



ELSEVIER

Contents lists available at ScienceDirect

Technovation

journal homepage: www.elsevier.com/locate/technovation

Motives to standardize: Empirical evidence from Germany



Knut Blind^{a,b,c,*}, Axel Mangelsdorf^{a,d}

^a Technische Universität Berlin, Chair of Innovation Economics, Germany

^b Fraunhofer Institute of Open Communications Systems, Germany

^c Rotterdam School of Management, Chair of Standardization, The Netherlands

^d BAM Federal Institute for Materials Research and Testing, Germany

ARTICLE INFO

Article history:

Received 29 September 2014

Received in revised form

9 December 2015

Accepted 3 January 2016

Available online 13 January 2016

Keywords:

Standardization

Strategic alliances

Knowledge spillovers

Market access

Regulation

Innovation

R&D

Factor analysis

ABSTRACT

In this paper, we identify the strategic motives of German manufacturing companies in the electrical engineering and machinery industry to be involved in standards development organizations. First, we present the general motives for the formation of strategic alliances and relate them to specific standardization motives. Then, we identify pursuing specific company interests, solving technical problems, knowledge seeking, influencing regulation, and facilitating market access as motives to standardize by means of factor analysis. In a second step, we test hypotheses on the relationship between the importance of strategic motives and firm level variables, e.g. R&D intensity, innovation activities, and firm size. The results reveal that firms in electric engineering and machinery have a particularly strong interest in ensuring industry-friendly design of regulations, which can be achieved by standards. Moreover, the results confirm that small firms also from these two sectors are active in standardization alliances to access knowledge from other involved stakeholders.

© 2016 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Firms' involvement in standards setting alliances is attracting increasing attention within industry, among policy makers and researchers (Choi et al., 2011; European Commission, 2008). A firm participating in standards development organizations (SDOs) can increase its competitiveness by actively influencing standards towards its own preferred specializations or by passively gaining knowledge from the standardization process (e.g. Sherif, 2015). Our analysis identifies firms' specific strategic motives related to their involvement in standardization committees and their relation to companies' characteristics.

For policymakers, standards – the results of the standardization process – play an important role in internalizing externalities and achieving international trade liberalization. In the European Union (EU), the introduction of the 'New Approach' to technical harmonization aims to establish a European Single Market by prescribing essential health and safety requirements in harmonized standards. At the global level, international standards gain importance through Agreement on Technical Barriers to Trade of the World Trade Organization (WTO) (Büthe and Mattli, 2011; Mattli, 2001; Sykes, 1999).

Given the fundamental impact of standardization on growth (Blind and Jungmittag, 2008), policymakers in industrialized and newly-industrialized countries recognize the importance of standardization for the competitiveness of their economies. Within the last decade, Canada, China, Germany, Japan, Russia, the UK, and the USA have implemented national standardization strategies (Hemphill, 2009; Limin et al., 2005). However, considering that standards are mainly set by private actors, surprisingly little is known about *firm-specific motives* towards their involvement in standardization. Existing literature on firm strategies in standards setting is limited to firms in industry consortia in the information and telecommunication sector (Chiesa et al., 2002; David and Steinmueller, 1994; DeLacey et al., 2006; Greenstein and Stango, 2007; Grotne, 2008; Ranganathan and Rosenkopf, 2014), on factors influencing standards battles (Shapiro and Varian, 1999), or dominant designs (Suarez, 2004), e.g., in the case of computer workstations (see e.g., Khazam and Mowery, 1994). Examples of a standards battle in SDOs is ODF vs OOXML within ISO (Blind, 2011). However, battles between de facto standards are more common, like VHS vs. Betamax (Cusumano et al., 1992 or Gallagher and Park, 2002), or Sony's Blu-ray vs. Toshiba's HD-DVD in blue laser DVDs (e.g., Gallagher, 2012). Only one recent case study attempts to capture firms' different motives to standardize in formal standards setting (Riillo, 2013). To this end, this paper is a first attempt to derive an empirically-based taxonomy of firms' motives in standardization alliances organized by officially-accredited

* Correspondence to: Technische Universität Berlin, Faculty of Economics and Management, MAR 2-5, Marchstraße 23, D-10587 Berlin, Germany.

E-mail address: Knut.Blind@TU-Berlin.de (K. Blind).

URL: <http://www.inno.tu-berlin.de> (K. Blind).

formal SDOs. We base our contribution on survey data collected among German firms in the electrical engineering and machinery industry that participate in national, regional (European) or international standards setting processes in formal SDOs. In contrast to other manufacturing sectors, like the chemical industry, or services sectors (Wakke et al., 2015), these companies are much more active in formal SDOs (Blind and Mangelsdorf, 2013) and have therefore developed more sophisticated strategies. The focus of our paper is on the formal standardization process as opposed to de facto standardization.

Whereas de facto standards emerge naturally through market processes, formal standards arise out of voluntary open and transparent, consensus based standardization processes of interested parties organized by SDOs. Formal standards therefore have greater legitimacy, especially in Europe, and are often of a higher quality (Belleflamme, 2002; Leiponen, 2008). Consensus-based standards represent coordination within an industrial segment (Rysman and Simcoe, 2008), despite occasional standard was even their occurrences are less likely that in the case in de facto standards (e.g., Gallagher, 2007; Schilling, 2002; Shapiro and Varian, 1999; Shurmer and Swann, 1995; Suarez, 2004). Moreover, formal SDOs in Europe – as opposed to rather informal consortia – are characterized by government recognition. In the EU, formal European and national SDOs are recognized by Directive 98/34/EC. Concurrently, the WTO Agreement on Technical Barriers to trade requires member states to establish ‘enquire points’ for information requests regarding technical regulations, standards, and conformity assessment procedures (WTO, 1995). This means that formal standards become legal requirements when governments mandate the development of technical specifications to standardization alliances organized by formal SDOs (Tassey, 2000).

With the exception of Axelrod et al. (1995) and Riillo (2013), who focus on the role of company size, and Van de Kaa and De Bruijn (2015), who identify the incentives for consensus building, companies' strategic motives to participate in standardization have yet not been comprehensively investigated, nor empirically validated. Consequently, the aim of this paper is twofold. First, we seek to derive a parsimonious set of motives for firms to participate in standardization alliances based on the large body of literature on strategic alliances. Second, we conduct a study on the explanatory factors for these motives by focusing on company specific variables including R&D intensity, innovation related activities, and company size.

The remainder of this paper is organized as follows. The second, subsequent section gives an overview of the literature, where we define the basic terms used throughout the paper and link general motives of alliance formation to specific standardization motives. In the same section, we formulate hypotheses about the relationship between companies' characteristics and standardization motives. In the third section, we provide descriptive statistics of our company sample and show the importance of various standardization motives. Next, we reduce the set of standardization motives with the help of factor analysis in order to derive a typology. The resulting factors are then explained in multivariate ordinary least squares (OLS) models, which help us to reveal the relevance of company specific characteristics for specific motives. In the last section, we show how our research contributes to the literature, summarize our results and derive a set of implications and recommendations for standardization management and policy.

2. Literature overview and hypotheses

In this section, we first define basic terms used in the paper. Then, we give general definitions of strategic alliances and show why standardization committees are a specific type of strategic

alliance. We employ a literature survey where we combine the two streams of literature, i.e., the review the literature on motives to form strategic alliances (the general issue) and link them to standardization motives (the specific issue). The resulting list of motives to participate in standardization alliances is tested in our empirical analysis in the following sections. Finally, we develop some general hypotheses regarding the relationship between company characteristics and the importance of standardization motives in an area missing both a comprehensive theoretical framework and empirical investigations in Section 2.2.

2.1. Strategic alliances and standardization alliances organized by SDOs

2.1.1. Definitions

Strategic alliances are defined as ‘inter-firm collaboration over a given economic space and time for attainment of mutually defined goals’ (Glaister and Buckley, 1996). They can be classified according to geographical (i.e., national versus international) and industry scope (i.e., intra- versus inter-industry) and to functional areas. The functional areas encompass several activities in the economic value chain, i.e. from joint R&D and technology development to manufacturing alliances and marketing (Varadarajan and Cunningham, 1995). The alliance governance literature has identified strategic alliances as opportunities for interfirm knowledge transfer (Kogut, 1988; Hamel, 1991; Doz, 1996). Learning from external sources has become a central factor for business success: successful transformation of information enables firms to exploit external knowledge internally for new product development (Cohen and Levinthal, 1990; Zahra and George, 2002). Successful knowledge acquisition from alliances is positively related to firm performance and innovation (Van Wijk et al., 2008).

