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Finnish standardization panel pilot study: Preliminary observations and a research agenda

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Abstract: Standardization ecosystems are arguably inseparable components of innovation ecosystems and national innovation systems. The design of standardization institutions may impact innovation incentives, appropriation of research and development investments and the rate and direction of technological progress. We evaluate the status of the Finnish standardization ecosystem and the role of standardization for the stakeholders of the Finnish standardization ecosystem. Extensive stakeholder interviews provided diverse perspectives of which the following saturated observations can be highlighted. First, the role and impacts of standards vary across industries, so the perspectives on the functioning of standardization systems vary accordingly. Second, standardization education is not systematic in Finland, indicating that standardization education could be improved to complement the learning by doing approach in organizations. Third, the role of standardization is expected to increase in the future, but geopolitical tensions cast a shadow on the functioning of the system. The pilot study provides one benchmark for the analysis of national standardization ecosystems in other (European) small open economies. We conclude by presenting a research agenda.

Keywords: standardization ecosystem, national standardization system, small open economy, Finland

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Highlights:

1. There is scant evidence on the functioning of standardization ecosystems of small open economies.
2. We apply the snowball sampling method to interview stakeholders on the status of the Finnish standardization ecosystem.
3. The role and impacts of standards and standardization vary across industries, so there is a need for industry- and context-specific case studies.
4. Standardization education is not systematic in Finland and could be improved.

1 Introduction

Standardization systems are arguably important components of national innovation (eco)systems, even though their impacts on the rate and direction of technological progress seem to be chronically understudied (e.g., Blind et al., 2021), partially due to a lack of data until recently (Baron & Spulber, 2018; Blind & Kromer, 2024). Therefore, there is a need to investigate how national, regional and international standardization ecosystems coevolve in the

era of rapid technological progress and heightened geopolitical tensions (Blind, 2025; Marcovitch & Wilner, 2024; Zúniga et al., 2024).

An important underlying question is how standardization impacts the returns on research and development investments. In the Finnish context, the parliamentary target is to increase research and development expenditure (input) to four per cent of GDP (Finnish Government 2024), but the role of standardization for the returns (output) remains unclear. This paper presents preliminary findings of the "Finnish Standardization Panel" pilot study, which is a descriptive qualitative study of the status of the Finnish standardization ecosystem and the role of standardization for Finnish companies, see also Heikkilä (2024). The main contribution to the existing literature is that the approach could be applied to study the functioning of the national standardization ecosystems in other countries, in particular, in a small open economy context.

The paper is structured as follows. Section 2 discusses the notions of standardization ecosystems at different regional levels and develops the research questions. Section 3 describes the institutional context. Section 4 presents the method and data, and Section 5 reports the findings. Section 6 presents a research agenda based on the findings and Section 7 concludes.

2 Ecosystem perspective on standardization

Standards are ubiquitous and standardization may impact industry dynamics in all fields (Grillo et al., 2024; Swann, 2010). Standards are always developed in specific institutional contexts that vary across regions and evolve over time. Hence, rigorous and transparent contextualization is of utmost importance to make it clear under which conditions the empirical observations are made. From the regional perspective, there are national, regional and international institutions and policies that may impact standardization incentives, processes and outcomes. The focus here is on consensus- and formal committee-based standardization (cf. Wiegmann et al., 2017) and the European context. In the EU context, national standardization systems are integrated into the European standardization system. Generally, globalization and the deepening European integration have meant that international and regional European standards have increased in importance at the cost of national standards.

Given this institutional trend, there is a need for empirical evidence on the coevolution of national, European and international standardization institutions, strategies and ecosystems. Institutions matter and predict which countries prosper and which do not (Acemoglu et al., 2005). Historical empirical evidence suggests that countries with inclusive political and economic institutions seem to succeed while those with extractive ones fail (Acemoglu & Robinson, 2012; Koyama & Rubin, 2022). However, in a globalized world, in the context of multilateral trade institutions and global value chains, it is not only national institutions that matter, but the interplay between national, regional and international institutions. To what extent are national, European and international standards development systems inclusive and extractive institutions? Presumably, the evolution and interaction of regional standardization ecosystems and related institutions may have a significant impact on the rate and direction of technological progress and innovation that are the drivers of productivity, economic growth and our increasing living standard in the long run (Heikkilä et al., 2021).

It is well known that there can be significant knowledge spillovers in standardization work and that learning from others is one important motive to participate in standardization (e.g., Blind & Mangelsdorf, 2016). When spillovers are studied, the chosen level/unit of analysis matters (national, regional, industry tech, etc.) and the ecosystem is an important unit of analysis (cf. Baldwin et al., 2024). However, the concept of "standardization ecosystem" is not yet well-established and more often standardization activities are considered to be activities within

broader business or innovation ecosystems (Granstrand & Holgersson, 2019; Grillo et al., 2024; Nylund & Brem, 2023; Wiegmann et al., 2023; Yildiz, 2025). For instance, Granstrand and Holgersson (2019) have defined innovation ecosystem as "*the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors.*" Importantly, they also note regarding their empirical cases that illustrate the validity of their definition that "technical compatibility standards, often with some shared technologies, played a key role in creating value as well as capturing value within and between actor groups in all cases" (Granstrand & Holgersson, 2019, p. 8).

If we build upon this concept, we may define a standardization ecosystem as "the evolving set of actors engaged (or not) in standardization, standardization activities, and artifacts subject to standardization, and the institutions relevant to standardization and relations, including complementary and substitute relations, that are important for the performance of an actor or a population of actors."[1] In essence, standardization actors co-create standards (and value) in a standardization ecosystem. When viewing standardization via the Baldwin et al. (2023) ecosystem lens on innovation, the following questions can be considered as focal in the analysis of standardization ecosystems: Who are the actors in the standardization ecosystem and why do they join? How do the actors jointly create value through standardization and other means? How are members of standardization ecosystem coordinated and interdependencies managed? Who captures value and how in standardization ecosystems?

