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Strategies in network industries: the importance of inter-organisational networks, complementary goods, and commitment

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This paper focuses on technology battles that are fought in network industries. The literature primarily focuses on battles that have occurred in single industries. With the convergence of industries, products that originate from different industries can be connected in technological systems, and battles are fought over standards for these systems. In this paper, we focus on these types of battles and investigate which factors impact their outcome and how these factors are related to each other. We analyse two technology battles: for wireless home networking and for an e-purse technology. Our findings show that provided that the actors are committed to the success of the standard, size and diversity in the inter-organisational network increase the availability and variety of complementary goods which positively influence the installed base of the standard which then may lead to its dominance.

Keywords: standards; technology battles; strategies in network industries; inter-organisational networks

1. Introduction

This paper focuses on strategies in network industries (Shapiro and Varian 1999). In these industries, innovation relates strongly to stable interfaces between different elements of systems (Andersen 2013). Specifications of these interfaces may be laid down in standards. Different companies, providing products for one or more elements of the system, may innovate their product while continuing to support a standard and compete with competitors who adhere to the same standard. However, also different compatibility standards may compete for dominance in technology battles, each of them with its own installed base of users who apply one of the standards in their products. Specifically, in this case, the actual competition occurs between (a variety of) products that are based on competing standards. Such battles have been studied

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before (Cusumano, Mylonadis, and Rosenbloom 1992; Gallagher 2012) and factors for technology dominance have been identified (Schilling 1998; Suarez 2004; Van de Kaa et al. 2011). However, it is unclear which factors are key to winning a technology battle and how these factors are related to each other. The few empirical studies that exist primarily focus on technology battles that have occurred in single industries (Schilling 2003; de Vries, de Ruijter, and Argam et al., 2011; Cozzarin, Lee, and Koo 2012; Gallagher 2012; Van de Kaa, Greeven, and van Puijenbroek 2013). With the ongoing convergence of industries, products that originate from different distinct industries can become interconnected (Van de Kaa, Den Hartog, and de Vries 2009). As a result, systems that consist of subsystems that originate from different converging industries can be realised, and battles are fought over standards for these 'converged systems'. In this paper, we focus on these types of battles. In this case, standards are implemented in products from different industries and a battle is fought for one dominant standard to be used in the products from each industry. Early examples of such systems are stereo systems and microcomputers (Langlois and Robertson 1992). More recent examples include smart grids, e-purse systems, and inland transportation systems for maritime containers.

Thus, this article addresses two issues: (1) what are the major factors that influence technology dominance for converged systems, and (2) how are these factors related to each other. To examine these issues, we reviewed past research on technology battles and formulated an initial framework and tested its validity with two case studies (Eisenhardt 1989; Yin 2009).

In Section 2, we begin by reviewing the literature on technology dominance. Subsequently, in Section 3, we discuss our methodology. The results of our case studies are presented in Section 4. Section 5 includes a discussion of our findings and the conclusion.

2. Theory

Scholars from various schools have approached the topic of technology battles in network industries. In this paper we distinguish between three bodies of research that each has a different and unique view towards technology dominance: industrial economics, institutional economics, and technology management. In the following subsections we describe each theoretical stream.

2.1. *Industrial economics*

Traditionally, scholars in the field of industrial economics studied the role of innovation in the dynamics of industries (Gort and Klepper 1982). They focused on the environment in which technologies compete and offer, for instance, demand-based explanations for the emergence of dominant standards (Adner 2002). For example, through network effects, technologies increase in value the more they are used (Katz and Shapiro 1985; Arthur 1996). As a consequence, technology lock-in may occur (Katz and Shapiro 1985), unless switching costs are very low. From the network economics literature, we learn that there are specific *market mechanisms*, which can hardly be influenced by individual firms, that affect technology dominance and lock-in. These comprise (1) network effects resulting in switching costs and bandwagoning behaviour and (2) uncertainty which can be the result of the rate of change in a market as well as the number of options available in the market.

