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Technical Standards Alliance Networks and Firm Performance: The Role of Knowledge Absorptive Capacity and Environmental Uncertainty – A Literature Review

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Abstract: *Firms tend to promote inter-organizational collaboration in standardization through standards alliances. In standardization cooperation, technical standards alliances (TSAs) networks serve as a collection of TSAs between stakeholders organized for a common goal: the development, revision and promotion of technical standards together, which helps firms gain external knowledge and increase their influence on the standard-setting process. However, although TSAs qualify as a specific form of strategic alliances, most available studies on alliance networks focus on other strategic alliances rather than this context. In order to fill this gap, a comprehensive literature review is undertaken to integrate social network theory, organizational learning theory and the knowledge-based view in this paper. We introduce knowledge absorptive capacity and environmental uncertainty into the relationship between TSA networks and firm performance. By analyzing the relationship between these variables, we put forward four research hypotheses and construct a conceptual framework.*

Keywords: technical standards alliances, alliance networks, knowledge absorptive capacity, environmental uncertainty, firm performance, literature review

1 Introduction

As the cost and complexity of innovation increase, firms tend to promote inter-organizational collaboration in standardization through standards alliances (Kamps et al., 2017). In recent decades, standardization studies have highlighted the benefits of a firm's involvement in technical standards alliances (TSAs) (Blind and Mangelsdorf, 2012; De Vries and Veurink, 2017). Through cooperating with other stakeholders to draft a common standard, a firm can better meet its own standard-related needs, share and gain knowledge (Kamps et al., 2017), get access to markets (Blind and Mangelsdorf, 2016), and learn from other participants (Wakke et al., 2015; Blind and Mangelsdorf, 2012), thereby not only increasing its competitiveness, but also influencing the interoperability, quality and safety enabled by technical standards towards its own preferred specifications (De Vries, 2013). As a collection of TSAs between stakeholders organized for common goals (De Vries, 2006), a successful TSA network is supposed to serve as a fruitful platform for standard-setting cooperation so that a firm can access external sources of knowledge relevant for innovation (Blind et al., 2012).

Standardization is a coordination mechanism (Kwak et al., 2011). The firm's TSA network covers a set of relationships formed by cooperation among stakeholders included in the development, revision and promotion of technical standards (De Vries et al., 2003). By

developing standards or technical specifications for open use, technology and market developments in specific areas could be coordinated. Essentially, most standards are socially constructed during complex and lengthy interactions, and firm performance could be better understood by examining embedded network relationships (Van den Ende et al., 2012). Alliance members with similar interests contribute the knowledge they possess in standardization process and articulate their preferences in the design of technical standards. Despite a set of impressive results, effectiveness of alliances management has aroused increasingly attention (Gomes et al., 2016), because sometimes technical standards developed by a TSA failed to provide proper solutions to the matching problems.

A TSA qualifies as a specific form of a strategic alliance (Blind and Mangelsdorf, 2016). However, most available studies on alliance networks focus on other strategic alliances such as R&D alliances, industry-university-research alliances and technology alliances (e.g. Cohen and Caner, 2016; Rojas et al., 2018; Phelps, 2010), rather than TSAs. It is unclear to which extent theory developed for alliances also applies to TSAs. In this way, there is still an important literature gap surrounding the research context of alliance networks. Specifically, the issue how a firm's TSA network shapes its performance is still a largely untapped territory, which requires further studies to expand network research to the TSAs situation. Most available standardization studies aim at macro or meso perspective instead of micro-level, such as partnering firms, and at a positive impact of standards rather than evaluating participation in standards development (De Vries and Veurink, 2017). Also, there is limited empirical evidence that reveals the antecedents of a participating firm's performance, merely verifying the direct impact of other alliance networks on firm performance (e.g. Lee and Kim, 2011; Xie et al., 2016). Thus, this study tries to fill these gaps by examining the mechanism of a TSA network's impact on performance at the firm level.

