Research article

Overcoming the harmony fallacy: How values shape the course of innovation systems

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A B S T R A C T

The technological innovation systems (TIS) framework is one of the dominant perspectives in transitions studies to analyze success conditions and system failures of newly emerging technologies and industries. So far, TIS studies mostly adopted a rather harmonious view on the values of actors and by this were unable to address competition, conflicts and, in particular, battles over diverging directionalities within the system. To empirically assess this potential "harmony fallacy", we identify values as part of underlying institutional logics of major organizations in the field of modular water technologies in Switzerland by means of 26 expert interviews. We show how logics may condition collaboration patterns and technological preferences. This analysis inspires key conceptual tasks of innovation system analysis, like the identification of system failures, the setting of appropriate system boundaries and the formulation of better policy recommendations.

1. Introduction

Over the past decades, research in innovation studies has informed innovation policy based on different rationales. While prior innovation studies research focused on fixing market failures to foster economic growth, from the 1980s on, the analytical perspective broadened to account for weaknesses of innovation system structures to explain competitiveness and innovative performance at the level of countries, regions or specific technological fields (Woolthuis et al., 2005, Edquist, 2005, Weber and Truffer, 2017, Schot and Steinmueller, 2018). Policy advice was then mostly oriented at overcoming of diagnosed "system failures" such as deficiencies in capabilities of actors, coordination deficits among actors or mismatches with extant institutional structures (De Oliveira et al., 2020, Chaminade and Edquist, 2010, Wieczorek and Hekkert, 2012). In transition studies, this second generation of innovation policies primarily gained prominence through the technological innovation system (TIS) framework (Bergek et al., 2008a, Hekkert, 2007) as applied to green technology and industry dynamics. More recently the innovation system perspective got criticized for being too knowledge and technology focused, too "naïve" in terms of power relationships and politics, and thus unable to address grand challenges which would be required for a more transformation-orientation innovation policy (Weber and Rohracher, 2012, Schot and Steinmueller, 2018, Markard et al., 2015).

Tackling this problem notably requires to embrace diverging value orientations of actors, associated interests, and conflicts (Stirling, 2009, Wirth et al., 2013, Kern, 2015, Jeannerat and Kebir, 2016, Weber and Truffer, 2017). The currently dominant view in

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most TIS studies implicitly assumes that relationships among actors in a new technological field derive from a rather homogenous set of shared goals and interests (Kern, 2015), which engender largely harmonious relationships inside the TIS. Conflicts and competition are assumed to mostly occur in relation to the incumbent technological systems, which the TIS has to outcompete (Bergek et al., 2015). Empirically, however, we know that emerging technological fields are not dominated by undisputed, single development trajectories. Rather we often see a multitude of different variations, which compete for resources such as funding or legitimacy. Furthermore, as TIS by definition consist of different types of actors, besides companies also citizen groups, scientists, associations or government departments, we expect that each of them adheres to specific goals, values and interests to participate in the development of this new technology. Value dispositions of actors have therefore to endogenized in order to understand which alternative trajectories are preferred by which types of actors.

So far in the TIS literature, values have not been fully absent. However, they are mostly subsumed under the "function" of legitimation (Bergek et al., 2008b). Recent transitions research has made considerable progress in conceptualizing technology legitimation (Fuenfschilling and Truffer, 2016, Binz et al., 2016, Markard et al., 2016, Heiberg et al., 2020, MacKinnon et al., 2021, Rohe and Chlebna, 2021 among others). However, these studies still mostly focused on the overall societal legitimation of a novel technological field, not elaborating on how diverging trajectories get promoted and legitimized within a TIS (for exeptions see Yap and Truffer, 2019, Yang et al., 2020).

As a consequence of this rather restricted view, lacking innovation success is often explained by a rather narrow understanding of system failures: Coordination deficits are typically framed as stemming from lacking awareness among actors, implying the need for more efficient forms of exchange (e.g. through intermediaries, conferences, research programs). Similarly, capability failures result from insufficient knowledge and expertise, which can be remedied by providing platforms for mutual learning or building up regional educational programs. Thirdly, institutional failures are mostly assumed to stem from prevailing sectoral norms, rules and regulations that limit the further development of the TIS. Resulting policy advice has therefore often revolved around mobilizing external support, overcoming external hindering conditions and providing better conditions for internal knowledge exchange. Little room is left for conflicts and competition among different actors within the technological field and hence internal battles over directionality (Stirling, 2009).

Hence, we diagnose a potential "harmony fallacy" in much of innovation systems research. This fallacy is likely to over-estimate the potential of policies that aim for creating synergies among innovating actors assuming that lack of knowledge and other resources represent the main impediment for innovation success. On the other hand side, the focus on harmonious relationships carries the risk of trying to prematurely close in on seemingly successful technological trajectories instead of supporting the competition among alternative designs. A better understanding of value positions is therefore key for assessing directionality failures and by this being able to reflect how innovation systems may contribute to tackling grand societal challenges. While, we will not be able to solve this entire puzzle in a single article, we aim at providing some first stepping stones by asking the following research questions: how does a value-sensitive perspective enrich or alter the existing innovation system framework regrading system failures, the handling of directionality choices, and in terms of setting appropriate system boundaries?

To do so, we conceptualize value orientations of actors by drawing on the concept of prevalent institutional logics in a technology field (Friedland and Alford, 1991, Thornton and Ocasio, 1999, Fuenfschilling and Truffer, 2014). Institutional logics denote specific "coherent" combinations of values, visions, beliefs and rules that guide actor behavior and which provide rationales for specific actor groups to rationalize their actions (Thornton and Ocasio, 1999, Kooijman et al., 2017, Kieft et al., 2020). Conflict and competition in a TIS may therefore result from diverging visions, values and technology preferences different actors rally around. The institutional logics lens enables to group the different actors in terms of "value-based proximities" and from this to derive an overall assessment of the degree of harmony (or conflict) in the technological field. We assume that value-based proximities may help explain TIS- internal institutional failures, collaboration patterns, and competing directionalities.

We apply this value perspective to recent innovation system dynamics in the field of modular water technologies in Switzerland, during the past two decades (2000-2020). Various types of modular water technologies have been proposed as sustainable additions, or even alternatives, to the globally dominant urban water management regime, which builds on large-scale centralized water infrastructures (Fuenfschilling and Binz, 2018). Modular technologies may be more resilient to challenges of climate change and rapid urbanization (Larsen et al., 2016, Hoffmann et al., 2020) by allowing to close water and resource cycles near to the point of use and by this dispense of expensive sewer networks. Due to economies of scale of mass production, cost competitiveness with current centralized treatment technologies could improve rapidly (Dahlgren et al., 2013, Wilson et al., 2020) promoting a transition in the urban water management sector (Eggimann et al., 2018, Eggimann et al., 2016). Switzerland constitutes an interesting case to study the emerging technological field due to the presence of top-notch research institutes with expertise in both conventional and modular water technologies (Hoffmann et al., 2020).

The empirical case study builds on 26 semi-structured interviews with diverse experts (companies, consultants, user organizations, researchers) engaged in the development or deployment of modular water technologies in Switzerland, and the analysis of supplementary documents, like project homepages, reports, and media coverage. The experts were asked to elaborate on the most important organizations that had been active in the field over the last decade and to assess their strategies, motivations and technology preferences. Based on these expert judgements, we identify portfolios of basic institutional logics for 57 of overall 88 organizations that were mentioned. These value portfolios were further aggregated by applying the recently proposed method of socio-technical configuration analysis (STCA) (Heiberg et al., 2022), which enables to reconstruct networks from associations of actors and values. This enables to "measure" proximities among actors in terms of their value positions and to identify overarching "field logics". The proximity measure may be used to explain the presence or absence of collaboration patterns among different actor groups and their spatial reach. Furthermore, it enables revisiting characteristics of system failures, delimit geographical system boundaries, as well as

identify alternative directionalities that actors might pursue in the future in modular water technology development and implementation in Switzerland.

In the following section, we will elaborate the theoretical foundations of this paper building on work on innovation system failures, institutional logics and proximities. Section three introduces the methodological approach. Section four presents the results of the Swiss case study. Section five discusses implications for system failures, system boundaries and policy implications for the Swiss case. Section 6 concludes drawing broader conceptual implications, elaborating limitations of the chosen approach, and proposing avenues for future research.

2. Considering values in technological innovation systems

One of the major reasons for implicitly assuming harmonious relationships within a TIS might stem from the fact that most of the studies were conducted in particular countries (Markard et al., 2012) with the aim of informing national industrial policy makers (Hekkert et al., 2007). At the level of national industrial policy, interests, values and goals could be considered as rather uniform due to shared overall policy visions, industrial structures and regulations, as well as homogenous language and culture. This assumption matches with lessons from economic geography, that spatial proximity can be an important condition for innovation success generating high potentials of interaction, a specialized labor market or focused and coherent policy strategies leading to regional hotbeds of innovation like silicon valley, Terza Italia or Southern Germany (Saxenian, 1994, Malmberg and Maskell, 2002). However, scholars have early noted that in face of the increasing globalization of innovation and production, spatial proximity may not be a necessary condition for reaping systemic synergies (Carlsson et al., 2002, Bathelt et al., 2004, Saxenian, 2006).

