CHAPTER 7

Conclusions: Managing Innovation and Standards Within the Company and Beyond

Abstract This chapter concludes the book by discussing the findings in light of literature and giving clear managerial advice. The study extends the literature on effects of standards and regulation on innovation, integrating them into new product development, and associated dynamics on the industry level. In addition, the results link to other streams of literature, such as theories about sociotechnical systems, regulatory uncertainty, co-opetition, and the need for rules in the functioning of markets. This chapter shows these links and outlines trajectories for future research to explore them further. It also highlights the study's managerial implications and translates them into clear advice for innovators and other actors, such as industry associations.

Keywords Effects of standards on innovation · Managing standards in innovation contexts · Standardisation · Regulation Innovation management · Industry dynamics

In this study, we aimed to develop a grounded theory about innovative companies' management of the critical implications that standards and technical regulation have for developing new technologies. In Chapter 6, we detail the core concepts (three levels at which various activities occur), which make up this theory, and the relationships between them. This concluding chapter highlights the theory's contribution to literature

P. M. Wiegmann, *Managing Innovation and Standards*,
https://doi.org/10.1007/978-3-030-01532-9_7

(Sects. 7.1–7.3), main managerial implications (Sect. 7.4), and implications for future research (Sect. 7.5).

A first contribution of our study therefore lies in the new insights it provides into the effects of standards on innovation (see the discussion in Sect. 7.1). It clearly demonstrates their critical implications and provides new insights into some of the causal mechanisms behind the effects. In order to address them, our study shows that managers need to align the innovation with the relevant standards by adapting the technology, standards, and/or regulation. Our grounded theory approach revealed that this 'managing', which motivated our interest in the topic, does not only happen on the company level. In addition, processes that happen beyond the company at the industry level and in the wider context turned out to be more important than expected. We can therefore relate these findings to Van de Ven's (2005) concepts of 'running in packs' and 'political savvy'. Furthermore, while our study focuses on the 'managing', it also links to related topics like sociotechnical systems (e.g. Geels, 2004; Smith & Raven, 2012; Smith, Voß, & Grin, 2010), and the functions of standards and regulation in establishing markets (Polanyi, 2001).

At the outset of our study, we identified three important gaps in the existing literature (see Sect. 1.2.4) addressing our research question about managing standards, which guide our subsequent discussion: (1) a lack of attention to activities at the firm level, (2) few findings about companies' interactions with the industry level, and (3) limited findings about industry-level dynamics. Our study's detailed findings and open insights allow us to contribute to closing all three gaps. In addition, our study also highlights the importance of dynamics that are associated with the innovation's wider context. In Sect. 7.2, we discuss our theoretical contribution on the company level. Sect. 7.3 addresses the dynamics that affect the industry level and wider context.

7.1 Standards' Effects on Innovation

As we show throughout our study, standards have very profound effects on innovation. Our contribution to the literature on these effects is threefold. First, we show the causal mechanisms behind these effects and demonstrate the importance of coherent sets of standards for an innovation (Sect. 7.1.1). Second, we add to existing findings on the circumstances under which standards are likely to have the strongest effects on

innovations (Sect. 7.1.2). Finally, we identify the lack of standards as a key source of ambiguity and uncertainty for an innovation (Sect. 7.1.3).

7.1.1 Existing Standards' Effects on Innovation

In Table 1.1, we summarised extant findings on how standards can support and/or hinder innovation. Our study adds to these findings by providing more detailed insights into causal mechanisms behind the effects already identified by the current literature. In particular, legitimacy and market access (see, e.g. Borraz, 2007; Botzem & Dobusch, 2012; Delemarle, 2017; Tamm Hallström & Boström, 2010) and creating supporting infrastructures (see Teece, 1986, 2006) are key to our study and illustrated in much detail by our case. Furthermore, the mCHP case exemplifies other effects found in extant literature, e.g. standards being an important information source for NPD activities (see, e.g. Allen & Sriram, 2000; Blind & Gauch, 2009; Egyedi & Ortt, 2017; Featherston, Ho, Brévignon-Dodin, & O'Sullivan, 2016; Van de Ven, 1993) or their role in specifying testing and performance requirements (see Abraham & Reed, 2002; de Vries & Verhagen, 2016; Swann, 2010).

Interestingly, some of the effects outlined in Table 1.1 and Sect. 1.1 were not recognised by the experts in our interviews. For example, literature (e.g. Kondo, 2000; Tassey, 2000) states that standards limit available options for innovation. Most interviewees clearly stated that standards as such did not prevent them from any choices that they deemed beneficial for the technology and left considerable degrees of freedom for innovating (see Sects. 4.2.4 and 5.3). What they did criticise was particular standards posing difficult requirements or reflecting strategic moves by other actors who were attempting to use standards for blocking the technology (also see Sect. 7.3). This shows that at least some of the effects identified in the literature (both positive and negative) do not apply to all standards per se. Instead, whether a particular standard has positive or negative implications for an innovation depends on that standard's contents. In particular, it depends on whether the innovation can be designed in such a way that it conforms to the standard (see Sect. 3.5) and how easily this can be done.