2.2. *Institutional economics*

Institutional economists have studied *complementary assets and strategies* (Williamson 1975; Williamson, 1985; Teece, 1986) that may be applied to achieve technology dominance. Examples include resources such as financial resources (Willard and Cooper 1985) and strategies such as a timing of entry strategy (Lieberman and Montgomery 1988a, 1988b) and marketing strategies (Besen and Farrell 1994). Financial resources may be used to fund marketing campaigns and they may be used to pursue a penetration pricing strategy whereby the technology in which the standard is implemented is priced below cost in order to increase sales (Schilling 1999). Furthermore, firms may apply an open systems strategy which can increase technology dominance as users can gain access to the technology for free. For example, Sun's open systems strategy for its middleware technology Java contributed to its dominance (Egyedi 2001).

2.3. *Technology management*

Technology management scholars draw on both industrial economics and institutional economics. These scholars have studied various cases of technology battles (Cusumano, Mylonadis, and Rosenbloom 1992; Khazam and Mowery 1994; Funk and Methe, 2001; Gallagher, 2012) and have developed several models with which it is possible to explain technology dominance in network industries (Hill, 1997; Gallagher and Park 2002; Schilling 2002). They put forth that under the influence of market mechanisms such as network effects, the *installed base* of users and the *availability of complementary goods* in which the standard is implemented become pivotal for winning technology battles (Schilling 2002, 2003; Suarez 2004).

2.4. *A proposed model for technology dominance*

Based upon the three presented research streams and various existing frameworks (Hill 1997; Gallagher and Park 2002; Schilling 2002), 'market mechanisms', 'installed base', 'availability of complementary goods', and 'complementary assets and strategies' can be identified as the main factors that could explain technology dominance according to the extant literature. The relationships of these factors with the process of technology dominance are shown in Figure 1.

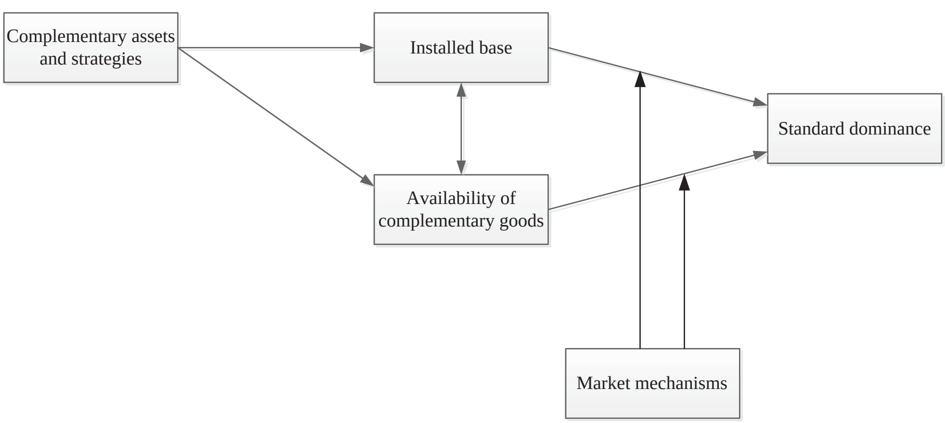

Figure 1. Proposed model for standard dominance.

3. Methodology

In order to explore what the main factors for technology dominance for converged systems are and how they are related to each other, we studied two historical cases of technology battles. We chose two cases of technology battles whereby the standards are applied in products from different converging industries.

Our two cases are the battle between WiFi and HomeRF for wireless home networking and the battle between Chipper and Chipknip for a Dutch e-purse system. The first battle involved the information technology (IT) industry, the consumer electronics (CE) industry, and the telecommunications (TE) industry. The core product is a wireless router. The standard specifies the interface to different complementary goods from multiple industries relevant to the wireless home networking market (including PCs from the IT industry and wireless telephones from the TE industry). The second battle involved multiple industries including TE, automobile parking, retail, restaurants, bars and canteens, automatic merchandising machines, and banking. The standard specifies the essential features of the chipcard (core product) and the interface to reloading terminals and point of sales (POS) terminals (complementary goods). Different types of POS terminals include terminals placed in telephone boxes, parking lots, shops, canteens, and vending machines.

