processing computers (Yoffie, 1997). Since then, no common definition of convergence has existed in the academic literature (Hackin, 2008). At the industry level, convergence is broadly defined as "[blurred] boundaries between industries by converging value propositions, technologies, and markets" (Choi and Valikangas, 2001).

Previous studies have identified the main convergence drivers that can be generally attributed to technology, product-market and firm levels. Innovations and the evolution of technology drive the development of new complex products, and diffuse new technologies across industries (Yoffie, 1997; Borés et al., 2003). Globalization and other socio-economic developments affect customer needs and product markets (Pennings and Puranam, 2001). Government deregulation removes barriers between industries (Lei, 2000; Pennings and Puranam, 2001). Kim (2008) sees convergence as the result of market saturation and as a way to create new product markets. Managerial creativity drives convergence through the development of new integrated and complementary products (Yoffie, 1997). Innovations in business models also affect industry composition and boundaries (Rim et al., 2009). Convergence is neither solely the movement of the economy nor the deterministic outcome of managerial action, but the interplay of external drivers and collective action of players within the business ecosystem (Hacklin et al., 2010).

Based on technology and market demand forces, several convergence typologies have been introduced in the academic literature. Wegberg (1995) distinguishes between convergence on the supply side, when industries increasingly use the same knowledge base, and on the demand side, meaning that market boundaries become fuzzier. In another typology, Greenstein and Khanna (1997) define convergence in substitutes and complements. In the case of substitutes, different products share the same features and provide the same function to end-users by substituting for each other. In addition, convergence in complements occurs when previously unrelated products can be used together to create higher utility to consumers. Building on the substitutes-complements and demand-supply convergence classifications, Pennings and Puranam (2001) and Stieglitz (2003) offer similar convergence classifications consisting of four types (see Table 3).

Table 3. Types of industry convergence (adopted from Stieglitz, 2003).

	Substitution	**Complementarity**
Technology-based convergence	Technology substitution	Technology integration
Product-based convergence	Product substitution	Product complementarity

Technology-based industry convergence makes industries, sharing the same technologies, related from a technological point of view. Technology substitution industry convergence is defined as the displacement of an older established technology used in a specific industry by a newer technology commonly used in other industries. This type of convergence is often characterized by the advent of a new process or general-purpose technology. New technologies require different technical skills and render some companies' traditional competencies obsolete. For example, Voice over Internet Protocol (VoIP) threatens traditional voice telecommunication technologies and serves as the key enabling technology underlining future unified voice, messaging and other productivity applications. The second type of convergence, technology integration industry convergence, is defined as the combining of new or existing technologies previously associated with different established industries into a new product, process or service. Modern smart phones that integrate into one device, wired and wireless modalities, such as a traditional mobile telephony system, Wi-Fi, technologies enabling multimedia communication sessions over Internet Protocol, Bluetooth and USB connectivity, illustrate this type of convergence.

In the case of product-based industry convergence, previously distinct markets become related by customer demand though complementary and substitutive product characteristics (Kim et al., 2005). Product substitution industry convergence is the result of increasing similarity of the features of previously unrelated products from different industries, when market participants treat the products as interchangeable. Shaped by customer demand, an established product in one industry evolves to integrate features of other established products from another industry. The market trend of the substitution of traditional MP3 music players with smart phones with integrated MP3 music players illustrates this case. Finally, the product complementarity industry type of convergence is the case of turning two formerly unrelated and independent products from different industries into complements that create greater value to the consumer if used in combination with each other. The advent of Web 2.0, embracing the power of collective user intelligence and mobile Internet, has created the booming consumption on smart phones of Internet services such as social networking (Facebook), Google Maps, photo sharing (Flickr) and online content stores (Apple iTunes, Android Market) illustrating this type of convergence.

An important issue in defining convergence is the frame of reference or the observer's level, as the same process can be viewed as convergence in substitutes for some actors and convergence in complements for the others (Greenstein and Khanna, 1997). Stieglitz's (2003) convergence model relies on Saviotti's (1996) concept, which integrates supply and demand characteristics and represents the product by its technology and product features,

respectively. Technology-based convergence is mainly driven by companies' innovation, and incorporated technologies are projected to consumers by product features. Hence, this study takes the incumbent company-level view to analyze technology convergence. Similarly, the end-user perspective is considered the most appropriate to elaborate on product-based convergence, characterized by product substitution and complementarity relationships.

Both technology push and demand pull approaches, which describe either the sources of innovation at the technology level or the motivations for innovators at the product market level, are important for understanding convergence and technological paradigms development. In explaining the technology paradigm evolution, either technology or demand factors play a key role at specific periods for specific technology fields (van den Ende et al., 2008). Industry convergence at the initial stage of evolution is mainly driven by technology convergence and the technology push innovation approach, when the stimulus for a new product and processes comes from company innovation activities and research. The initial focus on technology at the early stage of the product life cycle is followed by market factors at the later product diffusion stages (Pavitt, 1984). Technological capability is moved toward commercial use of the new expertise, and demand factors may not be clear at this stage.

Research literature debates whether convergence is the end point or the process, and several dynamic convergence models have recently been developed. Curran et al.'s (2010) concept assumes that convergence starts with scientific convergence, when distinct science disciplines cross-reference each other, followed by the application of scientific knowledge in the technologies and by the next stage of technology convergence. Then, new product-market combinations lead to market convergence, and the process is finalized by industry convergence, when companies operate across blurring industry boundaries. Lee et al. (2010) see the convergence evolving through six levels of component, functional, organizational, technology, industry and bio-artificial system types of convergence. Hacklin et al. (2010) sequence convergence evolution through four stages: knowledge, technological, application and industrial convergence. However, to limit the complexity of the current study, a static snapshot of the industry is taken.

Defining convergence as a concept, the opposite scenario should also be mentioned to fulfill the criterion of concept definition—that is, divergence (Herzhoff, 2009). In most of the cases, a complete merger between different industries has not materialized, although boundaries become blurred through interrelated technologies and product concepts. Instead, the creation of new niches and sub-segments is witnessed, targeted to specific user needs and tastes. The "long tail" concept coined by Chris Anderson (2006) highlights this phenomenon of an infinite number of goods available for niche markets enabled by new digital technologies. On the product level, consumer preferences are the key factor defining the extent of product convergence and the number of product variations on the market (Kim et al., 2005; Sawng and Han, 2005).

Convergence represents a multilevel phenomenon with effects at the industry and firm levels (Lei, 2000). At the industry level, the blurring of once distinct industry boundaries leads to the re-definition of industry concept as industries become similar in competitive, technology and product characteristics (Lei, 2000; Yoffie, 1996). New segments are created at the intersections of original industries with new sets of technologies, products and business

models (Bröring, 2010). Industry concentration and rivalry are increasing as low entry barriers and low knowledge cumulativeness facilitate new niche players from adjacent industries in challenging incumbent companies (Bernabo et al., 2009; Borés et al., 2003; Kaluza et al., 1999). New technologies and integrated products increase the threat of substitutes. On the other hand, complementary products reduce the degree of competition. Dynamic reconfiguration of the industry value chain takes place between new and incumbent players yielding a new more competitive structure, and the industry structure is changing (Borés et al., 2003; Wirtz, 2001; Krishna and Ghatag, 2008; Rim et al., 2009). Government regulatory responses are required to harmonize across formerly distinct sectors and establish rules for the new industry (Yovanof and Hazapis, 2008).

Firms in a convergent environment face technology uncertainties and substitution, changing customer expectations and regulatory requirements, increased competition and the continuous pressure to innovate. Substitutive technologies and market needs bring significant changes to core competencies and knowledge requirements, and even render current technological and market competencies obsolete (Lei, 2000; Stieglitz, 2003). Cross-fertilization between different areas of technological disciplines creates an era of escalating device and system complexity embracing a highly diverse set of interacting technologies (Bonometti, 2009). It creates a dilemma between path dependence and traditional core competencies, on one hand, and convergence and opportunities for diversification on the other (Lei, 2000; Pennings and Putranam, 2001). A firm's response to convergence is reflected in the development and commercialization of new products. New functionality is created, based on the technology fusion (Rao et al., 2006), product features are extended into new market areas (Yoffie, 1997), and products are bundled together to create complementary offerings (Cunha, 2009). Business model innovation becomes as important as innovation in products and services (Rim et al., 2009; Yovanov and Hazapis, 2008; West and Mace, 2010), including open innovation models using external ideas (Chesbrough, 2006).

Convergence has catalyzed the growing shift in the locus of innovation from within the firm to collaborative development outside the firm. The crumbling of traditional industry boundaries and the creation of products and services that transcend the competencies and capabilities of the individual company lead to a growing number of collaborative arrangements between firms (Borés et al., 2003; Duysters and Hagedoorn, 1998). The knowledge domains of new technologies and products increasingly span several firms and industries. Companies are adopting new business models to harness collective intelligence outside internal R&D teams, building new, vibrant business ecosystems with external companies, innovators and customers and adopting mass collaboration, open source and crowdsourcing ways of working. Organizations introduce new creative ways to work, building networked organizations and a creative collective intelligence (Karakas, 2009). Emerging business ecosystems, which include a network of suppliers, distributors, technology providers and other collaborating organizations, enhance innovation and productivity and speed up the creation and delivery of a company's own offering by providing complementary assets to the core product (Li, 2009).

2.2 Inter-company collaboration

As an effect of industry convergence, the breadth of technologies and capabilities required for the company has increased enormously. Companies have the options of developing technologies internally or gaining access through collaborations. As companies have limited resources and cannot internalize all possible needs, collaboration often is the only feasible option, especially when taking into account the tendency to focus on a few selected core technologies, increasing need for flexibility, complementary assets, market power and economies of scale (Narula and Duysters, 2004).

The expansion of new technologies and services has, more than ever, required collaboration between new players, and to be successful, a firm needs to develop relationships with external parties (Chesbrough, 2006). In the current convergence environment, collaboration types take a new form of the dynamic networked cooperative business process. Convergence can be seen as a composite business model enabled by collaboration between different network players (Rim, 2009). New business models take the form of cross-sector networks or 'value webs' between players from different industries and different positions in the value chain (Berkhout and van der Duin, 2007). Traditional intercompany links and industry value chains are evolving into business ecosystems and value networks providing a broader research perspective and creating the need to understand the new success factors required in such environments (Peppard and Rylander, 2006).

The business ecosystem is a community of businesses and individuals that co-evolve, sharing one or more resources based on a common strategic destiny (Moore, 2006), and takes the form of a loose network of suppliers, distributors, outsourcing firms and technology providers. The value of the business ecosystem shifts from the product value to the network value; and competition in the industry shifts from competition between individual products and firms to competition between platforms and business ecosystems (Iansiti and Levien, 2004). Still, the value network and business ecosystem logic raises the importance of understanding of the particular inter-organizational relationships as these inter-firm relationships are the building blocks of the ecosystem and facilitate the flow of knowledge and other recourses throughout the network (Peppard and Rylander, 2006).

As the number of collaborative arrangements has been growing, a wide body of literature on alliances has emerged. Inter-company collaborations have been studied from different approaches including among others industrial economics, historical and evolutionary approaches, organizational economics, organizational perspective, strategy and general management, resource dependence and social network perspectives (Grandori and Soda, 1995; Basole, 2009; Gulati, 1998). In the current thesis, the organizational theory perspective, rather than organizational economics, frames the view on the convergence context with an emphasis on the strategic and operational aspects of management.

Governance modes of inter-company collaborations have been another topic extensively studied in the literature. Collaborative arrangements come in numerous forms, determined by technology and industry characteristics, including alliances, partnerships, joint ventures, technology licensing, marketing agreements, supply and manufacturing collaborations (Todeva and Knoke, 2005; Gulati, 1998; Oxley, 1997). Generally, non-equity-based

governance forms provide better flexibility than equity arrangements and are associated with environments of high uncertainty and early stages of the industry lifecycle (Osborn and Hagedoorn, 1997; Vilkamo and Keil, 2003): the factors characterizing the technology convergence environment.

In a review of the theoretical explanations for companies to collaborate, the following main motivations were identified by Kogut (1988): transaction cost–based savings, strategic behavior to enhance competitive position or market power, and organizational learning and knowledge quest to acquire critical knowledge. Other persuasive reasons include searching for the new resources, developing new competencies through inter-organizational learning and accessing new markets (Dodourova, 2009; Gueguen and Isckia, 2011). In the convergence setup, collaboration can be assessed from Teece's (1986) perspectives of complementary assets and dynamic capabilities theories (Cunha, 2009), collaborations for standards development (Stieglitz, 2003) and learning alliances (Gomes-Casseres and Leonard-Barton, 1997).

Similarly, based on the collaboration motives, alliances can be sub-classified into three types, which can be applied in the convergence context: contractual, knowledge and standards types (Rice and Galvin, 2006). Contractual alliances are targeted to manufacturing or distribution arrangements between companies to achieve sustainable economic rents. Knowledge alliances include research and development and technology acquisition collaboration types to speed up product development by facilitating the exchange of capabilities and competencies and provision of operational expertise. Standards promotion alliances are formed to promote interoperability between technological systems and provide positive network externalities for users and producers.

An important characteristic that influences the objectives of intercompany collaborations is the industry lifecycle stage (Rice and Galvin, 2006). During the early stage of the industry lifecycle, alliances are motivated by the risk mitigation strategies and by the search for new knowledge and knowledge acquisition to facilitate innovation. The middle phase is characterized by increasing returns to scales reflected in operational alliances to seek operational efficiency improvement as well as application research and development capabilities. During late stages of the industry life cycle, technological innovation is driven by better use of organizational competencies within product networks, entrance of late movers and creation of standards alliances when there are signs of the new technology generation approach (Rice and Galvin, 2006). Industry convergence creates new technological and product disruption and brings industry to the early stage of evolution. Technology integration can bring different combinations between old and new technologies; however, the result will be setting the technology back to an early stage of the technology S curve (Hacklin et al., 2005).

In the current study, contractual alliances based on transaction cost-saving motivations are excluded from the scope of inquiry. In relation to industry convergence, technology alliances with a focus on complementary assets, knowledge base, learning, new product development and standards are the main point of interest. Technology collaboration can be defined as "inter-firm cooperation for which a combined innovative activity or an exchange of technology is at least part of their agreement" (Hagedoorn, 1993).

A firm's response to technological change is often reflected in the development and commercialization of new products (Benner, 2009). New product development (NPD) is one of the main reasons for collaboration (Hagedoorn, 1993). The literature on NPD is mature (Cooper, 2003; Craig and Hart, 1992). For example, Craig and Hart (1992) compiled six groups of related success factors: process activities, management, communication, strategy and company characteristics. However, the classic NPD stage-gate process model (Cooper, 2003) needs revisiting under turbulent environment conditions, and new managerial practices have been developed with a focus on flexibility, including rapid project iterations, frequent product tests at the early stages of product development, customer enrolment and agile project management practices (Benner, 2009).

Technology collaborations, as the prime means for gaining access to new tacit technology that cannot be obtained through direct market mechanisms, have been growing the fastest in high-technology sectors and especially in ICT (Hagedoorn, 2002). Several empirical studies have been conducted to identify collaboration success factors in ICT (Dodourova, 2009; Kelly et al., 2002; Littler et al., 1995; More and McGrath, 1999; Rai et al., 1996; Taylor, 2005; Wilson et al., 1995).

2.3 Collaboration success factors selection

Based on the theoretical discussion and literature review, the following important themes were defined for partnering success: company strategy, management, process, people and offering. Within these themes, using a logical deduction process through the lens of relevance to convergence, the most frequently cited collaboration success factors have been highlighted for the exploratory study as alternative parameters possibly differentiating collaboration in different types of convergence. Parameters were selected based on a comprehensive review of relevant literature in established research publications. A list of literature references on the critical success factors identified by different authors is presented in Table 4.

In selecting the CSFs, the following assumptions have been made. First, as convergence is complex in nature and operational collaboration guidelines are only vaguely defined in the convergence literature, the study focuses on an inclusive exploratory set of parameters to find the success factors that differentiate types of convergence. The exploratory findings should guide future studies to focus on a particular, limited set of parameters. Second, the perceptual measure of alliance success is used, as it is difficult to measure the alliance success in objective terms in reality. If properly conducted, managerial assessment of alliance performance is a reasonable way to measure collaboration performance (Dyer et al., 2007).

Table 4. Literature sources of the selected variables.

Company Strategy	
Partner's complementary know-how, skills, capabilities	Kelly et al., 2002; Littler et al., 1995; More and McGrath, 1999; Rai et al., 1996
Strategy sharing between partners	Kelly et al., 2002; Littler et al., 1995; Taylor, 2005
Cultural and process fit between partners	Kelly et al., 2002; More and McGrath, 1999; Taylor, 2005; Wilson et al., 1995
Compatible strategy between partners	Taylor, 2005
Clear and profitable market prospects	Littler et al., 1995; Wilson et al., 1995
Changing company position in industry value network	Bores et al., 2003; Brandenburger and Nalebuff, 2005; Krishna and Ghatak, 2008
Exploring new technologies beyond current own portfolio	Macher, 2004; March 1991; Rice and Galvin, 2006; Rothwell, 1994; Vilkamo and Keil, 2003;
Exploiting existing own technology portfolio	March 1991; Rice and Galvin, 2006; Vilkamo and Keil, 2003
Management	
Flexible organizational structure	Greenstein and Khanna, 1997; More and McGrath, 1999; Rothwell, 1994; Todeva and Knoke, 2005; Yoffe, 1997
Legal arrangements between partners	More and McGrath, 1999; Taylor, 2005
Clear objectives of collaboration	Dodourova, 2009; Littler et al., 1995; Rai et al., 1996
Clear roles and responsibilities	Kelly et al., 2002; Littler et al., 1995; Taylor, 2005; Wilson et al., 1995
Balance of power and partner dominance in collaboration	Chin et al., 2008; Dodourova, 2009; Littler et al., 1995; Taylor, 2005
Flexibility to changing pre-defined goals	Littler et al., 1995; Taylor, 2005; Wilson et al., 1995
Trust	Chin et al., 2008; Kelly et al., 2002; Littler et al., 1995; More and McGrath, 1999; Taylor, 2005; Wilson et al., 1995
Process	
Communication	Craig and Hart, 1992; Dodourova, 2009; Kelly et al., 2002; Littler et al., 1995; More and McGrath, 1999; Taylor, 2005; Wilson et al., 1995
Interdisciplinary teams	Craig and Hart, 1992; Kandemir et al., 2006; Littler et al., 1995; Rothwell, 1994; Wilson et al., 1995
Customer and market need orientation	Cooper, 2003; Kandemir et al., 2006; Littler et al., 1995; Rothwell, 1994
Clear specification and requirements	Assmann and Punter, 2004; Cooper, 2003
Prototyping and concept pre-testing processes	Gomes-Casseres and Leonard-Barton 1997; Rothwell, 1994
Technology and new elements integration process	Iansiti and West, 1997; Yoffie, 1997
Processes to accelerate product development	Cooper, 2003; Rothwell, 1994
Learning processes	Bierly and Chakrabarti, 1999; Chin et al., 2008; Littler et al., 1995; Taylor, 2005
Capturing acquired competencies, building absorptive capacity	Bierly and Chakrabarti, 1999; Hill, 2003; Taylor, 2005
Systems of control	Chin et al., 2008; Littler et al., 1995; More and McGrath, 1999
People	
Top management support	Chin et al., 2008; Craig and Hart, 1992; Kandemir et al., 2006; Littler et al., 1995; More and McGrath, 1999; Rothwell, 1994; Taylor, 2005
Commitment to collaboration at all levels	Chin et al., 2008; Littler et al., 1995; More and McGrath, 1999; Dodourova, 2009;
Collaboration champions	Kandemir et al., 2006; Littler et al., 1995
Importance of personalities, personal chemistry	Kelly et al., 2002; Littler et al., 1995; Taylor, 2005; Wilson et al., 1995
Partners commit best personnel	Rai et al., 1996; Rich, 2003; Taylor, 2005
Offering (products and services)	
Unique differentiated product (e.g. features, performance)	Cooper, 2003
Relative product advantage to the customer	Davis, 1989; Narayanan, 2001; Rogers, 1995; Saviotti, 2001;
Developing standards, compatibility, industry ecosystem	Bores et al. 2003; Greenstein and Khanna, 1997; Stieglitz, 2003
Quality	Kaluza et al., 1999; Rothwell, 1994
Ease of use, customer understanding of the product	Davis, 1989; Malerba, 2007; Narayanan, 2001; Rogers, 1995; Saviotti, 2001

A company's strategy in complex and fast-changing environments should not only include prescriptive and planned elements but also be dynamic and adaptive with a focus on the external environment, as the firm intensely networks with its partners (Dasgupta and Sanyal, 2009). Several empirical studies on collaboration critical success factors in the context of the ICT industry (More and McGrath, 1999; Kelly et al., 2002; Littler et al., 1995; Rai et al., 1996; Taylor, 2005; Wilson et al., 1995; Dodourova, 2009) have produced a consistent set of ingredients for success. Partners' complementary capabilities contribute to a firm's own core

competencies to provide a convergent offering (Lei, 2000). The compatible strategy of alliance members ensures inter-company collaboration success as well as overall ecosystem health and development.

The dilemma of focusing between current core competencies and the exploration of new knowledge and insights, which can become the basis for future competencies, is the consequence of technology convergence (Greensten and Khanna, 1997; Lei, 2000) with theoretical roots in the firm's resource base. An exploitative approach to innovation and product development is characterized by an intensive search and experimentation within the existing knowledge dimension. Exploration is based on the extensive search for potential new knowledge and involves product development derived either from completely new knowledge or recombination of new knowledge with knowledge a company already possesses (March, 1991).

A company's position in the industry value chain reflects the important ecosystem concept of companies' roles and constant evolution. Managers need to evaluate whether an intended value-chain position has deviations from the current state in terms of core technology and market competencies and find the right partners to close the competence gap in an open innovation approach (Bröring, 2010). Profitable market prospects increase the successful outcome of the collaboration endeavor, especially in the challenging environment of finding monetizing mechanisms in the payment-free realm of Internet services and the commoditizing of ICT products (Yovanov and Hazapis, 2008; West and Mace, 2010).

The *management* group of collaboration success factors focuses on operational issues of collaboration management and product development. The collaboration objectives of both partners should be clear, and the motives and goals for the collaboration must be well defined. Legal arrangements are important, as are alliances based on strategy sharing and trust. Trust is a vital success factor, leading to more effective information sharing and willingness to allocate scarce resources to joint efforts. Trust is built over time, is based on a commitment or mutual desire to continue the relationship into the future and helps to avoid power struggles between dominant incumbent companies and small technology providers (More and McGrath, 1999; Kelly et al., 2002; Littler et al., 1995; Rai et al., 1996; Taylor, 2005; Wilson et al., 1995; Dodourova, 2009). The balance of power over the relationship is also important, including both the dyadic inter-company relationships and the contexts of business ecosystem managing relationships between niche players, keystones and especially dominators (Inasiti and Levien, 2004).

Convergence implies the need for developing new core competencies and requires multiple dynamic learning routings to understand new products and technologies. A firm needs an organizational design that provides for a high degree of flexibility in learning from external sources (Lei, 2000). In addition, flexibility of goals is especially important in a turbulent environment as one of the key concepts in the operations management field is defining a firm's ability to meet market needs without organizational disruptions and incurring excess time and costs (Buganza et al., 2010).

The *process* area reflects project-level activities and decisions about collaborative new product development. Critical success factors identified for NPD (Cooper, 2003; Craig and

Hart, 1992) can be equally applied for collaborative new product development, bearing in mind collaboration specifics (Littler et al., 1995). Effective communication in the dynamic environment is absolutely critical to alliance success. Open and bidirectional communication flows ensure effective sharing of information, which can sometimes even be considered proprietary, about partners' progress, potential needs and problems. Cross-functional and cross-level communication should be ensured by organizing management groups of representatives from different areas and levels. Coordination and control mechanisms allow firms to maintain an adequate contribution by partners, and avoid any inadequate use of assets and opportunistic behavior.

Technology integration with the new convergent product causes uncertainty regarding customer demand and forces companies to experiment with different product designs and features (Gomes-Casseres and Leonard-Barton, 1997). Customer and market need orientation is critical in such environments. In addition, prototyping, concept pre-testing and experimentation with a wide variety of low trials are tools for understanding customer needs and the key to a commercially successful product. The ability to create inter-functional teams with the proper coupling and integration of individual experts and teams is a critical aspect of innovation competence (Christensen, 2000). Kodama's (1992) concept of technology fusion and Iansiti and West's (1997) work on technology integration are especially relevant to firms experiencing technology convergence.

Integration of different assets also brings the question of coherence as at the local coherence level, i.e., the fit between the elements of the technological base, as at the contextual level, i.e., the fit with the broad corporate context and strategy (Christensen, 2000). Adding a new technology asset to the existing technological base has the potential to create innovative asset fusion and synergy effects between the assets. It creates the potential not only to build a new strategic asset but also to improve existing ones due to synergetic links with other capabilities in the firm. Managing technology base explorative efforts to achieve innovative assets fusion and synergy effects is a challenging task and includes such actions as identifying the prominent course of assets building, establishing synergetic alignment and ensuring contextual coherence between the old and new assets (Christensen, 2000).

Inter-company collaborations are important vehicles for externally focused organizational learning that, due to convergence, cuts across multiple technologies and industries (Lei, 2000; Duysters and Hagedoorn, 1998; Bierly and Chakrabarti, 1999; Borés et al., 2003; Bröring and Cloutier, 2008; Hacklin et al., 2005; Pennings and Puranam, 2001). Learning involves acquiring and exploiting the new explicit and tacit knowledge by the organization (Kumar and Nti, 1998). Absorptive capacity is the ability of the firm to value, assimilate and apply new knowledge (Cohen and Levinthal, 1990), and determines the final value of the technology alliance to the firm.

The *people* category refers to the people involved in the collaborative project and the way these people are organized as critical success factors. To successfully manage through industry fusion, top management should be able to envision the technology evolution, future products and customer requirements (Bierly and Chakrabarti, 1999). The support and commitment of senior management to the alliance are crucial as they reflect management's attitude to cooperation. The role of top management is also important in a co-opetition

environment, caused by convergence (Chin et al., 2008). A company's commitment to collaboration can be reflected in making irreversible investments in a partnership and by reducing opportunistic behavior. Collaboration champions at the project management level, qualified personnel and training for new skills are essential from a people perspective. Employees' participation is also important from an organizational learning and absorptive capacity perspective (Craig and Hart, 1992, Kandemir et al., 2006). Current Web 2.0 technologies, such as web-based communities, social networking sites, wikis, blogs and folksonomies, enable professionals to collaborate, interact and innovate on an unprecedented scale (Karakas, 2009). In addition, as products become more complex, product development requires more functional groups and individuals, and organizational complexity increases. Complex products require different organizational arrangements and forms of management than traditional products (Karlsson and Loven, 2005).

The *offering* group includes success factors related to the final products and services as the outcome of collaborative new product development. A unique product is the main driving force of successful innovation following technology push logic (Cooper, 2003), and is a result of technology convergence. However, following the technology push approach, firms should be aware of such risks as getting "locked-in" into a particular technical solution, focusing on market applications that can be easily researched and addressing the needs of the "atypical" user and designing a solution for which there is no significant problem (Brem and Voigt, 2009).

In addition, as convergence is characterized by the effects of substitution and complementarity, related elements of innovation diffusion and technology acceptance models are included in the framework, specifically, the relative product advantage for customers and the ease of use (Davis, 1989; Rogers, 1995). Technology fusion and complementary products entail standards development as one of the most important reasons for collaboration in a convergent environment. Standards development becomes part of the business model (Hawkins and Ballon, 2007), as companies try to establish their own version of the system architecture as the dominant design in the industry, control the ecosystem platform, encourage the development of complementary products and harvest the benefits through positive network effects (Schilling, 1999; Srinivasan et al., 2006).

3. RESEARCH DESIGN AND METHODOLOGY

3.1 Research philosophy

To answer the research question, business research is characterized by a number of different orientations or philosophies of science that refer to the ways of thinking related to understanding the nature of knowledge and reality. These perspectives can vary significantly in their theoretical background and focus of interest (Saunders et al., 2009). However, the implications of different approaches are an important consideration for the research project, as these perspectives affect research strategies, methodological choices, data collection and data analysis techniques, and interpretation of the investigation at hand. The extent to which the complexity of the research question is addressed depends on the paradigmatic perspective and the extent to which the chosen perspective enables the complexity of the research question to be addressed (Kazi, 2000).

The current research has several main contemporary perspectives to consider and choose from. Research paradigms can be categorized based on epistemological, ontological and methodological frameworks. Ontology is concerned with the nature of reality, and epistemology debates what constitutes acceptable knowledge (Saunders et al., 2009). The main contemporary perspectives of research in the social sciences include the following (Kazi, 2000): (1) positivism and empirical practice, (2) pragmatism or methodological pluralism, (3) interpretivist approaches and (4) post-positivist approaches such as scientific realism.

At the level of ontology, the positivist position claims that there is an objective reality independent of social actors out there in the world to strive for. Alternatively, the interpretivism approach argues that there is no reality to be used as a standard: reality exists in the form of multiple mental constructs, which are all equally true even when they are contradictory. Within the epistemological debate, positivism believes in the certainty of objective knowledge as the true reflections of reality and in the certainty of casual links. Positivism draws law-like generalizations through highly structured data collection methods and quantitative techniques. Interpretivism focuses on the subjective meanings, motivations and details of the situation and applies a dialogic approach that helps the enquirer elaborate on underlying values, meanings and interpretations of the participants. Interpretivism employs mainly qualitative data collection techniques and in-depth investigations (Kazi, 2000; Saunders et al., 2009).

Both positivism and interpretivism approaches have strong research records; however, there is a growing debate over recognizing philosophical approaches that embrace the middle ground (Miller and Tsang, 2010; Pansiri, 2005; Stiles, 2003). This thesis takes the scientific realism perspective on research that overcomes the extremes of objective positivist and subjective interpretivist views on reality. Scientific realism interrelates ontology and epistemology. Ontology of the critical realism views reality as objective but interpreted through social conditions. On the other hand, from the fallibilist epistemological standpoint of realism, phenomena create sensations that are open to misinterpretations. Scientific realism affirms the possibility of truthful knowledge; however, because of the existence of an external referent, knowledge claims should be critically evaluated and assessed logically and

empirically. Using the realism perspective, the content is analyzed with greater insights, and objective data is combined with the wider range of the subjective perspective. Similarly to the pragmatism perspective, scientific realism adopts qualitative and quantitative research methodologies; however, unlike pragmatism, scientific realism not only concentrates on the needs of the stakeholder but also retains a holistic approach to reality to improve practice (Miller and Tsang, 2010).

Most of the research on inter-firm collaboration and alliances reflect the positivist academic perspective using mostly quantitative methods and large sample multivariate statistical techniques (Pansiri, 2005). A limitation of this approach is that using quantitative data is unlikely to capture such important soft issues as motives for alliance formation, partner selection, balance of power, trust, control mechanism and alliance performance, which could be done more effectively through the use of qualitative data sources. Tacit managerial behavior cannot be neglected in dealing with inter-company collaboration (Pansiri, 2005). In addition, the less structured context of convergence requires an exploratory research approach and the use of qualitative data to focus upon the details of the situation and subjective meaning motivating actions in this context. On the other hand, an interpretive philosophy requires direct experiential contact with the phenomenon under investigation and inductive development of the theory emerging from the field of study. Within the interpretive philosophy, the meaning is developed from the point of view of the participant using a qualitative approach to data collection and interpretation. The concern is that the resulting work can be prone to distortion imposed by the researcher's values and purposes and characterized by less precision and credibility than the positivistic philosophy (Stiles, 2003). Relying solely on interpretivism and starting from empirical data would lose the benefit of relying on previously discovered theoretical input. These issues make the idea of mixing methods imperative; and the scientific realism philosophy presents a consistent approach for triangulating qualitative and quantitative methods (Miller and Tsang, 2010).

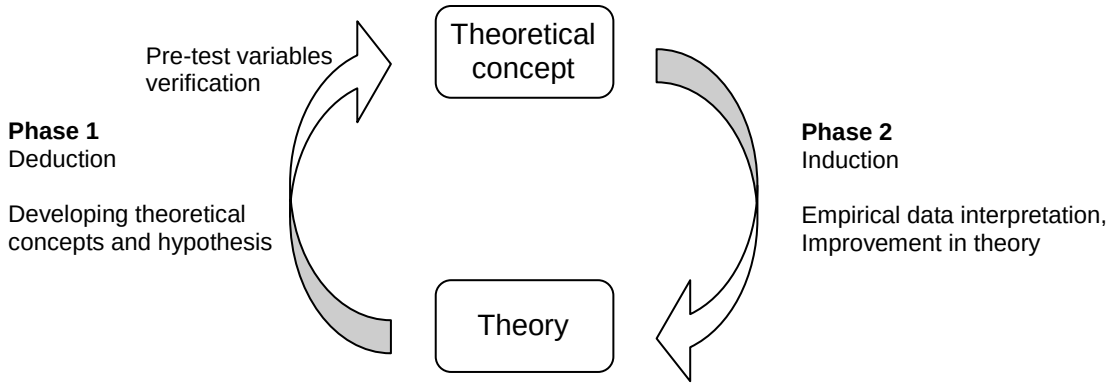
Realism portrays reality as stratified. It recognizes the world as an open system consisting of the constellations of stratums with structures, mechanisms and contexts (Kazi, 2000). The mechanisms operating at each stratum are unique; however, emerging properties must be treated as dependent upon other layers. This multilevel perspective is able to benefit research on the convergence phenomenon that, according to Hacklin (2008), can be conceptualized to occur at the industry, company and inter-company collaboration levels. In addition, collaboration mechanisms can be affected at the company strategy, project or personnel levels. To take collaboration and convergence mechanisms at different levels into account, the list of research variables for an exploratory project should be inclusive.