While each distinct standard that touches on an innovation is relevant on its own in this context, our study and existing literature (Featherston et al., 2016; Ho & O'Sullivan, 2017) show that innovations can depend on large sets of standards. Innovations therefore do not only depend

on a small number of individual standards but often must incorporate requirements laid down in a variety of standards. Even for a relatively simple technology like mCHP (compared to systemic innovations like autonomous driving or Smart Cities), this set encompasses a substantial number of standards coming from all categories in Table 3.3 and covering multiple economic functions (see Blind, 2004, 2017; Egyedi & Ortt, 2017; Swann, 2010). Even more extensive arrays of standards are likely to become relevant for technologies that are more complex. In many cases, these sets may include different standards formulating requirements for related aspects of a product and/or standards that relate and build on each other. This underlines the need for coherence among standards (see de Vries, 1999; Featherston et al., 2016; Ho & O'Sullivan, 2017) and architectures on which individual standards are based (see, e.g. van Schewick, 2010) in order to realise their potential positive effects.

Overall, our study suggests that the positive effects of standards on innovation by far outweigh the negative ones. The case clearly shows that standards not only impact on innovation positively in many ways, but may even be a necessary condition for bringing a new technology to the market. This also relates to our observation in Sect. 6.4 that standards fulfil the important function of specifying technological requirements that result from needs of actors in the wider context.

There is some previous standardisation literature which relates to this observation: Delemarle (2017), Botzem and Dobusch (2012), and Van de Ven (1993) discuss the role of standards in forming markets and legitimising innovations. Tassey (2000, p. 588) describes standards as "a balance between the requirements of users, the technological possibilities (…) and constraints imposed by government for the benefit of society in general". De Vries and Verhagen's (2016) case of energy performance standards for houses shows how standards that impact on innovation can directly result from demands associated with trends in a technology's wider context. Nevertheless, despite Geels's (2004) recognition of the function that standards fulfil in technological transitions, extant standardisation literature does not explicitly link to this literature. Our observations suggest that standards may fulfil a role in facilitating technology transitions by helping to define technological niches and providing protective space (see Smith & Raven, 2012; Smith et al., 2010).

7.1.2 Strength of Standards' Effects on Innovation

While all standards that are relevant for an innovation have some impact, our study also shows that the strength of this impact differs across standards. Several such factors can already be derived from the existing literature: Multiple authors (e.g. Blind & Gauch, 2009; Tassey, 2000) argue that the progress of the technological trajectory at the point in time when a standard is developed influences the standard's eventual effect on the innovation. Tassey (2000) also points out that 'design-based' standards have potentially much more profound constraining effects than 'performance-based' standards (see Sect. 1.1). Another factor mentioned in this context is the degree to which a technology is subject to network effects and switching costs which determines the degree to which lock-in poses issues for innovations (e.g. David, 1985). Based on the types of standards that we encountered (see Table 3.3), we add the strength of the link between a standard and regulation as a factor that amplifies both potential positive and negative effects of the standard.

Increases in positive effects driven by standards that support regulation mainly relate to an innovation's market access. In this context, support from standards goes beyond legitimising innovations in the eyes of potential users and other stakeholders (as already discussed by, e.g. Botzem & Dobusch, 2012; Delemarle, 2017; Tamm Hallström & Boström, 2010). Our study shows that close connections between standards and regulation facilitate the proof of an innovation's regulatory compliance substantially and provide additional (legal) certainty to innovators and other stakeholders alike. Such standards therefore arguably enable the innovation being offered in the market in the first place.

On the other hand, closer links between a standard and regulation also make implementing solutions that do not conform to the standard more difficult (e.g. because of expensive documentation and testing procedures to prove such solutions' equivalent performance). Particular standards which might hinder an innovation therefore become difficult to avoid or de facto compulsory in this situation. Whereas a hindering standard with no link to regulation only requires an innovator to invest in developing an alternative solution and/or find other ways of legitimising the product, a hindering standard with strong links to innovation may effectively lock a product out of the market.

7.1.3 Uncertainty Resulting from Missing Standards

All of the above assumes that the contents of standards are known. However, our study shows that this is not always the case and relevant standards may not yet exist at a point in time when they are needed to support the innovation. As far as we are aware, in the current literature only Blind and Gauch (2009) offer insights about the effects of standards being unavailable when needed for a technology's further development. In particular, they find that missing terminology standards contribute to a proliferation of heterogeneous terminology. Our study goes further by clearly showing that lacking standards are a core source of uncertainty for both innovators and other stakeholders (users of the innovation, component suppliers, complementors, etc.), similar to the ambivalence resulting from regulatory uncertainty (see Hoffmann, Trautmann, & Schneider, 2008). This therefore underlines the argument that markets need clear rules guiding actors within them (Fligstein & McAdam, 2012; Polanyi, 2001).

Such unavailable standards lead to a multitude of ambiguities for innovation, such as unclear requirements for the technology, risks of supporting infrastructures not fitting the product, and users not understanding its benefits. These ambiguities are further amplified by the importance of the entire set of standards that applies to an innovation (see Sect. 7.1.1). For any missing standard in such a set, aspects like how it will relate to other standards once it emerges, which economic functions it will fulfil, or where it will fall into our taxonomy may be unknown a priori. Such missing standards therefore impact on all stages of the innovation's development, including conceptualising the product, working with suppliers and others on the technology, and introducing it in the market. Once all relevant standards are known, much of this ambiguity is resolved. Although standards are subject to change under some conditions—as both this study and previous literature (Egyedi & Heijnen, 2008; Wiegmann, de Vries, & Blind, 2017) show—they resolve this instability and uncertainty that would otherwise hinder innovation.