For each technology battle, we utilised secondary data in the form of previous scientific papers, company and consortia press releases, and news archives (for a detailed overview of the secondary sources used, refer supplemental file 1). Based on these, a chronological case description was made. Also, we collected primary data by conducting interviews with people who were involved in the technology battles. We conducted both structured and semi-structured interviews. In the structured interviews we started with asking the interviewee to give a historical overview of the most important events that took place during the technology battle from the rise till the downfall of the standard. During this first stage of the interview, the interviewees mentioned various factors implicitly or explicitly. In a later stage of the interview, through several questions, we directly asked why the winning standard had won the battle. The full list of questions can be found in supplemental file 2 that is attached to the paper. The semi-structured interviews were open. In these interviews (which were partly follow-up interviews and partly new interviews), we verified the chronological case descriptions made and we raised interview-specific questions which were developed during the conversations.

We have ensured that we have conducted interviews with at least one expert who was involved in each standard and one objective outsider per technology battle. For the case of WiFi vs. HomeRF, we interviewed representatives of the IEEE802.11 work group, HomeRF working group, a university, and a research institute. For the case of Chipper vs. Chipknip, we interviewed representatives of Chipper Netherlands, Interpay (the association responsible for electronic money transfer), the Dutch Banking Association, and a university. Unfortunately, Interpay had to be reluctant to share any information they had about the motives of the actors and about financial impacts of the technology battle, and some data had to remain confidential. In total, 15 interviews were conducted. Specific details of the respondents are presented in supplemental files 3 and 4.

We transcribed the interviews and highlighted text that (implicitly or explicitly) points towards factors for technology dominance. Based upon the literature, it was subsequently assessed whether these factors could be categorised under any of the (groups of) factors mentioned in the proposed model of technology dominance (Figure 1). Factors that could not be categorised under the existing factors were categorised as 'other' factors. In a cross-case analysis the results were compared and a single model was constructed which includes the factors that were important in the cases.

4. Results

4.1. *WiFi vs. HomeRF*

4.1.1. *Case description*

Several standards have competed to become the accepted solution for wireless home networking. The most important standards in this battle were WiFi and HomeRF.

In 1990, the IEEE 802 Executive Committee passed a motion to establish the 802.11 working group. In December 1997, IEEE 802.11, the first version of the WiFi standard, was published. In 1999, the WiFi alliance was established to promote the standard. In 1997, Compaq, Ericsson, HP, Intel, and Microsoft established the Home Radio Frequency Working Group. From 1997 to 1998, several meetings were held in which the companies worked on a first specification. In 1998, the Working Group introduced the first version of HomeRF (version 1.0) for wireless networks, enabling voice and data communication. In 2001, the Working Group introduced HomeRF 2.0, which was a direct competitor of WiFi. In 2003, the HomeRF Working Group was disbanded and, eventually, WiFi became the dominant wireless home networking solution.

4.1.2. *Case analysis*

WiFi had the advantage of being promoted by a large and diverse network of actors from IT, CE, and TE industries. Initially (1997–1999), mainly IT companies adopted the WiFi standard, but after the introduction of IEEE 802.11b, companies in other industries such as CE and TE followed. In 2000, the IEEE 802.11 committee consisted of companies from several industries such as CE (Philips), TE (Nokia and AT&T), and companies with a diverse background in the IT industry (Intersil, Intel, Cisco, 3Com, and Agere). Later, in 2002, Boeing became active in the IEEE 802.11 committee and established the IEEE 802.11s Task Group. Each of these companies implemented the WiFi standard in their products which increased the variety and number of complementary goods considerably. In each industry involved, the standard's installed base grew substantially. This led to standard dominance due to strong network effects. For example, in 1999 Apple introduced the iBook which enabled wireless data communication using the WiFi standard. From that moment on, the number of adopters of WiFi increased substantially. As more users adopted WiFi, demand for complementary goods such as the iBook increased, resulting in more complementary goods. Also, the variety of complementary goods gradually increased (WiFi enabled cameras, WiFi enabled phones, etc.)