In the following, we will revisit the harmonious view on system failures, and whether and how they coincide with a given spatial system boundary by means of the concept of institutional logics which accounts for value orientations of distinct groups of actors in innovation systems. The institutional logics approach states that value orientations do not exist as individual combinations of idiosyncratic preferences of each individual actor, but rather that values typically come in coherent configurations aligned with the requirements of specific societal realms such as the state, the organization, the market, the profession, the community or the family (Friedland and Alford, 1991). Depending on how individual actors relate to and combine these different institutional logics, collaborations can be more or less easily established also over long geographical distances or lead to system failures and resource conflicts even within countries. This sets clear limits on how national policy may support the growth and maturation of TISs.

2.1. An overly harmonious view on system failures

One of the core assumptions of innovation system thinking is that resources for successful innovation do not only reside at the level of individual actors, such as innovating companies. Especially, more radical innovations require competencies and resources that only emerge out of the interaction of a wide variety of actors, like companies, users, government departments, associations, media or academic research (Weber and Truffer, 2017). Compared to conventional approaches in economics or political sciences, which would side either for state or market failures to explain lacking innovation success, systemic approaches emphasize "system failures" providing more powerful explanations (Bergek et al., 2008a, Woolthuis et al., 2005, Wieczorek and Hekkert, 2012). System failures consist of deficiencies in interaction or coordination among different actors (Edquist, 2005, Lundvall, 1992, Carlsson and Stankiewicz, 1991), mismatches between rules and regulations of the emerging technology and the established sectoral context (institutional failures), or lacking appropriate capabilities (capability failures).

Network and interaction failures may come in strong or weak form (Carlsson and Jacobsson, 1997). Weak network failures reflect that innovating actors might be insufficiently aware or each other while building up similar or complementary technological assets. This may hamper innovation success by slowing down learning and knowledge diffusion, and by missing out on potential synergies. Strong network failures, on the other hand, point to the opposite problem of existing networks overly restraining the search for new solutions, which may lead to path-dependencies and an insufficient exploration of promising alternative technological opportunities (ibid., see also Granovetter, 1973, Granovetter, 1983, Burt, 1992). Thus, there seems to be a trade-off between "not enough" and "too much" coordination of actors (Boschma, 2005). Therefore, network and interaction or – as we will call them – coordination failures were mostly understood as a lacking awareness about knowledge stocks among the key actors in an innovation system. Equally related to the knowledge dimension of innovation systems, capability failure points to a mismatch between existing expertise and the requirements of further developing a focal technology. As a consequence, policy is called to promote the exchange of knowledge through platforms, workshops and conferences. In a similar vein, institutional failures were often seen as resulting from a mismatch between the set of rules and norms that actors working on more radical innovations agree on, and those rules that prevail in established sectors, mostly favoring more incremental innovations. All told, we state that innovation system thinking has mostly assumed to portray socio-technical innovation dynamics as a battle between a homogenous set of new actors, technologies, visions and interests against an equally homogenous incumbent socio-technical system (Smith et al., 2005, Smith, 2007).

The harmonious view on innovation systems resonates well with early work on the geography of innovation, such as territorial innovation system concepts (Lundvall, 1992, Asheim and Gertler, 2005). The core assumption of this work is that spatial proximity would enable actor collaboration due to short travel distance, or a shared cultural, educational and industrial background. From here, it is a small step to assume that the boundary of technological innovation systems will often coincide with the jurisdictional boundaries of industrial or environmental policy making. This fact may explain why most transition research delimited their scope of analysis to specific countries or regions (Hansen and Coenen, 2015). This national focus is all the more remarkable as the founders of the TIS concept Carlsson and Stankiewicz (1991) had originally criticized the national and regional innovation system framework for taking

territorial boundaries for granted and not following the networks wherever they would take the analysis (Coenen et al., 2012, Binz et al., 2014).

Boschma (2005) provided a major contribution to resolve this contradiction by arguing that spatial proximity was only one possible condition to enhance innovative collaboration and learning, especially through related knowledge, which is hard to codify and requires personal interactions and learning (Martin and Moodysson, 2013). However, cooperation may also be enabled above and beyond spatial nearness by other forms of proximity, like similar educational backgrounds (cognitive), working in a same organization (organizational), shared friendship ties (social), or similar behavioral rules and regulations (institutional proximity).

We take from this discussion, that different forms of proximities between actors may exist, which enable or impede collaboration and the emergence of systemic resources. Depending on the actual distribution of such proximities, we may determine how harmonious or conflictual a technological field is at a certain point in time and how to best delimit an innovation system in spatial and technological terms.

2.2. Measuring harmony and conflict from an institutional logics perspective

To arrive at a more coherent conceptual framing of these different forms of proximity, we draw on insights from organizational studies and their reception in innovation and transitions studies (Fuenfschilling and Truffer, 2014, Turner et al., 2016, Kooijman et al., 2017, Binz et al., 2016, Yap and Truffer, 2019, Kieft et al., 2020, Yang et al., 2020, Wittmayer et al., 2021). Cognitive, organizational, social and institutional proximities can be seen as stemming from different institutional logics that actors subscribe to (Friedland and Alford, 1991, Thornton and Ocasio, 1999). Institutional logics have been defined as "the socially constructed, historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality" (Thornton and Ocasio, 1999, p. 804). Society is seen as composed of different basic logics, which individuals or organizations draw on, and that guide their actions and rationalizations. Typical examples of these basic logics encompass i) the market logic which is aligned with the goal of profit or utility maximization; ii) the state logic defined by constitutions, regulations and law, mostly aiming for justice; iii) the family or community logic, which defines interactions based on loyalty, love, mutuality and solidarity; and iv) the logics of religion and science to, who seek to find truth (Friedland and Alford, 1991). More recent studies have also considered various professional logics that shape interactions in different professions (Thornton and Ocasio, 1999) and a sustainability or ecology logic that embraces the protection of natural resources (see e.g. Runhaar et al., 2020).

In a given technological field, actors will typically have to more or less coherently combine basic logics for being able to operate coherently. Departing from these concepts we can define "value-based proximity" by how similar two actors are in terms of the different basic logics they adhere to. Similarity and dissimilarity in terms of basic logics then may correlate with harmony or conflict among two actors in the field. Specific combinations of basic logics, which are shared by substantial groups of actors and therefore may potentially determine the further development of the technological field can be interpreted as field logics. Depending on the power base of actors subscribing to the different field logics, collaboration and exchange among actors might be easier or competition and conflict may be prevalent (DiMaggio and Powell, 1983, Thornton and Ocasio, 1999, Fuenfschilling and Truffer, 2014). We can therefore conceptualize the "degree of harmony or conflict" in a technological field by the diversity of prevailing field logics.

These conceptual elaborations provide a theoretically grounded definition of "value-based proximities". Actors subscribing to different field logics may find it difficult to coordinate and share knowledge or resources, due to conflicting visions of legitimate types of knowledge, preferred modes of upscaling, roles of specific actors or ways to use natural resources. For instance, Fuenfschilling and Truffer (2014)'s study identified three field logics in the Australian water sector building on earlier findings in the US publishing industry identified by Thornton and Ocasio (1999) (see table 1): i) Utilities and public authorities were mostly subscribing to a "hydraulic" field logic combining the basic professional engineering logic and the state logic. It proposed rather technocratic vision of achieving security of water supply through large-scale infrastructure investments like dams and pipelines, building primarily on engineering knowledge, where users were not foreseen to have an active role and nature being seen as a resource to be technically managed. Consultancies and multi-national companies adhered to a "water-market" field logic, which encompasses primarily elements of the basic market and the corporate logic. For these actors, the vision of the future sector structure mostly revolved around installing an efficient water market that would treat users as consumers and the choice of technologies would be determined by cost-benefit

Table 1

Conflict dimensions among water sector field logics. Own table, building on Fuenfschilling & Truffer, 2014

	Core values	Vision for transforming the sector	Legitimate knowledge	Role of users	Perception of nature
Hydraulic field logic	Securtiy of supply, national welfare, social equity	Continue to produce safe and hygienic water for drinking, irrigation and energy production	Analytical & synthetic knowledge	Test persons and Trial users	Nature can be managed (technocratic view)
Water market field logic	Economic efficiency, rationalization	Transform the water sector into a water market	organizational, marketing and market knowledge	Consumers	Nature is an externality of an otherwise independent market (capitalist view)
Water sensitive field logic	Environmental sustainability, liveability	Uptake of technology through like-minded organizations or groups. Wider diffusion not necessarily the goal	Tacit/symbolic & synthetic knowledge	Adopters and innovators	All technologies need to adhere to the laws of nature (ecologist view)

calculus. iii) A third group of actors, mostly environmental engineers and activists, rallied around a "water sensitive" field logic, building primarily on elements of the basic logics of community and professional engineering. They envisioned a more sustainable sector that would take environmental and societal concerns more seriously and would build on more decentralized, small-scale water recycling technologies as part of integrated water management. Knowledge generation, here, was more interactive, based on practical experiences and trial and error.