7.2 Managing Standards, Regulation, and Innovation

Extant literature extensively documents the substantial effects of standards on innovation (see Sect. 1.1), yet it offers few insights about how companies can manage this important topic. Extant literature

on company-internal standardisation management mainly addresses companies' engagement in standardisation (e.g. Axelrod, Mitchell, Thomas, Bennett, & Bruderer, 1995; Blind & Mangelsdorf, 2016; Jakobs, 2017; Wakke, Blind, & De Vries, 2015), and the implementation of standards within companies (e.g. Adolphi, 1997; Foukaki, 2017; van Wessel, 2010). However, Großmann, Filipović, and Lazina (2016) are—to our knowledge—the only researchers who address managing standards in the context of innovation. Furthermore, the literature on standards mostly omits the link to regulation that we show to be essential in many situations. Our grounded theory model of managing standards and regulation at the company level (see Fig. 6.2 and Sect. 6.1) contributes findings that add to the literature on both counts.

Some aspects of these findings resemble existing theory about managing standards, showing that it also extends to the specific context of innovation. For example, our model distinguishes between short- to medium-term activities needed to address standards and regulation, and a number of supporting factors that enable these activities. This resembles the distinction between long-term governance and short-term management activities in van Wessel's (2010) framework, although the elements that make up these categories differ.

On other aspects, our model significantly extends the extant theory on company-level management of standards, as we outline below. In particular, our discussion of our model's firm-level parts revolves around three aspects: (1) the company-level support structure for managing standards and regulation (Sect. 7.2.1), (2) firms' approaches to integrating standards and regulation into their NPD processes and these approaches' effects on an innovation (Sect. 7.2.2), and (3) their involvement in external developments through engaging in standardisation and related activities (Sect. 7.2.3).

7.2.1 Organisational Support for Managing Standards and Regulation

Existing literature already addresses some elements of the organisational support structure needed. Adolphi (1997) focuses to a large extent on how firms integrate standardisation into their functional divisions. Van Wessel (2010) highlights the need for governance, which includes elements such as investment decisions and defining strategies, to support day-to-day activities related to standards. Foukaki (2017) identifies

distinct 'standardisation management approaches' in companies that drive much of the subsequent activities. In line with this, several authors (Adolphi, 1997; Foukaki, 2017; Großmann et al., 2016; van Wessel, 2010) highlight the need for a strategic approach to standardisation. Our study confirms this need. In our theorising (see Sect. 6.1.1), we clearly argue that a strategic orientation towards standards enables companies to build an organisational support structure that contributes to handling standards and regulation in NPD. Our results suggest that such a strategic approach allows companies to coordinate their standardisation activities across their business and exploit the long-term effects of standards. Beyond this confirmation of the need for a strategic orientation, our study makes two further contributions on organisational support for managing standards and regulation to the literature.

First, we identify awareness, expertise, and financial resources as necessary conditions for developing a strategic orientation towards standards and regulation. These factors are in line with the findings of de Vries, Blind, Mangelsdorf, Verheul, and van der Zwan (2009) and Foukaki (2017)[1] but we add further insights into *how* they contribute to successfully addressing standards and regulation. According to our findings, awareness of the topic's importance and expertise (in particular strategic) help companies to assess standardisation in light of their business model and innovation activities. These factors therefore help them formulate a standardisation strategy (also see Adolphi, 1997; Jakobs, 2017), which covers aspects such as engaging in external standardisation and lobbying, and identifying areas where existing standards can be used. In addition, financial resources are essential for deriving such a strategy because of the associated costs (e.g. for qualified staff and travelling), which often are beyond the means of smaller companies.

Second, we show how a strategic approach helps to build the organisational support structure that underlies day-to-day activities, which may sometimes even be underdeveloped in large, otherwise professionally run companies (see Großmann et al., 2016). In this context, Adolphi (1997) focuses on different models regarding where firms incorporate standardisation work into their functional structures. Our study suggests that

[1] Foukaki's (2017) study was not yet available when we conducted the literature review underlying our work. Interestingly, her cases also lead her to identify awareness as a core concept in standardisation management that has not been addressed in the mainstream academic literature.

the specific organisational function (e.g. the R&D or production department) to which these tasks are attached is of secondary importance. While we observe different approaches across companies in that regard, none of them appears to be preferable per se. Instead, clearly defined responsibilities for planning standardisation work and ensuring that the responsible staff have sufficient influence and authority to ensure that these plans are implemented appear to be important for providing optimal support.

7.2.2 Integrating Standards and Regulation into the Innovation Process

The organisational support discussed above enables activities related to integrating standards and regulation into the innovation process. On a very fundamental level, we distinguish between active and passive approaches. They somewhat resemble Foukaki's (2017) assertive and vigilant approaches to participating in standardisation, but go further because they also touch on aspects like product design and involvement of third-party consultants. Whether a company adopts an active or passive approach is likely to be driven by the commonly held image of standards and regulation within the firm (i.e. whether they are seen as a welcome support or a necessary evil). Companies which appreciate the value of standards are more likely to adopt a (pro)active approach. Such approaches can be implemented, e.g. in terms of using the available leeway regarding which standards and regulation to apply, or exploiting the open nature of many standards (see the data in Sect. 4.2 and our theory in Sect. 6.1.2 for details). Our results suggest that doing so can lead to substantial degrees of freedom for developing an innovation. We therefore question to some extent the commonly held view that "firms need to strike a balance between both flexibility and standardization" (Lorenz, Raven, & Blind, 2017, p. 29).

