Effects of participation in standardization on firm performance from a network perspective
Evidence from China

Wu, Yuhao; de Vries, Henk J.

DOI
10.1016/j.techfore.2021.121376

Publication date
2022

Document Version
Final published version

Published in
Technological Forecasting and Social Change

Technological Forecasting & Social Change 175 (2022) 121376

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

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

Effects of participation in standardization on firm performance from a network perspective: Evidence from China☆

Yuhao Wu [a], Henk J. de Vries [b,c,*]

[a] School of Economics and Management, Weifang University, Weifang 261061, China
[b] Rotterdam School of Management, Erasmus University Rotterdam, Rotterdam 3062 PA, Netherlands
[c] Faculty of Technology, Policy and Management, Delft University of Technology, Delft 2628 BX, Netherlands

ARTICLE INFO

Keywords:
Standardization
Technical standards alliances
Network
Absorptive capacity
Environmental uncertainty
Firm performance

ABSTRACT

A technical standards alliance (TSA) is a collection of firms organized for a common goal: developing, revising, and promoting technical standards. A firm may participate in standardization through one or more TSAs: its TSA network. However, little is known about the influencing factors and their boundary conditions for gaining firm-level benefits from such involvement. This study fills this gap. Drawing on a network perspective on standardization, we examine the effect of the firm's TSA network and its absorptive capacity. Using a sample of 437 Chinese IT and automotive industry firms participating in non-governmental Chinese standardization groups, we find positive impacts of participation. A firm's central position and relationship strength within a TSA network positively affect firm performance, and absorptive capacity contributes to this effect. Environmental uncertainty acts as a moderator in the relationship between absorptive capacity and firm performance. These findings add to the literature on the impacts of standardization and are informative for companies that consider participating in standardization.

1. Introduction

The integration of technologies induces increasingly complex systems. Firms need agreed-upon interfaces between system parts and increasingly decide to participate in standardization alliances. Together with other stakeholders, they develop and promote common technical standards (Wen et al., 2020). A committee within a formal standardization organization, such as the International Organization for Standardization (ISO) and its national member bodies, is a specific form of a technical standards alliance (TSA). Firms can participate in ISO technical committees, working groups, and the national mirror committee providing national input for this ISO work. They may also participate in other technical committees with working groups and in an overarching ISO policy committee. Standards consortia differ in access rules, voting, and decision-making procedures (Egyedi, 2001). They may have less variation in participating stakeholders, allowing a firm to better control its standardization efforts, outputs, and strategy (Kamps et al., 2017). Standardization is a social coordination mechanism (Kwak et al., 2011). Both types of standards developing organizations can be seen as an alliance: a partnership between firms (and sometimes other stakeholders as well). A firm's TSA network covers a set of relationships formed by cooperation among stakeholders included in the development, revision, and promotion of technical standards (Blind et al., 2012).

Participation in standardization may bring benefits (Menon Economics, 2018) such as the possibility to influence standards, network with other experts, and gain early information, which provides the possibility to anticipate changes. In a sample of German manufacturing companies, Blind and Mangelsdorf (2016) mention three other reasons: designing industry-friendly regulations, enforcing own content, and preventing formal standards that conflict with own interests. For SMEs in German industry, R&D intensity exhibits an inverse U-shaped relationship on the likelihood of joining alliances. SMEs exceeding a certain threshold of R&D activity are reluctant to participate because their knowledge is too essential to disclose to competitors (Blind and Mangelsdorf, 2012). A similar effect was found in Japan (Tamura, 2015). However, according to De Vries and Veurink (2017), academic research pays more attention to the impact of standards than to the effects of TSA involvement. These latter studies tend to focus on the macro-economic or sector level (Blind and Mangelsdorf, 2012; Wakke et al., 2015) rather than the firm level (Wen et al., 2020).

☆ *Standardization Law of the People's Republic of China*. See http://www.sac.gov.cn/sbgs/flfg/fl/bzhf/201803/t20180323_342012.htm

* Corresponding author.
E-mail address: hvries@rsm.nl (H.J. de Vries).

https://doi.org/10.1016/j.techfore.2021.121376
Received 25 January 2021; Received in revised form 1 October 2021; Accepted 18 November 2021
Available online 27 November 2021

Participation in TSAs can be beneficial. A firm may access markets by influencing the interoperability, quality, and safety enabled by technical standards towards its preferred specifications (Blind and Mangelsdorf, 2016) and learn from other participants (Blind and Mangelsdorf, 2012; Wakke et al., 2015). However, these studies do not identify the factors influencing the benefits of such participation: under which conditions can a firm obtain more benefits? Some case studies try to open the black box of companies (De Vries, 2006; De Vries and Wiegmann, 2017; Hurd and Isaak, 2008), but most of these studies are qualitative instead of quantitative. An exception is a study by Wen et al. (2020) based on data about 170 Chinese car manufacturers involved in formal standardization. They confirm that a firm's position in a standardization alliance network can affect its introduction rate and time to market of new products.

A TSA is a specific form of a strategic alliance (Blind and Mangelsdorf, 2016; Wen et al., 2020), but research on the network perspective mainly focuses on other alliance contexts rather than standardization, for instance, R&D alliances (e.g., Caner et al., 2014; Cohen and Caner, 2016; Lin et al., 2012). Essentially, most standards are socially constructed during complex and lengthy interactions, so examining network relationships may help to understand firm performance (Van den Ende et al., 2012). It is unclear to which extent network theory developed for alliances also applies to TSAs. What benefits can firms get from participating? Why does the effect on performance differ among allied firms? Therefore, we need to clarify factors influencing firm performance. We do this by taking a network perspective, but different than done by Wen et al. (2020). They discuss the effect of some structural characteristics of standardization alliance networks on new product outcomes based on archival data from formal standards. We integrate network structure and relationship dimensions and adopt survey data from informal standardization to explore the impact of TSA networks on firm performance. The effectiveness of TSA networks may also be affected by the firm's characteristics i.e., the firm's capabilities. We therefore examine the role of absorptive capacity in the impact of TSA networks on performance. In doing so, this study makes several contributions:

First, we include two important aspects of a firm's participation in TSA networks: centrality and relationship strength. This allows us to investigate the extent to which this participation is beneficial for the firm and if the benefits depend on centrality and relationship strength. Taking firm performance as the outcome to analyze the impacts of participation in standardization on the firm itself, we show that participation is indeed beneficial, and benefits increase when a firm is at the center of the network and maintains strong relationships within the TSA network. In this way, we extend current standardization literature that tends to focus on influencing the content or market adoption of standards and expand network research to the TSA situation.

Second, we examine the effect of absorptive capacity on firm performance and identify its moderating role on the relationship between TSA participation and performance. Participation in TSA networks allows a firm to acquire and utilize external knowledge resources. By addressing this intersection of standardization and knowledge management, we contribute to a better understanding of the mechanisms behind the business effect of participation in TSA networks.

Third, we consider an essential characteristic of the external environment faced by allied firms, namely uncertainty, and study its moderating effect on the relationship between absorptive capacity and performance. We argue that firms need absorptive capacity to notice and understand the environmental changes and take appropriate measures to leap at opportunities, to achieve better performance.

The remainder of the paper is organized as follows. Section 2 presents a literature review and derives hypotheses. Section 3 articulates the research methodology, including the research context, questionnaire design, data sources, and variable measurements. This is followed by a presentation of our empirical results in Section 4. Section 5 discusses the findings and finally Section 6 summarizes the paper.

2. Literature review and development of hypotheses

2.1. TSAs and TSA networks

Technical standards are established in cooperation between interested parties involved in a TSA. TSAs can be seen as interfirm arrangements to develop, promote, and maintain technical standards together (Blind and Mangelsdorf, 2012, 2016). Other stakeholders may participate as well. TSAs have some unique features compared with other strategic alliances. First, the main purpose of a TSA is to develop and promote technical standards. Participants are expected to contribute to this common achievement (Blind and Mangelsdorf, 2012). Second, TSAs often have a broader scope than other alliances as the technology innovation output from one or more technology alliances may be needed for one technical standard. Third, firms are supposed to play a key role in the standardization process. A limited number of companies and other stakeholders develop technical standards within a TSA, whereas many firms advocate these standards as adopters (Keil, 2002; Oshri and Weeber, 2006). Sometimes government involvement is needed to ensure alignment between stakeholders and regulators, or because governmental inspection bodies are future standards users.

Technical standard-setting includes several levels (e.g., international, national, and industry sector level), so firms may participate in one or more standard-setting alliances at various levels (Axelrod et al., 1995). However, they may play a proactive role in only a few of them. Besides, cooperation is needed among various TSAs to align activities and stimulate the adoption of technical standards (Delcamp and Leiponen, 2014). This makes standardization processes even more complex. A firm is linked to other participants through the TSAs it participates in, and its TSA network comprises all interorganizational ties that arise from these standardization partnerships (Wen et al., 2020).

2.2. TSA networks and firm performance

The social dimension of standardization is relevant to the parties involved, who must reach consensus on a standard. The success probability depends on the characteristics of the network (Van den Ende et al., 2012). According to social network theory, centrality and relationship strength may explain how firms capture social capital from embedded resources (Freeman, 1979; Granovetter, 1973), essential for interorganizational coordination.

Network centrality. Network centrality is the positional advantage of the firm in TSA networks (Freeman, 1979; Wen et al., 2020). A central position in the TSA network increases the possibilities to influence the standards' contents (Blind et al., 2012; Leiponen, 2008) and may help to shape or modify alliance routines such as procedures to regulate the standardization activities of other participants. This can ensure the achievement of the alliance target and improve the speed and quality of their own standardization work (Maggetti and Gilardi, 2011).

Standardization is a negotiation process of cooperation and compromise (Schueler et al., 2008). Central positions such as the chairperson or secretary of a standardization committee have to balance the parties' needs. The chair is assumed to have a neutral position, which may hinder proposing arguments that favor his/her firm's position. However, if the chair's firm has a special interest in the standards to be developed, sometimes it may tip the committee's balance in its direction (De Vries and Simons, 2006). Thus, despite neutrality, central firms are positioned better than peripheral firms to influence the content of technical standards in line with their proprietary interests, which may be a driver of higher performance.

