AN EXPERT VIEW ON THE ROLE OF COMPLEMENTARY ASSETS FOR THE ADOPTION OF SMART HOME PLATFORMS

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Abstract

Smart home (SH) products and services aim to enhance the comfort, convenience, security, entertainment, health, education and communication of tenants and their guests enabled by information technology platforms. Despite ongoing waves of enthusiasm, the SH market has remained a niche for more than three decades. At the same time, recent forecast expect the market to grow at high rates in the upcoming years as various global players, like Google, Apple, AT&T, Cisco and Samsung, are lining up with own SH platform initiatives. Accounting for the multi-sidedness of the market, we employ a platform ecosystem perspective to investigate the role of complementary assets for SH adoption by consumers and firms. Based on interviews with 25 experts from 22 companies, our qualitative content analysis reveals and prioritizes complementary goods, sales channels, brand image, expertise, support infrastructure, operational footprint and financial resources as critical complementary assets. Further, we provide managerial implications for platform sponsors regarding the affiliation with complementary suppliers, the legitimacy of sponsorship, platform openness as well as on platform envelopment.

Keywords: technology adoption, platform ecosystems, smart home platforms, complementary assets, expert interviews.

1 INTRODUCTION

Smart Homes are residences "equipped with computing and information technology that anticipate and respond to the needs of occupants […] through the management of technology within the home and connections to the world beyond" (Aldrich 2003). When the concept of the Smart Home (SH) emerged in the 1980s radical changes to domestic life were envisioned (Mitchell 1996). In particular, SH technologies are designed to enhance the comfort, convenience, security, entertainment, health, education and communication of tenants and their guests (Aldrich 2003; Solaimani et al. 2013). However, the diffusion and evolution of SH technology have been facing a variety of technical, societal, conceptual and managerial challenges in the last three decades (Aldrich 2003; Barlow & Venables 2003; Edwards & Grinter 2001; Wilson et al. 2013). As of today, the SH market has remained a niche with SH products and services provided through various sector-specific, barely interoperable nor fully standardized platforms falling short on adoption from consumers, device manufacturers and service providers (Nikayin & Reuver 2012).

At the same time, recent trends are expected to path the way for wide-spread adoption of SH technology, including price declines for microelectronic components, increasing digitalization of societies, high availability of broadband connections, progresses in cloud computing technologies as well as potentials for energy savings. The market for smart home appliances alone is forecasted to grow from USD 40 million in 2010 to USD 26 billion by 2019 (International Energy Agency 2013). In this context, multiple global players from different industries, like telecommunication operators, network equipment manufacturers, household appliance manufacturers and large IT firms are targeting the mass market with own SH platforms – e.g., launches of AT&T's Digital Life (AT&T 2013) and Deutsche Telekom's QIVICON (DTAG 2013) platforms in 2013, Google USD 3.2 billion acquisition of Nest (GOOGLE 2014), Apple's announcement of the HomeKit platform (APPLE 2014) and Samsung's USD 200 million take on SmartThings (SAMSUNG 2014) all in 2014, as well as the joint platform initiative of Cisco, Bosch and ABB (ABB 2014).

In this sense, the SH market is characterized by a 'battle for dominance'(Peine 2008), i.e., "[. . .] different technological trajectories or designs, sponsored by different actors, compete for dominance through a process where economic, technological, and socio-political factors are intertwined" (Suarez 2004). From a market perspective, such format battles are impacted by adoption from two sides (Van de Kaa et al. 2011): on the one hand, suppliers choose which of the competing interface specifications to implement in complementary goods, on the other hand, customers make a purchase decision on these derivative products and services. A key factor that determines technology adoption and thus, the outcome of battles for dominance are complementary assets (Schilling 1998; Suarez 2004). Owners of rare and specific complementary resources and capabilities may replace an original innovator and win dominance battles (Teece 1986). As such, choices on the technological design and the engagement with complementary assets have to be coordinated in parallel to successfully commercialize the technological innovation.

In correspondence to Nikayin and Reuver (2012), we understand SH platforms as hardware, software, network infrastructure or their combination hosting a set of core functions, e.g., data storage, processing power, decision-making component, to develop, operate, deliver and access services dedicated to enhancements of the domestic live. Based on this definition we aim to investigate:

> Which complementary assets have significant influence on consumer and firm adoption of SH platforms, regarding the direction of influence?

Following the call for more qualitative IS research by Hirschheim (2012) we conduct a qualitative content analysis based on 22 interviews with 25 industry experts from 22 companies to identify and evaluate complementary assets that determine the adoption SH platforms.