2.3. Harmony, conflict and directionality

Based on these characterizations of field logics, one may identify the degree of harmony (conflict) in the field by checking for how compatible or reconcilable (conflict prone) values, visions, types of knowledge and as well as the perception of users and nature are. At the level of the whole field, we may assess how much tension is likely to emerge between different actor groups in terms of these dimensions. Low conflict will be expected in a situation with one or a few distinguishable field logics, which are largely overlapping, and which are endorsed by the most powerful actors in the field. High levels of conflict will result from fundamentally incompatible value positions, which are supported by competing powerful actor coalitions. Actors with disagreements along the core value dimensions might perceive each other as competitors for resources like funding, legitimacy or public attention.

Depending on the technological preferences that are associated with the different field logics, we may furthermore identify whether conflicts over the future directionality of the field are likely to emerge and how specific policies may support the development of one trajectory at the expense of another, more (or less) sustainable one, for instance (Yap and Truffer, 2019). As a result, different actor coalitions and collaboration patterns will emerge in the field with more or less potential for creating synergies and forming a harmonious TIS. Adopting this value based view, the remediation of system failures may mean many different things. Coordination failures might primarily be due to diverging value orientations and merely offering information exchange platforms will not be effective to make actors join forces. Institutional failures might be more due to disagreements about joint rules and moral orientations within the field. And capability failures will emerge because of diverging overall goals and specific preferences relating to technologies and knowledge.

Diversity and conflict might however not only be a bad thing for the development of a technological field. A field hosting a wide diversity of field logics will typically generate a variety of potential development pathways. Regarding sustainability transitions, this may be important if the actual sustainability of a technology is debated and if potential rebound effects might develop. Then a premature dominant design might lock-in the technology on rather unsustainable tracks. On the other side, agreement on the directionality of a field will be important to create critical mass for reaping economies of scale and eventually substitute incumbent technological systems. The actual directionality resulting from the interplay of different actor constellations, institutional logics and technological designs will therefore depend on how different actors can mobilize resources, how they can bridge diverse field logics, and how external pressures will support or hinder particular pathways. Our proposed approach therefore enables to address the broader question of how technological dynamics may lead to sectoral transitions without having to adopt politically naïve assumptions.

This leads us to a final set of policy implications. For national or regional policy makers, a technology field hosting strong conflicts will require a differentiated approach that goes beyond providing platforms of knowledge exchange. Actors might oppose to be forced into collaborations at the national level, because they can access critical resources more efficiently though international networks building on value-based proximities. Setting the analytical system boundaries at a national or regional level will, therefore, essentially misrepresent the core processes and structures in the TIS and the resulting policy advice will likely be inappropriate. Thus, we posit that effective policies will have to consider value-based proximities. It enables, in particular, to assess the potential directionality of a TIS aiming at tackling grand challenges (Weber and Rohracher, 2012).

3. Methodological approach

We will proceed the empirical analysis of value-based proximities and the degree of harmony/conflict in the field of modular water technologies in Switzerland in three steps: i) setting the system boundary for collecting data, ii) conducting qualitative content analysis of the collected data regarding TIS structure, collaboration networks, technological preferences and institutional logics, and iii) applying the STCA methodology to operationalize and measure value-based proximities and the degree of harmony in the field by means of a network representation of actor-value associations.

3.1. System delineation and data collection

We delineate the empirical system by including all national and foreign organizations working on or collaborating in the field of modular water innovations in Switzerland. We start by inquiring whether we can actually identify a coherent TIS within Switzerland. Following the standard procedure in TIS analyses (Bergek et al., 2008a, Hekkert, 2007), we further guide the selection of relevant organizations by the definition of the focal technology. "Modular water technologies" are defined as technologies for the treatment of separated or non-separated water and wastewater streams, which do not need to be connected to a centralized sewer system and can work off-grid. Starting from expert interviews with key researchers from the leading research institute Eawag (the Swiss Federal Institute of Aquatic Science and Technology) further experts were identified via snowballing (Bergek et al., 2008a), asking each interviewee to name their formal and informal collaborators as well as other actors they were aware of that had an influence on the potential formation of an innovation system in Switzerland. Formal collaborations are here defined as contractual collaborations

within projects. Informal collaborations relate to regular informal exchanges among organizations regarding technological questions, funding, legal issues or the like. Overall data collection involved 26 interviews that were conducted with representatives of companies, consultancies, research institutes, as well as representatives of civil society organizations (see appendix 1 for an anonymized list of interviewees). Interviews were subsequently transcribed by the first author and detailed interview notes were collected for all interviews. All data was entered into the qualitative content analysis software Nvivo12 and additional attributes for actors, projects and collaborations were collected based on desk research.

3.2. Qualitative content analysis: identifying system structures and value orientations of actors

The objective of the qualitative content analysis was, first, to provide a comprehensive overview over all important structural features of the emerging innovation system, that is all relevant organizations and projects, as well their evolution over time. Second, for each organization, technology preferences, as well as collaboration partners (both formal and informal) were derived from the statements of the interviewed experts. Third, statements indicating that organizations endorsed a specific basic institutional logics were coded. The coding started by deductively deriving basic logics common in industrial and technological fields form the literature (relying on Thornton and Ocasio, 1999, Fuenfschilling and Truffer, 2014), and inductively making smaller adjustments to the coding scheme according to the empirical evidence presented by the case. Basic logics were identified in the interview transcripts through expert statements about interests, goals and strategies of the identified key organizations in the field. Thus, we did not ask directly about values, but rather derived the basic logics from the narratives of the interviewed experts about specific organizations. As a result, each organization could potentially be associated with multiple basic logics. Figure 1 provides an exemplary representation of the coding, interpretation, and the resulting association between organization and basic institutional logic.

In order to further analyze these associations by means of social network analysis (SNA) methods, we constructed an unweighted two-mode matrix, where each row represents an organization and each column represents a basic logic. To identify value-based proximities among organizations, we transform this two-mode matrix into a "one-mode" matrix among organizations, where cells represent overlaps in terms of institutional logics (see figure 2 for an intuition for how the two-mode relationships can be translated into one-mode networks). Unlike more classical SNA applications (Wasserman and Faust, 1994), links between organizations do not represent jointly attended events or material collaborations, but rather the similarity in terms of portfolios of basic logics.

Similarity among actors in terms of their portfolio of endorsed basic logics may be measured by the relative overlap between their respective portfolios. A widely adopted measure is provided by the Jaccard index (following Gower and Legendre, 1986), which measures the ratio of joint codings relative to the total number of occurrences of both codes. Or put more formally:

$$s = a/(a+b+c)$$

where $n11 = a$, $n10 = b$, $n01 = c$ *and* $n00 = d$

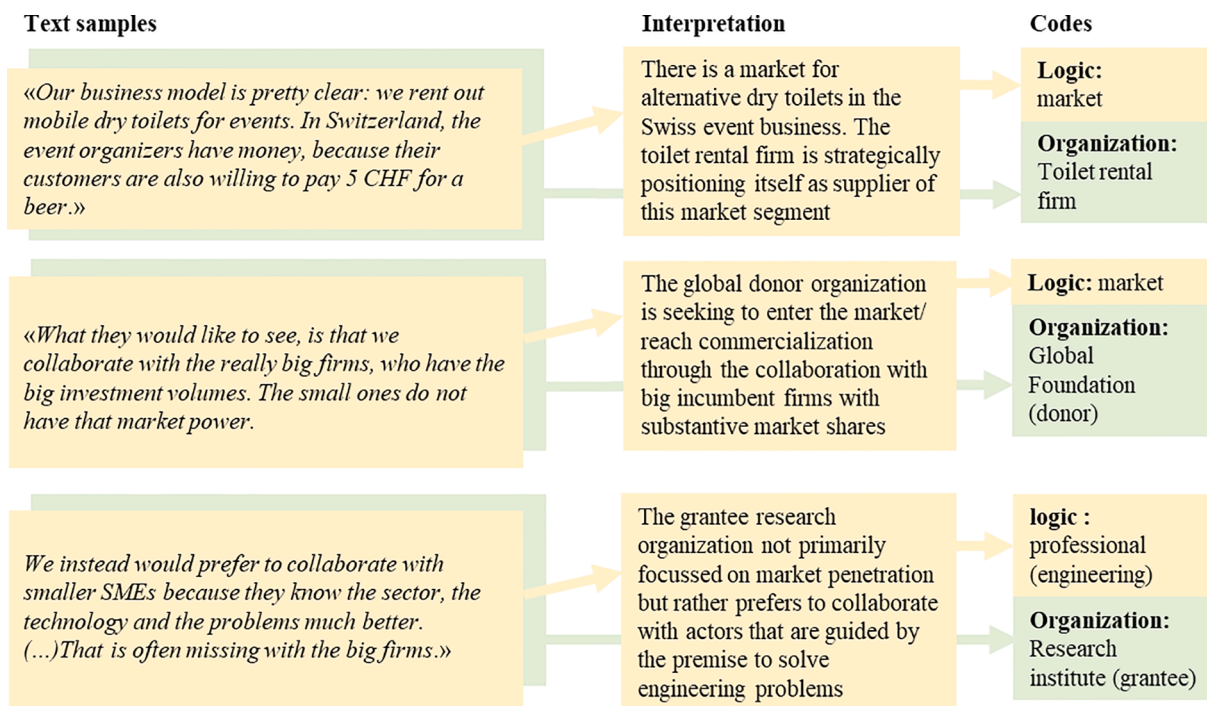| Text samples	Interpretation	Codes
«Our business model is pretty clear: we rent out mobile dry toilets for events. In Switzerland, the event organizers have money, because their customers are also willing to pay 5 CHF for a beer.»	There is a market for alternative dry toilets in the Swiss event business. The toilet rental firm is strategically positioning itself as supplier of this market segment	**Logic:** market **Organization:** Toilet rental firm
«What they would like to see, is that we collaborate with the really big firms, who have the big investment volumes. The small ones do not have that market power.	The global donor organization is seeking to enter the market/ reach commercialization through the collaboration with big incumbent firms with substantive market shares	**Logic:** market **Organization:** Global Foundation (donor)
We instead would prefer to collaborate with smaller SMEs because they know the sector, the technology and the problems much better. (…)That is often missing with the big firms.»	The grantee research organization not primarily focussed on market penetration but rather prefers to collaborate with actors that are guided by the premise to solve engineering problems	**logic :** professional (engineering) **Organization:** Research institute (grantee)

Figure 1. STCA, coding process for associating different organizations with basic institutional logics.