Some recent studies have taken a knowledge-based view (KBV) in their strategic alliances research (Grant, 2015). In the KBV, as the importance of internal R&D activities is declining, the acquisition and utilization of external knowledge resources are often associated with the improvement of organizational performance (Martin and Javalgi, 2019). On this basis, many studies focus on knowledge absorptive capacity (e.g. Santoro et al., 2018; Gkypali et al., 2018), which contributes to the accumulation of knowledge within a firm (Pedro et al., 2018), and this may be relevant to TSAs as well (Blind and Mangelsdorf, 2012). In particular, firms embedded in networks can gain access to knowledge and technology from alliance partners, this has been a focus in network studies. In TSA networks, influencing standard-setting is core but acquiring knowledge from other involved stakeholders is another important reason to participate (Blind and Mangelsdorf, 2016). For both, knowledge absorptive capacity is important (Tsai, 2001). Higher levels of knowledge absorptive capacity help a firm identify and gather knowledge resources from partners more efficiently (Andrawina et al., 2009). Recent research addresses the consequences of knowledge absorptive capacity (Xie et al., 2018), but it fails to reveal its role between alliance networks and firm performance. Therefore, this paper incorporates such capacity into the mechanism of how a firm's TSA network affects its performance, and explores whether it plays a moderating role. Inter alia, it partly explains why participants who are exposed to the same external knowledge resources within a network differ in the benefits they get.

At the beginning of a standardization, project the standard's contents is uncertain, not only because of the process within the committee but also due to technical and market developments competition outside the network. Therefore, environmental uncertainty is expected to play a moderating role in the inter-organizational collaboration (Krishnan et al., 2016). An organization's capabilities (such as marketing, technology, learning, and operation capability) and success rely on the external environment (Su et al., 2010). Technical standards

determined by a TSA are expected to decrease the risks of technology and market (Blind and Mangelsdorf, 2016), so technical standards should be kept in line with market requirements (Keil, 2002). During the standardization trajectory, the pressure of environmental uncertainty is likely to promote a firm's motivation to re-evaluate its resource disadvantages and seek unique resources and capabilities for future actions. Hence, the relationship between knowledge absorptive capacity and firm performance is inevitably affected by environmental uncertainty, which necessitates organizational flexibility (Luo and Yu, 2016).

Following this reasoning, this study examines the relationship between the TSA network and firm performance by discussing the role of knowledge absorptive capacity and environmental uncertainty. Theoretically, we integrate social network theory, organizational learning theory and the knowledge-based view, introducing knowledge absorptive capacity and environmental uncertainty into the relationship between the TSA network and firm performance, in order to build an integrated theoretical framework of the TSA with internal and external linkages. We take a process perspective on the impact of the TSA network on firm performance, which will deepen and broaden the research context of alliance networks to TSAs. Practically, our research may help firms explore and exploit heterogeneous knowledge resources from other stakeholders within a TSA network, and cultivate a more trusting and shared relationship among alliance members by learning from each other, providing guidelines for a firm to better achieve its goals/objectives in standardization cooperation.

The remainder of the paper is organized as follows. Section 2 presents a review of related literature on general alliances and TSAs in order to provide theoretical evidence in favor of the role of alliance networks in this context. Then, through analyzing the relationship between variables, several research hypotheses are proposed. The paper concludes with the study conclusions of policy and managerial implications in Section 3.

2 Literature Review and Research Hypotheses

2.1 Literature on the Alliance in General

In the past decades, the attention for networks has gradually increased in business practice as well as in the literature. Strategic alliances have become popular in an environment where rapid access to the latest technologies and emerging markets is more important than ever (Lin and Darnall, 2015), referring to the interfirm cooperative agreements characterized by the commitment to pursue a mutual goal that requires the pooling of their resources and activities (Das and Teng, 2003; Grant and Baden-Fuller, 2004). In forging direct inter-organizational relationships with partners, a firm becomes part of strategic alliances, and reduced transaction cost is an insufficient reason to explain this phenomenon (Eisenhardt and Schoonhoven, 1996). Beyond that, alliance networks enable a firm to seek heterogeneous resources, to reduce search costs for alliance partners, and to develop a new technology (Gomes et al., 2016) since joining an alliance network helps a firm with different knowledge stock levels to learn external knowledge and skills from other interested participants. Thus, there is increasing recognition that strategic alliance networks play a key role in achieving superior firm performance, some scholars even see networks among stakeholders as the main determinant of firm performance (Macaulay et al. 2018).