Network centrality provides firms with a vast array of knowledge sources that are essential for developing new technical standards or innovative ideas (Blind et al., 2012; Caner et al., 2014; Wen et al., 2020). Central firms are located at the nexus of numerous knowledge resources within the TSA network. Such a positional advantage allows them to enjoy more alternative paths to access the unique knowledge, information, and social connections than other members, which is needed for knowledge integration and knowledge creation (Lee and Kim, 2011; Slowak, 2008). Central firms can also partly steer the knowledge flow within the TSA network and influence the conversion from tacit knowledge to explicit knowledge, which promotes standardization output because the standard itself is a form of explicit knowledge (De Vries and Van Delden, 2011). They can gain knowledge spillovers and reduce the costs of implementing technical standards. They can also make a difference in the market adoption of the standard through a richer understanding and a better evaluation of future changes in the standards, the technology, and the market (Axelrod et al., 1995; Chellappa and Saraf, 2000; Lai and Weng, 2013), and thus gain additional benefits by seizing first-mover advantage (Wen et al., 2020).

We assume that a central position of a firm within a TSA network may contribute to standardization outcomes that meet the firm's interests, leading to higher firm performance. This leads us to the following hypothesis:

Hypothesis 1a. *The closer a firm is to the center of a TSA network, the better firm performance will be.*

Relationship strength. As a social mechanism for coordinating different actors, relationship strength is a relevant feature of social networks (Lee and Kim, 2011). In line with Wen et al. (2020), we define the relationship in a TSA network as a set of linkages between a firm and manufacturers, consumer associations, governmental agencies, research institutes, and other stakeholders in the standard-setting process. At the TSA level, strength refers to the frequency of interaction, including time spent in a relationship and the depth of the relationship (Granovetter, 1973; Marsden and Campbell, 2012). Coordination between the participants is a prerequisite for fruitful standardization. Based on their experience in international standardization, De Vries and Simons (2006) argue that it is essential that participants in standardization committees attend all meetings to be effective. Because an open exchange of opinions and interests is needed for developing common standards, it is necessary to maintain close relationships within the TSA network – both during and in between meetings, formally and informally.

Standardization is associated with a combination of certain knowledge and skills shared by participants (e.g., academic level, standardization expertise, strategic vision). Network relationships provide an opportunity to intensify R&D cooperation and enhance productivity, rather than just developing and promoting a specific standard (Leiponen, 2005). Participants are given access to heterogeneous knowledge sources beyond the scope of a single firm (Ranganathan and Rosenkopf, 2014), benefiting from the complementarities among participants to solve the actual or potential problems together in a good manner (Leiponen, 2005). As the relationship strength increases, the resource protection of participants may decrease and further generate the enthusiasm of tacit knowledge transfer (Eisingerich et al., 2010). As a result, this knowledge creates potential value for firms, increasing their chances of success.

The relational characteristics of TSA networks influence organizational action. A cohesive network may help participants experience ongoing commitment, trust, and common understanding among stakeholders (Baloglu et al., 2010), making it easier to reach agreements (Kenis and Knoke, 2002). Although firms have different motivations to participate in TSAs and possibly opposing interests, the technical standards developed are an acceptable compromise that more or less fulfills all actors' requirements (De Vries and Verhagen, 2016; Farrell et al., 2012; Maggetti and Gilardi, 2011), and reduces the likelihood of opportunistic behavior among participants (Eisingerich et al., 2010). Most notably, the efficiency of standardization may be enhanced by intensifying the interaction within a TSA network (Delcamp and Leiponen, 2014), which has a positive effect on improving the common benefits of participants. These findings lead to the following hypothesis:

Hypothesis 1b. *The stronger the relationship with other participants within a TSA network, the better firm performance will be.*

2.3. Absorptive capacity and firm performance

Standardization is considered as a knowledge-sharing and knowledge-creating activity (Blind et al., 2012). In most cases, technical standards do not only arise from the knowledge developed by a single company, but rather from the resources and capabilities possessed by several cooperators. More in general, absorbing external knowledge is an indispensable element in a firm's innovation and adaptation to changes in its competitive environment (Liu et al., 2018). Therefore, some recent studies focus on the role of absorptive capacity in value creation within a firm (e.g., Gkypali et al., 2018; Santoro et al., 2018).

The dynamic capability to generate, combine, recombine, and exploit knowledge is a critical source of performance (Xie et al., 2018). Cohen and Levinthal (1990) define absorptive capacity as the dynamic capability of a firm to identify and evaluate the value of new external knowledge and promote the development of the organization by digesting, absorbing, and integrating it. In TSA networks, influencing standard-setting is core but acquiring knowledge from other involved stakeholders is another important reason to participate (Blind et al., 2012). For developing technical standards, an integration of various forms of knowledge is necessary. Firms with different levels of knowledge stocks cooperate through TSAs, absorb external knowledge, and internalize this. Higher levels of absorptive capacity allow firms to gain more benefits from participation in standardization (Lin et al., 2012), and are conductive to more effective identification and knowledge resources such as technical specifications and commercial products from network partners (Flatten et al., 2011), and further generate new ideas to drive the standard-setting process. Thus, absorptive capacity is all-important to a firm's knowledge reserve and contributes to the goal fulfillment of participants.

Participating firms use knowledge resources to prepare technical standards and to learn from each other. The effectiveness of inter-firm organizational learning depends on the external knowledge firms absorb and use in standardization. Through diversified external sources within TSA networks, absorptive capacity promotes innovation output directly and enhances knowledge value through R&D cooperation (Gkypali et al., 2018). It also enables a firm to acquire new knowledge and information related to development opportunities (Engelen et al., 2014) and improves a firm's standardization capabilities due to learning-by-doing (Hesser et al., 2010). This flexibility allows standards to keep pace with changing requirements, thereby shaping a firm's competitive advantages and contributing to its performance. This performance partly relates to the standard itself, to which extent it will meet company requirements, and partly relates to other corporate interests such as innovation and marketing.

Accordingly, examining the role of absorptive capacity may partly explain why participants who are exposed to the same external knowledge sources within a TSA network differ in the benefits they acquire. This leads us to the following hypothesis:

Hypothesis 2. *Higher levels of absorptive capacity lead to increased firm performance.*

2.4. Interaction between TSA networks and absorptive capacity

Social networks enable the creation of new knowledge among organizations (Grant, 2015). The interaction between alliance network and absorptive capacity plays a critical role in knowledge sharing within organizational networks (Tsai, 2001). A productive TSA network gives participants more opportunities for collaborative learning. It contributes to balancing the distribution of knowledge resources among stakeholders and enabling a firm to develop cutting-edge technical standards (Leiponen, 2005). However, strong complementarities with external knowledge sources require a significant absorptive capacity to increase firms' knowledge base through exploiting the absorbed or co-generated knowledge (Blind et al., 2012). The better a firm's absorptive capacity, the more it may apply external knowledge to standardization activities in the future, increasing its corporate intelligence and contributing to better standardization outcomes.

Firms that occupy a central position in a TSA network have better access to standardization-related knowledge and practices of other participants (Srivastava et al., 2015). Close connectedness among participants also provides the benefit of acquiring external knowledge. However, although a firm gains new opportunities and knowledge by connecting with other stakeholders, knowledge is distributed unevenly within a TSA network, so the outcome of knowledge transfer across organizations varies (Tsai, 2001). If an allied firm lacks sufficient absorptive capacity to internalize the generated knowledge and codify this in standards, it will be less able to improve its performance (Wakke et al., 2015). Firms with a certain level of absorptive capacity to learn, implement, and disseminate new knowledge internally are likely to apply expertise and other resources necessary to properly implement standards (Cohen and Levinthal, 1990; De Vries et al., 2009).

To conclude, an allied firm with a certain level of absorptive capacity is likely to benefit more from TSA networks, not only by exploiting the opportunities presented but also by boosting the effects of standardization. This leads us to the following hypotheses:

Hypothesis 3a. *The centrality of a firm's position in a TSA network is more positively related to firm performance when the firm has a high rather than a low absorptive capacity.*

Hypothesis 3b. *The relationship among participants in a TSA network is more positively related to firm performance when the firm has a high rather than a low absorptive capacity.*

2.5. The moderating effect of environmental uncertainty

Technical standards bring stability and allow firms to cope with uncertainty. Organizational research distinguishes between two types of environmental uncertainty: objective and perceptual (Hoffmann et al., 2009; Milliken, 1987; Parnell et al., 2015). The former reflects the state of the organizational environment, and the latter describes the state of organizational managers who perceive themselves to be short of vital information about the environment (Milliken, 1987). Decisions in organizations are made in uncertainty (Jalonen, 2011). A standard is perceived as optimal or at least acceptable by the TSA developing it. Thus, for the purpose of this study, we use perceptual environmental uncertainty. This uncertainty is inherent to standardization (Jalonen, 2011; Roca and O'Sullivan, 2020) because of the perceived inability to predict the organization's external environment (Hoffmann et al., 2009; Milliken, 1987; Song et al., 2016). Technical uncertainty and market uncertainty are two primary sources of environmental uncertainty (Jalonen, 2011; Lu and Yang, 2004; Song et al., 2016). The contents of most standards relate to technology, although the standard is used in a business context, so both forms of uncertainty are relevant.

Technical uncertainty is caused by technological developments and insufficient knowledge of new technology details or the shortage in knowledge needed for new technology application (Jalonen, 2011). This uncertainty becomes stronger with increasing technical complexity and development (Song et al., 2016). Facing high technical uncertainty, firms may become more actively involved in the standardization process (Slowak, 2008; Su et al., 2010) because they may find themselves lacking the broad range of skills and resources needed to remain competitive in the changing environment (Srivastava and Frankwick, 2011). They can absorb relevant technical knowledge from network partners to vitalize and expand their knowledge stock and improve the accuracy of judging emerging opportunities to consolidate their technical level and status (Lee, 2014; Wakke et al., 2016).

Technical standards are developed and implemented to meet market demand, and only those with broad market prospects are valuable (Delcamp and Leiponen, 2014). The emergence of market uncertainty is due to the unforeseen changes in the relationship between firms and customers and/or unpredictable changes in the relationship between competitors, which give rise to new markets (Jalonen, 2011). When facing high market uncertainty, firms are more likely to continually optimize their technical standards to proactively respond to customers' changing preferences and demands (Blind et al., 2017; Su et al., 2010). Thus, to ensure they understand the market better than competitors, firms are likely to put more effort into absorbing knowledge relevant to the market success of technical standards, and their performance will largely depend on their ability to absorb the latest knowledge about market developments via TSA networks (Engelen et al., 2014).

During the standardization trajectory, firms' adaptive responses to the environment depend on their internal conditions, especially on the resources they control (Eisingerich et al., 2010). A firm will maximize performance when resources and capabilities match the external environment (Srivastava and Frankwick, 2011). Environmental pressure may urge a firm to reevaluate its resource disadvantages and seek resources and capabilities for future actions (García-Sánchez et al., 2018). The more turbulent the environment, the more need to do so.