Network representation of organization – logic associations
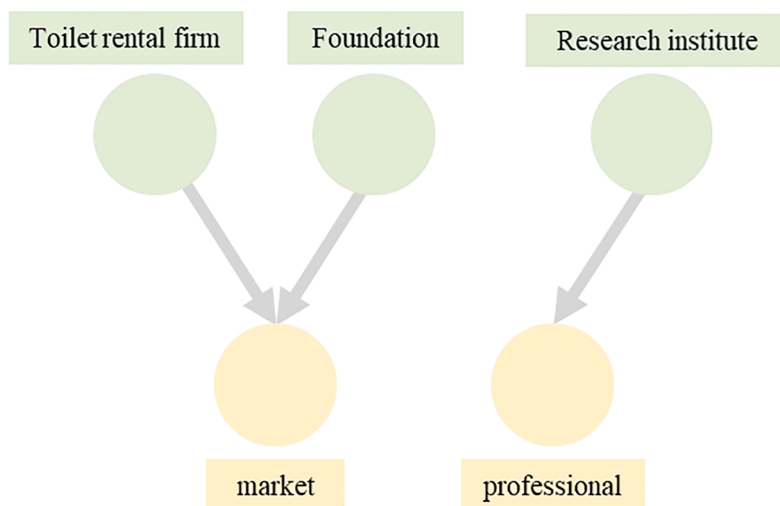
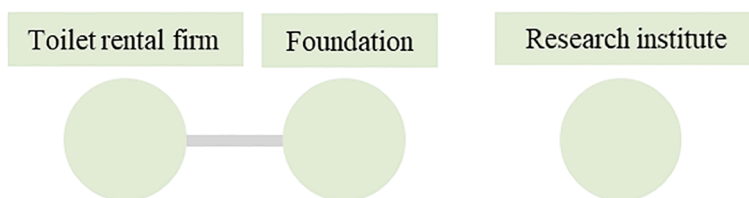## Projection as one-mode organization configurations

Figure 2. Types of one-mode network relationships among organizations following the STCA approach. The toilet rental firm and the foundation both adhering to the market logics will result in a direct link between the two organizations in the one-.mode representation. The research institute only endorsing the professional basic logic will instead stay unconnected to the other two organizations in the one-mode network.

n11 *(a)* represents the number of basic logics that both organizations endorse. n10 *(b)* and n01 *(c)* represent the number logics of that one of the organizations endorsed but not the other. n00 *(d)* reflects the number of basic logics that were not endorsed by either actor. Thus, the similarity measure *s* takes the value of 1 in a situation where two organizations have a complete match in their portfolio of basic logics. It will be 0 in the case where basic logics do not overlap at all. Values between 0 and 1 denote the relative overlap of the portfolios of basics logics of the two organizations. Figure 3 illustrates the calculation of value based proximity for the exemplary toilet rental firm and the foundation, assuming that apart from the market logic the toilet rental firm has also been coded adhering to an ecology logic, and the foundation is additionally adhering to a legal logic. The two organizations in this example, therefore, are weakly similar as they share one basic logic but differ in terms of two other ones.

The *s* values for each pair of organizations provides a measure for their bilateral value based proximity. In order to assess over-arching field logics, we aggregate organizations into groups, which exhibit high proximities within but differ strongly with other groups. This is a typical application case for clustering methods. Cluster identification aims at identifying coherent subgroups within a larger population by minimizing differences within clusters and maximizing differences among clusters based on a specific characteristics. In our case, the core characteristic for differentiating clusters is the similarity measure *s*. Field logics may be considered as stemming from coherent combinations of basic logics endorsed by specific actors groups sharing similar basic logics portfolios (Fuenfschilling and Truffer, 2014). Hence, applying clustering algorithms to the one-mode organization matrix will provide a bottom-up measure for field logics. More specifically, we chose Ward's method, an agglomerative clustering algorithm, which starts from each node as a cluster and then iteratively merges organizations into higher level clusters by minimizing the squared distance of any point within a newly merged cluster from the centroid of the cluster, compared to the squared distances from the centroid of any other potential cluster merger (see Murtagh and Legendre, 2014 for its implementation in R). The procedure is repeated until all actors end up in one cluster. This iterative construction of clusters results in a hierarchical tree of alternative groupings of the field between one and N clusters (N representing the actual number of organizations). The analyst may then choose the number of clusters that provides an "optimal" differentiation in terms of minimal within and maximal across distance between the respective clusters. A simple
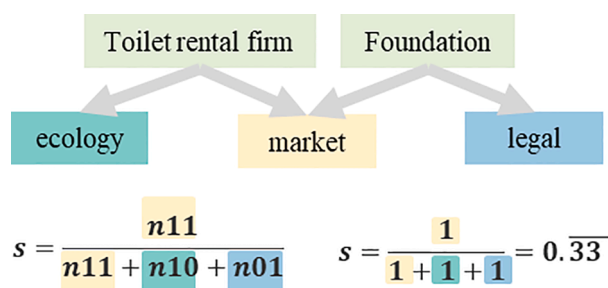
Figure 3. Jaccard similarity calculation example.

way of judging the coherence of each cluster is by comparing overall network density with each cluster subgraphs' density. Density is defined as the "proportion of possible lines that are actually present in the graph" (Wasserman and Faust, 1994, p. 101).

Once, an optimal set of distinct field logic clusters is identified, one may proceed to characterize these groups according to the basic institutional logics that actors within the cluster endorse. Basic logics that are particularly salient in each cluster, i.e. endorsed by a high percentage of organizations within the cluster, may be used to label the cluster. In a second step, the analyst may check whether these field logics correlate with actual collaborations, technology preferences or other characteristics.

4. Value-based proximities in the field of Swiss modular water technologies

The empirical analysis splits up into three sub-sections. First, we reconstruct the development of the innovation system over the past 20 years, the key organizations and activities, as well as their geography and technological foci. Second, we reconstruct the major field logics based on value-based proximities among actors, and examine whether and how these logics influence actual collaborations and technology preferences of actors. Third, we will assess potential conflict lines and the overall degree of harmony/conflict in the field. Eventually, we will use the contextual knowledge from the interviews to reflect on historical field-level and organizational level dynamics that might shape the future directionality of the field.

4.1. Evolution of the technological field in Switzerland over the past two decades

In Europe, research and experimentation with modular water technologies started in the 1990s mainly in Sweden and Germany, where pioneers experimented with on-site blackwater treatment as well as dry toilets and composting of urine and feces at household and district scale (Larsen et al., 2013). In Switzerland, the modular water technology field had its inception with an early publication by Larsen and Gujer (1996) at Eawag, laying the foundations for so-called urine-separation systems separating urine and feces in the toilet, to more efficiently recycle resources like phosphorous or nitrate. After this early research phase, the emergence of the field in Switzerland can split up in three phases (figure 4).

In the "inception phase" starting around 2000, the Novaquatis project at Eawag included the first experimental-scale demonstration project of modular urine separation technologies in Switzerland. The experimental technologies were temporarily installed in three public and a private cooperative buildings. Collaborating with the two pioneering urine-separation toilet manufacturers from Sweden, BB Innovation and Wostman, as well as the German firm Roediger (Larsen and Lienert, 2007), the project helped improve the technology substantially. The project, however, also led to some frustration especially among the cooperative, who had to replace the toilets after a series of failures within the first two years after installation (In6). In parallel to these developments at Eawag, an architectural company from Fribourg and another cooperative from Geneva started using dry toilets and composting technologies in an office building and a cooperative-housing block in the French-speaking, Western part of Switzerland from around 2007 (In15, In10; "Western-part" will henceforth be used to denominate the French-speaking part of Switzerland). Despite the legal obligation to connect to the sewerage system, public authorities in both cities soon found arrangements to allow for unconventional solutions to be implemented, partly because water stress in both cities is more severe than in other places in Switzerland (Interviews In15, In10).