The following three characteristics are conditions for inter-firm collaborations to be considered as strategic alliances: (1) the partner firms remain independent after the formation; (2) the partner firms share benefits and control over the performance of assigned tasks; and (3) the partner firms continuously contribute to the mutually-defined strategic areas (Yoshino and Rangone, 1995). Standardization alliances qualify as strategic alliances (Blind and Mangelsdorf, 2013), because they satisfy these three conditions. Based on a consensus decision making process in committees, participating firms share control and benefits of the content of the specifications. Finally, standardization – defined by De Vries et al. (2003) as the development or revision of a standard or a cluster of related standards – involves a continuing contribution by participants, especially in the form of technical expertise.

Although standardization is considered as a form of strategic alliance organized by formal SDOs, they feature specific elements compared to other alliances and industry consortia. First, standardization alliances organized by SDOs are characterized by heterogeneity of participants. Beside firms, consumer organizations and government take sometimes the opportunity to get involved in standardization (De Vries and Slob, 2006). Second, outcomes of standardization alliances – the technical specifications (standards) – have public good characteristics that may lead to free riding behavior and non-participation in standards setting alliances (Cabral and Salant, 2014). However, incentives for participation exist because engagement in standardization can generate private benefits in the form of knowledge spillovers and reduced costs related to the implementation of the produced standards (Blind, 2004). Third, SDOs follow a variety of different rules (Chiao et al., 2007) that influence the degree of openness, the level of consensus and the treatment of intellectual property rights in the standards developed. In general, formal SDOs provide a *neutral* platform – neutral in the sense that the SDOs do not influence the standards setting process itself.

2.1.2. Motives for alliance formation

The literature on strategic alliances suggests that companies have a number of different motives for alliances (Kogut, 1988). The motives range from (1) decreasing market uncertainty; (2) knowledge acquisition; (3) access to markets; and (4) conformance with government policies (Kogut, 1988; Bai, O'Brien, 2008; Beeby and Booth, 2000; Buckley et al., 2009; Deeds and Hill, 1996; Frankel and Schmitz-Whipple, 1996; Glaister and Buckley, 1996; Grant and Baden-Fuller, 2004; Hagedoorn, 1993; Varadarajan and Cunningham 1995). In the remainder of this section, we discuss these general motives and relate them to specific motives in standardization alliances.

2.1.2.1. Decreasing technological and market risks. Alliances allow risk sharing among participating firms. Within alliances, firms can spread the risk of large projects over more than one firm, enabling technology or product diversification and consequently the reduction of technological and market risks (Glaister and Buckley, 1996; Hagedoorn, 1993; Varadarajan and Cunningham, 1995).

Companies participating in standardization alliances can avoid – or at least reduce – technology related risks and can reduce market uncertainty (Swann, 2000). The risk associated with R&D investments, e.g., failure and unexpectedly higher costs, is reduced when firms actively influence the content of the standard in order to shape technological trajectories. Consequently, firms in standard setting have the incentive to enforce company specific content, i.e., technologies, in standards and prevent incompatible or conflicting standards which could lead to sunk investment costs (Besen and Farrell, 1994; Katz and Shapiro, 1994). Especially, firms are keen to join alliances in standards setting that consists of many firms in order to increase the probability that the own technology becomes a dominant standard (Axelrod et al., 1995) or to win a standards battle (Gomes-Casseres, 1994; Vanhaverbeke and Noorderhaven, 2001).

2.1.2.2. Knowledge acquisition. Strategic alliances are means of transferring and exchanging knowledge among firms (Kogut, 1988; Hamel, 1991; Buckley et al., 2009; Grant and Baden-Fuller, 2004). Knowledge transfer in alliances requires that knowledge needs to be disclosed by one party and absorbed in the partner firms (Easterby-Smith et al., 2008). Alliance partners benefit from knowledge spillover effects, where knowledge obtained from can be used by recipient firms to enhance their own innovation performance (Sampson, 2005) and competitive advantage (Lavie, 2006).

In the paradigm of the resource-based view of the firm, a firm's resources become the center of its strategy in order to achieve a sustainable competitive advantage (Barney 1991). As argued by Eisenhardt and Schoonhoven (1996), also external resources, in form of alliances, can be used to integrate resources external to the firm. Alliances are therefore especially attractive for smaller firms that lack the resources to invest in R&D (Varadarajan and Cunningham, 1995). Narayanan and Chen (2012) identify knowledge acquisition as one of companies' motives to join SDOs. Through the standardization process, companies can complement their own R&D with access to the technological developments of other firms and benefiting from unintended knowledge spillovers (Blind, 2006). Moreover, the participation of research institutes and universities in standard setting leads to the integration of up-to-date scientific and technological knowledge in the standards' specification (Blind and Gauch, 2009). They can represent industry specific problems, but also problems at the company level. Similarly, Hawkings (1999) identifies standardization consortia as a strategy for companies to pool their knowledge.

Participation in strategic alliances allows firms to access other firms' technological know-how, which reduces the time to

develop new products and the time to introduce them to market (Delcamp and Leiponen, 2014). Thus, firms have an incentive to participate in strategic alliances in order to exploit first mover advantages (Ranganathan and Rosenkopf, 2014) and capture significant market shares (Deeds and Hill, 1996).

In standardization, participating companies benefit vis-à-vis non-participants because they enjoy earlier knowledge of technical and regulatory specifications. This first-mover advantage leads to shorter time to market or to adjust products being already in the market and thus to a competitive advantage compared to latecomers (Egan, 1998).

2.1.2.3. Access to markets. In the literature, access to markets is a further motive to join strategic alliances (Beeby and Booth, 2000). For instance, alliances facilitate entry to foreign markets. Firms that lack international experience are especially those that join strategic alliances, for international expansion of their activities (Glaister and Buckley, 1996).

As for standard-setting alliances, firms especially active in network industries, like telecommunication and transportation, but also computer software and hardware, achieve market access by setting compatibility standards. Achieving compatibility with producers of complementary products allows firms to access markets of network goods and services (David and Steinmueller, 1994) and to improve their innovation performance (Soh, 2010). Standardization also enables new markets to emerge by setting anticipatory standards. They define interfaces to expected interoperability requirements in new network industries prior to the existence of markets. The UMTS (Universal Mobile Telecommunications Service) is an example for an anticipatory standard (Egyedi and Sherif, 2008).

Market acceptance by consumers is related to market access. It is facilitated through the involvement of multiple stakeholders in standardization, i.e. the involvement of consumer organizations and occupational safety organizations facilitate market acceptance of standardized products by consumers (De Vries and Slob, 2006).

2.1.2.4. Conformity to governmental policies. The market access is often linked to the conformity to governmental policies. For instance, in international strategic alliances firms can conform more easily to local government policies through local partners (Glaister and Buckley, 1996). Firms also use inter-firm collaborations to influence governmental regulations. For instance, Delmas and Montes-Sancho (2010) analyze voluntary environmental agreements between firms and regulators. In such agreements participating firms have strategic opportunities to influence the implementation of existing regulations and the content of future regulations. In addition, companies participating in standardization alliances organized by SDOs can also be perceived as "institutional entrepreneurs", whose output, i.e. standards, substitute for already established solutions. According to Hargrave and Van De Ven (2006), the institutional entrepreneur must also take into account the regulatory framework and related political processes. This interaction is supported by the case study of Backhouse et al. (2006), who identify the role of exogenous contingencies, especially government pressure, for the development of the first information security management standard.

Besides this reactive behavior, firms participating in formal standardization alliances are also actively involved in defining regulations. This is especially true for firms in Europe producing goods and services covered by New Approach Directives. The New Approach in the European Union delegates responsibilities for setting market rules to private institutions, i.e. European standardization organizations. Whereas 'essential requirements', e.g. protection of consumer health, are defined in European Directives, firms in European standards bodies are able to define technical

Table 1
Linking alliance formation motives to standardization motives.

Alliance formation motives	Standardization motives
<ul style="list-style-type: none"> ● Decreasing market uncertainty ● Knowledge transfer 	<ul style="list-style-type: none"> ● Enforce company specific content ● Prevent conflicting standards ● Benefit from unintended knowledge spillovers ● Keep track of other companies' technical knowledge ● Solve technical problems at industry level ● Solve technical problems at firm level ● Acquire competitive advantage through head start in knowledge
<ul style="list-style-type: none"> ● Access to markets 	<ul style="list-style-type: none"> ● Open up new markets ● Facilitate compatibility with other producers of complementary products
<ul style="list-style-type: none"> ● Conform to government policies 	<ul style="list-style-type: none"> ● Define technical specifications in regulations ● Reduce barriers to trade

specifications in 'harmonized standards' that meet the requirements of these New Approach Directives (Egan, 2002). Therefore, firms in a consensus based decision making process in formal standardization have incentives to define technical specifications that are favorable for themselves and the whole industry.