Taking networks of R&D alliance as an example, Caner et al. (2014) developed an interactive model around knowledge transfer, centrality in R&D alliance networks, and innovation output. Using panel data from 287 biopharmaceutical firms, it was confirmed that the center-invention output depends on the level of knowledge transfer within and outside the firm. Cohen and Caner (2016) discovered that heterogeneous knowledge acquired in a firm's R&D

alliance network contributes to the number of breakthrough innovations, and involving participants with heterogeneous knowledge enhances the positive role of exploitative inventions to breakthrough innovations for a firm's production. Lin et al. (2012) pointed out that key benefits of R&D alliances are information transfer and learning. They used empirical data to confirm that R&D alliance networks provide various benefits needed for new technologies creation, and a firm with a high level of absorptive capability gains more benefits from the alliance. Rojas et al. (2018) focused on the multiplicity of R&D alliance networks, and empirical findings indicated that structural characteristics of networks have a positive impact on innovativeness.

Moreover, researchers also have focused on networks in other alliances. For instance, by investigating telecommunication equipment manufacturers, Phelps (2010) explained the impact of a firm's network structure and composition on its exploratory innovation, and network density among alliance members promotes the impact of technological diversity on exploratory innovation. Gilsing et al. (2008) described the importance of novelty creation and efficient absorption for technology-based alliances, and the role of alliance networks is analyzed in terms of technological distance, network centrality and network density. Xie et al. (2016) explored the relationship between collaborative innovation networks and knowledge transfer performance using fuzzy-set Qualitative Comparison Analysis (fsQCA), revealing the scale, connection strength and centrality of networks determine the level of knowledge transfer performance.

In brief, the previous literature explores the role of alliance networks in firm performance from a wide range of perspectives. However, the black box of the impact of alliance networks on performance has not been fully opened, and whether such benefits apply to TSAs remains unclear.

2.2 Literature on the Technical Standards Alliance

TSAs are defined as the firms develop, promote and maintain technical standards together (Blind and Mangelsdorf, 2012; Blind and Mangelsdorf, 2016; Kamps et al. 2017). Essentially, a TSA has unique features compared with other strategic alliances. First, in addition to innovation and new technology development (Gilsing et al., 2016), the main purpose of a TSA is to develop and promote technical standards (Axelrod et al., 1995). Participants are expected to contribute to this common achievement (Blind and Mangelsdorf, 2012). Second, the function of TSAs often has broader scope than other alliances. A technical standard developed by a TSA may adopt the technology innovation output from one or more technology alliances or in the form of R&D-oriented alliances and pre-competitive research alliances. Third, firms are supposed to play a key role in the standardization process. A limited number of companies and sometimes also other stakeholders develop technical standards within a TSA while a huge number of firms advocate these standards as adopters (Keil, 2002; Oshri and Weeber, 2006), covering R&D, production, inspection, sales and other fields. Sometimes there is government involvement as well, e.g. to ensure alignment between stakeholders and regulation.

Earlier studies on technology and society may help us analyze standard-setting process whereby the economic connection between organizations in the TSA is a manifestation of a social network (West, 2014) with the aim to establish an available standard to solve matching problems and obtain benefits (De Vries, 2008). Technical standards arise not only from resources that can be developed within a single company, but also from resources and capabilities possessed by other partners, and that the firm itself is linked to through a TSA, so the TSA network is formed by stakeholders (De Vries, 2006).