While national innovation systems have been extensively studied (see e.g., Lundvall, 1992), there is much less research dealing with national standardization systems (Blind & Kromer, 2024; de Vries, 1999) and more broadly the interaction of stakeholders within national standardization ecosystems (Kallestrup, 2017; Moon & Lee, 2021). Arguably, national standardization systems are focal parts of and cannot be separated from the national innovation systems. Regarding the question "who captures value and how in standardization ecosystems", national ecosystem perspective helps evaluate the role and impact of standardization in appropriating returns from R&D investments at the national level. As noted, in Finland, the national R&D intensity target is 4 % of GDP (Finnish Government, 2024) and the question is: How does standardization impact the returns on R&D investments in the Finnish context? While this exploratory pilot study cannot directly answer this question, we will focus on the following research questions related to the Finnish standardization ecosystem and its stakeholders[2] in order to build a future research agenda.

RQ 1: What are the roles and impacts of standards for stakeholders of the Finnish standardization ecosystem?

RQ 2: What is the status of the Finnish standardization ecosystem and standardization education in Finland?

RQ 3: How does the future of standardization look from the perspective of stakeholders of the Finnish standardization ecosystem?

[1] Alternatively, Yildiz (2025) defined a standardization ecosystem as "an interdependent network of diverse, self-interested actors, coordinated by both formal and informal mechanisms, that collectively develop, diffuse, and maintain technical standards, thereby jointly creating and enabling value across an industry or technological domain".

[2]We prefer using the broader term "stakeholder" instead of "actor" throughout the paper since we are intentionally not limiting the attention to actors active in standardization and, in this context, stakeholders include also actors.

3 Institutional context: Finnish standardization ecosystem

Finland is a small open economy with a population of 5.6 million people and GDP of ca. 278 billion euros in 2023. According to the SFS Finnish Standards, of 29,500 valid standards in Finland, over 97% were of European or international origin as of 2022. There is an analogy between the European integration related to standardization and intellectual property rights (IPR) systems, where there has been a similar shift from national IPR filing channels to European and international filing channels (e.g., Hall & Helmers, 2019). Heikkilä and Peltoniemi (2023) documented how an increasing share of patents and other IPRs in force in Finland are based on filings at the European IP offices (the European Patent Office EPO and the European Union Intellectual Property Office EUIPO) instead of the national Finnish Patent and Registration Office PRH. SFS Finnish Standards (hereafter SFS) reports on its website that in 2023 there were 950 firms and other organizations participating SFS's formal standardization activities (excl. SESKO and telecom.) and of the participating companies 45 % were SMEs.

Anecdotal evidence indicates that European and international standards and standardization have played very significant roles in the success and scaling of several Finnish companies and multiple Finnish companies have been active in standards development. However, Heikkilä et al. (2024) provide empirical evidence suggesting that even relatively large Finnish companies do not have explicit standardization strategies. Since Finland is among the most innovative countries in the world (WIPO, 2024) and Europe (Hollanders et al., 2023), it offers a particularly interesting case to investigate the role of a national standardization ecosystem as a component of the broader national innovation system and as a component of the wider European and international standardization and innovation ecosystems.

One additional motivation to analyze particularly the Finnish standardization ecosystem is the important role of standard essential patents (Bekkers et al., 2020; European Commission, 2023) for specific Finnish companies. The European Commission (2023, p.77) reported that Finland ranked as the EU country with the highest share of declared SEPs at the time. Therefore, presumably, any changes to the "rules of the game" related to the licensing of SEPs may impact disproportionately (either positively or negatively) the returns of R&D investments by Finnish companies as a whole. The national target in Finland is to increase R&D investments to 4 % of GDP level (of which ca. two-thirds are R&D investments by the private sector) and presumably, no other country's total returns on R&D investments have relied relatively more on the functioning of the SEP licensing market.

4 Method and data

Obtaining empirical evidence on the functioning of standardization systems can rely on various data collection techniques. While the obvious benchmark, the German Standardisation Panel, has focused on gathering a large number of responses using structured online surveys and analyzing general patterns and trends, the Finnish Standardization Panel aims to dig deeper into the functioning of the Finnish standardization ecosystem. In the context of a small country with a smaller stakeholder population, it is more challenging to obtain a large number of survey responses. Therefore, a more qualitative approach based on stakeholder interviews is justified. With flexible semi-structured interviews, it is possible to obtain more in-depth qualitative evidence and explore more flexibly different perspectives of various stakeholders, as well as develop a research agenda based on preliminary observations.

Another significant difference is that while the German Standardisation Panel (Blind & Kromer, 2024) categorizes respondents by sector (industries, associations, universities, certification organizations), here, the initial idea was to be as inclusive as possible with respect

to specific stakeholder categories in a broader sense to obtain as diverse a set of perspectives as possible. There is empirical evidence that larger companies that have more resources are more likely to participate in standards development (e.g., Wakke et al., 2015) and SMEs may face barriers in benefitting from standards (de Vries et al., 2009). Relatedly, lack of participation by civil society groups or other stakeholder groups can be considered a challenge to "input legitimacy" of standardization (Kallestrup, 2017; Werle & Iversen, 2006). The European standardization regulation (European Commission, 2012, Article 5) specifically notes: "European standardisation organisations shall encourage and facilitate an appropriate representation and effective participation of all relevant stakeholders, including SMEs, consumer organisations and environmental and social stakeholders in their standardisation activities." However, there was no publicly available list of the population of these Finnish standardization ecosystem stakeholders, so we decided to choose a non-probability sampling approach.

We followed snowball (network) sampling approach (Parker et al., 2019). There, known experts in the field are interviewed and they are asked to provide contacts of and recommendations for the next informants. The choice is justifiable because there is no common concept of "standardization ecosystem" and related actors and stakeholders (de Vries, 1999; Heikkilä & Ojanen, 2025; Kallestrup, 2017; Moon & Lee, 2021; Nylund & Brem, 2023; Yildiz, 2025). A significant disadvantage of this non-probability sampling and information collection method is that the eventual sample is not representative of the population related to the Finnish standardization ecosystem, questioning the generalizability of the findings. However, the objective was to be as inclusive as possible in interviewing the stakeholders and eventually, interview invitations were sent in addition to national standards bodies to industry associations, companies, civil society organizations (e.g., consumer organizations), ministries, investors and financiers, research organizations, universities, universities of applied sciences and certification and accreditation organizations. This categorization of standardization ecosystem actors is broadly consistent with de Vries (1999, pp. 30-35) who categorized standardization stakeholders to producers, users, consumers, governments, consultancy firms, scientists and others (trade unions, testing, certification and accreditation, ecology movement)[3].