3.2 Research methodology

In the current study, the realism philosophy is applied through the following two-phase methodological approach (Stiles, 2003). First, a comprehensive review of the existing literature provides a basic theoretical framework for inter-company collaboration. The deductive research approach was used to develop an inclusive list of collaboration success factors from secondary data sources on R&D alliances, collaborative new product development and convergence topics. This theoretically driven deductive approach enabled to

develop an initial set of variables and underlying explanations for the mechanisms of collaboration in the convergence environment. Deduced theoretical statements or hypotheses are used as the initial structure and provide guidance for exploratory research. This phase represents a "theory before research" type of strategy (Ghauri and Gronhaug, 2005, p. 36). In this context, the task is to identify relevant theories and concepts, and adjust the concepts to the problem under scrutiny. Existing literature on general R&D collaboration, new product development and convergence makes the research problem partially structured and enables available a priori information to be used. Pre-test phase interviews at the end of the deduction phase were used to verify the two main concepts of the study—collaboration and convergence. Four different types of convergence were clarified; and a list of relevant collaboration variables has been identified for the subsequent empirical phase.

The second phase of the methodological approach is the empirical verification and development of the deduced theoretical model through more in-depth exploratory techniques. The interview process revealed a number of additional insights into collaboration in the convergence environment, verified the initially constructed list of success factors and defined the most important factors for various types of convergence. The inductive research approach of the empirical phase enables to achieve depth into socially constructed intangible issues of collaboration. The theoretical construct, in other words, a list of variables, developed from the literature was enriched and refined to incorporate primary research data from the interviews. Research findings, drawn from this closed circle of deductive-inductive analysis, as depicted in Picture 1, are considered more robust, and therefore provide a more accurate reflection of reality (Stiles, 2003). The exploration of underlying reasons against initial deductions provides the ability to establish a clear and true picture of the research subject under scrutiny.



Picture 1. The methodology of the realism research approach.

This research is an applied study contributing practical knowledge and potential value to the domain of business problems and practitioners. The research problem is normative and supports the decision-making process for collaboration managers. Since the nature of collaboration mechanisms in a convergence environment has not been extensively studied earlier, this study is exploratory to seek new insights and assess collaboration in light of

convergence phenomena. However, as the study aims to find differences between types of convergence, it also has descriptive characteristics, which extend the exploratory nature of the research and further clarify the picture of convergence phenomena.

Emory (1985, p. 62) recommends such principal ways of conducting exploratory research as a search of the literature and an experience survey. These two methods are also consistent with realism research philosophy and are selected as the primary research methods for the current study. The literature search contributes to the first deductive part of the study, and the survey is used to gain empirical insights from persons experienced in the area under investigation.

The research objective and selected perspective on knowledge make the current study and collected research data qualitative. Qualitative research focuses on understanding the subject from the respondents' point of view, reflects an explorative orientation, builds a holistic perspective and shares an interpretation and rational approach (Ghauri and Gronhaug, 2005, p. 110). Qualitative methods are used to describe the phenomenon (What?) and explain the complex issue (How?) in a specific context. Qualitative data are the most useful for the inductive part of the research. However, qualitative data is quantified and coded in a manner that allows statistical analysis using non-parametric statistical methods.

3.3 Critical success factors method

Critical success factors have a long history of empirical research tradition. Originally, the concept was introduced by Daniel (1961) and elaborated by Rockart (1979) to design management information systems to monitor and improve existing areas of a business. Later the concept was applied to business strategy (Ellegard and Grunert, 1993) and subsequently influenced a wide range of research areas including collaboration management. "Critical success factors thus are… the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization. They are the few key areas where 'things must go right' for the business to flourish" (Rockart, 1979). In the context of collaboration, CSFs are those that determine the success or failure of an alliance.

The CSF concept has several characteristics (Rockart, 1979). First, it is not designed for strategic planning; rather, CSF targets the needs of operational management and control, to monitor and improve existing areas of the business, and hence, addresses the scope and objectives of the current study. Second, the CSF approach is contextual and applicable to companies operating in a particular environment. In the current thesis, industry convergence provides the context for identifying CSFs. Third, the CSFs are time contingent, and factors that are critical to the business at one time may become commonplace at another time. The latest concepts of convergence (Curran et al., 2010; Hacking et al., 2010) acknowledge the dynamic nature of convergence and explain how types of convergence evolve and change each other. The current study assumes that CSFs are static within a specific timeframe for the type of convergence; however, the degree of CSF importance is subject to change within the convergence lifecycle when the types of convergence change.

The methodological approach in CSFs studies is traditional and well defined (de Vasconcellos and Hanbrick, 1989; Ellegard and Grunert 1993). First, the set of attributes for describing a particular concept is developed. Second, hypotheses are set forth about the settings in which each attribute constitute key success factors. These first steps are performed based on literature review, logical reasoning and pilot studies methods. Third, the hypothesized factors are tested in an empirical setting against either perceived or objective success factors. The current thesis uses a similar proven methodological approach.

3.4 Data collection methods

This study is exploratory by nature to enlarge the canvas of the relatively unexplored industry convergence phenomenon and to seek new insights from the operational perspective of inter-company collaboration management. For the theoretical deduction phase of the research, secondary data was used to better understand and frame the research problem, and position the research question within the research area (Ghauri and Gronhaug, 2005, p. 91). Academic books and journal articles from such electronic databases as EBSCO, Elsevier Science Direct, Emerald, JSTOR Business Collection and IEEEXplore provided reliable secondary data, complied by experts using rigorous methods, on general inter-company collaboration and convergence topics. However, these sources did not address the issue of collaboration in the convergence environment specifically. To answer the main research question, primary data was collected during an empirical survey to provide direct opinion and judgment for the research problem at hand.

As the result of the deductive phase of the research, inclusive lists of variables defining collaboration and convergence concepts were compiled. The concepts and variables were verified with two pre-main empirical phase tests. The first empirical test focused on the convergence concept; the results of the test are reviewed in detail in Paper 2 in Part 2 of this thesis. The objective of the second empirical test was to verify the list of collaboration success factors deduced from the secondary literature, to confirm the factors' importance in the convergence environment and to review whether the listing provides a comprehensive list of factors to be considered. Five interviews with collaboration managers were completed using the first version of the questionnaire with the initial list of success factors. Based on an assessment of the collected data from the pilot, the list of success factors in the questionnaire was refined. Duplicated success factors with similar meaning were combined; factors addressing multiple variables were split into separate questions ensuring that each question dealt with only one dimension. In addition, the interview questionnaire was refined: questions were formulated in simple and concise language, the level of difficulty was verified to be appropriate and the questionnaire was tested do that all interviewees understood the questions in the same manner. Results of the pilot phase were presented at an academic conference, but were not used for statistical analysis of this study. They helped to define final list of success factors for the main research phase and gave exploratory insights.

After the pre-test phase, the main empirical phase of the research was conducted using a survey research method with interviews based on the questionnaire as a tool for recording the verbal behavior of respondents to get opinions, attitudes and descriptions on the subject. The questionnaire used was structured, where the questions and answers to be given were pre-

determined (Ghauri and Gronhaug, 2005, p. 123). However, during the interview process the respondent could reply in his own words and share more insights into the question. Triangulating several methodologies in the study of the same phenomenon improves the accuracy of judgments and therefore results. Collecting data through different methods and collecting different kinds of data produces a more complete, holistic and contextual portrait of the object under study.

All interviews in the current study were conducted with key collaboration managers from a big international company in the ICT industry. The ICT industry was selected as a focal point, where technology- and product-based convergence is a phenomenon, and the high number of inter-firm collaborations contributes to the development of virtually all new technologies and products. The focus company for the study was selected on the basis that it had a high number of inter-company collaborative arrangements and operated in the ICT environment characterized by technology and product convergence, high competition, network externalities and compatibility requirements. It was argued that this company, producing devices incorporating the functionality of the telecommunication, consumer electronics and media industries, would allow a valid basis for collecting primary data. The unit of analysis for this study is an inter-company collaboration between the company and its partners related to new product development.

Study data was collected with structured interviews lasting about 1 hour per interview with 28 collaboration managers to assess the collaboration success factors identified in the previous section. The first group of managers included six respondents representing the technology substitution type of convergence, where projects were facing new technologies, which would have a radical influence on the companies and the industry. The second group with eight respondents represented the technology integration convergence type of collaboration, where product development took place between companies providing different technologies, which were incorporated into the main products. The third group with six respondents represented the product substitution category, where projects with demand drove further development of existing products by adding features from established products from another industry that created a substitution for traditional products. The fourth group of eight respondents accounted for the product complements convergence, where development took place between companies representing standalone complementing products from the different segments of the ICT industry, and in other cases, the collaboration focused on developing industry compatibility standards between these products.

All respondents, aged 35-50, represented middle- and upper-middle management with experience in inter-company collaborations of 5-15 years. Interviewees were encouraged to comment their views around structured questions. During the interview, comments were recorded to ensure as much accuracy as possible in terms of their interpretation. Once interviews were conducted, the combined results of the survey answers and comments were analyzed to allow further consideration and development of the theoretical framework. All interviews were conducted during the 2008-2010 period.

3.5 Data analysis methods

By defining the rule of assigning the numbers to an empirical property, the "importance" property can be measured. A number gives a meaning and in this way enables the use of mathematical techniques for descriptive purposes (Israel, 2008). Quantitative analysis based on numbers may reveal new information about the qualitative research question. Managers were asked how important they perceived the influence of the stated variables to be for the collaboration success. A Likert scale from 1 to 7, ranging from "very low" to "very high," was used for respondents to rate the importance of each critical success factor regarding the specific technology convergence collaboration project.

Scale properties define permissible statistical operations. In this study, the Likert scale is considered an interval scale with equal constant distance between each observation value. The mean and standard deviation (SD) values were calculated to reflect the relative importance of each success and the dispersion between the answers. In addition to statistical methods, because of the limited sample size, the ranking of the success factors for each type of convergence was also considered.

To statistically measure the significant difference for each success factor between two types of convergence, a nonparametric Mann-Whitney U test was applied. The Mann-Whitney test is the most powerful nonparametric alternative to the parametric t-test, and is very well suited for analyzing a Likert scale, which lies in between ordinal and interval data (Israel, 2008). For the results to show a significant difference, a 10% significance level was chosen (p-value<0.10) in the two-tail test. The 10% significance level was used, first, to accommodate an unexplored area of convergence with ambiguous definitions of concepts, and the level is still in line with standard reporting procedures for the 1%, 5%, and 10% levels. Second, the relaxed p-level threshold enabled the maximum number of possible differences for the exploratory study to be highlighted. In addition to the statistical method, the rank difference in the importance of each collaboration success factor between types of convergence was calculated.

To statistically measure the significant difference for each success factor between all four types of convergence, a nonparametric Kruskal-Wallis one-way ANOVA test was applied. In statistical practice, the test is used for three or more independent groups of variables. The Kruskal-Wallis test is the most powerful nonparametric alternative to the parametric one-way ANOVA, and does not require assumptions of normal distribution, interval data and homogeneity of group variance (Israel, 2008). Due to the exploratory nature of the research and lack of existing studies, the significance and probability cut-off level was set at 10% (p-value<0.10). Once the Kruskal-Wallis test revealed the significant statistical difference between the mean ranks for different types of convergence, Dunn's multiple-comparison test for four independent samples was used to reveal what groups are significantly different from each other. The test was applied only to the success factors that showed a significant difference in the Kruskal-Wallis test. The same 10% significance level (p-value<0.10) was applied in Dunn's test.

Spearman's rank correlation (r_s) allows the similarity between two hierarchies of variables from two samples with the same list of variables to be determined. Spearman's rho is a non-

parametric test used for variables measured on an ordinal scale (Israel, 2008). For each type of convergence, the variables (critical success factors) were ranked in order of importance, and then the ranking was compared between the types of convergence, to determine how similar the hierarchies of the variables' importance were between the types of convergence. A value of '0' indicates no relationship at all; a value '+1' indicates a perfect positive relationship.

4. STUDY RESULTS

4.1 Summaries of the research publications

This section of the thesis introduces original research papers that constitute the second part of the dissertation. Five publications, which are summarized below, follow a logical sequence to illustrate the phenomenon under study and, together with the next section of this chapter, create a holistic view of the research problem and address the research question. The summaries present the main objectives and contributions of each publication in relation to the research objectives and questions and explain the links between the papers and the research phases.

1. Rikkiev, A. & Seppänen, M. 2008. Success factors for technology convergence collaborations. In: Abu-Hijleh, B., Arif, M., Khalil, T., Hosni, Y. (eds.) 17th International Conference on Management of Technology, IAMOT, 6th-10th April 2008, Dubai, U.A.E. 19 p.

The first publication provides an exploratory overview of the research subject and focuses on the following main objectives. First, the paper outlines the problem of managing inter-company collaborations in a convergence environment, sets the research scope and introduces the general framework for the study. The publication highlights that one of the global phenomena affecting company behavior and entire industries is industry convergence. One effect of convergence is the growing number of collaborative relationships between companies as convergence makes companies look for new skills, technologies or market knowledge to adapt products for new markets. A dynamic environment affected by convergent technologies and markets has specific implications for managing technology collaborations and factors determining partnering success that are potentially different from other environments.

Second, the paper reviews the academic literature in the areas of convergence and inter-company collaborations to discover the current state of knowledge in relation to the research problem. The concepts of convergence, collaboration and critical success factors are defined. The publication reveals that although the term convergence has been known since the 1960s and gained considerable popularity in management during the last few decades, the academic research of this area is not currently sufficient. There are different definitions and types of industry convergence. Technology-based convergence occurs on the technology side and makes previously unrelated industries converge on a technological basis. Product-based industry convergence is related to the demand side due to growing consumer demand similarities. The effects of industry convergence at the industry and company levels are reviewed. On the other hand, the academic literature on inter-company collaboration is extensive and focuses on different perspectives of the phenomenon. A number of studies identify reasons for collaboration, define collaboration modes suitable for particular circumstances, measure collaboration success and identify problems and factors leading to collaboration success. However, the paper reveals that there is a clear research gap in the literature on the effects of industry convergence at the operational management level for inter-company collaborations.

Third, using a logical deduction process and the current academic literature on convergence and inter-company collaboration, the paper builds initial theoretical propositions on what collaboration success factors may be relevant in the convergent context. A list of 35 collaboration success factors was compiled for empirical verification in the subsequent research phases. In addition, based on the assumption that various types of convergence differ according to context, the paper hypothesizes about the most important and significant ingredients for the success of different types of convergence. Technology substitution convergence destroys a company's current technological competencies and stresses the importance of exploring new technologies through collaboration, building absorptive capacity and the attention of top management. To be successful in the technology integration convergence context, companies need to improve technology integration processes and verify the concepts of new products with consumers. In the product substitution convergence case, companies leverage existing technological capabilities to add complementary functionality required by customers. The key focus of the product complementarity type of convergence is product interoperability and standards development activities.

The key contribution of the paper is building the nexus between the convergence and collaboration literature and developing an initial set of propositions to address inter-company collaboration in a convergence environment from the operational management perspective.

2. Rikkiev, A. & Mäkinen, S. 2008. Technological and industry convergence types: definitions and empirical assessment. 9th International CINet Conference, Radical Challenges in Innovation Management, Valencia, Spain, 5-9 September 2008, 12 p.

The main objective of the second paper is to clarify the concept of industry convergence and with the help of a small-scale empirical test confirm the conceptual definitions of different types of convergence. The paper contributes to the answer to the first research sub-question: what are the types of convergence? The convergence concept is still ambiguous in the academic literature, and to address the research question of the current study and facilitate future theory building, the concept should be clarified and well understood. Conceptualization of industry convergence as different types provides the means for classifying and generalizing collaboration success factors according to the convergence context and builds a solid foundation for communicating convergence implications to practitioners. The paper, first, provides a literature review of the available convergence concepts and typologies. Stieglitz's (2003) convergence typology is selected as the framework to be used in the current study to map collaboration success factors to different types of convergence in the next research phases.

Second, the industry convergence concept of four types of convergence is converted into variables to enable empirical verification of different convergence contexts' existence. The variables are selected using the logical deduction method and available secondary data sources in the innovation and technology management literature areas. The literature reveals that innovation and technology represent the main driving forces for convergence, industry evolution and organizational renewal. In addition, demand factors shape the direction and rate of technological change, and demand is related to the emergence of disruptive technologies. As the beginning of the new competitive domain stems from technological or market disruptions, the key deduced determinants of industry convergence are combined into three

groups: innovation-, technology- and demand-related variables to represent technological and market perspectives of industry convergence. In total, 16 determinants were selected to define and differentiate convergence contexts. Next, theoretical propositions were made to assign the values of determinants to different types of convergence.

Third, empirical validation using the interview method was conducted to verify the differences between types of convergence based on innovation, technology and demand determinants, and overall, the empirical results showed conformance with the proposed conceptual model. Technology substitution convergence is driven by disruptive innovation with high technological potential, which is applied to the old market. Technological integration has predominantly architectural innovation content and brings new products to the new market. Product substitution is driven by incremental market pull innovation and has high technology and high market knowledge cumulativeness. Product complementarity convergence is characterized by sustaining innovation impact, creates high technological opportunity and requires complementary assets.

The main contribution of this paper is in developing the convergence concept and in proving insights into different convergence contexts from innovation, technology and demand perspectives. Clarified convergence concept can be practically applied in collaboration management and other management domains in the future.

3. Rikkiev, Andrei. 2009. Successful partnering in convergent environment: product complements development case. The European Conference on Entrepreneurship and Innovation ECEI 2009 Antwerp/Belgium. 10-11 September 2009, 9 p.

The paper focuses solely on the context of the product complements type of industry convergence from the empirical perspective. Product complementarity is a significant trend in the current business environment and is reflected in inter-company collaborations and ecosystem networks. This type of convergence is mainly driven by customer demand, as customers place increasing value on cross-product integration and bundling of services. The literature review, which starts the paper, defines that a complementary product is a product that enhances the value of a focal product when the two are used together by customers. Complementary products and services leverage the positive externalities of the focal product by enhancing market visibility, product repute customer trust and accelerating product reach. The importance of product complementarity as a business success factor is especially high in high-tech markets.

After a general literature review on industry convergence and complementary product strategy, the paper offers an empirical study of the importance of the various collaboration success factors, identified at the earlier stage of the research, in the product complementarity convergence environment. The importance of collaboration success factors is ranked in accordance with the data received during the interview process with collaboration managers in an international ICT company. The following success factors have received high importance ratings.

Legal arrangements between parties head the importance table in the co-opetition case, when companies cooperate and compete simultaneously in different markets or different levels of

the value chain. Legal protection of intellectual property rights is needed during promotion of proprietary standards by the companies or joint interoperability standards development between multiple parties. Often standards are developed through formal committee-based (or de jure) processes, where clear arrangements are important. Another top success factor highlighted by the respondents is quality that is considered not as a differentiation feature but as a general prerequisite for success in today's competitive environment to achieve customer loyalty. All people-related issues, including collaboration champions, personal attributes and involvement of best personnel, score high in the importance table. The high importance of collaboration clear objectives is in line with other studies about partnering in the ICT industry. Clear specification and requirements are particularly important in product complements development cases, when often the goal of partnering is developing interoperability standards. Standards require clearly specified interfaces between elements of the technological system.

The paper contributes to the theoretical understanding of product complementarity convergence and inter-company collaboration concepts. In addition, practical insights and focus areas are offered to collaboration managers operating in the context of product complementarity convergence.

4. Rikkiev Andrei, Seppänen Marko & Mäkinen Saku. 2012. Product convergence perspective on collaboration success factors. International Journal of Business and Systems Research, Vol. 6, Iss. 1, pp. 36-58.

The paper contributes to the empirical part of the study by developing a body of knowledge on convergence and intercompany collaboration from an operational management–level point of view. The main objective of the publication is to determine and compare the main success factors needed for partnering under product types of convergence. Empirical data provides the answers to the research sub-questions regarding success factors differentiating between types of convergence and regarding the most important success factors for each type of convergence focusing on the product convergence context. The facts acquired from empirical observations test the initial theoretical propositions developed in the deductive part of the study and contribute to the theory building on managing inter-company collaboration in a convergence environment.

The paper begins with an outline of the context of two types of product convergence. Product substitution convergence is defined as the established product in one industry evolves to integrate the features of another established product from another industry and becomes increasingly similar to the features of another product. Market participants treat the products as interchangeable with each other, and consumer preferences are the most important determinant for the direction the product substitution convergence will follow. Product substitution in the academic literature is researched through general innovation diffusion, technological cycles of product obsolescence and new product acceptance models. Convergence in complements is the second type of product-based industry convergence and is defined as the type when two existing formerly unrelated and used independently products from different industries turn into complements from the end-user perspective. Complementary products and services leverage positive externalities of the focal product by enhancing market visibility, product repute and customer trust and accelerating product

reach. The importance of product complementarity as a business success factor is especially high in high-tech markets, where the number of inter-company collaborative arrangements and ecosystems based on complementary product strategy is constantly growing.

Next, the paper proceeds with an empirical comparison of the importance of collaboration success factors between product substitution and product complementarity types. The statistical analysis of the importance of the collaboration success factors, applying the Mann-Whitney U test, shows a significant difference for three factors: changing company position in the industry value network, a unique differentiated product and relative product advantage to the customer. The product substitution type of convergence is characterized by the strong focus the collaborating companies place on the product features, relative product advantage to the customer and the ease of use, compared to product complements convergence. Customer demand and acceptance of the new product make new and incumbent products interchangeable and drive product substitution convergence. While in the product complements convergence case, the partners focus on their own products and markets and develop interoperability between the products to enact a complementary offering strategy. Operating in their own product markets in the product complements convergence case, the companies do not look into changing positions in the industry value network but play specific roles in the collaboration ecosystem. Technology convergence is not significant in the product complements context, and companies from different industries still concentrate on core competencies, existing technology portfolios and traditional products.

The main contribution of the publication is in clarifying the concept of product-based industry convergence and in the empirical assessment of differences in the importance of collaboration success factors between product substitution and product complementarity types of convergence.

5. Rikkiev, A. & Mäkinen, S. Forthcoming. Technology convergence and intercompany R&D collaboration. International Journal of Innovation and Technology Management. Accepted August 9, 2011.

Having a clear understanding, developed in the first publications, of the industry convergence concept and managerial problems, the paper's objective is to proceed with finding the answers to the research sub-questions: first, about differentiating success factors and, second, about the most important success factors focusing on the technology-based side of industry convergence. The empirical-based paper highlights the differences in technology substitution and technology integration convergence contexts and tests initial propositions outlined in the theoretical part of the research about possible differences in collaboration success ingredients.

The literature review on technology convergence and collaboration provides the following insights. Technology substitution industry convergence is defined as the displacement of an older established technology used in a specific industry by a newer technology commonly used in other industries, making industries to converge on a technological basis. Technology substitution is a competence-destroying discontinuity, which renders obsolete the company's expertise embodied in the replaced technology. In addition to a firm's own capabilities, technological change may negatively affect the network of partners, and a firm needs to resolve the dilemma of staying with the old supplier of inferior technology or establish new

vertical relations with suppliers upstream. In contrast to substitution, technology integration industry convergence is defined as the combining of new or existing technologies previously associated with different established industries into a new product, process or service. The notion is directly related to technological diversification as the increased complexity of the products causes firms to broaden their technological base. Horizontal alliances, which can be assessed from a resource-based view of the strategy, are formed between firms at the same level of the value chain in the industry with the aim to combine their efforts in research and development activities.

The empirical part of the paper is based on interviews with collaboration managers to address the objective of finding the differences in collaboration factors importance between technology-based industry types of convergence. Applying the Mann-Whitney U test, the study results show a significant difference for three factors: focus on product features, relative advantage to the customer and market need orientation. Unique product features and relative advantage to the customer success factors exhibit similar behavior in higher importance for technology integration convergence. Driven by the technology push approach, the collaboration aims to introduce a unique product to the market and differentiate it from competitors' products; however, acceptance of new technology combinations by customers is critical for future product success. In contrast, technology substitution convergence often starts as process innovation with general-purpose technologies, and initial process innovation is not associated with the final product directly, explaining the lower-rated product characteristics in the technology substitution environment. The disruptive nature of the new substituting technology, unclear market potential and possibly inferior performance at the initial phase highlight the importance of market prospects in the technology substitution context.

The study contributes to the conceptual model of different convergence scenarios and shows that there is a difference in the focus of collaboration activities and success factors' importance at the strategy, operational, process and product offering levels caused by different contexts of technology substitution and technology integration types of convergence. In addition, the study provides empirically grounded support for use of the convergence theory in operational management of collaborations.

Research Paper 4 and Paper 5 provide empirical evidence of differences in CSFs' importance between two pairs of types of convergence. Paper 4 compares two types of product-based convergence, and Paper 5 outlines the differences between technology-based convergence contexts. The next section of the thesis develops a theory on convergence and provides the answer to the research question by comparing the importance of collaboration CSFs among all four types of convergence.

4.2 Analysis of the collaboration CSFs differences between all types of convergence

This section accumulates empirical material and induced theory to compare the importance of collaboration CSFs between all four types of convergence. Four groups of collaboration managers, one group for each type of convergence, were asked to rate the perceived importance of each collaboration success factor on a Likert scale from 1 to 7, ranging from

"very low" to "very high," regarding the specific convergence collaboration project. Table 5 presents the mean, standard deviation and rank of each success factor for the corresponding type of convergence.

Table 5. Collaboration success factors' importance.

Collaboration success factor	Technology Substitution		Technology Integration		Product Substitution		Product Complementarity	
	Mean (SD)	Rank	Mean (SD)	Rank	Mean (SD)	Rank	Mean (SD)	Rank
Company Strategy								
Partner's complementary know-how, skills, capabilities	5.67 (1.51)	5	6.38 (0.92)	1	6.17 (2.04)	5	6.13 (0.83)	3
Strategy sharing between partners	4.17 (1.17)	12	5.13 (1.36)	9	5.00 (1.79)	12	4.13 (1.36)	16
Cultural and process fit between partners	4.17 (1.17)	12	4.50 (1.41)	14	4.67 (1.63)	13	4.25 (1.39)	15
Compatible strategy between partners	5.67 (1.51)	5	5.25 (1.16)	8	3.83 (1.94)	15	4.63 (1.51)	13
Clear and profitable market prospects	5.17 (1.83)	8	4.75 (2.05)	12	5.00 (1.79)	12	5.25 (1.67)	9
Changing company value and position in industry value network	3.67 (1.51)	14	3.50 (1.77)	18	5.33 (1.21)	10	3.38 (1.60)	17
Exploring new technologies beyond current own portfolio	5.00 (0.89)	9	5.88 (1.13)	4	6.00 (0.89)	6	5.00 (1.93)	11
Exploiting existing own technology portfolio	5.33 (1.37)	7	4.75 (1.75)	12	5.33 (1.03)	10	5.63 (1.30)	6
Management								
Flexible organizational structure	5.17 (1.47)	8	4.38 (1.51)	15	5.00 (1.67)	12	4.50 (1.60)	14
Legal arrangements between partners	5.33 (1.86)	7	4.63 (1.30)	13	6.00 (0.63)	6	6.25 (1.16)	2
Clear objectives of collaboration	6.17 (1.33)	2	5.38 (1.51)	7	6.50 (0.55)	3	6.38 (0.52)	1
Clear roles and responsibilities	5.50 (1.87)	6	4.88 (1.64)	11	6.17 (0.98)	5	5.88 (0.83)	5
Balance of power between partners in collaboration	4.83 (1.72)	10	5.00 (2.00)	10	4.50 (2.07)	14	5.00 (1.41)	11
Flexibility to changing pre-defined goals	5.17 (1.47)	8	5.25 (1.83)	8	5.33 (1.37)	10	5.50 (1.07)	7
Trust	6.50 (1.22)	1	6.38 (1.41)	1	6.83 (0.41)	1	6.13 (0.83)	3
Process								
Communication	6.17 (0.75)	2	5.75 (1.28)	5	6.33 (0.82)	4	6.00 (1.69)	4
Interdisciplinary teams	4.83 (0.98)	10	4.13 (0.99)	16	5.83 (1.17)	7	5.50 (1.20)	7
Customer and market need orientation	6.00 (0.89)	3	5.00 (0.93)	10	6.17 (0.98)	5	6.25 (1.04)	2
Clear specification and requirements	5.83 (0.75)	4	5.00 (1.41)	10	5.50 (1.05)	9	6.00 (0.53)	4
Prototyping and concept pre-testing	4.33 (1.75)	11	4.63 (1.60)	13	5.33 (0.82)	10	4.50 (1.20)	14
Technology and new elements integration	5.00 (1.41)	9	4.88 (1.55)	11	5.50 (1.05)	9	4.63 (1.30)	13
Speed to market	5.33 (1.03)	7	4.63 (1.19)	13	6.00 (0.63)	6	5.00 (1.51)	11
Learning	4.00 (0.63)	13	4.38 (1.60)	15	4.67 (1.03)	13	4.25 (1.16)	15
Capturing acquired competencies, building absorptive capacity	4.17 (1.83)	12	4.00 (1.41)	17	5.00 (1.26)	12	5.13 (0.99)	10
Systems of control	4.33 (2.07)	11	4.50 (1.69)	14	5.17 (2.14)	11	4.25 (1.49)	15
People								
Top management support	5.83 (1.33)	4	5.25 (1.28)	8	4.67(1.51)	13	5.38 (1.51)	8
Commitment to collaboration at all levels	5.67 (1.21)	5	5.38 (1.92)	7	5.33 (1.37)	10	5.63 (0.92)	6
Collaboration champions	5.50 (1.05)	7	5.13 (1.96)	9	5.33 (1.51)	10	5.88 (0.99)	5
Importance of personalities, personal chemistry	4.83 (1.33)	10	4.63 (1.85)	13	5.17 (0.98)	11	5.88 (0.83)	5
Partners commit best personnel	5.67 (1.51)	5	5.63 (1.19)	6	5.67 (1.03)	8	5.88 (0.64)	5
Offering (products and services)								
Unique differentiated product (e.g. features, performance)	5.17 (1.72)	8	6.38 (0.74)	1	6.50 (0.55)	3	4.75 (1.83)	13
Relative product advantage to the customer	5.17 (1.47)	8	6.38 (0.74)	1	6.17 (0.75)	5	4.88 (1.81)	12
Developing standards, compatibility, industry ecosystem	6.00 (1.26)	3	4.75 (1.49)	12	5.17 (1.72)	11	5.38 (1.69)	8
Quality	5.33 (1.37)	7	6.13 (0.64)	2	6.67 (0.52)	2	6.38 (0.52)	1
Ease of use, customer understanding of the product	5.83 (1.60)	4	6.00 (0.53)	3	6.50 (0.84)	3	5.25 (2.12)	9

The Kruskal-Wallis test identifies statistically different success factors among all four types of convergence. The subsequent Dunn's multiple-comparison test reveals among which particular types of convergence the factors identified by Kruskal-Wallis test are different. Results at the 10% significance level (p-value<0.1) are represented in Table 6.

Table 6. Statistical results of Kruskal-Wallis one-way ANOVA and Dunn's tests.

Collaboration success factor	Kruskal-Wallis		Dunn's test p <0.1					
	H	p	TS vs TI	TS vs PS	TS vs PC	TI vs PS	TI vs PC	PS vs PC
Legal arrangements between partners	6.533	0.088					Yes	
Interdisciplinary teams	9.307	0.025				Yes	Yes	
Customer and market need orientation	6.925	0.074					Yes	
Unique differentiated product	8.319	0.039						Yes
Relative product advantage to the customer	6.443	0.091						
Quality	6.488	0.090		Yes				

Legend: TS - Technology Substitution, TI - Technology Integration, PS - Product Substitution, PC - Product Complementarity

To verify the Kruskal-Wallis and Dunn's test results, and seek additional insights into the differences between all possible pairs of types of convergence, a second nonparametric Mann-Whitney U test was applied for all pairs of types of convergence. In addition to the statistical method, the rank difference in importance of each collaboration success factor between types of convergence is calculated. Results at the 10% significance level (p-value<0.1) are represented in Table 7. Tables 6 and 7 answer the research sub-question regarding differentiating success factors between types of convergence.

Table 7. Comparison of collaboration success factors' importance between types of convergence.

Collaboration success factor	TS - TI		TS - PS		TS - PC		TI - PS		TI - PC		PS - PC	
	Rank diff	MW p <0.1	Rank diff	MW p <0.1	Rank diff	MW p <0.1	Rank diff	MW p <0.1	Rank diff	MW p <0.1	Rank diff	MW p <0.1
Company Strategy												
Partner's complementary know-how, skills, capabilities	4		0		2		-4		-2		2	
Strategy sharing between partners	3		0		-4		-3		-7		-4	
Cultural and process fit between partners	-2		-1		-3		1		-1		-2	
Compatible strategy between partners	-3		-10	Yes	-8		-7	Yes	-5		2	
Clear and profitable market prospects	-4		-4		-1		0		3		3	
Changing company value and position in industry value network	-4		4	Yes	-3		8	Yes	1		-7	Yes
Exploring new technologies beyond current own portfolio	5		3		-2		-2		-7		-5	
Exploiting existing own technology portfolio	-5		-3		1		2		6		4	
Management												
Flexible organizational structure	-7		-4		-6		3		1		-2	
Legal arrangements between partners	-6		1		5		7	Yes	11	Yes	4	
Clear objectives of collaboration	-5		-1		1		4	Yes	6		2	
Clear roles and responsibilities	-5		1		1		6	Yes	6		0	
Balance of power between partners in collaboration	0		-4		-1		-4		-1		3	
Flexibility to changing pre-defined goals	0		-2		1		-2		1		3	
Trust	0		0		-2		0		-2		-2	
Process												
Communication	-3		-2		-2		1		1		0	
Interdisciplinary teams	-6		3		3		9	Yes	9	Yes	0	
Customer and market need orientation	-7	Yes	-2		1		5	Yes	8	Yes	3	
Clear specification and requirements	-6		-5		0		1		6	Yes	5	
Prototyping and concept pre-testing	-2		1		-3		3		-1		-4	
Technology and new elements integration	-2		0		-4		2		-2		-4	
Speed to market	-6		1		-4		7	Yes	2		-5	
Learning	-2		0		-2		2		0		-2	
Capturing acquired competencies, building absorptive capacity	-5		0		2		5		7	Yes	2	
Systems of control	-3		0		-4		3		-1		-4	
People												
Top management support	-4		-9		-4		-5		0		5	
Commitment to collaboration at all levels	-2		-5		-1		-3		1		4	
Collaboration champions	-2		-3		2		-1		4		5	
Importance of personalities, personal chemistry	-3		-1		5	Yes	2		8		6	
Partners commit best personnel	-1		-3		0		-2		1		3	
Offering (products and services)												
Unique differentiated product (e.g. features, performance)	7	Yes	5		-5		-2		-12	Yes	-10	Yes
Relative product advantage to the customer	7	Yes	3		-4		-4		-11	Yes	-7	Yes
Developing standards, compatibility, industry ecosystem	-9		-8		-5		1		4		3	
Quality	5		5	Yes	6	Yes	0		1		1	
Ease of use, customer understanding of the product	1		1		-5		0		-6		-6	

Legend: TS - Technology Substitution, TI - Technology Integration, PS - Product Substitution, PC - Product Complementarity, MW p - Mann-Whitney test p value

Results of the Spearman's rank correlation (r_S) analysis are presented in Table 8. At the 1% significance level (p-value<0.01), the calculations indicate no statistically significant similarities in collaboration CSF importance hierarchies between the technology integration and product complementarity types of convergence. The smaller the value of r_S in the table, the fewer similarities found in CSF importance hierarchies between types of convergence. Results of the correlation analysis are consistent with the Kruskal-Wallis and Mann-Whitney tests, as the closer the value of correlation to zero, the more statistically significant differences are identified with independent samples tests.