Initially, HomeRF was also promoted by a diverse and large group of actors from IT, CE, and TE. However, Intel, the leading firm behind HomeRF, was also investing in WiFi. This led some companies to conclude that Intel was not fully committed to HomeRF. Other firms that promoted HomeRF were also less committed to the standard (Van de Kaa and de Vries 2014). As one respondent indicated (referring to the companies that were active in the HomeRF working group): 'Some believed that HomeRF would not become successful' As a consequence, many suppliers of complementary goods chose not to implement the standard in their products. Another respondent indicated in reference to the meetings that were held in HomeRF: 'HomeRF had quite a number of problems from the start'. This respondent indicated that Philips Semiconductors, which was also active in the HomeRF meetings, initially provided support for HomeRF but gradually focused more on WiFi.

Both networks were also very powerful in terms of financial strength. These financial resources enabled HomeRF supporters to offer lower prices for complementary goods that implemented HomeRF. For example, HomeRF network interface cards were cheaper than their WiFi

Table 1. Summary of technology battle 1.

Technology battle 1: wireless home networking
Time period: 1990–2003
Successful standard: WiFi
Unsuccessful standard: HomeRF
Main actors WiFi: IEEE, WiFi alliance
Main actors HomeRF: HomeRF working group

Factor for technology dominance	Description
Complementary assets and strategies	Each generation of the WiFi standard was backwards compatible so that users could easily upgrade to the new generation of the standard
	Both networks were powerful in terms of financial strength and could thus offer low priced complementary goods
Complementary goods	WiFi was implemented in more types of different complementary goods as compared to HomeRF
Installed base	WiFi outperformed HomeRF in terms of installed base of the current and previous generation
Market mechanism	Initially, network effects were resulting in increased installed base for both standards
	Later, as WiFi became more popular, users were reluctant to switch from WiFi to HomeRF
Other factors	Intel, the leading firm behind HomeRF, was also promoting other standards. WiFi promotors were more committed
	A large and diverse amount of powerful actors promoted the WiFi standard

counterparts (Van de Kaa and de Vries 2014). However, the availability of complementary goods that met the WiFi standard was higher, leading to a growth in its installed base. Eventually, the costs to switch from HomeRF to WiFi or vice versa were high due to the costs of replacing complementary goods. Furthermore, each generation of WiFi was backwards compatible. This provided access to the previous installed base and assured availability of complementary goods. The case is summarised in Table 1.

4.2. *Chipper vs. Chipknip*

4.2.1. *Case description*

In the early 1990s, banks and retailers were searching for an alternative for regular ATM cards, credit cards, and cash payments because all of these were relatively expensive and time-consuming. A cheaper and faster solution was found in e-purse technology which allows the customer to put virtual money onto a smart card before spending it. Purchases can be made at POS terminals. The card can be reloaded at reloading terminals, usually placed next to ATMs, at public payphones, or at home (via a device connected to the telephone network). The debiting of money between the bank and the retailer takes place only once a day, thus saving transaction costs. In 1994, the three main Dutch banks, Postbank, ABN Amro, and Rabobank, decided to develop a common e-purse system: Chipknip. In 1995, it was successfully tested. However, at the end of 1995, Postbank formed an alliance with the leading Dutch telecom provider KPN to develop another format called Chipper. The cards could also be used and loaded in KPN's public phones. Together, Postbank and KPN had almost every Dutch household as a customer. Chipper provided the option to add other functionality than just the payment option, for instance for retailer loyalty programmes or for library applications. A fierce battle started in which both alliances tried to distribute cards to consumers and ally with retailers and other business partners to install POS terminals and reload facilities. After a year, it was clear that Chipper had failed to benefit from its market access and card functionality possibilities and finally, in 2001, the Chipper alliance decided to stop and replace all Chipper cards with Chipknip. So, Chipknip was the winner.