The interview protocol is presented in the Annex. These were shared with the interviewees before the actual interviews. During and at the end of the interview sessions, the interviewees were given the chance to discuss and raise any additional perspectives and themes that, in their opinion, should be part of the following interviews. One such topic that was mentioned by several interviewees – mainly standardization organizations – was the public financial support for standardization activities and how it has recently decreased due to the government's budget cuts.

Heikkilä (2024) compares the methodological approaches of the Finnish Standardization Panel pilot study and its benchmarks, the German and the recently piloted European standardisation panels (Blind et al., 2024). Blind and Kromer (2024) define "A panel survey is a survey carried out among the same economic players (persons or companies) on the same topic and over time." The idea with the Finnish standardization panel survey is also to repeat the data collection in the future, but with the focus on "clusters of standardization ecosystem stakeholders" (perspectives of companies, industry associations, academia, civil society organizations, etc.).

The primary data collection using the described snowball sampling method proceeded as follows. First, in late 2023 and early 2024, we contacted Finnish standards organizations for the initial first interviews and asked them to suggest further interviewees who had then had the

[3] Moon and Lee (2021) developed a slightly different categorization emphasizing : technology producers, standard-setters and relevant participants in the standardization process, technology users and regulators.

chance to recommend further interviewees and so on. Altogether 215 invitations were sent, and 87 informants (40.5% response rate) participated in the interviews (80 online or in-person meetings) or replied in writing via email. In four interviews, there were two informants. An average interview duration was 45 minutes 17 seconds (ranging from 24 minutes to 78 minutes) and in total 57 hours and 21 minutes of interviews were recorded. Table 1 illustrates the stakeholder categories that participated in the pilot study interviews and indicates also which groups are over- and which underrepresented among the respondents. This interview data was selectively transcribed to preserve the anonymity of the respondents, coded and analyzed to answer the research questions. The respondents were also given the opportunity to comment on an earlier version of this manuscript between 15 January and 15 February 2025.

Table 1: Interviewed standardization ecosystem stakeholders. Authors' illustration.

Stakeholder/Actor	**Number of respondents**	**Share**
Standardization organizations	21	24.14 %
Industry associations (without official standardization duties)	5	5.75 %
Companies	30	34.48 %
of which		
Large (>250 employees)	13	
SMEs (10-250 employees)	10	
Micro (<10 employees)	7	
certification and accreditation organizations	1	
Universities and universities of applied sciences	21	24.14 %
Government	2	2.30 %
Research organizations	4	4.60 %
Civil society	0	0.00 %
Investors and financiers	0	0.00 %
Others	4	4.60 %
Total	87	100.00 %

The snowball sampling approach was complemented with interview invitations sent to all the leading companies of Business Finland's Veturi ecosystems (Lähteenmäki-Smith et al., 2025). This funding instrument is an important national mechanism to allocate public R&D subsidies and is explicitly linked to achieving the national target of 4 % of GDP R&D expenditures. As part of the interviews, the idea was to improve our understanding of how standards and standardization may affect the R&D collaboration within these organizations and impact the returns on R&D investments. Eventually, three persons representing three leading companies of Veturi ecosystems (of 23, 13 % response rate) participated, so unfortunately, the external validity of Veturi ecosystem perspectives might be limited. However, of the interviewed companies, nine were leading Veturi ecosystem companies, but the interviewed persons were not directly involved in the Business Finland funded Veturi ecosystem projects.

Out of the 215 contacted persons, 128 (59.5%) were considered "non-responses". It is important to distinguish between the reasons for non-response. Non-responses can be categorized into two: 1) no response to email invitation and two remainders (97 persons, 45.1%), 2) declined due to low level of knowledge about standardization or replied that there is no time to participate (31 persons, 14.4 %). Some persons who declined themselves shared the invitation to colleagues and/or recommended other specific persons that could be interviewed and, thus,

contributed to the snowball sampling. There were so many recommended respondents that eventually it was not possible to invite and interview all of them. Also, given the small country context characterized by limited standardization expert networks, some persons were recommended by several interviewees.

As noted, SFS reports that in 2023, there were 950 firms and other organizations participating in SFS's formal standardization activities (excl. SESKO and telecom). If we had followed the approach of the German standardisation panel, we would have contacted these active organizations and their experts. This could be one potential option for future rounds of the Finnish standardization panel study. While the final sample of 87 respondents is not representative of the Finnish standardization expert population, it is a large set of standardization stakeholders in a qualitative interview study.

5 Preliminary findings

Here, we present the observations at a high level with only exemplar quotes from the interviews, since the systematic analysis of the collected interview material is still in progress. After more than 100 years of Finnish standardization and 30 years of the European Single Market, the following saturated findings regarding the Finnish standardization ecosystem can be reported.

5.1 The role and impacts of standards and standardization

In line with previous studies (Menon Economics, 2018; Vennerød et al., 2023), standards are viewed as particularly important as enablers of compatibility, market access and scaling, as well as (product and cyber) safety and trust. Thus, we may say that all the types of standards listed in their common classification (variety reduction, minimum quality, safety, measurement, compatibility and interoperability) (Swann, 2010; Blind & Kromer, 2024) were covered. Competitiveness was also mentioned as one important aspect which is affected by standardization.

"Well, from societal point of view, the main goals of standardization, ensuring safety, ensuring compatibility and keeping the number of product variations in some reasonable amount – probably all of these serve the society quite well."

"You must always start with safety. Safety is the backbone and for society, like Finland, we rely heavily on exporting, hence, competitiveness."

"somehow all these [standardization] are related to competitiveness and that the competition is fair, transparent and open."

"Well, in my opinion, it [standardization] maintains order, you know that when a thing is standardized and it conforms to s standard, it meets certain requirements. It is safe, the quality is uniform, it is like the basis - - you know what you get."

"From the perspective of a consumer, the trust on the product, so that I know what I get when I buy something."

In addition, the important role of standards in promoting international trade and decreasing barriers to trade got mentioned both in the context of the European Single Market and globally.

"With standards you create a single market. You can also create a new market with standards and create yourself temporary – or hopefully more permanent competitive edge in the markets."

"Yes, it [standardization] is considered a very important element with which it is ensured that the products can enter the markets and they meet the requirements and then it enables this free movement of goods in Europe. Of course, now the goal is global standards."