Table 8. Correlation in CSF importance hierarchies between types of convergence.

Similarity between convergence types	TS vs TI	TS vs PS	TS vs PC	TI vs PS	TI vs PC	PS vs PC
Spearman's rho, r_s	0.597	0.499	0.722	0.575	0.419	0.582
Critical value for sample size n=35	0.43 at p <0.01					

Legend: TS - Technology Substitution, TI - Technology Integration, PS - Product Substitution, PC - Product Complementarity

The Mann-Whitney test between all possible pairs of types of convergence, summarized in Table 7, reveals, in total, 26 statistically significant differences based on success factors and confirms that the types of convergence differ from one another. In total, 14 collaboration success factors differentiate various types of convergence pair comparisons. The differences, identified with the Mann-Whitney test across all possible pairs of types of convergence, include all the combinations of differences resulting from the Kruskal-Wallis and Dunn's tests. The Mann-Whitney test across all possible convergence pairs, compared to the Kruskal-Wallis and Dunn's tests, provides more additional points for investigation and focus on the differences in convergence contexts that can be explored in future studies using larger samples. Below, the most noticeable findings are reviewed.

The offering group of success factors accounts for a significant number of differences between types of convergence. Product-related attributes, reflected in unique differentiated features, performance and relative advantage to customers, show a high importance for technology integration and product substitution convergence. Both types of convergence are characterized by a strong focus on new product development. Technology integration is technology driven, while product substitution is market driven. In comparison, technology substitution is related to process technologies, and product complementarity focuses on compatibility between complementary products; and both types of convergence scored lower in product characteristics. This result agrees with the definition of types of convergence (Stieglitz, 2003). Quality is considered a generally required but not sufficient factor in convergent industries (Kaluza et al., 1999); however, a lower quality rating differentiates technology substitution from other types of convergence. Initially, a new disruptive technology may have some inferior characteristics when compared to existing technologies; however, as the new technology improves in quality, performance and price characteristics, it substitutes mature technologies (Christensen, 1997).

The process group provides the highest number of differentiation success factors. Technology integration convergence expresses a significant difference with other types of convergence, having the lowest customer and market need orientation, and creates an interesting paradox. On one side, strong arguments in the academic literature call for thorough customer need analysis and repeated market experimentation, especially for new convergent products (Gomes-Casseres and Leonard-Barton, 1997). On the other hand, recent industry examples, e.g., Apple's tablet computer, the iPad, show successful new product concepts developed based on managerial creativity and a technology push approach (Furfie, 2010). Another contradicting factor in this group is the low score of interdisciplinary team importance for the technology integration type of convergence that can be partially explained by the predominance of technology driven by managerial style in this type of convergence. A high differentiating score of specifications and requirements, important for product

complementarity versus technology integration convergence, is clarified by the standards and compatibility development work in the former case (Stieglitz, 2003; Hawkins and Ballon, 2007), and the constant search for a new product concept and fighting technology uncertainty in the latter convergence cases (Bores et al., 2003). Faster speed to market in the product substitution case, compared to technology integration convergence, is consistent with product and industry life cycle theories, highlighting the intensifying competition in the industry as the dominant design is established, and required product characteristics are defined (Rice and Galvin, 2006).

In the management group of success factors, the high importance of legal agreements between partners differentiates product complementarity convergence from technology-based types of convergence. Complementary product strategy, especially in the form of complex business ecosystems with a variety of players in the game for platform dominance or in a co-opetition state, requires legal agreements between the parties. In addition, standardization activities in formal de jure committee-based arrangements call for legal arrangements (Iversen and Tee, 2006). Clear objectives for collaboration, clear roles and responsibilities success factors score highly for product substitution and differentiate it from product integration convergence. An explanation is found in more stable product feature specifications of product substitution cases when objectives, roles and responsibilities are easier to define.

Compatible strategy between partners, in the company strategy group of success factors, shows opposite behavior to management-related factors in relation to product and technology types of convergence. The more uncertain the nature of the product changes, the less clarity witnessed in detailed collaboration objectives and roles in technology integration, but strategic compatibility between partners becomes more important. Both technology convergence cases require higher strategy compatibility compared to the product substitution type. Company strategy is the critical element in the face of radical changes (Macher, 2004). Adaptation and change in a company's position in the industry value network reflect the key notion of the current business ecosystems' organization - the constant evolution of the ecosystems (Iansiti and Levien, 2004). In the study, this factor differentiates the higher importance of product substitution compared to other types of convergence, as explained by more predictable industry evolution states of product substitution.

The people group of success factors do not show significant statistical differences, except the importance of personalities factor between technology substitution and product complementarity types. The difference can be attributed to the nature of standardization work at the industry level of consortiums, forums and government committees with many people involved compared to typical project-level activities for all other types of convergence.

To provide the answer to the third research sub-question regarding the most important collaboration CSFs for each type of convergence, the rank values success factors are used. Table 9 outlines the top five most important collaboration CSFs according to the convergence contexts. The findings are discussed in more detail in Chapter 5.1.2, the managerial implications section, of the thesis.

Table 9. The top five most important collaboration CSFs per type of convergence.

Convergence type	Top ranked success factors	
	Rank	**Success factor**
Technology Substitution	1	Trust
	2	Clear objectives of collaboration
	2	Communication
	3	Customer and market need orientation
	3	Developing standards, compatibility, industry ecosystem
	4	Clear specification and requirements
	4	Top management support
	4	Ease of use, customer understanding of the product
	5	Partner's complementary know-how, skills, capabilities
	5	Compatible strategy between partners
	5	Commitment to collaboration at all levels
	5	Partners commit best personnel
Technology Integration	1	Partner's complementary know-how, skills, capabilities
	1	Trust
	1	Unique differentiated product (e.g. features, performance)
	1	Relative product advantage to the customer
	2	Quality
	3	Ease of use, customer understanding of the product
	4	Exploring new technologies beyond current own portfolio
	5	Communication
Product Substitution	1	Trust
	2	Quality
	3	Clear objectives of collaboration
	3	Unique differentiated product (e.g. features, performance)
	3	Ease of use, customer understanding of the product
	4	Communication
	5	Partner's complementary know-how, skills, capabilities
	5	Clear roles and responsibilities
	5	Customer and market need orientation
	5	Relative product advantage to the customer
Product Complimentarity	1	Clear objectives of collaboration
	1	Quality
	2	Legal arrangements between partners
	2	Customer and market need orientation
	3	Partner's complementary know-how, skills, capabilities
	3	Trust
	4	Communication
	4	Clear specification and requirements
	5	Clear roles and responsibilities
	5	Collaboration champions
	5	Importance of personalities, personal chemistry
	5	Partners commit best personnel

5. CONCLUSION

5.1 Contribution of the research

5.1.1 Contribution to the theory

Whetten (1989) identifies the four building blocks of theory development, and each may provide a legitimate, value-added contribution to the theory. The first building block is 'what,' and it defines concepts, variables and constructs that should be considered part of the explanation of the phenomena. The second area of contribution is 'how,' which introduces the relationships between the identified variables and concepts. The third block is 'why,' which justifies the selection and casual relationships between the variables. The final, fourth block, is the context, defining the boundaries of the research in terms of temporal and contextual factors. Based on the assessment model above, the current section summarizes the contribution this thesis makes to the literature and theory.

In Whetten's (1989) 'what' category, which maps out all relevant factors of the phenomena, the current study contributes to theory development by listing all considerable variables of the two main concepts used in the research: industry convergence and inter-company collaboration. First, the abstract and still ambiguous concept of industry convergence receives further clarification. The study results, using four-type convergence typology, confirm that convergence is not a homogenous phenomenon but can be conceptualized to different convergence contexts. Both logical reasoning and empirical evidence suggest that collaboration success factors have different importance, which arise primarily from the convergence context, and differentiate between types of convergence. Hence, the notion of different types of convergence is statistically confirmed based on different requirements for inter-company collaborations. Second, the study adds new insights into the concept of inter-company collaboration by compiling a list of collaboration CSFs relevant in the convergence context. The comprehensive list of 35 collaboration CSFs grouped into five management categories is logically deduced and then empirically verified to adequately reflect the inter-company collaboration concept in the convergent environment.

In the 'how' category of theory contribution, the study introduces the relationships between industry convergence and inter-firm collaboration concepts. The thesis provides the nexus between two lists of variables developed in the 'what' category above: four-type convergence typology and 35 collaboration CSFs. The results show that various types of convergence place differential demand on collaboration management, and the empirical investigation specifies the relationships between convergent contexts and collaboration management capabilities. That is, for each type of convergence, the study outlines the most important collaboration success factors as empirically verified by collaboration managers. In addition to the most important collaboration CSFs, collaboration success factors that statistically differentiate between types of convergence are listed. Prior research has not explicitly related the concepts of inter-company collaboration and industry convergence, and has not differentiated between types of convergence by providing specific lists of required collaboration CSFs. Existing convergence typology has received the mean for reality classification and generalization from the collaboration management point of view. The types of convergence can be described and differentiated in light of different collaboration CSFs being important.

In Whetten's (1989) 'why' category, the provided contribution to the theory is insignificant, as the focus of the current study is aimed at exploratory and descriptive targets. While deductive logic reasoning is applied to select the list of collaboration CSFs relevant in the convergence environment, some rudimentary cause-effect relationships between collaboration CSFs and types of convergence are described to justify the selection of variables in terms of subsequent empirical implications. In addition, the empirical results section provides limited explanations for observed behavior.

The 'context' category makes a theoretical contribution in the current study, as one of the key concepts of the research, industry convergence, is a contextual variable. Convergence represents a special case in technology systems, and different types of convergence possess distinctive features that place demands on specific collaboration factors. The new convergence context necessitates the need to verify and test existing operational management concepts and tools that have not been examined before in this context. The original management concept of inter-company collaboration is applied and verified in the new convergence context by compiling the list of 35 logically deduced and then empirically tested collaboration CSFs. In addition, the existing research method of managerial critical success factors demonstrates new implications in the convergence environment. Originally developed for the strategy field, the concept of critical success factors is applied in the operational management domain of inter-company collaboration management in the industry convergence setup. However, in defining the context, the limitation for generalization should be noted, that current study uses Stieglitz's (2003) specific four-type convergence typology, which defines contextual boundaries of each type of convergence, and all study results should be examined within the selected typology.

To summarize the discussion above, the main theoretical contribution of the thesis lies in identifying variables that define convergence and collaboration concepts and, what is more important, in expressing the relationships between these variables. The thesis, first, differentiates between types of industry convergence by the importance of the collaboration success factors, and second, finds what success factors are the most important for each type of convergence. Results suggest that the convergence context is heterogeneous, and different types of convergence place demands on specific identified collaboration success factors. The theoretical contribution achieved constitutes a prerequisite for further theoretical and empirical investigation of the effect of the convergent context on the collaboration management capability with the aim of justifying casual relationships between the variables in future studies.

5.1.2 Contribution to management practice

The study results and four outlined types of convergence can help managers understand the difference in convergence effects and implications for company strategic, and particularly operational, management and guide practitioners toward effective collaboration management in a convergent environment. Managers, first, should identify the type of industry convergence that affects the collaboration setup and, second, recognize that different types of convergence place demands on different factors leading to collaboration success. Top-ranked

CSFs, listed in Table 9, constitute an effective management toolkit for different convergence environments that would help to bring collaboration to a successful outcome.

Three success factors in the study received the highest ratings for all types of convergence, i.e., a partner's complementary capabilities, trust and communication. These are key prerequisites for all collaborations regardless of the type of convergence and the focal points of managerial attention. Another three success factors received the recognition in top-five group for three types of convergence. Clear objectives of collaboration and customer and market need orientation factors received high ratings except for the technology integration type of convergence. Despite the technology push-driven innovation approach in the technology integration type of convergence, managers still should emphasize up-front innovation activities of building market knowledge and identifying market opportunities and product concepts. The quality factor was excluded from the top group in the technology substitution case because of the process nature of disruptive technology; however, this factor is critically important for new product development-related collaborations, as quality defines product success in the market.

Technology substitution presents competence destroying radical change for the majority of incumbent companies as new technology renders existing core competencies and technological knowledge obsolete. New strategy, based on external knowledge and collaboration, is required for the incumbent company to avoid technological lockout to obsolete technologies. Managers should focus on building the relevant absorptive capacity and switch to the new technology to survive. The top management role is critical to envision future technological shift, select the right partner, ensure compatible strategy between partners and actively sponsor important collaboration projects. All people-related success factors received a high rating for the technology substitution type of convergence, highlighting the severe effect of this type of convergence on collaboration and partners' success. As the new disruptive technology sets the industry in a state of flux and absence of dominant design, companies should collaborate in standards development activities and pay attention to developing specifications and requirements.

Technology integration convergence is driven by managerial creativity through innovative combinations of new and existing technologies for new product creation. Collaboration partners should focus on bringing to the market a product with a unique superior set of characteristics, including quality dimension, delivering relative advantage to the customer and ensuring ease of product use. Product attributes show the highest rating of importance for technology integration convergence collaboration projects. On the other hand, this type of convergence creates new knowledge requirements for the firm and originates the dilemma between exploring the existing technology portfolio and diversification toward new technologies. According to the study results, managers opt for the latter option, and collaborative arrangements provide the right tool to easily access required complementary technologies and capabilities without capturing and internalizing them. Absorbing the new technologies is not on the managerial agenda because of the high technology and market risks associated with this type of convergence. In operational processes, managers should focus on market research activities, fast technology integration and flexibility in alliance management.

Product substitution convergence resembles the technology integration type in the focus on product characteristics with the difference that product substitution is driven by market requirements. Inter-company collaborations are formed to explore new technologies; however, the required product characteristics are already specified by the market. In these conditions, partners are able to focus on defining clearer collaboration objectives, roles and responsibilities. Interest in learning and absorbing new competencies is higher than in the technology integration case. The top management role and people-related factors, in general, show the lowest ratings among all types of convergence, and reflect lower technology and market uncertainty. Considerable power struggle problems between partners are not identified, and roles in the business network are clear; however, by delivering substitutive products, partners change their own position within the business ecosystem. Collaboration practitioners should use interdisciplinary teams to bring products to the market faster than possible competitors to explore the market opportunity window.

In the product complementarity convergence context, the main objective of collaboration is delivering a complementary product set. Developing standards and compatibility between products is the most important success factor among all other offering-related attributes. Each partner focuses on its own technology portfolio to develop its own part of the complementary proposition, and the importance of exploring new technologies is rated the lowest among all types of convergence. This industry convergence case is characterized by market convergence through complementary products rather than technology fusion within the product. Collaboration partners should concentrate on standardization and compatibility work, and developing clear specifications and requirements for elements of the complementary system on the process side. On the management side, inter-industry wide standardization activities emphasize clarification of roles and responsibilities, and focus on legal and regulatory arrangements. The high ratings for people-related factors highlight the importance of competent people working in such a demanding industry convergence environment.

5.2 Assessment of the research

5.2.1 Validity

Validity is the degree that defines whether a measure actually measures the abstract concept being used to represent (Carmines and Woods, 2005). The abstract concept of collaboration success in convergence environment is represented by empirical indicators - the importance of collaboration success factors, for which there are direct observations. Observable response, indicated by the answers on a questionnaire, allows moving from the theoretical concept to the measures generated through the scoring process. Several types of validity are identified in the social research measurement literature to account for different aspects of validity (Carmines and Woods, 2005; McDonald, 2005).

Content validity is the extent to which a particular empirical measure reflects a specific domain of concept in an adequate and comprehensive way. To obtain content validity, first, the entire domain of content relevant to a particular measurement situation should be specified, and second, the specific measurement indicators should be selected (Carmines and Woods, 2005). In the current thesis, the domains of convergence, R&D collaborations and

new product development were thoroughly reviewed based on secondary data in trusted academic research publications to identify the list of variables relevant in the convergence context. To achieve a high degree of content validity, the list of collaboration success factors is designed as quite inclusive to cover a wide range of collaboration aspects from strategic to operational perspectives, and to account for vaguely defined in empirical context convergence concept. In the exploratory research settings, it is preferable to begin with rather more indicators to sample content to ensure the representativeness of the indicators, because deficient items can be dropped in future studies (Whetten, 1989).

Criterion-related validity concerns the correlation between a measure and some criterion variable of interest that is supposed to be a direct measure of the concept under study (McDonald, 2005). Criterion validity has limited use in this thesis because it is hard to find a direct measure to validate against. Convergence is still a relatively abstract concept, and although different measures of alliance success exist in the literature, such as profitability or knowledge gained, success criteria can differ depending on the convergence context. The objective of the research is not to measure the alliance success in any tangible or intangible terms; instead, the research question adds to the convergence conceptualization and possible criterion definition by focusing on the differences between collaboration success factors in various convergence scenarios.

From the research philosophy perspective, positivism-based research approaches resolve the limitations of reality apprehension through the application of reliability and validity tests; interpretivism paradigm clarifies reality through the language and narratives; while realism approach uses a cyclical evaluation to link knowledge and reality (Kazi, 2000). Construct validity is an important criterion for judging the validity of qualitative research within the realism paradigm (Healy and Perry, 2000). Construct validity is essential in conditions of the absence of relevant direct measurement criteria, and when there is no agreement on the domain of content for the phenomenon (Carmines and Woods, 2005). In this thesis, construct validity is measured as the correlation between the theoretical predictions about original concepts under study and observed empirical outcomes. As the first step, in the deductive part of the study based on the academic literature, the theoretical relationships between the concepts of convergence and collaboration were outlined and converted into the list of variables for empirical measurement–collaboration success factors. Initial propositions for the importance of different success factors in various convergence settings were built. Second, empirical relationships between the concepts were examined and measured. Rules for measuring operational definitions of the concepts were defined: scoring was applied for measuring the importance of the success factors, and empirical data was gathered. Third, the empirical evidence was interpreted in light of theoretical constructs. Different types of convergence required specific collaboration capabilities. As a result, empirically observed outcomes were consistent with the theoretical predictions, and this significant relationship in the expected direction constituted evidence of the high construct validity of the study.

5.2.2 Reliability

In quantitative positivistic research that stems from classical experimental traditions, reliability is the degree by which repeated scoring of a measure provides consistent values

(McDonald, 2005). However, a qualitative study requires different criteria for quality, and reliability has limited usefulness. The basic distinction between quantitative and quantitative studies is the measurement method. Qualitative studies have the purpose of generating understanding, and use research methods with a deeper relationship between researcher, data generation and interpretation, such as interviews. Repetitive correctness is not relevant in the domain of conditional subjectivity, a relevant demand in inductive research (Stenbacka, 2001).

Healy and Perry (2000) propose methodological trustworthiness criteria to judge the reliability of qualitative research within the realism paradigm, which relies on multiple perceptions of a single reality. Methodological trustworthy refers to the extent to which research can be audited. In the current thesis, methodology is illustrated in thorough details, and references to research publications used for selecting variables and deducing the logic behind selections are provided; quotations and summaries of the observable responses are available. In addition, key procedures for collecting data and statistical methods used for the data analysis are described. Pilot interviews were used to improve the survey questionnaire and remove bias.

To improve the reliability and validity of the research, and account for multiple perceptions of a single reality of the realism paradigm, a triangulation strategy can be involved (Healy and Perry, 2000). Triangulation strengthens a study by combining several kinds of methods or data sources, including using quantitative and qualitative approaches. In the current study, the triangulation method is used by applying the deductive literature review method in the hypothesis-building part of the study and the survey method in the inductive empirical part. Triangulation between quantitative and qualitative data collected during interviews also contributed to the research reliability.

Addressing the issue of reliability in qualitative research, Lincoln and Guba (1985, p. 316) reveal the congruence of reliability and validity: “Since there can be no validity without reliability, a demonstration of the former [validity] is sufficient to establish the latter [reliability].” Lincoln and Guba (1985) use dependability criteria to assess reliability in qualitative studies. To address the dependability, the process within the research should be reported in sufficient detail to enable another researcher to repeat the work, if not necessarily to achieve the same results. In the current thesis, to allow the reader to follow research practices, the research design and its implementation described what was planned and executed, the operational details of data gathering were revealed, and reflective appraisal of the study was given in the current chapter.

5.2.3 Generalizability

External validity refers to the generalizability of a relationship outside the settings of the study (McDonald, 2005). In quantitative research, the large statistically driven sample ensures representativeness for the whole population, and that the resulting conclusions are general for a population. However, the nature of the qualitative samples, that is, small size and the inductive approach, makes the criteria of the generalizability assessment different, since the qualitative research findings are specific to a small number of individuals and the

particular context environment (Stenbacka, 2001). As observations are defined by a specific context in which they occur, the question of generalizability relates to the issue of transferability of findings to similar situations described in the study (Lincoln and Guba, 1985). The current thesis provides a full description of all the contextual factors regarding the inquiry and conveys the boundaries of the study. Information on the following issues are provided to the reader: type of organization participating in the study and industry context, type and number of participants involved in the interviews, data collection methods employed, the number and length of the data collection sessions and the time period over which the data was collected. These details enable the reader to compare the instances of the phenomena described in the current thesis and determine the degree of confidence in transferring the current research results and conclusions to other situations.

Healy and Perry (2000) recommend, in the settings of realism paradigm, employing analytical generalization quality criteria, initially developed by Yin (1989) for the case study type of research, for assessing generalizability quality criteria. Compared with positivism philosophy, whose main concern is testing the applicability of a theory to a population, realism research is primarily a theory-building tool for addressing the complexity of the reality. Analytical generalization differs from statistical generalization by making theory-building and understanding of phenomenon possible through analyzing causes, behaviors and motivations, choosing the informants relevant to the study but not by statistically driven samples. In the current thesis, initial propositions for the theory of collaboration management in the convergence context were developed and then subsequently tested in the empirical environment. The developed theory is suitable for further tests on its generalizability to a population in the future studies using larger samples and positivist methods.

5.3 Limitations and future research

This study contains several limitations, which provide opportunities for future research. First, at the conceptual level, one important issue concerns the definition and typology of convergence. The current thesis attempts to track the differences in convergence typology based on technology-product and substitution-complementarity dimensions; however, alternative convergence typologies exist, including dynamic concepts. The selected typology views the convergence as a cross-section at a given point in time, while dynamic concepts would better accommodate process studies over a period. The absence of common convergence definitions and tools to define or measure convergence indicates the need for future research on concept building and verification.

Second, differentiation criteria for different types of convergence are based on a set of collaboration success factors that requires further verification. A wide range of non-comparable collaboration success indicators are used in different collaboration, new product development and convergence studies ranging from perceived success measures to profit indicators and from operational- to strategic-level parameters that may not indicate the realized performance of the collaboration adequately. The representativeness of the critical success factors relevant in the convergence context should be verified in future studies using larger samples and factor analysis statistical techniques in terms of finding a potentially lower number of uncorrelated variables. The information gained about the potential

interdependencies between the observed variables and factor-loading values can reduce the set of variables in a dataset in future studies and help focus on the most important parameters.

Third, at the methodological level, the current study focuses on a subjective measure of perceived success factors, or how the importance is perceived by the interviewed managers, rather than on the objective measure of success factors that can be validated against objective success criteria. Different measures of collaboration success are outlined in the academic literature, including financial indicators, intangible aspects of relationships between parties, measures of alliance longevity or achievements of particular goals (Littler et al., 1995). However, considerable difficulties are found in defining the success of the alliance and measuring performance constructs (Vilkamo and Keil, 2003). Different objectives may exist depending on the context, for example, the type of convergence, or company strategy. Further, collaboration can be analyzed at different levels, and success at, for instance, the project level may not necessarily lead to success at the company level. In addition, the effect of the technology alliance on profitability may be indirect. Hence, objective measuring of collaboration CSFs often is not possible in reality. Nevertheless, the advantage of the CSFs method is in giving the ability to decision makers to win insights into their perception in regard to relevant success factors and perceived ones (Dess and Robinson, 1984). The exploratory scope of the current study provides a solid theoretical and qualitative empirical foundation for the subsequent empirical validation of the identified perceived success factors versus selected objective success criteria.

In addition, the current research was conducted in the context of the ICT industry, and generalizability to other industry sectors should be tested in future studies. Referring to the fundamental work of Pavitt (1984) on sectoral patterns of technological change, assumption on differences between industry sectors should be taken into account. However, convergence effects are witnessed in various industries where similar convergence typologies were successfully applied and tested (Bröring and Cloutier, 2008; Karvonen and Kässi, 2010).

Moreover, although the study finds tentative evidence of differences between types of convergence, more work is needed to verify the findings with a larger sample size and parametric statistical methods to improve the validity and generalizability of the study. The research on convergence is relatively young in empirical and methodological terms with no dominant research design yet available in the academic literature. The majority of the studies to date have been theoretical (Kim et al., 2010). As the value of convergent products and service has increased for consumers, the number of empirical studies, including case studies, surveys, field studies and experiments, has begun to grow. Future empirical studies with a positivistic research approach and methods will provide additional insights into industry convergence.

To summarize the outlook for future studies, the results of the current thesis contribute to the following recent research trends that have the potential for further theory and managerial practices development in the convergence domain. First, convergence is a complex phenomenon with an apparent effect in many industries and with tremendous implications and significance for the economy as a whole. Research on convergence is constantly growing, and particularly in recent years, the focus of the research is shifting toward the empirical-level and operational management perspectives to provide value to practitioners

(Kim et al., 2010). Second, growing product complexity, expansion of new technologies and the need for complementary services require collaboration between parties from different industries more than ever (Chesbrough, 2006). Endogenous convergence contexts and industry differences bring the need for a specific collaboration research agenda in the convergence environment (Bröring, 2010), and the current study addresses this need. Third, convergence creates new business models of the collaboration between the players in cross-sector value networks or ecosystems (Berkhout, 2007). Ecosystem logic raises the importance of understanding of companies' roles and collaborative behavior within the ecosystem as well as co-opetition between different ecosystems. The results of the current thesis contribute to these promising trends of enquiry and make a further step into the fascinating field of research and understanding of the effect of different types of convergence on the governance mechanisms of the collaborations.

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PART 2:

ORIGINAL PUBLICATIONS

PAPER 1

Success factors for technology convergence collaborations

by
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SUCCESS FACTORS FOR TECHNOLOGY CONVERGENCE COLLABORATIONS

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ABSTRACT Inter-firm technology collaboration has received significant attention in research literature during last decades. The reason has been increasingly growing number of technological alliances of different types especially in high-tech industry sectors such as telecommunications and information technology. Companies enter alliances in non-core or even core business areas with growing frequency and often are engaged in several collaborations simultaneously. The reasons for companies to collaborate are ranging from strategic to industry and company specific. Technology collaboration is acknowledged as a source of competitive advantage for companies, and partnering skills are treated as special strategic skills to be developed. As collaboration becomes the way of life it is important to understand factors affecting positive outcome of collaboration in order to develop abilities to collaborate successfully and capitalize on collaboration benefits.

Recent advances in electronics and digitalization of media and equipment have brought technology convergence as global trend affecting company strategy and having significant managerial implications. Previously followed distinct trajectories technologies from adjacent areas as telecommunication and computers started to overlap and merge together to form new products or develop new applications and markets for converged products. Integration of different technologies becomes important for new product development and also challenging as technological choices span across various industries. Process leads to blurring industry boundaries and changing industry structure. In convergent industries company does not have all required competencies and capabilities to develop convergent products itself and, taking into account technological and market uncertainties surrounding new product development, collaboration often is used to enact company strategy. Dynamic environment affected by convergent technologies has specific implications for managing technology collaborations and factors determining partnering success are potentially different from other environments.

The purpose of this paper is to review the most significant determinants of success in inter-firm technology collaboration though the lens of managing technological convergence in ICT industry. Although several studies have identified factors affecting technology collaboration success, there is a research gap to understand critical success factors needed to manage collaborations for technology convergent product development. This paper refines technology collaboration success factors already identified in research literature, classifies them and outlines results applicable for managing technology convergence collaborations. The focus of the review is as strategic and structural as operational and process dimensions of collaboration. Finally, the paper gives indications for key success factors in technology convergence context to be proven empirically and makes recommendations for further research.

Keywords: *industry convergence, technological convergence, success factors, collaboration, partnerships, ICT*

Introduction

Inter-firm technological collaboration is widely accepted way of doing business in current business environment. During the past four decades there is a clear trend of growing number of inter-firm R&D collaborations. Trend is especially visible in high-tech industries as at the end of 1990s over 80% of the newly made R&D partnerships are found in IT and pharmaceutical industries (Hagedoorn, 2002). Dense horizontal structure R&D networks with growing number of collaborating companies emerge in computer industry during last two decades of 20th century. In horizontally organized computer industry R&D partnerships became a major tool of getting access to wide variety of external resources and technology in a flexible manner (Cloodt, Hagedoorn, & Roijakker, 2006).

The reasons for collaborations differ from technology acquisition to getting marketing knowledge for developing products for new markets. Partnering becomes effective skill needed by companies to survive in current turbulent business environment. This skill can create competitive advantage for the company, and improve company performance and its bottom-line profitability. In addition to collaboration skill, company needs to know determinants which can bring collaboration to successful results.

One of the global phenomenon affecting not only company behavior but the whole industries is convergence. The term known from 60s gained considerable popularity in management during last decades, although academic research of this area is not currently sufficient. There are different definitions and types of convergence. Technological convergence occurs on technology side and makes previously unrelated industries converge on the technological basis. Product convergence, on the other hand, is related to demand side due to growing consumer demand similarities. Products are substituting or complementing each other forcing industries and technologies to converge. Convergence has also a significant effect on industry structure, industry dynamics and company itself. One effect of convergence is a growing number of collaborative relationships between companies as convergence makes companies to look for new skills, technologies or market knowledge to adapt products for new markets. Dynamic environment affected by convergent technologies and markets has specific implications for managing technology collaborations and factors determining partnering success are potentially different from other environments. In academic literature market convergence is studied from industry dynamics and company strategic management perspectives. However, there is a research gap on effects of convergence at operational management level.

In this study, we elaborate the effect of convergence on the company both from the strategic level, and what is more important, from the operational level. Firstly, we define convergence, populate a list of drivers causing convergence and describe different convergence types identified in the literature. We also discuss about the effects convergence has on industry structure, industry dynamics and company strategy. Secondly, we define collaboration as company response to convergence environment and continue by elaborating on reasons for collaboration, risks and critical success factors identified in the literature which are needed to make collaboration successful. Finally, we match factors leading to collaboration success with different convergence types in order to propose which of them may be the most critical to focus depending on convergence type.

Our research is qualitative and exploratory by nature to keep holistic view and to investigate relatively unexplored area of convergence at operational management level. Research approach is conceptual analysis based as the primary method on literature review in the areas of convergence and collaboration. The main research question to be addressed in this paper is what the major factors are contributing to inter-firm collaboration success in different types of convergent environment.

Literature search has been done through the books and such electronic databases as EBSCO, Elsevier Science Direct, Emerald, and IEEEXplore. Data sources on collaboration and collaboration critical success factors can be considered as reliable as this area of research is well explored, empirically tested and there is general consensus among the authors. Number of books and journal papers on convergence is limited compare to literature on collaboration and several conference papers were used for elaborating on convergence as this area of research is relatively new, although some empirical case studies have been already done.

This paper makes several contributions to existing body of knowledge:

i. Brings input to the body of relatively unexplored area of technology and industry convergence
ii. Discusses the impact of convergence on company operational management
iii. Contributes to the literature on inter-firm collaboration from convergence point of view
iv. Outlines success factors needed for collaboration in convergent environment

The ICT sector is selected as a framework for this study because the ICT sector can be considered particularly competitive and volatile in terms of technological and market changes with a high frequency of collaboration arrangements, and where the effect of convergence is the most apparent.

This study is not drawing on differences between organizational types of arrangements between collaborating companies and the terms “partnership”, “alliance”, “collaboration” and “cooperation” are used equally as synonymous in a sense of “partnerships among firms that work together to attain some strategic objective” (Harrigan, 1988). Literature on collaboration types, frameworks of selection and advantages of each mode depending on business environment conditions is available (Chiesa & Manzini, 1998; Colombo & Delmastro, 2001; Todeva & Knoke, 2005). Also in this paper we are not elaborating on definition and measurements of collaboration success in tangible, e.g. profit received or costs saved, objectives met, or intangible terms, e.g. experience and knowledge gained, as this is rather complex area requiring special investigation (Littler, Leverick, & Bruce, 1995). Instead we will concentrate on factors leading to collaboration success. We conclude with several propositions that should be examined empirically in further studies.

Convergence

Convergence is the popular term in business environment during last two decades and especially frequently used in relation to technological convergence in ICT industry, where information technologies, telecommunications, entertainment and media are evolving into

giant multimedia industry. As phenomenon became apparent and gained practical importance, academic research picked up, and currently amount of literature in this area is growing, although conceptual confusion within the field of convergence still exists (Lind, 2004).

