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## Competing Standard-Setting Organizations: A Choice Experiment

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### ABSTRACT

Standard-setting organizations (SSOs) establish goal-directed networks for innovators to jointly shape technology and markets through standards. The degree to which this can succeed depends to a large extent on network characteristics, which may differ substantially between SSOs. Many technological fields face intense competition between SSOs. Choosing the right one is thus a key strategic decision for innovators. Simultaneously, SSOs must reflect members' preferences in their network set-ups and governance. Yet, little is known about these preferences. Based on extant literature, we derive hypotheses about how three themes of network attributes (membership base, rules, transaction costs) and contextual factors drive decision makers' preferences. We conduct a comprehensive choice experiment with 141 standardization professionals in the Internet of Things field. Based on our data, we provide a more realistic indication of what firms value in SSOs than has been previously available. We also discuss our results' implications for studying networks in other contexts.

### 1. Introduction

Innovators increasingly rely on other parties, e.g., for joint technology and ecosystem development, provision of complementary goods, and technology sharing. This is especially true in contexts of complex systems and technology convergence, such as in the cases of 5G telecommunication networks and the Internet of Things (IoT). Researchers from different backgrounds highlight the importance of standards in these contexts (e.g. Blind et al., 2017; Dattée et al., 2018; Miller and Toh, 2020; Ranganathan et al., 2018; Teece, 2018, 2006; Toh and Miller, 2017). Standards are key for shaping and coordinating innovation (e.g. Toh and Miller, 2017; Wiegmann et al., 2017), for example when no "platform leader" exists in an ecosystem (Miller and Toh, 2020). Engaging in standardization therefore serves multiple important

purposes. For example, it (1) allows shaping technology development and its surrounding context (e.g. Garud et al., 2002; Jain, 2012; Leiponen, 2008; Wiegmann, 2019), (2) offers a platform for joint technology development (e.g. Garud et al., 2002; Jain, 2012; Leiponen, 2008), (3) enables access to valuable information for innovation (e.g. Blind and Mangelsdorf, 2016; Nambisan, 2013), and (4) helps legitimizing technical solutions (e.g. Botzem and Dobusch, 2012; Iversen et al., 2004; Tamm Hallström and Boström, 2010). Such benefits are reflected in the substantial resources that firms often invest in engaging in standardization (e.g. Leiponen, 2008; Ranganathan et al., 2018).

Much of this takes place in standard-setting organizations (SSOs).<sup>1</sup> Some fields of technology have one SSO as the "go-to venue" for standard development. For example, standardization related to WiFi takes place almost exclusively at IEEE-SA,<sup>2</sup> and mobile telecommunication

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<sup>1</sup> SSOs are heterogeneous and include e.g., global and national standardization committees, permanently established and ad-hoc consortia, and certain industry associations. See Section 2 for more detail.

<sup>2</sup> The Institute of Electrical and Electronics Engineers Standards Association.

standards are mostly developed at 3GPP and ETSI.<sup>3</sup> However, in many fields, there is an intensive competition between SSOs (Baron et al., 2019; Delimatsis, 2015; Teubner et al., 2021). Often, there are numerous (sometimes dozens) SSOs working on the same topics (e.g. in e-Health (European Commission, 2018a), Smart Cities (European Commission, 2018b), and the Internet of Things (IoT) (AIOTI, 2017)).<sup>4</sup> In fields that have one established SSO, this is often the result of earlier competition, such as between IEEE-SA's WiFi and ETSI's HiperLAN efforts.<sup>5</sup> If actors in such fields want to influence standards, they must thus decide which SSO to join.

These decisions are likely to be driven by contextual factors, such as the industry context and a decision-makers' firm characteristics, and especially SSOs' characteristics. Based on literature on interorganizational relationships (IORs) (Parmigiani and Rivera-Santos, 2011; Provan et al., 2007; Provan and Kenis, 2008), SSOs can be characterized by (1) their membership bases, (2) their rules, and (3) transaction costs related to participation. They vary extensively on these characteristics (e.g. Baron et al., 2019; Baron and Spulber, 2018; Delimatsis, 2015; Iversen et al., 2004; Leiponen, 2008; Teubner et al., 2021; West, 2007). These variations impact SSOs' abilities to provide effective settings for joint technology development, facilitate consensus (Ranganathan et al., 2018), and subsequently establish widely accepted standards (Wiegmann et al., 2017). This makes the selection of an SSO a critical strategic decision, which involves several tradeoffs.

Despite the choice of SSO being this critical for innovators, previous research provides limited insights on the issue. Extant work on forum shopping among SSOs (Chiao et al., 2007; Lerner and Tirole, 2006) has based its analysis on extremely simplified characterizations of SSOs that may arguably be unrecognizable in practice, and has omitted important tradeoffs in this decision. Consequently, a key aspect of the strategies to influence innovation through standardization remains poorly understood. In order to contribute towards closing this gap, we want to find out which attributes of SSOs affect managers' decisions and how this is moderated by decision makers' contexts.

To do so, we draw from the standardization and wider IOR literatures. This allows us to hypothesize about the key tradeoffs related to the three themes (membership base, rules, transaction costs) that companies need to make in selecting an SSO, and how contextual factors (decision-makers' experience, company size, the industry's knowledge intensity) affect these tradeoffs in decision making. We initially investigated our hypotheses' plausibility in a qualitative pre-test and subsequently tested them in a choice experiment with 141 standardization professionals. By examining tradeoffs in firms' strategies across competing SSOs, we directly respond to recent calls for new research on "firm strategy across competing standards" (Ranganathan et al., 2018, p. 3218) and "what draws firms to participate in standard setting via SSOs" (Miller and Toh, 2020, p. 30). Moreover, we provide new evidence on how firms engage in networks in general, thereby contributing to the literature on IORs. In Section 2 we review theory and derive our hypotheses. In Section 3, we present our qualitative pre-test, the design of our choice experiment, our sample, and the data analysis. Section 4 presents the experiment's results, followed by a concluding discussion in Section 5.

<sup>3</sup> The 3<sup>rd</sup> Generation Partnership Project and the European Telecommunications Standards Institute.

<sup>4</sup> In the IoT example, AIOTI (2017, p. 7) identifies eight application domains and a "horizontal / telecommunication" domain. The least competitive domain ("wearables") is addressed by only five major SSOs, whereas more than 20 SSOs are active in some of the other domains, and 42 SSOs work in the "horizontal / telecommunication" domain.

<sup>5</sup> We thank an anonymous reviewer for highlighting this insight and providing this example.

## 2. Theory: Tradeoffs in SSO selection

Influencing innovation can depend strongly on participating in effective SSOs. Some authors (e.g. Baron et al., 2016; Delcamp and Leiponen, 2014) distinguish between formal SSOs (e.g. ISO, ETSI) where standards are developed, and consortia where complementary activities occur. However, a recent study of 100 consortia in the telecommunications sector (Teubner et al., 2021) found that many develop standards on their own and hence also qualify as SSOs.<sup>6</sup> This is also evident from practitioner reports (e.g. AIOTI, 2017; European Commission, 2018a, 2018b), which discuss competition between SSOs and do not distinguish between consortia and formal SSOs. Managers looking to engage in standardization are thus likely to consider both formal SSOs and many consortia as viable alternatives. We therefore use the term SSO to cover both.

Existing work on forum shopping in standardization (Chiao et al., 2007; Lerner and Tirole, 2006) establishes that SSOs' characteristics (e.g., how they handle intellectual property (IP) and resolve conflicts) determine to what extent innovators can shape standards according to their preferences, but also how attractive these standards are to the market. Typically, there is a tradeoff between these two elements, e.g. standards giving too much room to particular interests may be perceived as less legitimate by potential users (e.g. Botzem and Dobusch, 2012; Tamm Hallström and Boström, 2010). Furthermore, additional tradeoffs (e.g., between access to knowledge and influence on standards) may need to be made in choosing an SSO. Yet, it remains unclear how decision makers evaluate SSOs in light of these tradeoffs.

As a foundation for assessing systematically how SSOs' characteristics cause such tradeoffs, we conceptualize SSOs as goal-directed interorganizational networks. Parmigiani and Rivera-Santos's (2011, p. 1119) taxonomy of purposefully created interorganizational relationships (IORs) defines goal-directed interorganizational networks (such as consortia and trade associations) by "the existence of multiple, intertwined partners with a many-to-many structure". SSOs also fit this definition: They are goal-directed interorganizational networks, which serve the purpose of standard and technology development. This conceptualization allows us to draw on the IOR literature's approach of analyzing networks. A similarly systematic approach is not available in the standardization literature. The IOR literature characterizes networks based on (1) their membership base (e.g., who is part of a network, what ties exist between members), (2) the rules through which they are governed, and (3) the transaction costs that participating in them induces (Parmigiani and Rivera-Santos, 2011; Provan et al., 2007; Provan and Kenis, 2008).

We review what effects different types of SSOs' membership bases and rules are likely to have, and how innovators are likely to trade them off (Sections 2.1 and 2.2).<sup>7</sup> Furthermore, we address the impact of contextual factors on these preferences (Section 2.3) (see the conceptual model in Figure 1).

### 2.1. SSOs' membership base

The membership base constitutes a network, making it a likely core consideration in joining an SSO. Simultaneously, firms may face substantial information asymmetry because they only get limited views of this membership base before joining. They may thus be unable to observe attributes considered important in partner selection, such as the

<sup>6</sup> A prominent example of such a consortium that also qualifies as an SSO is the Bluetooth SIG.

<sup>7</sup> We do not address the transaction-cost dimension in detail, as there is little doubt that decision makers prefer lower costs. However, we discuss in Section 2.3 how a potential tradeoff between low transaction costs and a favorable membership base and rules may be handled differently according to decision makers' contexts.