2 THEORY BACKGROUND

2.1 Technology acceptance

Research on technology acceptance is a continuing topic in information systems community aiming to understand the factors that cause people to accept and make use of technology (Choudrie & Dwivedi 2005). Various theories have been applied and developed to explain technology acceptance, see Oliveira et al. (2011) and Venkatesh et al. (2003). In this regard, one of the most popular models was proposed by Davis (1989) in 1989, i.e., the technology acceptance model (TAM). Based on the Theory of Reasoned Action and Theory of Planned Behavior the original TAM understands the actual use of technology as a successor of the user's behavioral intention to use (BI). In turn, the BI is modelled as the user's attitude towards using the technology and its two constituents, i.e., perceived usefulness and perceived ease of use. The simplicity and understandability of TAM have contributed both to its popularity and to its evolution in technology acceptance research (King & He 2006). In this sense, the original TAM has been extended in many ways – compare King and He (2006), Lee and Baskerville (2003) and Legris et al. (2003) for comprehensive listings – and applied to many types of information systems, see Lee and Baskerville (2003).

Technology acceptance studies can be distinguished by the level of analysis applied, i.e, acceptance may be investigated at the organizational and individual level (Choudrie & Dwivedi 2005). While studies at the organizational level are concerned with the adoption behavior of organizations and firms as a whole, e.g., Oliveira et al. (2011), the individual perspective focuses on acceptance of individuals in the context of firms or other organizations (employee context), e.g., Venkatesh et al. (2003), as well as in the context households (consumer context), e.g., Venkatesh et al. (2012). With respect to the innovation decision process, the scholar's interest may be directed towards different target behaviors (Karahanna et al. 1999). As such, the factors influencing pre-adoption, i.e., the intention to adopt or adoption behavior, can differ from post-adoption, i.e., actual or real usage behavior – e.g., the attitude of potential adopters typically builds on a richer set of innovation characteristics than those of actual users (Karahanna et al. 1999). In this paper we investigate the factors influencing consumers' and firms' intentions to adopt SH platforms.

2.2 Platform ecosystems

Under the theoretical lens of platform ecosystems a platform is as "a set of shared core technologies and technology standards underlying an organizational field that support value co-creation through specialization and complementary offerings" (Thomas et al. 2014). An increasing number of researchers has been employing the platform ecosystem perspective to investigate adoption of information technology (IT) in a variety of contexts (Gawer & Cusumano 2014). Examples of IT platforms include desktop and mobile operating systems, like Microsoft Windows and Google's Android, mobile devices, like Apple's iPod and iPhone designs, or video-game consoles, Sony's Playstation and Microsoft's Xbox.

Such platforms constitute the centers of platform ecosystems, i.e., networks of firms from a diverse set of technological fields, by coordinating technologies, services and complementary assets (Cusumano & Gawer 2002; Gawer 2009). Benefits to the owners of industry-wide platforms (platform sponsors) come as economies of scale through efficient use of their core technologies and competencies and as economies of scope through complementary innovation (Baldwin & Woodard 2009). In order to gain and maintain platform leadership, sponsors share ownership and control over platform components to stimulate complementary value creation (Cusumano & Gawer 2002). As such, a key managerial challenge for sponsors consists in the balance of value capture and creation while understanding their mutual dependencies (Tilson et al. 2012).

In this regard, platform openness refers to the degree to which strategic control over the development, use and commercialization of a platform is distributed within the ecosystem (Eisenmann et al. 2009).

More specifically, platform openness defines the extent of participation in a platform ecosystem, i.e., access and restrictions for third-parties to participate as platform sponsors, platform providers, supply-side and demand-side users of the platform. According to Eisenmann et al. (2009), sponsors own the design and intellectual property rights and license the platform to providers. The latter serve as primary points of contact for supply-side and demand-side users. Supply-side users employ the platform to offer complements consumed by demand-side users. As such, platform sponsors have to stimulate both demand-side adoption by consumers and supply-side adoption by firms in order to achieve platform leadership in the SH mass market.

2.3 Complementary assets

In his seminal paper on technological innovation Teece (1986) examines the commercial success of innovations. He argues that the core technology needs to be utilized in combination with other assets and capabilities in order to achieve successful commercialization – so called complementary assets. In this regard, he distinguishes generic, specialized and co-specialized assets. Generic assets are of general purpose, i.e., they can be utilized without any tailoring to the innovation of concern. As generic assets are easily accessible either in the marketplace or through own development they constitute only little, if any, competitive advantage to the innovator. In contrast, competitive advantages stem from the rareness and specificity of specialized and co-specialized assets complementing the core technology. While these assets differ in their dependence from the innovation – which is unilateral for specialized assets and mutual for co-specialized assets –, their relevance for competitive advantage unites them to the subject this study aims to explore.