Moreover, standards can represent barriers to trade. Especially idiosyncratic national standards can raise compliance costs and discourage firms from exporting (Chen et al., 2006). Consequently, firms in standards-setting alliances also have the incentive to reduce technical barriers to trade in order to access foreign markets. Table 1 summarizes the relationship between the general alliance formation motives and the more particular standardization motives.

2.2. Hypotheses about the influence of companies characteristics on motives to standardize

Before we conduct the empirical analysis regarding firms' standardization motives in the third section, we derive a set of hypotheses about the relationship between the importance of standardization motives – i.e., the extent of strategic objectives – and companies characteristics'. Our hypotheses are based on the expected correlation between firm level characteristics and the general importance of strategic objectives in standardization alliances, but focus on specific standardization motives. Since there is only little conceptual and empirical literature about companies' motives to standardize, we assume a two-stage decision process. First, companies decide whether to join or not to join standardization committees. Meanwhile, we can rely on several studies about companies' characteristics, which drive their involvement in standardization. Consequently, we assume that these factors have also an influence on the various strategic motives within standardization.

Based on previous research (e.g., Blind, 2006; Blind and Mangelsdorf, 2013; Wakke et al., 2015), we know that with increasing R&D intensity up to a certain threshold, companies are more likely to join standardization. At first, companies with intensive R&D activities often face problems, which might be solvable in the context of standardization activities involving companies with similar challenges. In addition, these companies are keen to push their developed technologies into standards in order to avoid the dominance of competing technologies. Thirdly, R&D intensive firms have a particularly high incentive to act extremely carefully in standardization, since they face a significant risk of losing the results of their investment in R&D, when entering standardization activities. Moreover, a firm's ability to use external knowledge depends on its absorptive capacity (Cohen and Levinthal, 1989, 1990). Therefore, we particularly expect a positive correlation

between R&D intensity (as indicator for firms' absorptive capacity) and the standardization motive related to 'knowledge acquisition'. In summary, we derive the very general **Hypothesis 1**:

Hypothesis 1. Companies' R&D intensity has a positive influence on their assessment of strategic motives to standardize.

Similar to R&D, innovation is a driver for companies' engagement in standardization (e.g., Wakke et al., 2015) innovations that are new to the market – or market novelties – are introduced by a firm to a specific market for the first time. A market can represent a geographical area or a specific product line. The geographical area depends on the firm's own activities and can include the domestic market, European or international markets (OECD/Eurostat, 2005). Due to the "sunk costs" related to investments in innovation, a firm introducing market novelties has a strong incentive that standards correspond to-or at least do not conflict with - the firm's new product. We expect that firms producing market novelties have an incentive to ensure that newly-developed standards do not endanger the business success of these market novelties. This is especially important in the framework of the 'New Approach to Technical Harmonization' of the European Union, where compliance with mandatory European regulations is linked to compliance with voluntary European standards (Egan, 2002). Through the 'New Approach', standardization becomes an important element of the regulatory infrastructure (Blind, 2008). Therefore, we expect that – in addition to the importance of standardization in facilitating market access – the importance of motives related to 'government regulations' is positively linked to firms producing market novelties. However, in a similar fashion as for the first hypothesis, we derive a general **Hypothesis 2**:

Hypothesis 2. Companies with innovations new to the market have a stronger emphasis on strategic motives to standardize.

Based on theoretical considerations, e.g., the fix-cost effect connected with an investment in standardization and numerous empirical studies (e.g., Blind and Thumm, 2004; Blind, 2006; Blind and Mangelsdorf, 2013; Wakke et al., 2015), we know that larger companies are more likely to participate in standardization. Consequently, we also can expect a positive correlation between company size and the importance of standardization motives, because larger firms have more financial and human resources devoted to standardization and therefore a stronger bargaining position in standardization processes. As such, larger firms will translate the greater bargaining power into more explicit strategies.

As argued above, smaller companies face relatively higher costs compared to larger companies, when they participate in standardization. Therefore, they might try to enforce specific objectives, after they have decided to make this rather high investment. Consequently, the influence of the company size on specific standardization motives might be contradictory. In addition, alliances in general and standardization committees in particular are more attractive for smaller firms that lack the resources to invest in their own R&D and that aim to benefit from the knowledge disclosed during the standardization processes. Smaller firms become involved in standardization, because they get access to the often-required complementary resources. Therefore, the general company size-driven argument might be counterbalanced especially related to the 'knowledge acquisition' motive. Nevertheless, we derive the following third general hypothesis.

Hypothesis 3. Company size has, in general, a positive influence on company assessment of strategic motives to standardize.

In addition to the company size, empirical studies (e.g., Blind, 2006; Blind and Mangelsdorf, 2013; Wakke et al., 2015) reveal that

companies who export are more likely to join standardization. Since strategically-important standardization decisions – i.e., the development of standards related to market access – occur at the supranational level, defined as active participation of companies at the European or international level, we expect a positive correlation between supranational standardization activities and the motives to standardize in general, and in particular the use of standardization activities to facilitate market access and to penetrate international markets.

Hypothesis 4. Companies active in supranational standardization have a stronger emphasis of strategic motives to standardize.

The existence of a patent department reflects an understanding of the strategic value of patents (Blind et al., 2006). Likewise, a standardization unit is related positively to the strategic motives to standardize. Consequently, we argue in the same way related to positive influence of a standardization department on the strategic motives to standardize. We assume that firms with a separate standardization unit can bundle their in-house competencies and resources particularly related to technical regulations better than firms without such a unit. Based on confidential information about companies having a standardization unit, it becomes obvious that most of them have a broader focus on technical regulations as such. Consequently, we expect firms with standardization units to act more strategically related to influencing governmental regulations. However, links to other departments, e.g., R&D, could also be better exploited in enforcing their standardization strategies:

Hypothesis 5. Companies with a standardization unit place a stronger emphasis on strategic motives to standardize.

Finally, the competitive environment has a mixed influence on companies' likelihood to join standardization and, consequently, on their motives to standardize. On the one hand, the higher the competition a company faces, the more standardization can help to reduce its technological and market risks. On the other hand, standardization might endanger a company's competitive advantage if a competitor's solution is preferred or too much proprietary information is revealed during the standardization without adequate compensation. However, we expect that a high competition correlates positively with the motive 'knowledge acquisition', because firms in highly competitive markets are forced to become more innovative also via relying on external know-how (see literature on Open Innovation, e.g., Chesbrough, 2003; Laursen and Salter, 2006). Finally, companies acting in a very competitive environment might use their influence on the regulatory framework, especially relevant for competition, to reduce the competitive pressure. By building market barriers via developing competitors' cost raising standards, (Salop and Scheffman 1987) companies can reduce the competitive pressure. Consequently, we derive the following hypothesis:

Hypothesis 6. Companies' competitive environments have an influence on their assessment of strategic motives to standardize.

3. Methodology and empirical results

3.1. Methodology

To empirically test the hypotheses developed in the last section, we perform a two-step procedure. In a first step, we rank the importance of standardization motives that we obtain from our company survey. With the help of an exploratory factor analysis, we condense the reasons for involvement into a smaller number of central standardization motives. In a second step, we analyze the relationship between the standardization motives derived from the factor analysis and firm level variables using multivariate OLS

analysis. From a methodological point of view, we use the same approach as in the paper on motives to patent (Blind et al., 2006).

3.2. The sample

Before we present our typology of standardization motives derived from the literature review, we describe the data used in our analysis. We base our analysis on firm level data obtained from a 2008 survey of German manufacturing companies in the electrical engineering and machinery industry. A questionnaire was designed in cooperation with representatives from two industry associations (VDMA – the German Engineering Federation – and ZVEI – the German Electrical and Electronic Manufacturers' Association). These two associations cover the majority of the companies in their respective sectors, and as such our sample can be regarded as representative.

In total, 375 companies answered the questionnaire, providing a response rate of 9.38%. Thirty-eight percent of this sample are small and medium-sized companies (SMEs) according the definition of the EU. The remaining 62% have more than 250 employees. The machinery industry accounts for 156 companies and the electrical engineering industry for 169. The remaining 26 firms represent the overlap between these two sectors, as some firms are active in both the electrical and the machinery industry.