To conclude, superior absorptive capacity enables firms to proactively seize opportunities to achieve self-renewal and regeneration in an uncertain environment. When allied firms lack the necessary resources and skills, they must develop a higher absorptive capacity to obtain them from the external environment to overcome resource constraints or to exploit emerging opportunities. This leads us to the following hypothesis:

Hypothesis 4. *The positive effect of a firm's absorptive capacity on its performance is moderated by environmental uncertainty; as the extent of uncertainty increases, the positive effect of firms' absorptive capacity on its performance is strengthened.*

Based on the above theoretical analysis and hypotheses, Fig. 1 shows the conceptual framework of this paper and describes the relationship between TSA networks, absorptive capacity, environmental uncertainty, and firm performance.

3. Research methodology

To empirically test our hypotheses, we used a survey to collect firm-level data. Surveys are often used to investigate incidents of firm performance (Chu et al., 2018; García-Sánchez et al., 2018), especially when the strategic-alliance information is not readily accessible from secondary sources (Ariño, 2003). We developed a structured questionnaire to collect primary data from allied firms participating in TSAs, which is a common practice in strategic-alliance and resource-based research (Dess and Robinson, 1984; Newbert, 2008).

3.1. Research context

We collected most of the empirical data from high-tech companies in China's Information Technology (IT) industry. The People's Republic of China is the biggest emerging economy. Participating in the development of international technical standards has become an important way to strengthen technology leadership and market power (Williams et al., 2011). Chinese high-tech companies increasingly participate in TSAs to facilitate the internationalization of the Chinese IT industry. Standards are a prerequisite for ensuring interoperability within and between IT systems (De Vries et al., 2003). High-tech firms participating in TSAs develop common IT standards to deal with the dynamic and turbulent environment and strengthen their market position through new technical breakthroughs, products, and services. Therefore, TSAs related to the IT industry are appropriate for our research, and China provides a rich and proper context.

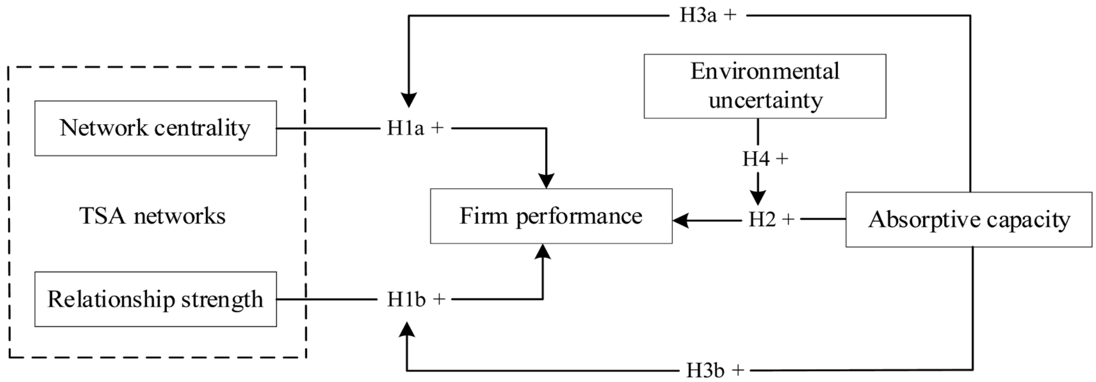

Fig. 1. Conceptual framework and hypotheses.

China's manufacturing industry ranks first in the world. It is gradually integrating with the new generation of the IT industry, for example, by developing intelligent manufacturing. Our setting is a traditional manufacturing industry: the automotive industry. The rapid progress in car technology benefits from the IT industry, and prolific alliances in the automotive industry have been established to develop technical standards related to compatibility between components, software architecture, energy safety, environmental issues etc. (Traub et al., 2017; Wen et al., 2020). Thus, the target group comprises these two industries.

Traditionally, most standards in China are developed by governmental agencies and are obligatory. However, the new China Standardization Law published in 2017 and implemented on January 1, 2018, gives more room for market-driven standards next to government-led standards (see the link below). Firms are encouraged to participate in voluntary standardization to develop market-driven standards, especially in important industries, strategic emerging industries, common key technologies etc. Through self-declaration disclosure and a supervision system, enterprises shall disclose the number and name of standards they implement. They shall organize production and business activities according to standards. The products they make and the services they provide shall meet the technical requirements of the standards that they have disclosed. Firms are expected to develop enterprise standards according to their own needs or jointly develop group standards with other enterprises voluntarily. This new category of Chinese standards is flexible, experimental, and unofficial (Van de Kaa et al., 2011). Unlike government-led standards, government agencies do not set administrative licensing for group standards. Representatives of producers, operators, users, consumers, educational and scientific research institutions, testing and certification bodies, government departments, and other relevant parties are involved in the development of group standards to fully reflect the relevant interests. Group standards with positive implementation fects can be further transformed into local standards, sector standards, or national standards. Standardization administration departments and relevant administrative departments of the people's governments at or above the county level shall, in accordance with their statutory duties, guide and supervise the formulation of group standards, and supervise and inspect the implementation of group standards. Despite this governmental involvement, the formulation of group standards is open to the market players. Next, the market can choose standards independently, and in case of competing standards the fittest will survive. Each group standard is prepared in a group-based TSA. A firm may participate in the development of one or more group standards. This leads to partnerships with various stakeholders: a TSA network. Therefore, Chinese firms participating in an alliance to develop common voluntary standards are appropriate for this study.

3.2. Questionnaire design

We followed a comprehensive approach to pretest, refine, and validate the scales (Sarkar et al., 2001). First, we generated the questions by making full use of the literature on standardization and alliance networks, identifying mature methods, and developing new ones. Taking into account language differences, we translated the original questionnaire measurements into Chinese and then carefully checked the translation accuracy by using the back-translation technique. Second, we invited two experienced researchers to evaluate the questionnaire design and measurement indicators. Third, we verified whether the questionnaire items were suitable for real standardization conditions (Wang et al., 2018). A research team including the first author and five PhD candidates majoring in business management, all with extensive knowledge of standardization, each conducted three interviews with managers familiar with their firm's cooperation practice in standardization. The PhD candidates received pre-interview training, including instructions and practice on the exact meaning of each question in the questionnaire. Thus, when respondents filled out the questionnaire, team members could help to answer any questions. Each recorded interview lasted an average of sixty minutes. The interviewees were allowed to consult with other managers when in doubt. The first author did two interviews by phone because he was not in China. Thanks to the previous project contacts, we communicated with corporate managers familiar with standardization practices in the IT and automotive industries, and asked them to make suggestions during the questionnaire filling process. Before distributing the questionnaire on a large scale, through an online survey, we conducted a series of early pretests with 30 high-tech IT firms and 30 automotive firms (not in the final target sample) to verify the clarity of questions in the questionnaire (pilot study). We combined their feedback with our research purpose and context, made minor wording modifications, and removed vague descriptions to enhance content validity.

3.3. Sample and data collection

Considering the significant regional differences in China, the targeted sample of this study included firms in Beijing, Guangdong, Zhejiang, Jilin, and Heilongjiang province. Local economic development and innovation capabilities are relatively advanced in the first three areas, but not so in the Jilin and Heilongjiang provinces. This provides variety in the sample to minimize the bias caused by the area-specific characteristics (Su et al., 2010). We focus on the new form of standardization added in the new China standardization law: standards developed by groups of companies. These standards are voluntary, and in that sense, they deviate from the national standards. We identified target firms via the China Group Standard Information Disclosure Platform. The information available includes group name, standard number, standard name, and drafting unit. To get a large sample based on the information provided by the China Enterprise Standard Information Public Service Platform, we contacted some companies disclosing their enterprise standards via this platform. Because these firms actively develop enterprise standards, they may also participate in TSAs. Based on industry (IT or automotive) and disclosure of group standard information, we initially formed a list of allied firms.

For inclusion in our sample, firms should have participated at least one year in the relevant TSAs in our target sample to ensure that respondents had at least one year of experience (Muthusamy and White, 2006). Each firm should be linked to at least two other firm-level cooperators to be considered a TSA network member (Eisingerich et al., 2010). In fact, firms may be involved in multiple TSAs to develop one or more standards, thereby embedded in an informal collaborative standardization network with other firm-level stakeholders through many direct and indirect ties (Kenis and Knoke, 2002; Ranganathan and Rosenkopf, 2014).

The questionnaires were distributed via different channels to gather more data and reduce risks such as non-response and respondent bias (Roy et al., 2001). First, thanks to a government-funded research project (Chinese National Key Research and Development Project), we received help from two government departments: Jilin Institute of Scientific and Technical Information and the Heilongjiang Science and Technology Resource Sharing Service Center. They issued and collected the questionnaires by email with a cover letter emphasizing the purpose and significance of the present study. Governmental backing is likely to increase the response rate to some extent. Specifically, based on our selection criteria, we searched and identified the basic information (e.g., the name, contacts, and industry) of firms in the government database and sent questionnaires to the target TSA firms that met the requirements. We requested key informants acquainted with their standardization practice to complete and return them within two weeks. The list provided by the government included the company's name and contact information. We contacted each selected company by telephone in advance to confirm their willingness to participate, enabling the research team to carry out additional field research visits to collect data face to face. Second, we used the network of Jilin University's MBA and EMBA programs. We sent questionnaires to both current and former students, all of whom are in corporate management positions across China. Third, we hired a qualified and reputable data service agency to send the questionnaires to the target firms in their database. This agency had a comprehensive list of TSA firms and their contact information and had previous experience in similar research, which provides confidence in the quality of the collected survey data. Through the strict control of these data sources, each allied firm only received one questionnaire.

Knowledgeable respondents included main decision-makers and standardization experts such as product, technology, or project managers who had worked for the company for at least one year. These managers are expected to be familiar with their firm's standardization process in each standardization community (Keil, 2002). Several *ex ante* procedural remedies can limit the potential common method bias (Engelen et al., 2014; Podsakoff et al., 2003). Specifically, we separated the order of independent and dependent variables by using unrelated questions. This reduces the impact of contextual cues and checks the attention of the respondents' when filling out the questionnaire. Also, we promised that the data collected would only be used for this research, and that respondents would be anonymous. Besides, we encouraged respondents to answer according to the reality of standardization in their companies, and emphasized that there were no right or wrong answers. Informants could receive a summary of the results if they were interested. We thus made every attempt to have an acceptable response rate and high-quality feedback.