"the promotion of global trade, and let's say reducing barriers to trade, that is what it is about."

"It [standardization] is dismantling trade barriers – that is by far the most important thing. In the EU, these standards have a significant role – at least in the field that I represent. There are these so called harmonized standards that are linked to legislation and in that way trade barriers are removed so that no single member state can set additional requirements. The playing field is levelled."

On the other hand, the politicization of standards was also mentioned.

"It seems to me that the urge of the European Commission to have an impact, shakes the standardization field."

It should be noted that some of the interviewed large companies operate in multiple industries and the role of standards may differ between different units within such a company. There are significant industry differences that make generalizability questionable. For instance, safety was highlighted in the context of machinery and electrotechnical field, measurement methods in the field of chemistry and interoperability, compatibility, interfaces and network effects in information and communications industry. Also, the standardization environments vary across industries – and at the interviewee level – so that, for instance, the telecommunication sector relies heavily on global standards while standards in the construction industry are more target market specific. To conclude, it is challenging to compare the importance of standards between interviewees as the types of relevant standards are different by industry.

The majority of the respondents were not familiar with standard essential patents, as they are mainly related to businesses that operate in the telecommunication sector. The following response was quite typical: *"I am completely unfamiliar with them."* This is consistent with the observations of the European standardisation panel pilot study (Blind et al., 2024, p. 32), which reports that "the whole set of problems related to IPRs in standardisation is not perceived as a challenge by most respondents". This further highlights the need for industry-specific case studies and analyses that consider the different roles and impacts that standards may have, as well as specific intellectual property (IP) policies of standardization organizations and related patent licensing practices. Sharing own know-how, critical intangible capital, via standards is a strategic decision.

"And then it is an intentional decision of the management that a specific part of this knowledge that has been accumulated over the years is given for free via standards and it brings credibility and eases others' operations in this field."

When asked about the association between standardization and regulation, multiple interviewees noted that standards may prevent overregulation in the European Single Market. However, the association between standardization and regulation varies across industries.

"I represent that school, which thinks that with standards one can avoid overregulation. I strongly believe that."

"Regulation as a term has more negative connotation among companies whereas standardization does not, in my opinion."

"Now, increasingly European Commission tries to use standardization as an extension of legislation and sometimes it succeeds sometimes less so."

However, the concept of co-regulation (CEN-CENELEC 2015; Kallestrup, 2017) ("yhteissääntely" in Finnish) is not widely known. The concept of coregulation was touched upon in some of the interviews when the association between standardization and regulation was discussed, and only a few informants knew the concept.

The descriptions regarding the associations between standardization and innovation varied a lot across interviewees and by industry like the descriptions of the relation between standardization and regulation. Typically, standardization was considered to promote innovation activity, but there were also more critical perspectives.

"I think innovations come first and then standards."

"Standardization is essential part of the risk management that is related to developing a new solution. It would be important to know the existing standards and their development trajectories, to which one can anchor with own innovation and R&D activity so that it, in a sense, creates a road map of the topics which should be taken into consideration in R&D."

Regarding Business Finland's Veturi ecosystems, the following quote illustrates how one leading company considered standardization know-how and sharing it to be central to successful R&D collaboration.

"If we consider our Veturi activities which are executed in very close collaboration with industry collaborators, be it in X or Y industry, they [standards] play a very important role and the reason is that from the perspective of competitiveness and innovation, it is not enough to know standards [of own industry]. - - It equally requires that we can ensure with collaborators that we understand very well also the prevailing standards in each industry as well as competing standards which there can also be. And bringing these together is extremely important when considering developing new solutions related to, for instance, digitalization."

When interviewees were inquired whether there is too little or too much standardization in their field, several responded that there is "an appropriate" amount ("sopivasti").

"The problem is not that there is too many or too little standards. The problem is that these actors do not broadly speaking even know which are the most relevant standards for their own industry, which development would be important to monitor."

However, there were some concerns that there is overlapping or competing standardization work in different groups creating inefficiencies.

"There are indeed a huge amount of standards and there has also been such developments that for the same purpose different groups are developing own standards. Which is not good because it dilutes the original idea of standardization, there are too many standards."

Furthermore, understanding the European regulations and standards that are related to CE markings was considered a challenging task for newcomers.

"As a producer, if you were starting a new business, then how would you know which European directives [to follow], is it one, two or three, so that you can put CE marking. Then you need to know, which are the standards, the relevant standards. That can be quite a – at least it is not easy."

5.2 Status of the Finnish standardization ecosystem and standardization education in Finland

Generally, respondents did not view the status of the Finnish standardization ecosystem as very competitive or positive but rather reported multiple weaknesses and raised areas for development. Standardization education in Finland is not viewed as systematic (with a few exceptions) and standardization experts' learning paths related to standardization are quite diverse, even random. Standardization experts often "learn by doing" in organizations which requires long-term commitment, consistent with earlier anecdotal evidence from the Finnish context (Heikkilä et al., 2024).

"If we talk about standardization know-how, I don't feel that there is at least too much of it. - - I think that there is room for improvement and I refer to the awareness of companies about what standards are, how they may impact competitiveness, why one should be interested about them and, especially, how one can join working groups and what one's role could be there."

Here, the fragmentation of career paths was seen as a risk; some interviewees claimed that young experts change employers more frequently, which hinders the development of new standardization experts. The majority of the interviewees reported that they did not learn about

the role of standards for business during their studies (most often in Finnish universities) and Finnish universities do not offer any basic courses on the role of standards and standardization. *"Standards were not even touched upon during studies"*, according to one interviewee. This is consistent with observations reported by Gabriel et al. (2022).

As part of the data collection, we invited respondents from various faculties and disciplines to provide their perspectives and examples of how standards are included in curricula, but due to a low response rate, it is not possible to make strong conclusions. Low response rate may indicate that the topic is not considered to be of high importance, as even some of those who responded note that standardization is not part of curricula:

"In our discipline there is no specific education on standardization. Standardization is discussed at very high level and some standards are mentioned that are related to procurement and responsibility, for example, ISO 20400, ISO 26000. The contents of standards might be discussed a bit. In practice, standardization is not included in [our curriculum]." (business)

However, there were some exceptions as illustrated by the following quote from the field of mechanical engineering:

"Students are guided to search and use standards developed by different organizations as source material for, e.g., measurement, dimensioning, choices of material, designing, evaluating the solutions from the perspective of sustainable development, identifying safety aspects, quality thinking, etc." (mechanical engineering)

Based on the interviews, we may argue that it is important to distinguish between different types of standardization know-how: 1) The technical substance know-how related to standards (what information standards provide and how they are interpreted and used in practice in specific industry contexts). 2) The process know-how related to the development and production of standards. 3) The know-how related to the strategic role of standards and standardization for businesses.

