Product Convergence Perspective on Collaboration Success Factors

Andrei Rikkiev, Marko Seppänen* & Saku J. Mäkinen

Center for Innovation and Technology Research (CITER)
Department of Industrial Management
Tampere University of Technology
P.O. Box 541, FI-33101 Tampere Finland
E-mail firstname.surname@tut.fi
* Corresponding author

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 ICT 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 in order 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 inter-company 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, 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; F. Hacklin, Marxt, and Fahrni, 2009; Lee, Olson and Trimi, 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 IP networks convergence (VoIP), 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, GPS 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, companies increasingly enter into collaborative arrangements. Alliances extend the knowledge boundaries of the firms, and during the last few decades, the number of inter-firm alliances has been growing rapidly (Cloodt, Hagedoorn, and Roijakker, 2006; Hagedoorn, 2002). Managing collaborations in a dynamic environment affected by converging technologies and products requires 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. Product-based industry convergence, on the other hand, 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, characterized 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.

The 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. The study identifies success factors under convergence and helps managers to focus on the most significant ones in order to bring collaboration to a successful outcome. In the first section of the paper, taking primarily the ICT industry as an example, convergence definitions and implications given in the existing literature are reviewed. Second, two product-based industry convergence types are elaborated and selected for the subsequent empirical test. Third, based on the current literature, a list of inter-firm 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, characterized 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 (F. Hacklin, Marxt, and Fahrni, 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 conceptualizations 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, 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 conceptualizations by four types (see Table 1). The technology side characterizes 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.

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

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

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.

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, 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 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, first, external environment forces, such as technology innovations, market deregulation, and shifts in consumer demand due to socio-economic developments, and, second, company internal inputs, such as managerial creativity (Bernabo et al., 2009; Borés, Saurina, and Torres, 2003; Curran, Bröring, and Leker, 2010; F. Hacklin, Marxt, and Fahrni, 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, Blecker, and Bischof, 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 P. V. 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 P. V. and Ghatak, 2008; Swatman, Krueger, and Beek, 2006).

Convergence brings disruption to the current setup of the industry, setting the industry to the initial fluent state of ferment. Companies, in order 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 inter-organizational 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, Lilien, and Rangaswamt, 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 summarize 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, Bröring, and Leker, 2010). Industry convergence can be technology-based 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, Jeong-Dong Lee, and Koh, 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, Bayus, and Kim, 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, Lee, and Cho, 2009). Currently, only limited research is available in the academic literature on convergence product diffusion models (Lee, Lee, and Cho, 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, Jeong-Dong Lee, and Koh, 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 commercialization (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 inter-organizational 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 in order 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 P. V. 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, Jain, and Kumaraswamy, 2002). Companies can achieve significant competitive benefits by shaping common standards, especially in the ICT field, characterized 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 toward 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 characterized 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 behavior, 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 SW 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 organizations 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 improve their strategies and bring partnerships to successful outcomes.

4 Critical success factors for collaboration

Inter-company collaborations are critical for the success of new product development 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 inter-actor 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 the next empirical section of the 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, Schaan, and Joncas, 2002; Littler, Leverick, and Bruce, 1995; More and McGrath, 1999; Rai, Borah, and Ramaprasad, 1996; Taylor, 2005; Wilson, Littler, Leverick, and Bruce, 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 organizational 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 new product development 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 new product development (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 (1992) compiles six groups of related success factors: process activities, management, communication, strategy, 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; F. Hacklin, Raurich, and Marxt, 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, Chan, and Lam, 2008), including management leadership, conflict management, development of trust, and long-term commitment. 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).

Finally, searched in the books and electronic 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 new product development, 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 in order to determine which are the 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, 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*., 2007; 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*., 2007; 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; Osarenkhoe, 2009; Rothwell, 1994
Clear specification and requirements	Assmann and Punter, 2004; 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; Rothwell, 1994
Learning processes	Bierly and Chakrabarti, 1999; Chin *et al*., 2007; 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*., 2007; Littler *et al.*, 1995; More and McGrath, 1999
People	
Top management support	Chin *et al*., 2007; Craig and Hart, 1992; Kandemir *et al*., 2006; Littler *et al.*, 1995; More and McGrath, 1999; Rothwell, 1994; Taylor, 2005; Wilson *et al*., 1995
Commitment to collaboration at all levels	Chin *et al*., 2007; Dodourova, 2009; Littler *et al.*, 1995; More and McGrath, 1999
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
Customer sophistication and understanding of the product	Davis, 1989; Malerba, 2007; Narayanan, 2001; Rogers, 1995; Saviotti, 2001

5 Method 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 characterization of the operational level processes and does not study specifically intercompany collaborations. General new product development and innovation management literature also does 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, Bröring, and Leker, 2010; Hacklin, Marxt, and Fahrni, 2009; Lee, Olson, and Trimi, 2010). For example, Hacklin, Marxt, and Fahrni (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 inter-company 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 address the complex and ill-defined area of convergence. Study data were collected with exploratory structured interviews lasting about 1 hour per interview with 14 collaboration managers with the aim of assessing the success factors identified in the previous section. 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, age 35-50, represented middle- and upper-middle management and had experience in inter-company 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 standard deviation 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 nonparametric 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 nonparametric 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 summarizes the differences in success factors' importance between convergence types by listing the mean, standard deviation, 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 factor	Mean (SD)		Rank		Mann-Whitney U value	p-value
	Product Subst.	Product Compl.	Product Subst.	Product Compl.		
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
Management						
Flexible organizational 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
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, 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 characterized 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, Lee, and Cho, 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 new product development 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 toward 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 in order 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 P. V. and Ghatak, 2008; Swatman, Krueger, and Beek, 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 as a differentiation feature but 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, Leverick, and Bruce, 1995; Rai and Ramaprasad, 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 in order not to dilute a company's competitive advantage. A partner not only can access information but also can internalize 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 emphasizes 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, Chan, and Lam, 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, Jain, and Kumaraswamy, 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 toward a high cultural and process fit between the parties.

The balance of power between the parties in collaboration is considered a more 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 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 inter-firm collaboration success under a product convergent environment. Focusing on these factors and prioritizing them, business executives can understand the factors' 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 shows 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 characterized 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 characterized 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 the current study, which are the relatively small sample size and nonparametric statistical methods, can be overcome in the future studies. Future research can focus, first, on the convergence phenomenon itself, as it remains largely unexplored, especially in the area of convergence implications for company operational management. Second, collaboration success factors under each convergence type should be investigated and compared to support effective operational management under different environments. Third, 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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