The topic is still relatively unexplored both theoretically and empirically. Existing literature on convergence can be divided on 1) studies from technical perspective, 2) industry convergence as phenomenon itself and its drivers, and 3) implications of industry convergence to strategic management and business models. Effect on operational management is relatively unexplored and empirical research is largely missing.

In this section, we populate a list of drivers for the convergence, elaborate on convergence classification given by different authors, and discuss implications that convergence has on industry and company. There is a consistent set of drivers leading to technology and market convergence identified by several authors. Yoffie (1997) lists three major forces for digital convergence: 1) semiconductor, software and digital communication technologies, 2) governmental deregulation, and 3) managerial creativity. First two we can refer to influence of external environment and the last one to internal company driver. Although digital technology is assessed as a major trigger towards convergence, all three driving forces are needed in order for digital convergence to materialize. Pennings (2001) defines three drivers as deregulation, socio-economic developments and technological innovations. According to Borés (2003) technological convergence is possible because of technological factors, such as evolution of information and communication technologies, and economic factors due to world liberalization of telecommunication markets.

Widely accepted definition of convergence is given by Yoffie (1997, p. 3) as "In its simplest form, convergence means the uniting of the functions of the computer, the telephone, and the television set." As one of the drivers for convergence is digitalization of media and the way computing equipment works, Kaluza (1999) is using term digital convergence to elaborate on implications. Technological convergence is the trigger for market convergence, when industries become related from technological point of view. Below we elaborate on convergence definitions given by different authors.

First mentioning of technological convergence goes back to Rosenberg's (1976) study of evolution of US machine tool industry. Application of same sets of mechanical skills like drilling or grinding to diverse products led different industries of final products technologically converge on the basis of technologies used. Conceptualization of convergence by two types is given by Greenstein (1997). Convergence in substitutes happens when different products share same features and provide same function to end-users substituting each other. An example of this type of convergence is mainframe and microcomputers merging into currently widely spread PCs. On the other hand, convergence in complements occurs when previously unrelated products due to some technological change can be used together to create higher utility to consumers or bundled into new type of products with added value to end user. Integrating camera, music player and PDA applications in handheld mobile devices or smart phones provides example of this types of convergence.

Pennings (2001) expand convergence definition by adding demand and supply dimensions to convergence of substitutes and complements creating a 2x2 matrix with four convergence types. Demand side convergence characterizes customer needs and is sub classified to convergence of substitutes caused by growing similarity of needs across different consumer groups and to "product bundling" or complementarity when the same set of consumers at one stop shopping tries to obtain a product satisfying different needs. Supply side convergence focusing on technology and firms is archetyped to technology substitution, when new technology overlaps and offers the same benefits with already existing technology but, for example, at lower costs. The second type of supply side convergence is technology bundling, when two technologies are combined together to develop new or improve existing product.

Stieglitz's (2003) classification offers similar four types of market convergence as above, but demand and supply dimensions are called product and technology correspondingly (see Table 1). We adopted this model as a base for our study of critical success factors needed for each category and now elaborate more on different convergence type. This model is selected for our study as the latest one in convergence area in academic literature and as it is build upon previous convergence models of Kaluza (1999) and Pennings (2001). Also several studies in convergence field refer to Stieglitz's (2003) model (See e.g. Bally, 2005; Bröring, 2004; Gerum, Sjurts, & Stieglitz, 2004; Lind, 2004; Weaver, 2007)

Table 1. Types of industry convergence (Adapted from Stieglitz, 2003).

	Substitution	**Complementarity**
Technological convergence	Technological substitution	Technological integration
Product convergence	Product substitution	Product complementarity

Within the industry in the case of technological substitution new technology is able to replace currently used technologies. New general purpose technologies can be applied to different industries making previously unrelated markets converge from technological point of view. Products are created at lower costs or with improved quality and product characteristics can be unaffected. However, quality improvements and process innovation at first stage can remove design tradeoffs and lead to product innovations later. In any case, new technologies require different technical skills and even make some traditional competencies obsolete. Invention of semiconductors or every next generation of telecommunication networks (NMT, GSM, 3G) are examples of technological substitution.

Bundling existing technologies to create new products for new markets due to technical or regulatory possibilities constitutes technological integration convergence type. Its feature is high market uncertainty as product is new to consumers and it is unclear what characteristics should constitute added value. In addition, existing technological capabilities should be modified in order to improve or enhance new products, and process of technological learning should also take place. Example of technological integration can be creating of Wireless

Local Area Network (WLAN) technology as integration of computer networking Ethernet technology with wireless radio mobile communication technologies.

Product convergence in substitutes sparked by new technology or governmental regulations leads formerly unrelated products to share similar characteristics by incorporating features of the products from other markets. Changing product characteristics also leads to changing technological bases of the companies as companies need to assimilate technological capabilities of other markets in addition to new technology that sparked change. Product convergence in substitutes is often followed by technological convergence. Markets are merging into larger market with similar product characteristics and technologies. Substitution by smart phones with integrated telephony and PDA functions of PDAs without connectivity or simple mobile phones illustrates this type of convergence.

Finally, new technology can cause product convergence in complements when existing previously unrelated products become complementary and create greater value to the consumer if used in combination. These are still different products and convergence in complements does not lead to technological convergence. The most important consideration here is the common standard that would enable products interoperate successfully. Advent of mobile internet and consumption of internet services on mobile devices due to common standards triggers this type of convergence.

Classification of different types of convergence provides structure to explain technology and market convergence, and also to elaborate on consequences of convergence on industry and company and trace strategic reactions of firms to technological and market change. Below we list some implications to industry and company at strategic level.

At industry level, first of all, markets are enlarging as technological base of the companies becomes more diverse (Fai & von Tunzelmann, 2001), number of product feature is growing and products are entering adjacent markets. Industry boundaries are blurring and we witness creation of giant media industry from computing and telecommunication industries. At the growing market size competition is intensifying as new players emerge with substituting or complementing products. In the case of new technology emerging, entry barriers can be low as incumbent firms do not have enough knowledge of new technologies and markets (Borés et al., 2003; Kaluza et al., 1999).

Industry structure is also changing as vertical disintegration happens or horizontal collaboration networks emerge. In the study of telecommunication industry, Rao (1999) witness to vertical disintegration of telecommunication industry R&D activities and growing number of technology based alliances between telecommunication and Internet firms or telecommunication firms and microelectronic firms.

As a result of industry enlargement, entering of new players and structure change the whole industry value chain is reconfigured between new and incumbent players (Wirtz, 2001). Borés (2003) suggests that strategy of securing access to the market by been the last link in the value chain to consumers can give companies decisive competitive advantage. Also owning rights to content may be deceived in ICT industry in new configuration. Even incremental technology integration may become disruptive and lead to deconstruction of

existing value chains and formation of new value networks (Hacklin, Raurich, & Marxt, 2004).

On the company level, probably the most dramatic effect of technological convergence and blurring industry boundaries causing companies to face new technologies and markets is obsolescence of current organizational capabilities. This effect is common for all types of convergence (Pennings & Puranam, 2001). Possible discrepancies between old set of skills and new capabilities coherent with new products and diversification into new markets are resolved through company strategy. To adapt to new technological regime company is forced to redefine its core business and acquire new competencies by means of strategic technology alliances. The clear effect of convergence on company is growing number of collaborations and alliances (Borés et al., 2003; Duysters & Hagedoorn, 1998; Hacklin et al., 2004).

Choices regarding internal development versus collaboration as well as most suitable organizational form and mode of cooperation depend on convergence type and environment characteristics as speed to market needed or relatedness to core technology (Pennings & Puranam, 2001). Stieglitz (2003) develops framework of firms strategy and industry dynamics in convergent environment based on (Malerba, 2002) sectoral system of innovation adding special elements for convergence.

In response to convergence, company's strategy in telecommunication market can include bundling, differentiation and diversification, merges and acquisitions (Bauer, 2005). Kaluza (1999) develops concept of dynamic product differentiation strategy focusing on four critical success factors: costs, differentiation, flexibility and time, which provide a company with capabilities to simultaneously produce products of high differentiation at low costs.

In the discussion of company strategy there are two strategic frameworks how a firm can sustain competitive advantage over time: the resource-based view (J. B. Barney, 1991; J. Barney, Wright, & Ketchen, 2001; Foss & Knudsen, 2003; Grant, 1991; Wernerfelt, 1984) and traditional emphasis on industry structure and position of the firm within industry (Porter, 1979). The resource-based view extended to the concept of dynamic capabilities (Eisenhardt & Martin, 2000; Teece, Pisano, & Shuen, 1997) is more applicable and used as framework for convergence (Hacklin, Adamsson, Marxt, & Norell, 2005) and high velocity environments (Vilkamo & Keil, 2003).

Companies can enter into partnering arrangements, according to resource-based view, in order to complement or expand its current capabilities, or, from industry and competitive market perspective, to improve its competitive environment position. In the following section, we elaborate on inter-company collaboration and critical success factors on company level needed for successful collaboration in convergent environment.

Collaboration and Critical Success Factors for Collaboration

Current business environment is characterized with high degree of technological and market uncertainties. On market side it is difficult to predict demand for a new product, especially when market needs time to be educated. On technology side a disruptive innovation may give

a rise to new technology paradigm, which makes old competencies obsolete, lack of standards at early stage leads to compatibility issues among different products and indirect network externalities are not present. Often significant investments required for new product development create additional risk, as innovation diffusion speed is not known, and economic impact cannot be calculated. Collaboration is one way for the companies to reduce these risks and uncertainties. Number of inter-firm collaborative arrangements is constantly growing.

The literature on collaboration is extensive and focusing on different perspectives of the phenomenon. Numbers of studies identify reasons for collaboration, defining collaboration modes suitable for particular circumstances, measuring collaboration success, identifying problems and factors leading to collaboration success. In this section, we briefly discuss on the reasons for collaborations and then focus on critical success factors already identified in the literature that a company may need in order to collaborate successfully. We identify and classify factors in order to reflect them on convergence dimensions and to elaborate which particular ones may be the most crucial for convergent environment.

Most frequently mentioned in the literature reasons for companies to enter collaborations are acquiring know-how and learning new skills that reside outside of the organization, access to complementary assets, defraying costs and sharing risks, altering competitive position, gaining market power at the expense of other competitor (Stuart, 2000).

For telecommunication industry the reasons to collaborate are increased innovation and access to labor and expertise, market access, government requirements, global market capability, access to technology, access to capital and risk sharing (More & McGrath, 1999). In addition to developing innovations and new products, complementary products and defining industry standards can be added as reasons for partnering (Mohr, 2001). These reasons are also consistent with several other studies in ICT field (Amesse, Latour, Rebolledo, & Séguin-Dulude, 2004; Hagedoorn, 1993; Rao, 1999). In the study of US communication industry Bauer's (2005) reasons include co-branding of internet access, interactive advertising, new digital service offering such as mobile TV broadcasting, cross-distribution of SW, integration of different services (instant messaging), providing business and enterprise solutions. Cost-economizing and strategic motives for many R&D partnerships are interrelated. Strategic rational is apparent in new and high risk related areas of R&D partnering, when the future importance of technological capabilities remain unclear, or when companies are selectively entering into partnerships not related to their core activities (Hagedoorn, 2002).

Although partnerships and alliances are often prescribed as essential tool for success, many risks are inherited to partnership efforts. The most frequently sited are loss of autonomy and control, loss of know how and trade secrets, legal issues and antitrust concerns, failure to achieve objectives (Mohr, 2001).

Previous section of this paper listed the implications of convergence on industry and also on the company at strategic level. At operational level, company response to convergence is reflected in new product development as, for example, in technology complements type of convergence it is no longer a strategic option but a necessity. From the wider perspective all types of convergence cause product development or modifications placed on the continuum

from incremental product modifications in product complementarities to possible radical innovations brought by radical new technologies in technology substitution type. Some critical success factors already identified for new product development (NPD) can be equally applicable for collaborative new product development bearing in mind some risks of collaborative relationships (Littler et al., 1995).

Importance of NPD is widely acknowledged in academic literature from strategic and innovation perspectives. Literature on critical success factors on new product development is mature and over the years has reached consistent conclusions on most important elements. As a summary of research in this field extensive classification is provided by Craig (1992) compiling six groups of related success factors: NPD process activities, management, information, strategy, and company characteristics. Focused research literature is also available on particular segment of success factors; for example organizational structure and style (Rothwell & Whiston, 1990).

New product development, responding to new disruptive technologies or combining existing technologies into a new product is not possible without innovation activities. Product innovation and innovation management especially in high-technology industry is crucial to company survival. Developing innovations and new products is one of the reasons for partnering in high-tech industry (Mohr, 2001). As a summary of critical success factors for product innovation we use the work of Cooper (2003).

Several empirical studies have been done on collaboration critical success factor in ICT industry (Kelly, Schaan, & Joncas, 2002; Littler et al., 1995; More & McGrath, 1999; Rai, Borah, & Ramaprasad, 1996; Taylor, 2005; Wilson, Littler, Leverick, & Bruce, 1995) that produce consistent set of ingredients for success. Effective collaborations have been proven to exhibit following characteristics.

Strategic objectives of both partners should be clear, motives and goals for collaboration are well defined. Both partners must share mutual dependencies and provide resources and skills to each other which are valued and hard to obtain elsewhere. Equal motivation ensures alliance success. Support and commitment of senior management to the alliance is crucial.

Governance structure should reflect reasoning and level of risk in the partnership. Legal arrangements are important but not the most critical ingredient as there is a move from formal contractual relationships to broader form of alliances based on strategy sharing and trust. In addition to governance structure and valuable skills possessed by partners, corporate culture of alliance members should be compatible otherwise culture clashes will prohibit common strategy and synergies realization.

All studies mention trust as the vital success factor, when partners make decisions that serve best mutual interests of partnership. Trust is build over time, leads to more effective information sharing and willingness to allocate scares resources to joint efforts. Trust is also based on commitment, or mutual desire to continue relationship into the future, which stems from goodwill, positive feeling and respect for each other contribution. Commitment can be reflected in making irreversible investments into partnership and reduction of opportunistic behavior.

Effective communication in the dynamic environment is absolutely critical to alliance success. Communication flows should be open and bidirectional sharing information that even sometimes can be considered proprietary about partners' progress, potential needs and problems. Role of personalities and one-to-one communication is pivotal. A formal structure for communications in terms of regular reports and meetings should be established.

Coordination and control mechanism should be developed as contact points between organizations and dedicated teams for operational processes. Committees at different management levels can facilitate coordination and communication processes. Joint project management committee of some sort from both sides should be established. Cross functional and cross level communication should be ensured by organizing management groups of representatives from different areas and levels. Control mechanisms also should be agreed.

All critical factors leading to successful NPD, innovation and collaboration management identified by each author were collected by us in one table. Then most frequently mentioned and the most significant ones, as identified by authors, were selected and grouped according to similarity to several management areas. Also logical induction process was used to prescreen what factors above have relation to convergence. Finally, based on that list we identified following groups of critical success factors (see Table 2) to be used in matching to different convergence types in next paper section in order to determine which of them are the most significant for particular type of convergence.

Collaboration Critical Success Factors for Convergence

In current academic literature two fields of research on technological convergence and on collaboration success factors for new product development exist largely unrelated. Second section of this paper summarizes latest research in convergence area and lists main effects convergence has on industry and on company at strategic management level. However, more specific management guidelines, which can be utilized at operation level, are relatively unexplored in research. On the other hand, over the years extensive body of literature exists on collaboration management including factors leading to collaboration success, which are outlined in previous section of the paper. In this part we attempt to match these two fields of research and elaborate what collaboration success factors are significant in convergent environment and what are the most critical ones for different convergence types.

Table 2. Critical success factors for alliances in ICT industry identified in the literature.

Strategy
Integrating partnering into company strategy
Strategy sharing between partners
Managing exploration and exploitation
Balancing partnership portfolio
Proactive strategy: monitoring and balancing technology portfolio
Proactive strategy: monitoring markets and value networks
Clear profitable benefits of collaboration, market need
Company selection
Complementary know-how, skills, capabilities
Cultural and process fit
Compatible objectives
Management
Flexible organizational structure
Legal arrangements
Clear objectives
Clear roles and responsibilities
Balance of power in collaboration
Flexibility with respect to changing needs and opportunities
Absorptive capacity
Knowledge management, learning
Process
Communication
Interdisciplinary teams
Collaboration between departments within company
Strong market orientation
NPD: unique superior product
NPD: Prototyping
NPD: Agility, speed to market
NPD: Quality, usability
NPD: Compatible design
NPD: Integration
Systems of control
People
Top management support
Collaboration champions
Importance of personalities, personal communication
Partners commit best personnel
Training for new skills
Trust
Trust
Commitment to collaboration

As a framework to identify in details what factors lead to collaboration success under technology and market convergence we use matrix where columns are different convergence types defined by Stieglitz (2003) and rows are collaboration success factors identified in research literature and summarized in previous section of this paper. Based on that framework we make propositions what are the most relevant and significant elements of success for different convergence types (See Table 3).

Table 3. Collaboration critical success factors for different convergence types

		Technological substitution	Technological integration	Product substitution	Product complementarity
Strategy					
	Integrating partnering into company strategy	√√√	√√√	√√√	√√√
	Strategy sharing between partners	√			√
	Managing exploration and exploitation	√			
	Balancing partnership portfolio		√	√	
	Proactive strategy: monitoring and balancing technology portfolio	√	√	√	
	Proactive strategy: monitoring markets and value networks		√		√
	Clear profitable benefits of collaboration, market need		√	√	√
Company selection					
	Complementary know-how, skills, capabilities	√√√	√√√	√√√	√√√
	Cultural and process fit		√	√	
	Compatible objectives				√
Management					
	Flexible organizational structure	√√√	√√√	√√√	√√√
	Legal arrangements	√			
	Clear objectives	√√√	√√√	√√√	√√√
	Clear roles and responsibilities				√
	Balance of power in collaboration				√
	Flexibility with respect to changing needs and opportunities	√	√		
	Absorptive capacity	√		√	
	Knowledge management, learning	√		√	
Process					
	Communication	√√√	√√√	√√√	√√√
	Interdisciplinary teams		√		√
	Collaboration between departments within company		√	√	
	Strong market orientation		√		
	NPD: unique superior product	√			
	NPD: Prototyping		√		
	NPD: Agility, speed to market	√			√
	NPD: Quality, usability		√	√	
	NPD: Compatible design				√
	NPD: Integration		√	√	
	Systems of control	√			
People					
	Top management support	√	√		√
	Collaboration champions	√	√	√	
	Importance of personalities, personal communication		√	√	√
	Partners commit best personnel	√			√
	Training for new skills	√		√	
Trust					
	Trust	√√√	√√√	√√√	√√√
	Commitment to collaboration	√√√	√√√	√√√	√√√

Legend:
√ significant success factor for convergence type
√√√ critical success factor regardless of convergence type

Before going to particular collaboration factors of high importance for specific convergence type we identify following elements of success that are equally important for any inter-company collaboration regardless of convergence type as these elements are critical cornerstones for collaboration success.

First of all, mix of partner's complementary skills and resources is the key reason for collaboration. It is crucial to determine during partner selection process that potential collaboration candidate has required capabilities to match the requirements for which alliance is initiated (Rao, 1999). Choice of the partner has impact on alliance performance as it determines mix of skills available to alliance. Values, commitment and capabilities of partners should be evaluated. Collaboration strategy and partner selection processes should be integral part of company strategy rather than ad-hoc tool to access given technology at competitive price (Vilkamo & Keil, 2003). From resource-based view company enters into partnering arrangement to enhance and complement its in-house capabilities, and partnering is enactment mechanism of company strategy and should be considered as integral part of company strategy.

Another important ingredient of successful collaboration is clearly set goals, objectives and responsibilities for collaboration that are clearly understood by all partners involved (Littler et al., 1995). Lack of definition in goals combined with communication problems and cultural differences can be highly detrimental to collaboration. If short- and long-term objective of the partners are misunderstood, direction of the alliance can be fuzzy (Rai et al., 1996).

Open communication and information sharing is also critical to any collaboration success. Formal and informal communication at all company management levels as between partners as within each company helps to understand goals and objectives of the collaboration, create trust and quickly resolve early stage behavioral discrepancies (Kelly et al., 2002). Interpersonal communication, strong ties contributing to social capital and not redundant channels of knowledge sharing allows firms to bundle tacit knowledge in divergent and complementary areas (Pennings & Puranam, 2001).

Trust is acknowledged to have significant influence on collaboration outcome across different studies (Kelly et al., 2002; Littler et al., 1995; More & McGrath, 1999; Taylor, 2005). Ability to rely on mutual trust is critical ingredient to manage economic conflicts, completive changes and shifts in corporate priorities along partnership lifecycle (Arino, de la Torre, & Ring, 2001). Reliance on trust also reinforces unilateral commitment to collaboration by each partner (Gulati & Khanna, 1994). Commitment represents desire to continue relationship into the future and is reflected in investments solely to that partnership. If commitment is not based on positive and voluntary desires but forced, the impact on alliance is negative (Mohr, 2001).

Flexible organizational design is important to respond rapidly to environmental changes. Company structure should be highly modular with flexible ability to add and remove units. New developments can be structurally segregated and plugged into company without disturbing its internal organization (Pennings & Puranam, 2001). Loosely coupled business units facilitate local adaptation and increased sensitivity to environmental changes (Hill & Rothaermel, 2003). New radical technologies, for example in the case of technological substitution, can be spotted sooner. Also different technologies, that require different business models, can be managed through autonomous units.

In addition to common critical success factors for all convergence types, there are some success elements which are relatively less important in convergent environment. Kaluza (1999) in implications of convergence on firm's critical success factors states that while importance of flexibility and time to market increased, importance of cost and quality – decreased. Also under rapidly changing environment and flexible non-equity based types of collaborative arrangements strong focus on legal agreements should not rule the relationships. Collaboration often starts without formal agreement in place (More & McGrath, 1999).

Technological substitution

In technological substitution convergence type, new advanced technology diffusion triggers substitution of current less efficient technologies. At strategic level new general purpose technologies triggering convergence lead to vertical disintegration of industries and forming specialized suppliers upstream (Stieglitz, 2003). Illustrative example of industry reconfiguration in ICT is emergence of specialized semiconductor industry. To survive

incumbent companies need to form alliances with firms which possess new substitute technology. Strategy sharing and open communication with suppliers upstream is critical for successful collaboration. More detailed legal arrangements and systems of control are common in vertical alliances. Proactive strategy of monitoring technology developments will help to identify disruptive trends and switch to more efficient technologies. Balancing exploitation of current technology and exploration of new one should be integral part of company strategy.

Technology substitution convergence is a classical example of competence destroying change leading companies to update their technological base. Incumbent firms often react by pursuing multitechnology strategy broadening their technological capabilities (Gerum et al., 2004). Knowledge management, learning and absorptive capacity are ingredients of success in such conditions. High uncertainty of new technologies and multitechnology strategy also require flexible management style and fast ability to react to changes. As new technology brings drastic improvements in terms of quality or costs, threat of new entrants to the market is high, forcing company to deploy more agile development methods to increase speed to market.

General purpose technologies triggering technology substitution in addition to broad application across products and processes also offer wide scope for improvement and elaboration. Initial process innovation due to new technologies leads to improved product quality and even better design, which in the next stage evolves to product innovation (Stieglitz, 2003) and new product development results in new superior products.

Technology substitution in terms of existing capabilities obsolesce, low cumulativeness of technology and upstream market knowledge has serious impact on the company, hence top management support, collaboration champions, best personnel and training for new skills are essential from people perspective.

Technological integration

In technological integration type of convergence existing technologies used in different markets are combined to develop entirely new technologies and products for new markets. Incumbent company already has parts of necessary technological capabilities and can gain access to missing complementary technologies through collaboration with other companies usually in the form of horizontal alliances.

Effective technology integration is critical capability a company should possess, as competitive advantage often goes to the companies that are most adept at choosing among number of technological options and not necessarily to the companies who pioneer inventions. Right technology integration process is much more important than project management methods, leadership attributes and organizational structure (Iansiti & West, 1997). Also adopted technology integration approach should match company's capabilities and its local culture and conditions. In telecommunication industry large service providers are less dependent on innovation but on ability to combine internal resources with outsourced technology to configure and market one-stop-shopping solutions for the customers (Rao, 1999). Leveraging technological skills across the company and multidisciplinary approach to new product development are important.

Although company may have solid technological base required for new convergent product development, same does not apply to companies' market knowledge and capabilities. Demand for new product is unclear and required product feature set meeting customer preferences is unknown. Market intelligence, study of consumer needs and reactions to new product in such condition is the key. By trial and error process company can test market response and derive product characteristics and dominant design valued by potential customers. Fast prototyping, piloting and testing consumer response will lead to successful product concept. In addition to right feature set, good usability and attention to quality are also important that new product is accepted by market.

Partner portfolio is balanced to develop only features that have market backing and management process should support flexibility in response to demand uncertainties. Market demand for new product will also contribute to collaboration success.

Product substitution

In the product substitution case new technology emerges that makes possible to modify existing product characteristics, and unrelated products become substitutes sharing similar feature set. Companies in related industries are starting to extend functionality of existing products and lateral market entry happens. Product convergence changes technological base of the firm and companies need to absorb new triggering technology and technologies from related markets. In general sense incumbent company has already solid knowledge about market and has sufficient technological base (Stieglitz, 2003). It just needs to absorb some additional related technologies leading to importance of knowledge management and absorptive capacity. Flexible and modular organizational design provides better structure to absorb new capabilities and to respond rapidly to technological and market changes. Due to existing strong technological base company can also leverage existing internal capabilities for new developments. Internal development in combination with strategic technology alliances can make acquisition of new competencies more effective (Duysters & Hagedoorn, 1998).

Horizontal strategic alliances are the main tools for acquiring new technologies and it requires general collaboration capabilities from the company such as clear collaboration objectives and partner selection methods ensuring cultural and process fit, effective personal communication and collaboration champions. Company also needs to balance partnership portfolio in regards to needed complementary capabilities.

Although industry boundaries are reshaping and some ambiguity about competitors, customers and market reaction remains, demand for new products is more clear compare to technology integration convergence type. Technology substitution is technology push, while product substitution is market pull type of innovation. In order to replace product existing on the market, new product should provide good quality, usability or other benefits to customer. Speed to market in general is less important as cumulativeness of technological and market knowledge by incumbent companies is high and threat of new entrants on the market is low.

Product complementarity

When products complement each other and bring extra value to consumers if used together, the key focus of collaboration is often product interoperability and technical standards that

products are able to work together. From product development perspective architecture and common compatible interfaces are needed for interoperability. Also in product development speed to market is important as partners aim to set dominant industry design. Top management support, best personnel and clear communication are needed for successful outcome.

Complimentary products come from different related industries, it also means that new actors enter value system and gain importance in exploitation of technological opportunities. Interdependence of innovation in parallel systems leads to greater need of coordination partner activities in value net (Gerum et al., 2004). New mobile internet services as photo uploading and sharing, for example, can illustrate dynamics in value net, when new players from internet services industry arrive to existing chain of network operators and mobile terminal manufacturers. This type of cooperation is often called co-opetion when cooperation and competition happens at the same time. Partners cooperate in setting industry standards and developing added value to customers but compete for created surplus in value chain. Coordination of value chain roles, activities and balance of power in collaboration are important in addition to clear objectives and strategy of collaboration. New separate product technologies do not bring value by themselves and clear profitable benefit for collaboration and market need should be identified from strategic perspective and right partners with complementary competencies are selected.

The dominant form of collaboration in such circumstances is horizontal strategic alliances providing flexible structure and less dependence to legal agreements compare to vertical alliances. The rest of the critical success factors in Table 3, which we not marked specifically for different convergence types, are still important to collaboration success as proven by previous empirical studies and should be considered by managers during collaboration process. In this study we concentrated on the most significant ones relevant for convergent environment.

Conclusion

In this paper we attempted to relate two separate bodies of research literature – inter-firm collaboration and convergence, in order to answer main research question what are the factors leading to inter-firm collaboration success under convergent environment. Academic literature on convergence is currently relatively unexplored and is concentrating mainly either on technical aspects of convergence or industry dynamics and company strategy levels. Contrarily, wide body of literature exists on inter-firm collaboration and phenomenon is studied from different angles including new product development processes and operational management issues. In second section of the paper we reviewed existing literature on technological and market convergence and outlined inter-firm collaboration as one of the outcomes of convergence influence on the company. In next paper section we reviewed inter-company collaboration literature, focused on already identified factors leading to collaboration success and grouped them into several categories. The main contribution is this paper is developing a matrix between different convergence types and collaboration critical success factors and elaborating which success factors are the most significant for particular convergence type.

Technological substitution convergence is characterized by advent of more efficient general purpose technologies resulting in obsolesce of company's current capabilities. Company needs to develop dynamic capabilities for partnering, pay attention to knowledge management and absorptive capacity, be flexible to react to drastic changes and adopt new technologies fast. In technological integration convergence case market response to new product is unclear and company needs to develop fast prototyping processes to come up with proper product feature set. Collaborating with suppliers of complementary technologies company's technology integration capabilities can be more important than internal innovation. Product substitution convergence forces company to lateral market entry and expanding technological base. Absorbing related technologies during collaboration with right partners is the key in such environment. Market convergence by product complementarities changes industry structure due to new entrants to value chain. Balance of power in collaboration, clear roles, responsibilities and business models contribute to collaboration successful outcome. Compatible products design and agile development methods increasing speed to market are cornerstones of new standard development, what is often the target of collaboration in last convergence type.

Since convergence is relatively new area in academic research, and particularly critical success factors for inter-firm collaboration have not been studied before, this study is explorative to establish a set of measurable constructs. Qualitative research methodology allows increasing understanding of complex and multidimensional phenomenon in specific context. As nature of the research is theoretical and descriptive, conceptual analysis approach is used aiming at examining new concepts and system. Two research methods are utilized: literature review provides the background on the areas of convergence and collaboration and logical induction helps to develop propositions for the most significant success factors for different types of convergence.

Regarding limitations of the study it is worth to mention that inter-company collaboration itself is dynamic and processual phenomenon affected by many factors, which play important role and are difficult to separate. Same complexity applies to convergence phenomenon, which is highly dynamic and caused by interrelated factors. Describing dynamic environment is demanding task. One of the limitations of study is the method used, that is literature review, which is not empirically proven and does not allow statistical generalization. However, this method is logical and justified choice at the starting point of new phenomenon investigation.

Empirical verification of the results should be done in the further studies. Case study based approach would be the next step to refine results and achieve empirical evidence on how well identified critical success factors could support collaboration operational excellence under technological and market convergence. Firstly, case studies can determine what group of critical success factors has the strongest influence on collaboration successful outcome, and, secondly, this group can be elaborated and studied in more details. Further theoretical and empirical studies would require issues of trust and balancing exploitation of existing technologies and exploration of new ones in dynamic convergent environment to help companies to find a good balance between continuity and change. Alternatively, further empirical research can focus on particular type of convergence and define the most

significant factors affecting collaboration success in given convergence setup. Convergence by product substitution is apparent process in ICT industry illustrated by substitution of PDAs by smart phones or desktop PCs by notebooks and this type of convergence can be a good start to concentrate on.

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PAPER 2

Technological and industry convergence types: definitions and empirical assessment

by
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TECHNOLOGICAL AND INDUSTRY CONVERGENCE TYPES: DEFINITIONS AND EMPIRICAL ASSESSMENT

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ABSTRACT

Convergence is a popular term in business environment and especially frequently used in relation to technological integration evolution in ICT industry. Recent advances in electronics, digitalization of media, de-regulation of markets and changes in consumer preferences have led technologies and markets that previously followed distinct trajectories to overlap and merge. Due to convergence, markets are enlarging as technological base of the companies becomes more diverse, number of product features grows and products enter adjacent markets. Therefore, convergence has significant implications on companies' innovation activities posing increasing challenges to continually innovate in altering domains. Managing integration of different technologies, adapting to technological and market disruptions and making technological choices spanning across various industries renders continuous innovation important and challenging. To adapt to new technological regimes and markets companies are forced to continually redefine their core business and acquire new competencies e.g. by means of strategic technology alliances. However, despite its importance, convergence is still relatively unexplored both theoretically and empirically, and the goal of this paper is to contribute to conceptual definition of convergence. In the paper we define four types of convergence that differ by innovation, technology and product demand determinants. In addition, impact on industry and company, and innovation management implications are discussed.

Keywords: Technological convergence, Industry convergence, Innovation

1. INTRODUCTION

Innovation is the necessity for companies competing in environments characterised by unpredictable, pervasive and continuous change (Brown, Eisenhardt 1997), and it contributes to company's competitive advantage in a number of ways (Tidd, Bessant & Pavitt 2005). In the domains of strategy and organisational theory punctuated equilibrium model of change assumes that long periods of small incremental change are interrupted by periods of discontinuous radical change (Abernathy, Utterback 1978, Tushman, Anderson 1986). In relation to innovation, these changes are correspondingly characterised as continuous and discontinuous innovation. Discontinuous innovations encompass high order changes in scope and breadth able to create new industries, products and markets. Continuous innovations are lower in breadth of impact and constitute augmented changes to products, process improvements in the way existing products are produced, management determined procedural improvements and structural modifications. Despite discontinuous shifts, most of the time innovation

happens in continuous incremental fashion, and companies compete by continuously changing themselves through continuous new product development.

One of the themes affecting company strategy and innovation activities is convergence, the popular term in business environment, which is especially frequently used in relation to technological convergence in ICT industry, where information technologies, telecommunications, and media are evolving into giant multimedia industry. Recent advances in electronics, digitalization of media and equipment have led technologies that previously followed distinct trajectories to overlap and merge together to form new products for new markets. Therefore, managing integration of different technologies and continuous innovation becomes important and also challenging task as technological choices span across various industries. As convergence phenomenon gained practical importance, academic research in this area has been growing, although conceptual confusion within the field of convergence still exists (Lind 2004).

