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

Jonas Heiberg[1,2]
E-mail: jonas.heiberg@eawag.ch

Bernhard Truffer[1,2]
E-mail: bernhard.truffer@eawag.ch

[1]Copernicus Institute of Sustainable Development, Utrecht University, the Netherlands
[2]Eawag, Swiss Federal Institute of Aquatic Science and Technology, Switzerland

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

Abstract

The technological innovation systems (TIS) framework is one of the dominant perspectives in transitions studies to analyze success conditions of newly emerging technologies and industries. Key conditions for innovation success reside in overcoming so-called system failures. So far, TIS studies mostly adopted a rather harmonious view on the values, goals and interests that motivate the different actors and by this were unable to address competition, conflicts and, in particular, battles over diverging directionalities within the system. To tackle this "harmony fallacy", we propose an institutional logics based measure for "value-based proximities" among actors, which serve to identify the "degree of harmony" in the field. To operationalize these concepts, we apply socio-technical configuration analysis (STCA) based on transcripts from 26 interviews, covering the case of modular water technologies in Switzerland. Results indicate that value orientations crucially affect system failures, diverging technological preferences and collaboration patterns. Conflictual field logics may prevent the stabilization of system structures in a specific country and drive actors to engage in sub- or transnational networks. This analysis enables to inspire 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 implications.

Keywords: Technological innovation systems (TIS), values, institutional logics, socio-technical configuration analysis, geography of transitions, modular water technologies

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 was broadened to account for innovation system structures to promote 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 geared towards the overcoming of diagnosed "system failures" such as deficiencies in capabilities of actors, coordination deficits among actors or mismatches with extant institutional structures (Chaminade and Edquist, 2010, Wieczorek and Hekkert, 2012). In transition studies, this second generation of innovation policy advice 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 unable to address grand challenges, which will require a more transformative orientation for 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, conflicts power and politics for explaining system performance and directionality of industry development and associated socio-technical transformations (Stirling, 2009, Wirth et al., 2013, Kern, 2015, Jeannerat and Kebir, 2016, Weber and Truffer, 2017). The currently dominant view in most TIS studies, however, implicitly assumes that relationships among actors in a new technological field are conditioned by widely shared goals and interests (Kern, 2015) and therefore largely harmonious relationships inside the TIS. Conflicts and competition are assumed to mostly occur in interactions with actors of the existing (old) technological systems (Bergek et al., 2015). As a consequence, system failures are largely seen as technical or knowledge-related impediments for system maturation. Coordination deficits were often framed as lacking awareness about other actors' innovation resources, implying a need for more efficient forms of exchange (e.g. through regional clusters or intermediaries). Capability failures are due to insufficient technical knowledge and expertise, which can be remedied by providing platforms of mutual learning and the formation of technical expertise in local labor markets through educational programs, conferences and workshops. Institutional failures stem from prevailing sectoral norms, rules and regulations that limit the further development of the TIS. As a consequence, the ultimate direction of developments is mostly explained by mobilizing external support or withdrawing external hindering conditions and providing better conditions for internal exchange. Little room is left for conflicts and competition among different actors within the technological field and hence battles over directionality (Stirling, 2009). Values are not totally absent in the TIS literature, though. But they are mostly subsumed under the "function" of legitimation (Bergek et al., 2008b). And while recent transitions research has made considerable progress in conceptualizing legitimation processes in emerging technological fields (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), these studies mostly focused on the overall legitimation of a novel technology, not elaborating on diverging value orientations within a TIS (for exeptions see Yap and Truffer, 2019, Yang et al., 2020).

The current neglect of actors' value orientations has definite consequences for how system boundaries are set and what kind of policy implications are proposed. Often studies assume implicitly that system structures, actor strategies and policies will be homogenous and consensual within a given region or country, because of a shared cultural background, knowledge base and the goal of providing a more sustainable society or developing an indigenous industry. Little attention is given on whether and how opposing actor groups compete for alternative trajectories in a given country or region. Policy makers may therefore not only have to understand how to support the development of one homogenous TIS, but may be confronted with directionality questions in the selection of appropriate policies. Considering value orientations also extends an earlier critique of the prevailing "spatially containerized" view in innovation systems, which risks to missing out on the relevance of international networks (Carlsson and Stankiewicz, 1991, Coenen et al., 2012, Binz and Truffer, 2017).