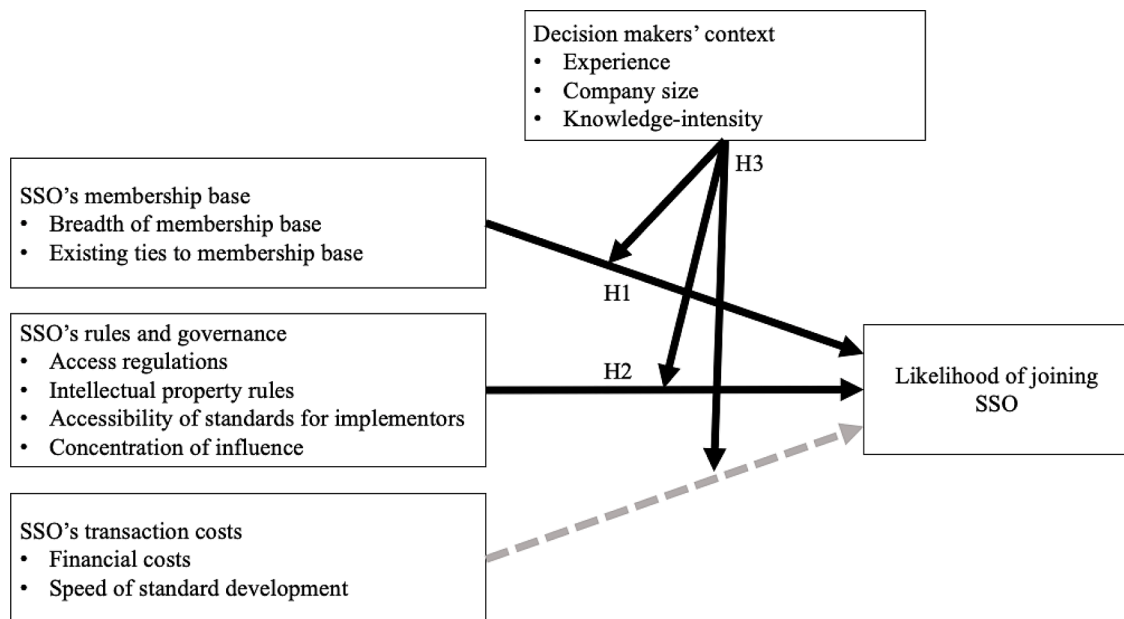


Figure 1. Conceptual Model

trustworthiness of individuals participating on other firms' behalf (e.g. Gomes et al., 2016; Kale and Singh, 2009), and network characteristics like the existence of cliques and structural holes (e.g. Borgatti and Halgin, 2011; Provan et al., 2007). Furthermore, SSOs are constantly evolving with new parties joining and others leaving (e.g. Bar and Leiponen, 2014; Leiponen, 2008). SSO selection is therefore likely to be based on assessing relatively generic permanent characteristics of the membership base, but may incorporate *expectations* about trust and other unobservable factors. Literature suggests two such potential choice criteria: breadth of the SSO's membership base, and existing ties with firms that are already in the SSO.

SSOs vary on their membership base's breadth. Some consist of a few firms from the same industry, whereas others encompass many players from different sectors and even regulators and NGOs (Baron et al., 2019; Baron and Spulber, 2018; van den Ende et al., 2012; West, 2007). Engaging in an SSO with broad membership involves a tradeoff between advantages related to (1) knowledge access, and (2) its standards' competitiveness, and disadvantages related to reduced influence:

As networks get broader, members from a larger variety of backgrounds are likely to provide access to additional knowledge and technology that is complementary to what is already available (Bar and Leiponen, 2014; Kale and Singh, 2009). Moreover, broader membership bases imply larger support networks for standards (Axelrod et al., 1995; Dan, 2019; van den Ende et al., 2012) and including more varied stakeholders increases legitimacy in potential standard users' eyes (Baron et al., 2019; Botzem and Dobusch, 2012; Iversen et al., 2004; Tamm Hallström and Boström, 2010). This may be key for SSOs' members being able to shape innovation trajectories if their standards subsequently compete in market battles (den Uijl, 2015; van de Kaa et al., 2011; Wiegmann et al., 2017). In contrast to these benefits of broader networks, they also have some drawbacks: The support network and legitimacy that help market success rely on considering diverse preferences and interests (e.g. Brunsson et al., 2012; Iversen et al., 2004; Leiponen, 2008; Ranganathan et al., 2018; Simcoe, 2007). As a membership base gets broader, the diversity of interests increases and each individual firm has less influence on the process (Axelrod et al., 1995; van den Ende et al., 2012). Consequently, firms often must accept outcomes against their interests (Markus et al., 2006; Ranganathan et al., 2018). These disadvantages may eventually outweigh the advantages. I. e., when a certain 'critical mass' has been reached, more variation in members may provide little additional knowledge and legitimacy,

whereas individual influence keeps decreasing. In this situation, decision makers are likely to prefer an alternative SSO, which already has sufficient 'critical mass' but also gives them more influence on decision-making:

*Hypothesis 1a: The breadth of an SSO's membership base has an inverse u-shaped influence on a firm's likelihood of joining this SSO.*

Furthermore, ties between actors are key elements of networks (e.g. Dokko and Rosenkopf, 2010; Provan et al., 2007). Firms are thus likely to value existing ties to an SSO's members, which they can leverage to avoid costs of building new ones (Bar and Leiponen, 2014). This lowers risks related to collaborating with unknown parties (Gulati, 1995a; Provan et al., 2007), reduces uncertainty about counterparts' capabilities and needs (Dan, 2019), may lead to higher levels of trust (Dokko and Rosenkopf, 2010; Gulati, 1995b; Gulati et al., 2009; Kale and Singh, 2009), and enables reliance on existing knowledge sharing and conflict resolution mechanisms (Dokko and Rosenkopf, 2010; Gulati et al., 2009). Good relationships can be used to coordinate activities and jointly influence standards and technology development (Leiponen, 2008), e.g. by forming additional consortia outside the SSO to accompany activities (Baron and Pohlmann, 2013). Firms are thus likely to prefer SSOs where they have existing ties to the membership base.

*Hypothesis 1b: Firms are more likely to join SSOs where they have existing ties with the membership base.*

## 2.2. SSOs' rules and governance

Literature on IORs and networks highlights networks' governance mechanisms (Gulati and Singh, 1998; Kale and Singh, 2009; Parmigiani and Rivera-Santos, 2011; Provan et al., 2007; Provan and Kenis, 2008). It identifies three governance modes: (1) participant-governed networks, (2) lead-organization-governed networks, and (3) network administrative organizations (NAOs) (Provan and Kenis, 2008). NAOs define and enforce rules for members (Provan et al., 2007; Provan and Kenis, 2008), meaning that SSOs act as NAOs in their respective

standardization networks.<sup>8</sup> Rules differ substantially across SSOs, e.g. in terms of intellectual property (IP) policies, conflict resolution mechanisms, and charges for (potential) standard implementors (Baron et al., 2019; Baron and Spulber, 2018; Chiao et al., 2007; Lemley, 2002; Lerner and Tirole, 2006; West, 2007). Altogether, these rules influence strongly whether firms can effectively contribute to standard and technology development, and whether standards are subsequently accepted by users (e.g. Baron et al., 2019; Chiao et al., 2007; Lerner and Tirole, 2006; West, 2007). In general, more restrictive rules may limit firms' influence in an SSO but may increase the SSO's legitimacy, thereby requiring tradeoffs in SSO selection.

Based on the overview by West (2007), extensively reviewing other literature, and interviews with standardization experts (see Section 3.1), we find four areas of rules that are key in distinguishing between SSOs: (1) access regulations for new members, (2) intellectual property licensing rules, (3) access to standards for implementors, and (4) the concentration of influence in the SSO.

### 2.2.1. Access regulations for potential contributors

SSOs vary in their openness to new members: whereas many are open to anyone, others regulate access, e.g. by imposing criteria for new members (Botzem and Dobusch, 2012; Chiao et al., 2007; Dan, 2019; Delcamp and Leiponen, 2014; Teubner et al., 2021; West, 2007). Standard implementors perceive completely open SSOs as more legitimate (e.g. Brunsson et al., 2012; Iversen et al., 2004). This comes at a cost: Since anyone may join at any time, it is difficult to predict ex-ante what compromises will be needed (see Axelrod et al., 1995; Markus et al., 2006; van den Ende et al., 2012), and whether the membership base is attractive in other terms, e.g. knowledge sharing, technological overlap, and relational influence (see e.g. Bar and Leiponen, 2014; Kale and Singh, 2009; Ranganathan et al., 2018). Decision makers thus need to tradeoff legitimacy against influence and predictability. In this situation, a loss of legitimacy caused by access restrictions may be compensated by other means, such as selectively admitting members with high impact on legitimacy or keeping costs of standard adoption low, whereas it would be challenging to offset a lack of influence and predictability. We therefore expect decision-makers to prefer predictability, assuming that they can get access themselves to the SSO in question.

*Hypothesis 2a:* An SSO imposing criteria to regulate access for contributors increases a firm's likelihood of joining that SSO.

### 2.2.2. Intellectual property rules

Forum shopping approaches to SSO selection (Chiao et al., 2007; Lerner and Tirole, 2006) focus almost exclusively on rules for handling intellectual property. Generally, literature often (sometimes implicitly) assumes that contributors to standardization own intellectual property (IP) which they aim to get recognized as standard-essential (e.g. Miller and Toh, 2020; Simcoe, 2014; Toh and Miller, 2017). Owning such standard-essential IP allows firms to benefit from the underlying innovations in multiple ways, e.g. by improving or defending their market positions, earning licensing revenues, and increasing the value of complementary IP (Bekkers et al., 2002; Kang and Motohashi, 2015; Miller and Toh, 2020). Furthermore, owners of standard-essential IP may use it to gain substantial advantages vis-à-vis both other members of the SSO and standard users (e.g. Leiponen, 2008; Lemley, 2002). Consequently, many SSOs restrict how IP can be used by imposing rules to assure openness and prevent the exploitation of IP-based monopoly positions (e.g. Baron et al., 2019; Chiao et al., 2007; Simcoe, 2014; West, 2007). Lemley (2002) locates these rules on a continuum: At one extreme, very

strict rules require members to fully disclose relevant IP and license all standard-essential patents royalty-free. This favors standard users and other parties without standard-essential IP (Lerner and Tirole, 2006). At the other end, very lenient rules make no requirements about disclosure or licensing terms. Lenient rules do not only impose the least restrictions on what firms can do with their IP. They also reduce IP owners' substantial costs (Chiao et al., 2007; Toh and Miller, 2017) and expropriation risks (Toh and Miller, 2017) associated with disclosing IP in standardization. Furthermore, they leave most flexibility in dynamically evolving IP situations (see e.g. Bekkers et al., 2002; Berger et al., 2012; Kang and Bekkers, 2015), including the option to give up IP claims in specific situations when this is beneficial (Garud and Kumaraswamy, 1993). Altogether, actors with relevant IP are thus likely to prefer SSOs on the lenient end of Lemley's (2002) spectrum (Chiao et al., 2007; Lerner and Tirole, 2006):

*Hypothesis 2b:* An SSO imposing less strict IP rules increases the likelihood of a company holding essential patents joining that SSO.