The goal of this paper is to contribute to the conceptual definition of the convergence by defining it in terms of innovation, technology and demand determinants in order to address strategic and operational management implications for continuous innovation in this environment and facilitate future research. In addition to management challenge, convergence presents great intellectual challenge to capture convergence definition and develop framework, which would help to analyse and organize various patterns of change accompanying convergence.

2. CONVERGENCE BACKGROUND

Technological and industry convergence is the observed effect of discontinuous and continuous innovation in a globalized industry driven by technological innovations, new business opportunities opened by governmental de-regulations, and evolving customer needs. There is no explicit commonly accepted definition of convergence in academic literature and the topic is still relatively unexplored both theoretically and empirically. Existing literature on convergence can be divided on 1) technical perspectives, 2) industry convergence as phenomenon itself and its drivers, and 3) implications of industry convergence to strategic management. Effect on operational management and innovation activities is relatively unexplored and empirical research is largely missing.

This section of the paper populates a list of drivers for the convergence, elaborates on convergence classification given by different authors, and discusses implications that convergence has on industry and company. There is a consistent set of drivers leading to technology and market convergence identified by several authors. Yoffie (1997) lists three major forces for digital convergence: digital technologies, governmental deregulation, and managerial creativity. First two drivers can be referred to influence of external environment and the last one to internal company input. Although technology is treated as a major trigger towards convergence, all three driving forces are needed in order for convergence to materialize. Pennings (2001) defines three convergence drivers as deregulation, socio-economic developments and technological innovations similar to Borés (2003) attributing convergence to technological factors of IT evolution and economic factors of market liberalisation.

First mentioning of technological convergence goes back to Rosenberg's (1976) study on convergence of different industries on the basis of technologies used. Conceptualization of convergence by two types is given by Greenstein (1997). Convergence in substitutes happens when different products share same features and provide same function to end-users substituting each other. Convergence in

complements occurs when previously unrelated products due to technological change can be used together to create higher utility to consumers or bundled into new products with added value to end user. Von Tunzelmann (1999) identifies also two types of technological convergence when many technologies are used to produce a single product and when many products are produced from a given technology.

Pennings (2001) has expanded convergence definition by adding demand and supply dimensions to convergence of substitutes and complements creating a 2x2 matrix with four convergence types. Demand side convergence characterizes customer needs and is sub-classified to convergence of substitutes caused by growing similarity of needs across different consumer groups and to "product bundling" or complementarity when the same set of consumers at one stop shopping tries to obtain a product satisfying different needs. Supply side convergence focusing on technology and providing firms is sub-classified firstly to technology substitution, when new technology overlaps and offers the same benefits with already existing technology for example at lower costs and secondly to technology bundling, when two technologies are combined together to develop new or improve existing product.

Stieglitz's (2003) classification offers similar four types of market convergence as above, but demand and supply dimensions are called product and technology correspondingly (see Table 1). This model is selected as a base for current study as the latest concept for convergence in academic literature referred in several studies (see e.g. Bally 2005, Bröring 2004, Gerum, Sjurts & Stieglitz 2004, Lind 2004, Weaver 2007).

	Substitution	**Complementarity**
Technological convergence	Technological substitution	Technological integration
Product convergence	Product substitution	Product complementarity

Table 1. Types of convergence (adapted from Stieglitz, 2003)

In the case of technological substitution new technology is able to replace currently used technologies. Often, new technologies represent general purpose technologies and can be applied to different industries making previously unrelated markets converge from technological point of view. Products are created at lower costs or with improved quality and product characteristics initially can be unaffected. However, quality improvements and process innovation at first stage can remove design tradeoffs and lead to product innovations later. In any case, new technologies require different technical skills and even make some traditional competencies obsolete. Invention of semiconductors or every next generation of telecommunication networks (NMT, GSM, 3G) are examples of technological substitution.

Bundling existing technologies to create new products for new markets due to technical or regulatory possibilities constitutes technological integration convergence type. Its feature is high market uncertainty as product is new to consumers and it is unclear what characteristics should constitute added value. In addition, existing technological capabilities should be modified in order to improve or enhance new products, and process of technological learning should also take place. Example of technological integration can be developing of Wireless Local Area Network (WLAN) technology as integration of computer networking Ethernet technology with wireless radio mobile communication technologies.

Product convergence in substitutes sparked by new technology, governmental regulations or growing similarity of consumer needs leads formerly unrelated products to share similar characteristics by incorporating features of the products from other markets. Changing product characteristics also leads to changing technological bases of the companies as companies need to assimilate technological capabilities of other markets in addition to new technology that sparked change. Product convergence in substitutes is often followed by technological convergence. Markets are merging into larger market with similar product characteristics and technologies. Substitution by smart phones with integrated telephony and PDA functions of PDAs without connectivity or simple mobile phones illustrates this type of convergence.

Finally, new technology can cause product convergence in complements when existing previously unrelated products become complementary and create greater value to the consumer if used in combination. These are still different products on the market and convergence in complements does not lead to technological convergence. The most important consideration here is the common standard that would enable products interoperate successfully. Advent of mobile internet and consumption of internet services on mobile devices due to common standards triggers this type of convergence.

It is important to notice that technological convergence does not always lead to convergence in markets (Gambardella, Torrisi 1998). Companies can widely accumulate technological capabilities, especially generic ones, from different industries to produce more complex products and extract greater rents from core product markets. However, these industries remain different by market structure and other industry characteristics. The reason is specific nature of downstream markets with distinct required capabilities missed by the companies because of their cumulative experience path or inability to connect to new value networks.

Classification of different types of convergence provides framework to elaborate on consequences of convergence at industry and company levels. At industry level, first of all, markets are enlarging as technological base of the companies becomes more diverse (Fai, von Tunzelmann 2001), number of product feature is growing and products are entering adjacent markets. At the growing market size competition is intensifying as new players emerge with substituting or complementing products. In the case of new technology emerging, entry barriers can be low as incumbent firms do not have enough knowledge of new technologies and markets (Borés, Saurina & Torres 2003, Kaluza, Blecker & Bischof 1999).

Industry structure is changing as vertical disintegration happens or horizontal collaboration networks emerge. Rao (1999) witnesses vertical disintegration of telecommunication industry R&D activities and growing number of technology based alliances between telecommunication and Internet firms or telecommunication firms and microelectronic firms. As a result of industry enlargement, entering of new players and structure change the whole industry value chain is reconfigured between new and incumbent players (Wirtz 2001).

On the company level, probably the most dramatic effect of technological convergence and blurring industry boundaries causing companies to face new technologies and markets is obsolescence of current organizational capabilities. This effect is common for all types of convergence (Pennings, Puranam 2001). Possible discrepancies between old set of skills and new capabilities coherent with new products and diversification into new markets are resolved through company strategy. To adapt to new technological regime company is forced to redefine its core business and acquire new competencies

by means of strategic technology alliances. The clear effect of convergence on company is growing number of collaborations and alliances (Borés, Saurina & Torres 2003, Duysters, Hagedoorn 1998, Hacklin, Raurich & Marxt 2005).

3. DEFINING CONVERGENCE

In this section of the paper key determinants defining different convergence types are identified taking adapted form Stieglitz's (1993) convergence typology as a base. To describe technological change, innovation process and patterns it takes through different historical periods and industrial settings several contributions have been made (Dosi 1982, Freeman 1982, Nelson, Winter 1982, Pavitt 1984). In this paper basic determinants of different observed patterns of convergence based on patterns of innovation activities across technologies and markets will be identified.

Technological change is the single most important force driving economic growth (Abramovitz 1956). Innovation and technology represent main driving forces for convergence, industry evolution and organizational renewal. In addition, consumer preferences and demand consumers put on the product affect performance improvements, new features development, technology evolution and trigger market convergence. Demand factors shape direction and rate of technological change (Klepper 1996) and demand is related to emergence of disruptive technologies (Christensen 1997). As beginning of new competitive domain stems from technological or market disruptions, innovation, technology and demand are selected as the key determinants of convergence to focus on both technological and market perspectives of convergence.

This paper does not draw on industry characteristics to define convergence as concept of industry in the face of radical technological and market changes needs revisiting. Traditionally industry is defined as a group of firms producing close substitutes with management strategies using positioning theory (Porter 1979) or resource-based theoretical perspective (Barney 1991). Industry boundaries definition is of high importance for managerial decision making as boundaries determine company actions towards other actors in competitive arena, define substitute products and influence industry concentration. However, in convergent environment under disruptive changes competition for incumbents coming from several directions well beyond traditional boundaries defined. To address this issue alternative concepts have been developed in the literature (Bettis 1998, Munir, Phillips 2002). In addition, innovation process differs across industry sectors in various dimensions such as structure of innovation activities and the way technologies develop (Malerba 2002, Pavitt 1984).

Current conceptual model is also omitting company specific characteristics from convergence determinants, although relationships between convergence on one side and industry and company on the other are not unidirectional. Company capabilities are one of the main drivers behind technological change (Dosi 1997), which leads to convergence. Big established companies with significant research budgets and research teams are major players to promote innovation (Pavitt 1994). Industry structure also has effect on technology evolution. High concentration stimulates innovation due to cumulativeness of learning, technical advance, available financial resources and research capabilities (Dasgupta, Stiglitz 1980, Nelson, Winter 1982). However, company and industry characteristics are often idiosyncratic and sector specific.

One of the key determinant for convergence is innovation, that is "the technical, design, manufacturing, management, and commercial activities involved in the marketing of a new (or improved) product or the first commercial use of the a new (or improved)

process or equipment" (Freeman 1982). Currently academic literature on innovation is populated by a number of taxonomies attempting to characterise innovation by significance, similarity, technical domain and other characteristics (Garcia 2002).

Two broad types of innovation processes can be distinguished (Narayanan 2001). Market pull innovations orient technology towards a specific market need, as technology push advancements direct technology primarily towards increase in technical performance. Innovation can be generally categorized as product, process and market (Johne 1999). This typology is chosen as market dimension is especially important in convergent environment. Market innovation is about identifying potential markets, segmenting markets, improving the mix of target markets and serving the chosen markets in the best way. Product innovation is the changes in the products and services which organization offers, while process innovation is the changes in the ways in which they are created and delivered (Tidd, Bessant & Pavitt 2005). Innovation can also be categorized as to whom it is new. General units of adaptation refer to newness to the company and newness to the market (Cooper 1993, Kotabe, Swan 1995). Market based framework focuses mainly to product innovation, and to account for process innovation Johannessen (2001) adds new to industry dimension.

Another view of classifying innovation impact is provided by Christensen (1997) distinguishing innovation between sustaining and disruptive and by related Anderson's (1990) concept of continuous and discontinuous innovation. Discontinuous innovations "command a decisive cost or quality advantage and strike not at the margins of the profits and the outputs of the existing firms, but at their foundations and their very lives" (Schumpeter 1942). Such innovations, termed technological discontinuities, dramatically affect either products themselves or underlying processes to produce them. Technological discontinuities can be further classified as competence enhancing, that builds in know-how embodied in the technology it replaced, or competence destroying, that renders obsolete the expertise required to maser technology it replaces (Tushman, Anderson 1986). Continuous innovation is incremental building on existing knowledge in existing markets without challenging underlining structures or assumptions.

Types of innovation outputs are classified across two dimensions: degree of innovation component knowledge departure from earlier knowledge, and degree of configuration of technologies in innovation compare to earlier ones making widely used taxonomy of incremental, architectural, modular and radical innovation types (Henderson, Clark 1990). Incremental innovations refer to minor improvements to the elements of products, technologies and processes. Modular innovations represent significant changes in the elements of products, technologies and processes, while existing configuration of the elements remain unchanged. Architectural innovations use existing technologies and processes but reconfigure them in a new ways. Radical innovations are characterised by revolutionary changes requiring significant departures from existing technologies and practices and also utilising new configuration of system components (Narayanan 2001).

Technological change plays the central role in industry evolution and convergence. Technology can be defined as those tools, devices, and knowledge that mediate between inputs and outputs (process technology) and/or that create new products or services (product technology) (Rosenberg 1972). Considerable productivity gains of the economy can be attributed to the diffusion of several general purpose technologies, which play central role in technological convergence making markets converge on the base of technology (Rosenberg 1976) spreading across wide range of sectors and technological domains. General purpose technologies are characterized by

pervasiveness of use across different sectors, inherent potential for technological improvement, dynamism and creating complementarities (Bresnahan, Trajtenberg 1995).

The way innovative activities of a technological class are organised can be explain as the outcome of different technological regimes (Breschi, Malerba & Orsenigo 2000). The notion of technological regime holds relation to the concept of technological trajectories (Dosi 1982, Nelson, Winter 1982, Rosenberg 1976), namely, cumulative and self-generating directions of technological development, which can be explained by sources of technology, nature of user needs and appropriability (Nelson 1982). Technological regimes specify conditions that have major effect on intensity of innovation, degree of industry concentration and rate of entry. Technological regime describes technological environment in terms of four fundamental factors: technological opportunities, appropriability of innovation, cumulativeness of technical advances and properties of company knowledge base (Malerba, Orsenigo 1990).

Technological opportunities reflect intensity of investments in innovation activities. New technological knowledge applicable to wide variety of products and leading to large increase in product performance or quality provides high technological opportunities. Appropriability conditions present the possibilities of protecting innovations from imitations. Cumulativeness of technical advances highlights path-dependent learning process of a firm and accumulation of knowledge used in subsequent innovations. Cumulativeness can take place at four different levels: technological, organisational, market and industry. Technological knowledge cumulativeness represents technological capabilities of the firm and understanding of underlying technologies. Market knowledge cumulativeness include specific knowledge about markets, products, user preferences and customer demand representing marketing capabilities of the firm. However, not all technological regime attributes can be used for convergence definition as they do not have stable relationship with convergence types.

Technological change can create turbulence as well as incremental change in competitive domains follow technology evolution cycle (Anderson, Tushman 1990). Technology emergence phase begins with technological discontinuity created by radical innovation starting period of high technical uncertainty testing new products thorough the process of trial and error. Technology race starts with introduction of competing designs and solutions as between technologies as with new radical innovation constituting the era of ferment in technology cycle. Gradually dominant design takes form of the product winning allegiance of the marketplace, providing base for standardisation, reducing variations and in the product class. Further technological progress is driven by various incremental innovations, first elaborating improvements in the products, and then shifting focus of innovation towards process improvements. Finally, new technological discontinuity arrives and evolution cycle starts over again.

Next group of convergence determinants in the model is related to demand that has been a major factor affecting industrial dynamics and innovation (Malerba 2007). Market forces are fundamental drivers of innovation within established technological paradigm (Dosi 1982). There is a strong fit between customer demand and producer ability to meet these needs with respect to the rate and direction of improvements in product cost and performance. Demand can also be related to emergence of disruptive technologies, when emergent new markets with different needs move into the mainstream and eventually change the rules under which mainstream operates utilizing improved technology serving both markets in a better way (Christensen 1997). In addition, there is clear relationship between demand and innovation diffusion (Hall 2004).

Malerba (2007) identifies two aspects of demand which are relevant for innovation in industries: consumer behaviour and consumer capabilities. Consumer behaviour is driven by information asymmetry about new products and reflects in inertia and habits towards new products and technologies. Consumer capabilities are represented in this study model as customer technological sophistication. Saviotti (2001) also highlights importance of two parameters for using innovation: consumers must have enough knowledge to understand properties of new goods, and new goods must have minimum level of efficiency for consumption to start.

Several attributes of innovation influence the process of innovation diffusion. Relative advantage is the degree to which innovation is perceived as better compare to preceding idea. Compatibility is the degree of innovation consistency with existing values or past experience to potential adopters (Narayanan 2001). The need and availability of collateral assets (Teece 1986) also affects innovation diffusion speed. Collateral assets are defined as complementary products or complementary value constellations.

Finally, based on the literature review and discussion above conceptual model for convergence determinants is outlined in Table 2. Convergence typology is adapted from Stieglitz (2003) and logical induction process is used for making propositions to test them empirically.

DETERMINANTS / CONVERGENCE TYPES	Technological substitution	Technological integration	Product substitution	Product complementarity
INNOVATION				
Innovation process type	Technology push	Technology push	Market pull	Market pull
Prevalent innovation dimension	Process, Product	Product, Market	Product	Market
Innovation impact	Disruptive	Sustaining	Sustaining	Sustaining
Technological discontinuity	Competence destroying, enhancing	Competence enhancing	Competence enhancing	Competence enhancing
Innovation content	Modular, Radical	Architectural	Incremental	Architectural, Incremental
Innovation newness to	Company, industry	Company, market	Company	Company, market
TECHNOLOGY				
Technological pervasiveness	General purpose	Specific	Specific	Specific
Technology knowledge cumulativeness	Low	High	High	Low
Technological opportunity	High	Low	Low	High
Technology evolution stage	Technological Discontinuity	Era of ferment	Incremental Product innovation	Emergence of dominant design
DEMAND				
Market newness	Old	New	Old	New
Knowledge cumulativeness of demand	Low	Low	High	High
Relative technological advantage	High	Low	Low	High
Customers technological sophistication	Low	Low	High	High
Need for collateral assets	Low	Low, High	Low	High
Compatibility with user values	Low	Low	High	High

Table 2. Convergence determinants

For empirical validation four interviews each lasting about 1 hour were conducted in the in big international ICT company producing devices incorporating functionality of telecommunication, consumer electronics and media industries. Respondents were project managers and collaboration managers of the age 35-45 working in partnerships representing different convergence types and having experience in the area for 5-10 years. Projects and interviewees were chosen to represent particular convergence type and it made one interview to verify conceptual model for each convergence type. In essence the study presents an exploratory, pre-test phase of research confirming the existence of different convergence types as well as testing of conceptual model defining convergence types in terms of innovation, technology and demand determinants.

Overall, empirical results summarised in Table 3 show conformance with the proposed conceptual model, despite some discrepancies with initial propositions. Although general technology is prevalent driver for radical technological substitution, specific technologies also play the role in technological substitution convergence type. Need for collateral assets exists in technology substitution case and relationship is idiosyncratic in technology integration and product substitution convergence types. Innovation content in product complementarity type seems more incremental while product substitution encompasses both incremental and architectural innovation types. Technology evolution stage in product substitution type may not be steady incremental process but possibility of new design appearance always exists highlighting disruptive nature of convergence. Innovation impact in technology integration case can also be disruptive even if old existing technologies are combined leading to possible high technological opportunity and high relative technological advantage. In product substitution case in addition to product there is also a flavour of market innovation dimension. Finally, product complementing each other create innovation newness to market by its combination.

DETERMINANTS / CONVERGENCE TYPES	Technological substitution	Technological integration	Product substitution	Product complementarity
INNOVATION				
Innovation process type	True	True	True	True
Prevalent innovation dimension	True	True	FALSE	True
Innovation impact	True	FALSE	True	True
Technological discontinuity	True	True	True	True
Innovation content	True	True	FALSE	FALSE
Innovation newness to	True	True	True	FALSE
TECHNOLOGY				
Technological pervasiveness	FALSE	True	True	True
Technology knowledge cumulativeness	True	True	True	True
Technological opportunity	True	FALSE	True	True
Technology evolution stage	True	True	FALSE	True
DEMAND				
Market newness	True	True	True	True
Knowledge cumulativeness of demand	True	True	True	True
Relative technological advantage	True	FALSE	True	True
Customers technological sophistication	True	True	True	True
Need for collateral assets	FALSE	FALSE	FALSE	True
Compatibility with user values	True	True	True	True

Table 3. Empirical results of convergence determinants

4. DISCUSSION AND CONCLUSION

Innovation, technological and market changes play the central role in convergence, which poses radical challenge to innovation management requiring continuous innovation activities in multi-technology and multi-market domains. In general, management in convergent environment characterized by emergence of disruptive conditions in technologies and markets. In addition to new radical technological disruptions, even integration of exiting technologies together can shift technological trajectory to radical direction (Hacklin, Raurich & Marxt 2005). On the market side emergent new segments due to improved technology can eventually change the rules under which mainstream market operates (Christensen 1997). Traditional strategic management concepts based on static industry analysis do not reflect changing technological landscape accurately and can even act as barriers to receiving signals and effectively responding to threats and opportunities associated with radical shifts. Convergence represents example of Christensen's innovator's dilemma, when great companies fail because of inability to escape the past. Co-evolution of innovation,

technology and market deserves more attention and this paper aims to reduce this research gap through defining convergence for further managerial implications building.

To respond to uncertain conditions management can invest in information gathering, tools for tracking markets and technological trends, and flexible organisational structures (Yoffie 1997). General key routings for successful continuous innovation capability include aligning business strategy with innovation activities, acquiring needed capabilities from external knowledge sources, generating internal technology, effective technological strategy execution, continuous learning and organisation development (Bessant 2003).

There are different managerial implications for innovation management depending on convergence type. In the case of technological substitution marketing opportunities for the new products caused by radical innovation are often unspecified and unclear. Conventional market research techniques may be inappropriate or even detrimental (Trott 2003, Veryzer 1998). For less radical technology integration case traditional new product development model with emphasis on up-front activities, such as building market knowledge, clear product and opportunity definition, can be applicable (Ulrich, Eppinger 1995). In product substitution case characterised by incremental innovation company can leverage internal capabilities to expand into adjacent technologies and markets. Focus strategy is applicable for companies operating under product complementarities convergence as complementary products are unrelated to current company capabilities and historical heritage with limited absorptive capacity reduce ability to expand rapidly into new areas. As convergence is evolving form one type to another there are different patterns of innovation opportunities and returns to innovation effort depending on technology lifecycle and consumer demand characterised by convergence type. Taking innovation and convergence type into account organisation structural variables can be adjusted to adapt to convergence type as some organisations are better suited for one type of innovation than the other (Van de Ven et al. 1999).

Another issue for management to consider is what project type to pursue. Focusing to both technological and market types of convergence will definitely leave company with competence gaps, while pursuing only one side of convergence company can leverage existing competencies if project fits to current skills. Also as companies are able to cope with technological side convergence, different market structures may pose considerable challenges to expand downstream (Gambardella, Torrisi 1998, von Tunzelmann 1999). Resource-based view of innovation considers that in volatile environment firm relies on own knowledge and capabilities to cultivate its own markets as long-term technology and innovation strategies are difficult to develop (Cohen, Levinthal 1990, Hamel, Prahalad 1994). On the other hand, convergence brings the need for companies to have capabilities from different technological and market areas presenting challenges to formulate right innovation strategy.

As companies have strong path dependence for technologies and markets, and convergence brings competence lack in either of these dimensions, companies always need to use collaborations to fill competence gap. Investigation of collaboration success factors needed in convergent environment would be a proposal for future research. Second, future research is needed to investigate convergence itself and other environmental and organisational determinants affecting it, such as industry and firm characteristics as well as inter-organisational relationships and networks. Lastly, research should continue investigation of different innovation management implications companies face depending on convergence type.

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PAPER 3

Successful Partnering In Convergent Environment: Product Complements Development Case

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Successful Partnering In Convergent Environment: Product Complements Development Case

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Abstract: Convergence is an apparent trend in current technological and business environment bringing the need for fundamental changes in companies' innovation activities and operational practices. This paper focuses on product complements convergence type, which has general practical importance especially to technology and innovation management, and product development. Convergence in complements takes place when previously unrelated products become complementary and create greater value to the consumer if used in combination. Complimentary products come from different related industries, and companies enter new value systems to exploit technological opportunities. Often the key focus of collaboration is product interoperability and technical standards enabling products to work together. This type of cooperation is often called coopetition, when cooperation and competition happens at the same time. Partners cooperate in setting industry standards and developing added value to customers but compete for created surplus in the value chain. In relation to ICT industry, the recent technological innovations, digitalization of media, de-regulation of markets and changes in consumer preferences have led technologies and markets that previously followed distinct trajectories, to mix and partially merge. Products embed features from related industries and enter new markets leading to market enlargement and new industry value ecosystems creation. To adapt to new technological and market conditions, companies need to increasingly innovate and develop new products often by means of collaborative arrangements to get access to new competencies and knowledge. Factors determining partnering success under convergence are different from other environments, studied in earlier literature. This paper contributes to existing body of knowledge on convergence and inter-company collaboration from operational management level point of view by ranking collaboration success factors needed under product complements convergence type. Managers should pay particular attention to setting clear collaboration objectives and specifications, legal arrangements between parties, quality of the product, developing trust, ensuring management support and customer orientation.

Keywords: Collaboration, convergence, complementary products

1. Introduction

Today's business environment is characterized by accelerated pace of change. Emerging new technologies and evolving customer lifestyles are changing industry boundaries, nature of competition and socio-cultural trends. One of the apparent phenomenon constituting the change is convergence - the collision of previously distinct industries like computers, consumer electronics, telecommunications and entertainment driven by relentless evolution of technologies, digitalization of media, companies' innovation activities and adoption of new standards (Baker et al. 2004). There are different definitions and types of convergence identified in the literature. Technology convergence occurs on supply side and makes previously unrelated industries to converge on the technological basis. Product convergence, on the other hand, is related to demand side and attributed to growing consumer demand similarities. This paper focuses on product complements convergence type, which has general practical importance, especially to technology and innovation management, and product development.

To capitalize on convergence, companies broaden their offering by developing and executing complementary product strategy (Sengupta et al. 2006). Complements are products or services that add value to potential customers if consumed in combination. Complementary products create multiplier effect to original product sales. As capabilities for complementary product development may lie away of the company roots and core competencies, collaboration with other partners become the tool for the company to enact its strategy. Often the key focus of collaboration for complementary product development is product interoperability and technical standards enabling products to work together. Technical standard development is often a battle between competing group of players supporting own interests. Cooperation in such conditions is often called coopetition, when cooperation and competition happens at the same time. Partners cooperate in setting industry standards and developing added value to customers but compete for created surplus in the value chain.

Another convergence implication is the need for the companies to expand their technological base to produce new products, which become more complex and combine features from related industries. Expanded list of required new technologies, competencies and capabilities is not always available for

the companies internally and, taking into account technological and market uncertainties surrounding new product development, companies increasingly enter into collaborative arrangements. Managing of collaborations in dynamic environment effected by converging technologies and markets requires specific success factors that are different to traditional environment.

This paper contributes to the existing body of knowledge on convergence and inter-company collaboration from operational management level point of view by ranking collaboration success factors needed under product complements convergent environment. The study helps managers to identify success factors needed under convergence and to focus on the most significant ones in order to bring collaboration to successful outcome. In the paper, taking primarily ICT industry as example, firstly, convergence definitions and implications given in existing literature are reviewed. Secondly, convergence type of product complements is selected for subsequent empirical test. Thirdly, based on current literature, a list of technology collaboration success factors is outlined, and survey is conducted to define the most important factors leading to collaboration success. Finally, results are statistically reviewed, managerial implications for technology and innovation management in product complements convergence case are outlined, and areas for future research are indicated.

2. Convergence and complementary products

Convergence is the frequently used term in business environment, especially in relation to technological convergence in ICT industry, where information technologies, telecommunications, entertainment and media are evolving into giant multimedia industry. As the phenomenon has become apparent and gained practical importance, academic research has increased, although conceptual confusion within the field of convergence still exists, and the topic is still relatively unexplored both theoretically and empirically in the management research literature.

Conceptualization of convergence has been provided by several authors. Von Tunzelmann (1999) defines convergence at technology and product level. On one side, many technologies are used to produce a single product and, on the other side, many products are produced from a given technology. Focusing on product side, Greenstein (1997) defines convergence in substitutes and in complements. In the case of substitutes, different products share the same features and provide the same function to end-users by substituting each other. On the other hand, convergence in complements occurs, when previously unrelated products can be used together, due to some technological change, to create higher, new utility to consumers. Adding demand (product) and supply (technology) dimensions to Greenstein's classification of substituting and complementary products, Pennings (2001) and Stieglitz (2003) offer similar convergence conceptualizations by four types (see Table 1). Technology side characterizes company's technologies and innovation activities, while product side attributes to demand and customer needs.

Table 1: Types of convergence (adapted from Stieglitz 2003)

	Substitution	**Complementarity**
Technology convergence	Technology substitution	Technology integration
Product convergence	Product substitution	Product complementarity

In the case of technology substitution convergence-type, new technology replaces currently-used technologies. New technologies require different technical skills, and they may even render some companies' traditional competencies obsolete. Technology integration convergence takes place when existing technologies are integrated into new and innovative configurations, to create new products for new markets, as a result of technical or regulatory possibilities. Product based substitution, sparked by new technology, governmental regulations and evolution of customer preferences, results in the effect that previously-unrelated products share similar characteristics by incorporating features of the products from other industries. Finally, in the case of product complements convergence, existing and previously unrelated products become complementary due to new technical interfaces and create greater value to the consumer if used in combination with each other. This paper focuses on the last convergence type.

Convergence has considerable effect on the industry, leading to redefinition of traditional industry concept and boundaries between product-markets (Bernabo et al. 2009). Number of product features

is growing and products are entering adjacent markets; this process results in blurring market boundaries and market enlargement (Fai, von Tunzelmann 2001). At the growing market size, competition is intensifying, as new players emerge with substituting or complementary products (Borés et al. 2003, Kaluza et al. 1999). The industry structure is changing because of vertical disintegration or horizontal collaboration networks emergence (Rao et al. 1999), and the whole industry value chain is reconfigured between new and incumbent players (Borés et al. 2003, Wirtz 2001, Krishna, Ghatak 2008). One of the illustrative examples of complementary product convergence and related industry value network reconfiguration is the development of internet services, like online music distribution, photo sharing and social networks accessed through mobile smart phones. Entrance of new non-traditional players into industry value network results in the complex interactions between mobile network operators, telecommunication equipment manufactures, Internet service providers, SW companies and media content owners (Swatman et al. 2006, Krishna, Ghatak 2008).

Product side convergence, and product complements convergence type in particularly, is mainly driven by customer demand. The main purpose of any technology is fulfilling a customer need, and technological innovation of companies is driven by the expectation of fulfilling a need. Customers place increasing value on cross product integration (Nambisan 2002) and bundling of services (Krishna, Ghatak 2008), forcing companies to develop complementary product strategies. A complementary product is the product that enhances the value of a focal product when the two are used together by customers (Sengupta 1998). Complementary products and services leverage positive externalities of the focal product by enhancing market visibility, product repute, customer trust and accelerating product reach. The importance of product complementarity as a business success factor is especially high in high-tech markets (Nambisan 2002).

Complementary products through technologies related to them exist within technological systems, comprised from the set of components that interact with each other. Standards represent interface specifications that define how individual components of technological system function and interoperate with each other to provide utility to users. Compatibility between components is achieved due to common standards. Common standards provide framework within which product-markets operate, and enable individual companies to produce components of a larger technological system (Garud et al. 2002).

Companies can achieve significant competitive benefits by shaping common standards especially in ICT field, characterized by network externalities and increasing returns (Shapiro, Varian 1999). General purpose technologies and common standards create opportunities for complementary innovations. Successful business model in such environment is to maintain control over the overall technical and business architecture by acquiring control over interfaces between different technical and commercial modules and imposing specific architecture upon entire market (Hawkins, Ballon 2007). Generating a unidirectional action towards common standard development between different companies, which have private interests and some of which may be rivals, creates tensions and often results in “coopetitional” setup.

Traditionally, strategic management literature has been focusing purely either on competitive or collaborative paradigms. Competitive behavior of the firm is driven by the goal to achieve competitive advantage by developing strategies to better fit to the industry structure (Porter 1979) or by developing and nurturing hard-to-copy competencies (Barney 1991). An alternative collaboration paradigm in strategic management views business environment as a network of collaborating companies pooling together complementary resources, skills and capabilities, and exploiting mutual benefits by fostering positive interdependencies (Hakansson, Snehota 1995). These extreme paradigms are rear in current business environment, and interactions between the companies are often based on both positive and negative interdependencies. Companies’ interaction is characterized by partially convergent interests and building competitive advantage over competitors by exploiting the opportunity for win-win structure, when cooperation and competition happens at the same time - “coopetition” (Brandenburger, Nalebuff 1995).

Coopetitive relationships between companies can happen on two domains: value-chain and product-market (Bengtsson, Kock 2000). In the former case, companies are interacting in functional areas within primary value chain activities (both upstream and downstream). In the latter, competition and cooperation is divided between product areas, when parties can compete in certain markets and

cooperate in other. Product complements convergence type is generally related to value-chain domain coopetition.

A mix between simultaneous cooperation and competition in companies' relationship depends on several structural conditions. High resource complementarity and low market commonality are the conditions contributing to collaborative behavior, and vise versa, common markets and homogeneous resources lead to the rise of rivalry (Luo 2007). Also exogenous issues of environmental characteristics and endogenous drivers of company knowledge profile can affect the mix between cooperation and competition in coopetition (Padula, Dagnino 2007). In addition, firms tend to compete more frequently in activities closer to the buyer in the value chain and cooperate in activities carried out at a greater distance from the buyer (Bengtsson, Kock 2000).

Several classifications of coopetitive relationships are available in the literature to define implications for strategic management (Bengtsson, Kock 2000, Luo 2007). In relation to convergence, useful alliance classification by two types is provided by Mitchell (2002). Scale alliances are created between companies contributing similar resources to achieve scale advantages. Link alliances, on the other hand, are based on partners' complementary resources to expand their business activities with the focus on marketing resources and strong protection mechanisms. Link alliances involve joint manufacturing, as long as components produced by the partners are distributed along value chain, and can be attributed to product complements convergence type. Luo (2007) develops coopetition typology, where depending on the intensity of competition and cooperation, that simultaneously occur between parties, different strategic alternatives are outlined. Convergence in product complements refers to the case, when two players depend on each other to achieve own goals maintaining high cooperation and high competition across different contexts, e.g. parts of the industry value-chain.

Effect of the product complementarity convergence type on the company is reflected in complementary product strategy on the continuum from make to buy. Regardless of the scenario, one of the key alternatives for the company to ensure complementary products availability is collaboration arrangements with other organizations. Understanding of the convergence context and collaboration critical success factors can help managers to improve their strategies and bring partnership to successful outcome.

3. Collaboration and critical success factors for collaboration

Convergent technologies and markets drive companies into collaborative efforts to broaden technological base, develop complementary products or specify new standards. The existing literature on collaboration is extensive and dealing with various perspectives of the inter-actor relationships. This section focuses on the critical success factors already identified in the traditional literature that company may need to collaborate successfully. Factors are identified to determine, which particular ones may be the most crucial for convergent environment, and next empirical section of the paper studies importance of them in relation to product complementarity convergence type.