Instead, it appears to be a question of managing standards in such a way that they enhance flexibility rather than constrain it. As we explained in Sect. 1.2.1, existing literature on how this can be done is extremely scarce. We are aware of only one earlier study (Großmann et al., 2016) that explicitly addresses the management of standards during an NPD process. This study therefore forms a 'benchmark' against which we compare our findings.

Großmann et al. (2016, p. 322) (integrate standardisation-related activities into a model of a generic stage-gate NPD process (covering six stages from idea to market introduction), which shares the core activities needed with our model (see Fig. 6.2) but differs on how these activities relate to each other. They suggest two specific standardisation-related tasks that take place in parallel to the core sequence of innovation development activities: (1) 'screening standards', which takes place in parallel to the early phases of the product's development, and (2) 'participating in standard setting committees', which happens next to later stages. Both closely resemble activities that we identify in our model: 'identifying regulation and standards', and 'engaging in standardisation and regulation' (see Fig. 6.2). In addition, our model entails 'specifying the product' and 'evaluating conformity to requirements' as distinct necessary activities in this context. Großmann et al.'s (2016) model includes these activities within the regular stages of the core NPD process ('development', followed by 'testing & validation').

While we find similar necessary activities, our findings challenge the sequential approach of Großmann et al.'s (2016) model. Our theorising (see Sect. 6.1.2) shows that this is unlikely to work in situations which are characterised by factors such as uncertainty about future standards (see Sect. 7.1.3), technological learning by the company,[2] and attempts by actors in the technology's wider context to influence standards and regulation (see Sect. 7.3). These circumstances imply, among other things, that some relevant standards and regulation are not known at the outset of the NPD process and are continuously subject to change (see, e.g. Wiegmann et al., 2017). Therefore, all activities related to standards and regulation need to be carried out iteratively or in parallel and throughout the entire NPD process. Similarly, we also identify testing as a continuous activity. Starting testing early on and continuing it throughout the NPD process prevents potentially expensive re-work to change designs that do not conform to standards at a late stage in the process. Our study therefore highlights the need for an iterative approach in order to reap the benefits of standards outlined above.

[2] As we observed in our case when companies were initially unaware of important aspects of electricity generation where standards applied (see Sect. 4.2.1).

7.2.3 Addressing External Developments on the Industry Level and in the Wider Context

One of Adolphi's (1997) key findings relates to companies facing a 'make-or-buy decision' when they require standards. Our study clearly shows that innovating firms frequently face a similar choice between adapting their technology to standards and regulation or (attempting to) adapt(ing) standards and regulation to the technology. This choice applies in particular when addressing uncertainties resulting from a lack of needed standards (see Sect. 7.1.3). While this choice—to our knowledge—has not yet been documented in the standardisation literature, it closely resembles some strategies identified in studies on regulatory uncertainty (e.g. Engau & Hoffmann, 2011a, 2011b; Fremeth & Richter, 2011).

Such attempts to influence standards and regulation are the core channel through which companies can affect the dynamics on the industry level and in the technology's wider context. In line with earlier findings (e.g. de Vries et al., 2009; Foukaki, 2017; Jakobs, 2017), we show that this option is only open to companies with sufficient awareness of the topic, financial resources, expertise, etc. (see the argument above). This means that companies without these supporting factors have a very limited impact (if any at all) on external developments. De Vries et al. (2009) argue that they can be represented by trade associations (as we observed to some degree in our case). However, relying on such proxies implies (1) that this element of the industry structure (see Sect. 6.2.1) is sufficiently developed and (2) that industry associations act in line with the interests of member companies that do not engage in standardisation. Even when there are strong industry associations, the second assumption may not always be true: Our case shows associations are likely to be dominated by the same companies that are active in standardisation, because engaging in them is similarly resource intensive as participating in standardisation. Companies that engage neither in standardisation nor industry associations are therefore often 'standard takers' rather than 'standard makers' (see the distinction by Meyer, 2012) and interactions between the company level and external developments are mostly inwards-flowing for them through the activities discussed above.

Furthermore, companies that engage in standardisation and regulation need a long-term outlook. This is not only needed because standardisation and regulation processes tend to be lengthy, but also because

of the 'public good nature' of standards (see Berg, 1989; Blind, 2006; Tassey, 2000). Standard takers eventually also enjoy many of the benefits from being able to access the market once standards and regulation have been adapted to the technology, but incur none of the costs. Standard makers need to accept that many (but not all) benefits of their work are public. Our study shows that they tend to be motivated by the opportunity to shape the contents of standards and regulation based on their individual preferences. In addition, the required standards and regulation are unlikely to be developed if no company takes action and everyone waits for other players to take the initiative.