As shown in Table 1, 525 of the 800 firms participating in TSAs completed our survey. A total of 437 valid responses were collected from three sources, yielding a valid response rate of 54.6%. Table 2 shows the characteristics of the sample, including industry type, firm ownership, firm age, firm size, network size, number of standard-setting projects, government support, and patents. The IT and automotive industry accounted for 69.3% and 30.7%, respectively. In terms of ownership, 76% of the sample was composed of private-owned firms and 98.4% of the firms had been operating in related industries for more than five years. More than half (55.6%) of the firms had between 100 and 500 employees, and 49.2% of firms had five to ten alliance partners. The number of standard-setting projects mainly ranged from four to six, most firms received government support, and slightly more than half the firms (51.9%) have essential patents for the standard-setting process in one or more cases.

Table 1
Results of data sources.

Source	TSA(s) participants	Non-participants	Total
Source 1	336	119	455
Source 2	95	37	132
Source 3	369	95	464
Total	800	251	1051

Return: $N = 525$; Properly filled out: $N = 437$ (Source 1: 183; Source 2: 58; Source 3: 196).

Table 2
Sample profiles.

Classification	Item	Number	Percentage (%)
Industry	IT industry	303	69.3
	Automotive industry	134	30.7
Ownership	State-owned	39	8.9
	Privately owned	332	76.0
	Joint venture	55	12.6
	Foreign owned	11	2.5
Firm age (years)	≤ 5	7	1.6
	6–10	96	22.0
	11–15	146	33.4
	16–20	89	20.3
	> 20	99	22.7
Number of employees	≤ 100	12	2.7
	101–300	127	29.1
	301–500	116	26.5
	501–1000	70	16.0
	1001–2000	32	7.4
	> 2000	80	18.3
Number of alliance partners	2–4	150	34.3
	5–10	215	49.2
	11–20	51	11.7
	> 20	21	4.8
Number of standard-setting projects	1	3	0.7
	2–3	118	27.0
	4–6	212	48.5
	7–9	75	17.2
	≥ 10	29	6.6
Government support	Never	4	0.9
	In some cases	281	64.3
	In most cases	152	34.8
Patents	Never	3	0.7
	In some cases	227	51.9
	In most cases	207	47.4

3.4. Variables and measures

3.4.1. Dependent variable

Firm performance describes to what degree a firm's alliance goals are achieved (Das and Teng, 2003; Lunnan and Haugland, 2008). As participants usually have multiple goals (Gravier et al., 2008), we adopt subjective measurements to capture firm performance, which is a common practice in studies in the field of strategic alliances (Christoffersen et al., 2014). We collect assessments from allied firms' informants and assess firm performance from the fulfillment of specific financial and non-financial goals that reflect the firm's benefits gained through TSAs, aiming at combining both short-term and long-term levels (Ariño, 2003; Townsend, 2003). Based on this, we measure firm performance using seven items on a five-point scale ranging from 'strongly disagree' to 'strongly agree'. All items are developed based on the literature to guarantee the scale's content validity (Simonin, 1997; Zollo et al., 2002).

3.4.2. Independent and moderating variables

TSA networks. We distinguish two critical dimensions for alliance networks: centrality and relationship strength (Lee and Kim, 2011). Centrality refers to a firm's leadership in standardization in terms of, for example, influence, prestige, independence, and control in the TSA network. We measure network centrality using five items adapted from the literature (Leiponen, 2008; Tsai, 2001), capturing the position of a participant within the TSA network. Network relationships are related to participants' subsequent allied behavior. We adopt measures for relationship strength developed from previous studies (Eisingerich et al., 2010; Sarkar et al., 2001) and use five indicators to reflect the intensity, frequency, stability, and trust of interactions among participants within the TSA network.

Absorptive capacity. The efficiency of accessing external knowledge resources depends on the level of absorptive capacity, which is important for an allied firm to create value and obtain and maintain competitive advantages of technical standards. Following Zahra and George's (2002) model of absorptive capacity, this construct is divided into potential absorptive capacity and realized absorptive capacity. The former is more concerned with acquiring and assimilating external knowledge, and the latter provides evidence of a firm's ability to transform and exploit adopted external knowledge. Focusing on these dimensions, we use 11 questionnaire items from Engelen et al. (2014), Flatten et al. (2011) and Flor et al. (2018) to measure this construct.

Environmental uncertainty. Researchers widely use technical and market uncertainty to measure environmental uncertainty (Song et al., 2016). Forecasting technology changes accurately provides opportunities for firms to develop common technical standards. Based on Lee (2014) and Lu and Yang (2004), we use three items to measure technical uncertainty in terms of the amount and unpredictability of changes in the technologies related to technical standards. Besides, allied firms need to frequently develop and revise technical standards to satisfy customer demand in a highly dynamic market (Van den Ende et al., 2012). We adopt three items from Lu and Yang (2004) and Su et al. (2010) to capture the difficulty of anticipating changes in the marketplace.

3.4.3. Control variables

Several other factors may affect organizational performance at the network and firm level. We measure them as control variables to partly eliminate alternative antecedents of firm performance.

Network size is an important contributor to the firm's innovation outcomes because a firm with numerous cooperators in its network can gain more access to external resources and utilize them to develop common standards (Phelps, 2010). For a target firm embedded in TSA networks, the firm's network size can be operationalized by four ordinal values (1 = '2 - 4′ to 4 = '> 20′, measuring the total number of cooperators cooperating with the firm (Wang et al., 2018; Xie et al., 2016).

Alliance experience. More alliance experience may help allied firms develop more knowledge and capabilities that will contribute to standards development (Gilsing et al., 2016). Diverse knowledge sourcing and learning opportunities may also be provided so that these firms are likely to gain more benefits. We measure alliance experience by an ordinal variable with five values: the average number of cooperative standard-setting projects the firm has participated in each year in the past three years (1 = '1′ to 5 = '≥ 10′).

Patents may play a role in standards development (Blind et al., 2012). Companies with a patent that is essential for the standard have more bargaining power (Leiponen, 2005). These patents are more likely to be cited by other stakeholders in subsequent patents, which is important for developing technical standards (Delcamp and Leiponen, 2014). We control whether the firm has any essential patents with an ordinal variable (never = '0′, in some cases = '1′, in most cases = '2′).

Industry type. Standardization activities are highly sector specific. Therefore, we control for the effects of the industry sector as a dummy variable (IT industry = '1′, Automotive industry = '0′).

Firm ownership and the level of government support affect the level of resources and capabilities to participate in standardization (Xie et al., 2018). We divide this variable into state-owned, privately-owned, joint venture, and foreign-owned enterprises. As a dummy variable, ownership is set as '1′ for state-owned enterprises and 0 for others.

Firm age and size. Previous research shows that, on average, an aging firm has higher productivity, profits, and equity and lower debt ratios so that firms may improve with age (Coad et al., 2013). Macaulay et al. (2018) believe that the firm size affects access to resources, whereas SMEs may face barriers to benefit from standardization (Blind and Mangelsdorf, 2012; De Vries et al., 2009). We measure age by taking five ordinal values, that is, in years from the date of creation of the firm (1 = '≤ 5′ to 5 = '> 20′), and use the total number of employees in the firm to measure size, via six ordinal values (1 = '≤ 100′ to 5 = '> 2000′).

3.4.4. Adequacy of the measures: reliability, validity, and common method bias

We adopted Cronbach's alpha (α) to judge reliability. As shown in Table 3, the α value of each scale is higher than the threshold value of 0.70, indicating that the reliability of the measurement results of this scale is good with a high internal consistency degree. We used confirmatory factor analysis (CFA) to test validity, and the results demonstrate that the measurement model fits the data well (χ^2=667.216, p = 0.000, χ^2/df=1.319, IFI=0.978, TLI=0.976, CFI=0.978, GFI=0.919, RMSEA=0.027), proving that the model is well constructed. All items loaded on the corresponding latent constructs significantly, and all the standardized loadings were higher than 0.60. The average variance extracted (AVE) is > 0.50 (ranging from 0.541 to 0.662), and the composite reliability (CR) also exceeds the critical value of 0.70 (ranging from 0.837 to 0.911), demonstrating that convergent validity is ensured in our sample. Moreover, in Table 4, the square roots of AVE values on the diagonal are all greater than the correlation coefficients among the variables, thus providing strong evidence for discriminant validity. Additionally, following Podsakoff et al. (2003), we used Harman's one-factor analysis to examine the common method bias and conducted exploratory factor analysis for all the variables using the principal component method. The results show that the first factor explains the total variance of 22.716%, less than the critical value of 40%. We also conducted a CFA, restricting all items of the model to a common single factor. The fit index result shows that the model cannot fit the data well (χ^2 /df =9.915, IFI=0.362, TLI=0.318, CFI=0.359). Therefore, we found no significant common method bias in the data and subsequently tested out hypotheses.

4. Results

Table 4 presents the descriptive statistics, including the means, standard deviations, and correlations among the variables. All correlations between variables are less than 0.7, within the acceptable thresholds. The results indicate that network centrality, relationship strength, and absorptive capacity positively correlate with firm performance. To match the regression model, we tested the normality of the main independent variables (Song et al., 2016). We found that the skewness and kurtosis of each variable do not have a serious non-normal distribution (for network centrality, skewness is -0.014 and kurtosis is -0.911; for relationship strength, skewness is 0.030 and kurtosis is -0.990; for absorptive capacity, skewness is 0.117 and kurtosis is -0.837; for environmental certainty, skewness is -0.090 and kurtosis is -0.394). To check for multicollinearity, we calculated the variance inflation

Table 3
Construct measurement model and CFA.