4.2.2. *Case analysis*

Both Chipknip and Chipper tried to introduce their standard as quickly as possible. The first Chipknip cards were introduced in September 1996. Due to technical problems, the first Chipper cards were not introduced until May 1997. By 1997, Chipknip had distributed over eight million cards compared to one million Chippers (the country had 15.6 million inhabitants). Moreover, the first Chipper terminals were only introduced in January 1998 because Chipper first needed permission from the Dutch Banking Association. So, initially, the Chipper owners could not use their cards.

The Chipknip banks incorporated more different suppliers of complementary goods (including retailers, vending machine operators, and canteen operators) in their network, increasing network diversity. Establishing such alliances was relatively easy for the Chipknip banks because many of these suppliers already banked with one of the Chipknip-supporting banks. Chipknip also actively encouraged retailers that had adopted Chipper to switch to Chipknip by offering them financial incentives. As more suppliers of complementary goods were involved, the number of reloading and POS terminals increased. They were installed in almost all shops, and in many vending machines and canteens in businesses.

Chipper offered additional functionality and the card could be used, for instance, for loyalty programmes or public transport tickets, but retailers and other organisations showed hardly any interest. According to one respondent: ‘Chipper was too complex [and] therefore perhaps less user-friendly’. Moreover, Chipknip banks managed to upgrade Chipknip’s functionality within one year. During the battle, the banks pursued an aggressive publicity campaign to promote their technology. Both Chipknip and Chipper pre-announced their standard in an attempt to attract users. However, Chipper was not able to deliver on most of their promises, which damaged its reputation considerably as indicated by one respondent: ‘Postbank pre-announced their card but time and again they postponed it. This affected their reliability’. As a result, many suppliers of complementary goods chose to adopt Chipknip instead of Chipper. For example, in 2001, the Dutch Parking Association Vexpan adopted Chipknip. This increased diversity in the network and led to additional complementary goods (paying terminals at parking lots). Some actors in the Chipper network were not fully committed. For example, KPN created the possibility for users to pay using Chipknip in all their 20,000 public telephone boxes. This further increased the variety of complementary goods in which Chipknip was implemented while signalling that KPN was not fully committed to its Chipper anymore. The latter led to more uncertainty about Chipper. This, in turn, reduced the acceptance of the technology among suppliers of complementary goods and consequently resulted in a lack of complementary goods. The case is summarised in Table 2.

4.3. *Cross-case analysis*

Each battle unfolds in a unique way. The set of important factors and their interrelations differ per case. Nevertheless, we can observe some commonalities. The cases show that because the standards are implemented in products from different markets, two factors are important: complementary goods and the standard’s installed base in each market involved. The winning

Table 2. Summary of technology battle 2.

Technology battle 2: Dutch e-purse system
Time period: 1994–2001
Successful standard: Chipknip
Unsuccessful standard: Chipper
Main actors Chipper: Postbank, KPN,
Main actors Chipknip: ABN Amro, Rabobank, Interpay