Technical standards setting includes several levels (e.g. international, national, industrial level), so firms may participate in one or more standard-setting alliances at these levels (Axelrod et al., 1995), although they may play a proactive role in only a few of them. Besides, cooperation is also being carried out among various TSAs to align activities and stimulate adoption of technical standards (Delcamp and Leiponen, 2014), which makes standardization processes more complex, with more diversified and overlapping stakeholders. Participants with similar or complementary capabilities and resources play different roles (such as technological or market experts, and design coordinators) within a TSA network, and focal firms provide other partners with their specification and hope that it will become the dominant standard by winning their approval (Oshri and Weeber, 2006). However, some partnering firms lack the necessary power or resources to make continuous contributions, so they may have little or no influence in the end.

TSAs are assumed to be market-oriented (Keil, 2002). Partnering firms develop and agree on specific technology specifications to benefit the interested parties. Owing to this cooperation, TSAs send positive signals about potential winners in technology and market competition, or provide access to learn how to design new services or products from partners (Lyytinen and King, 2006), so that they are able to gain knowledge spillovers and reduce costs of implementing technical standards.

Resource flow is an important driving force for firms to enter an alliance in general (Xia et al., 2018). For alliance members, networks contain a large number of heterogeneous knowledge resources (Grant and Baden‐Fuller, 2004). A TSA can be seen as a platform for knowledge exchange and sharing as well. Such knowledge is needed anyhow for developing common standards, so it is important for a firm to share knowledge and learn from each other within a TSA network, which may conduce to higher profits to be derived (Blind et al., 2012).

In standardization cooperation, a firm's technology standardization capabilities (such as R&D capability, resource capability and management capability) (Hesser et al., 2010) required to achieve the goals of a TSA are improved thanks to learning-by-doing. On the one hand, participants exchange knowledge which facilitates the implementation of these technical standards, providing value to firm performance. On the other hand, firms and other main stakeholders (such as governmental agencies, research institutes, and manufacturers) (De Vries, 2006) establish cooperative relationships characterized by mutual trust and support, thus reducing the transaction cost of technical standards development. This cooperation should result in the win-win situation of achieving respective goals (De Vries and Verhagen, 2016).

Summarizing, other alliances do not develop or disseminate standards, TSAs do. The mechanism of how a TSA network affects firm performance is not clear. This is because a TSA has its own characteristics different from other networks. We are unable to draw conclusions from the existing literature on whether the mechanism of the TSA network on organizational performance is consistent with other strategic alliances, or what differences exist. Therefore, this paper expands alliance networks literature to TSAs, and research hypotheses are proposed and verified in the following parts.

2.3 Hypotheses Development

2.3.1 TSA Networks and Firm Performance

According to social network theory, centrality and relationship strength may explain how firms capture social capital from embedded resources (Granovetter, 1973; Freeman, 1979), which is essential to inter-organizational coordination. This is expected to be relevant to

TSAs as well (Van den Ende et al., 2012). Firms occupying a central position and maintaining close connections to other participants in a TSA network have more access to external knowledge resources and achieve a better understanding of other alliance members' interests. Thus, they could have more influence in the knowledge transformation from tacit to explicit knowledge. The latter is laid down in the common standard, standards are a form of explicit knowledge (De Vries and Van Delden, 2011). The social dimension of standardization is relevant to the parties involved, who must reach consensus on a solution. That is to say, such involvement leads to solutions to matching problems that are most beneficial to participants (Slowak, 2008).

(1) Network Centrality

In general alliance literature, centrality reflects the structural positions of partnering firms in the cooperative network (e.g. Lee and Kim, 2011; Lai and Weng, 2013; Macaulay et al., 2018). Freeman (1979 defines centrality as the locations of positions or points in a network, including control, independence and activity. On this basis, Wang and Fang (2012) suggest that centrality represents the degree to which a firm has fast and independent access to other participants in the network. Caner et al. (2014) define centrality as the extent to which a focal company connects with other partnering members in the network. According to Macaulay et al., (2018), network position reflects the status, power and linkage of an alliance member in its network. They agree that centrality represents positional advantages in leadership, power and linkage.