Most of the interviewees reported that, particularly, the learning of the role of standards for businesses has happened via "learning by doing" in companies and other organizations and/or by participating in technical committees. Hence, the know-how related to the use of standards seems to be in most industries on a higher level compared to standardization process know-how or the strategic use of standards.

"We need standardization process experts, these people who know when to influence, where to influence, what are the rules of CEN and ISO, how we can influence and what cannot be done - in essence, to know the systemic level."

Some interviewees referred to the small number of leading standardization experts. Several standardization experts have retired (and some still participate in standardization) or are close to retirement age. This challenging demography and aging standardization community is a risk related to continuity management and resiliency in national as well as European standardization, consistent with the observations of the European Standardisation Panel (Blind et al., 2024) and the German standardisation panel (Blind & Kromer, 2024).

"It's quite a small group of experts from different countries. - - It's the same fellows there. It just shows that standardization is even in big companies on quite small shoulders. There are a few fellows, who have been interacting with these standards for years and they feel some kind of attraction to them and interest – and that is what is required."

"This gang is old. There are several ones who have already retired, but have not stopped working [in standardization]."

5.3 Future of standardization

Many of the respondents expected that the role of standards will increase or at least not decrease in the future. When asked about opportunities and threats related to the future of standardization, the interviewees identified multiple challenges: standardization processes are too slow, decreasing national financial support to standardization, aging standardization experts and geopolitical tensions.

The increasing speed of technological change was viewed as a challenge for the traditional way of developing standards.

"Well, this is a remarkable turning point that if standardization society cannot renew itself, then, my view is that, its importance will decrease and I justify this claim by the fact that world is changing so fast that with this classical way of doing things, that standard is ready in three, five or ten years, we will not be relevant anymore. This is due to the accelerating technological progress."

Relatedly, there were some concerns that the production process of European harmonized standards is "too slow" or even "broken" in the current context, where technological progress is faster than ever.

"I think that the process how the Commission makes standardization requests and then the production of standards is broken at the moment. There are plenty of examples of this."

For instance, a few interviewees complained that the Harmonised Standards (HAS) consultants' assessment process can take very long and the reasons for delays are not transparent.

"And then these harmonized standards, these are, let's say bluntly very big problem and challenge. - - These HAS consultants, who make this assessment whether the standard is compliant with the [X] directive. - - Somehow this process must be sped up."

Several interviewees noted the increasing standardization activity and contributions of China and Chinese players, which is noted and documented by multiple authors (Rühlig 2023, Marcovitch & Wilner 2024). Given this development, there was a concern that the relative power of Finnish as well as European players decreases if no action is taken.

"If you take an international perspective, there this geopolitical tension is such that it undoubtedly impacts and it is visible in the competition, like competing standards, there are examples and it probably continues that competing standards are created that can be directly related to this political situation, the tensions. - - And then some large companies have the capability to influence and direct political debate regarding, for instance, regulation as an example, and I don't believe - - that this would somehow decrease."

"- - standardization initiatives and suggestions from China – their quality is improving at a very fast pace. They are very convincing, and a lot of work has been put into them. They are justified by the goals of the United Nations and the EU, CEN's and ISO's own goals. So, they are very well-developed standardization topics, but there are many question marks on the background, what is the goal of this."

The competition and lack of collaboration between standardization organizations were also considered a challenge, although it is not necessarily related to geopolitical tensions.

"Well, we have seen this unfortunate [development] that some standards organizations - we have witnessed this at X and Y levels – they are not able to collaborate. So, that there are crazy situations that we cannot refer to X standard if it becomes part of Y standard. This competition between standardization organizations, which is visible to us, is very unfortunate."

As was noted above, the perception of the demography of Finnish standardization experts based on the interviews was that more old experts are exiting than new experts entering the talent pool. However, confirming this claim would require statistical data on participation to standardization by Finnish stakeholders. One interviewee noted that in order to get the next generation of standardizers inspired, there is a need for a "new societal narrative".

"*A new societal story should be created for standards, or what is their role now for us, our society, our economic area in the EU and for the world. How can we promote good things via standards. We should find a new narrative, in my opinion, what is it that we are heading towards*."

Finally, the respondents had the opportunity to raise standardization topics that they considered important, but which were not included among the themes of the interview protocol (Heikkilä, 2024). One such topic that was raised by multiple interviewees was the public support for standardization – or the lack of it. Increasing participation costs (reduced support from the ministries) have led some monitoring participants to drop from standardization groups. In 2023, 81 % of SFS's revenue originated from the sale of standards documents[4] and there were some concerns what the implications of the recent judgement by the European Court of Justice in the case C-588/21 P ("Malamud case" as referred to by some of the interviewees) will be concerning public access to specific Harmonized Standards under Regulation 1049/2001 (Kanevskaia, 2025).

Another specific topic discussed in some of the interviews was the link between public R&D funding and standardization. Should standardization be considered more systematically in public R&D (mainly Business Finland) funding applications and reporting and what could be learned from other countries?

"I would say that for research organizations it is very important to obtain earmarked funding to develop standardization know-how. - - When Business Finland grants funding to research of some technology field, then it would also expect that the research organization is active in standardization."

Some interviewees noted that participating and contributing to standardization is not an acknowledged merit in academia like research publications. This observation is in line with the findings of the European Standardisation Panel survey (Blind et al., 2024).

"It is a big problem, indeed, that it [standards development] does not bring any merit, it is not visible in the curriculum vitae. Or maybe one could note there that 'I've participated actively the development of X [standard]', but it has not been the custom."