Further, innovators have to decide on how to engage with complementary assets. In this regard, integration-based and contractual-based modes of engagement can be distinguished (Teece 1988). The former refer to own development and purchase of the complementary assets, the latter involve licensing the core technology to other firms. According to Teece (1986), the strategic decision on the mode of engagement will depend on the given appropriability regime. In tight regimes the business environment favors the innovators ability to capture rents related to the innovation, e.g., through existing patents or copyright protection, while this is the contrary in weak regimes in which imitators face lower entry barriers. In this context, Baldwin and Woodard (2009) find that licensing platforms to outside complementors is especially valuable in markets where consumer tastes and technological developments are uncertain.

With respect to the SH market, Peine (2008) observes a shift from a tight coordination of the innovation process to a loose way of organization. While initially sponsors of SH platforms integrated complementary assets into all-encompassing designs, the focus of attention shifted to platforms able to mediate between complements of heterogeneous designs. In this sense, the perception of the SH moved from integrated systems to a more open view on the involvement of complementary assets from different actors.

3 RELATED LITERATURE

3.1 Complementary assets as determinants of technology adoption

In order to be adopted by consumers and other firms, technology platforms have to be purposefully managed. Consequently, determinants of platform dominance have been studied predominantly in technology and innovation management research (Murmann & Frenken 2006; Thomas et al. 2014). In this regard, complementary assets have been identified as a major influence factor (Schilling 1998; Suarez 2004).

As any asset supporting the commercialization of an innovation can be considered a complementary asset different categorizations can be applied. Knowledge-based taxonomies distinguish tangible and intangible assets as well as assets based on technical and non-technical knowledge, while functionally-

based classifications group assets according to business functions, like marketing, production and human resources (Taylor & Lowe 1997). The role of complementary assets for technological innovation has been investigated in different industries (Chiu et al. 2008), ranging from typsetter (Tripsas 1997) and pharmaceutical industries (Rothaermel 2001) over TV (Klepper & Simons 2000) and video console markets (Cenamor et al. 2013; Gallagher & Park 2002) to high-tech firms (Colombo et al. 2006) and software and IT service platforms (Dedrick & West 2003; Rosemann et al. 2011; Song 2013).

Consequently, a variety of critical complementary assets has been identified. Tripsas (1997) underlines specialized manufacturing capabilities and the sales and service network, while Rothaermel (2001) highlights the importance of extensive product testing and logistics. Further, the availability of complementary goods (Cenamor et al. 2013; Schilling 1999) and brand awareness (Gallagher & Park 2002) can play an important role. Further, the availability of distribution channels, marketing systems and customer relationships have been revealed as crucial assets related to the sales network in different markets (Chiu et al. 2008; Schilling 1999, 2009; Willard & Cooper 1985). Additionally, the support infrastructure given as available technical support services and adequate skills of IT workers seems critical for open source software (Dedrick & West 2003) and mobile software development platforms (Song 2013). Additionally, competitive advantages may stem from financial resources and human capital, such as innovativeness and creativity as well as industry experience and market knowledge (Colombo et al. 2006; Dedrick & West 2003; Klepper & Simons 2000).

3.2 Complementary assets in the Smart Home literature

Many scholars have investigated the issue SH technology adoption. The overwhelming majority of studies deals with consumer adoption, while determinants of firm adoption have been addressed to a lower extent – for extensive literature reviews compare Ciesielska and Li (2011), Wilson et al. (2013), Solaimani et al. (2013). To the best of our knowledge, there is no study explicitly examining the influence of complementary assets on SH adoption. However, the relevance of some complementary assets can be deduced from several studies as described in the following.