In the second, the "internationalization phase", starting around 2009, the Seattle-based Bill and Melinda Gates Foundation (BMGF), a powerful, globally-active donor organization entered the Swiss modular water field. It provided major resources in terms of funding various technology development projects at Eawag and other Swiss research institutes in the context of their "Reinvent the toilet" challenge. But it also set clear boundary conditions on the kind of systems to be researched on (Interviews In5, In21, In16). Rooted in its strong corporate culture based in software engineering (Schurman, 2018), the BMGF approached its core grantee, Eawag, with a clear framing to solve the problems through a high-tech pathway (for example fully integrated systems based on supercritical water oxidation), challenging Eawag's civil engineering based culture of developing urine separation toilets and separate urine treatment. The application case was set to situations with a lack of access to safe water, sanitation and electricity in the global south. Other grantees or collaborating institutions during this phase included the universities of applied sciences (FHNW), a former nuclear research institute (PSI), as well as Swiss multinational chemical firms (Firmenich), all of which are based in German-speaking part of Switzerland (Interviews In21, In16, In3). Collaborations within BMGF projects was very internationally oriented, often involving the establishment of sounding boards including Swiss and foreign technology firms, which were expected to commercialize the
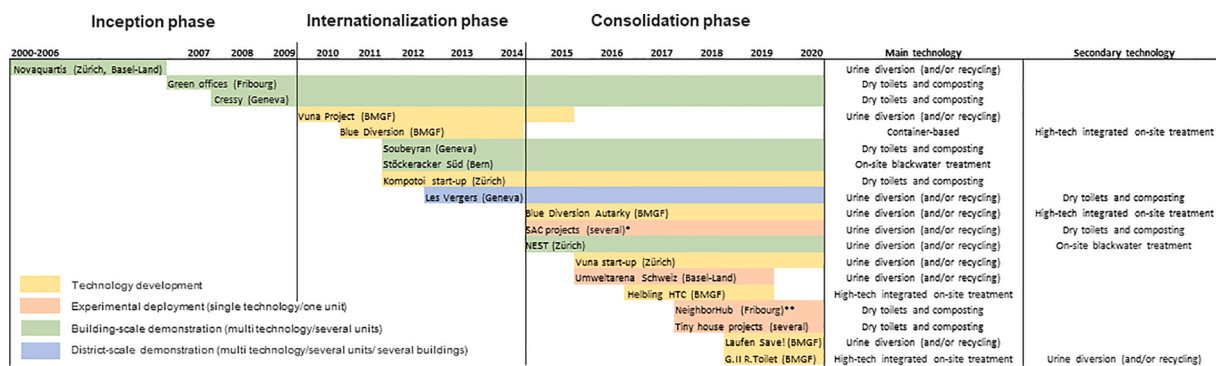
Figure 4. Timeline of major projects in the Swiss innovation system.

technologies at some point, in the future (Interviews In21, In16, In5, In20, In3). Largely disconnected from the developments around the BMGF, a Western-Swiss cooperative Equilibre developed two demonstration sites in Geneva implementing comparatively low-tech, dry toilet and composting systems (Interviews In10, In7, In24). In contrast, implementation attempts of similar technologies by co-operatives in the German-speaking part largely failed due to technological challenges as well because of a lack of capabilities and push back from public authorities and utilities (Interviews In6, In9, In7). As an exception, Kompotoi, a start-up renting out mobile dry toilets for events was founded in Zürich, and the city of Bern started developing a district with a more advanced on-site blackwater treatment system (Interviews In2, In8, In26). These developments were mostly driven by actors lacking any serious interaction.

This, however, started changing gradually in the "consolidation phase" starting from around 2014. BMGF accepted to embrace urine diversion in their funding strategy (Interview In21, In16). One of the BMGF-funded projects at Eawag led to a spin-off (Vuna) in 2015, to commercialize urine recycling technology. Another BMGF-funded collaboration between Laufen Bathrooms and Austrian design firm EOOS led to the commercialization of a design-improved urine-diversion toilet in 2018 (Interviews In5, In25). BMGF funded projects were increasingly diversifying their technological focus by embracing the urine-diversion technology, which proved an interface technology compatible with both low and high-tech configurations. Urine diversion was also taken up by the Geneva cooperative by implementing the Laufen toilet in their latest development projects. More recently, a newly founded cooperative (La Bistoquette) took-up these ideas and started a spin-off to further commercialize composting, dry toilet and urine-diversion technologies (Interviews In10, In7, In24). In parallel, the Fribourg-based public-private partnership utility SINEF decided to develop a whole district using modular water technologies (Interview In15), including both low- and high-tech solutions. While collaborations of these projects in the Western part of Switzerland were more localized than in the BMGF networks, early pioneers had strong linkages to dry toilet pioneers in France (Interview In10, In7). In recent years, informal collaborations between actors from the French and the German speaking parts of Switzerland was facilitated by the establishment of a technology testing platform, the "NEST", at Eawag starting in 2015 (Interviews In12, In10), and by Vuna's activities in market segments like mountain huts all over the country (Interviews In22, In12). Thus, we see a complex geography unfolding in the technological field, with a mix of regional, national and global actors, relationships and activities. Whether this technological field increasingly developed into a nationally delimited TIS, however remains an open question.

4.2. Identifying field logics through value-based proximity

Through the interviews, we identified 118 organizations that either directly engaged in modular water technology projects or were mentioned as collaborators regarding the development or deployment of modular water technologies. 60% of all identified organizations (71) originate from Switzerland, 40% from abroad (47). The left hand graph in figure 5 shows the one-mode actor network based on the Jaccard-normalized relations among the subset of 57 organizations[1] for which our interviews provided sufficient evidence for the basic logics that have guided actors' engagement in modular water technology projects. The graph layout results from applying a stress minimization algorithm (Multi-Dimensional Scaling) that places organization nodes closer to one another, that share a higher value-based proximity (see Brandes and Pich, 2009 for the layout method). To strengthen the visual interpretation, we chose to set the link width proportional to the jaccard similarity between two organizations. Based on these data, the Ward clustering identified three groups with similar value dispositions: cluster *A* consisting of 18 organizations, cluster *B* of 19 and cluster *C* of 20. *A* and *C* show a larger subgraph density (>0.900) than the overall network (0.568). *B* is more densely connected than the overall network but only marginally (0.617). So, *A* and *C* are more coherent in terms of sharing at least one basic logics, whereas *B* is less clearly

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[1] Including all important organizations involved in the projects in figure 3
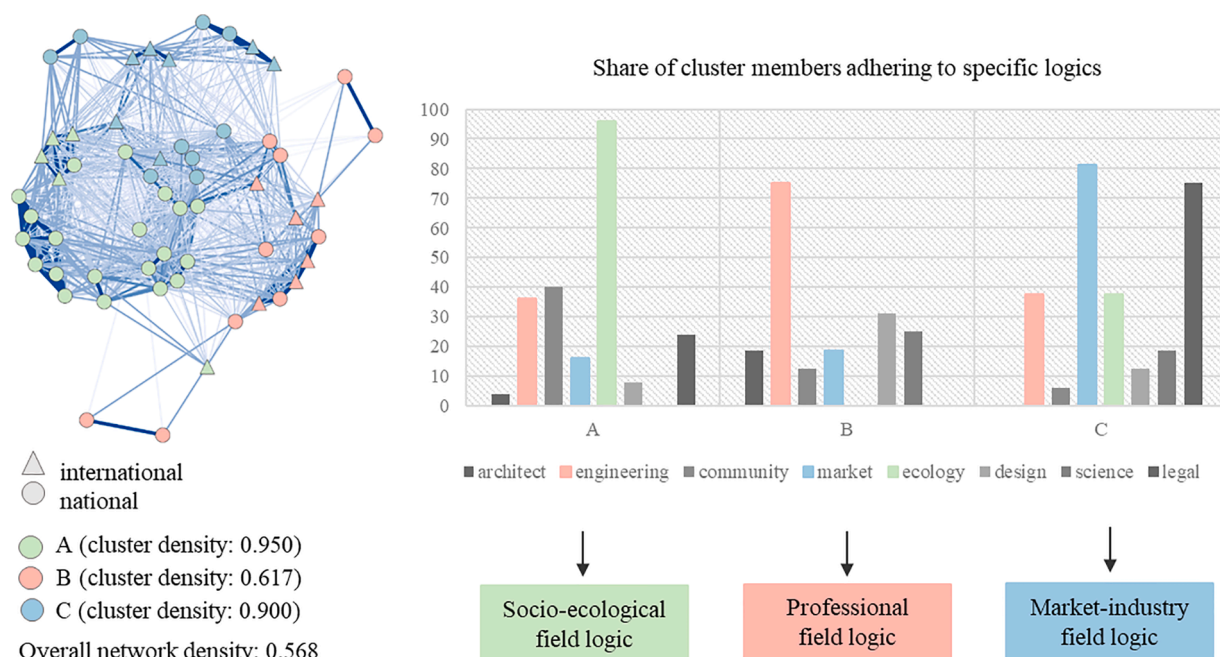
Figure 5. Network graph of institutional proximity, modularity cluster, and within cluster composition of institutional sector logics.

distinguishable.[2]

Analyzing the distribution of basic logics in each of these clusters in terms of the share of cluster members that follows specific basic logics (see bar chart at the right hand of figure 4), enables to identify three aggregated field logics. Cluster A seems to be dominated by organizations following what we would call a **socio-ecological** field logic, dominated by the ecology logic but also comprising smaller elements of the professional engineering, legal and community logic. Cluster B may be characterized by a semi-coherent **professional** field logic dominated by the logic of professional engineering but also encompassing architect, designer, academic, and community logics. Cluster C represents a field logic dominated by elements of the market logic and the legal logic which reflects actors' involvement in a global industrial ISO-standardization process. We may therefor speak of a **market-industry** field logic. Both the network topology and the clustering algorithm identify rather clearly distinct groups of actors, which depict rather homogenous internal profiles in terms of basic logics. Furthermore, from the network graph, a rather clear center-periphery structure emerges with a center populated by actors following a broad range of basic logics, whereas most of the actors are located in rather peripheral realms of the graph, indicating adherence to more specific basic logics.