Seventy-one percent indicated to have participated in formal standard setting processes (see Blind and Mangelsdorf (2013) for further information). At the national level, 66% were involved in the German Institute for Standardization or German Commission for Electrical, Electronic & Information Technologies of DIN and VDE. European or international standardization participation represents 48% and 43% of the companies, respectively. In the empirical part of our paper, we only use the answers of the companies that actively participated in standardization.

3.3. Motives to standardize

Standardization motives were derived from the large body of literature about the motives for alliance formation summarized in the literature review and complemented by the very few sources focusing explicitly on motives of companies to participate in standardization (e.g., Meeus et al., 2002; Blind, 2006). After several meetings with representatives of VDMA and ZVEI, and the performance of pilot tests including interviews with a few companies being members of these industry associations, twelve company specific motives to standardize have been included eventually in the survey (see Table A2 in the Annex), reflecting industry-specific considerations, the perception of company representatives active in standardization and total length of the questionnaire. The respondents were asked to rank the importance of each motive on a five-point Likert scale. Table 2 presents the results.

The most important motive is to design industry-friendly requirements of regulations through influencing underlying standards, i.e. companies ensure that standards, which often specify the technical content of regulations or which implementation is presumed to assure conformity with regulatory requirements in general, are efficiently to implement. The second important motive is to enforce company-specific content in standards. Moreover, the motives related to knowledge exchange, i.e., to achieve a head start in knowledge, to acquire knowledge in undocumented discussions in committees, and to keep track of other companies' technical knowledge are evaluated as being important, but less than regulation-related motives.

3.3.1. Factor analysis

We condense the twelve motives to standardize, which have been developed by applying the motives to form alliances to the

Table 2
Importance of standardization motives in formal standardization.

Standardization motive	Rank	Mean	SD
Design industry friendly regulations	1	1.18	0.95
Enforce own content	2	0.82	0.85
Prevent formal standards that conflict with own interests	3	0.79	1.06
Solve industry specific technical problem	4	0.77	1.08
Acquire competitive advantage through head start in knowledge	5	0.70	1.09
Prevent or anticipate regulation	6	0.64	1.10
Acquire knowledge in undocumented discussions in committees	7	0.59	1.10
Reduce barriers to trade actively	8	0.55	1.09
Open up of new markets through formal standardization	9	0.54	1.03
Facilitate compatibility with producers of complementary products	10	0.49	1.16
Keep track of other firms' technical knowledge	11	0.35	1.02
Solve company specific technical problems	12	−0.06	1.14

The mean is the average on a scale of −2 (=low importance) to +2 (=high importance)

SD=standard deviation

Number of observations=268

specific form of standardization alliances (see Table 1) to a smaller number of central objectives to becoming involved in standardization. We use exploratory factor analysis to identify unobserved underlying factor structures. Exploratory factor analysis is a statistical technique used in social science to identify a relatively small number of factors that can be used to represent relationships among sets of many interrelated variables. In terms of mathematical statistics, factor analysis is a method which tries to find few 'latent' variables among many, not linearly independent ones. A result, factor analysis shows if there are any latent variables, and if so how many such latent variables (factors) exist and to what extent these explain the variances between the cases (respondents). Doing so revealed five factors which explain 68% of the total variance as displayed in Table 3. Based on the literature review, we define the following motives: Decreasing technological and market risks; knowledge acquisition; market access; and conformity to governmental policies. In this context, we now discuss and interpret the resulting factors.

3.3.1.1. Factor 1: "Knowledge Seeking". The first factor has high factor loadings with the following motives: acquire knowledge in undocumented discussions in committees, acquire competitive advantage through a head start in knowledge, and keep track of other companies' technical knowledge. We interpret this factor as an opportunity for participants to benefit from the knowledge of other firms disclosed within standardization committees' discussions. This concerns both intended and unintended knowledge

spillovers. The former means that firms acquire advanced knowledge exclusively disclosed and required for standardization work, which is not available to non-participants. The latter relates to the knowledge from committee discussions that may reveal technological know-how of other participating firms, which is either not necessary for the progress of standardization or not planned to be used outside the core purpose of standardization.

3.3.1.2. Factor 2: "Market Access". The second factor has high factor loadings with the following three motives: opening up of new markets through formal standardization, actively reducing barriers to trade, and facilitating compatibility with producers of complementary products. This factor is related to the possibility to access markets both related to specific product and international markets. On the one hand, standards help to achieve compatibility with other products and components, becoming increasingly important in complex systems technologies. On the other hand, they are able to reduce barriers to trade in international markets.

3.3.1.3. Factor 3: "Technical Solution". This factor corresponds with high factor loadings with the motives: solve company-specific technical problems and solve industry specific technical problems. This factor represents the benefits resulting from synergies of expert knowledge in standardization alliances. In other words, technical committee meetings are held to discuss technical problems and find solutions in line with the interests of the involved stakeholders.

3.3.1.4. Factor 4: "Regulation". The fourth factor has high factor loadings with design industry-friendly requirements of regulations via standards including preventing and anticipating regulation. Therefore, this factor is clearly related to the function of achieving flexible regulatory framework conditions via standardization.

3.3.1.5. Factor 5: "Company Interests". The fifth factor has high and positive factor loadings based on the following two motives: enforce own content and prevent formal standards that conflict with own interests. The first factor therefore represents a rather generic or horizontal motivation insofar as technical experts in committees act on behalf of the company they work for and promote the company's interests in all of the aforementioned issues.

In summary, we argue that the five factors revealed by the factor analysis correspond well to the factors derived from the literature in the previous section. On the one hand, they represent the general motives to joining formal alliances presented in Table 1. The factor 'decreasing market uncertainty' in the general alliance formation motive corresponds with 'company interests' in standardization. 'Knowledge acquisition' and 'first move

Table 3
Exploratory factor analysis.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Enforce own content	−0.0176	0.0571	0.0548	−0.0521	0.8753
Prevent formal standards that conflict with own interests	0.1663	−0.1952	−0.0945	0.3614	0.6038
Solve company specific technical problem	0.0358	0.0479	0.8500	−0.0727	0.1347
Solve industry specific technical problem	0.0589	0.1967	0.7656	0.2041	−0.1542
Acquire knowledge in undocumented discussions in committees	0.8796	−0.0125	0.0088	−0.0413	−0.0217
Acquire competitive advantage through head start in knowledge	0.8271	0.1736	0.0396	0.1935	−0.0045
Keep track of other firms' technical knowledge	0.7063	0.1235	0.1885	0.0986	0.1497
Design industry friendly regulations	0.0867	0.244	0.0627	0.8179	−0.0715
Prevent or anticipate regulation	0.0794	−0.0724	0.0580	0.8097	0.1205
Open up new markets through formal standardization	0.3314	0.7102	0.1076	0.0316	0.0867
Reduce barriers to trade actively	−0.0015	0.7947	0.0924	0.2801	−0.0048
Facilitate compatibility with producers of complementary products	0.0592	0.7339	0.1893	−0.1375	−0.084

Notes: Factor analysis method: principal-component factors with orthogonal varimax rotation. Amount of variance explained: 0.68.

Table 4
Importance of standardization motives in formal standardization.

Standardization motive	Rank	Mean	SD
Factor 4 "Regulation"	1	0.91	0.87
Factor 5 "Company interests"	2	0.81	0.79
Factor 1 "Knowledge seeking"	3	0.55	0.96
Factor 2 "Market access"	4	0.53	0.86
Factor 3 "Technical solution"	5	0.35	0.95

Notes: The mean is the average on a scale of -2 (=low importance) to $+2$ (=high importance). SD=standard deviation. $n=268$.

advantage' correspond to the 'knowledge seeking' motive of firms in standards setting committees. 'Access to markets' in the general alliance formation motives is associated with 'market access' in standardization motives and 'conform to government policies' corresponds well with achieving flexible 'regulation', which allows easier compliance to regulation via standards setting in the context of the New Approach. On the other hand, 'technical solution' represents a specific technology-oriented standardization motive, as the original intention to standardize.

Table 4 presents the average importance of the motives from the factor analysis. The most important factors are 'regulation' and 'company interests', followed by 'knowledge seeking' and 'market access'. 'Technical solution' is evaluated as being important, but significantly less than the other four factors.