5.4 Limitations

While the qualitative primary data collected in the interviews is very rich and diverse, these preliminary findings are not directly generalizable to represent the perspectives of the whole Finnish standardization ecosystem. Snowball sampling method is inherently prone to selection bias (Parker et al., 2019) and, presumably, due to the self-selection to participate in interviews, the perspectives on the importance of standards are positively biased. The German Standardisation Panel survey is subject to similar criticism since there it is reported that experts participating formal standardization consistently find formal standards to be more important than other types of standards (consortia, de facto, company standards) (Blind & Kromer, 2024). Second, regarding the representation of different stakeholder groups, start-ups, investors and civil society groups are not well represented. Third, we did not describe the changing regulatory and legislative context in detail. Interested readers are recommended to consult, for instance, European Commission (2003), CEN-CENELEC (2015) and Kanevskaia et al. (2024) on the interaction between European Standardization Organizations. In the Finnish context, there have been some discussions about the decentralized structure of the national formal standardization system (Bonner & Potter, 2000; Niemelä & Jokinen, 2018), but analyses of these are beyond the scope of this study and are left to future research. Fourth, while management standards are the most popular standards bought from SFS Finnish Standards, in this pilot study their role was not particularly considered. In contrast, the German Standardisation Panel study (Blind &

[4] See https://sfs.fi/sfs-ry/meista/sfs-lukuina/ Accessed 18 Dec 2024

Kromer, 2024) contains a dedicated section that follows the certification of activities of organizations regarding management systems ISO 9001, ISO 14001, ISO 50001 and ISO/IEC 27001.

6 Towards a research agenda

Based on the preliminary observations presented in Section 5, we suggest here selected future research topics and research questions that are particularly relevant when analyzing the functioning of the Finnish standardization ecosystem as well as national standardization ecosystems in other countries. Section 6.1 argues for the elaboration of the ecosystem lens on standardization, Section 6.2 focuses on standardization capabilities and education and Section 6.3 raises some Finland-specific topics.

6.1 An ecosystem lens on standardization and impact assessment

While this paper has used the notion of "standardization ecosystem", it is not yet well-established and elaborated in the academic literature (Grillo et al., 2024; Nylund & Brem, 2023; Yildiz, 2025). Ecosystem perspective requires identification of actors and stakeholders of the standardization ecosystem (Granstrand & Holgersson, 2019; Kallestrup, 2017; Moon & Lee, 2021) as well as the understanding of the interaction between standardization actors and more widely the players of the national innovation system. We aimed to be as inclusive as possible in inviting stakeholders to provide their perspectives on the subject. However, it should be noted that here the focus and snowball sampling were focused on formal standards with less weight on, among others, consortia standards (Wiegmann et al., 2017) that are particularly common in the ICT field (e.g., Teubner et al., 2021). Future studies would benefit from clarifying the relation of "standardization ecosystem" to the more established – but still vague – innovation, knowledge and business ecosystem concepts and literature (e.g., Granstrand & Holgersson, 2019; Scaringella & Radziwon, 2018; Yildiz, 2025). Moreover, the role of standardization ecosystems as components of wider innovation ecosystems (Baldwin et al., 2024; Granstrand & Holgersson, 2019; Heikkilä & Ojanen, 2025; Nylund & Brem, 2023) merits further research. As complementarity lies at the core of ecosystems (Teece, 2018), what are the complementarities between innovation ecosystems and standardization ecosystems?

From the perspective of impact assessment, there are several open questions: How does standardization impact the appropriation of the returns from increased R&D investments? The national target in Finland is to increase R&D expenditures to 4 % of GDP (Finnish Government, 2024). A significant amount of R&D funding is channeled via Business Finland's "Veturi ecosystems" led by large Finnish companies, which begs the question: How are these ecosystems engaged in the development of international, European and Finnish standards? Obviously, many of the leading companies of Veturi ecosystems are also actively participating in standards development, but more evidence is needed on the standards-related collaboration and information sharing among these leading companies and other actors in their Veturi ecosystems. Presumably, ecosystem collaboration promotes the exchange of standards-related information, but its impacts on innovation outcomes are less clear. How could Business Finland assess the role of standards development when granting R&D subsidies and loans to companies? How does standardization impact technological progress, scaling of businesses and productivity in the Finnish context?

Like existing innovation studies also empirical standardization studies take different perspectives varying from industry-level analyses, standard-specific to standards-competition analyses, among others. However, there is a lack of national-level standardization ecosystem analyses that take into account specific national institutional contexts. In the Finnish context,

as well as the context of any other EU member state, the interplay between national, European and international standardization ecosystems is of particular interest. Also, in the Nordic context, there are deep collaboration networks and systematic information exchange practices in various sectors, industries and policy levels, so that more systematic documentation of the long history of Nordic standardization collaboration would earn more attention (Menon Economics, 2018; Niemelä & Jokinen, 2018; Vennerød et al., 2023).[5] One topic that was not covered in the pilot study is: What kind of international collaboration opportunities are there for national standards ecosystems? How could the standardization systems and institutions at national, European and international levels be developed further, as it is clear that currently they are not functioning as well as they could? Since standardization is one transmission mechanism of the Brussels effect (Bradford, 2020), which stakeholders drive (undermine) the Brussels effect by leading (hindering) the development of European and global standards?

Globalization and European integration have meant a shift from national standardization to European and international standardization. The obvious policy implication is that a national standardization strategy and policies (Heikkilä & Ojanen, 2025; Hemphill, 2009) cannot be developed in a vacuum and in isolation as a disconnected exercise from the EU-level standardization strategy (European Commission, 2022). National standardization ecosystems of the EU member states are linked to the EU-level standardization ecosystem (CEN-CENELEC, 2015) that is inherently linked to the international standardization ecosystem, CEN with ISO via the Vienna agreement and CENELEC with IEC through the Frankfurt agreement.[6] In the EU context, a national standardization strategy must take into account the EU level standardization strategy (European Commission 2022), although there can be national priorities, as is typical in existing strategy documents (Heikkilä & Ojanen, 2025). How are national standardization strategies and policies of the EU member states linked to the standardization strategy of the EU?

If we want to better understand and evaluate the (co)evolution of standardization ecosystems, we need improved statistics, standardized metrics and key performance indicators (KPIs) for assessing their functioning. What is the return on standardization investments ("ROSI")? What are the costs and benefits? Knowledge spillovers are an obvious measurement challenge, and they mean that the returns on standardization investments vary by region depending on the amount of cross-border knowledge diffusion. The same measurement challenges persist in the measurement of returns on R&D investments where social returns exceed private returns (e.g., Lucking et al., 2019). What are the national, European and global returns on standardization investments? To what extent is the development of standards production of national, European and global public goods?