Factor for technology dominance	Description
Complementary assets and strategies	In spite of their pre-announcements, Chipper was not able to deliver their technology in time and this led to a loss of their reputation
	Initially, Chipper's technology was superior to Chipknip's because it offered additional functionality. However, after a year Chipknip was upgraded to offer similar functionality. Chipknip was superior in terms of ease of use because it did not require an additional PIN for the chip transaction, whereas Chipper users had to remember an additional PIN code
	Chipknip was introduced earlier than Chipper
	Both Chipknip and Chipper had engaged in extensive publicity to convince users and prospective partners to choose their technologies
Complementary goods	There were more Chipknip than Chipper POS terminals and in more diverse application areas. Additional functionality was hardly used
Installed base	Chipknip has a higher installed base of POS terminals, Chipper initially had more cards and recharge points: the public phone cells. In particular, Chipknip's number of POS terminals where consumers had no other choice (parking or canteens) contributed to its dominance under the influence of network effects
	Chipknip's lead in terms of POS terminals relates to another installed base: almost all retailers and supermarkets were already customers of Chipknip banks
Market mechanism	Network effects and other reasons for bandwagoning: availability of the solution, information increasing returns, avoiding uncertainty, economies of scale, and functionality (de Vries and Hendrikse 2001)
Other factors	KPN was an important stakeholder for the Chipper alliance. However, they decided to allow the Chipknip banks to use their pay stations (to increase their revenue). Apparently, they were not fully committed to the Chipper alliance
	Chipknip was developed by a consortium of banks and Chipper was developed by Postbank and KPN. The Chipknip banks incorporated various suppliers of complementary goods in their network, resulting in a high network diversity

standards outperformed their rivals in these aspects. Apart from the availability of complementary goods, the *variety* of complementary goods also plays a crucial role. Every market has its own type of complementary goods. In our cases, we see that the higher the availability of complementary goods in each of the involved markets, the higher the installed base in each of those markets, and thus, the higher the overall installed base. Furthermore, we observe that, in line with prior research (Schilling 1998, 2002), a higher installed base results in more demand for complementary goods and, in turn, in a higher availability of those goods.

In line with prior studies (David 1985; Cusumano, Mylonadis, and Rosenbloom 1992; Funk and Methe 2001; Gallagher and Park 2002; Schilling 2003), different strategies affect the installed base including timing of entry and marketing communications. Aspects that influence

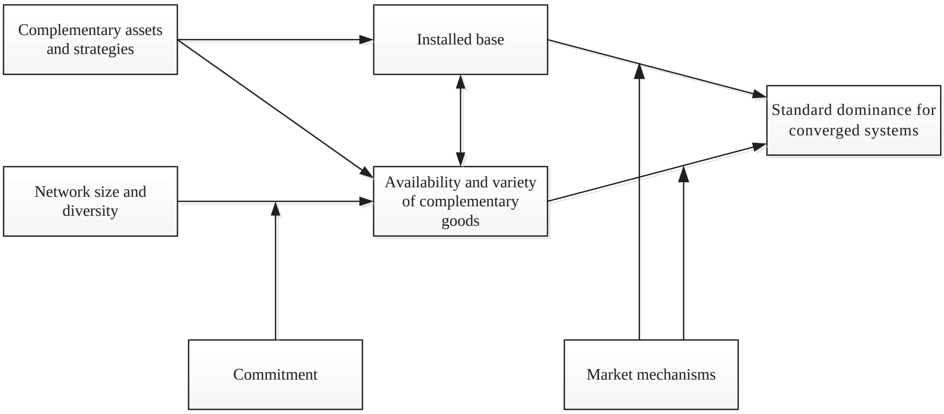

Figure 2. Revised model for standard dominance for converged systems.

the availability and variety of complementary goods include reputation and pricing strategy. However, the main strategy to increase the availability and variety of complementary goods appears to be to build up a large and diverse network of suppliers of complementary goods that supports the standard. For example, WiFi was being promoted by a large and diverse network of actors from IT, CE, and TE industries and each of these implemented the WiFi standard in their products, increasing the number and variety of complementary goods considerably. Also, the Chipknip banks were more successful in convincing suppliers of complementary goods to install their POS terminals. Chipknip also actively encouraged retailers that had adopted Chipper to switch to Chipknip by offering financial incentives.