Item description summary	Standardized loading	AVE	CR
Network centrality (α = 0.866)			
Our firm's products and technical capabilities are recognized by allied partners	0.680	0.570	0.868
Allied partners often communicate with us about technical standards	0.835		
We have better access to different information and knowledge relevant to the market success of the standard	0.756		
In the collaborative standard-setting process, our firm has a certain power to influence or determine the contents of standards	0.700		
We provide powerful information regarding standardization to allied partners	0.792		
Relationship strength (α = 0.861)			
Our firm often drafts standards together with allied partners	0.704	0.556	0.861
Our firm and allied partners are willing to dedicate the necessary resources to make technical standards a success	0.882		
There is intense contact with allied partners (e.g., visits to each other's firms, standardization meetings, written and telephone communications)	0.668		
We frequently share standardization information with allied partners	0.763		
Our firm has honest and truthful relationships with allied partners	0.692		
Absorptive capacity (α = 0.854)			
Potential absorptive capacity (α = 0.851)			
We collect industry information through informal means (e.g., lunch with industry friends, talks with trade partners)	0.704	0.541	0.854
In our firm, ideas and concepts are communicated cross-departmental	0.794		
New opportunities to serve our clients are quickly understood	0.681		
We are slow to analyze and interpret shifts in market demands®	0.769		
We quickly recognize the usefulness of new external knowledge to existing knowledge	0.723		
Realized absorptive capacity (α = 0.884)			
Our employees can structure and use collected knowledge	0.703	0.567	0.886
Our employees successfully link existing knowledge with new insights	0.864		
Employees record and store newly acquired knowledge for future reference	0.732		
We thoroughly grasp the opportunities new external knowledge offers our firm	0.726		
Our firm has difficulty implementing new knowledge to products and services effectively®	0.699		
Our firm regularly reconsiders technologies and adapts them accordant to new knowledge	0.780		
Environmental uncertainty (α = 0.787)			
Technical uncertainty (α = 0.849)			
Our industry is characterized by rapidly changing technology	0.811	0.662	0.854
It is difficult to acquire the latest technologies due to rapid technical changes	0.876		
If we don't keep up with changes in technology, it will be difficult for us to remain competitive	0.748		
Market uncertainty (α = 0.835)			
Changes in customers' product preferences are difficult to predict	0.815	0.631	0.837
It is difficult to know customers' needs	0.751		
	0.815		

Table 3 (*continued*)

Item description summary	Standardized loading	AVE	CR
It is difficult to understand competitors' strategies			
Firm performance (α = 0.908)			
Allied standardization cooperation contributes to our firm's market share	0.898	0.596	0.911
Allied standardization cooperation helps our firm generate additional profits	0.815		
Our firm's competitive advantages have been enhanced by participating in allied standardization cooperation	0.755		
Our firm's ideas are incorporated in the alliance standard(s)	0.748		
Allied standardization cooperation has created new opportunities for our firm	0.795		
Allied standardization cooperation provides an effective medium of learning exchange	0.746		
Allied standardization cooperation contributes to the knowledge accumulation of our firm	0.618		
Model fit index			
$\chi^2 = 667.216$, $p = 0.000$, χ^2/df =1.319, NFI=0.915, IFI=0.978, TLI=0.976, CFI=0.978, GFI=0.919, RMSEA=0.027			

Notes: ®: Indicates items were reverse-coded; Scale ranging from 1 (strongly disagree) to 5 (strongly agree).

factor (VIF) for all variables. All are below the threshold of 10 (maximum VIF is smaller than 2), indicating that the regression models do not exhibit multicollinearity.

Table 5 provides a hierarchical regression analysis of control variables, TSA networks (including centrality and relationship strength), absorptive capacity, environmental uncertainty, and firm performance. We introduced control variables in Model 1, which explain 12% of the variance in firm performance. Regarding the regression coefficients of control variables, we found a significant positive correlation between network size and firm performance in all models. As expected, allied firms are likely to gain more benefits from large TSA networks than small networks.

We used Model 1 and Model 2 to examine the effect of network centrality and relationship strength on firm performance. Model 1 only includes control variables. Model 2 has an R^2 of 0.180 (the adjusted R^2 is 0.163) and an F-value of 10.408 ($P < 0.001$) and adds the primary effect of network centrality and relationship strength. Allied firms may achieve greater firm performance due to the critical position they occupied within TSA networks. The results of Model 2 show that network centrality is positively correlated with firm performance ($\beta = 0.193$, $p < 0.001$). Thus, we find support for H1a. H1b is also supported, that is, relationship strength has a significant positive effect on firm performance ($\beta = 0.127$, $p < 0.01$).

To test H2, we introduced the primary effect of absorptive capacity based on Model 1 and thus obtained Model 3. Model 3 has an R^2 of 0.228 (the adjusted R^2 is 0.214) and an F-value of 15.830 ($P < 0.001$) and shows the effect of absorptive capacity on the dependent variable. The results in Model 3 indicate that absorptive capacity is positively correlated with firm performance ($\beta = 0.343$, $p < 0.001$). Hence, H2 is supported. Then, to test the moderating effect of absorptive capacity, taking firm performance as the dependent variable, we introduced network centrality, relationship strength, and absorptive capacity in turn, and finally added the interaction term based on Model 4. Model 5 has an R^2 of 0.365 (the adjusted R^2 is 0.347) and an F-value of 20.337 ($P < 0.001$) and presents the effect of the interaction term between absorptive capacity and network centrality as well as the interaction term between absorptive capacity and relationship strength on firm performance. Before the construction of the interaction term, we mean-centered the independent and moderator variables to reduce the potential effects of multicollinearity. The results indicate that the moderating effect of

Table 4
Descriptive statistics and correlation matrix.

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. Network size	1.000											
2. Alliance experience	0.577**	1.000										
3. Patents	0.149**	0.134**	1.000									
4. Industry type	0.103*	0.103*	0.015	1.000								
5. Ownership	0.112*	0.077	0.012	-0.262**	1.000							
6. Firm age	0.332**	0.328**	0.138**	-0.272**	0.291**	1.000						
7. Firm size	0.309**	0.240**	0.104*	-0.231**	0.365**	0.631**	1.000					
8. Network centrality	0.230**	0.331**	0.075	-0.014	-0.053	0.122*	0.098*	**0.755**				
9. Relationship strength	0.065	0.134**	0.044	-0.006	-0.001	0.000	0.062	0.281**	**0.746**			
10. Absorptive capacity	0.160**	0.264**	0.027	0.079	0.018	0.054	0.103*	0.217**	0.101*	**0.745**		
11. Uncertainty	0.287**	0.304**	0.011	-0.057	0.081	0.195**	0.119*	0.230**	0.082	0.222**	**0.804**	
12. Firm performance	0.281**	0.301**	-0.012	0.067	0.043	0.056	0.108*	0.300**	0.212**	0.404**	0.275**	**0.772**
Mean	1.870	3.021	1.467	0.693	0.089	3.405	3.510	3.344	3.506	3.433	3.476	3.732
S.D.	0.798	0.858	0.513	0.462	0.285	1.110	1.499	0.729	0.713	0.546	0.607	0.757

Notes: The square root of the AVE values is shown on the diagonal (in bold).
$N = 437$ allied firms.
* $p < 0.05$ level.
** $p < 0.01$ level.

Table 5
Results of regression analysis.

Variables	Dependent variable (DV): Firm performance						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Control variables							
Network size	0.168**	0.158**	0.169**	0.161**	0.169**	0.145**	0.126*
Alliance experience	0.228***	0.149**	0.138*	0.082	0.107*	0.115*	0.158**
Patents	-0.060	-0.069	-0.057	-0.065	-0.067	-0.051	-0.042
Industry type	0.018	0.038	0.000	0.017	0.006	0.012	0.019
Ownership	0.017	0.042	0.018	0.038	0.006	0.015	0.034
Firm age	-0.115	-0.098	-0.087	-0.074	-0.076	-0.101	-0.078
Firm size	0.078	0.059	0.041	0.028	0.030	0.052	0.052
Independent variables							
Network centrality		0.193***		0.148**	0.138**		
Relationship strength		0.127**		0.118**	0.121**		
Absorptive capacity			0.343***	0.314***	0.314***	0.320***	0.282***
Environmental uncertainty						0.141**	0.167***
Interaction terms							
Absorptive capacity × Network centrality					0.198***		
Absorptive capacity × Relationship strength					0.192***		
Absorptive capacity × Environmental uncertainty							0.357***
R^2	0.120	0.180	0.228	0.269	0.365	0.245	0.368
Adjusted R^2	0.106	0.163	0.214	0.251	0.347	0.229	0.354
F-value	8.378***	10.408***	15.830***	15.638***	20.337***	15.417***	24.846***

Notes: $N = 437$ allied firms.
* $p < 0.05$ level.
** $p < 0.01$ level.
*** $p < 0.001$ level.

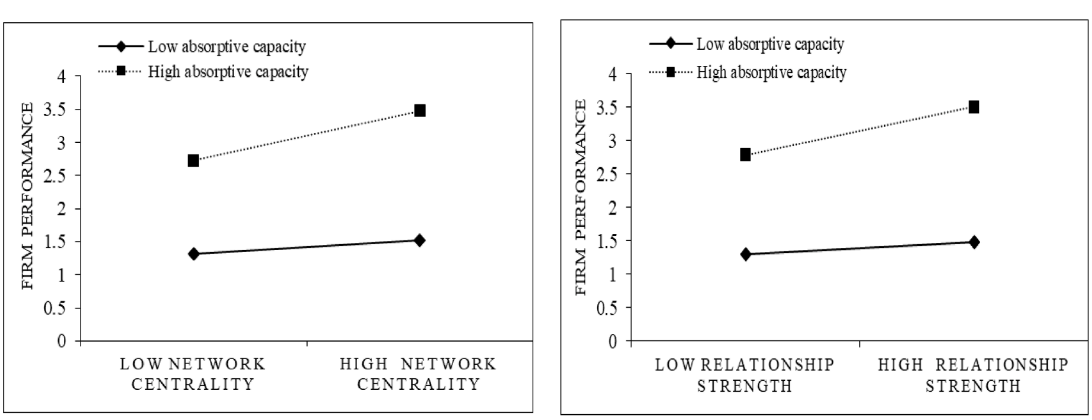

Fig. 2. The moderation of absorptive capacity.

absorptive capacity on the relationship between network centrality and firm performance is positive and significant ($\beta = 0.198$, $p < 0.001$), so H3a is supported. Similarly, absorptive capacity also has a significant positive moderating effect on the relationship between relationship strength and firm performance ($\beta = 0.192$, $p < 0.001$), supporting H3b.

To better demonstrate the moderating effect of absorptive capacity on network centrality and firm performance and the relationship between relationship strength and firm performance, we plotted their relationships as the level of absorptive capacity varies in Fig. 2. According to Fig. 2, as the absorptive capacity increases, the positive relationship between the TSA networks and firm performance becomes stronger, confirming the hypotheses. However, this relationship tends to weaken for allied firms with little absorptive capacity.

We also examined the moderating effect of environmental uncertainty on the relationship between absorptive capacity and firm performance. Given the independent variable, Model 7 included the control variables, absorptive capacity, environmental uncertainty, and the interaction term between absorptive capacity and environmental uncertainty. The R^2 for Model 7 indicates that this model explains 36.8% of the variance in the dependent variable of firm performance ($R^2 = 0.368$, adjusted $R^2 = 0.354$, F-value = 24.846, $p < 0.001$). Fig. 3 demonstrates that the moderating effect of environmental uncertainty on the relationship between absorptive capacity and firm performance is positive and significant ($\beta = 0.357$, $p < 0.001$), providing support for H4. As the extent of uncertainty increases, the positive effect of firms' absorptive capacity on its performance is strengthened.