The question is to which extent the above applies to TSAs as well. Some standardization studies indeed adopt social network analysis (Chellappa and Saraf, 2000). Standard-setting is influenced by a firm's position in a TSA network (Maggetti and Gilardi, 2011; Leiponen, 2008). We consider that centrality refers to competitive positions of the firm in a particular TSA network with quick and independent access to other firms. First, centrality may refer to its access to knowledge that is essential for the content of technical standards (Blind et al., 2012). Second, centrality may refer to the company's role in the negotiation process: the bargaining power to shape the standard according to their proprietary interests (Delcamp and Leiponen, 2014). Third, centrality refers to power to make a difference in market adoption of the standard through a better understanding of future changes (Chellappa and Saraf, 2000; Axelrod et al., 1995). It could also influence the standard's approval and the legitimacy of the standardization activities (Baloglu et al., 2010).

Companies closer to the center appear to hold more power to influence standard-setting outcomes (Delcamp, 2005; Kamps et al., 2017; Delcamp and Leiponen, 2014), this suggests that the distribution of power in a TSA network is asymmetric (Delcamp and Leiponen, 2014). Central firms with richer alliance experience tend to have specialized functions, which may provide opportunities to dominate the standard-setting activities. Compared with marginal firms, central firms are more likely to influence the standards' contents in the way most profitable to them (Blind et al., 2012; Kamps et al., 2017; Leiponen, 2008).

Centrality may have the visible form of providing the chairman or secretary of a standardization committee. (S)he has to seek a balancing of the needs of the parties involved. It can be difficult for other participants to avoid this influence. The chairman is assumed to have a neutral position, and this may hinder proposing arguments that favor his/her firm's position. However, in the case of chairman's firm that has a special interest in the standards to be developed as well, sometimes (s)he may tip the committee's balance in its direction (De Vries and Simons, 2006). In standardization committee discussions, this firm may gain more tacit knowledge as well (Wakke et al. 2015). Thus, a focal firm is positioned better to

influence the content of technical standards in line with this firm's interests better than peripheral firms.

Centrality in a TSA network for a participant may also be associated with a combination of certain knowledge and skills shared by alliance members (such as academic level, standardization expertise, strategic vision). A TSA network provides central firms with more access to unique resources, information and social connections than other members have, which, in turn, shapes a better position to provide support for partners' technical and other proposals (Slowak, 2008). Some partnering firms are in a position closer to the center than other actors because of owning patents, knowledge or technology bottlenecks (Blind et al., 2012).

Seen in this way, we assume that a central position of a firm within a TSA network may contribute to the firm's influence on standards output (the contents of standards developed by a TSA), leading to a higher firm performance (Chellappa and Saraf, 2000). Consequently, the following hypothesis is proposed:

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

(2) Network Relationship Strength

As an antecedent variable, relationship strength is associated with alliance performance. Granovetter (1973) introduces the notion of the strength of ties as the combination of four elements: time, emotional intensity, intimacy, and reciprocal services. As a social mechanism for coordinating different actors, the network relationship strength describes the ties (ranging from weak to strong) among participants. Also, relationship strength is made up of two distinct aspects, time spent in a relationship and the depth of the relationship (Marsden and Campbell, 2012). Focusing on cluster performance, Eisingerich et al. (2010) define the network strength as a function of the frequency, intensity, stability of interactions and levels of trust between cluster members.

Relationship strength is a relevant feature of social networks (Lee and Kim, 2011) so it may be relevant in TSA networks as well. Coordination between the participants is a prerequisite for fruitful standardization. In line with De Vries (2006), we argue that in a TSA network, relationship is defined as a set of linkages between firms and other manufacturers, consumers, governmental agencies, research institutes, and other stakeholders in the standard-setting process. At the TSA level, "strength" refers to the frequency of interaction (Granovetter, 1973). Based on their experience in international standardization, De Vries and Simons (2006) argue that for participants in standardization committees it is essential for being effective to attend all meetings.