### 2.2.3. Accessibility of standards for implementors

While some SSOs make their specifications available for free and fund their operations by other means (e.g. charges for participation, government funding), others charge for implementing their standards, often through (sometimes high) fees for access to specifications and/or mandatory certification of products implementing their standards (Baron et al., 2019; West, 2007). For example, the International Telecommunication Union (ITU) provides all specifications as free downloads (ITU-T, 2020), whereas ISO and its national member bodies charge a per-download fee (ISO, 2020), and the Zigbee Alliance requires implementors to become due-paying members and charges additional certification fees per implementing product (Zigbee Alliance, 2020). Such costs have been found to affect standard implementation negatively (Rada and Berg, 1995). Companies engaging in standardization are likely to value widespread use of the standards they develop, e.g. because this (1) generates revenues from product sales and/or licensing IP (e.g. Bekkers et al., 2002; Kang and Motohashi, 2015), and (2) gives them greater leverage on technology development and related business aspects (Ansari and Garud, 2009). They are thus most likely to prefer more open SSOs, which do not charge standard implementors – even if this may come at a higher cost for themselves:

*Hypothesis 2c:* An SSO not charging for standard implementation increases the likelihood of a company joining that SSO.

### 2.2.4. Concentration of influence in the SSO

The distribution of power and influence is a key issue in the IOR literature (e.g. Dyer and Singh, 1998; Kale and Singh, 2009; Parmigiani and Rivera-Santos, 2011). While the NAO network governance model aims to prevent concentration of power in the hands of few, the degree to which it does so effectively depends on the network's rules (e.g. Provan et al., 2007; Provan and Kenis, 2008). SSOs vary in the degree to which influence on standards is concentrated in the hands of a few influential members or distributed among all. This aspect of SSOs' openness often manifests itself in whether all members have equal voting rights (Baron et al., 2019; Baron and Spulber, 2018; Iversen et al., 2004; Teubner et al., 2021; West, 2007). Given the high stakes often involved in standardization, one would expect companies to welcome any means to secure more influence (in line with the arguments of Chiao et al., 2007; Lerner and Tirole, 2006). They should thus value opportunities to secure additional votes. However, this does not only come at a financial cost (see the examples in Online Appendix 1), but may also impact legitimacy. Standards' input legitimacy depends on fair involvement of all interested parties in their creation (e.g. Botzem and Dobusch, 2012; Iversen et al., 2004). Allowing some parties to exert stronger influence may therefore make standards less legitimate in potential implementors' eyes. This lack of legitimacy may be a minor issue

<sup>8</sup> Nascent standardization networks, where one or multiple companies initiate new SSOs which initially lack the structure to act as NAOs, may be considered as participant-governed and/or lead-organization governed networks. Such nascent SSOs are out of scope for this paper.

for large companies with sufficient clout to push a standard into the market (see e.g. den Uijl, 2015; van de Kaa et al., 2011), but may be an important concern for smaller firms which cannot do so. We thus formulate the following hypotheses:

*Hypothesis 2d:* Differences in voting rights among members of an SSO increase the likelihood of large companies joining the SSO.

*Hypothesis 2e:* Differences in voting rights among members of an SSO decrease the likelihood of small companies joining that SSO.

### 2.3. Decision makers' context

In Sections 2.1 and 2.2 we discussed key network attributes which affect firms' ability to benefit from participating in SSOs. Blind et al. (2021) show that different types of companies act differently in joining SSOs. While advantageous attributes arguably apply to most firms, decision makers may attach different weights to them depending on their context. Literature suggests decision makers' experience, the size of their companies, and their industry's knowledge intensity as likely to affect their tradeoffs. Decision-makers' context may thus moderate the strength of SSOs' attributes' effects on a firms' choices.

Less experienced decision makers who have been involved in fewer standardization cases are likely to focus on network attributes that can be observed and evaluated relatively easily. This arguably applies to transaction costs of participation.<sup>9</sup> Conversely, they may be unfamiliar with the mechanisms through which the membership base and rules influence success (e.g., legitimacy and standards' support networks). Similarly, decision makers at small firms are likely to pay more attention to transaction costs because of the resource constraints that they often face, which may prevent them from choosing more costly options (see e.g. Blind et al., 2021; de Vries et al., 2009; Leiponen, 2008).

*Hypothesis 3a:* Less experienced decision makers put a stronger emphasis on transaction costs in joining an SSO.

*Hypothesis 3b:* Decision makers at smaller companies put a stronger emphasis on transaction costs in joining an SSO.

Beyond the characteristics of decision makers and their companies, the industry environment where they operate is also likely to affect their SSO choice (Blind et al., 2021). Knowledge-intensity of decision makers' industries has been shown to affect how companies act in networks in general (Salavisa et al., 2012; Zaheer et al., 2010), making this potentially also important in the standardization context. Zaheer et al. (2010, p. 1072) "define a knowledge-intensive firm as one that has significant knowledge-based assets, which consist of proprietary knowledge (...) and tacit knowledge (...)". In knowledge-intensive industries (e.g., ICT) much of value creation depends on such knowledge-based assets, whereas other industries' value creation may rely more on other types of assets. In converging industries (see Teece, 2018), such as the IoT, participants in SSOs come from industries with varying knowledge intensity. As we argued in Section 2.2.2, the handling of proprietary knowledge in SSOs implies a need for suitable IP rules. The degree of importance which decision makers place on these rules is likely to differ according to how knowledge-intensive their industry is. Firms in knowledge-intensive industries, whose value creation and capture most strongly depends on their knowledge (Salavisa et al., 2012; Teece, 2018; Zaheer et al., 2010), are likely to place a higher emphasis on this:

*Hypothesis 3c:* Decision makers in knowledge-intensive industries put a stronger emphasis on IP rules in joining an SSO.

<sup>9</sup> Participation in standardization incurs costs, both in terms of money and time needed to develop standards (Baron et al., 2019; Baron and Spulber, 2018; de Vries and Veurink, 2017; Delcamp and Leiponen, 2014; Leiponen, 2008). We use the term "transaction costs" to refer to both types of costs.

In summary, selecting a suitable SSO involves a number of tradeoffs. This concerns the characteristics of SSOs, which may e.g., affect influence and legitimacy. Furthermore, there may be tradeoffs between characteristics (e.g., whether a decision maker focuses on costs or rules), which are likely to differ between decision makers. Comprehending these tradeoffs, which underlie a key strategic decision, is key for understanding innovators involvement in standardization.

## 3. Methodology

To test our hypotheses, we conducted a choice experiment, which we analyzed using choice-based conjoint analysis (see Eggers et al., 2018; Hair et al., 2006, chap. 7; Johnson et al., 2013; Louviere et al., 2000). Despite the method's potential in strategy and innovation research (Priem, 1992), it has been used relatively rarely in the innovation field. The few examples include studies of technological discontinuities (Hoisl et al., 2015), internationalization strategies (Ambos et al., 2020), and about how firms profit from innovations (Fischer and Henkel, 2013). Section 3.1 presents a qualitative pre-test, through which we gained input for designing the choice experiment. Section 3.2 provides detailed information about the design, data collection, and analysis of our study.

### 3.1. Qualitative pre-test

In a qualitative pre-test, we interviewed 16 standardization experts in the ICT field (nine managers who have led and/or consulted companies in standardization, four representatives of SSOs, three standardization researchers). We contacted them through our network in two waves in May 2016 (five interviewees) and October/November 2016 (eleven interviewees). Interviews in the first wave were conducted through e-mail, the second wave via phone calls lasting between 30 and 75 minutes. All telephone interviews were voice-recorded. The interviews were semi-structured. We first asked interviewees to list all characteristics that they consider when choosing an SSO, without giving prompts. Subsequently, we provided interviewees with the characteristics identified from literature, and asked them to assess their relevance. The last nine interviewees were also asked to evaluate the realism of the scenario and attribute-level combinations in our choice experiment (see Section 3.2).

We analyzed responses by tabulating interviewees' assessment of the attributes from literature, and additional attributes suggested by them. One attribute discussed in Section 2 was added to our study following input from interviewees (concentration of influence, stressed as important by nine interviewees). Furthermore, interviewees stressed the importance of transaction costs (expressed as participation costs, highlighted by six interviewees; and process speed,<sup>10</sup> stressed by eleven interviewees). These transaction-cost-related attributes are not theoretically interesting by themselves in the context of SSO selection, as there can be little doubt that decision makers prefer lower transaction costs. Nevertheless, they are relevant for three reasons: (1) Interviewees' input gave grounds for formulating H3a and H3b, (2) the transaction-cost related attributes make the experiment more realistic (thus adding to external validity, see Section 3.2), and (3) explicitly including transaction costs in the experiment ensures that participants answer based on their actual preferences for the other attributes, rather than on their expectations regarding how these attributes may affect costs (thus increasing measurement reliability). Altogether, our procedure ensured that our theory-derived concepts were recognizable to practitioners and

<sup>10</sup> To maintain consistency with the framework to characterize SSOs according to their membership bases, rules, and transaction costs (see Section 2), we place speed of the process under this heading. Slow processes within an SSO may be both an antecedent and a result of higher transaction costs (see Williamson, 1981), meaning that speed is closely related to the transaction costs of participating in the SSO.