In the context of high technology buildings, Gann et al. (1999) point out that competencies for design, development, manufacturing, installation and maintaintence of automation systems are distributed over firms from different sectors, including telecommunciations, electro-mechnanical, electronic and software. Similarly, Barlow and Venables (2003) find it challenging to foresee the involvement of current and future players in the installation, integration, provision and aggregation of SH services and products. Further, customer relationship management is assigned a critical role in several empricial studies – please, refer to Ciesielska and Li (2011) for an overview. In particular, adequate customer support for system installation, repair and maintenaince is seen as a challenge (Demiris et al. 2004; Gann et al. 1999). Additionally, scholars stress the relevance of a product marketing as misconceptions of SH functionalities, benefits and risks have been revealed (Bonino & Corno 2011; Krishnamurti et al. 2012). The availablity of adequate distribution channels plays a crucial role both from a consumer and firm perspective. Coughlin et al. (2007)'s study on elderly care services suggests that consumer adoption is dependent on who takes on the service provider role, e.g. pharmaceutical companies, retailers, insurers or hospitals, while Ciesielska and Li (2011) attribute the lack of consumer adoption to poorly developed distribution channels. Nikayin et al. (2012) one of the few studies on firm-side adoption, finds that the platform owners ability to provide access to customers is a major point of attraction for supply-side users, especially small-sized companies. Moreover, Balta-Ozkan et al. (2013) conclude that governments and utility companies have to position themselves as trusted brands in order to faciliate adoption of smart home products, particularly smart meters. In addition, they stress that independent testing and certification of compatibility and reliability are critical competencies to mitigate consumers' concerns about system quality, identified as well by Coughlin et al. (2007). Brush et al. (2011) find that availability of compatible devices and services from different vendors is desired by consumers. Finally, the contribution of policy makers is

highlighted with respect to effective privacy policies in the case of smart meters (Kranz et al. 2010) and subsidizations to ensure affordance of elderly care services (Coughlin et al. 2007).

4 METHODOLOGY

Quantitative methods focusing on theory testing have dominated acceptance research of IS technology (Choudrie & Dwivedi 2005; Lee & Baskerville 2003). Such approach may overlook relevant influence factors (Wu 2012), while qualitative studies have successfully build theory identifying new factors and relationships, e.g., (Ouadahi 2008; Zoellner et al. 2008; Vogelsang et al. 2013). As such, we strike a qualitative approach that comprehends the research ideas of (Mayring 2010) and is adopted from (Vogelsang et al. 2013) as seen in Figure 1.

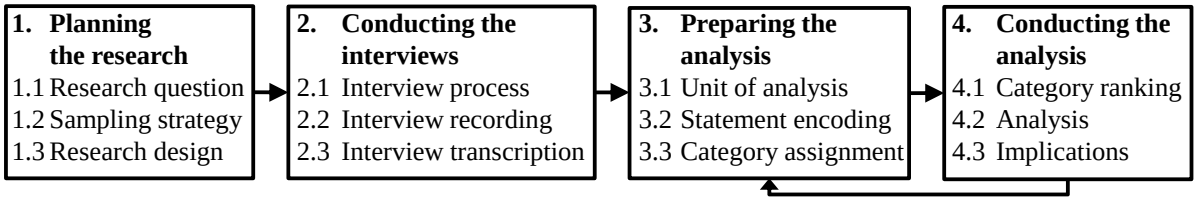

Figure 1. Steps of applied research methodology adopted from Vogelsang et al. (2013)

First, to address our research question as stated above, we chose to conduct interviews with industry experts, i.e., persons with privileged access to information and knowledge on the subject (Bogner et al. 2009). Referring to mid- and top-level managers responsible in their companies for the development and marketing of SH platforms and/or their complementary products and services allowed us to draw from a large pool of knowledge based on long-time market experience and primary customer insights from various application domains. To support this broad view we included 22 companies claiming different stakes in the SH market – namely, telecommunication (2) and utility network operators (2), IT and communication equipment manufacturers (3), household appliance (3) and home system manufacturers (2) and home automation specialists (10), including an open source SH platform initiative. Contact acquisition was initiated at CeBit 2014, the world's largest and most international computer show, through in person presentation of the research project. In addition, experts were sourced based on existing and inquired contacts. Additionally, during the interview phase we employed snowball-sampling as interviewees would refer further contacts to us. An exploratory research design was chosen based on a semi-structured interview guideline. This way experts could free-associate with the questions and were not bound to specifics, like certain products, use cases, customer types or phases of the decision process.

Second, we conducted 22 interviews with 25 experts. The interviews took place either in person or via telephone from March to September 2014 and lasted between 60 and 75 minutes. All experts hold middle to executive management positions and each disposes of several years of working experience in the SH field. The experts agreed to the audio-recording of the interviews which allowed us to transcribe them at a later stage.