3.4. Driving factors for standardization motives

3.4.1. Empirical model

We complete our empirical investigation by examining the impact of firm level variables on the importance of standardization motives as describes in Section 2.2. The dependent and independent variables are shown in Table 5. Dependent variables are the condensed standardization motives that we obtained from the factor analysis and are shown in Table 3. Independent variables are R&D intensity (RD), the existence of market novelties (MN), company size (SIZE), participation in supranational standardization committees (SUP), the existence of a unit responsible for standardization (UNIT), and competition intensity (COM). The correlations between the independent variables are displayed in Table A1 in the Annex.

In our investigation to find factors explaining standardization motives, we assume linear relationships between the importance of standardization motives and the independent variables. Therefore, our five regression models are set up in the

following way:

$$\text{Factor}_i = \beta_0 + \beta_1 \cdot \text{RD} + \beta_2 \cdot \text{MN} + \beta_3 \cdot \text{SIZE} + \beta_4 \cdot \text{COM} + \beta_5 \cdot \text{SUP} + \beta_6 \cdot \text{UNIT} + \epsilon$$

$$i = 1.. 5$$

4. Results

The results of our multivariate OLS models are shown in Table 6. The five different models can explain the differing degrees of importance placed on standardization motives. The models explaining the knowledge seeking motive and regulation motive have the best fit, whereas the interest motive and technical solution motive have the lowest fit. Nevertheless, the results presented below allow an assessment of the hypotheses presented in Section 2.2, as well as the interpretation of the control variables.

First, R&D intensity has the positive sign expected, and is statistically significant in the knowledge seeking model and in the market access model, as proposed in the Hypothesis 1, whereas it has no influence in the other three models. We can confirm that R&D intensity has a positive impact on the knowledge seeking aspect, complemented by the fact that a firm's ability to use external knowledge from standardization alliances depends on its absorptive capacity. In addition, companies active in R&D are obviously also interested in facilitating te market access for the output of their R&D activities. However, standardization is not perceived as a strategy to solve technical problems related to companies' R&D activities.

Second, the relationship between producing market novelties and the importance of standardization motives (Hypothesis 2) is positive and statistically significant in the case of the regulation motive, but not related to the market access motive. The first finding confirms that highly innovative firms participate in standards setting alliances in order to influence the technical content of mandatory regulations, with the goal of facilitating the market introductions of their innovations. The missing relationship to the market access motive may have been covered already by the closed related R&D intensity, because companies with R&D activities generally perceive the regulatory framework conditions relevant for the intended technologies and products to be developed.

Regarding Hypothesis 3, our results show that company size is only significantly negatively correlated with the importance of importance of the knowledge seeking motive. Our regression results suggest that the importance of knowledge exchange decreases with firm size. Obviously, smaller firms with a small resource base-which also includes resources to innovate-use

Table 5
Description and means of model variables.

Model variable	Indicator	Means (SD)
Dependent variables		
Factor_1 Company interests	Average importance of company interest motive (-2 =low importance; $+2$ =high importance)	0.81 (0.79)
Factor_2 Technical solution	Average importance of technical solution motive (-2 =low importance; $+2$ =high importance)	0.35 (0.95)
Factor_3 Knowledge seeking	Average importance knowledge seeking motive (-2 =low importance; $+2$ =high importance)	0.55 (0.96)
Factor_4 Regulation	Average importance regulation motive (-2 =low importance; $+2$ =high importance)	0.91 (0.87)
Factor_5 Market access	Average importance market access motive (-2 =low importance; $+2$ =high importance)	0.53 (0.86)
Independent variables		
RD R&D intensity	Expenditure on R&D divided by total turnover in 2007	3.99 (3.91)
MN Market novelties	1 if a firm produced market novelties between 2005 & 2007, 0 otherwise	0.67 (0.47)
SIZE Firm size	Logarithm of total turnover in 2007	4.85 (2.18)
COM Competition intensity	Average perceived competition intensity in domestic, European and international markets; -2 =very low; $+2$ =very high	1.28 (0.75)
SUP Supranational standardization activities	1 if a firm was only active in supranational standardization committees between 2005 & 2007, 0 otherwise	0.85 (0.35)
UNIT Standardization unit	1 if a firm has a unit responsible for standardization issues, 0 otherwise	0.50 (0.50)

Table 6
Results of multivariate OLS models.

Variable	Factor 1 Knowledge seeking	Factor 2 Market access	Factor 3 Technical solution	Factor 4 Regulation	Factor 5 Company interest
RD (R&D intensity)	0.0383** (2.20)	0.0284* (1.73)	−0.0117 (−0.64)	−0.00467 (−0.30)	0.00196 (0.14)
MN (Market novelties)	0.212 (1.40)	−0.0392 (−0.27)	−0.14 (−0.88)	0.242* (1.77)	0.129 (1.07)
SIZE (Total turnover)	−0.0810** (−2.50)	0.0197 (0.64)	−0.00534 (−0.16)	0.0211 (0.72)	−0.0132 (−0.51)
SUP (Supranational standardizing)	−0.035 (0.16)	0.362* (1.88)	0.240 (1.15)	0.263 (1.44)	0.348** (2.11)
UNIT (Standardization unit)	0.0309 (0.23)	0.102 (0.79)	−0.0198 (−0.14)	0.280** (2.28)	0.159 (1.47)
COM Competition intensity	0.228*** (2.65)	0.0136 (0.17)	−0.0295 (−0.32)	0.151* (1.93)	0.0813 (1.18)
Constant	0.964*** (3.68)	0.373 (1.51)	0.493* (1.78)	0.820*** (3.46)	0.978*** (4.69)
Observations	205	205	205	205	205
R-squared	0.095	0.046	0.013	0.091	0.053

t statistics in parentheses. A correlation matrix of the endogenous variables is provided in the Annex.

** $p < 0.05$.

* $p < 0.10$.

*** $p < 0.01$.

standardization alliances to access the knowledge of larger firms. Using a case study approach, Riillo (2013) confirms that small compared to larger firms participate in standardization in order to increase their technical knowledge base. However, our general expectations that company size is positively correlated with the assessment of standardization motives are not confirmed.

The dummy variable for focusing on national standardization activities is statistically significant in the market access model and in the company interest model. Obviously, firms participating at the supranational (European or international) standardization levels try to pursue their company interests and to gain access to markets more intensively compared to firms only active in national markets. Therefore, the result partly supports Hypothesis 4.

The dummy variable indicating whether a firm has a standardization unit shows the positive sign expected and is statistically significant in the regulation model. Firms with standardization units act more strategically regarding regulatory issues in standardization, obviously due to existing synergies between standardization and regulation. Hence, Hypothesis 5 is only confirmed related to the motive of influencing regulation.

Finally, the variable for perceived competition intensity has the expected positive sign and is statistically significant for the knowledge seeking and regulation model. We interpret this result one the one hand as a driver of (small) firms in highly competitive markets, seeking to increase their knowledge base by accessing the knowledge of partner firms and other stakeholders. On the other hand, firms in highly competitive markets are forced to create more explicit strategies in regulatory issues. Obviously, firms in highly competitive markets aim to influence regulatory constraints in order to reduce the competitive pressure. Consequently, Hypothesis 6 is partly confirmed.

5. Discussion

In summary, our research confirms that formal standardization qualifies as a form of a strategic alliance. We relate existing general motives to form strategic alliances to specific standardization motives and derive an empirically-based taxonomy of standardization motives by means of a factor analysis. The exploratory factor analysis reveals five broad clusters of motives to participate

in standardization alliances: 'knowledge seeking', 'market access', 'technical solution', 'regulation', and 'company interests'. The factors represent general motives for alliance formation, but also reveal that some motives to form strategic alliances can be grouped into more specific standardization motives.

The most important objective to participate in standardization is to define technical specifications in standards documents in order to prevent mandatory regulations. This motive is followed by the objective to ensure that company-specific interests are included in standards documents, which is supported by the recent work of Ranganathan and Rosenkopf (2014) about companies' voting behavior related to new standards proposals. The objectives connected to knowledge flows in standardization processes are ranked third. The latter cluster includes the ability to acquire knowledge from undocumented discussions in standardization committees which confirms Blind's (2006) notion that standardization processes themselves represent a channel for knowledge acquisition. The knowledge seeking motive is followed by the 'access to market' motive, which means the opportunity of firms to open up and establish new markets through standardization, to achieve compatibility with complementary products, and to reduce barriers to trade in international markets. Finally, our analysis reveals that firms participate in standardization in order to find technical solutions.