Given that the data are from multiple regions in China, we further test the robustness of the results by area-specific differences (developed/underdeveloped). In Table 6, grouping regression results shows that the relationship between TSA networks and firm performance varies in different regions. In developed regions, network centrality and relationship strength have a significant positive effect on firm performance ($\beta = 0.183$, $p < 0.01$; $\beta = 0.152$, $p < 0.01$). However, this relationship is not significant in underdeveloped regions ($\beta = 0.105$, $p > 0.05$; $\beta = 0.111$, $p > 0.05$). Thus, firms in developed regions can better mobilize network resources to serve standardization and achieve superior performance.

5. Discussion and implications

Firms increasingly participate in TSAs to jointly develop common standards. This should be beneficial for the participating company. However, in standardization practice, not all firms can achieve the intended benefits. From the extant standardization literature, it is difficult to know which factors contribute to achieving better firm-level

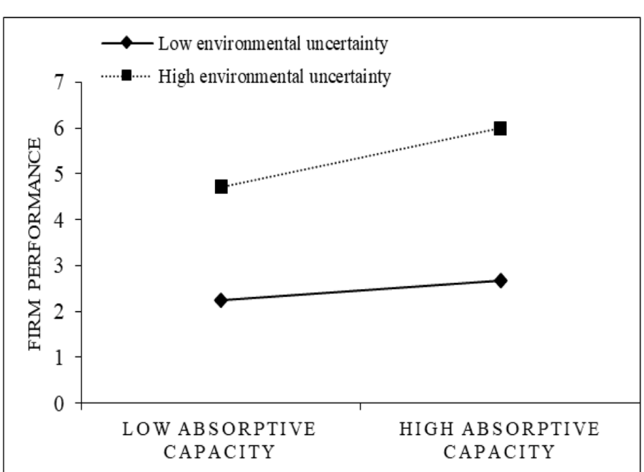

Fig. 3. The moderation of environmental uncertainty.

Table 6
Results of grouping regression analysis.

Variables	Dependent variable (DV): Firm performance			
	Developed region		Underdeveloped region	
	Model 8	Model 9	Model 10	Model 11
Control variables				
Network size	0.188*	0.139*	0.124	0.174*
Alliance experience	0.204**	0.066	0.277**	0.112
Patents	-0.050	-0.029	-0.066	-0.097
Industry type	0.033	0.019	-0.002	0.008
Ownership	0.072	0.090	-0.095	-0.066
Firm age	-0.087	-0.025	-0.155	-0.115
Firm size	0.072	0.034	0.090	0.007
Independent variables				
Network centrality		0.183**		0.105
Relationship strength		0.152**		0.111
Absorptive capacity		0.290***		0.335***
R^2	0.132	0.302	0.124	0.254
Adjusted R^2	0.107	0.273	0.089	0.211
F-value	5.299***	10.412***	3.569**	5.918***

Notes: N (Developed region) =252 allied firms, N (Underdeveloped region) =185 allied firms.
* $p < 0.05$ level.
** $p < 0.01$ level.
*** $p < 0.001$ level.

outcomes from participating in standardization. Seeking empirical evidence from participating firms, this paper examines the influence of participation in a TSA network and the role within this network on firm performance while exploring the mechanism of absorptive capacity and environmental uncertainty in this link. By doing so, this paper extends network literature to the field of standardization. It provides empirical evidence for better firm performance due to participation in standardization. These empirical findings from China confirm the literature that has mostly studied a Western context. This suggests the generalizability of our findings, including additional factors that influence company benefits from participation in TSA networks.

5.1. Theoretical implications

This study finds a positive correlation between participation and firm performance. This confirms at form level what earlier research (e.g., Blind and Mangelsdorf, 2016; Wakke et al., 2015, 2016) found at macro-economic level. Firm-level studies are needed because of the huge diversity between firms and their objectives, and between standards. Therefore, we asked the respondents about the achievement of their firm's goals and objectives. We took a network and found that firms closer to the center of a TSA network can take advantage of this influential position to better achieve their targeted alliance goals. Wen et al. (2020) and Van de Kaa (2018) took a network perspective as well. Wen et al. (2020) focus on market introduction rates and time to market only. Van de Kaa's (2018) unit of analysis is the TSA (in his terms: the individual standards organization). He relates this to the firm level by means of board positions in the consortium. He finds that a standards organization's influential position in a TSA network (in his terms: an industry-wide standards network) positively affects the chances that its standard achieves dominance. Our results are in line with his findings that central positions in a TSA network contribute to success. However, our approach is different, including the definition of centrality, and the category of standards – his study is limited to compatibility standards that compete with other standards for acceptance in the market. Such battles do not apply to most standards. We measure success as perceived benefits at the firm level, constituted by seven items measured on a five-point scale, whereas his measure of success is related to the standards – winners or losers.

Second, we address some factors that influence the relationship between involvement in TSAs and firm performance. We find that close-knit interactions among participants within a TSA network have a positive impact. This finding is consistent with Delcamp and Leiponen (2014) and confirms the positive effects of such connections among firms shown in non-standardization literature.

Third, this paper not only demonstrates the direct positive effect of absorptive capacity on firm performance, but also the positive effect of the interaction between absorptive capacity and TSA networks on performance. This finding improves our understanding of standardization from a knowledge perspective. TSA networks enable allied firms to acquire knowledge, but its effects on performance depend on firms' capability to absorb such knowledge. Firms with strong absorptive capacity can use external knowledge sources more effectively and, as a result, achieve higher performance. In this way we extend prior standardization literature – Blind et al. (2012) and Blind and Mangelsdorf (2016) suggested that external knowledge sourcing is an important motivation for a firm to participate in standardization and identify absorptive capacity as a source for producing important organizational outcomes but they did not provide any empirical evidence. De Vries and Van Delden (2011) expounded the role of knowledge management in standardization.

Fourth, this research pays attention to the changing environmental conditions confronting an allied firm. Alignment between standardization strategy and the firm's environment is essential for a firm to improve its performance (Parnell et al., 2015). The absorption of external knowledge related to standardization has become a common basic element for allied firms to innovate and adapt in a dynamically changing environment (Slowak, 2008; Wiegmann, 2019). The pressure of environmental uncertainty may cause firms to reevaluate their resource disadvantages and seek new resources or capabilities for future standardization practices (Engelen et al., 2014; García-Sánchez et al., 2018). This paper suggests that the more uncertain the environment, the more firms benefit from active involvement in standardization. Our findings highlight the value of absorptive capacity for allied firms in developing standardization strategies to resolve high uncertainties in technology and market areas.

Finally, this study is the first to find evidence of the added value of the new category of market-driven Chinese standards. Wen et al. (2020) used older data about formal standards in China.

5.2. Managerial implications

Our findings provide several important insights for practitioners. First, participation in standardization tends to bring benefits to the company. Such participation should be well managed. Taking central positions, managing interactions in the TSA network, and strengthening external knowledge acquisition ability leads to increased benefits. A standardization committee includes a secretary, chairperson, and 'normal' members. Firms that occupy a central position, e.g., the chairperson or secretary, can increase their power to influence the contents of technical standards: a standard that better reflect their interests, enhances innovation opportunities and brings competitive advantage. These firms also are in a better position to obtain knowledge. Standardization outcomes do not only depend on the firm's position in a community but also on the strength of relationships among participants. Our findings show that a cohesive TSA network enables participants to exchange and share information and knowledge across organizational boundaries. Maintaining close cooperation with alliance partners is essential to ensure the stable operation of the TSA and its long-term development. Our findings confirm that a firm's network size positively impacts firm performance. Participation allows firms to establish extensive cooperative networks with other companies and stakeholders such as the government, scientific research institutes, universities, and conformity assessment bodies. They primarily facilitate the development of common standards together – often to enable interoperability, demonstrate certain characteristics such as quality or safety attributes, and test methods related to quality or safety. However, due to resource capacity constraints, a large TSA network may sometimes fail to help participants achieve better performance. Although firms may participate in multiple TSAs, they should maintain a limited number of valuable networks to avoid distraction.

Second, the higher the absorptive capacity, the better the performance. It thus makes sense to improve absorptive capacity. This capacity is closely related to the efficient utilization of knowledge obtained from external sources, which can help acquire heterogeneous knowledge from the TSA network more effectively. Firms internalize knowledge from TSAs and other external sources and use it as input for their standardization cooperation and other company activities such as R&D. This knowledge dynamics may be particularly important for SMEs (Blind and Mangelsdorf, 2012; De Vries et al., 2009). Besides, firms should consider the industry characteristics of the knowledge they are exposed to in the TSA. For example, manufacturing firms in traditional sectors can choose to participate in alliances across industries, absorb advanced knowledge from high-tech industries, and provide input for the standards in their sector, thereby paving the way for industrial transformation and upgrading.

Third, firms need to place greater emphasis on the available alliance environment. The environment is uncertain, technology development and market changes bring opportunities as well as challenges. Firms must improve their perception of the external environment and formulate reasonable standardization strategies. They should rely on developing their absorptive capacity to adjust and optimize technical standards to respond to environmental changes sensitively (Xie et al., 2018). Specifically, to enter and open markets, firms should develop and promote technical standards that meet users' needs. It may also be necessary to conduct pre-normative research to provide contents for technical standards that can solve emerging problems (Gauch, 2007; Narula, 2002). So, managers should consider both external networks and internal capabilities to prepare for a firm's standardization practices.

Our empirical data relate to standardization projects in China. Most of these standards are drafted to meet the needs of a particular region or industry. The standards are voluntary. Despite this, the Chinese government supported most standard-setting cooperation projects in our sample. This can be the government at the national, provincial, or local level in the Chinese context. It thus makes sense for firms to establish and maintain close contacts with the local government to receive their assistance in the standard-setting process (e.g., funding, policies, and services). This also helps to further promote and diffuse standards. This recommendation does not necessarily apply to other countries. But due to the significant benefits, policymakers in any country should create an atmosphere conducive to standardization cooperation that encourages non-participants, including SMEs, to join TSAs and help them break down barriers to entry (De Vries et al., 2009; EIM, 2006).

5.3. Limitations and further research directions

Our approach was helpful to examine the influence of participation in TSA networks on firm performance. However, this research also has several limitations, which may provide reasons for future research.

First, our results were based on survey data collected from China's IT and automotive industry, whereas our hypotheses were developed based mainly on Western literature. As mentioned earlier, China's standards system is not the same as in other countries. However, as our hypotheses were confirmed, we assume that our findings can be generalized to other countries. Replication studies can test this.