Third, the unit of analysis are the transcripts generated for each interview. Statements discussing the influence of complementary assets were extracted, encoded to core statements and assigned to categories. Extraction, encoding and assignment were revised by different persons and in feedback loops to ensure comprehensiveness and objectivity. Data preparation and analysis was supported by ATLAS.ti, a leading computer program for qualitative content analysis that enhances the systematic identification of hidden constructs in unstructured data.

Fourth, we assessed the relevance of each category according to the following criteria. First, we counted the interviews the category was mentioned (frequency). Second, for each interview we

evaluated the relevance (relevance) in the following way: overall, the interviewee explicitly doubts or denies the relevance of the concept (-1), considers the category a complementary asset (1) and highlights the relevance of the concept in particular (2). As a result, the analysis provides a detailed description of the discussed categories and a ranking of these categories according to the summed frequency and relevance over all interviews.

5 ANALYSIS RESULTS

In this section we present the results of the content analysis of the expert interviews as summarized in Table 1 and described in detail in the following subsections. A total of 5 complementary assets is identified determining consumer adoption and 7 complementary assets are revealed in the context of firm adoption. An average of 2.1 and 2.2 assets per interview were considered critical for consumer and firm adoption respectively, while in each interview at least 1 complementary asset was pointed out.

Complementary assets		**Influence on adoption of consumers**		**firms**	
		Freq.	*Rel.*	*Freq.*	*Rel.*
Complementary goods	*Devices, services and applications compatible with the platform*	15	20	10	13
Sales channels	*Scope and quality of sales channels available to the platform*	12	17	8	11
Brand image	*Recognition and reputation linked to the platform*	8	12	6	9
Expertise	*Experience and know-how associated with the platform*	7	10	5	10
Support infrastructure	*End user and partner support provided by the platform*	4	4	11	12
Operational footprint	*Geographical reach and market coverage of the platform*			5	7
Financial resources	*Extent of financial assets committed to the platform*			3	4

Table 1. Ranking of complementary assets according to their relevance for consumer and firm adoption of SH platforms as identified in the expert interviews.

5.1 Complementary goods

The availability of complementary goods, i.e., compatible devices, services and applications that can be used with SH platforms, is regarded as the most critical complementary asset for adoption: with relevance scores of 20 and 13 based on statements found in 15 and 10 interviews respectively, complementary goods seem fundamental to both consumer and firm adoption.

In terms of consumer adoption, it is expected that user benefits can be increased drastically if SH services work across different functional domains that complement each other, e.g., the usefulness of energy management applications seems to grow with the range of integrated white, brown and red goods. At the same time, consumers are not willing to be bound to only one or few vendors when equipping different domains in their homes. Consumers value freedom of choice both across and

within various home domains, like home automation, entertainment, security, energy or care. Further, SH platforms that rely on a large portfolio of complementary hardware and software more likely come up to a specific consumer's expectation.

From a firm perspective, the availability of complementary goods is considered to be a major driver of adoption as both platform providers and supply-side users may mutually enrich their offerings. E.g., manufacturers of home appliances and systems may refer to intelligent control solutions for home automation or energy optimization, while technical support and security services may be extended towards additional home devices and areas. In this sense, firm-side users are expected to appreciate the possibility to harness software and hardware functionalities shared within the platform ecosystem. In addition, it is stated that a growing number of associated firms stimulates further adoption as viability of the platform initiative is signalled to potential partners.

5.2 Sales channels

Access to adequate sales channels is identified as a major determinant of consumer and firm adoption of SH platforms in 12 and 8 expert interviews respectively.

Several experts find that control over a far-reaching distribution network is essential for marketing SH technologies to consumers. In this regard, both offline and online sales channels are expected to play an important role: e.g., commercial success of SH platforms is associated with the sales capabilities of large electronic retailers, home improvement stores, telecommunication equipment chains as well as e-commerce marketplaces and application stores. At the same time, the quality of the point of sale is considered a distinctive criterion. As consumers are yet relatively unfamiliar with SH technologies, more explanation is needed to sell these products. However, the interviews reveal that poor consulting and inferior product placement at the point of sale has been experienced as a relevant barrier to consumer take-up. In this sense, educated sales personnel and appealing product presentation including the opportunity to experience SH solutions are expected to make a difference for adoption. Finally, consumers may find it obvious and convenient to procure SH products and services based on existing commercial relations with providers. As such, marketing based on existing customer relations is expected to benefit from customer loyalty and relatively low acquisition costs.