In sum, we diagnose a flagrant "harmony fallacy" in innovation systems research and propose a reconceptualization that is open for diverging interests, to competition and to conflicts over alternative directionalities within an emerging technological field. We therefore aim at tackling the following research question: in what respects and how does a value-based perspective enrich or alter the existing innovation system frameworks, and how does it enable them to better inform policies related to grand challenges?

To do so, we conceptualize value orientations by drawing on the concept of competing institutional logics (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). Harmony, and correspondingly, conflict and competition in a TIS may therefore be characterized by how many and what kind of visions, values and technology preferences are present. The institutional logics lens enables to group the different actors based on measures of "value-based proximity" and to derive an overall degree of harmony (or conflict) in a technological field. We assume that value-based proximities may explain TIS- internal institutional failures, actors' preferred geographical collaboration patterns, competing directionalities and will ultimately enable more effective policies oriented at solving grand challenges.

The concept of value-based proximity furthermore builds on, but also extends, the well-known proximity framework of Boschma (2005). He argues that geographical proximity -- which is widely assumed to be supportive to innovation success by fostering collaborations -- can be substituted by other forms of proximity, such as cognitive, organizational, social or institutional forms of proximity. We will argue that the institutional logics approach enables to redefine these non-spatial forms of proximities as different facets of value-based proximities.

We apply this value-based perspective to potential 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. 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 make expensive sewer networks obsolete. 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 case study builds on 26 semi-structured interviews with organizations (companies, consultants, user organizations, researchers) engaged in the development or deployment of modular water technologies in Switzerland, and analysis of supplementary documents, like project homepages, reports, and media coverage. We identify key actors as well as their value orientation profiles, which we aggregate into main institutional field logics and associated technology preferences. This aggregation builds on the recently proposed method of socio-technical configuration analysis (STCA) (Heiberg et al. 2021), which enables to reconstruct network-based topologies between actors and institutional logics, and by this, to "measure" value-based proximity. Further, we draw on collaboration networks and their geography, to account for how values might shape system failures and how this impacts the appropriate geographical boundaries of "the" TIS, as well as the major directionality tensions that policy makers would have to consider when promoting modular technologies 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 presents the methodological approach. Section four presents the results of the Swiss case study, section five proceeds with a discussion of implications of these results for system failures, geographical boundaries and TIS policy. Eventually section 6 concludes and proposes avenues for future research.

2. Considering values in technological innovation systems

One reason 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 coincides 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 introduce the concept of institutional logics, which states that value orientations do not exist as individual combinations of idiosyncratic preferences that each actor may cater for, but rather that values typically come in coherent configurations according to 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 alternatively they lead to institutional 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. Rather, more radical innovations require competencies and resources that only emerge out of the interaction of different actors, like companies, users, government departments, associations, media or academic research (Weber and Truffer, 2017). Compared to more conventional approaches in economics or political sciences, which would side either for state or market failures to explain deficits in innovation success, systemic approaches emphasize the under-production of "system failures" as crucial explanations (Bergek et al., 2008a, Woolthuis et al., 2005, Wieczorek and Hekkert, 2012): deficiencies in interaction or coordination (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 the lacking of 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 synergies. Strong network failures, on the other hand, point to the opposite problem of existing networks overly narrowing down the search of 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, interaction, complementarity 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 hrough 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 established socio-technical system (Smith et al., 2005, Smith, 2007).

2.2 The spatial correlate of the harmonious view

In line with different forms of territorial innovation system concepts, economic geography has for long embraced a similarly harmonious view on innovating actors in a specific country or region (Lundvall, 1992 , Asheim and Gertler, 2005). Assuming that spatial proximity would enable actor collaboration due to short travel distance, or a shared cultural, educational and industrial background, 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 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) offered a major missing element to this contradiction by arguing that spatial proximity can 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 may provide an inroad for identifying groups of actors who share similar values, interests, visions and cultures. Depending on the actual diversity of such proximities, we may determine how harmonic 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.