4.3. How value orientations shape collaboration patterns and technology preferences

In order to assess whether value-based proximities shape preferences for collaborations among actors, we have to analyze the actual collaboration networks. The network graph in figure 6 shows the formal and informal collaborations of 88 organizations that we identified through the interviews, including the 53 organizations, which we analyzed in the previous part. To more solidly ground the interpretations of the visual patterns, we derived different network statistics based on three guiding questions around coordination failures, the degree of harmony and conflict, as well as the role of geography.

First, we want to understand the propensity of collaboration of actors within specific field logics, assuming that the higher the collaborations, the more interested in (or dependent on) the existence of system level resources these actors are. The assumption is that the higher the average number of collaborations of each actor in the network, the lower the probability that we will find coordination failures. The second question asks whether adherence to a specific field logic limits the ability to collaborate with actors holding different value positions. Here, we assume that the more open actors are for collaborations across field logics, the lower the potential degree of value conflicts and hence the more harmonious the innovation system. And third, we want to know how strongly value-based and spatial proximities are correlated, and what implications this has for drawing appropriate system boundaries.

To answer these questions we will report the following network statistics (I1-I5) derived for the whole network and the different

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[2] We also explored the cluster tree at higher cut-off values to better understand the diversity within the clusters. At a value of 8, we find that the professional cluster splits up into clusters of different professions (engineering, architecture, design), the socio-ecological logic cluster splits into two subgroups of pure ecology and ecology-engineering. For simplicities sake, we finally decided to restrict the presentation to three groups and allowed for heterogeneity where it seemed suitable (like among different professions).
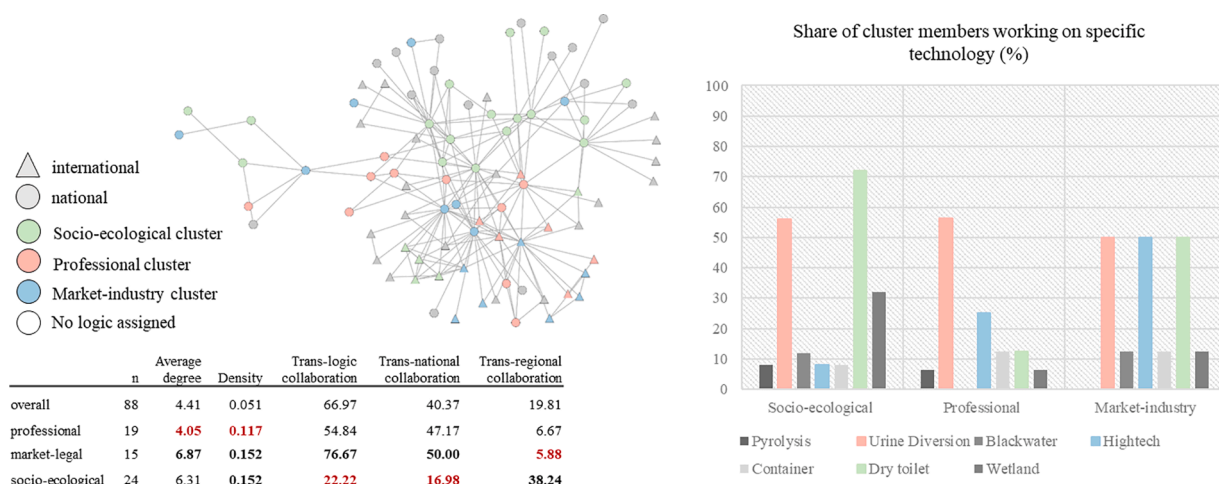
	n	Average degree	Density	Trans-logic collaboration	Trans-national collaboration	Trans-regional collaboration
overall	88	4.41	0.051	66.97	40.37	19.81
professional	19	4.05	0.117	54.84	47.17	6.67
market-legal	15	6.87	0.152	76.67	50.00	5.88
socio-ecological	24	6.31	0.152	22.22	16.98	38.24

Figure 6. Analysis of collaboration networks and technological foci at the level of cluster members.

sub-networks of field logic clusters. For answering the first question, we report the indicator of the "average degree" (I1) of organizations in each field logic cluster. It counts how many collaborations each organization in a given field logic cluster has on average. To answer the second question, we introduce two complementary indicators. One measures the intensity of collaborations among organizations of the same field logic, compared to the intensity of the technological field as a whole. We use the statistics of "network density" (I2) within each field logic related subgraph for this purpose. The opposite indicator reports on how frequently organizations of a specific field logic collaborate with organizations form other field logics. This is expressed as a percentage share of these collaborations compared to all collaborations in the whole field (I3). Regarding the third question, we apply one indicator to measure the propensity of organizations from a given field logic to collaborate with international partners. It is given as a percentage share of connections of organizations from a specific logic to organizations from outside their home country compared to all collaborations (I4). The second indicator reports cross-regional collaborations inside Switzerland as a percentage share of collaborations of Swiss organizations that are crossing the "Rösti-trench"[3] compared to all collaborations within Switzerland.

With these statistical indicators, we may now answer the three questions. The average degree indicator shows that members of the market-industry and socio-ecological field logic tend to have more collaborators (>6) than members of the professional field logic (~4). This might indicate that organizations adhering to the professional field logic have more potential to find synergies with other organizations. Regarding the openness of organizations adhering to different field logics, higher density scores of the market-industry cluster and the socio-ecological cluster may imply that these two cluster are more inward oriented and that value-based proximities play a more important role (0.152 for both). Members of the professional field logic cluster (0.117) instead seem to be more open and able to connect to different value positions. As emerges from the qualitative material, the market-industry field logic was strongly reinforced through the engagement of the BMGF, which encouraged collaborations between Swiss grantees and firm actors in order to commercialize modular technologies through particular terms of reference in the funding scheme (Interviews In21, In16, In18). Members of the socio-ecological cluster started out as rather inward looking local initiatives mostly in the western part of the country. More recently, however, they started to reach out more proactively beyond their project contexts, even envisioning the foundation of a national association (Interview In24). A second indicator for the openness of the field logics relates to trans-logic collaborations. It shows that within field logics collaborations are much more common among the socio-ecological cluster than for the other two. The socio-ecological field logic cluster only entertains 22 % collaborations with other field logic members. This is substantially lower than for the professional (55 %) and the market-industry cluster (77 %). Thus, the socio-ecological field logic seems to be most inward oriented, while the organizations from a market-industry logic entertain a more open approach, however, under very clear conditions regarding the enforcement of the market logic. The engineering cluster, too, is more versatile and potentially able to bridge different value orientations.

Finally, assessing the geographical reach of collaborations indicates that members of the market-industry (50%) as well as the professional cluster (47 %) are strongly internationally oriented, whereas the socio-ecological cluster members show clearly a more local orientation (17 %). Again, this can be explained by the origins of both organization configurations. The BMGF with its international network, is a prominent initiator of the market-industry field logic. Instead, international collaborations among the socio-ecological and professional cluster members are less frequent. Notable exceptions are the participation of companies like Kompotoi and Vuna in the French and German industry association for off-grid sanitation (Interviews In2, In22). The latter company also frequently collaborates with French companies. The Western Swiss cooperative- and public authority-driven movements, instead, had privileged local and regional collaborations in the beginning (Interview In10, In24, In15). More recently, the socio-ecological field

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[3] The Rösti-trench is a popular denomination of the cultural differences between the German and French speaking parts of Switzerland, called after the German name for the signature dish of hash browns, which is more popular in the German than in the French speaking parts.

logic members have started to engage more actively in national-scale networks (38 % vs. < 7 %), as also the cross-Rösti-trench collaboration indicator illustrates. Especially, the Geneva cooperatives Equilibre and La Bistoquette have become active in promoting their ideas in the German-speaking part (Interview In10, In24, In9, In7) but also Vuna, and more recently Eawag have engaged in cross-regional networking (In22, In10, In12, In9)

We may now ask whether and how the value-based proximities and the identified field logics have implications on the likely direction of innovation activities different organizations prefer. The bar chart to the right of figure 5 summarizes the preferences for specific technological designs among the field logics groups. It clearly shows, in line with the low-tech vs. high-tech divide elaborated above, that low-tech solutions are more prevalent among proponents of the socio-ecological field logic, whereas high-tech is only important among the market-industry configuration members. In contrast, urine diversion technologies that were recently picked up both by socio-ecologists in the Western part and by the BMGF are supported across all logic clusters.