**Table 1**  
Operationalization of attributes in our questionnaire.

Hypothesis (characteristic of SSO)	Attribute in questionnaire	Attribute levels in questionnaire
<i>SSOs' membership base</i>		
1a: Breadth of SSO's membership	Backgrounds of other members [than respondent]	<ul style="list-style-type: none"> <li>• [Members from] All industry sectors mentioned in the scenario<sup>1</sup> and governmental organizations</li> <li>• All industry sectors mentioned in the scenario (*)</li> <li>• Mainly your [the respondent's] own industry sector</li> <li>• None</li> <li>• 1/3 (*)</li> </ul>
<i>SSOs' rules</i>		
1b: Existing ties with membership base	Share of actors [members] in the SSO with whom you [the respondent] have collaborated before	<ul style="list-style-type: none"> <li>• None</li> <li>• 1/3 (*)</li> </ul>
2a: Access regulations	New members must fulfil pre-defined criteria	<ul style="list-style-type: none"> <li>• Yes (*)</li> <li>• No</li> </ul>
2b: IP rules	Intellectual property (IP) licensing requirements for participants	<ul style="list-style-type: none"> <li>• Royalty-free licenses</li> <li>• FRAND (fair, reasonable and non-discriminatory) licenses</li> <li>• No licensing requirements (*)</li> </ul>
2c: Fees for standard users and implementers	Standard implementation is subject to payments to the SSO	<ul style="list-style-type: none"> <li>• Yes</li> <li>• No (*)</li> </ul>
2d/2e: Differences in voting rights	Voting rights depend on amount of membership fees paid	<ul style="list-style-type: none"> <li>• Yes (*H2d)</li> <li>• No (*H2e)</li> </ul>
<i>Transaction costs of participating in SSOs</i>		
Financial cost of participating	Total cost of participation per year	<ul style="list-style-type: none"> <li>• US\$ 15,000<sup>2</sup></li> <li>• US\$ 90,000</li> </ul>
Speed of standard development	Average duration of standard development process	<ul style="list-style-type: none"> <li>• 1 year</li> <li>• 3 years</li> </ul>

<sup>1</sup> We showed a scenario of a fictitious standardization case to respondents, which specified the industries involved in the case (“telecommunications, IT, consumer electronics, and mechanical engineering”), see the text below and Online Appendix 4.

<sup>2</sup> Monetary costs of participating in an SSO do not only include membership fees charged by the SSO, but also ancillary costs for establishing and maintaining ties in the network (e.g. salaries for companies' representatives, travel expenses), which may often exceed membership fees (Bar and Leiponen, 2014; de Vries and Veurink, 2017; Leiponen, 2008). The values chosen for the experiment were deemed realistic to cover the total yearly cost, including ancillary expenses, by the interviewees in our pre-test.

important attributes not highlighted by theory were added.

### 3.2. Choice experiment

In a choice experiment, respondents choose among several alternatives defined by attributes, in our case the ones discussed in Sections 2 and 3.1. Different attribute-levels describe each alternative (e.g., “cost of participating” as attribute with levels US\$15,000 or US\$90,000). Rather than stating each attribute's importance directly, respondents choose their preferred option among experimentally varied alternatives. Following Random Utility Theory (Manski, 1977), decision makers would most likely choose the SSO that scores the highest utility  $U$  among a set of alternatives. For example, if we observe that a respondent chooses alternative  $i$  instead of  $j$  we can infer that it is more likely that  $i$  has a higher utility, or  $U_i > U_j$ . Furthermore, conjoint analysis assumes that the overall utility  $U_i$  can be expressed as a combination of the partworth utilities  $\beta_n$  that the attributes  $X_{in}$  provide, i.e.,  $U_i = \sum_n \beta_n X_{in} + \varepsilon_i$ . We can estimate the partworth utilities from the observed choices with a conditional or multinomial logit model when assuming that the error term  $\varepsilon_i$  follows a type I extreme-value distribution (see Section 3.2.3). The partworth utilities constitute the respondents' preferences and indicate the relative impact of the attributes on the likelihood of joining an SSO.

Below, we show our experiment's design (Section 3.2.1), explain our sample (Section 3.2.2), and describe the analysis (Section 3.2.3).

#### 3.2.1. Design of the choice experiment

We first identified attributes to be included based on our hypotheses and the pre-test. We operationalized each attribute by defining varying

levels that are common in the field. Subsequently, we validated these attribute-level combinations during our qualitative pre-test (see Section 3.1) to maximize realism and thus external validity (Schram, 2005).<sup>11</sup> Online Appendix 2 provides example profiles of prominent real-life SSOs in the IoT field, which further demonstrate the realism of how we operationalized our variables.

We opted for an asymmetric design (i.e., two attributes can take three levels each, whereas all other attributes can take two levels each). We used three levels for the breadth of SSOs' membership bases and IP rules, as these characteristics vary to a large degree among SSOs (see e.g. Baron et al., 2019; Baron and Spulber, 2018; Lemley, 2002; West, 2007), thus requiring more levels for a fair representation of reality. The validation of attributes showed that two levels each were sufficient for the other attributes, permitting us to reduce the possible number of attribute-level combinations and thus the experiment's complexity. Table 1 shows how we operationalized each hypothesis in the questionnaire and how attribute levels were described to respondents. Attribute levels which our hypotheses expect to be preferred are marked with (\*) in Table 1.

We reduced the full factorial to a blocked fractional factorial experimental design because there are too many attribute-level combinations ( $3^2 \cdot 2^6 = 576$  possible combinations) for respondents to evaluate. As the qualitative pre-test did not identify implausible attribute-level combinations, we did not exclude any combinations a-priori and used the choice experiment design macros by SAS Institute Inc. (Kuhfeld, 2010) to derive a suitable design. Our design consists of nine blocks of eight choice tasks with four alternatives each (i.e., respondents are randomly assigned to one block where they complete eight tasks, see Online Appendix 3 for an exemplary task). This design has a high

<sup>11</sup> This validation covered both whether attributes' level values (e.g., monetary values for cost of participation) were realistic, and whether combinations of some attribute levels in one choice profile (e.g., the combination of a specific type of IP rules and voting rights) would be implausible. Interviewees confirmed that all operationalized attributes shown in Table 1 were realistic, and did not identify any implausible combinations.

relative D-efficiency (97.149 out of 100) while pre-tests showed the cognitive burden required from respondents to be reasonable. Respondents had to choose exactly one SSO, although they may in practice join several (e.g. Baron and Spulber, 2018) or none at all. Other designs, where respondents rank alternatives would have substantially increased the cognitive burden, and may therefore have negatively affected the quantity and quality of responses. While asking for just the most preferred option may limit realism, it is in line with established practice: e.g., in many marketing studies consumers choose one product although they could buy several or none. This allows identifying relative preferences, our primary objective, but is limited in inferring how many SSOs a respondent would actually join.

Our questionnaire started with a (fictitious) scenario to ensure that choices were based on the same information (see Online Appendix 4), which we made as realistic as possible to maximize external validity (Schram, 2005). We chose the Internet of Things (IoT) as a particularly appropriate setting for two reasons: (1) Standards in this innovative field affect and may potentially be used by firms from a large variety of industries, regulators, and other stakeholders (AIOTI, 2017). (2) The field is characterized by intense competition of both standards and SSOs, with often dozens working in the same application area (AIOTI, 2017). Our scenario included information reflecting typical standardization issues in the area (e.g., about affected stakeholders) and assumptions on which our hypotheses are based (e.g., about owning IP). This scenario was validated in the qualitative pre-test (see Section 3.1) to ensure that it included all required information and was perceived as realistic. This confirmed that our scenario, as used in the experiment, was suitable for our purposes. Finally, we translated the questionnaire into German to facilitate responding for experts approached through the German SSOs DIN and DKE (see Section 3.2.2). To ensure equivalence across both versions, we used a translation-back translation procedure (World Health Organization, 2018). The first author (a German native speaker) performed the initial translation, the back translation was done by a bilingual assistant.

Overall, our experimental design is well suited to answer our research question, but is subject to two caveats. (1) We rely on individual respondents for information about decisions that would typically be made in a group. However, previous research (Aribarg et al., 2010, 2002) suggests that individual choices provide a good indication of group decisions on an aggregate level. (2) We do not observe real choices of SSOs. Despite our efforts, external validity therefore remains limited. However, even if we were able to obtain data on real-world choices, we would not be able to experimentally vary them. Ultimately, this concerns a tradeoff between internal and external validity.

### 3.2.2. Sample

We conducted our choice experiment among professionals who are active in IoT interface/compatibility standardization, in line with our scenario. To reduce the risk of sampling bias towards certain types of SSOs, we accessed our sample through five major SSOs in the IoT field (DKE, DIN, the Zigbee Alliance, ETSI, and Oasis, see Table 2 for more information). All five SSOs are active in multiple IoT standardization domains, covering both industrial and consumer-oriented IoT applications, where they face intensive competition from many other SSOs (see AIOTI, 2017).<sup>12</sup> These SSOs' members therefore needed to decide which SSO to join before commencing their engagement. Furthermore, three of the SSOs (DIN, DKE, ETSI) are part of the formal international standardization system whereas the remaining two are consortia. While a

<sup>12</sup> DIN and DKE are not named on their own in the AIOTI (2017) analysis of competition between IoT SSOs. However, they provide access to CEN/CENELEC and ISO/IEC, which AIOTI names as major players, for German-based companies. Furthermore, DIN and DKE are major players in industrial IoT applications in their own right, e.g. they have developed the widely used RAMI4.0 framework (DIN/DKE, 2015).

sample from an even broader range of SSOs may have been desirable,<sup>13</sup> this did allow us to gather data from different types of SSO.

We invited experts to participate in our experiment by posting messages on SSOs' internal mailing lists and/or approaching them directly at SSOs' events.<sup>14</sup> This makes our sampling frame diversified in terms of experts from national and international standardization, and from formal SSOs and consortia. The sample covers the population "participants in IoT standardization at leading SSOs" relatively broadly, but does not fulfil all requirements for randomly sampling populations (see e.g. Dul and Hak, 2008). In particular, we cannot calculate a response rate since we do not know how many people were invited to participate. Instead, we use the web questionnaire's completion rate as a proxy. Of the respondents who answered at least one question, 67.1% followed through until the end. A self-selection bias towards practitioners who are most interested in the topic thus likely exists in our sample.