The design of technical standards by alliance members emerges from co-participation ties within the TSA (Maggetti and Gilardi, 2011): a technical standard is the technical specification established in cooperation and approved by interested parties involved in the TSA network. The collaboration within a TSA network aims at a win-win outcome, which is conducive to cooperative and deliberative interactions (Maggetti and Gilardi, 2011). The formulation and promotion of technical standards requires high-frequency contribution for that purpose from alliance members (Blind and Mangelsdorf, 2012). On top of that, network relationships provide an opportunity for close R&D cooperation, rather than just develop and promote a specific standard (Delcamp, 2005). It provides participants with access to heterogeneous knowledge sources beyond the scope of a single firm (Ranganathan and Rosenkopf, 2014).

Moreover, a cohesive network may help alliance members carry strong expectations of on-going commitment, trust, and common understanding among stakeholders (Kamps et al., 2017; Baloglu et al., 2010), leading to reach an agreement in social interaction by exposing mutual independencies and obligations (Kenis and Knoke, 2002). It reduces the likelihood of opportunistic behavior among participants (Eisingerich et al., 2010). Ideally, the technical standards developed will fulfill requirements of all actors by making a consensus-based decision based on acknowledging shared goals (De Vries et al. 2017; Kamps et al., 2017). Most notably, the efficiency of standardization may be enhanced by promoting the interaction of alliance members (Delcamp and Leiponen, 2014), which has a positive impact on improving the common benefits of alliance members. These findings suggest the following hypothesis:

Hypothesis 1b: The stronger the relationship among alliance members, the better firm performance will be.

2.3.2 Knowledge Absorptive Capacity and Firm Performance

Knowledge-based resources are considered to be the most vital sources to explain firm performance (Blind and Mangelsdorf, 2012). Absorbing external knowledge has become an indispensable element in the firm's innovation and adaptation to changes in its competitive environment (Camisón and Forés, 2010; Liu et al., 2018), so knowledge absorptive capacity enhances firm performance (Flatten et al., 2011) because it enables them to leverage external relevant knowledge resources.

Cohen and Levinthal (1990) define knowledge absorptive capacity as the dynamic capacity 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. Flor et al. (2018) pointed out that knowledge absorptive capacity includes two dimensions: the potential absorptive capacity of the organization to acquire and assimilate new external knowledge, and the realized absorptive capacity of transforming and exploration new knowledge. Gkypali et al. (2018) provide empirical evidence that knowledge absorptive capacity does not only promote innovation output directly, but also enhances knowledge value through R&D cooperation. Xie et al. (2016) suggest that knowledge absorptive capacity is closely related to an enterprise's knowledge strategy, so it has a significant impact on firm performance. With the improvement of knowledge absorptive capacity, firms may gain more benefits from alliances (Lin et al., 2012).

In standardization practice, it seems difficult to find a participant with all the knowledge and skills necessary for the standardization process, because standardization is considered as a knowledge-sharing and knowledge-creating activity (Blind et al., 2012). For developing technical standards, a combination of standardization knowledge, market knowledge and technical knowledge is necessary. The participating firms use knowledge resources in preparing technical standards, and they learn from each other as well.

Participants in standardization may differ in terms of their interest but also resources, capabilities and the level of absorptive capacity differ. As a result, they will differ in the effectiveness of their participation and thus to its performance (Blind et al., 2012; Santoro et al., 2018). This performance partly relates to the standard itself – to which extent will it meet the company’s requirements – and partly relates to other corporate interests such as innovation and marketing. Accordingly, the following hypothesis is proposed:

Hypothesis 2: Increased firm’s knowledge absorptive capacity leads to increased firm performance.