At the macro-level (country), there are analyses that report the quantity of standards to correlate with economic growth and productivity (Blind & Jungmittag, 2008; Blind et al., 2021; Menon Economics, 2018; Vennerød et al., 2023), but such correlations obviously abstract away and do not control for the quality of standards. In the existing research literature, a variety of micro-level (organization or individual) metrics have been utilized to measure standardization activities depending on the context. For example, participation in standardization committees, number of chair positions and convenors (Baron & Kanevskaia, 2023; Blind & von Laer, 2021), number of standards contributions (Ali-Vehmas, 2016; Baron, 2020) and the number of standard-essential patents (Bekkers et al., 2023; Buggenhagen & Blind, 2022).

[5] Similarly, while there are interesting overviews of the history of international standardization (e.g., Yates & Murphy 2019), a comprehensive history of the European standardization ecosystem is missing.

[6] See https://www.cencenelec.eu/about-cen/cen-and-iso-cooperation/ and https://www.cencenelec.eu/about-cenelec/cenelec-and-iec-cooperation/ Accessed 18 Dec 2024.

Clearly, the listed metrics can be used to analyze, for instance, the level of inclusiveness in the development of technical standards, in particular, compared to a situation where there is a de facto standard imposed by a dominant player. It should be noted that many of the studies have focused on the ICT sector where there is a lot of data (incl. patent data) available and specific IP policies regarding the licensing of standard essential patents (Baron & Spulber, 2018; Kanevskaia et al., 2024). Governance structure differences and related differences in incentives should always be taken into account before making generalizations across industries and standardization environments.

When measuring the impacts of open and consensus-based standards, the choice of counterfactual is important. In many cases, it might be a lock-in to a dominant design, a de facto standard or a closed ecosystem developed by some specific dominant player. The former process of open and consensus-based standards development is obviously more inclusive, but, on the other hand, typically slower consensus-building process. Hence, the choice of time horizon should also be carefully considered when the impacts of standardization and evolution of standardization ecosystems are evaluated. What are the impacts of standardization ecosystems in the short, medium and long run?

6.2 Standardization capabilities and education about standardization

Standards and standardization may impact more or less all businesses in all sectors and industries. A key strategic question in the business context is whether or not to participate in standards development and how much resources to allocate to standardization work. Large incumbent companies have learned and accumulated experiences related to standardization over time (Heikkilä et al., 2024), but obviously, the challenge to navigate a complex standardization environment is much harder for a startup or an SME that does not possess an equal amount of standardization experience and in-house standardization know-how (de Vries et al., 2009). Therefore, the key question is: how to make the standardization learning paths and capability development processes more efficient in Finland? How to codify and transmit standardization-related tacit knowledge within and between organizations more efficiently? At a minimum, it is important that companies prepare for changes in the standardization environment proactively (Heikkilä et al., 2024). This requires standardization and regulation related to strategic foresight and anticipation of scenarios (Blind, 2008; Marcovitch & Wilner, 2024). How could companies improve their standardization capabilities and standardization foresight?

Empirical evidence indicates that larger firms are more likely to participate in standardization (e.g., Wakke et al., 2015). Therefore, it is important to analyze how start-ups and SMEs engage in standardization activities in their growth paths towards established players in the field and which barriers they may face (de Vries et al., 2009; Waguespack & Fleming, 2008). How does standardization impact both positively and negatively the performance of these companies?

This pilot study suggests that many of the interviewed experts have accumulated their standardization know-how via learning by doing ("experiential learning"), which is consistent with the findings of Heikkilä et al. (2024). One of the main findings in the interviews was that standardization education in Finland is not systematic and there is room for improvement. As noted in Section 5.2, standardization know-how could be classified into three categories: A. the technical substance know-how related to standards (what information standards provide and how they are interpreted and used in practice in specific industry contexts) and B. the process know-how related to the development and production of standards as well as C. the know-how related to the strategic role of standards and standardization for businesses.

Given this simple categorization, it is important to consider what is the efficient division of labor in the development of standardization capabilities. Standardization capabilities of local stakeholders and the national standardization ecosystems can be promoted via raising standards awareness and by more systematic standardization education (cf. Gabriel et al. 2022). It seems that obtaining a basic understanding of the standardization systems was considered to be an important learning objective by many respondents (Section 5.2). Some interviewees also pointed out that there is not necessarily need for an own standardization-specific course, but the standardization environment could be discussed as part of other courses. Further industry-specific details are then learned in organizations where graduates are employed. Via industry associations, companies can keep themselves up-to-date on the current status and forthcoming changes in the standardization environment and gain standardization foresight (Marcovitch & Wilner, 2024), but what else is needed? Could improved standardization education (e.g., at the university level) lead to better outcomes and the avoidance of repeated mistakes in experiential learning processes?

If the goal is to develop and strengthen the European standardization ecosystem, then there is a need for the standardization of European-wide standardization education (incl. the processes of the development of European harmonized standards). There are currently initiatives related to the development of European standardization education and standardization organizations provide teaching materials on their websites.[7] What is the best way to integrate education about the European standardization system into the curricula of degree programs in higher education?

Finally, the tacit knowledge regarding standards and standardization accumulated in organizations is valuable intellectual capital that, based on the interviews, is often concentrated in a few experts. From the resiliency perspective, companies might benefit from a more systematic transfer of standardization know-how from experienced employees to younger ones since the experience of many interviewees was that their standardization careers started when the previous standardization expert in their organization retired and they were given their old tasks (e.g., participation in standardization committees) without much orientation and mentoring. How could the transfer of tacit standardization know-how be promoted in a more systematic and efficient way?

In the current era of increased geopolitical tensions (Blind, 2025; Marcovitch & Wilner, 2024; Rühlig, 2023; Zúniga et al., 2024) and new industrial policy (Juhasz et al., 2024) standards may act as enablers or barriers to trade and there are significant risks of deepening protectionism. It seems that there has been a shift from globalization to de-globalization and geopoliticization. The recent reports by Letta (2024) and Draghi (2024) on the competitiveness of the European Single Market paid relatively limited attention to the functioning of the European standardization ecosystem. If countries engage more intensely in active industrial policy with directed innovation policies and picking winners, one should not forget the role of standards in those contexts. Hence, the central question is how to develop national, European and international standardization ecosystems in tandem and in a balanced and inclusive manner, taking into account the perspectives and interests of all stakeholders. How can standards, in an efficient way, promote digital and green twin transition as envisaged by the European Standardization strategy (European Commission, 2022)? In the era of increased geopolitical tensions and new industrial policies, what should be the (strategic) standardization priorities?