Even if companies participate in standardisation and attempt to influence e regulation, they are unlikely to succeed in doing so on their own. Cooperation with others is therefore needed. A fundamental decision in this context revolved around which forums for collaboration to engage in. In this context, they need to navigate potentially complex interdependent arrangements of organisations, including SDOs, industry trade associations, and consortia, that might span across multiple modes of standardisation (see Wiegmann et al., 2017). While the motivations identified in the earlier literature for participating in these settings (Blind & Mangelsdorf, 2016; Jakobs, 2017) are confirmed by our study, it appears that different forums for cooperation may fulfil distinct functions in companies' strategies. For example, we observe an emphasis on technological knowledge sharing when participating in technology development consortia. In contrast, firms' activities in SDOs and industry associations appear to be more geared towards ensuring conformity to regulatory requirements and arranging compatibility with other elements of a large system in our case. Ultimately, all of these activities observed in our study were driven by the goal of building a market in which the technology could succeed. This market required rules in the form of standards (also see Fligstein & McAdam, 2012; Polanyi, 2001) as well as a critical mass for the technology.

Cooperation in technology development and pursuing changes to standards and regulation is one side of firms' engagement on the industry level and in the wider context. On the other side, they remain rivals and compete with each other once their products enter the market. Participating in the processes at the industry level and beyond therefore requires firms to follow a co-opetitive approach (see, e.g. Bengtsson & Kock, 2000; Gnyawali & Park, 2009, 2011; Van de Ven, 2005; Walley,

2007). We explore the dynamics that occur in such co-opetitive relationships in Sect. 7.3.

7.3 Dynamics on the Industry Level and Beyond

While the needed well-functioning system of standards (see Sect. 7.1.1) may often be taken for granted, it actually is the result of a very dynamic process. We expected in our literature review that this process would mainly take place at the industry level (see Sects. 1.2.2 and 1.2.3). Unexpectedly, our study revealed that the industry's wider context (which covers stakeholders outside the industry where the innovation is developed) also plays a very important role. This reflects research approaches which highlight the embedding of markets in society (Fligstein & McAdam, 2012; Polanyi, 2001). Addressing influences coming from this wider context is facilitated by strong cooperation among stakeholders in support of the innovation, both within the industry and across its boundaries.

Our study contributes to the literature on these dynamics in three ways: (1) We show what causes these dynamics (Sect. 7.3.1). (2) We then reveal industry-level approaches to address these dynamics (Sect. 7.3.2). (3) Following on from this, we argue that these dynamics allow standards to fulfil their function of aligning the innovation with the needs of the wider context (Sect. 7.3.3).

7.3.1 Sources of Dynamics in the Industry and Wider Context

Much of the dynamics in the process of establishing standards and regulation for an innovation are caused by conflicting interests of involved stakeholders. In our case, the aims of parties involved in developing the technologies were aligned, but even an innovation's developers do not always agree on a common direction. For example, strong differences could be observed among the developers of GSM (e.g. Bekkers, 2001) or in the case of e-mobility charging (Bakker, Leguijt, & van Lente, 2015; Wiegmann, 2013). Our study shows that this picture is further complicated by stakeholders who are not involved in developing the technology but are nevertheless affected by it. The types of interests pursued by these stakeholders can be very diverse and relate to many topics, such as preserving a status-quo that works for them, facilitating another

technology that emerges in parallel, or government achieving its policy objectives.

This wide variety of interests and stakeholders, which can potentially be affected by the standardisation and regulation of an innovation, causes the core of the dynamics in the process. All involved parties can potentially intervene in the process at any time (see Wiegmann et al., 2017), either to support the innovation or to hinder it. In that context, we observed many different tactics to reach these goals. This wide range of tactics includes attempts to use standards as a tool to actively block a technology (also see Delaney, 2001), coalition building (also see Axelrod et al., 1995), or lobbying the government to intervene (also see Wiegmann et al., 2017). This potential variety of tactics also causes challenges for managing standards and regulation on the industry level, as we outline below.

7.3.2 Industry-Level Approaches for Addressing Dynamics in the Process

The dynamics discussed above challenge the view taken by some that the development of standards to support an innovation can be planned and coordinated by a central actor, such as a government (Featherston et al., 2016; Ho & O'Sullivan, 2017). Although governments (or other actors) sometimes play such a central role, others still can use a range of channels to challenge this (this study; Wiegmann et al., 2017). It may be possible to forecast at what stage of a technology trajectory certain standards would be needed through roadmapping and other tools (Blind & Gauch, 2009; Featherston et al., 2016; Ho & O'Sullivan, 2017). However, the actual emergence of such standards depends on whether the involved parties reach a balance of interests and whether they can sustain this compromise.

Nevertheless, our study shows that there are a number of ways to facilitate this outcome, if not to plan it. Strong collaboration among a technology's supporters and with industry-external actors who share the same or complementary interests is at the core of this. Our study highlights several factors that can support such cooperation and help the industry as a whole to navigate the dynamics in a way that increases the likelihood of establishing standards and regulation which support an innovation. Below, we discuss the role of supporting institutions and an optimal approach to IPR as factors that stand out as particularly

important for this collaboration. Following this, we address our findings regarding the resulting 'group dynamics'.