Several empirical studies have been done on collaboration critical success factors in ICT industry (Kelly et al. 2002, More, McGrath 1999, Rai et al. 1996, Taylor 2005), that produce consistent set of ingredients for success including among others clear objectives setting, effective communication, trust, support and commitment at different management levels, best personnel, legal arrangements, market understanding, learning and knowledge management.

Company's response to convergence is mostly reflected in new product development and innovation activities. Product innovation and innovation management, especially in high-technology industry, is crucial to company survival. Developing innovations and new products is one of the reasons for partnering in high-tech industry (Mohr 2001). Literature on critical success factors for new product development and product innovation is mature, and over the years has reached consistent conclusions on the most important elements (Cooper 2003, Craig, Hart 1992). Research on convergence also provides insights on success factors needed by companies to response to convergence challenges (Pennings, Puranam 2001, Borés et al. 2003, Bierly, Chakrabarti 1999, Hacklin et al. 2005). In addition, coopetition context has specific implications and contribution to the list of factors (Chin et al. 2008).

Finally, the most frequently mentioned and significant critical factors identified by each author and leading to successful new product development, innovation and collaboration management were

collected and grouped according to their similarity into several management areas. A logical induction process was used to prescreen these factors thorough the lens of their relation to convergence. Based on this process, following groups of critical success factors are identified (see Table 2) to be used in empirical part of this study in order to determine which of them are the most significant for product complementarity convergence type collaborations.

Table 2: Summary of the critical success factors for alliances in ICT industry

	Collaboration success factor
Company Strategy	
	Partner's complementary know-how, skills, capabilities
	Strategy sharing between partners
	Cultural and process fit between partners
	Compatible strategy between partners
	Clear and profitable market prospects
	Changing company value and position in industry value network
	Exploring new technologies beyond current own portfolio
	Exploiting existing own technology portfolio
Management	
	Flexible organizational structure
	Legal arrangements between partners
	Clear objectives of collaboration
	Clear roles and responsibilities
	Balance of power between partners in collaboration
	Flexibility to changing pre-defined goals
	Trust
Process	
	Communication
	Interdisciplinary teams
	Customer and market need orientation
	Clear specification and requirements
	Prototyping and concept pre-testing
	Technology and new elements integration
	Processes to accelerate product development
	Learning
	Capturing acquired competencies, building absorptive capacity
	Systems of control
People	
	Top management support
	Commitment to collaboration at all levels
	Collaboration champions
	Importance of personalities, personal chemistry
	Partners commit best personnel
Offering (products and services)	
	Unique differentiated product (e.g. features, performance)
	Relative product advantage to the customer
	Developing standards, compatibility, industry ecosystem
	Quality
	Customer sophistication and understanding of the product

4. Methodology and results

The unit of analysis for this study is inter-company technological collaboration in the ICT industry – dynamic sector the most affected by the changes in business environment. The data for the analysis were drawn in a international ICT company producing devices incorporating functionality of telecommunication, consumer electronics and media industries. Technology collaborations between this company and its partners were in the focus of the study.

Interview was selected as a research method to validate questionnaire list and address complex and ill-defined area of convergence. Study data were collected by exploratory structured interviews lasting about 1 hour with 6 collaboration managers with the aim to review the list of success factors identified in the previous section and define whether the listing provides a comprehensive set of factors to be considered. Interview respondents were selected from two groups of collaboration cases clearly representing product complementarity convergence type, when (1) product development collaboration happens between companies representing different parts of the ICT industry value network and (2) developing industry standards collaboration cases. Respondents of the age 35-45 represented middle and upper-middle management and had experience in inter-company collaborations for 5-10 years.

Respondents used Likert scale from 1 to 7 raging from “very low” to “very high” in rating the importance of each critical success factor regarding product complements convergence type collaboration projects. Answers for each collaboration success factor were summarized to get total score of importance for each factor, and total scores were ranked in descending order to compare importance between success factors (see Table 3). Standard deviation measures dispersion of the data set and variability of respondents’ answers.

Table 3: Importance of collaborations success factors for product complementarity convergence

Collaboration success factor	Respondent						Standard deviation	Total score
	1	2	3	4	5	6		
Legal arrangements between partners	7	7	7	7	6	4	1.21	**38**
Quality	7	7	6	6	6	6	0.52	**38**
Clear objectives of collaboration	6	6	6	7	6	6	0.41	**37**
Customer and market need orientation	7	6	7	7	6	4	1.17	**37**
Collaboration champions	6	5	7	7	6	6	0.75	**37**
Partner's complementary know-how, skills, capabilities	7	6	5	6	7	5	0.89	**36**
Clear specification and requirements	6	5	6	7	6	6	0.63	**36**
Importance of personalities, personal chemistry	5	6	7	7	6	5	0.89	**36**
Partners commit best personnel	6	5	7	6	6	6	0.63	**36**
Trust	5	6	5	6	7	6	0.75	**35**
Communication	7	6	2	7	6	7	1.94	**35**
Clear roles and responsibilities	5	5	5	6	7	6	0.82	**34**
Developing standards, compatibility, industry ecosystem	5	2	7	7	5	7	1.97	**33**
Exploiting existing own technology portfolio	4	4	5	7	6	7	1.38	**33**
Capturing acquired competencies, building absorptive capacity	5	5	5	6	6	6	0.55	**33**
Flexibility to changing pre-defined goals	3	5	6	6	6	6	1.21	**32**
Interdisciplinary teams	5	3	5	7	6	6	1.37	**32**
Commitment to collaboration at all levels	5	6	5	4	6	6	0.82	**32**
Exploring new technologies beyond current own portfolio	5	6	2	6	7	6	1.75	**32**
Top management support	5	5	3	7	7	4	1.60	**31**
Balance of power between partners in collaboration	4	3	6	6	6	5	1.26	**30**
Processes to accelerate product development	3	4	4	6	6	7	1.55	**30**
Technology and new elements integration process	5	4	6	5	6	4	0.89	**30**
Clear and profitable market prospects	4	2	5	7	5	6	1.72	**29**
Customer sophistication and understanding of the product	7	6	1	6	6	3	2.32	**29**
Flexible organizational structure	5	5	4	2	7	4	1.64	**27**
Prototyping and concept pre-testing processes	4	5	2	5	6	5	1.38	**27**
Relative product advantage to the customer	5	6	1	6	4	5	1.87	**27**
Cultural and process fit between partners	5	3	5	5	6	2	1.51	**26**
Compatible strategy between partners	5	4	6	4	5	2	1.37	**26**
Unique differentiated product (e.g. features, performance)	5	4	1	5	4	6	1.72	**25**
Learning processes	5	3	3	4	6	3	1.26	**24**
Systems of control over project and collaboration	4	2	3	5	6	3	1.47	**23**
Strategy sharing between partners	3	2	3	4	5	5	1.21	**22**
Changing company value and position in industry value network	2	1	2	4	5	5	1.72	**19**

5. Discussion

Legal arrangements between parties head the importance table in coopetition case. The reason for high importance of this factor can be attributed to reducing the risk of information leakage to other party in order not to dilute company’s competitive advantage. Partner can not only access information but internalize technology or market knowledge. Loosely governed and structured cooperative arrangements can lead to opportunism by one of the partner and gradual loss of competitive position by another. Another importance case for legal protection mechanism is promotion of proprietary standards by the companies. In such cases company can open only some interfaces but take full advantage itself from the complete implementation and functionality. In addition, some standards are

developed through formal committee-based (or *de jure*) processes, where clear arrangements are important.

Interview respondents with low variability between the answers consider quality as very important factor, bringing quality on top of the table. Quality is considered not as differentiation feature but as a general prerequisite for success in today's competitive environment to achieve customer loyalty.

All people related issues, including collaboration champions, personal attributes and involvement of best personnel, score high in the importance table. Statistical dispersion between answers is relatively low and shows unanimity in respondents' opinions. Top management support results in the average rating in the middle of the table, substituted by dedicated collaboration champions in the big ICT company, where top management can not participate personally in all ongoing collaborations. High people related factors' rating emphasizes importance of managers' ability to balance cooperative and competitive agenda items in coopetition case.

High importance of collaboration clear objectives is inline with other studies of partnering in ICT industry. In addition, clear specification and requirements are treaded particularly seriously in product complements development cases, when often the goal of partnering is interoperability standards development. Standards require clearly specified interfaces between elements of the technological system.

Developing of standards, compatibility and industry ecosystem activities score relatively high in the interviews. However there is considerable variance between respondent answers in this category, explained by the fact that not always complementary product development is accompanied by new standards development. In the case of mature technological domains, industry dominant design may be already established, and parties follow established standards in complementary product development.

In coopetition case, companies do not see significant benefit in complete own strategy sharing with the partner. Also there is no need in cultural, strategy and process fit between the parties. For collaboration to start, it is enough that companies complement each other in joint activities, and companies strategies are compatible and interrelated in some domain – ether in value-chain or product market. In other domains companies can compete with each other.

In this particular study, balance of power between the parties in collaboration is considered important element, although it is not listed on the top of the table. Coopetition between companies involves both collaboration and competitive activities happening at the same time and ranging by intensity as highlighted in several typologies (Bengtsson, Kock 2000, Luo 2007). According to study results for particular interview cases, collaborative dimensions dominated over competitive agenda, and parties do not have considerable power struggles or conflicts in collaboration area.

Talking about technology portfolio, study results show, that acquisition of new technologies is not on the top of the agenda in product complements development case. Parties rely more on own technology set in product development and focus on own core competencies. This observation is in line with convergence classification typology, explaining that product complements convergence does not lead to technology convergence, as companies still produce different products (Stieglitz 2003). Integration activities of different technologies together are also not critical in such cases.

Often in complements product development collaborations, the main focus is interoperability standards between products, rather than product and its features themselves. It explains relatively low importance of product characteristics, product relative advantage to the customer and customer sophistication to understand the product items, although respondent answers dispersion for these items is high, indicating that in some cases product should be superior. Also looking at standards development from technical perspective, some respondents did not rate products profitable market prospects as important. However, all respondent unanimously agree that customer and market need orientation is important for any new product development.

Collaborations for complementary products and standards development often have the form of horizontal alliances, open consortiums or other institutional arrangements with many players. In such circumstances it is hard to accomplish tight control over process, and it is reflected in the study by low

rating of control systems. However, when proprietary technologies or intellectual property rights are coming into focus, companies try to impose clear legal arrangements.

Low scoring of the item for changing company value and position in the industry value network requires further elaboration. Theoretically, by developing complementary product strategy or new standards, company tries to occupy central place or improve current position in industry ecosystem. One explanation can be that survey was conducted in multination ICT company, which already has strong position in the industry, and this item was overlooked by respondents. Also some project do not require changing position in the value network.

6. Conclusion

Technology and product convergence is apparent phenomenon in the current business environment effecting industries and forcing companies to enact strategy through collaborative arrangements. Different convergence types bring specific collaboration factors into focus. Product complementarity convergence takes place when products deliver extra value to customer if they are used in combination. In order for separate products to become part of the larger technological system, interface standards are required. To develop common standard, companies need to collaborate with each other. On the other hand, convergence influences business processes and leads to the reconfiguration of the industry value chain. Collaborating in developing common standards, companies at the same time compete to achieve surplus in different parts of the industry value chain. Resulting coopetition strategy requires specific set of collaboration skills

This paper addresses challenges, which product complementarities convergence places on management of collaborations, and empirically answers the main research question what factors are leading to inter-firm collaboration success under product complementarity convergent environment. Focusing on these factors and prioritizing them, business executives can understand their relative importance, devise improvement plans and leverage collaboration opportunities.

Future studies can focus on the following convergence and collaboration areas. Firstly, convergence phenomenon itself is largely unexplored, and special focus is needed on implications of convergence on company operational management. Secondly, collaboration success factors under each convergence type should be investigated and compared to support effective operational management under different environments. Thirdly, further empirical research can determine what group of critical success factors has the strongest influence on collaboration successful outcome under convergence, and this group can be elaborated and studied in more details.

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PAPER 4

Product Convergence Perspective on Collaboration Success Factors

by
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Product convergence perspective on collaboration success factors

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Abstract: Convergence represents an important trend in today's business environment and calls for system-wide perspective on interactions between technology, product, and strategy and operations management. In relation to the information and communications technology industry, technological innovations and changes in consumer preferences have led technologies and product features to partially merge. Two types of product-based industry convergence are identified in the literature: product substitution and product complementarity. To adapt to new business conditions, companies need to collaborate to get access to new competencies and knowledge for converged product development. This paper, using personal interviews as the research method, contributes to the existing body of knowledge on convergence and intercompany collaboration from an operational management level point of view by determining and comparing the main success factors needed for partnering under product convergence types. The differentiating factors are product features, relative product advantages for the customer and determining the company position in the industry value network.

Keywords: convergence; industry convergence; product convergence; technology convergence; success factors; collaboration; partnerships; ICT; information and communications technology; business systems.

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1 Introduction

Convergence represents an important trend in today's business environment and implies the dissolving of boundaries between previously distinct industries. In the information and communications technology (ICT) industry, the unfolding technical progress in digital technologies, semiconductors, telecommunication and, recently, in the wide range of new multimedia internet services has paved the way to technology- and product-based industry convergence and remarkable changes in the competitive framework and product and process innovation (Baker et al., 2004; Bernabo et al., 2009; Hacklin et al., 2009; Lee et al., 2010). Information technology, communication and media industries are overlapping, and new technologies, products and market segments are emerging.

General convergence examples include fixed and mobile telephony convergence, voice communication and internet protocol networks convergence, media convergence in game consoles, and massive convergence of technologies and functions in mobile phones, combining voice, messaging, television, camera, video, office applications and multimedia of all types. The telecommunication industry through technology convergence has entered the era of mobile services. On top of traditional voice and text messaging, such services as music downloads, gaming, online application stores, global positioning system navigation and e-mail are available to consumers. Recently, convergence has proliferated even within internet services themselves. Google has announced Google Buzz, a service integrating short messages, images, videos and links to articles on the web. The new service blends Gmail e-mail and features available on such social media sites as Facebook and Twitter. In addition, social network sites have shown a tendency to close convergence with music services.

In the dynamic environment, affected by convergence, the ability to continuously change is the critical factor for a company to succeed, and this change is reflected through product innovation (Brown and Eisenhardt, 1997). One of the major implications of convergence is the increasing complexity of new products, which now integrate a wide range of technologies from diverse technology domains. To expand the required list of technologies, competencies and capabilities, companies have two options: internal development or the acquisition of technologies and knowledge through collaboration. Taking into account the technological and market uncertainties surrounding new product development (NPD), companies increasingly enter into collaborative arrangements. Alliances extend the knowledge boundaries of the firms, and during the last few decades, the number of interfirm alliances has been growing rapidly (Cloodt et al., 2006; Hagedoorn, 2002). Managing collaborations in a dynamic environment affected by

converging technologies and products require specific success factors that are different from those in a traditional environment.

Various definitions and types of convergence are identified in the literature. The first type, technology-based industry convergence, related to the technology driven pattern, integrates more technologies into the products and makes unrelated industries converge on a technological basis. On the other hand, product-based industry convergence is related to the customer needs and is driven by changes in customer demand and product acceptance mechanisms. This paper focuses on the product convergence side, which has general practical importance, especially for new business strategies and technology management. Consumer acceptance becomes the main success criterion of the utility that the new product brings to the user, alters industry boundaries and changes business models, and managers should have the appropriate collaboration toolkit to operate in such an environment.

On the product side, there are two industry convergence types: product substitution and product complementarity. Driven by the technology developments and changes in customer preferences, different products become interchangeable from the consumer perspective. To acquire new technological capabilities, which may lie away from the current core competencies, companies enter into collaborative arrangements. On the other hand, through product complements and complementary product strategy, companies can create a multiplier effect on the original product sales (Sengupta, 1998). In addition to technology acquisition, often the focus of collaboration activities is technical standards development, characterised by a battle between competing groups of players supporting their own interests. Cooperation in such conditions is often called 'coopetition', when cooperation and competition happen at the same time.

This paper seeks to create the nexus between the models of industry convergence and theories related to successful collaboration management from the operational management level point of view by ranking the collaboration success factors needed under the product convergent environment. This study identifies success factors under convergence and helps managers to focus on the most significant ones to bring collaboration to a successful outcome. In the first section of this paper, taking primarily the ICT industry as an example, convergence definitions and implications given in the existing literature are reviewed. Secondly, two product-based industry convergence types are elaborated and selected for the subsequent empirical test. Thirdly, based on the current literature, a list of interfirm collaboration success factors is outlined, and an interviews-based survey is conducted to define the most important factors leading to collaboration success for each product convergence type. Finally, results are statistically reviewed, product convergence types are compared, managerial implications for business and technology management are outlined and areas for future research are indicated.

2 Convergence

Convergence between various technologies, previously distinct products and internet services, is the apparent trend in today's business environment, especially visible in the ICT industry, characterised by the fast pace of technology change, the high degree of network effects and critical mass effects. The phenomenon of convergence occurs when innovations or shifts in consumer preferences emerge at the intersection of previously defined industry boundaries, giving way to subsequent broad evolutionary or disruptive

developments of technologies, products and applications within affected industries (Hacklin et al., 2009). Although the concept of convergence has significant interest for the business community, there is a lack of operational level research in the academic literature, and ambiguity of convergence definitions and results still exists.

One of the first conceptualisations of convergence is dated to Rosenberg's (1972) work, which noticed that basic metalworking processes and the technical skills of the upstream machine tool industry were used widely in several downstream industries, such as firearms, bicycles and automobiles, making these industries converge on a technological basis. von Tunzelmann (1999) defines convergence at technology and product levels. At the technology end, general digital semiconductor technology is used in a wide range of products from computers to washing machines. On the product side, more and more technologies are incorporated in a particular complex product.

Focusing on the products, Greenstein and Khanna (1997) define convergence in substitutes and in complements. In the case of substitutes, different products share the same features and provide the same function to end-users substituting each other. On the other hand, convergence in complements occurs, when previously unrelated products can be used together, due to some technological change and to create higher utility for consumers. Adding demand (product) and supply (technology) dimensions to Greenstein and Khanna classification of substituting and complementary products, Pennings and Puranam (2001) and Stieglitz (2003) offer industry convergence conceptualisations by four types (see Table 1). The technology side characterises a company's technologies and innovation activities, while the product side contributes to demand and customer needs. Stieglitz's model is selected as a framework for this study due to the model's focus on both technology- and product-based industry convergence, and the model is one of the most recent convergence models in the academic literature.

The technology side of industry convergence resembles the 'technology-push' pattern, when innovation and development are mainly driven by invention and scientific research independently of the market. The linear model of technology-push projects the progression of basic scientific knowledge through applied research of product development to commercial products (Bush, 1945). In the case of the technology substitution convergence type, new technology replaces currently used technologies. New technologies, which are often general-purpose technologies, require different technical skills and even render some companies' traditional competencies obsolete. The wide application of general-purpose technologies eliminates costs or performance asymmetries across competitors and opens the way to intense product innovation. Technology integration convergence type takes place when existing technologies are integrated into new and innovative configurations, to create new products for new markets as a result of technical or regulatory possibilities.

Table 1 Types of industry convergence

	Substitution	*Complementarity*
Technology convergence	Technology substitution	Technology integration
Product convergence	Product substitution	Product complementarity

Source: Adapted from Stieglitz (2003).

Product-side industry convergence can be illustrated by 'market-pull' innovation, where the primary driver is demand and customers' needs. Changes in market conditions, certain product problems or the potential for new markets provides incentives for companies to invest in innovation and satisfy unmet customers' needs (Nemet, 2009). Product substitution convergence, sparked by new technology, government regulations and the evolution of customer preferences result in the effect that previously unrelated products share similar characteristics by incorporating features of the products from other industries. Finally, in the case of product complements convergence, existing and previously unrelated products become complementary due to new technical interfaces and create greater value for the consumer if used in combination with each other. This paper focuses on the two product-based industry convergence types.

As in practice, both demand and supply factors are needed to explain an innovation that combines technology and market opportunities (Dosi, 1982; Freeman, 1982), similar hypotheses can be created regarding convergence. The convergence drivers, as identified by several authors, include, firstly, external environment forces, such as technology innovations, market deregulation and shifts in consumer demand due to socio-economic developments, and secondly, company internal inputs, like managerial creativity (Bernabo et al., 2009; Borés et al., 2003; Curran et al., 2010; Hacklin et al., 2009; Pennings and Puranam, 2001; Yoffie, 1997). In general, the role of technology evolution and innovation is critical in shaping industries' and companies' future and is reflected in the work of Schumpeter (1942), Solow (1956) and Utterback (2004).

Convergence has a considerable effect on the industry leading to the redefinition of the traditional industry concept and boundaries between product markets (Bernabo et al., 2009). The number of product features is growing, and products are entering adjacent markets; this process results in the blurring of market boundaries and market enlargement (Fai and von Tunzelmann, 2001). As the market grows, competition intensifies, as new players emerge with substituting or complementary products (Borés et al., 2003; Kaluza et al., 1999). The industry structure is changing because of vertical disintegration or the emergence of horizontal collaboration networks (Rao, 1999), and the whole industry value chain is being reconfigured between new and incumbent players (Borés et al., 2003; Krishna and Ghatak, 2008; Wirtz, 2001). One of the illustrative examples of complementary product convergence and related industry value network reconfiguration is the development of internet services, such as online music distribution, photo sharing and social networks, accessed through mobile smart phones. The entrance of new non-traditional players into the industry value network results in complex interactions between mobile network operators, telecommunication equipment manufacturers, internet service providers, software companies and media content owners (Krishna and Ghatak, 2008; Swatman et al., 2006).

Convergence brings disruption to the current setup of the industry, setting the industry to the initial fluent state of ferment. Companies, to establish their own version of the system architecture as the dominant design in the industry, rapidly deploy their own technology and products and encourage the development of complementary goods (Schilling, 1999). This development is achieved through the creation of 'ecosystems' or value nets of the companies linked by different interorganisational partnering arrangements. Such networks consist of various product and technology stakeholders and allow synergy for innovation and productivity as well as collaboration in standards setting and the promotion of a specific technology trajectory (Kash and Rycroft, 2002; Srinivasan et al., 2006). The latest example of such developments to achieve dominant

design in the mobile ICT sector is the creation of the MeeGo mobile Linux platform by Intel and Nokia to support multiple architectures and to be used across a wide range of mobile and embedded form factors, including netbooks and smart phones.

To summarise on convergence models and typologies, we adapt following definitions in our study. Industry is the group of firms producing traded products, which can be considered close substitutes. Industry convergence includes complete or partial merge of boundaries of formerly distinct industry segments (Curran et al., 2010). Industry convergence can be technology- and product-based (Duysters and Hagedoorn, 1998; von Tunzelmann, 1999). Technology-based industry convergence is technology driven and can be classified to technology substitution and technology integration (Stieglitz, 2003). Product-based industry convergence addresses customer's needs and from end-user perspective offers products with substitutable or complementary characteristics (Greenstein and Khanna, 1997; Stieglitz, 2003).

3 Product convergence

The main purpose of any technology is fulfilling a customer need, and companies' technological innovation is driven by the expectation of fulfilling a need. Product-side industry convergence is mainly driven by customer demand. Consumer preferences are the most important determinant for the direction the device convergence will follow (Kim et al., 2005). Only technology cannot make convergence possible, and a converged device will fail if there is no consumer demand for the product.

Product substitution convergence is defined as the established product in one industry evolves to integrate the features of another established product from the other industry and becomes increasingly similar to the features of another product (Stieglitz, 2003), and market participants treat the products as interchangeable with the other (Greenstein and Khanna, 1997).

Product substitution in the academic literature is researched through general innovation diffusion, technological cycles of product obsolescence (Christensen, 1997; Tushman and Anderson, 1986; Utterback, 2004) and new product acceptance (Cooper, 2003; Shocker et al., 2004) models. In one of the pioneering works on the subject, Davis (1989) identifies two variables that are especially important. Perceived usefulness reflects the beliefs of people that new technology will help them to perform their job better. The second variable, perceived ease of use, affects acceptance by potential users through the belief that the performance benefits of the usage of the new technological product or system outperforms the effort of using the application. Rogers (1995) identifies five attributes that drive the process of diffusion: relative advantage, compatibility, observability, complexity and trialablity. Complexity is the degree to which an innovation is perceived to be difficult to understand and use, and, in terms of the meaning, is close to Davis's attribute of the ease of use. Relative advantage is the degree to which an innovation is perceived to be superior compared to the idea the innovation supersedes and is similar to the definition of perceived usefulness in Davis's model.

Diffusion of the new converged product is different compared to the diffusion of a traditional single-function product, although the diffusion is related to the diffusion of separate single products constituting a converged product. The relationship between the products is not straightforward because a converged product can be a substitute or a complement to single-function products, and this relationship can even change over time

(Lee et al., 2009). Currently, only limited research is available in the academic literature on convergence product diffusion models (Lee et al., 2009) and multiproduct diffusion models (Peterson and Mahajan, 1978).

The proven-by-the-market acceptance examples of products substitution are mobile phones with a camera and MP3 music player. The camera phone gained a solid market foundation due to continuous improvements in the quality of the embedded camera that became on par with the quality of the original digital cameras. A mobile phone with a music player is also a valid substitute for the original standalone MP3 players in terms of matching in functionality and memory capacity.

However, the extent of consumer preferences heterogeneity is the key driver to identify the outcome of convergence. Partial device convergence is more probable than absolute convergence. Diverse demand attributes are conveyed to different types of devices and lead to a number of application-specific devices available on the market (Kim et al., 2005). The process of convergence, rather than the creation of a big single market, leads to the development of submarkets and market niches. For example, despite the popularity of smart phones, other products also exist in the range of mobile internet appliances, e.g. laptops, internet tablets, and netbooks, targeted to specific consumer needs. Partial convergence protects incumbent companies from new entrants and allows newcomers to enter the submarket and exploit their own ideas. Cooperation between usually large incumbent companies and small startups brings new opportunities to both parties in bridging technological gaps and transferring resources for product commercialisation (M'Chirgui, 2009).

In the product substitution convergence case, companies need to modify their product offerings in accordance with the trends in demand. From the strategy point of view, such developments can be accomplished either through internal development or interorganisational collaboration. As required competencies for convergent product development can lie far from the current knowledge base, collaboration is often the only option. On the other hand, companies already have a technology portfolio of the converged product, which can be used as a strong base for the product to add new technologies.

Convergence in complements is the second type of product-based industry convergence and is defined as the type when two existing formerly unrelated and used independently products from different industries turn into complements from end-user perspective (Stieglitz, 2003). This convergence is sparked by the development of new technology capabilities and the increasing value that customers place on cross-product integration (Nambisan, 2002) and bundling of services (Krishna and Ghatak, 2008), forcing companies to develop complementary product strategies. A complementary product is a product that enhances the value of a focal product when the two are used together by customers (Sengupta, 1998). Complementary products and services leverage positive externalities of the focal product by enhancing market visibility, product repute, and customer trust and accelerating product reach. The importance of product complementarity as a business success factor is especially high in high-tech markets (Nambisan, 2002).

Complementary products are the components of the technological system, which are linked through technologies and interact with each other. Standards represent interface specifications that define how individual components of the technological system function and interoperate with each other to provide utility to users. Compatibility between components is achieved due to common standards. Common standards provide a

framework within which product markets operate and enable a number of individual companies to produce the components of a larger technological system (Garud et al., 2002). Companies can achieve significant competitive benefits by shaping common standards, especially in the ICT field, characterised by network externalities and increasing returns (Shapiro and Varian, 1999).

General-purpose technologies and common standards create opportunities for complementary innovations. The successful business model in such an environment is to maintain control over the overall technical and business architecture by acquiring control over interfaces between different technical and commercial modules and imposing a specific architecture upon the entire market (Hawkins and Ballon, 2007). Generating a unidirectional action towards a common standard development between different companies, which have private interests, and some of which may be rivals, creates tensions and often results in a 'coopetitional' setup. Companies' interaction is characterised by partially convergent interests and building a competitive advantage over competitors by exploiting the opportunity for a win–win structure, when cooperation and competition happen at the same time—'coopetition' (Brandenburger and Nalebuff, 1995).

A mix between simultaneous cooperation and competition in companies' relationships depends on several structural conditions. High resource complementarity and low market commonality are the conditions contributing to collaborative behaviour, and *vice versa*, common markets and homogeneous resources lead to the rise of rivalries (Luo, 2007). In addition, exogenous issues of environmental characteristics and endogenous drivers of the company knowledge profile can affect the mix between cooperation and competition in coopetition (Padula and Dagnino, 2007). In addition, firms tend to compete more frequently in activities closer to the buyer in the value chain and cooperate in activities carried out at a greater distance from the buyer (Bengtsson and Kock, 2000).

Complementary product strategy supports companies in the battle for dominant design in the industry. The wide variety of complementary products attracts extra users, increases the installed base and creates a lock-in effect (Suarez, 2004). An example of the platform competition for the dominant design in the ICT industry is the wide variety of mobile operating systems for smart phones available on the market: Apple's iPhone platform, Microsoft's Windows Mobile, Nokia's Symbian and Maemo, BlackBerry, Google's Android, Samsung's bada and the LiMo platforms. In the battle for dominance, each platform owner tries through collaborative arrangements to build a technology ecosystem around the owner's own system and to attract independent software developers, mobile network operators and consumers. Complementary products developed by third parties will increase the chances of the particular platform to win.

The effect of the product convergence on the company level results in the creation of collaborative arrangements between organisations with the activities targeted for new technology and knowledge acquisition, standards development, creation of technology ecosystems and operational efficiencies. Understanding of the convergence context and collaboration, critical success factors can help managers to improve their strategies and bring partnerships to successful outcomes.

4 Critical success factors for collaboration

Intercompany collaborations are critical for the success of NPD in a convergent environment. At the point of the industries' intersection, a company faces considerable competence gaps, as new required knowledge is typically not found in the company's own industry (Broring and Cloutier, 2008; Palmberg and Martikainen, 2006). In this work, we refer to collaboration as a form of cooperation between two or more companies, which is more substantial than simple market transactions or outsourcing, but less intense than equity-based joint ventures, mergers and acquisitions.

The existing literature on collaboration is extensive and deals with various perspectives of the interactor relationships. This section focuses on the critical success factors already identified in the traditional literature that companies may need to collaborate successfully. Factors are identified to determine which particular ones may be the most crucial for the convergent environment, and Section 5 of this paper studies their importance to product convergence types.

Several empirical studies have been done on collaboration critical success factors in the ICT industry (Dodourova, 2009; Kelly et al., 2002; Littler et al., 1995; More and McGrath, 1999; Rai et al., 1996; Taylor, 2005; Wilson et al., 1995) that produce a consistent set of ingredients for success, including, among others, clear objectives setting, effective communication, trust, support and commitment at different management levels, best personnel, legal arrangements, learning and knowledge management. Market orientation and customer-intimacy philosophy increase firm's probability to outperform competitors (Osarenkhoe, 2009). The need for new technologies and market knowledge because of convergence brings the issues of balancing exploitation and exploration in organisational learning, and refining the existing technology and the invention or acquisition of the new one (March, 1991).

A company's response to convergence is mostly reflected in NPD and innovation activities. Developing innovations and new products is one of the reasons for partnering in a high-tech industry (Mohr, 2001). The literature on critical success factors for NPD and product innovation is mature, and over the years has reached consistent conclusions on the most important elements (Cooper, 2003; Craig and Hart, 1992). Craig and Hart (1992) compile six groups of related success factors: process activities, management, communication, strategy, people and company characteristics. Some of the factors that have already been identified for NPD are equally applicable to product development *per se*, whether collaborative or not (Littler et al., 1995), and are included in our list.

Research on convergence also provides insights into success factors needed by companies in response to convergence challenges (Bierly and Chakrabarti, 1999; Borés et al., 2003; Broring and Cloutier, 2008; Hacklin et al., 2005; Pennings and Puranam, 2001), such as learning, absorptive capacity and changing company position in the value network. In addition, the coopetition context has specific implications and contributions to the list of factors (Chin et al., 2008), including management leadership, conflict management, development of trust and long-term commitment. As convergence is characterised by the effects of substitution and complementarity, related elements of innovation diffusion and technology acceptance models are included in our framework, specifically the relative product advantage for customers and ease of use (Davis, 1989; Rogers, 1995).

Finally, searched in the books and e-databases, such as EBSCO, Elsevier Science Direct, Emerald, JSTOR Business Collection and IEEEXplore, the most frequently

mentioned and significant critical factors identified by each author and leading to successful NPD, innovation, collaboration management and convergence were collected and grouped according to their similarity into several management areas. A logical induction process was used to prescreen these factors through the lens of their relation to convergence. To verify the grouping results, semi-structured interviews were conducted with five middle-level alliance managers of an international telecommunication corporation, who have experience in collaboration implementation and management. Based on this process, the following groups of critical success factors were identified (see Table 2) to be used in the empirical part of this study to determine which are most significant for product convergence type collaborations. The complete list of literature references on the critical success factors identified by different authors is also presented in Table 2.