On the other hand, we develop a number of hypotheses regarding the relationship between firm level variables and the general importance of strategic standardization motives – i.e., the extent of strategic objectives in standardization committees – and test them in multivariate OLS regression models. The empirical results reveal the following new insights. A firm's ability to acquire knowledge from alliance partners depends on its absorptive capacity measured by its R&D intensity (Hypothesis 1). Moreover, we can confirm that very innovative firms – i.e., firms producing market novelties – have particularly high incentives to participate in standardization in order to ensure that standards promote the business success of their market novelties (Hypothesis 2). In contrast to our general expectation, we cannot confirm that larger companies assess standardization motives more important than smaller companies. Our results show that the correlation is significantly negative for the 'knowledge seeking' motive, and suggest that small firms aim to increase their knowledge base through

participating in standardization alliances (*Hypothesis 3*). Firms that participate in supranational standardization activities assess the motives related to market access and company interests more important than firms who are active at only at the national level (*Hypothesis 4*). This result confirms that strategically-important standardization decisions occur at the supranational level. The organizational setting, i.e., the existence of a standardization department, also plays a role in the assessment of standardization motives (*Hypothesis 5*). Our results show that firms with a standardization unit regard the regulation motive as significantly more important than firms without such a unit. Regarding the competitive environment of firms (*Hypothesis 6*), we find that firms in highly competitive markets put more emphasis on ‘knowledge seeking’ and ‘regulation’ motives. We interpret this finding as being a firms’ attempt to reduce the competition intensity by increasing their knowledge base or influencing regulatory requirements.

Our findings provide a number of contributions. First, we provide a first taxonomy of motives to standardize conceptually derived from the alliance formation literature and empirically confirmed on the basis of a factor analysis by relying on our company survey data. The factors reveal that the motive to standardize can be structured along a multidimensional framework not only including technological aspects, but also knowledge management, market access, competition and especially complementarities to the regulatory framework. The latter is a European specificity partially originated and intended by the New Approach. Consequently, we expand the findings by *Axelrod et al. (1995)* and *Riillo (2013)* both by adding further drivers for joining standardization alliances in addition to the size of the alliances and the competition with rivals and by generalizing their case study based-results by our quantitative approach based on a company survey.

Second, we investigate the relevance of drivers for participating in standardization for the five motives to standardize, which have already been identified and confirmed. In general, our empirical results reveal that a two-step-decision perspective is needed to adequately study the participation in standardization, i.e., company characteristics that influence the participation in standardization do not necessarily explain the relevance of all motives to standardize. Most prominent is the contradiction between the well-established positive link between company size and the likelihood to join standardization alliances, and our new finding that small companies involved in standardization identify the knowledge seeking motive as being significantly more important than larger companies. This finding differs from the existing studies especially in biotechnology (e.g., see *Ahora and Gambardella (1990)* and *Audretsch and Feldman (2003)*) regarding strategic alliances. They conclude that smaller companies are more interested in larger companies’ assets, e.g. production capacities or marketing channels, whereas larger companies seek to get access to the knowledge of smaller companies. There are at least two possible explanations for this divergence. On the one hand, the type of knowledge exchanged in strategic alliances is different than the information shared in standardization processes. In the latter, small companies are also interested in meeting their customers, i.e., getting access to their markets. On the other hand, strategic alliances are typically closed networks, whereas formal standardization processes are open to all interested parties. Consequently, larger companies do not get exclusive access to the knowledge of small companies. Overall, these reasons are able to explain the high relevance of the ‘knowledge seeking’ motive for smaller companies.

Since we find that influencing regulation via standardization is the most important motive, our paper is able to contribute to the theory of “regulatory capture” (*Laffont and Tirole, 1991*).

“Regulatory capture” deals with the situation when the regulator follows the interest of the regulated industry instead of public interest. According to the existing literature, possibilities to capture the regulator include outright bribes, campaign contributions to politicians, and future lucrative employment opportunities. Our paper shows that standardization is an additional channel through which companies try to influence regulations according to their interests which in some cases may contradict public interests. Avoiding such opportunities for “regulatory capture” requires, among others, well-balanced stakeholder representation in standardization committees that includes participation of consumer and environmental groups.

6. Concluding remarks

First, our findings have implications for theory. Due to the high relevance of influencing regulation via standardization, the channels of “regulatory capture” addressed in the existing literature have to be expanded. Whereas at first glance the additional option might be used for “regulatory capture”, it could also have an efficiency enhancing impact by reducing “regulatory capture” at all by challenging the other rather inefficient channels of “regulatory capture”. Consequently, our findings call for theoretical work about companies’ strategies related to the interaction of existing strategies of “regulatory capture” with standardization, but also about the overall welfare implications of this new channel. Eventually, these new theoretical findings have to be empirically tested, which represents a major challenge.

Finally, a set of implications for standardization management and policy can be derived from these new insights. First, standardization managers, who are often either embossed in technical or in legal environments, have to be aware of the multidimensional motives to standardize. Obviously, the pure technical aspects are of relatively minor importance. The high relevance of the motives related to regulation reveals that companies active in standardization are not only developing common specifications, but are also trying to influence the regulatory framework. The common interests inherent in engagement with formal SDOs must be considered with respect to individual interests of participating firms. Consequently, joining standardization means entering into a specific type of cooperation. Involvement in standardization is typically a long-term commitment indicative of a strong interest to cooperate, e.g., companies cooperating in standardization try to open up new markets by defining common standards, which either reduce barriers to trade or achieve compatibility with complementary products or systems. Still, competition occurs within the standardization process through the selection of specific technologies out of often numerous possible options, in which many participants may have a stake.

Second, significant knowledge flows are apparent within standardization processes, especially from larger to the smaller German companies opposite of that seen in other types of strategic alliances. SDOs are – as shown in *Sherif (2015)* for Chinese companies – interactive learning spaces. Consequently, companies’ knowledge management, including their open innovation strategies, must take these opportunities into account when considering entrance into standardization. Company size remains an important contingent factor.

Consequently, our results imply a challenge for the human resource management and organizational setting of a company (*Dokko and Rosenkopf, 2010*). The human resource management of a company has to ensure the adequate training for the staff participating in standardization committees. It is important because the results show that standardization activities are not entirely focused on technical questions, but much more on strategic

objectives like influencing the regulatory framework, facilitating market access and seeking external knowledge. Therefore, the staff involved in standardization activities, mostly engineers, should also be knowledgeable about existing and future regulatory framework conditions and also about the research, innovation and knowledge activities of their company. The multidimensional motives to participate in standardization require that standardization activities are embedded in an organizational setting that allows the cooperation between the R&D departments, innovation management and units responsible for regulatory affairs.

In addition, we conclude with some policy implications of our empirical findings. First, the multivariate OLS models reveal that small and R&D intensive companies active in standardization put more emphasis on knowledge seeking motives compared to companies with moderate R&D spending. As such, public policy should develop support schemes that enable companies with restricted R&D capacities to participate in standardization activities, as these companies will benefit from the knowledge transfer taking place within these discussions. This justification complements findings regarding the general lack of human and financial resources of SMEs to participate in standardization (e.g., [Blind and Gauch, 2009](#)), as further legitimation for public support. Second, the development of consensus standards is obviously closely connected to influencing the regulatory framework, such that both SDOs and regulatory authorities have to assure the openness and transparency of the standardization process in order to avoid disadvantaging companies that are not involved. Overall, companies' participation in standardization has to be fostered in order to exploit the knowledge pool of "insiders" more efficiently and to avoid the negative impacts on "outsiders".

Despite these contributions, our analysis has certain limitations. First, the database covers two sectors and does not allow general cross-sectoral conclusions; an extension to other sectors would be appropriate to generate a more comprehensive picture. In addition, our study focuses on companies' involvement in formal standardization organizations, rather than other standards development mechanisms such as consortia. This can be justified by the currently strong focus of the machinery and electro-technical industry on standardization alliances hosted by formal SDOs, and reliance on the formal standards they produce. Furthermore, the data covers Germany only. However, many German companies have a very long and explicit tradition in standardization, follow often specific standardization strategies and in general active not only at the national, but international standardization level together with companies from other countries. Consequently, we can expect an explicit strategy that is more in line with our conceptual argument in contrast to the passive (free-riding) behavior of companies in many other small European companies. Finally, our hypotheses about the driving forces have only been partially confirmed. In conclusion, the expansion to other sectors, countries and informal standardization consortia is a first step to explaining the relevance of the different strategic motives to standardize more comprehensively. Particularly, the high relevance of the "knowledge seeking" motive for small companies requires more in-depth investigation to ascertain the specific characteristics of knowledge exchanged in formal standardization processes and the influence of its openness on all interested parties.