7.3.2.1 Supporting Institutions for Effective Collaboration

A first core element of our findings is the importance of an industry's supporting institutions, e.g. industry associations. They can enhance cooperation in a number of ways, e.g. by providing forums in which actors can agree on common positions to pursue (similar to the role of consortia observed by Baron et al. (2014) in ICT standardisation), or by implementing common technology development initiatives. In addition to facilitating industry-internal alliances, such supporting institutions may also have established links to actors in the wider context (e.g. governments, trade associations in other industries) that can be used strategically to influence standards and regulation in the technology's favour.

7.3.2.2 The Importance of Intellectual Property Rights in Effective Collaboration

A second factor underlying effective collaboration is an appropriate approach to IPR. Here, our study questions whether the widely held view of a tight link between standards and patents (e.g. Bekkers, 2017; Bekkers, Iversen, & Blind, 2011; Großmann et al., 2016; Lerner & Tirole, 2014; Rysman & Simcoe, 2008) always applies. Patents have been identified as a core element of many standardisation processes. However, giving them a similar role in our case would have undermined both effective collaboration within the industry, and the degree to which the resulting standards would have been perceived legitimate by others. Indeed, the involved parties aimed to keep patents as separate from standards as possible, although they still gave them a prominent role in the collaborations to develop the technology. The industry in our study managed to find a fine balance between protecting firms' intellectual input into the technology's development, while not crowding others out of the process.

To understand these different findings, we contrast our case to others where intellectual property played a more important role, such as mobile telecommunications (see, e.g. Bekkers, 2001; Funk & Methe, 2001; Leiponen, 2008), Ethernet (see Jain, 2012; von Burg, 2001), and optical disks (see den Uijl, Bekkers, & de Vries, 2013). This suggests that the type of standards that are being developed is core to the importance of patents in the process: Many cases where patents were important concern

interface standards (see the classifications by Blind, 2004, 2017; Egyedi & Ortt, 2017; Swann, 2010), which are by definition solution-prescribing (see, e.g. de Vries, 1998; Tassey, 2000). Such solutions are based on concrete designs that are usually patentable. On the other hand, most standards in our case fulfilled economic functions related to safety and measurement and were performance-based, meaning that little (if any) of their content could be patented.

However, not all standards in our case were performance-based: For example, standards for connecting to the electricity grid had important interface elements and therefore incorporated patentable solutions. Nevertheless, we also did not observe an important role of IPR in these standards' development. This can be explained by the 'standardisation culture' that applies in a specific context (see Wiegmann et al., 2017). In the industries in our case, this 'culture' clearly is collaborative and long-term oriented, and most standards that we found link strongly to regulation. This would make any attempts of bringing patents into standardisation unacceptable to many stakeholders. In other industries, such as ICT, most standards arguably concern interfaces that are based on the private intellectual property, and have few links to regulation. Under such circumstances, it is no surprise that the common approach to standardisation emphasises patents more.

In summary, the different emphasis on patents in standardisation is initially likely to result from the types of standards that prevail in an industry. This emphasis is then likely to perpetuate itself and become a part of the industries 'standardisation culture'.

7.3.2.3 'Group Dynamics' Resulting from the Collaboration in an Industry

The activities (both in terms of technology development and standardisation/regulation), which make up the cooperation in the industry, contribute to certain 'group dynamics'. In our case, we observed a strongly united industry with an 'us vs. them' mentality in its relations to other stakeholders. In other cases, these group dynamics may vary depending on the distribution of interests and contextual factors like the 'standardisation culture' (see Wiegmann et al., 2017). Our study suggests that such group dynamics affect the degree to which the innovators' activities are perceived as legitimate (see Botzem & Dobusch, 2012; Delemarle, 2017; Tamm Hallström & Boström, 2010) by other actors in the wider context. In particular, Botzem and Dobusch's (2012)

concept of standards' input legitimacy is likely to be strongly affected by the composition of an innovation's group of supporters and their activities. For example, in our case, the industry speaking with one voice signalled that mCHP was a genuine technological development for which changing standards and regulation was warranted, rather than a single company's attempt to get special treatment. However, this approach also carried the danger of being perceived as an industry that writes its own rules, similar to the European car industry in the wake of the Volkswagen Diesel scandal (see Neslen, 2015). Our study therefore suggests that the collaborative activities of an innovation's supporters have an important impact on the perceived legitimacy. Future research could compare different approaches and their effects in this regard, e.g. by involving more stakeholders (see Sect. 7.5).

7.3.3 Dynamics' Support for Aligning the Innovation with the Wider Context

In Sects. 6.4 and 7.1.1, we argued that standards fulfil an important function in aligning the innovation with the needs of relevant stakeholders in the technology's wider context. Arguably, the dynamics discussed in this chapter are core to standards fulfilling this function, because they end in the balance that stakeholders must reach for a standard to emerge (see Wiegmann et al., 2017). In that sense, the dynamic processes in standardisation and regulation that we observed are an important element of the wider sociotechnical transition needed to make an innovation successful. In such sociotechnical transitions, innovations either move out of the niches in which they emerge by reaching alignment with the sociotechnical system that are part of, or they fail eventually (e.g. Geels & Schot, 2007; Smith & Raven, 2012; Smith et al., 2010; van den Ende & Kemp, 1999).