We acquired complete data from 141 respondents, giving us observations of 1,128 choices among 4,512 alternatives.<sup>15</sup> Respondents are overwhelmingly male (90%) and mostly come from Germany (81 respondents, 57%) and the U.S. (24 respondents, 17%), 13 other countries are represented with less than 10 respondents each. Respondents work at companies of all sizes (rounded to the nearest percent: 15% work for companies <50 employees, 17% 50-500 employees, 9% 500-1000 employees, 17% 1000-5000 employees, 40% >5000 employees, 2% did not provide this information). They work in various industries (35 industries represented in the sample, 24% in ICT-related industries, 45% in the manufacturing sector, 16% in the service sector, 6% in the public sector, 9% provided insufficient information to be clearly allocated to one category<sup>16</sup>). Most have IoT experience (only 13% reported that their companies have no IoT-related activities). Table 3 provides further information about respondents' experience in standardization.

### 3.2.3. Data analysis

We analyzed our choice data using logit models. We derive effect-coded (i.e., mean-centered) parameter estimates that show how each attribute level affects the utility function. Individually, they show whether a specific attribute level adds or subtracts from an SSO's utility relative to the mean. The range of utility values can be compared between attributes to understand each attribute's relative impact on decisions. Furthermore, for every possible combination of characteristics, the corresponding parameters can be added up to estimate an SSO's utility for its members. When comparing two SSOs, respondents are more likely to choose the one with a higher overall utility.

We estimated two logit models (both shown in Table 4):<sup>17</sup> (Model 1) A main-effects-only conditional logit model (McFadden, 1974) estimates each attribute-level's effect on utility. (Model 2) A multinomial logit model incorporates respondents' sociodemographic information as

<sup>13</sup> We approached several other SSOs who refused to provide access to their membership bases.

<sup>14</sup> The first author attended two IoT standardization events. At both, our experiment was mentioned in the opening speeches and information about the experiment was included in the material distributed to participants. Furthermore, the first author approached potential respondents personally during breaks, conference dinners, etc.

<sup>15</sup> We dropped two respondents who did not complete the entire choice experiment in the paper questionnaire. Table 2 provides the number of complete, useable responses.

<sup>16</sup> We coded these categories based on the "open answers" provided by the respondents. To ensure consistency, the first and third author coded the sectors independently. We then jointly resolved cases where the coding diverged.

<sup>17</sup> When specifying both models, we included n-1 parameters per attribute with n levels to avoid overspecification. For better readability, we manually added the estimates for omitted parameters to the results presented in Table 4.



**Table 2**  
Overview over responses (SSOs ordered by number of respondents)

SSO	Approached Groups	Administration of Questionnaire	Number of Respondents
DKE	Members of standardization committees with IoT focus	Online, German	67
Zigbee Alliance	Attendees at the 2017 Barcelona membership meeting	Pen-and-paper at the event and online, English	37
DIN	Members of standardization committees with IoT focus	Online, German	15
ETSI	Attendees at the 2017 ETSI IoT week, members of the ETSI board	Pen-and-paper at the event and online, English	13
Oasis	Members of the organization's mailing list	Online, English	9
<i>Total</i>			<i>141</i>

**Table 3**  
Respondents' standardization experience

	Mean	Standard deviation	Median	Min	Max
% of respondents' daily workload related to standardization	34.48	30.46	23	0	100
Years of experience in standardization	12.07	8.97	10	0	40
No. of times respondents have been involved in selecting SSOs	5.58	15.26	2	0	120 <sup>1</sup>

<sup>1</sup>This number may seem extremely high at first. However, [Baron and Spulber \(2018\)](#) find that large firms, such as IBM, Intel, or Siemens are often involved in dozens of SSOs simultaneously and also end their memberships and join new SSOs on a frequent basis. It is therefore plausible that someone working at such a large player in standardization is involved in 120 SSO-selection decisions over his/her career.

moderators to identify how the concepts from H3 affect each attribute level's utility. In line with H3, we initially included standardization experience,<sup>18</sup> company size,<sup>19</sup> and whether a respondent works in the ICT sector<sup>20</sup> (the most knowledge-intensive sector represented in our sample) as interaction terms. Furthermore, Model 2 controls for the type of SSO (formal or consortium) through which a respondent was reached.<sup>21</sup> Model 2 uses all responses which include this information (128 respondents, instead of 141 in the full sample). Model 2 is therefore based on 4,096 profiles with 1,024 choices, giving sufficient statistical power for testing all interactions included in the model. We subsequently followed a stepwise backward-elimination procedure to identify which interaction terms improve model fit, using likelihood-ratio tests. Company size, ICT sector, and the type of SSO through which a respondent was reached each improve the model at the 5% significance-level, whereas adding standardization experience does not ( $p=0.096$ ). We therefore dropped standardization experience from the final Model 2. Some demographic variables that are used for the interactions in Model 2 are significantly related with each other. To check if potential multicollinearity masks the effects in Model 2, we also estimated separate models for each interaction effect. Our interpretation of results does not change with these models' results, and the parameters in the full model show a high correlation (0.983) with the parameters in

<sup>18</sup> Measured as the number of years that a respondent has been active in standardization.

<sup>19</sup> We estimated separate models with each available cut-off point for firm size in the data (50, 500, 1000, and 5000 employees) and compared these models to the main-effects-only model using likelihood ratio tests. Using 500, 1000, and 5000 employees all led to a significantly improved model ( $p<0.001$  for all three models). Our interpretation of all three models is consistent, which indicates that the effects of large company size on decision criteria are mainly driven by the 40% of respondents working at firms with >5000 employees. As the model with the 5000-employees-cut-off point also has a slightly better log-likelihood value than the alternatives, we use this cut-off point to distinguish between large and small firms.

<sup>20</sup> See [Section 3.2.2](#) for an explanation of how we coded this variable.

<sup>21</sup> Adding this control variable significantly improves the model ( $p<0.001$ ).

the separate models.

To test whether estimates for different attribute-levels are significantly different, we followed [Paternoster et al.'s \(1998\)](#) procedure (deriving z-values by dividing the absolute difference of two parameter estimates through the pooled standard error). Results of this procedure are shown in [Table 5](#). Finally, we calculated each attribute's relative importance for selecting SSOs by dividing the range of the attribute's partworth utilities by the sum of ranges across attributes ([Eggers et al., 2018](#); [Kuhfeld, 2010](#)) ([Figure 2](#)).

## 4. Results

An attribute has the hypothesized effect if (1) it has a significant impact on utility, (2) the preferred level is in line with the hypothesis (both shown in [Table 4](#)), and (3) the utilities of its levels are significantly different from each other (shown in [Table 5](#)). As explained in [Section 3.2.3](#), we estimated two models: The main-effects-only Model 1 shows the "ideal" SSO for the "average" decision maker, thus allowing us to test H1 and H2a-c that are formulated at the attribute level ([Section 4.1](#)). To test hypotheses for which we expected preferences to vary across decision makers (H2e/d and H3), we use Model 2 which incorporates interaction terms ([Section 4.2](#)). Furthermore, Model 2 provides additional interesting insights about which we did not hypothesize ([Section 4.3](#)). [Table 6](#) provides an overview over the number of respondents per demographic variable included in Model 2.

[Table 4](#) also shows the model-fit statistics for both models. Model 2 shows a pseudo- $R^2$  of 0.138. While literature often mentions a generic value of 0.2 for indicating a good model fit, this depends on many factors, such as the number of alternatives per choice-set, the number of attributes, or the number of respondents. Our study with four experimentally varied alternatives that are described by eight attributes is rather complex so that we consider this model fit acceptable. Nevertheless, future research may attempt to identify further factors that can explain variance in choosing SSOs (see [Section 5.3](#)).

### 4.1. Model 1: main-effects model (testing H1 and H2a-c)

In our main-effects model (Model 1 in [Table 4](#) and [Table 5](#)), a broader membership base increases the probability of a firm joining an SSO, *rejecting H1a* which expected a curvilinear relationship. The model shows a firm's existing ties to an SSO's membership base to increase utility, *supporting H1b*. The presence of access criteria does not significantly affect utility, *rejecting H2a*. Regarding IP rules, we find an inverse-u-shaped relationship, rather than a preference for lenient IP rules, *contrary to H2b*. Preferences regarding fees for standard users are *in line with H2c*, and decision makers prefer lower costs of participation and a faster speed of standard development. [Figure 2](#) shows that decisions in Model 1 are driven to a very large extent by financial costs, speed of standard development and breadth of the membership base (these three attributes account for 59.72% of total utility in this model).