We also observe that commitment is an important factor in winning the battle. Our cases show that a low level of commitment may decrease the effect of network size and diversity on the availability and variety of complementary goods. For example, Intel, the leading firm behind HomeRF, also invested in other standards, which signals they were not fully committed. Other firms promoting HomeRF were also not strongly committed to the standard. As a result, many suppliers of complementary goods chose not to implement the HomeRF standard in their products. In the Chipknip vs. Chipper case, KPN was not fully committed to Chipper and implemented Chipknip in their public telephone boxes. The resulting uncertainty among retailers affected the implementation of the standard, and thus resulted in fewer complementary goods.

So, six (sets of) factors for standard dominance were important in each technology battle that we studied: complementary assets and strategies, size and diversity of the inter-organisational network of the standard, commitment of the group of standard supporters, availability and variety of complementary goods, installed base, and market mechanisms. Our findings illustrate that a strong inter-organisational network in terms of size and diversity is essential for achieving dominance of the standard for converged systems as it contributes to the availability and variety of complementary goods, provided that the actors are committed to the success of the standard. In turn, we illustrate that a high availability and variety of complementary goods lead to a higher installed base in each of the different markets involved and that both factors affect standard dominance under the influence of network effects. We visualise this in Figure 2.

5. Discussion and conclusion

We contribute to the literature on technology management (Suarez 2004; McIntyre and Subramaniam 2009; Gallagher 2012) in several ways. First, although several studies have proposed common factors that explain the outcome of technology battles in network industries (Lee et al. 1995; Schilling 1998; Suarez 2004), most of these studies do not explicitly mention relations between factors. Furthermore, whereas most studies focus on technology battles that have occurred in single industries, we focus on technology battles for converged systems. Studying two cases has enhanced our understanding of the specifics of this type of technology battles. Through our cases, the proposed model for technology dominance as presented in Figure 1 is confirmed for the case of technology battles for converged systems. Furthermore, we refine the model. Apart from the availability of complementary goods, we introduce the notion of variety of complementary goods. Also, we introduce new factors that are specific for the case of technology battles for converged systems: the size and diversity of the inter-organisational network of parties supporting the standard and the commitment of the group of standard supporters. This results in a revised model for technology dominance for converged systems. The revised model contains six specific sets of factors that seem to be important for the case of technology battles for converged systems and we show how they are related: complementary assets and strategies, the size and diversity of the inter-organisational network of parties supporting the standard, the commitment of the group of standard supporters, the availability and variety of complementary goods, market mechanisms, and the installed base in every market involved.

The current study also has implications for the network literature. The studies that apply network literature to standardisation mostly study the impact of networks of end users on standard diffusion. For example, Weitzel, Beimborn, and Konig (2006) investigate the impact of network topology and density on standard diffusion. Other authors study the diffusion of standards among actors by drawing on social network literature and network economics (Suarez 2005). These studies have in common that they focus on the social network of end users that may adopt a certain standard. Some scholars have shown that network size (in terms of standard promoting actors) affects the availability of complementary goods (Cusumano, Mylonadis, and Rosenbloom 1992). Our research builds upon that research by showing that besides network size, network diversity is essential for the availability and variety of complementary goods. In doing so we also build on the study performed by Van den Ende et al. (2012) who focus on the antecedents of network size and diversity (e.g. standard flexibility). We focus on their effects. Our findings suggest that the higher the size and diversity of the network, the higher the availability and variety of complementary goods, and thus the higher the installed base of the standard in each market.

However, engaging in diverse networks might reduce the overall commitment in each market in which the firms compete. In our cases we have observed that some actors were not fully committed to the standard. Thus, the organisations in which the actors reside are not to be seen as unitary actors. Our findings suggest that the level of commitment of the actors involved moderates the effect of network size and diversity on the availability and variety of complementary goods. One of the reasons why actors may not be fully committed to standards for converged systems may lie in the fact that these battles are fought in markets that are often subject to high rates of technological change (resulting in the convergence of the markets). A high rate of change is often accompanied by increased uncertainty in the market. This increased uncertainty, in turn, may reduce the overall commitment for one particular standard as actors spread their risks by adopting multiple standards. An illustration of this phenomenon can be observed in the case of HomeRF as Intel, the leading firm behind HomeRF, was also investing in other standards.