By specifying clear technological requirements that result from the needs of other actors in the sociotechnical environment and the sociotechnical system (in our case, e.g. related to CO_2 emission targets, or the needs of other users of the electricity grid for grid stability), standards and regulation contribute to this alignment. This function explains the high stakes at play that lead to the dynamics that we observed. Simultaneously, we argue that standards would not be able to fulfil this function in support of sociotechnical transitions without these dynamics. A less dynamic process could most likely only be achieved if it failed

to take into account some of the diverse interests typically involved in sociotechnical transitions. The resulting standards would therefore not align the innovation with the needs of its wider context and miss important benefits for the innovation outlined in Sect. 7.1.

7.4 Managerial Implications

Our findings also have strong implications for managerial practice. In particular, we offer insights on three topics that are highly relevant for innovative companies: (1) We highlight important effects of standards (Sect. 7.4.1). (2) We show how innovators can successfully address standards and regulation (Sect. 7.4.2). (3) We identify impactful dynamics on the industry level and beyond, and show how they can be managed through cross-company collaboration (Sect. 7.4.3).

7.4.1 Important Effects of Standards

Standards can have major positive effects on innovation, such as supporting the technology's legitimacy, securing the links between complementary products, and facilitating proof of regulatory compliance. On the other hand, standards which are not in line with an innovation's needs can impose substantial hurdles, e.g. if standards lock the market into an old technology, or reflect vested interests that oppose the innovation. However, we find no support for the popular assumption that standards in general limit the freedom of innovation. Instead, the freedom for innovating depends on how well standards are managed and integrated in the innovation process (see Sects. 6.1.3 and 7.2).

In the European context, standards often are linked to regulation. This link further amplifies their effects on innovation. Harmonised standards, which are in line with an innovation's needs, can be used to show regulatory compliance and give innovators a high degree of legal certainty. On the other hand, innovators can face substantial costs and difficulties in proving regulatory compliance if harmonised standards are not in line with their innovation's needs. The required effort may sometimes even be prohibitively high, meaning that such standards can effectively lock an innovation out of the market.

The possible magnitude of standards' effects makes them a topic that innovation managers need to be aware of. Furthermore, they also mean that missing standards are an important factor causing uncertainty when

innovating. Fortunately, an innovation's developers can actively manage standards and their effects. Our study provides managers with useful insights into how this can be done effectively, as we outline in Chapter 6, Sects. 7.2 and 7.3.

7.4.2 Implications for Company-Internal Management

Our study shows successful approaches that companies can use to manage the effects of standards on their innovations. Within these approaches, we distinguish between the organisational foundation and the specific management activities.

In the long term, companies need to prepare themselves for dealing with standards and regulation. To do so, they should establish a solid organisational foundation that allows them to take a strategic approach to standards and regulation. Such a foundation is rooted in awareness, expertise, and financial resources. For large companies, this may mean establishing a department that is responsible for coordinating the topic. Small companies should aim to have at least some staff members with awareness and basic knowledge of standardisation and regulation. Such internally developed competences can be complemented by external experts (e.g. consultants, notified bodies). However, our study shows that relying on them too heavily may limit the company's freedom in innovating.

Such a foundation helps companies to carry out the activities needed to manage the topic: (1) identifying regulation and standards, (2) specifying the product, (3) assessing whether modifications in standards/regulation and/or the product design are needed, and, if necessary, (4) engaging in standardisation. Because firms operate in a dynamic environment, these activities need to be carried out concurrently and throughout the NPD process. This means that companies should identify potentially relevant regulation and standards as early as possible and then continue scanning for potential changes or additional requirements that they missed at first. It also means that the NPD process should involve regular checks whether the design is capable of meeting all requirements. Doing so in parallel avoids both being blindsided by changes in standards and regulation and having to redo large parts of the innovation if certain requirements cannot be met.

A further key decision is whether companies limit themselves to applying standards and regulation to their innovations or whether they also

attempt to influence standardisation and the passing of new regulation. Companies that do not engage in such external activities still benefit from the results of others that do. However, our findings suggest that this engagement has benefits, which often may justify the necessary expenditure. Most importantly, companies that contribute to external standardisation and regulation processes have an opportunity to participate in shaping the balance of interests enshrined in standards in their favour (see Sect. 7.3). This may substantially increase the company's freedom innovating.

7.4.3 Implications for Cross-Company Collaboration

Our study shows that these company-external processes are likely to be highly dynamic. These dynamics result from a potentially large number of stakeholders with conflicting interests, all of whom are likely to attempt influencing standards and regulation in their favour. Our study shows that even innovations like mCHP, which are relatively simple and small innovations,[3] can have substantial links to the wider context and affect many parties' interests. In addition to stakeholders from innovators' own industries, these stakeholders therefore often include actors from the wider context (e.g. regulators, developers of other technologies, NGOs).

Few companies (if any) are likely to be strong enough to be able to shift standards on their own under these conditions. Cooperation in developing both the technology and relevant standards is therefore at the core of influencing external standardisation and regulation. Consequently, innovative companies need to find partners who can complement their own strengths. This cooperation fulfils multiple functions, such as aligning industry actors to pursue a common line in standardisation, and legitimising the technology in the eyes of outsiders.