Table 2 Summary of the critical success factors for alliances in the ICT industry and corresponding literature references

Collaboration success factors	*Literature references*
Company strategy	
Partner's complementary know-how, skills and capabilities	Kelly et al. (2002), Littler et al. (1995), More and McGrath (1999) and Rai et al. (1996)
Strategy sharing between partners	Kelly et al. (2002), Littler et al. (1995) and Taylor (2005)
Cultural and process fit between partners	Kelly et al. (2002), More and McGrath (1999), Taylor (2005) and Wilson et al. (1995)
Compatible strategy between partners	Taylor (2005)
Clear and profitable market prospects	Littler et al. (1995) and Wilson et al. (1995)
Changing company position in industry value network	Borés et al. (2003), Brandenburger and Nalebuff (2005) and Krishna and Ghatak (2008)
Exploring new technologies beyond current own portfolio	Macher (2004), March (1991), Rice and Galvin (2006), Rothwell (1994) and Vilkamo and Keil (2003)
Exploiting existing own technology portfolio	March (1991), Rice and Galvin (2006) and Vilkamo and Keil (2003)
Management	
Flexible organisational structure	Greenstein and Khanna (1997), More and McGrath (1999), Rothwell (1994), Todeva and Knoke (2005) and Yoffe (1997)
Legal arrangements between partners	More and McGrath (1999) and Taylor (2005)
Clear objectives of collaboration	Dodourova (2009), Littler et al. (1995) and Rai et al. (1996)
Clear roles and responsibilities	Kelly et al. (2002), Littler et al. (1995), Taylor (2005) and Wilson et al. (1995)
Balance of power and partner dominance in collaboration	Chin et al. (2008), Dodourova (2009), Littler et al. (1995) and Taylor (2005)
Flexibility to changing pre-defined goals	Littler et al. (1995), Taylor (2005) and Wilson et al. (1995)
Trust	Chin et al. (2008), Kelly et al. (2002), Littler et al. (1995), More and McGrath (1999), Taylor (2005) and Wilson et al. (1995)

Table 2 Summary of the critical success factors for alliances in the ICT industry and corresponding literature references (continued)

Collaboration success factors	*Literature references*
Process	
Communication	Craig and Hart (1992), Dodourova (2009), Kelly et al. (2002), Littler et al. (1995), More and McGrath (1999), Taylor (2005) and Wilson et al. (1995)
Interdisciplinary teams	Craig and Hart (1992), Kandemir et al. (2006), Littler et al. (1995), Rothwell (1994) and Wilson et al. (1995)
Customer and market need orientation	Cooper (2003), Kandemir et al. (2006), Littler et al. (1995), Osarenkhoe (2009) and Rothwell (1994)
Clear specification and requirements	Assmann and Punter (2004) and Cooper (2003)
Prototyping and concept pre-testing processes	Rothwell (1994)
Technology and new elements integration process	Iansiti and West (1997)
Processes to accelerate product development	Cooper (2003) and Rothwell (1994)
Learning processes	Bierly and Chakrabarti (1999), Chin et al. (2008), Littler et al. (1995) and Taylor (2005)
Capturing acquired competencies, building absorptive capacity	Bierly and Chakrabarti (1999), Hill and Rothaermel (2003) and Taylor (2005)
Systems of control	Chin et al. (2008), Littler et al. (1995) and More and McGrath (1999)
People	
Top management support	Chin et al. (2008), Craig and Hart (1992), Kandemir et al. (2006), Littler et al. (1995), More and McGrath (1999), Rothwell (1994), Taylor (2005) and Wilson et al. (1995)
Commitment to collaboration at all levels	Chin et al. (2008), Dodourova (2009), Littler et al. (1995) and More and McGrath (1999)
Collaboration champions	Kandemir et al. (2006) and Littler et al. (1995)
Importance of personalities, personal chemistry	Kelly et al. (2002), Littler et al. (1995), Taylor (2005) and Wilson et al. (1995)
Partners commit best personnel	Rai et al. (1996), Rich (2003) and Taylor (2005)
Offering (products and services)	
Unique differentiated product (e.g. features and performance)	Cooper (2003)
Relative product advantage to the customer	Davis (1989), Narayanan (2001), Rogers (1995) and Saviotti (2001)
Developing standards, compatibility, industry ecosystem	Borés et al. (2003), Greenstein and Khanna (1997) and Stieglitz (2003)
Quality	Kaluza et al. (1999) and Rothwell (1994)
Customer sophistication and understanding of the product	Davis (1989), Malerba (2007), Narayanan (2001), Rogers (1995) and Saviotti (2001)

5 Methods and results

Prior literature stream on collaboration management provides extensive theoretical and empirical foundations; however, it does not focus directly on convergent environment. Literature on convergence is less common and does not adequately address detailed characterisation of the operational level processes and does not study specifically intercompany collaborations. General NPD and innovation management literature also do not consider specific aspects of product convergence. We draw in these diverse ideas, firstly, to define what success factors are the most important for collaborations under product convergence, and, secondly, to find what factors would differentiate two product convergence types.

Several convergence models assume dynamic nature of convergence and take into account temporal dimension (Curran et al., 2010; Hacklin et al., 2009; Lee et al., 2010). For example, Hacklin et al. (2009) sequence convergence evolution through four subsequent phases: knowledge, technological, application and industrial convergence. Stieglitz's model also supports the dynamic nature of convergence and assumes that one type of convergence evolves into another. However, in our study to simplify the model, we take static snapshot of the industry and select cases belonging to two product convergence type regardless any sequential order convergence types follow.

The unit of analysis for this study is intercompany technological collaboration in the ICT industry – the dynamic sector the most affected by changes in the business environment. The data for the analysis were drawn from an international ICT corporation producing devices incorporating the functionality of telecommunication, consumer electronics and media industries. Technology collaborations between this company and its partners were the focus of the study.

An interview was selected as a research method to validate the questionnaire list and to address the complex and ill-defined area of convergence. Study data were collected with exploratory structured interviews lasting about 1 hr per interview with 14 collaboration managers with the aim of assessing the success factors identified in Section 4. The first group included six respondents representing the product substitution convergence type, where projects were the demand driven further development of the existing products by adding the features from established products from another industry that created substitution effect to the traditional old style products. The second group with eight respondents represented the product complements convergence type of collaboration, where collaborative product development took place between companies representing standalone complementing products from the different segments of the ICT industry value network, and in other cases, the collaboration focused on developing industry compatibility standards between these products. All respondents, aged 35–50, represented middle- and upper-middle management and had experience in intercompany collaborations for 5–15 years.

Respondents were asked to use a Likert scale from 1 to 7 ranging from 'very low' to 'very high' in rating the importance of each critical success factor regarding the specific product convergence collaboration project. The answers were combined in the two tables for each convergence type. The mean was calculated to get the score of importance for each factor, and the factors were ranked in descending order according to the place in the table for each convergence type. Then the means were ranked to compare importance between the success factors. Standard deviation (SD) measures the dispersion of the data set and the variability of respondents' answers for each success factor. In calculating the

mean and SD between the factors, we assume that variables measured by the Likert scale are close to the interval data, and the intervals between the values are equally spaced.

To measure statistically the difference for each success factor between the convergence types, a non-parametric Mann–Whitney *U* test is applied. This test is used to compare two independent groups of variables in terms of the median-based central tendency for ordinal and interval distribution-free scales. In our study, two groups of managers are independent and each group belongs to specific product convergence type. The Mann–Whitney test is the most powerful non-parametric alternative to the parametric *t*-test and is very well suited for the analysis of a Likert scale, which lies in between ordinal and interval data (Israel, 2008). For the results to show a significant difference, we choose a significance level of 10% (p value = 0.1) in the two-tail test. Finally, Table 3 summarises the differences in success factors' importance between convergence types by listing the mean, SD, rank in own group, Mann–Whitney *U* value and significance level p for each success factor.

Table 3 Comparison of collaboration success factors' importance between convergence types

Collaboration success factors	*Mean (SD)*		*Rank*		*Mann–Whitney U value*	*p-Value*
	Product		*Product*			
	Substitution	*Complementarity*	*Substitution*	*Complementarity*		
Company strategy						
Partner's complementary know-how, skills, capabilities	6.17 (2.04)	6.13 (0.83)	5	3	14	0.197
Strategy sharing between partners	5.00 (1.79)	4.13 (1.36)	12	16	15.5	0.272
Cultural and process fit between partners	4.67 (1.63)	4.25 (1.39)	13	15	21.5	0.747
Compatible strategy between partners	3.83 (1.94)	4.63 (1.51)	15	13	16.5	0.333
Clear and profitable market prospects	5.00 (1.79)	5.25 (1.67)	12	9	22	0.897
Changing company value and position in industry value network	5.33 (1.21)	3.38 (1.60)	10	17	8.5	0.045
Exploring new technologies beyond current own portfolio	6.00 (0.89)	5.00 (1.93)	6	11	18	0.519
Exploiting existing own technology portfolio	5.33 (1.03)	5.63 (1.30)	10	6	20.5	0.651

Table 3 Comparison of collaboration success factors' importance between convergence types (continued)

Collaboration success factors	*Mean (SD)*		*Rank*		*Mann–Whitney U value*	*p-Value*
	Product		*Product*			
	Substitution	*Complementarity*	*Substitution*	*Complementarity*		
Management						
Flexible organisational structure	5.00 (1.67)	4.50 (1.60)	12	14	20	0.606
Legal arrangements between partners	6.00 (0.63)	6.25 (1.16)	6	2	16.5	0.333
Clear objectives of collaboration	6.50 (0.55)	6.38 (0.52)	3	1	21	0.846
Clear roles and responsibilities	6.17 (0.98)	5.88 (0.83)	5	5	18.5	0.478
Balance of power between partners in collaboration	4.50 (2.07)	5.00 (1.41)	14	11	20	0.606
Flexibility to changing pre-defined goals	5.33 (1.37)	5.50 (1.07)	10	7	21.5	0.747
Trust	6.83 (0.41)	6.13 (0.83)	1	3	12	0.130
Process						
Communication	6.33 (0.82)	6.00 (1.69)	4	4	22	0.796
Interdisciplinary teams	5.83 (1.17)	5.50 (1.20)	7	7	20	0.699
Customer and market need orientation	6.17 (0.98)	6.25 (1.04)	5	2	21	0.699
Clear specification and requirements	5.50 (1.05)	6.00 (0.53)	9	4	16.5	0.366
Prototyping and concept pre-testing	5.33 (0.82)	4.50 (1.20)	10	14	13.5	0.245
Technology and new elements integration	5.50 (1.05)	4.63 (1.30)	9	13	15	0.245
Speed to market	6.00 (0.63)	5.00 (1.51)	6	11	15.5	0.272
Learning	4.67 (1.03)	4.25 (1.16)	13	15	19	0.561

Table 3 Comparison of collaboration success factors' importance between convergence types (continued)

Collaboration success factors	Mean (SD)		Rank		Mann–Whitney U value	p-Value
	Product		Product			
	Substitution	Complementarity	Substitution	Complementarity		
Capturing acquired competencies, building absorptive capacity	5.00 (1.26)	5.13 (0.99)	12	10	20.5	0.651
Systems of control	5.17 (2.14)	4.25 (1.49)	11	15	14	0.197
People						
Top management support	4.67 (1.51)	5.38 (1.51)	13	8	18.5	0.478
Commitment to collaboration at all levels	5.33 (1.37)	5.63 (0.92)	10	6	21.5	0.796
Collaboration champions	5.33 (1.51)	5.88 (0.99)	10	5	17.5	0.401
Importance of personalities, personal chemistry	5.17 (0.98)	5.88 (0.83)	11	5	15	0.245
Partners commit best personnel	5.67 (1.03)	5.88 (0.64)	8	5	22	0.846
Offering (products and services)						
Unique differentiated product (e.g. features and performance)	6.50 (0.55)	4.75 (1.83)	3	13	7.5	0.028
Relative product advantage to the customer	6.17 (0.75)	4.88 (1.81)	5	12	11	0.093
Developing standards, compatibility, industry ecosystem	5.17 (1.72)	5.38 (1.69)	11	8	21	0.846
Quality	6.67 (0.52)	6.38 (0.52)	2	1	15.5	0.272
Ease of use, customer understanding of the product	6.50 (0.84)	5.25 (2.12)	3	9	13	0.156

6 Discussion

The statistical analysis of the importance of the collaboration success factors shows a significant difference at the $p = 0.1$ confidence level for three factors: changing company position in the industry value network, unique differentiated product and relative product advantage to the customer. A comparison of the means of other success factors, although

it does not show significant statistical confidence for this sample, still represents relevant difference in importance for each factor between product convergence types and provides valuable insights for future research with a bigger sample size.

Product substitution convergence type is characterised by a strong focus on product features, relative product advantage to the customer and the ease of use, compared to product complements convergence. This result is explained by the main role of demand and customer acceptance of the features in making the products interchangeable. The importance of demand stems from the product convergence typology itself (Greenstein and Khanna, 1997; Stieglitz, 2003) and supports this typology. High rating of relative product advantage and the ease of use gives support to the theories of innovation diffusion (Davis, 1989; Rogers, 1995) also in the convergent environment. Consumer preference is the main determinant of the direction the device convergence will take (Lee et al., 2009). Using collaborative arrangements, companies create products in accordance with consumer preferences. The right feature set, ease of use and relative advantage, is the recipe for product acceptance and substitution of the original product. There are a great number of newly available products and services in the ICT market; however, only a few of them, which bring real improved efficiency, effectiveness and convenience, are successful and accepted by customers. In the product substitution convergence case, companies have the advantage to know the feature set required by the market, compared to NPD under the technology integration convergence type. However, respondents agree that customer and market need orientation is important for the development of any new product regardless of the convergence type. Diffusion of the converged product is a complex process affected by the relationships with existing products. The key managerial implications are to follow customer demand, estimate consumer preferences, conduct usability studies and assess usability and relative advantage for the customers. Changing consumer needs and the trends towards the overlapping of products and services would have an effect not only on the convergence of products, but also on the market structures, business models and company position within the industry.

Changing company position in the industry value network also shows a statistically significant difference between convergence groups. The relationship to the current company's product market and technology portfolio explains this difference. In the product complements convergence case, companies operate in their own product markets developing separate complementary products linked by common interoperability standards. Due to convergence, existing unrelated products become complementary to each other. Technology convergence is not significant in this case, and companies from different industries still concentrate on core competencies, existing technology portfolios and traditional products. This finding is consistent with the convergence typology definition (Stieglitz, 2003). As a result, the changing company position factor scored low in the survey. Internet services, e.g. social network sites, accessed from mobile smart phones illustrate the case of product complements. The managerial implications for such cases are to focus on core capabilities, set clear targets and specifications for standards development and reinforce complementary product strategy to maintain control over the technical and business architecture.

On the other hand, during product substitute convergence, product market boundaries are fluid, as products substitute one another. By embedding the additional product features required by customers, a company enters a new market segment and new industry with the industry's own competitive setup and business models, and clearly changes position in the industry value network. Changes in the industry structure and

business models are reflected in the current literature (Krishna and Ghatak, 2008; Swatman et al., 2006). Embedding of the new features also implies technology convergence and the enlargement of the technology portfolio. The managerial implication is enforcement of the company's own version of the dominant design in the industry with the target to occupy the central place in the business value chain and improve the current position in the industry ecosystem. It is also worth mentioning at this point that the whole concept of industry needs revisiting in the face of convergence (Bernabo et al., 2009). The standard classification system is based on the assumption that industry boundaries are defined as a group of firms, which are engaged in production close substitutes and their performance is measured by market share and profitability. However, in the convergent environment under disruptive changes, competition for incumbents comes from several directions well beyond the defined traditional boundaries.

Quality and clear objectives of collaboration are the general factors to head the importance table with low variability between the respondents' answers regardless of the product convergence type. Quality is considered not only as a differentiation feature, but also as a general prerequisite for success or a hygiene factor in today's competitive environment to achieve customer loyalty. The high importance of collaboration clear objectives is in line with other studies of partnering in the ICT industry – the motives and goals of the collaboration should be well defined (Dodourova, 2009; Littler et al., 1995; Rai et al., 1996).

Legal arrangements between the parties scored higher than trust in the importance table for product complements convergence, where promotion of proprietary standards is often the case. In such circumstances, a company can open some interfaces but take full advantage from the complete implementation and functionality. In addition, some standards are developed through formal committee-based (or *de jure*) processes, where clear arrangements are important. A general point to mention is the reduction of the risk of information leakage to another party not to dilute a company's competitive advantage. A partner not only can access information, but also can internalise technology or market knowledge. Loosely governed and structured cooperative arrangements can lead to opportunism by one of the partners and gradual loss of competitive position by another.

All people-related issues, including top management support, collaboration champions and attributes of the personnel, score higher in product complements collaborations than in product substitutes. The statistical dispersion between the answers in product substitutes is relatively low and shows unanimity in the respondents' opinions. High people-related factors' rating in product complements emphasises the pattern of coopetition setup and the ability of managers and everybody involved in the collaboration to balance cooperative and competitive agenda items. This result is consistent with the studies of coopetition environment (Chin et al., 2008). Product substitute collaborations take place at a more stable state of the industry life cycle, when the industry dominant design is already settled, and no major competence-destroying discontinuities are expected.

The development of standards, compatibility and industry ecosystem activities score higher in the product complements convergence collaborations. However, there is considerable variance between the respondent answers in this category, explained by the fact that complementary product development is not always accompanied by new standards development. In the case of mature technological domains, industry dominant design may already be established, and parties follow established *de-facto* standards in complementary product development. In addition, clear specification and requirements

are treated as more important in product complements development cases, when often the goal of partnering is the development of interoperability standards. Standards require clearly specified interfaces between elements of the technological system (Garud et al., 2002).

Coopetition setup in the product complement case explains the lower importance of complete strategy sharing between partners. For a collaboration to start, it is enough that companies complement each other in joint activities, and companies' strategies are compatible and interrelated in some domain – either in a value chain or product market. In other domains, companies can compete with each other. In addition, there is no tendency towards a high cultural and process fit between the parties.

The balance of power between the parties in collaboration is considered as a most important element for product complements convergence, although balance of power is not listed at the top of the table. Coopetition between companies involves collaboration and competitive activities happening at the same time and ranging by intensity. According to the study results for particular interview cases, collaborative dimensions dominated competitive agenda, and the parties do not have considerable power struggles or conflicts in the collaboration area.

Expansion of the technology portfolio is higher on the agenda in product substitute cases, explained by the need to add missing functionalities in response to customer preferences. However, companies are building on top of the available technology set. For product complements collaborations, the study results show that the acquisition of new technologies is not on the top priority. Parties rely more on their own technology set in product development and focus on their own core competencies. This observation is in line with convergence classification typology (Stieglitz, 2003), which explains that product complements convergence does not lead to technology convergence, as companies still produce different products and focus on their own product markets. In addition, the integration of different technologies together in product complements cases is not as important as in the product substitution convergence type.

Collaborations for complementary products and standards development often have the form of horizontal alliances, open consortiums or other institutional arrangements with many players. In such circumstances, it is hard to accomplish tight control over the process, and this difficulty is reflected in the study by the low rating of control systems. In product substitution cases, controlling mechanisms are rated higher, and in many cases, as the industry matures and product and technology risks decrease, control can even be accomplished through company acquisition.

Learning and absorptive capacity scored relatively low in the product substitution cases, although in theory companies need to acquire missing competencies. An explanation is that new technology domains lie so far from the original competencies that companies more rely on the partner to replenish the competence gaps. Companies are accessing partner's complementary competencies rather than acquiring them. This finding supports the work of Grant and Baden-Fuller (2004) that firms tend to rather access complementary capabilities through the alliance and to concentrate upon a few core competencies. However, as the industry matures and the risks decrease, this issue of complementary competencies can be resolved through the acquisition of other companies.

7 Conclusion

This paper addresses the challenges that product-based industry convergence places on the management of collaborations, and empirically answers the main research question about what factors lead to interfirm collaboration success under a product convergent environment. Focusing on these factors and prioritising them, business executives can understand the factors' of relative importance, devise improvement plans and leverage collaboration opportunities.

Convergence between technologies and products is the apparent and increasing trend in the current business environment, affecting industry boundaries and business models and forcing companies to adapt by deploying a collaboration strategy. Different convergence types bring specific collaboration factors into focus. In addition, results reveal that the convergence type framework does hold and there is difference at operational level in collaboration factors importance between product substitution and product complementarity convergence types. The differences show statistical significance in the following three success factors: development of a unique product feature set, relative product advantage for customers and changing company position in the industry value network.

The product substitution convergence case is characterised by the market-pull pattern and is driven by customer acceptance of specific product features. Partners should focus on the right product feature set that is required by the market and brings higher relative advantage for customers. Product substitution is also characterised by a more visible change in the company position in the industry value network, as, through product substitution, a company enters adjacent markets. Product complementarity convergence takes place when products deliver extra value to customers if the products are used in combination. Parties put more emphasis on existing products, the companies' own technology portfolios and interoperability issues than on the new product features. In order for separate products to become part of the larger technological system, interface standards are required, which are developed through collaborations. Other general collaboration success factors such as trust, effective communication, clear collaboration objectives and customer orientation should not be neglected regardless of the convergence type.

The limitations of this study, which are the relatively small sample size and non-parametric statistical methods, can be overcome in the future studies. Future research can focus, firstly, on the convergence phenomenon itself, as it remains largely unexplored, especially in the area of convergence implications for company operational management. Secondly, collaboration success factors under each convergence type should be investigated and compared to support effective operational management under different environments. Finally, further empirical research can determine what group of critical success factors has the strongest influence on collaboration successful outcomes under convergence, and this group can be elaborated and studied in more detail.

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PAPER 5

Technology convergence and intercompany R&D collaboration

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TECHNOLOGY CONVERGENCE AND INTERCOMPANY R&D COLLABORATION

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ABSTRACT

Technology-based industry convergence brings forth new competence-destroying technologies, increases product complexity and drives companies to enter into collaborative R&D arrangements. The technology-based convergence context is classified as technology substitution and technology integration convergence types, and requires new collaborative competencies that are not identified in the current literature. This paper explores the critical success factors (CSFs) of inter-company R&D collaboration in different types of convergence projects. The study finds that the convergence types are differentiated by their focal areas: product features, relative product advantage and market need orientation. We further discuss the important CSFs of the convergence types and provide insights for managers in our results.

Keywords: industry convergence; technology convergence; critical success factors; collaboration; partnerships; ICT

1. Introduction

Convergence between various technologies, products and industries due to the impact of globalization and innovation interactions is one of the obvious megatrends affecting the current business environment (Lee et al., 2010). The trend is especially visible in the Information and Communication Technology (ICT) industry, where telecommunication, information technology, consumer electronics and media sectors are merging (Bernabo et al., 2009). On the technology level, increasing product complexity results in technology convergence reflected in complex products incorporating more and more technologies. On the product level, product convergence is attributed to the changes in customers' needs that lead products to become close substitutes or complements of each other.

Converged, increasingly complex products employ knowledge and technologies from the various original domains, widening the scope of the required competencies for the companies operating in such an environment. Companies, facing a lack of knowledge and expertise in the new field, cannot just rely on the traditional core competencies but need to explore new technologies and knowledge areas for successful innovation and new product development (Cunha, 2009). To fill the gaps in the technology base, companies have rapidly increased the number of intercompany collaborative arrangements in recent years (Cloodt et al., 2006). Given this proliferation of partnering, understanding collaboration success factors becomes a key to effective governance of the partnerships and bringing them to successful outcomes.

We focus on technology-based convergence since technological knowledge is one of the most important explanations for changes in techno-economic paradigms (Freeman and Perez, 1988), and technology, since Schumpeter's (1942) and Solow's (1956) work, has traditionally been acknowledged as the main driving force of economic growth. Technology convergence

has primary importance for research as it reflects front-end innovation activities, which are pivotal for innovation success (Broring and Cloutier, 2008). In addition, companies' technological diversification is usually greater than product diversification (Breschi et al., 2003).

Convergence appears to be "a special case of punctuation onto established equilibrium within innovation systems," represents a multilevel phenomenon of interactions between industry, company and inter-firm activities, and renders peculiar characteristics of technological and competitive dynamics (Hacklin et al., 2010). This environment may assign different requirements for collaboration management competencies. The trend of cross-sector convergence forces companies to cooperate with partners outside their own industry to ensure cross-industry innovative product development (Palmberg and Martikainen, 2006; Yoffie, 1997). Each industry has its own structure, technology portfolio, market characteristics, business models and rivalry patterns (Rim et al., 2009). Collaborations across different industries need to account for all of these factors. However "it remains unclear how these [collaborations] can be successfully implemented, given the industry differences" (Bröring, 2010).

In addition to the specific context of the convergence environment, different convergence scenarios have significant differences in innovation, technology and demand determinants (Stieglitz, 2003) that affect the nature of inter-company relationships. Technology-based industry convergence can be classified as technology substitution and technology integration types (Stieglitz, 2003). In the former case, companies collaborate in disruptive conditions of competence-destroying new technology from the outside, while in the latter type of convergence, partners are driven by managerial creativity and the search for complementary technology assets.

Despite the growing literature on convergence, few studies have addressed questions of intercompany collaborations in the convergence environment. Prior literature on general management of collaboration provides extensive theoretical and empirical foundations. Similarly, the literature on new product development at the project level is available to guide managers in how to handle internal aspects of the development projects. However, literature on convergence is less common and does not study intercompany collaborations as such, referring to them only as a means of coping with the changing environment. Prior research on technology-related issues of inter-organizational relationships, such as technology alliances, provides some insights; however, these studies do not consider technology convergence and their operational-level management. In this paper, we draw on a diverse set of ideas in our search for collaboration success factors in convergence environments at the operational R&D management level.

Therefore, the study aims to explore the fundamental question of whether the collaboration success factors differ for technology-based convergence types, and if so, how do these types differ?

2. Theoretical background

2.1. Convergence definitions and typologies

In relation to industry and technology changes, the term convergence has been used for the last four decades. A multitude of convergence definitions exists in academic literature, creating a certain vagueness in the perception of the term (Hacklin, 2008, pp. 29-30). In the general industry-level definition, convergence can refer to "[blurred] boundaries between industries by converging value propositions, technologies, and markets" (Choi and Valikangas, 2001). In the ICT industry, the visionary foresight of merging computing and communication systems stems from Farber and Baran's (1977) article. In ICT context, convergence headlines a number of developments from fixed-mobile telephone convergence to more complex cases involving technology spillovers between IT, telecom and media industries and transfer toward a set of common and ubiquitous technologies, equipment and services. The pervasiveness of convergence put it high on the agenda of policymaking: "Already emerging trends such as infrastructure convergence (e.g. internet-TV convergence and 'smart phones'), human-computer convergence (e.g. RFID) and utility convergence (e.g. cloud computing) are extending the economic reach of ICT applications. These technological trends are likely to have a positive effect on the extent and intensity of ICT usage … may also result in new industries" (European Commission, 2010, p. 127).

Several authors have identified a consistent set of convergence drivers that are attributed to the external environment, that is, technological innovations, governmental regulations, socio-economic developments and evolution of customer needs (Borés et al., 2003; Kaluza et al., 1999; Pennings and Puranam, 2001; Yoffie, 1997), as well as to internal company managerial creativity (Yoffie, 1997). Based on innovation drivers, convergence can be seen as an observed effect of technological change and innovation activities on the industry, and can be related to earlier studies of industry change driven by periods of incremental and radical innovations (Abernathy and Utterback, 1978; Tushman and Anderson, 1986), and to the influence of technological change on industry boundaries and structure (Porter, 1985). Similarly, on the demand side, consumer preferences also have been identified in the literature as a major factor affecting industrial dynamics (Bresnahan and Malerba, 1999; Malerba, 2007), fundamental drivers of innovation (Dosi, 1982) and even the source of disruptive changes (Christensen, 1997), leading to the convergence effect in the industry. Finally, drawing analogies with existing literature on industry dynamics, internal company managerial creativity can also lead to convergence, as a company's capabilities are one of the main drivers behind technological change (Dosi, 1997). Technology substitution convergence type is driven by radical innovation, while technology integration convergence can be attributed to incremental innovation and managerial creativity drivers.

In our study we adapt the following definitions and concepts. Industry is the group of firms producing traded products, which can be considered close substitutes. Industry convergence includes the complete or partial merger of the boundaries of formerly distinct industry segments leading to the creation of either a new substitutive inter-industry segment or a complementary segment (Curran, Bröring, and Leker, 2010). Industry convergence can be technology-based and product-based (Duysters and Hagedoorn, 1998; von Tunzelmann, 1999; Wegberg, 1995). Technology-based industry convergence is technology driven and can

be classified as technology substitution and technology integration (Stieglitz, 2003; von Tunzelmann, 1999). Product-based industry convergence addresses customers' needs and offers products with substitutable or complementary characteristics (Greenstein and Khanna, 1997; Stieglitz, 2003). We adapt four types convergence typology (Pennings and Puranam, 2001; Stieglitz, 2003) as the reference point for this study and continue with the review of technology-based convergence types (see Table 1).

Table 1. Types of industry convergence (Stieglitz, 2003).

	Substitution	**Complementarity**
Technology-based convergence	Technology substitution	Technology integration
Product-based convergence	Product substitution	Product complementarity

Technology substitution industry convergence is defined as the displacement of an older established technology used in a specific industry by a newer technology that is commonly used in other industries. Previously distinct industry sectors become linked through the common technology used in multiple sectors leading to industry convergence on a technology basis. The classic example of this type of convergence is given by Rosenberg (1976) in the study of the US machine tool industry.

The type of technology substitution convergence is generally sparked by "pervasive" or general-purpose technologies (GPTs). GPTs are applied in a broad range of product and processes across various industry sectors. Based on a particular GPT, industries become related or, in other words, technologically converge. In addition, GPTs play the role of enablers offering new opportunities in downstream sectors and opening innovation complementarities in GPT-using applications (Bresnahan and Trajtenberg, 1995). Illustrative examples of GPTs and technology substitution in the ICT industry include semiconductors, LCD displays and each subsequent generation of telecommunication technologies. In addition, developing GPTs and related technology markets have recently become a new source of competitive advantage, especially in the ICT industry (Gambardella and McGahan, 2010). Specializing in a particular technology, for example, security SW or digital maps SW, companies provide technology and products to downstream partners across different industry sectors and product platforms.

Tushman and Anderson (1986) classified technological discontinuities as either competence enhancing or competence destroying. Technology substitution is a competence-destroying discontinuity. Often, incumbent companies, successful in previous technology generations, fail to react adequately to a competence-destroying discontinuity, which renders obsolete the company's expertise embodied in the replaced technology (Benner, 2009). In addition to firm's own capabilities, technological change may negatively affect network of partners – the suppliers, customers and complementors on whose success a firm often depends (Afuah, 2000). In the face of a technology substitution convergence, a firm needs to resolve the dilemma of staying with the old supplier of inferior technology or establish new relations. It

highlights the importance of strategic decision of partner selection and prospective partner's skills and capabilities. Significant improvements of the new substitutive technology call for the fast management actions and speed to market (Stieglitz, 2003).

In contrast to substitution, technology integration industry convergence is defined as the combining of new or existing technologies previously associated with different established industries into a new product, process or service. The notion is directly related to technological diversification. During the last few decades, the complexity of the products increased considerably, causing firms to broaden their technological base in order to be able to develop multi-technology products. Technological diversification is a company's expansion of its technological competence into a broader range of technical areas (Granstrand et al., 1997; Quintana-García and Benavides-Velasco, 2008). Multi-technology competency is the dominant feature in the current ICT industry (Palmberg and Martikainen, 2006).

The importance of technology integration is growing as products become more complex and embrace an increasing number of technologies. In such an environment, the company's competitive advantage is often based not on the ability to create new technologies but on choosing successfully among the vast number of technologies and their integration. The success factor of technology integration is critical to the company's performance as this process brings products to the market much faster, compared to competitors with less effective processes (Iansiti and West, 1997).

A firm's technological diversification highlights the issues of knowledge trajectories, knowledge absorptive capacity and technology exploitation versus exploration. A diversification changes gradually over time, following incremental changes in the firm's competencies and overcoming the inertia of specialization (Breschi et al., 2003). Firms tend to develop technologies that are different but are highly related and interdependent with existing distinctive core competencies (Giuri et al., 2004). Technological diversification also depends on new required knowledge dimensions (Breschi et al., 2003). Firms can diversify into the new technology that is similar to the one the firm is already employing in current products as the result of an innovative search with close technological proximity. Moreover, firms can invest in complementary knowledge and technologies that lie further away from the current core competencies to be able to integrate technologies developed by external suppliers and collaborators. In the case of technology integration convergence, a firm has the advantage to utilize existing knowledge base for diversification, in contrast to low technology knowledge cumulativeness in technology substitution convergence environment.

External suppliers and partners provide new possibilities for technology and competence sourcing. External technology integration can be defined as the process of managing the acquisition and incorporation of technology from external sources (Stock and Tatikonda, 2004). External collaborations are used by firms to diversify and integrate technologies that lie further away from the current technological base (Giuri et al., 2004). Such alliances bring together complementary partners from different industries to jointly develop new products and applications. Alliances are often fixed or short term in nature and considered successful when a specific task has been accomplished (de Man and Duysters, 2005), and such alliances can be common in technology integration convergence conditions.

2.2. R&D collaboration and technology convergence

Companies need to adapt to changes due to convergence and acquire new competencies, questioning their traditional considerations for boundaries of the firm. Technology-based industry convergence is constantly increasing the number of collaboration arrangements that broaden a company's technological and market knowledge base (Borés et al., 2003; Duysters and Hagedoorn, 1998). Emerging business ecosystems, which include a network of suppliers, distributors, technology providers and other collaborating organizations, enhance innovation and productivity and speed up the creation and delivery of the company's own offering by providing complementary assets to the core product (Li, 2009).

Inter-company R&D collaboration has especially been considered from two main perspectives: transaction costs and the strategic perspective (Narula and Duysters, 2004); the latter originates from, for example, resource-based theory (Barney, 1991; Barney et al., 2001; Wernerfelt, 1984), dynamic capabilities (Teece, et al., 1997) and organizational learning and knowledge-based views (McEvily and Chakravarthy, 2002). Technology collaborations, as the prime means for gaining access to new tacit technology that cannot be obtained through direct market mechanisms, have been growing fastest in high-technology sectors and especially in ICT (Hagedoorn, 2002). Several empirical studies have been conducted to identify collaboration success factors in ICT (Dodourova, 2009; Kelly et al., 2002; Littler et al., 1995; More and McGrath, 1999; Rai et al., 1996; Taylor, 2005; Wilson et al., 1995).

Convergence literature identifies intercompany collaboration as one of the primary strategies in convergent environment (Borés et al., 2003; Duysters and Hagedoorn, 1998; von Tunzelmann, 1999; Yoffie, 1997). A firm involved in the new product development process can form an R&D alliance, which can be classified according to the partner position along the industry value chain to the vertical, including upstream and downstream alliances, and horizontal alliance. The firm can reach upstream in the product development process to gain access to general-purpose technology or a new research field. The firm can ally horizontally with other technology ventures to combine resources and technologies. Or using downstream alliances, the company can access manufacturing, distribution or marketing knowledge to commercialize the feasible technology into a marketable product. Each alliance type requires different alliance management capabilities because of the different types of partners involved and different types of knowledge transmitted (Rothaermel and Deeds, 2006).