Second, we used cross-sectional data collected in the same period, so the model cannot fully reflect the whole process of standardization cooperation. Strictly identifying the causality between variables may be limited. However, this concern can be dispelled for the following reasons: (1) The results of previous studies support the logic that TSA networks enhance standardization outcomes instead of the reverse (Wen et al., 2020); (2) The regression analysis provides convincing support for our theory. Nonetheless, further research extending the application of the model to various emerging countries or industries, using longitudinal research designs to confirm the direction of causality, may test our findings.

Third, our target sample comprised a diverse set of firms from two sectors. Each firm may have various motivations for participating in TSAs, leading to differences in standardization strategies and practices. Therefore, to better open the black box and provide more detailed evidence, future research could choose specific case companies to reveal the characteristics of their standardization practices. A comparative multiple case study addressing both participants and non-participants could yield interesting results.

Fourth, this study examined the role of absorptive capacity between TSA networks and firm performance at an internal level. However, we can reasonably expect that other factors may affect the network-performance relationship as well. For example, organizations need to seek stakeholder support and approval, so legitimacy may be needed to get standards that are acceptable in the market and acceptable to authorities, and this could help to make the firm's innovative products acceptable. At the individual level, managers' leadership styles and participant characteristics may also affect standardization cooperation outcomes.

6. Conclusions

The purpose of this paper was to study the firm-level effects of participation in standardization depending on network centrality and relationship strength. We added absorptive capacity and environmental uncertainty as moderating factors. Through survey data collected from 437 IT and automotive firms in China, we found a positive relationship between participation and firm performance. However, this depends on two aspects of TSA networks: centrality and relationship strength.

TSA networks also provide a platform for allied firms to access external knowledge resources. Our findings indicate that the firm's absorptive capacity can positively influence firm performance, both directly and via its participation in TSAs. These relationships depend on the level of environmental uncertainty. Absorbing external knowledge in a turbulent environment reduces the risks, improves the effectiveness of standardization cooperation, and increases firm performance. Furthermore, the positive effect of participation in TSA networks on firm performance is enhanced through increased absorptive capacity: an allied firm with higher absorptive capacity is more likely to benefit from standardization cooperation.

CRediT authorship contribution statement

Yuhao Wu: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Visualization, Project administration. **Henk J. de Vries:** Validation, Writing – review & editing, Supervision.

Acknowledgement

This research was supported by the National Natural Science Foundation of China (#71774067).

References

Ariño, A., 2003. Measures of strategic alliance performance: an analysis of construct validity[J]. J. Int. Bus. Stud. 34 (1), 66–79.
Axelrod, R., Mitchell, W., Thomas, R.E., et al., 1995. Coalition formation in standard-setting alliances[J]. Manag. Sci. 41 (9), 1493–1508.
Baloglu, S., Nayar, A., Beldona, S., 2010. Interoperability and open travel alliance standards: strategic perspectives[J]. Int. J. Contemp. Hospitality Manag. 22 (7), 1010–1032.
Blind, K., De Vries, H., Mangelsdorf, A., 2012. External knowledge sourcing and involvement in standardization-Evidence from the community innovation survey[C]. In: International Technology Management Conference. IEEE, pp. 1–9.
Blind, K., Mangelsdorf, A., 2012. Alliance formation of SMEs: empirical evidence from standardization committees[J]. IEEE Trans. Eng. Manag. 60 (1), 148–156.
Blind, K., Mangelsdorf, A., 2016. Motives to standardize: empirical evidence from Germany[J]. Technovation 48, 13–24.
Blind, K., Petersen, S.S., Riillo, C.A., 2017. The impact of standards and regulation on innovation in uncertain markets[J]. Res. Policy 46 (1), 249–264.
Caner, T., Sun, J., Prescott, J.E., 2014. When a firm's centrality in R&D alliance network is (not) the answer for invention: the interaction of centrality, inward and outward knowledge transfer[J]. J. Eng. Technol. Manag. 33, 193–209.
Chellappa, R., Saraf, N., 2000. Standards and alliances in non-standardized software industries[J]. In: AMCIS 2000 Proceedings, p. 362.
Christoffersen, J., Plenborg, T., Robson, M.J., 2014. Measures of strategic alliance performance, classified and assessed[J]. Int. Bus. Rev. 23 (3), 479–489.
Chu, Z., Xu, J., Lai, F., et al., 2018. Institutional theory and environmental pressures: the moderating effect of market uncertainty on innovation and firm performance [J]. IEEE Trans. Eng. Manag. 65 (3), 392–403.
Coad, A., Segarra, A., Teruel, M., 2013. Like milk or wine: does firm performance improve with age? [J]. Structural Change and Econ. Dynamics 24, 173–189.
Cohen, S.K., Caner, T., 2016. Converting inventions into breakthrough innovations: the role of exploitation and alliance network knowledge heterogeneity[J]. J. Eng. Technol. Manag. 40, 29–44.
Cohen, W.M., Levinthal, D.A., 1990. Absorptive capacity: a new perspective on learning and innovation[J]. Adm. Sci. Q. 35 (1), 128–152.
Das, T.K., Teng, B.S., 2003. Partner analysis and alliance performance[J]. Scandinavian J. Manag. 19 (3), 279–308.
Delcamp, H., Leiponen, A., 2014. Innovating standards through informal consortia: the case of wireless telecommunications[J]. Int. J. Ind. Organization 36, 36–47.
Dess, G.G., Robinson Jr., R.B., 1984. Measuring organizational performance in the absence of objective measures: the case of the privately-held firm and conglomerate business unit[J]. Strategic Manag. J. 5 (3), 265–273.
De Vries, H.J., 2006. Standards For Business – How Companies Can Profit from Participation in International Standards setting[M]. Standardization as a strategic tool, Geneva, Switzerland: IEC, pp. 131–141.
De Vries, H.J., Blind, K., Mangelsdorf, A., et al., 2009. SME access to European standardization[J]. Enabling Small and Medium Sized Enterprises to Achieve Greater Benefit from Standards and from Involvement in Standardization. Rotterdam School of Management, Erasmus University.
De Vries, H.J., Simons, J., 2006. Effectiveness of participation in standardisation[J]. Synthesis J. 15–20.
De Vries, H.J., Van Delden, M., 2011. Standardisation and knowledge management in services[J]. J. Standards and Standardization 1 (1), 70–78.
De Vries, H.J., Verhagen, W.P., 2016. Impact of changes in regulatory performance standards on innovation: a case of energy performance standards for newly-built houses[J]. Technovation 48, 56–68.
De Vries, H.J., Verheul, H., Willemse, H., 2003. Stakeholder identification in IT standardization processes[C]. In: Proceedings of the Workshop on Standard Making: A Critical Research Frontier for Information Systems. Seattle, WA, pp. 12–14.
De Vries, H.J., Veurink, J.L., 2017. Cost-benefit analysis of participation in standardization: developing a calculation tool[J]. Int. J. Standardization Res. 15 (1), 1–15.
De Vries, H.J., Wiegmann, P.M., 2017. Impact of service standardization on service innovation. In: Hawkins, R, Blind, K, Page, R (Eds.), Handbook of Standards and Innovation. Edward Elgar, Cheltenham, UK /Northampton, MA:, pp. 187–211.
Egyedi, T.M., 2001. Beyond consortia, beyond standardisation? New Case Material and Policy Threads. Delft University of Technology, Delft.
EIM. SMEs and standardisation in Europe –23 good practices to promote the participation of craft and SME enterprises in standardization and the use of standards. Zoetermeer, the Netherlands: EIM Business & Policy Research, 2006.
Eisingerich, A.B., Bell, S.J., Tracey, P., 2010. How can clusters sustain performance? The role of network strength, network openness, and environmental uncertainty[J]. Res. Policy 39 (2), 239–253.
Engelen, A., Kube, H., Schmidt, S., et al., 2014. Entrepreneurial orientation in turbulent environments: the moderating role of absorptive capacity[J]. Res. Policy 43 (8), 1353–1369.
Farrell, J., Simcoe, T., Barbara, S., et al., 2012. Choosing the rules for consensus standardization[J]. RAND J. Econ. 43 (2), 905–930.
Flatten, T.C., Greve, G.I., Brettel, M., 2011. Absorptive capacity and firm performance in SMEs: the mediating influence of strategic alliances[J]. Eur. Manag.Rev. 8 (3), 137–152.
Flor, M.L., Cooper, S.Y., Oltra, M.J., 2018. External knowledge search, absorptive capacity and radical innovation in high-technology firms[J]. Eur. Manag.J. 36 (2), 183–194.
Freeman, L.C., 1979. Centrality in social networks: conceptual clarification [J]. Soc Networks 1 (3), 215–239.
García-Sánchez, E., García-Morales, V.J., Martín-Rojas, R., 2018. Analysis of the influence of the environment, stakeholder integration capability, absorptive capacity, and technological skills on organizational performance through corporate entrepreneurship[J]. Int. Entrepreneurship and Manag. J. 14 (2), 345–377.
Gauch, S., 2007. INTEREST: integrating research and standardisation[J]. Int. J. IT Standards & Standardization Res. 5 (2), 50–52.
Gilsing, V.A., Cloodt, M., Bertrand–Cloodt, D., 2016. What makes you more central? Antecedents of changes in betweenness-centrality in technology-based alliance networks[J]. Technol. Forecasting Social Change 111, 209–221.
Gkypali, A., Arvanitis, S., Tsekouras, K., 2018. Absorptive capacity, exporting activities, innovation openness and innovation performance: a SEM approach towards a unifying framework[J]. Technol. Forecasting Social Change 132, 143–155.