With respect to firm adoption, potential adopters evaluate the distribution power associated with a platform. Platform supporters with strong sales capabilities are attractive for firm-side users as they may increase diffusion rates of their products and services. In particular, small companies seem to find it challenging to access critical mass market sales channels, like large electronic retailers and home improvement stores, and therefore, value the platform-associated sales power. As well, some experts point out to the benefits of joint marketing efforts facilitated through platform ecosystems able to raise awareness among consumers for SH products. In addition, it is reported that smaller firms as well as firms with no direct end customer relations, like home appliance manufacturers, appreciate the sales potential that stems from platform providers' proximity and direct access to customers. Finally, sales may be facilitated between firms in the platform ecosystem – e.g., a white good manufacturer may purchase the service of a software vendor to develop a mobile application for its appliances.

5.3 Brand image

The brand image of the platform sponsor, provider and associated supply-side users is considered a crucial complementary asset for consumer and firm adoption.

As for consumer adoption, the platform's reputation is discussed in 8 interviews of which 4 specifically emphasize its relevance. Especially in relation to certain SH services, like home monitoring and security offers and health services, a trustworthy image regarding data privacy is expected to facilitate adoption. Contrarily, consumers may refrain from engaging with platforms that are associated with non-transparent access, processing and utilization of user data as well as weak compliance with privacy policies. Further, positive and negative spillover effects are stated in relation

to brands reputed to be innovative and diligent to high quality standards for service provisioning and device manufacturing, or the opposite respectively. Finally, the experts expect consumers to be less reluctant to invest in platforms linked to well-known rather than little-known brands as their future viability seems to stand on less shaky grounds.

With a relevance score of 9, the platform's brand image is ranked the third most important complementary asset for firm adoption. The interviews reveal that establishing a trustworthy reputation based on the adjoined brands is an important means to attract new entrants to the ecosystem. It is highlighted that partnering firms need to trust each other and employ a collaborative mind-set. In addition, large and renowned brands create confidence among potential adopters in the viability of the platform initiative. Finally, some experts remark on the fact that smaller firms are eager to benefit from positive spillover effects marketing their products and services in alliance with broadly known brands. However, the specific image potential partners should be evaluated case by case, e.g., to avoid adjoining ventures with 'dusty' or 'unsuccessful' brands.

5.4 Expertise

In the interviews expertise as a complementary asset is referred to as the experience and know-how accumulated in the platform ecosystem, including platform sponsors, providers and supply-side users. The relevance of expertise for successful commercialization of SH platforms is discussed in 7 and 5 interviews regarding consumer and firm adoption respectively.

The experts consider the longevity of platform providers' market existence and experience as a critical reference point for consumers' adoption decisions. This is as, reportedly, consumers evaluate the orphaning risk inherent to a platform, i.e., the economic risk of investing in a platform that becomes unsupported. As such, platforms provided by more established companies are regarded to yield higher rates of adoption than those provided by newly-founded start-ups. Further, the type of expertise is found to determine consumer adoption. Most prominently, credibility of platform ecosystems is associated with firms experienced in in-home networking and communication, connecting home devices to electricity networks and the internet, servicing and billing consumers in their homes as well as enhancing user experience through customer analytics. In this sense, telecommunication operators, electric utilities and providers of IT services and equipment generally seem to be better positioned to provide cross-functional platforms than domain specialists, such as manufacturers of white, red or brown good manufacturers, lighting and heating systems or health devices.

Similar to consumers, potential partner firms evaluate the legitimacy of a SH platform based on the industry experience and SH-specific capabilities gathered in the ecosystem. It is articulated that newly found start-ups may find it more challenging to establish a sizable partner ecosystem than sponsors with long-term industry experience. Furthermore, the experts stress that legitimate sponsoring stems from specific knowledge and experience in the SH field. In this regard, competencies in system integration and operation of home automation and control specialists as well as product and customer knowledge of white, brown and red goods manufacturers are considered especially valuable.

5.5 Support infrastructure

The availability of support infrastructure is primarily discussed in relation to firm adoption as stated in 11 interviews, whereas it seems to play a minor role for consumer adoption as controversially discussed in 4 interviews.

In the consumer's point of view, the support infrastructure comprise all after sales services dedicated to the installation, configuration and maintenance of the SH platform. 4 interviews remark on the influence of perceived support availability on consumer adoption decisions. 2 experts recount platform initiatives challenged by unavailable and unknown customer contacts and warrantors required for system setup and troubleshooting. As such, they consider a clear and transparent assignment of support responsibilities as a very critical success factor for SH platform commercialization. Contrarily,

1 expert explicitly regards end customer support as a necessary, yet generic capability requested by consumers and organized as usual through service level agreements between ecosystem partners.