Following Rosenberg's (1976) classic notion of general-purpose technologies in upstream industries, the technology substitution convergence type is associated with vertical alliances. Vertical alliances entail a vertical division of labor between the companies along a value chain and have fewer conflicting goals in the strategic agenda, which make alliance management easier (Palmberg and Martikainen, 2006). Vertical alliances with partners at different levels of the value chain combine complementary technologies and provide a complete integrated solution to customers. Such alliances are also referred to as complementary alliances. Critical success factors for vertical alliances include intensive information sharing such that the supplier's operations can be better adapted to the customers' needs, and early supplier involvement to differentiate products in downstream markets or develop next-generation technology (Mohr, 2001).

Traditional economic theories review firms' vertical alliances and integration strategies from the transaction cost theory point of view. According to the theory, a comparison is made between production cost economies and governance cost economies to establish efficient boundaries of the firm (Williamson, 1985). The alliance structure enables the parties to align their interests and coordinate the joint work better than market transactions, and a key potential advantage of alliances over markets is the ability to pool and transfer the technological capabilities among separate firms (Gomes-Casseres et al., 2006). However, vertical R&D alliances in ICT can be governed not only by efficiency and transaction costs considerations, but also by the search for complementary assets to advance and commercialize technologies between upstream high-tech research and downstream commercially established partners.

Technology integration convergence type is related to horizontal alliances. Horizontal alliances are formed between firms at the same level of the value chain in the industry with the aim of developing a formal collaboration to combine their efforts in research and development activities. Horizontal alliances are often formed between competing firms in the same sector. In this context, in the new technology or innovation development cases, the risk of management conflicts in relation to, for example, intellectual property rights, is bigger (Palmberg and Martikainen, 2006). Horizontal alliances inherit more coordination problems and risks (Bengtsson and Kock, 2000).

The resource-based approach to strategy with an emphasis on the knowledge perspective provides a strong basis to build a theory on inter-firm collaboration in the technology integration convergence case. From the resource-based view of the firm, collaboration is essential to gain access to external resources and competencies (Barney, 1999; Grant and Baden-Fuller, 2004; Hamel et al., 1989). In dynamic markets, for successful innovation some firms need to combine internal resources with external complementary technological assets (Teece, 1986). Increased collaboration between the incumbent firm and its strategic partners leads to a division of labor and specialization among the firms. Strategic networks of organization emerge (Gulati et al., 2000) with the incumbent firm and its partners focusing on core competencies (Prahalad and Hamel, 1990). Firms leverage their own core capabilities through complementary resources, and the value creation process occurs outside the firm's traditional boundaries.

Although the new technology and knowledge requirements play a key role in alliance formation, the question remains in what way this knowledge will be used in different types of convergence environment. Two types of knowledge sharing within alliances can be distinguished: alliances to acquire knowledge and alliances to access knowledge (Grant and Baden-Fuller, 2004). The first type of collaborative arrangements can be a learning vehicle to transfer and absorb the partner's knowledge base. This type can be characterized as learning races between the parties to appropriate knowledge from each other as quickly as possible, behave opportunistically and dissolve the alliance when the objective has been reached (Gomes-Casseres et al., 2006). Alternatively, the goal of the collaboration can be access to the partner's knowledge in order to explore complementarities, maintain a distinctive base of core competencies and avoid competitive tensions. The latter type of learning has a much broader meaning than the learning race and includes learning about a partner's contribution and learning about how to manage the partnership (Zeng and Hennart, 2002). We would

assume that in certain conditions, accounting for technological uncertainty, the partners would be more interested to appropriate critical new technology in technology substitution convergence case.

2.3. Critical success factors and convergence

Based on a review of the theoretical literature in established research publications considering collaboration, we have identified collaboration success factors in studies related to three research areas: general collaborations, especially in ICT industry, new product development and convergence. Within these areas of research, using the logical induction process in relation to convergence, we have selected, by triangulating between two researchers, a list of the most frequently mentioned collaboration success factors that possibly differentiate collaboration in different convergence types as alternative parameters for our empirical study. Success factors were grouped in the following five themes: company strategy, management, process, people and offering. The complete list of exemplary literature references on the critical success factors is presented in Table 2.

This work does not attempt to establish a definite set of collaboration success factors, as the convergence problem is ambiguously defined in the current literature, in nature complex and additionally it is difficult to bind all the alternative factors within the limits of a single study. Instead, we focus on the broad exploratory set of factors that are frequently mentioned in the literature, are related to technology convergence, and, finally, possibly differentiate convergence types. The study results provide guidance for future investigations as far as whether convergence types differ and, if so, to focus on the limited set of significant variables and model these in detail in different convergence conditions.

The *company strategy* theme defines how a company translates its business objectives into a technology strategy and further enacts the technology strategy though collaborative arrangements. Several empirical studies on collaboration critical success factors in the context of the ICT industry (More and McGrath, 1999; Kelly et al., 2002; Littler et al., 1995; Rai et al., 1996; Taylor, 2005; Wilson et al., 1995; Dodourova, 2009) produced a consistent set of ingredients for success, which now can be examined in convergent environment The partner's complementary capabilities are the main reason to enter collaboration. Both partners must share mutual dependencies and provide resources and skills to each other that are relatively unique and hard to obtain elsewhere. Compatible corporate cultures of the alliance members helps to avoid culture clashes, which can prohibit the realization of a common strategy and synergies. Partners may have their own strategies; however, these strategies should not diverge considerably, and a common direction should be shared regularly.

Strategic choices in technology convergence conditions are directly related to the trade-off between exploitation of existing and exploration of new, innovative assets, and may differ between convergence types. The exploitative approach to innovation and product development is characterized by intensive search and experimentation within the existing knowledge dimension (March, 1991). Exploration is based on an extensive search for potential new knowledge and involves product development derived either from a completely new knowledge or recombination of new knowledge with the parts of the knowledge the

company already possesses, and may characterize technology integration convergence type. Convergence further reshapes existing industry value networks, and by exploring new technologies, innovative business models and alliances companies can find a profitable position or niche in the new industry value chain. Collaborative endeavors increase the prospect of finding profitable positions especially in the challenging environment of the payment-free realm of Internet services and commoditizing ICT products (Yovanov and Hazapis, 2008; West and Mace, 2010).

Table 2. Summary of the selected critical success factors of collaboration.

Company Strategy	
Partner's complementary know-how, skills, capabilities	Kelly et al., 2002; Littler et al., 1995; More and McGrath, 1999; Rai et al., 1996
Strategy sharing between partners	Kelly et al., 2002; Littler et al., 1995; Taylor, 2005
Cultural and process fit between partners	Kelly et al., 2002; More and McGrath, 1999; Taylor, 2005; Wilson et al., 1995
Compatible strategy between partners	Taylor, 2005
Clear and profitable market prospects	Littler et al., 1995; Wilson et al., 1995
Changing company position in industry value network	Bores et al., 2003; Brandenburger and Nalebuff, 2005; Krishna and Ghatak, 2008
Exploring new technologies beyond current own portfolio	Macher, 2004; March 1991; Rice and Galvin, 2006; Rothwell, 1994; Vilkamo and Keil, 2003;
Exploiting existing own technology portfolio	March 1991; Rice and Galvin, 2006; Vilkamo and Keil, 2003
Management	
Flexible organizational structure	Greenstein and Khanna, 1997; More and McGrath, 1999; Rothwell, 1994; Todeva and Knoke, 2005; Yoffe, 1997
Legal arrangements between partners	More and McGrath, 1999; Taylor, 2005
Clear objectives of collaboration	Dodourova, 2009; Littler et al., 1995; Rai et al., 1996
Clear roles and responsibilities	Kelly et al., 2002; Littler et al., 1995; Taylor, 2005; Wilson et al., 1995
Balance of power and partner dominance in collaboration	Chin et al., 2008; Dodourova, 2009; Littler et al., 1995; Taylor, 2005
Flexibility to changing pre-defined goals	Littler et al., 1995; Taylor, 2005; Wilson et al., 1995
Trust	Chin et al., 2008; Kelly et al., 2002; Littler et al., 1995; More and McGrath, 1999; Taylor, 2005; Wilson et al., 1995
Process	
Communication	Craig and Hart, 1992; Dodourova, 2009; Kelly et al., 2002; Littler et al., 1995; More and McGrath, 1999; Taylor, 2005; Wilson et al., 1995
Interdisciplinary teams	Craig and Hart, 1992; Kandemir et al., 2006; Littler et al., 1995; Rothwell, 1994; Wilson et al., 1995
Customer and market need orientation	Cooper, 2003; Kandemir et al., 2006; Littler et al., 1995; Rothwell, 1994
Clear specification and requirements	Assmann and Punter, 2004; Cooper, 2003
Prototyping and concept pre-testing processes	Gomes-Casseres and Leonard-Barton 1997; Rothwell, 1994
Technology and new elements integration process	Iansiti and West, 1997; Yoffie, 1997
Processes to accelerate product development	Cooper, 2003; Rothwell, 1994
Learning processes	Bierly and Chakrabarti, 1999; Chin et al., 2008; Littler et al., 1995; Taylor, 2005
Capturing acquired competencies, building absorptive capacity	Bierly and Chakrabarti, 1999; Hill, 2003; Taylor, 2005
Systems of control	Chin et al., 2008; Littler et al., 1995; More and McGrath, 1999
People	
Top management support	Chin et al., 2008; Craig and Hart, 1992; Kandemir et al., 2006; Littler et al., 1995; More and McGrath, 1999; Rothwell, 1994; Taylor, 2005
Commitment to collaboration at all levels	Chin et al., 2008; Littler et al., 1995; More and McGrath, 1999; Dodourova, 2009;
Collaboration champions	Kandemir et al., 2006; Littler et al., 1995
Importance of personalities, personal chemistry	Kelly et al., 2002; Littler et al., 1995; Taylor, 2005; Wilson et al., 1995
Partners commit best personnel	Rai et al., 1996; Rich, 2003; Taylor, 2005
Offering (products and services)	
Unique differentiated product (e.g. features, performance)	Cooper, 2003
Relative product advantage to the customer	Davis, 1989; Narayanan, 2001; Rogers, 1995; Saviotti, 2001;
Developing standards, compatibility, industry ecosystem	Bores et al. 2003; Greenstein and Khanna, 1997; Stieglitz, 2003
Quality	Kaluza et al., 1999; Rothwell, 1994
Ease of use, customer understanding of the product	Davis, 1989; Malerba, 2007; Narayanan, 2001; Rogers, 1995; Saviotti, 2001

Technological change, associated with technology substitution convergence, entails new product development based on new knowledge components and particular close interactions with suppliers (Afuah, 2000). Strategy and cultural compatibility, strategy sharing and communication can be of particular importance for technology substitution convergence collaborations. However, tacit content of knowledge and threat of opportunistic behavior creates a dilemma for strategy sharing and emphases the need for legal arrangements.

The *management* theme of collaboration success factors focuses on operational issues of collaboration and product development. The collaboration objectives of both partners should be clear, and the motives and goals for the collaboration well defined. Legal arrangements need to be in place, although there is a move from formal contractual relationships to a broader form of alliances based on strategy sharing and trust. Trust has been found in countless empirical research reports as a success factor, leading to more effective information sharing and willingness to allocate scarce resources to joint efforts. Trust is built over time, is based on a commitment or mutual desire to continue the relationship into the future and helps to avoid power struggles between dominant incumbent companies and small technology providers (More and McGrath, 1999; Kelly et al., 2002; Littler et al., 1995; Rai et al., 1996; Taylor, 2005; Wilson et al., 1995; Dodourova, 2009).

In addition, flexibility defines the firm's ability to meet market needs without organizational disruptions and incurring excess time and costs (Buganza et al., 2010). Flexibility refers to project goals as well as to the organizational structure in adapting to new technologies. Flexible organization structure is required in the face of radical technology change (Macher, 2004) and may be important in technology substitution conditions. Static management routings in the face of radical technology change hinder required organizational transformation (Benner, 2009). On the other hand, in less disruptive technology integration conditions, firm's developed collaboration processes can contribute to organizational effectiveness.

The *process* theme reflects the project-level activities and decisions for collaborative new product development (NPD). Critical success factors identified for NPD (Cooper, 2003; Craig and Hart, 1992) can be equally applied for collaborative new product development bearing in mind collaboration specifics (Littler et al., 1995). Effective communication should be ensured by organizing management groups of representatives from different areas and levels. Coordination and control mechanisms allow the partners to make adequate contributions, avoiding inadequate use of assets and opportunistic behavior.

Prototyping and experimentation with a wide variety of small trials is a tool in addition to real-time communication. Understanding which combination of integrated technologies in the product might become commercially successful requires marketing studies, user trials and experimentations (Gomes-Casseres and Leonard-Barton, 1997). The ability to create cross-functional teams with proper coupling and integration of individual experts and teams is a critical aspect of innovation competence (Christensen, 2000). In relation to technology integration convergence, special attention should be given to the technology integration

capabilities and teams of integrators, the people with extensive background in research and development in wide technology scope, who often are responsible for the whole project (Iansiti, 2000).

Research on convergence also provides insights into success factors needed by companies in response to convergence challenges (Bierly and Chakrabarti, 1999; Borés et al., 2003; Broring and Cloutier, 2008; Hacklin et al., 2005; Pennings and Puranam, 2001), such as learning and absorptive capacity. An understanding of technology integration, a firm's assets and assets portfolio coherence requires essential elements of the company's strategy such as learning and absorptive capacity development. Learning involves acquisition and exploitation of the new explicit and tacit knowledge by the organization (Kumar and Nti, 1998). Absorptive capacity is the ability of the firm to value, assimilate and apply new knowledge (Cohen and Levinthal, 1990), and determines the final value of the technology alliance to the firm. This capacity reflects organizational receptivity to the technological change and the ability to effectively use external knowledge from an alliance relationship for the company's own product development.

The *people* theme refers to the people involved in the collaborative project and the way these people are organized as critical success factors. Senior management's support of and commitment to the alliance are crucial as they reflect management's attitude to cooperation. Top management role is emphasized in co-opetitive interactions between the partners (Chin, 2008), which is an attribute of convergent environment. A company's commitment to collaboration can be reflected in making irreversible investments in a partnership and by reducing opportunistic behavior. Collaboration champions at the project management level, qualified personnel and training for new skills are essential from a people perspective. Employees' participation is also important from the organizational learning point of view (Craig and Hart, 1992, Kandemir et al., 2006).

The *offering* theme includes success factors related to the final products and services as the outcome of collaborative new product development. A unique product is the main driving force of the successful technology push innovation approach (Cooper, 2003), and is the result of technology convergence. A product is associated with quality attributes affecting the product's success in the market. In addition, as convergence is characterized by the effects of substitution and complementarity, related elements of innovation diffusion and technology acceptance models are included in our framework, specifically, the relative product advantage for customers and ease of use (Davis, 1989; Rogers, 1995). Another important issue related to industry convergence that recently received significant attention in the literature is standards and industry ecosystem development. Standards ensure interoperability between system elements, and through the ecosystems companies try to establish their own version of the system architecture as the dominant design in the industry and encourage the development of complementary goods (Schilling, 1999; Srinivasan et al., 2006). After technology generation shift, new standards and ecosystem development are particularly important in technology substitution convergence settings.

3. Methodology and data

The empirical part of this study is focused on the ICT industry, an industry characterized by a high number of partnerships, and in which technological convergence has been witnessed in many forms in recent years. The purpose of this exploratory study is to shed more light on the relatively unexplored phenomenon of convergence and seek new insights from the R&D management perspective. The unit of analysis for this study is inter-company projects in technological collaboration in the ICT industry. This context allows gathering of empirical data, first, on inter-company collaborations in convergence environment, and, second, on the project and operational management-level activities where the real critical work between the organizations is done. The data for the analysis were acquired with interviews and a survey in an international ICT corporation producing devices incorporating the functionality of telecommunication, consumer electronics and media industries.

A survey with an interview was selected as an exploratory research method to address the complex and ill-defined area of convergence. As a separate previous process, a pilot study was conducted with seven respondents in project manager roles to verify and refine the list of success factors to be used in the current study. The current study's data were collected in 2009-2010 with structured interviews lasting about 1 hour per interview with 14 collaboration managers with the aim of assessing the success factors for collaboration identified in the previous section. The first group included six respondents representing the technology substitution convergence type, where projects were facing new technologies, which would have radical influence on the companies and industry. The second group with eight respondents represented the technology integration convergence type of collaboration, where collaborative product development took place between companies providing different technologies, which were incorporated in the main products. All respondents, age between 35 and 50, represented middle- and upper-middle management and had 5-15 years' experience in inter-company collaborations.

Respondents were asked to use a Likert scale from 1 to 7 ranging from "very low" to "very high" in rating the importance of each critical success factor regarding the specific technology convergence collaboration project. In calculating the statistics of the factors, we assume that variables measured by the Likert scale are close to the interval data, and the intervals between the values are equally spaced. To measure statistically the difference for each success factor between the convergence types, a nonparametric Mann-Whitney U test was applied. The Mann-Whitney test is the most powerful nonparametric alternative to the parametric t-test, and is very well suited for analyzing a Likert scale, which lies in between ordinal and interval data (Israel, 2008). For the results to show a significant difference, we chose a significance level of 10% (p-value=0.10) in the two-tail test.

In addition to statistical methods, because of the limited sample size, we also considered the ranking of success factors for each convergence type. The factors were sorted by mean value in descending order to determine the rank number for each factor for a specific convergence type. The rank difference value shows the difference in places each factor has in the corresponding convergence tables and represents the difference in the importance of the success factor between two convergence types.

4. Results and discussion

Table 3 summarizes the differences in the success factors' importance between convergence types by listing the mean, standard deviation, Mann-Whitney U value and significance level for each success factor. In addition, each factor's importance rank number for the corresponding convergence and the rank difference between convergence types are also shown. The table provides the following information. First, the statistical difference and difference between ranks are meant to answer the research question whether collaboration success factors differ between the two convergence types. Second, the success factors' rankings contribute to understanding how the convergence types differ and what success factors are the most important for each type from a practicing point of view. In addition, qualitative data from the interviews was used to verify statistical and ranking results.

Table 3. Comparison of collaboration success factors' importance between convergence types.

Collaboration success factor	Mean (SD)		Mann-Whitney U value	p-value	Rank		Rank diff.
	Tech. Subst.	Tech. Integr.			Tech. Subst.	Tech. Int.	
Company Strategy							
Partner's complementary know-how, skills, capabilities	5.67 (1.51)	6.38 (0.92)	16	0.302	5	1	4
Strategy sharing between partners	4.17 (1.17)	5.13 (1.36)	14	0.197	12	9	3
Cultural and process fit between partners	4.17 (1.17)	4.50 (1.41)	19	0.519	12	14	2
Compatible strategy between partners	5.67 (1.51)	5.25 (1.16)	17	0.366	5	8	3
Clear and profitable market prospects	5.17 (1.83)	4.75 (2.05)	20.5	0.651	8	12	4
Changing company value and position in industry value network	3.67 (1.51)	3.50 (1.77)	22.5	0.846	14	18	4
Exploring new technologies beyond current own portfolio	5.00 (0.89)	5.88 (1.13)	13	0.156	9	4	5
Exploiting existing own technology portfolio	5.33 (1.37)	4.75 (1.75)	23	0.897	7	12	5
Management							
Flexible organizational structure	5.17 (1.47)	4.38 (1.51)	17	0.366	8	15	7
Legal arrangements between partners	5.33 (1.86)	4.63 (1.30)	15	0.245	7	13	6
Clear objectives of collaboration	6.17 (1.33)	5.38 (1.51)	17	0.366	2	7	5
Clear roles and responsibilities	5.50 (1.87)	4.88 (1.64)	15	0.245	6	11	5
Balance of power between partners in collaboration	4.83 (1.72)	5.00 (2.00)	20.5	0.651	10	10	0
Flexibility to changing pre-defined goals	5.17 (1.47)	5.25 (1.83)	21	0.699	8	8	0
Trust	6.50 (1.22)	6.38 (1.41)	19	0.519	1	1	0
Process							
Communication	6.17 (0.75)	5.75 (1.28)	21.5	0.747	2	5	3
Interdisciplinary teams	4.83 (0.98)	4.13 (0.99)	13	0.156	10	16	6
Customer and market need orientation	6.00 (0.89)	5.00 (0.93)	11	0.093	3	10	7
Clear specification and requirements	5.83 (0.75)	5.00 (1.41)	13	0.156	4	10	6
Prototyping and concept pre-testing	4.33 (1.75)	4.63 (1.60)	19.5	0.561	11	13	2
Technology and new elements integration	5.00 (1.41)	4.88 (1.55)	23	0.897	9	11	2
Speed to market	5.33 (1.03)	4.63 (1.19)	17.5	0.401	7	13	6
Learning	4.00 (0.63)	4.38 (1.60)	16.5	0.333	13	15	2
Capturing acquired competencies, building absorptive capacity	4.17 (1.83)	4.00 (1.41)	21	0.699	12	17	5
Systems of control	4.33 (2.07)	4.50 (1.69)	23.5	0.949	11	14	3
People							
Top management support	5.83 (1.33)	5.25 (1.28)	17.5	0.401	4	8	4
Commitment to collaboration at all levels	5.67 (1.21)	5.38 (1.92)	22.5	0.846	5	7	2
Collaboration champions	5.50 (1.05)	5.13 (1.96)	22.5	0.846	7	9	2
Importance of personalities, personal chemistry	4.83 (1.33)	4.63 (1.85)	23.5	0.949	10	13	3
Partners commit best personnel	5.67 (1.51)	5.63 (1.19)	21.5	0.747	5	6	1
Offering (products and services)							
Unique differentiated product (e.g. features, performance)	5.17 (1.72)	6.38 (0.74)	11.5	0.099	8	1	7
Relative product advantage to the customer	5.17 (1.47)	6.38 (0.74)	11	0.093	8	1	7
Developing standards, compatibility, industry ecosystem	6.00 (1.26)	4.75 (1.49)	12	0.121	3	12	9
Quality	5.33 (1.37)	6.13 (0.64)	16	0.302	7	2	5
Ease of use, customer understanding of the product	5.83 (1.60)	6.00 (0.53)	20.5	0.651	4	3	1

The statistical analysis of the results shows that three collaboration success factors are statistically different between the two convergence types (at $p < 0.10$), namely, customer and market need orientation, unique differentiated product and relative product advantage to the

customer. Although other success factors do not show significant statistical confidence for this sample, the comparison of their means still suggest that there may be other differences as well, but these differences were not confirmed in this study, probably at least partially due to the small sample size. In addition, the rank differences revealed that nine of the CSFs differ in their rank difference values with more than 6. This suggests possible differences in the CSFs for differing convergence types for future research to investigate. In conclusion, our exploratory findings should guide future studies to consider at least all of these suggested factors when managing R&D projects in differing convergent environments are under scrutiny. Next, we discuss our results in light of both quantitative statistical and qualitative interviews' findings, and start with the three statistically verified differences.

First, the results have shown that customer and market needs orientation is one of the most important factors for managers to consider in the technology substitution environment.

"The new technology requires considerable investment, but we are not sure whether customers will start using these services" (respondent).

This finding reflects the managers' understanding of the high market uncertainty associated with the technology substitution convergence type. Previous studies of alliances in the convergent environment have also highlighted the uncertainty of customer demand observed in product and process technologies (Gomes-Casseres and Leonard-Barton, 1997). Uncertainty is the crucial factor to manage through technological discontinuities, and uncertainty can be associated with technology, market and timing dimensions (Brem and Voigt, 2009).

"This [new] technology requires totally different methods and uses different infrastructure. We have being doing products based on our current technologies and standards" (respondent).

In terms of technology uncertainty, this convergence type has the most dramatic effects on the companies as it brings competence-destroying disruptions and renders firms' existing competencies and capabilities obsolete (Stieglitz, 2003). However, in the case of the technology integration convergence environment, there is no uncertainty associated with technology displacement, and the competence obsolesce effect is not as severe as in the technology substitution environment. Firms already possess some technologies in the portfolio and are able to access required ones through collaborative arrangements (Stieglitz, 2003). The resulting new converged products inherit the features of existing products, the cumulative product market knowledge is higher, and the market orientation factor scores lower compared to the technology substitution convergence type.

"Our market intelligence shows that customers increasingly use this feature, so we included it in our product" (respondent).

Second, the unique product features success factor scored the highest in importance for the technology integration convergence type.

"This is the first product on the market to embed this functionality. We will be the first to introduce it and differentiate from all other competitors" (respondent).

The advancement of technology oriented primarily toward an increase in product characteristics is a clear illustration of the technology push approach (Rothwell, 1994). This type of convergence is primarily associated with new product development activities and product innovation. In contrast, technology substitution convergence often starts as process innovation with general-purpose technologies, which bring process improvements and

remove some technological limitations in the production processes. As the next phase, these process improvements subsequently will result in product innovation and product improvements; however, initially process innovation is associated with the final product indirectly, and explains that the importance of product characteristics scored lower in the technology substitution environment.

"We may not necessarily need the best product, but we need to be on a par with the [technological] environment of this new technology" (respondent).

Third, the high importance of relative product advantage to the customer in technology integration collaborations shows the same behavior as the unique product features factor discussed above.

"When this [new] functionality is integrated, the customer does not need a separate device anymore, and it provides a benefit" (respondent).

The relative product advantage success factor represents market demand and is a critical determinant of technology acceptance and new converged product market success, which is consistent with Davis's (1989) and Rogers's (1995) technology acceptance models. This factor highlights managers' awareness that technology supply and market demand factors are crucial for successful innovation and new product development (Nemet, 2009). In the technology substitution case, process-related technologies may not initially bring a clear product advantage to the customer.

"New technology is not currently developed enough to provide significant advantage to consumer, although it has big potential for the future as its performance improves" (respondent).

In addition to statistical testing, we can make tentative conclusions based on the analysis of the factors ranking and qualitative interviews data. Trust, communication and a partner's complementary skills are common among the top five factors for both convergence types and can be considered factors of general importance. These factors have been consistently mentioned in other collaboration studies (see Table 2 for references).

"Effective communication with the partner is the key. It should be fast and fluent" (respondent).

"Trust is extremely important, especially when the objectives are not clear at the beginning. Fewer management efforts are required" (respondent).

However, a written contract, for example licensing agreement, sets the foundation for the formal alliances and defines rewards and penalties associated with compliance or noncompliance with stipulated actions.

"Licensing agreements protect IPRs [Intellectual Property Rights] and often incur high costs" (respondent).

The higher importance of a legal arrangement for technology substitution collaborations highlights the higher impact of the new substitution technology on the firm's survival, the importance of new technology intellectual property right protection and the higher formality of collaboration relationships in horizontal alliances.

A partner's skills and resources play a central role in forming alliances in the convergent environment as the partner's main contribution is the complementary technology or knowledge of the related industry. The importance of the partner's skills and new technology exploration are in the top five factors for the technology integration convergence type.

"We collaborate in order to get access to outside technologies" (respondent).

A flexible organizational structure to focus on new technology is an effective management tool for coping with technological substitution.

"The new team was set up to focus on new technology" (respondent).

A prime reason to enter an alliance is learning. However, there is no clear rule in the literature regarding the intention of knowledge transfer in alliances (Grant and Baden-Fuller, 2004). Our study shows that absorbing the competencies and learning success factors scored low in importance for both convergence types. This result means that companies are clearly accessing complementary competencies rather than acquiring them.

"Our partner is the best in the world in this technology, and we rely on it" (respondent).

"Their technology is protected by patents and cannot be copied" (respondent).

Reviewing the top success factors for technology substitution convergence, three, that is, top management support, commitment to collaborate and best personnel, belong to the people-related group. Other people-related factors were also rated higher for technology substitution rather than for technology integration convergence. These results are explained by the disruptive nature and high technology opportunity of this convergence type that require management attention and fast action.

"Top management needs to stick to it and communicate importance all over the organization" (respondent).

Quality is an important prerequisite for the success of a new product on the market and is rated high in the importance for new technology integration convergence products.

"To ensure final product quality and reduce internal testing efforts, we expect high quality standards of supplied technology upstream" (respondent).

However, quality is not among the most important elements for the technology substitution environment, where new technology is still in the early stage of the life cycle.

"New [technology] generation provides significant performance improvements, however service quality standards are not agreed yet" (respondent).

Technology integration processes are important but not at the top of the list and taken for granted by the respondents.

"Integration of partner's complementary technology is definitely important; however most of our SW components are still developed in-house by different teams and integrated in a similar way" (respondent).

A publicly available open source platform reduces the integration efforts as all interfaces are clearly specified and all system components can be tested and integrated together with smaller efforts.

Novelty and the disruptive nature of the substitutive technology highlight the importance of standards and compatibility development in the technology substitution convergence case.

"There are several technology alternatives; with partner we have selected to follow this path [standard]" (respondent).

Standards also set higher importance for clear specification and requirements in technology substitution environment. In opposite technology integration case, standards importance is rated lower.

"Integrated technology is already well-known and standardized and we adopt existing standard" (respondent).

In addition to interoperability requirements, standards provide opportunities for complementary product innovation regarding an established platform. The platform battle in the ICT industry has the goal of controlling the central architecture around which other companies would develop complementary technologies and products (Li, 2009).

5. Theoretical and managerial implications

5.1. Theoretical implications

The scope of this paper was targeted toward operation- and partly strategy-level issues, excluding technical questions of convergence. The study concentrated on technology partnerships, such as licensing and joint product development between non-equity bases partners. The study omitted the differences between the phases of partnership formation. A possible limitation of the study is caused by the dynamic nature of convergence and the difficulty in selecting projects corresponding to s particular convergence type. However, all efforts were made to verify that at the time of the interviews the projects corresponded to the convergence type in question. The generalizability of the study is partly limited by the relatively small sample size and the non-parametric statistical method used for the data analysis.

Convergence is a multifaceted concept with no universal agreement concerning the domain of content for the phenomenon and no relevant criteria; hence, construct validity of the research is important to review empirical indicators with theoretical expectations. Using valid success factors from existing literature on collaboration and similarly relevant studies on convergence as a theoretical ground, we formulated a prediction about collaboration differences according to convergence types. We have identified a pattern of consistent empirical findings that at least three variables even in a small sample size are significantly different between convergence types. The empirically observed outcomes are consistent with our theoretical predictions; hence, we consider the construct validity to be high.

The study draws the following conclusions. First, the conceptual model of different convergence scenarios is supported by the study results. The original conceptual model (Stieglitz, 2003), used in this study, is based on technology and market dynamics reflected in substitution and the complementary effects on the industry. The study results show that there is a difference in the focus of collaboration activities and success factors' importance at the strategy, operational, process and product offering levels caused by different scenarios of technology substitution and technology integration convergence types. Second, the study also demonstrates the applicability of the convergence model and collaboration management to the specific operational tasks of technology substitution and integration. The convergence model's prior application to operational context and empirical conformation has been relatively limited. This study contributes to convergence theory development and provides additional support for use of this theory in operational management.

A number of opportunities are available for future research. First, the existing literature is limited in examining collaboration management at the operational R&D management level in the context of convergence. Therefore, the first direction for future research would broaden the domain of the literature, addressing practical aspects of convergence and intercompany collaboration. The second direction for future research is the development of convergence assessment tools that would enable managers to determine the convergence type through a structured assessment process of the range of technology, industry, demand and innovation parameters. This research stream would contribute to the convergence conceptualization problem. The third avenue for future research is a more detailed exploration of the most important collaboration factors required in the convergence environment. Our exploratory study with rather limited sample provided significant differences in success factors between different convergence types and therefore, this study provides a good basis for selecting a limited set of success factors for further detailed investigations.

5.2. Managerial implications

Some useful guidelines for managers of collaborations in the convergent environment emerged from our study. From the beginning of the collaboration, both partners need to clearly define the collaboration objectives, agree on the roles and responsibilities and specify the product requirements. In the convergence environment, it is especially important as partners from different industries with different cultures and business procedures collaborate, and a clearly defined scope helps to minimize the potential divergence of interests at the later stages. A clear scope is even more important in the technology substitution case because of its high uncertainty and the disruptive nature of change.

Technology-based industry convergence is driven by the innovation and technology push approach with a focus on product features and performance. Although superior features are an important prerequisite for the product's success and profitability, only a technically driven product that lacks customer benefits has a high probability of failing. In addition to unique features and quality, the product should be superior in meeting customer needs, bringing a distinctive advantage and ease of use to the customer. Collaboration partners, contributing a high level of expertise in their own area of specialization, can achieve this result. Managers should build marketplace inputs into product development projects through user need recognition, market research, constant customer contact, prototyping and concept testing. Partners from a related industry can also contribute market knowledge to the collaboration.

Technology substitution convergence is characterized by a radical technological change that involves a shift to a new superior technological trajectory and renders the incumbent's accumulated technological knowledge and capabilities obsolete. Understanding and anticipating convergence would enable preparation in time and adaption for the necessary changes. Technology intelligence by scanning, monitoring and assessing specific environmental trends can help to determine their evolution. Managers should develop flexible and dynamic approaches to overcome organizational inertia and react to technology changes with collaboration arrangements with partners to gain access to the required technologies and capabilities. The top management's role and commitment are also crucial because of the high impact of the change. In addition, as technology substitution sets the industry in a state of

ferment, the issue of standards and compatibility development becomes important, especially in the ICT industry, and managers should follow industry standardization activities.

Technology integration brings managers the dilemma of exploring new technologies versus exploiting the existing technology portfolio. Although internal technological diversification expands a firm's innovative capabilities, limited resources and the high technology uncertainty of the early stages of the technology and industry evolution make the collaboration option more attractive. By focusing on core competences and accessing complementary capabilities through alliances, managers would achieve faster time to market and avoid conflicts of interest in collaboration. Developing effective technology integration processes is also a must. Other general success factors frequently mentioned in the literature for collaborative product development such as mutual trust, commitment, effective communication and flexibility are equally important in the technology convergent environment.

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