Granovetter, M.S., 1973. The strength of weak ties[J]. Am. J. Sociol. 78 (6), 1360–1380.
Grant, R.M., 2015. Knowledge-Based View[J]. Wiley Encyclopedia of Management, pp. 1–2.
Gravier, M.J., Randall, W.S., Strutton, D., 2008. Investigating the role of knowledge in alliance performance[J]. J. Knowledge Manag. 12 (4), 117–130.
Hesser, W., Feilzer, A.J., De Vries, H.J., 2010. Standardisation in Companies and markets [M]. Helmut Schmidt University, Hamburg, pp. 448–449.
Hoffmann, V.H., Trautmann, T., Hamprecht, J., 2009. Regulatory uncertainty: a reason to postpone investments? Not necessarily[J]. J. Manag. Stud. 46 (7), 1227–1253.
Hurd, J., Isaak, J., 2008. IT standardization: the billion dollar strategy. In: Jakobs, : K (Ed.), Standardization Research in Information technology: New Perspectives. Hershey, PA /London: Information Science Reference, pp. 20–26.
Jalonen, H., 2011. The uncertainty of innovation: a systematic review of the literature [J]. J. Manag. Res. 4 (1), E12.
Kamps, X., De Vries, H., Van de Kaa, G., 2017. Exploring standards consortium survival in high tech industries: the effects of commitment and internal competition[J]. Comput. Standards & Interfaces 52, 105–113.
Keil, T., 2002. De-facto standardization through alliances—Lessons from Bluetooth[J]. Telecomm. Policy 26 (3–4), 205–213.
Kenis, P., Knoke, D., 2002. How organizational field networks shape interorganizational tie-formation rates[J]. Acad. Manag. Rev. 27 (2), 275–293.
Kwak, J., Lee, H., Fomin, V.V., 2011. Government coordination of conflicting interests in standardisation: case studies of indigenous ICT standards in China and South Korea [J]. Technol. Anal. Strategic Manag. 23 (7), 789–806.
Lai, H.C., Weng, C.S., 2013. The effects of technological knowledge distance, network centrality and complementary assets[J]. Asian J. Technol. Innovation 21 (1), 136–152.
Lee, J., Kim, S., 2011. Exploring the Role of Social Networks in Affective Organizational commitment: Network centrality, Strength of ties, and Structural holes[J], 41. American Review of Public Administration, pp. 205–223.
Lee, W.L., 2014. Environmental uncertainty affects inter-organisational partner selection: the mediating role of cost and strategy in alliance motivations among SMEs[J]. J. Manag. Organization 20 (1), 38–55.
Leiponen, A.E., 2005. Clubs and standards: the role of industry consortia in standardization of wireless telecommunications[R]. ETLA Discussion Papers.
Leiponen, A.E., 2008. Competing through cooperation: the organization of standard setting in wireless telecommunications[J]. Manag. Sci. 54 (11), 1904–1919.
Lin, C., Wu, Y.J., Chang, C.C., et al., 2012. The alliance innovation performance of R&D alliances—The absorptive capacity perspective[J]. Technovation 32 (5), 282–292.
Liu, X., Zhao, H., Zhao, X., 2018. Absorptive capacity and business performance: the mediating effects of innovation and mass customization [J]. Ind. Manag. Data Syst. 118 (9), 1787–1803.
Lu, L.Y.Y., Yang, C., 2004. The R&D and marketing cooperation across new product development stages: an empirical study of Taiwan's IT industry[J]. Ind. Mark. Manag. 33 (7), 593–605.
Lunnan, R., Haugland, S.A., 2008. Predicting and measuring alliance performance: a multidimensional analysis[J]. Strategic Manag. J. 29 (5), 545–556.
Macaulay, C.D., Richard, O.C., Peng, M.W., et al., 2018. Alliance network centrality, board composition, and corporate social performance[J]. J. Bus. Ethics 151 (4), 997–1008.
Maggetti, M., Gilardi, F., 2011. The policy-making structure of European regulatory networks and the domestic adoption of standards[J]. J. Eur. Public Policy 18 (6), 830–847.
Marsden, P.V., Campbell, K.E., 2012. Reflections on conceptualizing and measuring tie strength[J]. Social Forces 91 (1), 17–23.
Menon Economics, 2018. The Influence of Standards On the Nordic economies. Menon Publication, Oslo: Menon Economics, 31/.
Milliken, F.J., 1987. Three types of perceived uncertainty about the environment: state, effect, and response uncertainty[J]. Acad. Manag. Rev. 12 (1), 133–143.
Muthusamy, S.K., White, M.A., 2006. Does power sharing matter? The role of power and influence in alliance performance[J]. J. Bus. Res. 59 (7), 811–819.
Narula, R., 2002. R&D collaboration by SMEs: new opportunities and limitations in the face of globalization[J]. Technovation 24 (2), 153–161.
Newbert, S.L., 2008. Value, rareness, competitive advantage, and performance: A conceptual-level empirical investigation of the resource-based view of the firm[J]. Strategic Manag. J. 29 (7), 745–768.
Oshri, I., Weeber, C., 2006. Cooperation and competition standards-setting activities in the digitization era: the case of wireless information devices[J]. Technol. Anal. Strategic Manag. 18 (2), 265–283.
Parnell, J.A., Long, Z., Lester, D., 2015. Competitive strategy, capabilities and uncertainty in small and medium sized enterprises (SMEs) in China and the United States[J]. Manag. Decision 53 (2), 402–431.
Phelps, C.C., 2010. A longitudinal study of the influence of alliance network structure and composition on firm exploratory innovation[J]. Acad. Manag. J. 53 (4), 890–913.
Podsakoff, P.M., MacKenzie, S.B., Lee, J.Y., et al., 2003. Common method biases in behavioral research: a critical review of the literature and recommended remedies [J]. J. Appl. Psychol. 88 (5), 879–903.
Ranganathan, R., Rosenkopf, L., 2014. Do ties really bind? The effect of knowledge and commercialization networks on opposition to standards[J]. Acad. Manag. J. 57 (2), 515–540.
Roca, J.B., O'Sullivan, E., 2020. The role of regulators in mitigating uncertainty within the Valley of Death[J]. Technovation, 102157.
Roy, A., Walters, P.G.P., Luk, S.T.K., 2001. Chinese puzzles and paradoxes: conducting business research in China[J]. J. Bus. Res. 52 (2), 203–210.
Santoro, G., Bresciani, S., Papa, A., 2018. Collaborative modes with cultural and creative industries and innovation performance: the moderating role of heterogeneous sources of knowledge and absorptive capacity[J]. Technovation 58 (8), 1980–1992.
Sarkar, M.B., Echambadi, R., Cavusgil, S.T., et al., 2001. The influence of complementarity, compatibility, and relationship capital on alliance performance [J]. J. Acad. Mark. Sci. 29 (4), 358–373.
Bargaining norms, arguing standards. In: Schueler, J, Fickers, A, Hommels, A. (Eds.), 2008. The Hague: STT Netherlands Study Centre for Technology Trends.
Simonin, B.L., 1997. The importance of collaborative know-how: an empirical test of the learning organization[J]. Acad. Manag. J. 40 (5), 1150–1174.
Slowak, A., 2008. Standard-setting capabilities in industrial automation: a collaborative process[J]. J. Innovation Econ. Manag. (2), 147–169.
Song, L., Augustine, D., Yang, J.Y., 2016. Environmental uncertainty, prospector strategy, and new venture performance: the moderating role of network capabilities [J]. Int. Entrepreneurship and Manag. J. 12 (4), 1103–1126.
Srivastava, M.K., Gnyawali, D.R., Hatfield, D.E., 2015. Behavioral implications of absorptive capacity: the role of technological effort and technological capability in leveraging alliance network technological resources[J]. Technol. Forecasting & Social Change 92, 346–358.
Srivastava, P., Frankwick, G.L., 2011. Environment, management attitude, and organizational learning in alliances[J]. Manag. Decision 49 (1), 156–166.
Su, Z., Xie, E., Peng, J., 2010. Impacts of environmental uncertainty and firms' capabilities on R&D investment: evidence from China[J]. Innovation 12 (3), 269–282.
Tamura, S., 2015. Who participates in de jure standard setting in Japan? The analysis of participation costs and benefits[J]. Innovation Organization & Manag. 17 (3), 400–415.
Townsend, J.D., 2003. Understanding alliances: a review of international aspects in strategic marketing[J]. Mark. Intelligence & Plann.
Traub, M., Maier, A., Barbehön, K.L., 2017. Future automotive architecture and the impact of IT trends[J]. IEEE Software 34 (3), 27–32.
Tsai, W., 2001. Knowledge transfer in intraorganizational networks: effects of network position and absorptive capacity on business unit innovation and performance[J]. Acad. Manag. J. 44 (5), 996–1004.
Van de Kaa, G., 2018. The influence of network structure on standard dominance[J]. R&D Manag. 48 (4), 438–446.
Van de Kaa, G., Van den Ende, J., De Vries, H.J., et al., 2011. Factors for winning interface format battles: a review and synthesis of the literature[J]. Technol. Forecasting & Social Change 78 (8), 1397–1411.
Van den Ende, J., Van de Kaa, G., Den Uijl, S., et al., 2012. The paradox of standard flexibility: the effects of co-evolution between standard and interorganizational network[J]. Organization Stud. 33 (5–6), 705–736.
Wakke, P., Blind, K., De Vries, H.J., 2015. Driving factors for service providers to participate in standardization: insights from the Netherlands[J]. Ind. Innovation 22 (4), 299–320.
Wakke, P., Blind, K., Ramel, F., 2016. The impact of participation within formal standardization on firm performance[J]. J. Productivity Anal. 45 (3), 317–330.
Wang, M.C., Chen, P.C., Fang, S.C., 2018. A critical view of knowledge networks and innovation performance: the mediation role of firms' knowledge integration capability[J]. J. Bus. Res. 88, 222–233.
Wen, J., Qualls, W.J., Zeng, D., 2020. Standardization alliance networks, standard-setting influence, and new product outcomes[J]. J. Product Innovation Manag. 37 (2), 138–157.
Wiegmann, P.M., 2019. Managing Innovation and standards: A case in the European heating industry[M]. Palgrave Macmillan Ltd, Basingstoke.
Williams, R., Graham, I., Jakobs, K., et al., 2011. China and global ICT standardisation and innovation[J]. Technol. Anal. Strategic Manag. 23 (7), 715–724.
Xie, X., Fang, L., Zeng, S., 2016. Collaborative innovation network and knowledge transfer performance: a fsQCA approach[J]. J. Bus. Res. 69 (11), 5210–5215.
Xie, X., Zou, H., Qi, G., 2018. Knowledge absorptive capacity and innovation performance in high-tech companies: a multi-mediating analysis[J]. J. Bus. Res. 88, 289–297.
Zahra, S.A., George, G., 2002. Absorptive capacity: a review, reconceptualization, and extension[J]. Acad. Manag. Rev. 27 (2), 185–203.
Zollo, M., Reuer, J.J., Singh, H., 2002. Interorganizational routines and performance in strategic alliances[J]. Organization Sci. 13 (6), 701–713.

Henk J. de Vries is Professor of Standardization Management at the Rotterdam School of Management, Erasmus University, and Visiting Professor at Delft University of Technology, Faculty of Technology, Policy and Management. His-research and teaching focus on standardization from a business point of view. Until recently Henk was President of the European Academy for Standardization EURAS. He is (co-)author of more than 400 publications in the field of standardization. The International Organization for Standardization ISO rewarded his education about standardization as best in the world. See http://www.rsm.nl/hdevries.

Yuhao Wu, Ph.D., graduated from Jilin University, China, Business Administration. Before that, he was a Guest Researcher at the Rotterdam School of Management, Erasmus University. He is currently a lecturer at the School of Economics and Management of Weifang University. His-research interests include standardization management, technological innovation and management, and knowledge management.