4.4. Assessing the impact of harmony/conflict in the field on future development trajectories

Mapping out these topologies of value positions among groups of organizations might be largely inconsequential if they just represent different motivations, rationales and mobilizing visions that guide a diversity of organizations to contribute to a shared overarching goal, namely the development of a new technology. The socio-technical systems literature has shown time and again how relevant such complementary resource stocks are for further developing a new technological system. The key question is, however, how we may assess the actual degree of harmony among these different groups of organizations and whether substantial conflicts emerge when organizations attempt to collaborate across different institutional logics. Hence, we will proceed to a systematic analysis of potential value based conflict lines building on the theoretical assumptions presented in section 2, table 1. Tab. 2 summarizes these for the Swiss technological field.

Most fundamentally, members of different field logics share different visions of the end-state of technological development and typically also different appropriate ways of upscaling modular water technologies. Members of the socio-ecological cluster, for instance, reject the capitalist growth orientation of market-industry cluster: "*They are not my friends (…). What is their motivation? It's advertisement, product placement, finance and most of all, sales*" (engineering consultant belonging to socio-ecological cluster). They are also wary of large multi-nationals who could steal and capitalize on their inventions: "*Folks sorry, but we do not really want to share with you what were are doing (…) We don't want to share all our secrets with you so you can make a patent, for which we will have to pay in the end*" (cooperative member belonging to socio-ecological cluster). Members of the market-industry logic, in turn, criticize the grassroots oriented innovators from the socio-ecological cluster for being too risk-and marketing-averse: "*I do not see anything happening. Nothing. (…) Someone would have to invest in this, put it into a box, which you can put in your basement.* (Engineering consultant from an MNC belonging to the market-industry cluster).

Conflicts among the professional and the socio-ecological cluster are most clearly identified through mismatches in the knowledge dimension: While the academic engineers from the professional cluster follow a strictly analytical knowledge base focused on scientific publications and lab-based prototypes, members of the ecological field logic engage much more strongly in an interactive mode of innovation rooted in practical experiences and trial and error experiments, leading an applied research biologist from the socio-ecological cluster to suggest: "*I think we have never had collaborations. (…) The worlds are really rather different. (…) They are all about science and publications. Why would they be interested in our [applied] work here?*" when talking about a major research institute in the field. In turn, members of the professional cluster and the socio-ecological cluster are united in their critique of the market-industry field logic in reducing users to mere consumers, which according to their critique won't work when diffusing modular technologies to global south countries: "*if someone comes and asks: «how can I implement this in my village in the global south?» All you need to give him is know-how! And not sell him some product. (…) You do not need to produce something high-tech* "(socio-ecological cluster entrepreneur). This also reflects the discrepancies in terms of high versus low-tech solutions, as well as modes of knowledge generation. Eventually, these statements further reflect different philosophical conceptions of nature, which are far from being easily compatible: a technocratic (technology-fix) view among the professional cluster members, an externality or marketing problem among the market-industry cluster members, and an ecologist view among the socio-ecological cluster members.

Table 2

Conflict dimensions among Swiss modular water field logics. Own figure

	Core values	Vision for upscaling	Legitimate knowledge	Role of users	Perception of nature
Professional field logic	Scientific method, security of supply and health	Scientific discovery, demonstration and teaching at universities	Scientific knowledge	Passive adopters	Technocratic
Market-legal field logic	Economic efficiency, rationalization	Risk investment by large players and increasing consumer demand	Design, market, scientific knowledge	Consumers	Capitalist
Socio-ecological Field logic	Environmental sustainability, liveability	Word-of-mouth propaganda and interactions among friends and other grassroots initiatives	Practical/ synthetic, symbolic knowledge	Active adopters, innovators, producers	Ecological

4.5. Field level and organizational dynamics

While the present study represents merely a snap-shot of the most recent constellations of actors and field logics, the content analysis of the interview transcripts further provides insights on developments in the field. In terms of the technology portfolio, certain technological components might be able to bridge between alternative trajectories, as the case of the Laufen Save! urine diversion toilet shows. Only after the Eawag engineers started to collaborate with the design company EOOS in order to propose a much improved toilet design, BMGF endorsed the commercial potential of the urine diversion path and started to co-fund urine related research, due to its compatibility with high-tech back-end treatment (Interviews In20, In21, In16). It subsequently also became an attractive option for the ecology-oriented actors due to its compatibility with the "low-tech" back-end of composting fecal matter (Interviews In4, In5, In2, In10, In24). This enabled the more professional-logic oriented actors to increasingly mediate between the opposing camps of the market-industry and socio-ecological field logic.

Also actors may change positions in the field. We had already identified that some actors are positioned more in the center of the value-based networks, while others are positioned at the peripheries. Circles in figure 7 encompass organizations that subscribe to the three basic logics of ecology (green), market (blue) and professional engineering (red). Overlap areas depict exactly those organizations that combine two or even all three of these basic logics.[4] The central realm where all circles overlap identifies organizations that could potentially serve as intermediaries in the field because they endorse all three basic logics that are instrumental in charactering the overarching field logics. Drawing on individual history of core organizations, we qualitatively traced their repositioning in terms of adherence to different logics in the field (see figure 7).

Equilibre moved from a pure ecological value base to increasingly embracing engineering principles in their three housing projects in Geneva. La Bistoquette started under similar conditions but then further moved towards a market logic when initiating a consultancy business based on the experiences already collected in Geneva. Vuna, the Eawag spin-off from a BMGF funded research project, moved away from a strong professional engineering value base to increasingly embrace elements of an ecology logic. The engineering research department at Eawag learned to increasingly adapt to the market-logic imposed by the BMGF funding terms. Later, they organized several workshops and involved ecology oriented planning consultants into their research projects. The major funder of recent initiatives, the BMGF started out from a very strong market logic, based on the corporate culture of managing innovations as software engineers. They approached the toilet business and wastewater engineering by primarily adding a philanthropy perspective to their usual market based approach. But ultimately, they agreed to endorse more and more elements of the professional engineering logic. Finally, EOOS, a product-design firm increasingly oriented itself to achieving socio-ecological goals in development contexts.

These exemplary re-positioning processes of individual organizations show that some consolidation and bridging activities took place in the technological field. Nevertheless, value-based conflict lines still persist and it remains open, which of the logics and directionalities will prevail in the near future, which form of modular water system will eventually be scaled and matured, and in how far this will contribute to a sustainability transition of the urban water management sector.

5. Discussion

What implications can be derived from the empirical analysis of value orientations in the Swiss modular water technology field in terms of system failures, system boundaries and directionality? Will it develop towards a well-aligned national TIS or will it splinter up into diverse initiatives, where actors establish collaborations and mobilize resources mostly following field logics, regionally or outside the national borders? The analysis of the Swiss modular water technology field illustrates that the implicit assumption of harmonious relationships inside the national container does not necessarily hold (Coenen, 2015). The different value-based proximities may give rise to manifold conflicts among actors, which might enable novel development trajectories but also stand in the way of further consolidating a "Swiss" TIS. This has implications for how to frame system failures, how to set adequate geographical system boundaries, and ultimately, for how to assess potential directionality failures.

The analysis of value-based proximities among the actors in the Swiss field shows that value considerations had strong impacts on how actors engage in collaborative activities, what kind of technological development pathways they prefer, how they perceive the role of end-users and even what kind of knowledge they consider legitimate. This leads to fundamental challenges in terms of agreeing on rules, norms and visions across actor groups in a future nationally bounded TIS. At least initially, the different proponents of modular technologies followed rather diverse technological avenues depending on the field logic they adhered to (low-tech dry toilets vs. high-tech fully integrated systems). This limited interactions and synergies among each other. The field is therefore confronted with very tricky questions of directionality. Depending on whether these different interests can be overcome, the field may either develop into a well-aligned TIS or the field will splinter into irreconcilable promotional factions.

In terms of geographical system boundaries, the Swiss technology field is constituted by complex geographies. We had witnessed a high diversity of sub-national activities, following cultural fault lines (the Rösti-trench!) and depending on very local agency to generate early innovation activities. Developments started to get a bit coordinated at the national level only since a couple of years and were not the result of a coordinated strategic plan but rather based on accidental encounters and opportunities. At the same time, we saw that transnational actors, networks and resource flows played a key role in the formation of innovation processes and that the different actor groups still entertain and even extend their own transnational co-operations. Hence, it is hard to conclude whether a

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[4] Actually only one actor does not comply with this general rule. It is the Zürich municipal waste cooperation (ERZ) that is positioned in the overlap area a but actually combines a legal and a professional engineering logic.
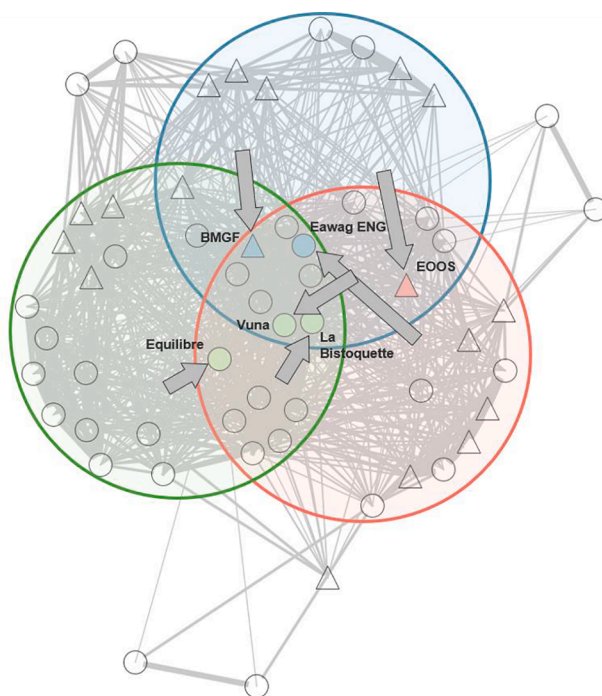
Figure 7. Field level repositioning on the basis of figure 5. Red circle: organizations following basic logic of professional engineering, green circle: organizations following basic logic of ecology, blue circle: organizations following basic logic of market. Node colors of highlighted nodes: field logic cluster membership. Arrows indicate moves of actors in the value field during the time of analysis.

real "Swiss TIS" is emerging or whether the national context only represents one among many contexts for occasional encounters and for raising specific resources (Heiberg and Truffer, 2021) . Beyond today's value orientation patterns, much is likely to depend on how intermediary organizations will position themselves, regarding technological preferences and efforts to adapt institutional structures.