Acknowledgments

We thank the representatives of the German industry associations VDMA and ZVEI for supporting the performance of the survey. Finally, comments from three anonymous reviewers helped to

improve the quality of our papers. However, all remaining shortcomings are, of course, solely our responsibility.

Appendix

See [Tables A1](#) and [A2](#).

Table A1
Correlation matrix of the independent variables.

	RD	MN	SIZE	COM	SUP	UNIT
RD	1.000 [0.000]					
MN	0.173 [0.006]	1.000 [0.000]				
SIZE	-0.074 [0.268]	0.213 [0.000]	1.000 [0.000]			
COM	-0.033 [0.620]	-0.017 [0.788]	0.110 [0.099]	1.000 [0.000]		
SUP	0.081 [0.206]	0.026 [0.661]	0.135 [0.034]	0.024 [0.703]	1.000 [0.000]	
UNIT	0.106 [0.096]	0.111 [0.069]	0.224 [0.000]	0.086 [0.181]	0.052 [0.388]	1.000 [0.000]

Notes: Table displays pairwise correlation coefficients. Significance levels in brackets.

Table A2
List of motives to standardize.

What corporate strategy does your company pursue when participating in standardization activities (-2=low importance; +2=high importance)?

1. Push proprietary matters
2. Solve company specific technical problem
3. Solve industry specific technical problem
4. Prevent standards that conflict with own interests
5. Acquire knowledge in undocumented discussions in the committees
6. Acquire competitive advantage through head start in knowledge
7. Keep track of other companies' technical knowledge
8. Industry friendly design of regulations
9. Prevent/anticipate regulation
10. Tapping new markets through standardization
11. Actively reduce barriers to trade
12. Facilitate compatibility with producers of complementary products
13. Other strategies: ...

References

- Arora, A., Gambardella, A., 1990. Complementarity and external linkages: the strategies of the large firms in biotechnology. *J. Ind. Econ.* 38 (4), 361–379.
- Audretsch, D.B., Feldman, M., 2003. Small-firm strategic research partnerships: the case of biotechnology. *Techn. Anal. Strateg. Manag.* 15 (2), 273–288.
- Axelrod, R., Mitchell, W., Thomas, R.E., Bennett, D.S., Bruderer, E., 1995. Coalition-formation in standard-setting alliances. *Manag. Sci.* 41 (9), 1493–1508.
- Backhouse, J., Hsu, C., Leiser, S., 2006. Circuits of power in creating de jure standards: shaping an international information systems security standard. *MIS Q.* 30, 413–438 (Special issue).
- Bai, Y., O'Brien, G.C., 2008. The strategic motives behind firm's engagement in co-operative research and development. A new explanation from four theoretical perspectives. *J. Model Manag.* 3 (2), 162–181.
- Beeby, M., Booth, C., 2000. Networks and inter-organizational learning: a critical review. *Learn. Organ.* 7 (2), 75–88.
- Belleflamme, P., 2002. Coordination on formal vs. de facto standards: a dynamic approach. *Eur. J. Political Econ.* 18, 153–176.
- Besen, S.M., Farrell, J., 1994. Choosing how to compete-strategies and tactics in standardization. *J. Econ. Perspect.* 8 (2), 117–131.
- Blind, K., 2004. *The Economics of Standards: Theory, Evidence, Policy*. Edward Elgar Publishing, Cheltenham, UK/Northampton, MA.