Correspondingly, the definition and assignment of service level agreements is regarded a self-evident necessity in the context of firm adoption. However, support services going beyond such agreements are considered to be differentiating criteria of SH platforms. Some experts find that the sponsor's on-going communication, assistance and involvement in the development of complementary products and services can make a difference. E.g., a device manufacturer representative was disappointed by the support received regarding the implementation of cross-domain applications jointly with other suppliers. In this regard, adequate maintenance of integration interfaces and management of connected devices and services seem to distinguish platforms from one another. Furthermore, several experts mention that the provision of business support services, like partner settlement and customer analytics, is appreciated by adopting service providers. In this regard, it is remarked that customer analytics services show their advantage mainly at later market phases as they stand and fall with high numbers of users.

5.6 Operational footprint and financial resources

The platform supporters' operational footprint and access to financial resources are identified as two additional determinants related to firm-side adoption.

According to 5 interviews, the breadth of markets covered by the roll-out of the SH platform plays a non-negligible role. In particular, multinational deployments of SH services, e.g., smart TV deployments of large manufacturers, can only be realized through platforms running global operations. As such, emphasis is put on the initial platform footprint together with its internationalization strategy. In this context, it may be reasonable to roll-out in a specific national market initially, whereas experts do not expect platforms to gain traction unless global ambitions are communicated and demonstrated to firm-side adopters early enough. Further, it is stated that the ability to provide local and personal support to partnering firms is especially critical in the initiation phase.

While the relevance of financial resources for consumer adoption could not be identified, its importance for firm-side adoption was stated in 3 interviews with 1 putting special emphasis on it. Financial resources are considered crucial for the establishment of a platform ecosystem regarding two aspects. On the one hand, financial resources are required as sponsors have to reach out to potential adopters, advertise their platform and cultivate partner relations. On the other hand, financial investments in a partner ecosystem demonstrate the sponsor's commitment and signal long-term viability of the platform initiative. This latter aspect seems especially relevant if appliances are characterized by relatively long life-cycles.

6 DISCUSSION

In this chapter we discuss the findings of the qualitative content analysis by relating them to insights from existing platform ecosystem literature. Putting the findings in the theoretical context, allows us to provide managerial implications for platform sponsors and suggest interesting fields for further research on SH platform adoption.

In line with other studies on platform adoption, e.g., Cenamor et al. (2013) or Schilling (1999), we find that complementary goods play an important role both in the consumer and firm context. The availability of compatible products and services increases consumer choice and allows service and device providers to mutually enrich their offerings. In this context, the experts articulate that complementary goods particularly add value if they are provided by different, ideally interchangeable vendors. In addition, platform initiatives backed by multiple vendors are perceived as more viable than platforms supported by a single or only few vendors only. This is in correspondence to Baldwin and Woodard (2009) that regard a wide network of complementary vendors as especially valuable in fields where technological trajectories are uncertain and consumer tastes are heterogeneous or unpredictable.

It can be concluded that a system lock-in strategy aimed to attract a variety of complementary vendors as described by Hax and Wilde II (1999) seems a promising strategic option in the Smart Home case. Sponsors may consider devolving control over the development, use and commercialization of the platform to thrid parties – i.e., pursuing open platform strategies as described by Eisenmann et al. (2009) – to yield higher rates of adoption. In this regard, further studies could investigate the facets of network effects and their influence on adoption (Katz & Shapiro 1986), i.e., the way and extent to which the value of SH platforms perceived by adopters depends on the number and type of other adopters.

Further, the interviews reveal the importance of adequate sales channels for effective marketing and promotion of SH platforms and its complementary goods to mass-market consumers. In this context, reliance on qualified sales personnel for sound product advice and the possibility to experience SH products at the point of sale seem crucial. These findings confirm other scholars, like Schilling (1999, 2009) and Willard and Cooper (1985), that have highlighted the role of marketing capabilities for successful commercialization of platform technologies. In particular, our insights support Schilling's (1999) proposition that investments in consumer education may be decisive in technological fields of which consumers are relatively unaware and unfamiliar. As such, this study suggests that platforms backed by large established companies disposing of existing relationships with customers and sales partners or even own distribution networks, may successfully take advantage of their marketing capabilities.