2.3.3 Interaction between TSA Networks and Knowledge Absorptive Capacity

Knowledge absorptive capacity is closely related to the characteristics of social networks (Pedro et al., 2018; Jiang et al., 2018). A diverse set of knowledge resources, including all kinds of skills or experiences, enhances innovation potential (Gilsing et al., 2008). Actually, a TSA network broadens external knowledge sourcing, and provides a firm with more opportunities to facilitate its knowledge base (Srivastava et al., 2015). Participation in a network encourages firms to enhance absorptive capacity to exploit absorbed knowledge (Lin et al., 2012), and convert it into the value output of technical standards in the process of knowledge exchange.

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 companies more opportunities for collaborative learning, contributing to balance the distribution of knowledge resources among stakeholders and enabling a firm to develop cutting-edge technical standards (Jiang et al., 2018). However, strong complementarities with external knowledge sources require significant absorptive capacity to increase firms' own knowledge base through exploiting the absorbed or co-generated knowledge (Blind et al., 2012). The better a firm's knowledge absorptive capacity, the more it may apply external knowledge to standardization activities in future, increasing its corporate intelligence and improving its standardization ability (Blind et al., 2012). Therefore, the interaction between TSA networks and knowledge absorptive capacity may contribute to competitive advantages.

According to the KBV, social networks promote the creation of new knowledge between organizations (Grant, 2015). Focal firms that occupy a central position in a TSA network have more unparalleled access to new standardization-related knowledge and practices of other alliance members (Srivastava et al., 2015). Meanwhile, close connectedness among alliance members provides the benefit of acquiring external knowledge. Although a firm gains new opportunities and knowledge by connecting with other stakeholders, the knowledge is distributed unevenly within a TSA network. By establishing extensive cooperative linkages with other alliance partners, firms may further consolidate their status and power through knowledge asymmetry that allows a firm to locate itself in a knowledge-rich position (Lai and Weng, 2013). In general, TSA networks provide access to resources for the realization of alliance members' initial goals and objectives, but the outcome of knowledge transfer across organizations is different. If a partnering firm lacks enough capacity to fully absorb and utilize these new knowledge resources, they will be less able to improve their innovation performance (Wakke et al., 2015). Thus, firms with a certain level of absorptive capacity to learn, implement and disseminate new knowledge internally, are likely to apply new resources to gain more benefits (Cohen and Levinthal, 1990).

As explained above, a firm's knowledge absorptive capacity can be put down to its existing knowledge base (Gilsing et al., 2008), which includes technical specifications, commercial products, etc. A firm may be at disadvantage if it lacks sufficient absorptive capacity to internalize the generated knowledge and codify this in standards (Blind et al., 2012). It includes a lack of expertise and other resources necessary for a proper implementation of standards (De Vries et al., 2009). A partnering firm with a certain level of knowledge absorptive capacity may be likely to benefit more from the knowledge sharing, not only making active use of opportunities presented but also boosting effects of standardization (Wakke et al., 2015). Accordingly, the following hypotheses are proposed:

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 knowledge absorptive capacity than when the firm has 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 knowledge absorptive capacity than when the firm has a low absorptive capacity.

2.3.4 The Moderating Effect of Environmental Uncertainty

Environmental uncertainty is a core concept in literature on strategy and organization. Following Miller and Friesen (1983), it can be defined as the unpredictability of future events. It describes the inability to forecast fast changes, and has been recognized to be closely related to organizational performance (Wang and Fang, 2012). Two primary sources of environmental uncertainty are markets (Chu et al., 2018; Doley and Sharma, 2019) and technology (Gelderman et al., 2016; Su et al., 2010). It is difficult to anticipate these changes outside a network (Krishnan et al., 2016; Song et al., 2016).

Knowledge absorptive capacity is closely related to the external environment (Tseng et al., 2011). Knowledge created in the firms' external environment becomes the main source for them to explore and appropriate new knowledge. A firm's adaptive responses to the environment depend on their internal conditions, especially the resources they control. In a stable environment, the knowledge resources that firms pay attention to are similar to their existing knowledge base and the need to survive is less urgent. However, when environmental uncertainty is high, firms may be more active in learning about new technologies and the potential evolution of markets from external resources (Slowak, 2008), 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). Without such capacity, the firm is hardly able to enhance resources or improve responsiveness.