Reaching these goals can be supported by an industry structure that enables effective collaboration. We identify three elements of the industry structure that are important in this context: (1) a network of supporting institutions (e.g. industry associations, consultants, research institutions), (2) an approach to IPR that facilitates cooperation, and (3) broad support for the innovation among firms in the industry. These

[3] Compared to large-scale systems like autonomous driving and Smart Cities.

three elements can support collaboration in many ways. For example, they can help resolve conflicts (or even prevent them from occurring), unlock additional sources of helpful expertise, and provide access to regulators. Companies and other actors in an industry are therefore advised to build these elements in time, so that they are available when needed.

We also show that basing industry-level collaboration on this support structure helps innovators to assert themselves in dealing with the complex dynamics of their industry's wider context, as the following three examples show. (1) Industry associations can help unite the industry behind an innovation, giving it a stronger voice when dealing with other stakeholders. (2) Involving other supporting actors, who have no direct commercial interest in the technology (e.g. researchers), can help the innovation's legitimacy and credibility. (3) Using suitable approaches to IPR in standardisation may make it more acceptable to link the resulting standards to regulation.

This also makes our findings important for actors other than companies. Especially industry associations can assume an important role in coordinating the collaboration between their members. For example, they can offer forums for industry to find a common position to pursue in standardisation committees and vis-à-vis regulators. They can also represent industry when dealing with external stakeholders on aspects that are not central to the innovation, but nevertheless need to be considered.

7.5 Limitations and Scope for Further Research

Our detailed grounded theory study provides novel insights into the management of standards as an example of the external requirements, which innovative companies face. First, this raises the question under which conditions our theory is likely to apply (Sect. 7.5.1). Furthermore, the results raise intriguing questions for future research (Sect. 7.5.2).

7.5.1 Generalising Our Theory

Our theory is based on a single nested case. This means that the company-level findings have undergone an initial replication (see Eisenhardt, 1989; Yin, 2009) whereas the industry-level elements of our theory are derived from a single observation. Nevertheless, we expect that similar observations can be made in other cases which share several key characteristics, which likely determined parts of what we witnessed with

our case. These key features of the case are (1) its European scope (due to the relationships of standards and regulation under the 'New Approach'); (2) the highly regulated nature of the industry on aspects like product safety which contributed to the particular importance of standards in the case; (3) the relationship with policy issues (energy and environmental policy in our case); and (4) the relative long-term outlook of the key players in the case which contributes to the industry's culture of collaboration. Other areas where we expect that cases with similar characteristics to exist include, e.g. the European medical and aerospace sectors. In addition to the factors outlined above, the 'self-evident' support for standards in our case most likely makes it a 'best practice case'. Future research therefore needs to confirm the extent to which our findings apply to both similar and other contexts, which do not share the four characteristics identified above. It also needs to establish the extent to which not following the practices identified in our case affects innovation.

7.5.2 Questions for Future Research

Many of our study's new insights raise questions that could lead to exciting new research. Some of them question findings in previous standardisation literature, whereas others point to links with other streams of literature that have not yet been explored extensively.

One issue that raises questions for future research is IPR's relatively low importance for standardisation in the heating sector (see Sect. 5.1.4). This raises doubts about the standardisation literature's emphasis on IPR. This emphasis may be related to the literature's empirical evidence largely coming from the ICT sector (see Wiegmann et al., 2017). Future research in other settings could establish whether our case is an anomaly and IPR is indeed as important for standardisation as the literature claims, or whether this only applies to ICT contexts. In doing so, such research should also consider factors like the type of standard at stake and the 'standardisation culture' that we identify as potentially important for the role of IPR in standardisation (see Sect. 7.3.2).

The most intriguing questions for future research relate to the link between standardisation and the wider context. Previous literature on the co-evolution between standards and innovation (e.g. Blind & Gauch, 2009; Featherston et al., 2016; Ho & O'Sullivan, 2017) does not emphasise this link and mostly focuses on the industry. Consequently,

the significance of this link was a surprising finding, which we did not anticipate when planning our study. Our theory identifies two important patterns related to this link (diverse types of interests and strategies for dealing with them, see Sect. 6.3), which were consistently addressed across interviews. However, in line with our research question's focus on innovators' management, we did not interview actors in the wider context. This means that more than the two prominent patterns, which we already identify, may exist in this link, e.g. related to impacts on large societal trends. Future in-depth research, which builds on this contribution, is needed therefore to completely uncover the connection between innovation, standards, and the wider context.

This research would potentially contribute to streams of literature beyond standardisation: Related to sociotechnical systems theories (e.g. Geels, 2004; Geels & Schot, 2007; Smith & Raven, 2012; Smith et al., 2010), the research could potentially offer new insights into how transitions occur and how they are supported by standards. In that context, research on the link between standards and the wider context could also contribute to theories on the needs of rules underlying markets (e.g. Fligstein & McAdam, 2012; Polanyi, 2001) and on regulatory uncertainty (e.g. Engau & Hoffmann, 2011a, 2011b).

Potentially, such research could build on the emerging literature that links co-opetition to standards (e.g. Allamano-Kessler, Mione, & Larroque, 2016; Benmeziane & Mione, 2016; Foukaki, 2017). As we argue in Sect. 7.3, co-opetitive approaches are likely to have a substantial effect on how the legitimacy of both an innovation and the applicable regulation and standards are perceived by stakeholders in the wider context. Future research could take this finding as a basis, for example to identify whether specific co-opetition patterns are particularly conducive to building legitimacy.

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