### 4.2. Model 2: interaction model with decision makers' context (testing H2e-d and H3)

Model 2 is shown on the right-hand side in [Table 4](#) and [Table 5](#): The

**Table 4**  
Decision makers' partworth utility estimates (including standard errors)

	Model 1: Sample level	Model 2: Including demographic information			
<b>Model n</b>	141			128	
<b>Model fit: Log Likelihood</b>	-1446.2			-1224.2	
<b>Model fit: McFadden's Pseudo-R<sup>2</sup></b>	0.075			0.138	
	Main effects only	Main effects	Firms > 5000 employees	H3: Interaction effects	
	Partworth utility estimate (standard error)	Partworth utility estimate (standard error)	Partworth utility estimate (standard error)	ICT sector Partworth utility estimate (standard error)	Consortia Partworth utility estimate (standard error)
<i>SSOs' membership base</i>					
<b>H1a: Breadth of SSO's membership</b>					
<b>All industries &amp; government</b>	0.193 (0.044)***	0.307 (0.075)***	-0.250 (0.101)*	-0.121 (0.111)	0.001 (0.105)
<b>All industries &amp; no government</b>	0.011 (0.045)	-0.052 (0.077)	0.158 (0.102)	-0.033 (0.113)	0.059 (0.107)
<b>Only respondent's industry</b>	-0.204 (0.047)***	-0.255 (0.079)***	0.092 (0.105)	0.155 (0.115)	-0.060 (0.111)
<b>H1b: Existing ties with membership base</b>					
<b>None</b>	-0.064 (0.031)*	-0.067 (0.052)	-0.110 (0.071)	-0.022 (0.078)	0.110 (0.074)
<b>With 1/3 of actors in SSO</b>	0.064 (0.031)*	0.067 (0.052)	0.110 (0.071)	0.022 (0.078)	-0.110 (0.074)
<i>SSOs' rules</i>					
<b>H2a: Access regulations</b>					
<b>No</b>	-0.025 (0.031)	-0.079 (0.053)	0.190 (0.071)**	-0.065 (0.078)	-0.061 (0.074)
<b>Yes</b>	0.025 (0.031)	0.079 (0.053)	-0.190 (0.071)**	0.065 (0.078)	0.061 (0.074)
<b>H2b: IP rules</b>					
<b>Royalty free</b>	-0.031 (0.045)	0.088 <sup>c</sup> (0.075)	-0.296 (0.105)**	-0.459 (0.122)***	0.278 (0.109)*
<b>FRAND</b>	0.151 (0.046)***	0.082 (0.079)	0.234 (0.105)*	0.496 (0.112)***	-0.590 (0.112)***
<b>None</b>	-0.119 (0.046)**	-0.170 (0.077)*	0.063 (0.102)	-0.037 (0.114)	0.312 <sup>e</sup> (0.106)**
<b>H2c: Fees for standard users and implementers</b>					
<b>No</b>	0.099 (0.031)***	0.124 (0.052)*	-0.015 (0.071)	0.244 (0.079)**	-0.212 (0.074)**
<b>Yes</b>	-0.099 (0.031)***	-0.124 (0.052)*	0.015 (0.071)	-0.244 (0.079)**	0.212 (0.074)**
<b>H2d/2e: Differences in voting rights</b>					
<b>No (H2e)</b>	0.181 (0.032)***	0.381 (0.055)***	-0.022 (0.072)	-0.065 (0.080)	-0.434 (0.076)***
<b>Yes (H2d)</b>	-0.181 (0.032)***	-0.381 (0.055)***	0.022 (0.072)	0.065 (0.080)	0.434 (0.076)***
<i>Transaction costs of participating in SSOs</i>					
<b>Financial costs of participation</b>					
<b>US\$15,000</b>	0.324 (0.032)***	0.587 (0.057)***	-0.225 (0.073)**	-0.321 (0.079)***	-0.130 (0.076)+
<b>US\$90,000</b>	-0.324 (0.032)***	-0.587 (0.057)***	0.225 (0.073)**	0.321 (0.079)***	0.130 (0.076)+
<b>Speed of standard development</b>					
<b>1 year</b>	0.224 (0.031)***	0.293 (0.053)***	0.038 (0.072)	-0.038 (0.079)	-0.125 (0.075)+
<b>3 years</b>	-0.224 (0.031)***	-0.293 (0.053)***	-0.038 (0.072)	0.038 (0.079)	0.125 (0.075)+

Significance codes: p ≤ 0.001\*\*\*, p ≤ 0.01\*\*, p ≤ 0.05\*, p ≤ 0.1+

column "main effects" shows an attribute's effect on utility for decision makers in the reference category, i.e., at smaller firms in the non-ICT sector who were reached via a formal SSO (DIN, DKE, ETSI). The subsequent columns contain the estimates for the model's interaction terms, i.e., they show how preferences change *ceteris paribus* for decision makers at large firms, in the ICT sector, and who were reached through consortia (Zigbee, OASIS). Hypotheses about different preferences are supported if the corresponding interaction term for at least one attribute level is significant and, for attributes with three possible levels, the interaction term significantly improves model fit (tested using likelihood ratio tests).

As expected, decision makers at smaller companies derive higher utilities from SSOs with no differences in voting rights, *supporting H2e*. The interaction between differences in voting rights and company size is

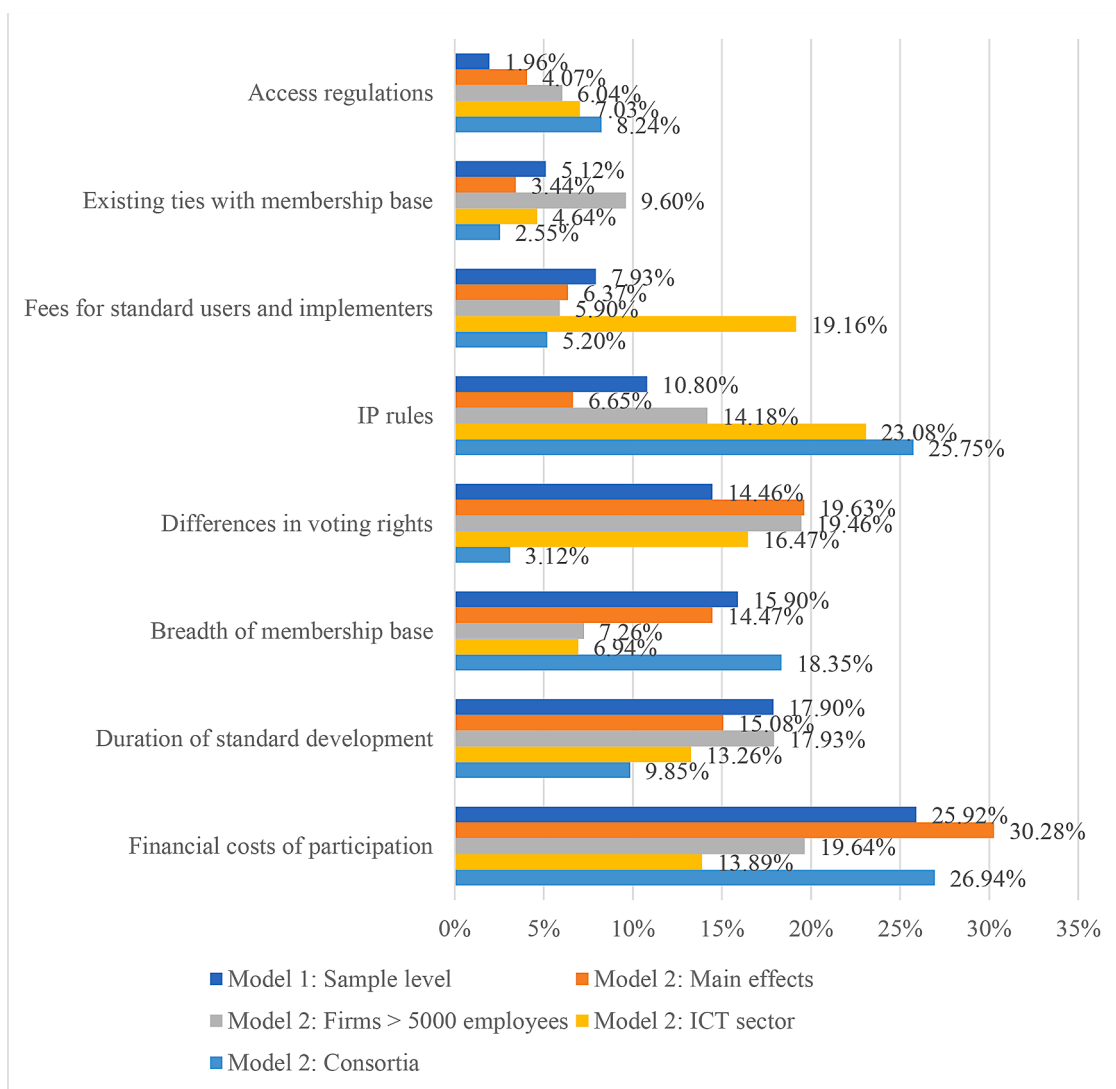
insignificant, i.e. this preference also holds for large companies, *rejecting H2d*. Preferences regarding transaction costs differ significantly according to company size (significantly improved model fit p=0.003), but not for standardization experience so that we removed this interaction term from the model because it does not improve model fit significantly (p=0.096).<sup>22</sup> Company size has a mixed influence on preferences regarding transaction costs: While respondents at large firms emphasize

<sup>22</sup> In a model incorporating all interaction terms, interaction effects between standardization experience and all attributes except "membership base from respondent's own industry" are insignificant at the 5% level, further demonstrating the interaction term's lack of explanatory power for the observed choices.

**Table 5**  
Statistical significance of differences between attribute-levels' parameter estimates

Model n	Model 1: Sample level	Model 2: Including demographic information			
	Main effects only	Main effects	Firms > 5000 employees	ICT sector	Consortia
<i>SSOs' membership base</i>					
<i>H1a: Breadth of SSO's membership</i>					
All industries & government / All industries & no government	0.004**	0.001***	0.004**	0.578	0.697
All industries & no government / Only respondent's industry	0.001*	0.068	0.653	0.243	0.438
All industries & government / Only respondent's industry	0.000***	0.000***	0.019*	0.084	0.689
<i>H1b: Existing ties with membership base</i>	0.004**	0.071	0.027*	0.686	0.035*
<i>SSOs' rules</i>					
<i>H2a: Access regulations</i>	0.266	0.034*	0.000***	0.236	0.245
<i>H2b: IP rules</i>					
Royalty free / FRAND	0.005**	0.952	0.000***	0.000***	0.000***
FRAND / None	0.000***	0.023*	0.242	0.001***	0.000***
Royalty free / None	0.174	0.017*	0.014*	0.011*	0.822
<i>H2c: Fees for standard users and implementers</i>	0.000***	0.001***	0.769	0.000***	0.000***
<i>H2d/2e: Differences in voting rights</i>	0.000***	0.000***	0.673	0.250	0.000***
<i>Transaction costs of participating in SSOs</i>					
Financial costs of participation	0.000***	0.000***	0.000***	0.000***	0.016*
Speed of standard development	0.000***	0.000***	0.450	0.490	0.035*