[7] See, e.g., ETSI's website: https://www.etsi.org/education/teaching-material Currently, there are new initiatives to foster European standardization education, e.g., Edu4Standards, https://www.edu4standards.eu/ and High-Level Forum on European Standardisation, https://single-market-economy.ec.europa.eu/single-market/european-standards/standardisation-policy/high-level-forum-european-standardisation_en. ISO maintains also a dedicated website on education about standardization: https://www.iso.org/education-about-standards.html Last accessed 4 Dec 2025.

Should specific technologies and ecosystems be given particular attention, weight and resources in the context of standardization?

6.3 Other Finland-specific topics

6.3.1 Standard essential patents

While many interviewed standardization stakeholders were not so familiar with patents, Finland is an extreme case of a country whose returns on R&D have been the most reliant on the functioning of SEP licensing (Baron et al., 2023). Standard essential patents are linked to specific technologies, such as wireless technologies (Baron & Spulber, 2018), where the ownership of SEPs is to a large extent concentrated in the hands of a few large corporations (Baron et al., 2023; Bekkers et al., 2020, 2023; Buggenhagen & Blind, 2022). Changes to the "rules of the game" related to the licensing of SEPs may disproportionately impact (either positively or negatively) the returns of R&D investments by Finnish companies, which has direct implications for the national target in Finland to increase R&D investments to 4 % of GDP level. Concurrently, an important and widely documented trend during the past decades has been the rise of Chinese companies in the field of SEP licensing (e.g., Bekkers et al. 2020; Rühlig, 2023). Hence, in the context of SEPs, there is a direct link between IPR (European Commission, 2020) and standardization strategies (European Commission, 2022) that needs to be carefully analyzed during these times of geopolitical tensions.

6.3.2 Digitalization and standardization

Heikkilä and Ojanen (2025) noted: "As Finland is one of the global leaders in digitalization (e.g., by the European Commission's Digital Economy and Society Index), could Finland also act as a forerunner in the field of digitalization of standardization-related processes and activities?" Digitalization, as well as the recent Court of Justice of the European Union decisions (PublicResourceOrg, "Malamud case"), challenge the traditional business models and funding bases of standardization organizations (Bonner & Potter, 2000; Kanevskaia, 2025; Niemelä & Jokinen, 2018). The future of business models that are based on selling copyrighted standards documents is challenging in an era of generative artificial intelligence systems (e.g., ChatGPT, etc.). Large language models are crunching full patent databases that aside from standards documents, are another important source of codified technical knowledge. A topical question is how the business models of standardization organizations can be developed.

6.3.3 Development of the Finnish Standardization Panel Study

This pilot study has explored the status of standardization activities in Finland. It can be utilized as a benchmark alongside the German and European Standardisation Panels if the status of the national standardization ecosystem is studied in other countries, in particular, in a small open economy context. As the title of the project refers to "panel study", the idea is to recollect information about the status and functioning of the Finnish standardization ecosystem in the future. The snowball sampling method worked well in this pilot phase, but the next round could follow the online survey data collection and methodological approaches of German or European Standardisation Panels (Blind et al., 2024; Blind & Kromer, 2024) and the next step could be to design a company survey questionnaire. Another option would be to develop the Finnish Standardization Panel towards a reoccurring foresight exercise following the Canadian approach (Marcovitch & Wilner, 2024). Regarding standardization education, there is a need to collect more systematic information about standardization-related courses in Finnish universities and universities of applied sciences to assess how they support the development of standardization capabilities and career paths of future standardization experts.

7 Conclusion

The economic success of small open economies such as Finland is dependent on the functioning of multilateral trade institutions, of which standardization systems (as well as IPR systems) are prominent examples. Hence, it is important to investigate how stakeholders from small open economies integrate into these institutions. The topic is highly relevant in the context of the European Single Market, where standardization activity on its part defines "who drives the Brussels effect" (standard-makers) and who follows (standard-takers).

This pilot study has shed light on the status of the Finnish standardization ecosystem and the role of standardization for the stakeholders of the Finnish standardization ecosystem. The collected rich interview data provided various perspectives, of which we highlight the following preliminary observations: First, the role and impacts of standards vary across industries, so that the perspectives on the functioning of standardization systems vary accordingly. This has implications for impact assessment and the choice of counterfactual therein, as well as stresses the importance of context-specific case studies. Second, standardization education is not systematic in Finland, indicating that standardization education could be improved to complement the learning by doing approach in organizations. Third, the role of standardization is expected to increase in the future, but geopolitical tensions cast a shadow on the functioning of the system.

The pilot study provides one benchmark for the analysis of national standardization ecosystems in other (European) small open economies. From the methodological perspective, snowball sampling of informants worked well in this pilot phase. In the future, qualitative interview-based methods might be preferred in small countries, such as Finland, compared to the online survey that has been applied in Germany for over a decade, if, for instance, the European Standardization Panel pilot study (Blind et al., 2024) will be followed by new rounds of data collection in the future.

Annex

Interview protocol

1. The role and impacts of standards and standardization

- A. For society B. For the industry C. For the company/organization/entity (depending on the interviewee)
- Which standards are the most effective ones?
- Which standards have you been involved in developing?
- Is there too much or too little standardization?
- Relationship between standardization and 1) regulation? 2) innovation?
- Special topics (depending on the interviewee):
    - Digitalization, data, AI, IoT, cybersecurity
    - Sustainability, responsibility
    - The role of IPRs, licensing and standard essential patents

2. Status of the Finnish standardization ecosystem and standardization know-how in Finland

- Current status, learning paths, education, information sources

- How should the system and know-how be developed further?
- Challenges and opportunities related to education

3. Future of standardization

- How the role of standardization will evolve in the future (opportunities, challenges, geopolitics?)
- How could the standardization ecosystem function better and be more effective?

4. Any other topics and themes raised by the interviewee

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Conflict Of Interest (COI)

There is no conflict of interest.

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