At the same time, a low level of commitment for a standard increases uncertainty towards that standard amongst suppliers of complementary goods as was the case for Chipper. Also, in the case of converged systems, large firms may consist of multiple divisions that may be involved in multiple technology battles that are fought in various industries. In that case, firms may have different conflicting agendas. Then, the question arises how players within organisations secure commitment for a standard (this has been studied before in, for example, Zhao, Xia, and Shaw 2011).

Thus, in technology battles for converged systems, there appears to be a dilemma that players face between focusing on central innovation pathways and diversification, and this tension should be properly managed. In the Chipper case this was solved by providing the chipcard from the outset with ‘empty rooms’ for different categories of additional functionalities (other than the basic payment functionality) in order to be prepared for use in different markets. After one year, Chipknip initiated an upgraded version with similar functionalities:

> The new Chipknip carried ‘generic’ functions for identification, savings programs, and tickets. These generic functions could be activated by an authorized customer, for instance railway tickets sold by a railway company to its passengers or cinema tickets sold by a chain of cinemas to moviegoers. (de Vries and Hendrikse 2001, 113)

Future research could study how this trade-off is made in other cases.

Our findings suggest that the variety of complementary goods and the installed base are important for obtaining standard dominance. Firms could pursue a strategy to find alternative uses for the standard in order to build up additional installed bases in different markets. For example, in the case of Blu-ray vs. HD-DVD, both standards were not only implemented in high definition DVD players but also in PCs and video gaming consoles, thereby creating a larger overall installed base (Gallagher 2012).

A limitation of this study is that we asked respondents about events that took place in the past, with a known outcome. This may create a potential risk of retrospective bias (Golden 1992). Also respondents were selected on the basis of their active involvement in the battle. This was done to ensure a proper and detailed recollection of the events. In so doing we could go into detail concerning, for example, commitment of actors towards standards. However, this resulted in a non-random group of interviewees which might result in a problem of sampling bias. To reduce sampling bias, we made sure that we interviewed at least one expert per standard and two objective outsiders. We contacted respondents through our personal contacts and directly. Furthermore, the number of cases is limited to two and we specifically focused on technology battles for converged systems. Another limitation is that we focused on the period beginning with the release of the first standard until one of the standards becomes dominant. Thus, we do not pay attention to the period before a standard is introduced in the market. Future research could study how standards are developed, managed, and negotiated by the different stakeholders involved. Also, future research might study more cases of technology battles for converged systems using the framework. In so doing, the research model can be validated. Our findings suggest that network size and diversity are essential for increasing the availability and variety of complementary goods and installed base. Future research might study whether these factors may even be more important than other factors both on the supply and the demand side as they were important in both battles. There are various other specific questions that arise for technology battles for converged systems which might provide interesting avenues for future research: To achieve technology dominance in converged system, it might be crucial to implement a standard in as many different types of complementary goods as possible so that the variety of complementary goods increases. It might also be the case that the effect of complementary goods and installed base is bigger in technology battles for converged systems than in other technology battles, as the former battles are fought in multiple converging markets, each having unique complementary goods and a unique installed base.

In conclusion, this study examines the importance of factors for standard dominance for converged systems by studying two cases of technology battles. Although each battle was unique, its outcome could be explained using similar factors for standard dominance. Six (sets of) factors were important in the battles; size and diversity of the inter-organisational network increase the availability and variety of complementary goods, provided that the actors are committed to the success of the standard. Furthermore, apart from different complementary assets and strategies, a large availability and variety of complementary goods positively influence the installed base which, under the influence of market mechanisms, leads to standard dominance.

Supplemental data

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Notes on contributors

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