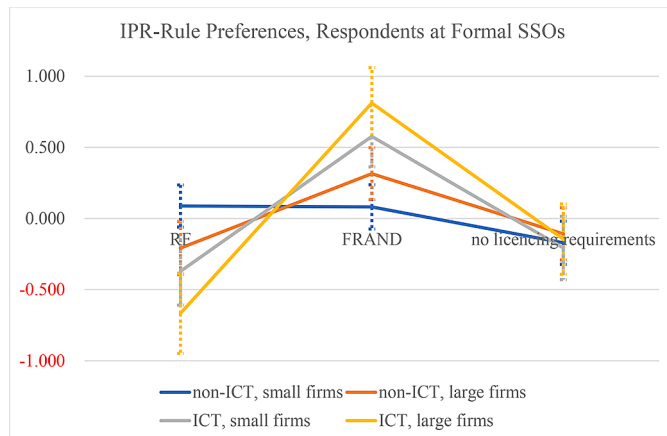
Significance codes: p ≤ 0.001\*\*\*, p ≤ 0.01\*\*, p ≤ 0.05\*, p ≤ 0.1+



**Figure 2.** Weights of SSOs' attributes in decision makers' utility

**Table 6**  
Numbers of respondents per demographic variable in Model 2

Company Size	Sector	Consortium	Formal SSO	Sum
<5000	non-ICT	9	45	54
	ICT	9	11	20
	Sum	18	56	74
>5000	non-ICT	18	22	40
	ICT	6	8	14
	Sum	24	30	54
Sum	non-ICT	27	67	94
	ICT	15	19	34
	Sum	42	86	128



**Figure 3.** IPR-Rule Preferences at Formal SSOs (incl. 95% confidence intervals)

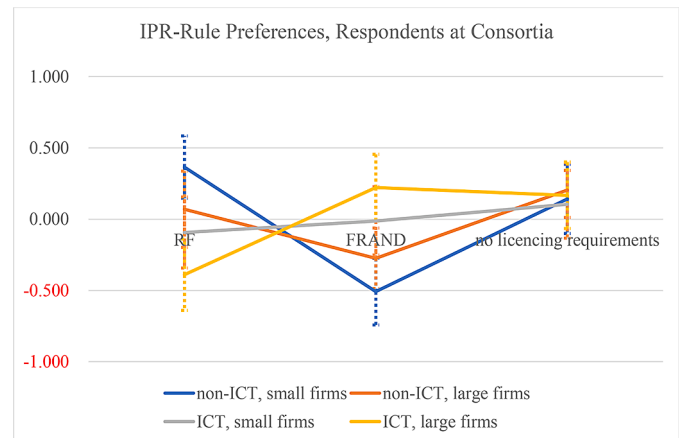
participation costs less (as do respondents in the ICT sector), preferences for speed of standard development do not differ significantly. Overall, 37.57% of their utility is determined by transaction costs (vs. 45.26% in the baseline). Altogether, we thus find support for H3b, but not for H3a. As expected, decision makers in the ICT sector (the most knowledge-intensive sector broadly represented in our sample) emphasize on IP rules substantially more than others (determining 23.08% of their utility vs. 6.55% in the baseline, improved model fit for including this effect  $p < 0.001$ ). We therefore find support for H3c.

4.3. Model 2: further observations

We observe several effects in Model 2 about which we did not formulate hypotheses. We mention three particularly notable ones: First, *ceteris paribus* preferences of decision makers at large firms appear to be consistent with H1a, i.e., there seems to be an inverse-u shaped relationship between breadth of membership base and utility. However, while there is a significant difference between these decision makers' preferences for the attribute-levels "all industries & no government" and "only respondent's industry" ( $p = 0.041$ ), differences in preferences between "all industries & government" and both other attribute levels are insignificant ( $p = 0.705$  and  $p = 0.098$ ). This means that there is no curvilinear effect, meaning that H1a is also not supported in this group of respondents.

Second, preferences for IP rules differ according to decision makers' contexts, not only in terms of weight in the decision but also in terms of preferred attribute levels. The main-effects indicate an almost equal preference for royalty-free and FRAND<sup>23</sup> licensing terms, followed by no requirements. This ranking changes in line with the interaction terms

<sup>23</sup> FRAND stands for "Fair, Reasonable, and Non-Discriminatory" licensing requirements.



**Figure 4.** IPR-Rule Preferences at Consortia (incl. 95% confidence intervals).

included in our model (Figure 3 and Figure 4): For example, respondents at smaller non-ICT firms in consortia have strong preferences against FRAND terms, whereas these are the preferred option for respondents at large ICT firms in formal SSOs.<sup>24</sup>

Third, we observe that the importance of access regulations for decisions is higher for all segments included in Model 2 compared to Model 1 (see Figure 2). This is due to the preferred attribute-level changing between groups of respondents (i.e., some prefer the presence of access regulations whereas others prefer their absence). In particular respondents from the ICT sector show a preference for having access regulations, and for respondents from smaller ICT firms at consortia this even is extremely important for their decision (accounting for 19.79% of utility). This causes smaller utility-value estimates in Model 1 for this attribute, which explains its lower importance.

5. Discussion and conclusions

Our study provides novel insights into the tradeoffs in joining SSO by demonstrating how SSO characteristics and innovators' contexts drive the decision. Based on our conceptualization of SSOs as goal-directed interorganizational networks, we characterize them by three attributes: (1) membership base, (2) rules, and (3) transaction costs of participation. We are – to our knowledge – the first to use the conceptualization by Parmigiani and Rivera-Santos (2011) in a standardization and innovation context. This allows us to comprehensively analyze SSOs by bridging the literatures on IORs and networks, and standardization. This generates a better understanding of "what draws firms to participate in standard setting via SSOs" (Miller and Toh, 2020, p. 30) (Section 5.1). Furthermore, we suggest avenues for future inquiry of firm behavior in goal-directed interorganizational networks in general (Section 5.2). Finally, we are – to our knowledge – the first studying SSOs (or indeed any type of IOR) using a choice experiment. Section 5.3 discusses the implications of our approach for future work.

Beyond the contributions to theory, the insights that we discuss below also have substantial value for practice. Managers of SSOs and other innovation networks may use our results to increase their networks' attractiveness for (potential) members, also bearing in mind which types of parties they want to attract. We therefore address the link between SSOs' policies and their attractiveness to members, which has been identified as an open question by Baron and Spulber (2018, p. 493).

<sup>24</sup> Although the 95% confidence intervals partly overlap between groups of respondents, Figure 3 and Figure 4 show clear differences in preferences between groups of respondents at smaller non-ICT firms and large ICT firms (the most extreme values shown in the figures).

Innovators looking to join SSOs can employ our conceptualization along the three themes to structure their assessment of the available options. Furthermore, our findings about decision makers' preferences may help them anticipate likely moves by competitors.

### 5.1. Contributions on companies' choice of SSOs: impact of SSO characteristics and contextual factors

Our main contribution is a more realistic and comprehensive assessment of forum shopping among SSOs than what has been offered by previous work (Chiao et al., 2007; Lerner and Tirole, 2006). These studies focus on IPR rules and SSOs' dispute resolution mechanisms as determining the choice of SSO. In doing so, they work with an extremely simplified conceptualization that may arguably be almost unrecognizable in practice. Our findings suggest that the characteristics considered in this earlier work are not even the most important to understand SSOs' institutional set-up and how it drives potential standardizers' tradeoffs. Dispute resolution mechanisms were excluded from our study, as interviewees in the qualitative pre-test did not deem them relevant enough.<sup>25</sup> IPR rules are relevant, but their importance varies enormously across respondents (see Figure 2). Instead, we reveal substantial variation in firms' decision criteria across the three themes of SSO characteristics. This points towards different priorities in standardization and innovation.

In short, our results reveal the following preferences: On the sample level (Model 1) respondents value a broad membership base to which they have established ties. They value FRAND IP rules, free-of-charge standard implementation, and equal voting rights. Both low costs and fast development are preferred. Access regulations are irrelevant. Model 2 distinguishes between managers' contextual variables. It shows that SSOs' preferred characteristics are mostly not affected. Only preferences for IP rules and access regulations depend on decision makers' context. For example, managers in smaller non-ICT firms in consortia prefer royalty-free rules; managers in large firms in the knowledge-intensive ICT sector prefer FRAND rules (see Figure 3 and Figure 4). Furthermore, managers weigh each attribute differently depending on the contexts that they operate in (see Figure 2). These findings support many of our hypotheses and the underlying reasoning. Below, we discuss unexpected findings and their implications.

Our hypotheses (H1a, H2a, H2d) are based on the idea that firms do value legitimacy and openness, but prefer to maximize their own influence whenever possible. This involves a tradeoff, because high degrees of legitimacy and openness of SSOs often come at the expense of individual firms' influence (see e.g. Botzem and Dobusch, 2012; West, 2007). Our results show that legitimacy and openness are more important for firms' standardization strategies than the literature suggests. This becomes even clearer in the comments which 45 respondents provided in the questionnaire: 19 out of them highlighted characteristics related to legitimacy and openness.<sup>26</sup> Consequently, the rejection of H1a, H2a, and H2d can be explained by a higher-than-anticipated preference for legitimacy and openness, and lower-than-expected emphasis on maximizing influence. This finding is particularly interesting in light of previous literature (e.g. Baron et al., 2019; Delcamp and Leiponen, 2014; West, 2007) which calls for policymakers to enact policy that ensures openness in standardization, as we show that this preference is actually shared by many actors in industry. This may partly be due to already existing policy interventions, like WTO rules and requirements for using open standards in public procurement (see Edler

and Georghiou, 2007).

While the preference for legitimacy over influence holds across the sample (Model 1), we show that the exact nature of this tradeoff differs between decision makers' contexts (Model 2). Respondents at smaller ICT firms in consortia prefer the presence of access regulations (in line with H2a, some others share this preference less strongly). Being able to assess future developments in the membership base ex-ante is likely to be particularly important for these managers: The settings to which these respondents are accustomed roughly correspond to Teubner et al.'s (2021, p. 13) "established standard developers" where substantial joint technology development takes place. Expropriation of knowledge by other members (see e.g. Toh and Miller, 2017) may be a particularly important risk for smaller knowledge-intensive firms in these settings. Our finding therefore suggest that more open and legitimate settings may sometimes be against the interests of weaker actors in standardization.