This has further implications for guidance and directionality of the emergent field. National industrial policy-making needs to consider the different field logics that co-exist in field, or it will run the risks of trying to enforce collaborations among actors with diverging values and interests. Furthermore, the different logics clusters may defend fundamentally different transition pathways, which may lead to what Weber and Rohracher (2012) have called "directionality failures" of policy. In the Swiss case, we see at least two opposing trajectories: one policy option might be to support comparatively low-tech, dry toilet and brown water treatment solutions, which might benefit from a strengthening of localized actor networks. A challenge of this avenue will be to accommodate for the value-based conflicts, which might occur when pushing towards market-based diffusion of the new solutions. A second policy trajectory might be to support high-tech modular technologies, which would require national policy makers to engage with potent multi-national companies and global actors like the BMGF. A major risk of this path is certainly the lack of institutional and industrial embedding of these technologies in Switzerland. Rather than solving local water and resource problems, policy would potentially be perceived as supporting industry formation for global market players and thus spending tax-payers' money for non-local benefits.

6. Conclusion

We started this paper by diagnosing a flagrant neglect of actors' value positions in the innovation system literature and stated that the scholarly field is suffering from an implicit harmony fallacy. We showed the shortcomings emerging from this neglect related to several core analytical tasks in empirical TIS analyses: i) a possible misrepresentation of system failures, ii) a potential misidentification of an appropriate system boundary, either in technological or in spatial terms, and iii) a potentially misleading formulation of policy recommendations related to the directionality of the system. With the development of a value-based proximity measure, we were able to identify actor groups holding similar value orientations, which we identified as field logics, and which coincide with distinct technology preferences, visions and conceptions of users and nature. This structuring enabled the identification of potential value-based conflict lines and by this to assess the degree of harmony or conflict in a technological field.

The general implications of this approach relate first to how system failures have to be conceptualized when addressing value positions explicitly. The most obvious extension is that coordination failures will not be limited to overcoming problems of ignorance of other actors' knowledge stocks or a lack of resources. Value considerations, mismatches in goals and visions, or differences in preferred development trajectories might seriously impact the willingness of actors to cooperate. Conventional approaches to overcoming coordination failures through organizing joint workshops, conferences or matchmaking may therefore fail because agreements about more fundamental questions cannot be achieved. This might even impact capability failures, because typically actors following

different logics also differ in the specific types of expertise they deem relevant for solving the original problem. And finally, institutional failures may also occur within the TIS if actors cannot agree on shared visions, standards and ways to proceed, which will hamper their ability to build up systemic resources or access them from "outside" the TIS in the form of government funding, legitimacy in public discourses, or user acceptance (Bergek et al., 2015). Ultimately, these failures are intimately connected to differences about the preferred directionality of the field and might prevent it from developing into a proper innovation system.

A second major conclusion relates to how system boundaries should be set, which is one of the key methodological steps of any TIS analysis (Bergek et al., 2008a). As elaborated above, differences in value positions may give rise to fundamentally different technological trajectories. If joint system resources cannot be built up within a given region or country, actors are likely to mobilize them from outside (Binz and Truffer, 2017). This may lead to a situation, where different TISs coexist in a specific region with little interaction among each other. We saw such a situation between the French- and the German- speaking parts of Switzerland, which exhibited strongly diverging technologies, visions and knowledge strategies, at least in the beginning. The different actor groups might then still aim at building up TIS structures. But they will primarily have to look for them outside their home country or region (Heiberg and Truffer, 2021). Setting the system boundaries in technological and spatial terms therefore becomes a key question where value positions have to be considered (van Welie et al., 2019) .

In a sense, we re-iterate insights that were already provided by Boschma's (2005) proximity framework. However, we maintain that be defining value-based proximities by means of different field logics, we are able to arrive at providing an conceptual base for Boschma's non-spatial proximities, which represent a rather intuitively plausible list: organizational proximities typically coincide with the basic logic of the organizational hierarchy, social proximity can easily be seen as some form of community or family logic, and finally, Boschma's "institutional proximity" coincides very much with specific state or legal logics. By means of the field logics concept, we are furthermore able to provide further arguments on how certain combinations of basic logics may enable or impede collaboration and exchange. The question of how spatial proximity relates to all these forms of value-based proximities remains largely an empirical question. Spatial proximity will be strong, if many of the field logics based proximities overlap in a territory without generating too strong conflicts.

Third and finally, all these considerations have implications on what policy makers can do to promote innovation success, especially in terms of how they will contribute to tackling grand challenges. This is the problem that Weber and Rohracher (2012) identified as the "directionality failure" in transformative policy making, or what Schot and Steinmueller (2018) see as the core of the third generation of innovation policies. Considering value-based proximities therefore promises to better connect innovation system research to socio-technical transition processes and therefore increases the synergies between different sustainability transitions frameworks as proposed earlier (Markard and Truffer, 2008).

Of course, the empirical, methodological and conceptual approach presented in this paper has various limitations. Empirically, the case of an early technology field on modular water technologies in Switzerland, was suitable for our analysis due the prevailing uncertainties about a dominant technological design and associated battles around directionality. However, future research will have to explore how value-orientations affect the course of more mature technological fields or already established TISs. Methodologically, applying STCA on a set of expert interviews proved to be suitable approach due to the limited size of the field, which could be covered in an interview campaign. This approach, however, might not be feasible when studying value-based proximities in larger fields. Here, researchers may want to draw on other textual databases as an input to derive organization-logic associations, such as media articles (Heiberg et al., 2022). Either way, the qualitative assignment of institutional logics to different organizations in a field remains a challenge and needs further to be systematized.

One aspect that this study could only touch upon, was that the deeper dynamics and in particular the processes of value creation could not be addressed. Elucidating value-based proximities at different points in time might further enable to bridge between innovation studies and valuation studies (Boltanski and Thévenot, 2006, Thévenot et al., 2000). The latter has a long tradition in studying different orders of worth, i.e. modes of evaluation which actor draw on in justifying their actions, which strongly resonate with the institutional logics perspective applied in this work. This implies a move from focusing on the development and diffusion of technology towards the co-creation of values in addressing grand challenges (Huguenin and Jeannerat, 2017). Future investigations might therefor bridge over to valuation studies by studying value-based proximities of actors in a field at different points in time.

Despite these limitations, we see the presented approach as promising for informing future transitions research not the least also because of the chosen methodological approach. Analyzing socio-technical alignments and field structures by means of network topologies enables to better understand the alignments but also misalignments that may emerge among system elements. This type of analysis coincides very naturally with configurational theorizing, which is mandatory in innovation and socio-technical systems research (Furnari et al., 2020, Weber and Truffer, 2017).

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

The authors are employed at the leading Swiss research institute within the field of modular water technologies, Eawag. However, the way the data have been gathered and analyzed does in our view not create any financial or otherwise benefits to our employer or to us as authors. We maintain to have respected all conditions of objectivity and impartiality when conducting the research.

Appendix 1

List of Interviews

Organisation	Code	Date
Research institute	I1	24.06.2019
Technology company	I2	01.07.2019
Research institute	I3	02.07.2019
Technology company	I4	16.07.2019
Research institute	I5	23.07.2019
Cooperative	I6	25.07.2019
Engineering consultancy	I7	29.07.2019
Engineering consultancy	I8	30.07.2019
Cooperative	I9	05.08.2019
Cooperative	I10	06.08.2019
NGO	I11	13.08.2019
Research institute	I12	15.08.2019
Research institute	I13	15.08.2019
Planning consultancy	I14	20.08.2019
Utility	I15	20.08.2019
Research institute	I16	21.08.2019
Technology company	I17	23.08.2019
Research institute	I18	19.09.2019
Research institute	I19	23.09.2019
Engineering consultancy	I20	08.10.2019
Research institute	I21	23.10.2019
Technology company	I22	29.10.2019
Research institute	I23	08.11.2019
Cooperative	I24	12.11.2020
Design consultancy	I25	02.12.2020
Engineering consultancy	I26	10.12.2020

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