TSAs are associated with technology risks as well (Delcamp and Leiponen, 2014). Technical uncertainty refers to the inability of a firm to predict the trend and speed of technical change accurately, which is mainly manifested in the rapid change of technology, and new products generated by breakthroughs in the development of new technologies in the industry (Gelderman et al., 2016). Standards provide stable solutions so they mitigate risks but changes in standards are another source of uncertainty. Participation in TSAs allows firms to know about new standards from the horse's mouth, and to influence their development. This creates valuable opportunities for firm survival and development (Marhold and Kang, 2017). In a dynamic environment, firms are required to absorb more external knowledge within a network to reshape their knowledge base, so as to improve the accuracy of judging emerging opportunities to overcome technology barriers and minimize technology distance (Wakke et al., 2016).

In brief, changes offer opportunities that may enhance and extend the interorganizational network and contribute to a standard's success by modifying it (Van den Ende et al., 2012), leading to more exploration of best applications for their standards (Kamps et al., 2017). That is, superior absorptive capacity improves the firm's ability to catch opportunities proactively rather than passively in a dynamic environment. When partnering firms lack the necessary resources and skills, they have to develop a higher absorptive capacity to obtain them from the external environment in order to overcome resources constraints or take the most from opportunities. Accordingly, the following hypothesis is proposed:

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

Based on the above theoretical analysis and hypotheses, the conceptual framework of this paper is shown in Figure 1, which describes the relationship between alliance networks, knowledge absorptive capacity, environmental uncertainty and firm performance.

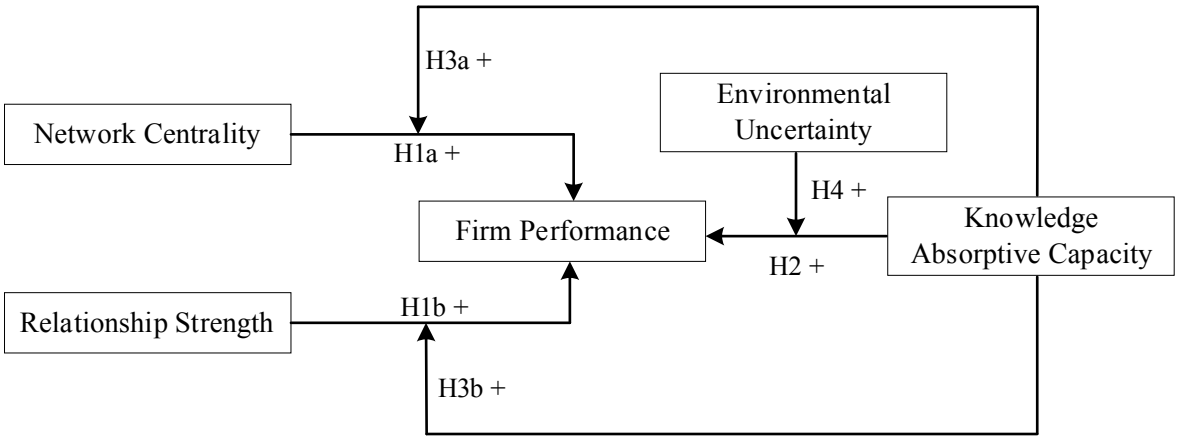

Figure 1 Conceptual framework and hypotheses.

3 Conclusion

In this paper, a theoretical model of the relationship between TSA networks, knowledge absorptive capacity, environmental uncertainty and firm performance is constructed through a comprehensive literature review. Most notably, we expand the research field of alliance networks to the TSAs context, from which we analyze the positive impact of alliance networks and knowledge absorptive capacity on firm performance, and discuss the moderating effect of knowledge absorbing capacity between alliance networks and firm performance. Besides, the moderating role of environmental uncertainty between knowledge absorptive capacity and firm performance is also revealed. Based on this, we put forward corresponding research hypotheses. The next step will be to test these empirically.

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