- Blind, K., 2006. Explanatory factors for participation in formal standardisation processes: empirical evidence at firm level. *Econ. Innov. New Technol.* 15 (2), 157–170.
- Blind, K., 2008. Regulatory foresight: methodologies and selected applications. *Technol. Forecast. Soc. Chang.* 75, 496–516.
- Blind, K., 2011. An economic analysis of standards competition: the example of the ISO ODF and OOXML standards. *Telecommun. Policy* 35, 373–381.
- Blind, K., Edler, J., Frietsch, R., Schmooh, U., 2006. Motives to patent: empirical evidence from Germany. *Res. Policy* 35 (5), 655–672.
- Blind, K., Gauch, S., 2009. Research and standardisation in nanotechnology: evidence from Germany. *J. Technol. Transf.* 34 (3), 320–342.
- Blind, K., Jungmittag, A., 2008. The impact of patents and standards on macro-economic growth: a panel approach covering four countries and 12 sectors. *J. Prod. Anal.* 29, 51–60.
- Blind, K., Mangelsdorf, A., 2013. Alliance formation of SMEs: empirical evidence from standardization committees. *IEEE Trans. Eng. Manag.* 60 (1), 148–156.
- Buckley, P.J., Glaister, K.W., Klijin, E., Tan, H., 2009. Knowledge accession and knowledge acquisition in strategic alliances: the impact of supplementary and complementary dimensions. *Br. J. Manag.* 20 (4), 598–609.
- Büthe, T., Mattli, W., 2011. *The New Global Rulers: The Privatization of Regulation in the World Economy*. Princeton University Press, Princeton.
- Cabral, L., Salant, D., 2014. Evolving technologies and standards regulation. *Int. J. Ind. Organ.* 36, 48–56.
- Chen, M.X., Otsuki, T., Wilson, J.S., 2006. Do standards matter for export success? *World Bank Policy Research Working Paper Series No. 3809*.
- Chesbrough, H.W., 2003. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Harvard Business Press, Boston, Massachusetts.
- Chiao, B., Lerner, J., Tirole, J., 2007. The rules of standard-setting organizations: an empirical analysis. *RAND J. Econ.* 38 (4), 905–930.
- Chiesa, V., Manzini, R., Toletti, G., 2002. Standard-setting processes: evidence from two case studies. *R&D Manag.* 32 (5), 431–450.
- Choi, D.G., Lee, H., Sung, T., 2011. Research profiling for 'standardization and innovation'. *Scientometrics* 88 (1), 259–278.
- Cohen, W.M., Levinthal, D.A., 1989. Innovation and Learning—the 2 Faces of R-And-D. *Econ. J.* 99 (397), 569–596.
- Cohen, W.M., Levinthal, D.A., 1990. Absorptive-capacity – a new perspective on learning and innovation. *Adm. Sci. Q.* 35 (1), 128–152.
- Cusumano, M.A., Mylonadis, Y., Rosenbloom, R.S., 1992. *Strategic Maneuvering and Mass-Market Dynamics: The Triumph of VHS over Beta*. *Business History Review* 66 (1), 51–94.
- David, P.A., Steinmueller, W.E., 1994. Economics of compatibility standards and competition in telecommunications networks. *Inf. Econ. Policy* 6, 217–241.
- De Vries, H., Slob, F.J.C., 2006. Best practice in company standardization. *J. IT Stand. Stand. Res.* 4 (1), 62–85.
- De Vries, H., Verheul, H., Willemse, H., 2003. Stakeholder identification in IT standardization processes. In: *Proceedings of the Workshop on Standard Making: A Critical Research Frontier for Information Systems*, pp. 92–107.
- Deeds, L., Hill, C.W.L., 1996. Strategic alliances and the rate of new product development: an empirical study of entrepreneurial biotechnology firms. *J. Bus. Ventur.* 11 (1), 41–55.
- DeLacey, B., Herman, K., Kiron, D., Lerner, J., 2006. Strategic behavior in standard-setting organizations. *Harvard Univ., Working Paper No. 903214*.
- Delcamp, H., Leiponen, A.E., 2014. Innovating standards through informal consortia: the case of wireless telecommunications. *Int. J. Ind. Organ.* 36, 36–47.
- Delmas, M.A., Montes-Sancho, M.J., 2010. Voluntary agreements to improve environmental quality: symbolic and substantive cooperation. *Strateg. Manag. J.* 31 (6), 575–601.
- Dokko, G., Rosenkopf, L., 2010. Social capital for hire? Mobility of technical professionals and firm influence in wireless standards committees. *Organ. Sci.* 21 (3), 677–695.
- Doz, Y.L., 1996. The evolution of cooperation in strategic alliances: initial conditions or learning processes. *Strateg. Manag. J.* 17, 55–83 (Special issue).
- Egan, M., 1998. Regulatory strategies, delegation and European market integration. *J. Eur. Public Policy* 5 (3), 485–506.
- Egan, M., 2002. Setting standards: strategic advantages in international trade. *Bus. Strateg. Rev.* 13 (1), 51–64.
- Egyedi, T.M., Sherif, M.H., 2008. Standards' dynamics through an Innovation lens: next generation ethernet networks. In: *Proceedings of the first ITU-T Kaleidoscope Academic Conference, 'Innovations in NGN'*, Geneva, 12–13 May 2008. Geneva, ITU, pp. 127–134.
- Eisenhardt, K.M., Schoonhoven, C.B., 1996. Resource-based view of strategic alliance formation: strategic and social effects in entrepreneurial firms. *Organ. Sci.* 7 (2), 136–150.
- European Commission, 2008. *Towards an Increased Contribution from Standardisation to Innovation in Europe*. DGEnterprise and Industry, European Commission (Ed.). Brussels.
- Easterby-Smith, M., Lyles, M.A., Tsang, E.W.K., 2008. Inter-organizational knowledge transfer: current themes and future prospects. *J. Manag. Stud.* 45 (4), 677–690.
- Frankel, R., Schmitz-Whipple, J., 1996. Alliance formation motives: a comparison of international perspectives. *Int. J. Logis. Manag.* 7, pp. 19–32.
- Gallagher, S., 2007. The complementary role of dominant designs and industry standards. *IEEE Trans. Eng. Manag.* 54, 371–379.
- Gallagher, S., Park, S.H., 2002. Innovation and Competition in Standard-Based A Historical Analysis of the U.S. Home Video Game Market. *IEEE Trans. Eng. Manag.* 49, 67–82.
- Glaister, K.W., Buckley, P.J., 1996. Strategic motives for international alliance formation. *J. Manag. Stud.* 33 (3), 301–332.
- Gomes-Casseres, B., 1994. Group versus group: how alliance networks compete. *Harv. Bus. Rev.* 72 (4), 62–74.
- Grant, R.M., Baden-Fuller, C., 2004. A knowledge accessing theory of strategic alliances. *J. Manag. Stud.* 41 (1), 61–84.
- Greenstein, S., Stango, V., 2007. *Standards and Public Policy*. Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore. Cambridge University Press, São Paulo.
- Grotne, E., 2008. Strategies for influencing the standardization process: examples from within. In: *ECIS 2008 Proceedings*. Paper 86. (<http://aisel.aisnet.org/ecis2008/86>).
- Hagedoorn, J., 1993. Understanding the rationale of strategic technology partnering—interorganizational modes of cooperation and sectoral differences. *Strateg. Manag. J.* 14 (5), 371–385.
- Hamel, G., 1991. Competition for competence and inter-partner learning within international strategic alliances. *Strateg. Manag. J.* 12, 83–103.
- Hargrave, T.J., Van De Ven, A.H., 2006. A collective action model of institutional innovation. *Acad. Manag. Rev.* 31, 864–888.
- Hawkins, R., 1999. The rise of consortia in the information and communication technology industry: emerging implications for policy. *Telecommun. Policy* 23 (2), 159–173.
- Hemphill, T., 2009. National standards strategy: public/private cooperation for global competitiveness. *Compet. Rev.: Int. Bus. J.* 19, 290–303.
- Katz, M.L., Shapiro, C., 1994. Systems competition and network effects. *J. Econ. Perspect.* 8 (2), 93–115.
- Khazam, J., Mowery, D.C., 1994. The commercialization of RISC: strategies for the creation of dominant designs. *Research Policy* 23, 89–102.
- Kogut, B., 1988. Joint ventures: theoretical and empirical perspectives. *Strateg. Manag. J.* 19, 319–332.
- Laffont, J.-J., Tirole, J., 1991. The politics of government decision-making: a theory of regulatory capture. *Q. J. Econ.* 106 (4), 1088–1127.
- Laursen, K., Salter, A., 2006. Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms. *Strateg. Manag. J.* 27 (2), 131–150.
- Lavie, D., 2006. The competitive advantage of interconnected firms: an extension of the resource-based view. *Acad. Manag. Rev.* 31, 638–658.
- Leiponen, A.E., 2008. Competing through cooperation: the organization of standard setting in wireless telecommunications. *Manag. Sci.* 54 (11), 1904–1919.
- Limin, M., Xiangqian, J., Zhengao, X., Zhu, L., 2005. An Investigation on the technical standard strategy for China's manufacturing industry. *J. Phys.: Conf. Ser.* 13, 389–393.
- Mattli, W., 2001. The politics and economics of international institutional standards setting: an introduction. *J. Eur. Public Policy* 8 (3), 328–344.
- Meeus, M.T.H., Faber, J., Oerlemans, L.A.G., 2002. Why do firms participate in standardization? An empirical exploration of the relation between isomorphism and institutional dynamics in standardization. Working Paper Department of Innovation Studies, University of Utrecht.
- Narayanan, V.K., Chen, T., 2012. Research on technology standards: accomplishment and challenges. *Res. Policy* 41, 1375–1406.
- OECD/Eurostat, 2005. *Oslo Manual. The Measurement of Scientific and Technological Activities. Guideline for Collecting and Interpreting Innovation Data. Third Edition*.
- Ranganathan, R., Rosenkopf, L., 2014. Do ties really bind? The effect of knowledge and commercialization networks on opposition to standards. *Acad. Manag. J.* 57 (2), 515–540.
- Riillo, C., 2013. Profiles and motivations of standardization players. *Int. J. IT Stand. Stand. Res.* 11 (2), 17–33.
- Rysman, M., Simcoe, T., 2008. Patents and the performance of voluntary standard-setting organizations. *Manag. Sci.* 54 (11), 1920–1934.
- Sampson, R.C., 2005. R&D alliances and firm performance. The impact of technological diversity and alliance organization on innovation. *Acad. Manag. J.* 50, 364–386.
- Schilling, M.A., 2002. Technology success and failure in winner-take-all-markets: the impact of learning orientation, timing, and network externalities. *Acad. Manag. J.* 45, 387–398.
- Shapiro, C., Varian, H.R., 1999. The art of standards wars. *Calif. Manag. Rev.* 41, 8–32.
- Sherif, M.H., 2015. ICT standardisation strategies and interactive learning spaces – the case of China. *Int. J. Technol. Mark.* 10 (2), 113–136.
- Shurmer, M., Swann, P., 1995. An analysis of the process generating de facto standards in the PC spreadsheet software market. *J. Evolut. Econ.* 5, 119–132.
- Soh, P.-H., 2010. Network patterns and competitive advantage before the emergence of a dominant design. *Strateg. Manag. J.* 31, 438–461.
- Suarez, F.F., 2004. Battles for technological dominance: an integrative framework. *Res. Policy* 33, 271–286.
- Swann, G.M.P., 2000. *The economics of standardization. Final Report for Standards and Technical Regulations*, Directorate Department of Trade and Industry. Manchester, University of Manchester.
- Sykes, A.O., 1999. The (limited) role of regulatory harmonization in international good and service markets. *J. Int. Econ. Law* 2 (1), 49–70.
- Tassey, G., 2000. Standardization in technology-based markets. *Res. Policy* 29 (4–5), 587–602.
- Van Wijk, R., Jansen, J.P., Lyles, M.A., 2008. Inter- and intra-organizational knowledge transfer: a meta-analytic review and assessment of its antecedents and consequences. *J. Manag. Stud.* 45 (4), 830–853.

- Varadarajan, P., Cunningham, M., 1995. Strategic alliances: a synthesis of conceptual foundations. *J. Acad. Mark. Sci.* 23 (4), 282–296.
- Van de Kaa, G., De Bruijn, J.A., 2015. Platforms and incentives for consensus building on complex ICT systems: the development of WiFi. *Telecommun. Policy* 39 (7), 580–589, Forthcoming.
- Vanhaverbeke, W., Noorderhaven, N.G., 2001. Competition between alliance blocks: the case of RISC microprocessor technology. *Organ. Stud.* 22, 1–30.
- Wakke, P., Blind, K., De Vries, H., 2015. Driving factors for service providers to participate in standardization: insights from the Netherlands. *Ind. Innov.* 22 (4), 299–320.
- WTO, 1995. Agreement on Technical Barriers to Trade. (https://www.wto.org/english/docs_e/legal_e/17-tbt_e.htm).
- Yoshino, M.Y., Rangan, U.S., 1995. *Strategic Alliances: An Entrepreneurial Guide To Globalization*. Harvard Business School Press, Boston, Mass.
- Zahra, S.A., George, G., 2002. Absorptive capacity: a review, reconceptualization, and extension. *Acad. Manag. Rev.* 27 (2), 185–203.