We call attention to important limitations regarding how benefits and drawbacks of different IP regimes are considered in previous work. We find a clear preference for FRAND rules on the sample level (Model 1, rejecting H2b). Comments and conversations with respondents show that managers are not only concerned about earning licensing fees and protection from expropriation of their own IP. They are also concerned about protection against other SSO members who abuse their IP. Our result highlights a key tradeoff: The ability of benefitting from own IP vs. protection against competitors. This tradeoff has been underemphasized in extant literature: According to a common view, IP owners favor lenient rules as they enable them to extract more value (e.g. through licensing fees) whereas strict rules are against IP owners' interests (e.g. because of increasing expropriation risks) (e.g. Chiao et al., 2007; Lerner and Tirole, 2006; Toh and Miller, 2017). Other literature highlights that the distribution of IP-related value is related to practices like "patent trolling", "just-in-time-patenting" and attempts to match patents to standards under development, but does not link these behaviors to different types of IPR rules in SSOs (e.g. Berger et al., 2012; Kang and Bekkers, 2015).

The deeper analysis of Model 2 shows how this tradeoff is contingent on managers' contexts. Large firm size, working in the ICT sector, and membership in a formal SSO<sup>27</sup> all increase the preference for FRAND rules. Conversely smaller firm size, not operating in the ICT sector, and consortium membership all contribute to more pronounced preferences for royalty-free IP licensing rules. These differences are most pronounced between respondents at (1) large ICT-firms in formal SSOs and at (2) smaller non-ICT firms in consortia (Figure 3 and Figure 4). A likely explanation of this is that large ICT firms have relatively strong IP portfolios. FRAND rules allow them to exploit these portfolios financially while still being protected to some degree from others' undesirable behavior. Conversely smaller non-ICT firms are likely to have relatively small IP portfolios. Royalty-free rules both enable them to benefit from others' IPRs and provide them with stronger protection against undesirable behavior. Furthermore, the aims of our respondents in standardization are likely to differ, with respondents approached through consortia likely to emphasize joint technology development more (Teubner et al., 2021). Restrictive IPR rules may hinder such collaboration, which is also reflected in the observation that both consortia through which we accessed respondents operate with royalty-free IPR rules (see Online Appendix 2).

These findings are in line with our conceptualization of SSOs as goal-directed networks, where many parties collaborate and contribute their knowledge and IP. We therefore add a novel network perspective on IP to the standardization literature by showing that – in network settings where multiple parties collaborate – some degree of restricting the use of

<sup>25</sup> Dispute resolution mechanisms also were not mentioned as relevant considerations in the 'open comments' fields of our questionnaire.

<sup>26</sup> The following quotes are representative of these comments: "Transparency of process.", "Governance – how it is run, e.g., a professional corporation, a democracy with officers coming from all participants, etc.", "Non-discrimination policy."

<sup>27</sup> We found that preferences vary depending on the type of SSO where respondents are currently active despite not hypothesizing about this control variable.

IP ultimately is likely to benefit everyone, even IP owners, to avoid a “tragedy of the anticommons”. This is contrary to earlier work (e.g. Chiao et al., 2007; Lerner and Tirole, 2006; Toh and Miller, 2017) which highlights the drawbacks of any kind of restrictive IP rules in standardization for IP owners. The collaborative nature of SSOs tilts the focus in decision makers’ tradeoffs away from benefitting from own IP towards preventing undesirable practices and regulating cooperation.

Finally, *H3a* (effect of standardization experience) was not supported. This suggests that benefits of favorable membership bases and rules already become apparent soon after becoming active in standardization.

## 5.2. Implications for interorganizational networks

Our findings in the specific standardization context may also be meaningful for the broader literature on goal-directed interorganizational networks. Shaikh and Levina (2019) raise questions about criteria used by managers to evaluate networks’ attractiveness before joining. We are among the first to consider what tradeoffs are made before firms join such networks. We found tradeoffs concerning three themes (membership base, rules, transaction costs), which are likely to apply in many networks. Decision makers’ contextual factors (e.g., firm size, knowledge intensity) also affect these tradeoffs. Our choice experiment helps understand how such tradeoffs are made.

A particularly noteworthy finding of our experiment concerns the decision weights of rules, transaction costs, and the membership base. The latter has a relatively low importance. Extant networks literature examines how firms act inside existing networks (e.g. Gulati, 1995b; Gulati et al., 2009; Jiang et al., 2018; Kale and Singh, 2009). This research highlights “soft factors” (trust, complementarity of knowledge) as key in determining collaboration in networks. We show that this plays a limited role *before* joining. This can be explained by difficulties in assessing “soft factors” a-priori due to information asymmetries. Our experimental design reflects these asymmetries by omitting information which network outsiders typically would not have. Changing network compositions (actors may join or leave) further complicate a-priori assessment. Our respondents therefore focus on “hard factors”, such as rules and transaction costs. This new finding, compared with extant literature, may be due to varying tradeoffs during different phases in navigating networks (pre-joining or post-joining).

Our findings also offer new knowledge about network governance, which Provan and Kenis (2008) and Provan et al. (2007) identify as an important topic that has often been neglected in literature. In line with Provan and Kenis’s (2008) typology, we conceptualized SSOs as Network Administrative Organizations (NAOs). An NAO is an organization that facilitates exchanges in its network, e.g., by managing it, defining rules and enforcing them, but does not provide technical input into the exchanges itself. It has already been shown that NAOs are an effective solution when trust between members is insufficient for alternative modes of governance (in particular “shared governance”) (Provan et al., 2007; Provan and Kenis, 2008). In addition, our findings suggest that effective NAOs, which limit opportunities for undesirable behavior, stimulate trust in the network as a whole. When an NAO clearly defines and enforces rules, this may encourage joining even if little is known about other members (e.g., in terms of trustworthiness and knowledge complementarity). Consequently, rules and their enforcement may be more important than much of the current literature recognizes.

Knowledge exchange is core to innovation-related networks, including SSOs. In this context, respondents from knowledge-intensive ICT firms pay disproportionate attention to IP protection compared to others. As we argued above, this is likely due to knowledge expropriation risks (see e.g. Toh and Miller, 2017) being particularly high for these firms. Trends of converging industries, where ICT has been becoming ingrained in other sectors, mean that both knowledge intensity has been increasing in many industries and value capture has

been becoming increasingly challenging (Teece, 2018). This raises interesting questions related to how firms’ networking strategies may evolve, and how networks as organizational structures may change in tandem. SSOs, as long-established (often global) networks<sup>28</sup> with clearly observable structures (rules, membership, etc.) which already adapted to past trends and continue doing so, provide excellent settings for studying these questions. Furthermore, the close attention to IPR rules in the standardization literature may provide useful insights for studying value distribution in other innovation network settings.

## 5.3. Methodological contributions and implications for future research

To our knowledge, we are the first to study SSOs (or indeed any type of IOR) using a choice experiment, which enables us to establish causality between the characteristics of an SSO and a decision maker’s likelihood of joining that SSO. By using responses from professionals in the field, we deliver evidence that is superior to experiments in student samples (e.g. Shah and Swaminathan, 2008). Furthermore, this experimental evidence complements research that can better incorporate the effects of contextual factors. We therefore show a workable way of studying IORs, which can be used for a range of questions in future research. Choice experiments also present opportunities for studying phenomena about which archival data are not readily available. Conducting our study based on actual decisions by companies to join SSOs would have been challenging: While it can be observed which SSOs a firm joins, information on which alternatives were considered is rarely available.

Although choice experiments present such novel research opportunities, researchers using them must consider some issues. First, many strategic decisions are made in groups. While individual preferences give good indications for group decisions, additional factors are also at play (Aribarg et al., 2010, 2002). Second, external validity remains a challenge for experiments on economics and business questions (Schram, 2005). We took appropriate steps to maximize external validity (see Section 3.2.1), but limitations and a fundamental tradeoff between external and internal validity remain. Research comparing internal and external validity and different forms of realism in choice experiments is insofar promising that the measured relative effects (e.g., relative importance) remain valid but mainly the error variance is affected (Hauser et al., 2019). Researchers following our example in using choice experiments to study innovators’ strategies may analyze findings in more detail if they can compare predicted and actual decision making. Third, variables that explain inconsistent choices or sources of heterogeneity should be taken into consideration. Our final Model 2 includes three such variables (firm size, membership of the ICT sector, type of SSO through which respondents were approached), but the model-fit statistics indicate that some unexplained variance remains. In the specific SSO-selection context, future research may thus attempt to identify more such variables. Possibly, multi-item scales that can capture more complex attributes, such as decision makers’ psychological characteristics, may be helpful in measuring these variables.

These limitations also mean that the results generated in our study should be complemented by other approaches in future research. A particularly important limitation that should be addressed concerns the dependent variable “joining an SSO”. Our experiment simplified reality in that respondents chose exactly one SSO (see Section 3.2.1), whereas firms often join several in practice (e.g. Baron and Spulber, 2018). This raises several questions, not only about whether our findings also apply when decision makers can join multiple SSOs. For example, firms that are members of several SSOs may strategically use these memberships for different purposes, and may take on various roles simultaneously (e.

<sup>28</sup> For example, the IEC (one of the major global SSOs in the field of electro-technology) traces its roots back to the year 1906 and the ITU (a major global SSO in the telecommunications field) was founded in 1865.

g., as active contributors or “watchers”).<sup>29</sup> In this context, our findings about the general trade-off between legitimacy and influence may change, because companies may be able to compensate the lack of legitimacy in one SSO with membership in another more legitimate SSO. In line with earlier findings that companies collaborate across SSOs’ borders (see e.g. Baron and Pohlmann, 2013), they may select SSOs with profiles that are appropriate for specific standardization-related activities and which may differ from the preferences identified in our study. To our knowledge, there is some research on different functions that SSOs may fulfil (e.g. Baron and Pohlmann, 2013; Teubner et al., 2021), but little work on how companies act in these situations. We therefore initially see a need for qualitative work to investigate firms that are represented at multiple SSOs in depth. This initial research would, e.g., identify common strategies, typical activities that may take place at different SSOs, and key decisions in this context. Once such evidence has been established and key tradeoffs are known, quantitative work could confirm the results. This may, for example, include further choice experiments similar to ours, which distinguish between SSOs to be chosen for specific activities.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.respol.2021.104427](https://doi.org/10.1016/j.respol.2021.104427).

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