The interviews that stress the relevance of the platform sponsor's brand image and expertise, express consumer concerns about data privacy, product and service reliability and usefulness as well as the platform's economic viability. Similarly, firms thinking of adopting a SH platform consider the brand reputation, experience and know-how gathered in the ecosystem as they aim for trustful alliancing, positive reputational spillover effects and minimized orphaning risk. In this sense, our study evidences the importance of credible and legitimate platform sponsorship that is pointed out by Dedrick and West (2003), Eisenmann et al. (2006) and Schilling (1999) and that seems particularly relevant when the market has yet to be created, according to Suarez (2004). Specifically, our findings suggest that companies with an innovative, well-known brand, proven competencies in standard setting and prior experience in home networking, like telecommunication, electricity and home automation providers, are in a good position to foster SH platform adoption. From this perspective we agree with Eisenmann et al. (2006) and Schilling (1999) that well-established firms – as opposed to newly found companies – generally possess the better means to drive wide-spread platform adoption in the SH market due to their long-term experience and reputation for past accomplishments. However, it must be noted that newly-found and/or small firms may successfully increase their visibility and prestige through partnering with large, well-established firms, as remarked by Ceccagnoli et al. (2012). As such, considering the legitimacy perspective employed by Tornikoski and Newbert (2007) we argue that platform sponsors in the SH market may either possess the attributes associated with legitimacy or should actively shape perceived legitimacy through strategic behavior. In this sense, platform sponsors must critically evaluate the legitimacy of their sponsorship and correspondingly, take strategic actions – e.g., affiliate with marquee partners (Eisenmann 2008; Evans 2009). In this context, investigating the perception of legitimacy of SH platforms and its influence on adoption seems a very interesting avenue for future research.

Lastly, we would like to highlight the finding that firms considering adoption evaluate the degree to which system integration and business operations are supported. In this context, relevant facets include the ways relationships with partners are managed, implementation efforts are eased, third-party product development is assisted and business models are enabled. On the one hand, these aspects relate to the perception of platform openness from a supply-side perspective as investigated by Hilkert et al. (2011). In particular, our analysis reveals that device manufacturers, service providers and application developers evaluate the degree of what Hilkert et al. (2011) call 'platform transparency'. In this sense, we find evidence for the importance of the way technical support is provided, exchange among complementors is facilitated, commercial terms for marketing complementary goods are

transparent and relationships with end-users are enabled. On the other hand, the discussion on the available support infrastructure sheds light on the concept of complement envelopment as described by Eisenmann et al. (2011), i.e., the degree to which a platform seeks to supplant or diminish complementary platforms. In this sense, the business support services offered by platform sponsors, like partner settlement, customer relationship management or analytics services, may substitute the systems already employed by potential supply-side users. If support services are tightly coupled to the platform, switching costs may be pre-emptively high, particularly for those firms already invested in proprietary or other third-party support systems (Zhu et al. 2006). As such, the integration and migration costs related to the support systems connected to the platform seem to be critical determinants of adoption. In this regard, investigating the moderating effects of switching costs in general and of investments made in existing service environments in particular would be an interesting subject of further research.

7 CONCLUSION AND LIMITATIONS

In this paper we conducted a qualitative content analysis of 22 interviews with 25 industry experts from 22 different companies to empirically explore the role of complementary assets in the adoption of SH platforms by consumers and firms. Our analysis reveals seven critical complementary assets: available complementary goods, access to adequate sales channels, the brand image and expertise associated with the platform, the availability of a support infrastructure, the operational footprint and accessible financial resources. Besides a detailed description, we provide a relevance ranking of the identified assets that may guide future endeavours of researchers and practitioners in the field of SH technology adoption. Further, we provide managerial implications for platform sponsors regarding the affiliation with suppliers of complementary goods and well-established, large supporters, the legitimacy of sponsorship, platform openness as well as on platform envelopment.

To put our results into perspective, several limitations of our study have to be considered. First, we extracted our insights from interviews with industry experts, namely representative of firms that play the role of platform sponsors, providers and supply-side users in the SH field. Thus, a comprehensive view of the ecosystem should be informed by current and potential consumers of SH platforms. Second, the qualitative methodology allowed us to explore the relevance of complementary assets. However, research rigor could be increased by quantitative methods able to test the identified relationships and significance evaluation. Third, besides complementary assets, technology adoption is influenced as well by other factors, e.g., the technological characteristics of the platform, support strategies, like pricing or entry timing, and moderating effects, like network externalities and switching costs (Suarez 2004; Schilling 1998). The role of complementary assets should be evaluated relative to these other constructs for more robust and comprehensive managerial implications.

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