2.3 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, Binz et al., 2016, Kooijman et al., 2017, 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 interacting along the lines 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 indicate harmony or conflict among two actors in the field. A specific combination of basic logics to which a substantial group of actors subscribes constitutes a so-called field logic. Depending on the presence and support of specific field logics, collaboration and exchange or competition and conflict among actors might be easier or more difficult (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 number and 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,

Tab 1: Conflict dimensions among water sector field logics. Own table, building on Fuenfschilling & Truffer, 2014

	Core values	**Vision for upscaling**	**Legitimate knowledge**	**Role of users**	**Perception of nature**
Hydraulic field logic	Securtiy of supply, national welfare, social equity	Demonstration of technology will lead to uptake and diffusion	Scientific, analytical knowledge (STI mode)	test persons and trial users	Nature can be managed (technocratic view)
Water market field logic	Economic efficiency, rationalization	Demand-driven uptake, supported by convincing business models, designs, technology	organizational, marketing and market knowledge (STI and DUI mode)	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 (DUI mode)	Adopters and innovators	All technologies need to adhere to the laws of nature (ecologist view)

roles of specific actors or ways to use natural resources. 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. This reflects a mode of knowledge formation along what Jensen et al. (2007) have coined the science-technology-innovation (STI) mode of innovation. 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 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, reflecting a doing-using-interacting (DUI) mode of innovation (Jensen et al., 2007).

2.4 Harmony, directionality and policies

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 the perceived role of certain actors and nature are. At the level of the whole field, we may assess how much tensions are likely to occur between different actor groups in terms of the five dimensions. Low conflict will be expected in a situation of one or a few distinguishable field logics, which are not too distant, and which are widely endorsed by the most powerful actors in the field. High levels of conflict result from strongly opposed and incompatible field logics that are each supported by 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 diverging directionalities are potentially associated with the field and how specific policies may support the development of a 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 may emerge. Compensating for system failures may then 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 preferences in types of knowledge.

While a field hosting a wide diversity of field logics may be the source of different development pathways, it may lack the critical mass for any of the trajectories to become dominant. 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 opens up for a diversity of transition pathways emerging from a TIS enabling to address the broader question of how a technological field may contribute to sectoral transition processes.

This leads us to a final set of implications in terms of appropriate policy approaches. For national or regional policy makers, a technology field hosting strong conflicts will make the anticipation of the effects of policies difficult. Actors might oppose to be forced into collaborations at the national level, because they can access critical resources more conveniently though international networks following value-based proximities. Averaging system structures over a national or regional system boundary would, therefore, essentially misrepresent the core processes and structures in the TIS and the resulting policy advice will likely be incoherent. Thus, we mayposit that the harmony fallacy can potentially be overcome by applying the concept of value-based proximities among actors and by qualifying the related degree of harmony (conflict) in the entire field. This enables, in particular, also to assess the potential directionality of policies in a TIS and whether or not it will contribute to the resolution of 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 the qualitative content analysis of the collected data regarding TIS structure, collaboration networks, technological complementarities and institutional logics, and (III) executing an STCA to operationalize and measure value-based proximities and the degree of harmony in the field by means of a network representation of organization-logic constellations.

3.1 System delineation and data collection

We delineate our system as including all national and foreign organizations working on or collaborating in the field of modular water innovations in Switzerland. Despite the earlier stated critique of taking a national delimitation for granted, we take the national boundary as a starting point to inquire, 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 the centralized sewer system and can work as off-grid solutions. Starting from expert interviews with key researchers from the leading research institute Eawag (the Swiss Federal Institute of Aquatic Science and Technology) the actor network was identified via snowballing (Bergek et al., 2008a), by asking each interviewee to name their formal and informal collaborators and informants, and other actors they were aware of that were working on modular technologies and had an influence on the potential formation of an innovation system in Switzerland. Formal collaborations are here defined as contractual collaborations within the same 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 companies, industry experts, researchers, as well as technology proponents from civil society (see App. 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 actors (in our case organizations) and projects, as well their evolution over time. Second, for each actor, technology preferences, as well as collaboration partners (both formal and informal) were identified. Third, statements about adherence to basic institutional logics of individual actors 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 based on interviewees’ narratives about the driving forces behind their own activities, as well as those that they believed were most important for their collaboration partners. Thus, we did not ask questions about values directly, or pre-assigned specific types of organizations to specific logics. Instead, we assigned actors to specific logics based on our own interpretation of their narratives on the innovation system. This way, one or more base logic was assigned to any individual actor. Figure 1 and provide an exemplary representation of the coding, and the resulting actor-logic affiliations (see also Heiberg et al., 2021 for a differnt application of the STCA method).

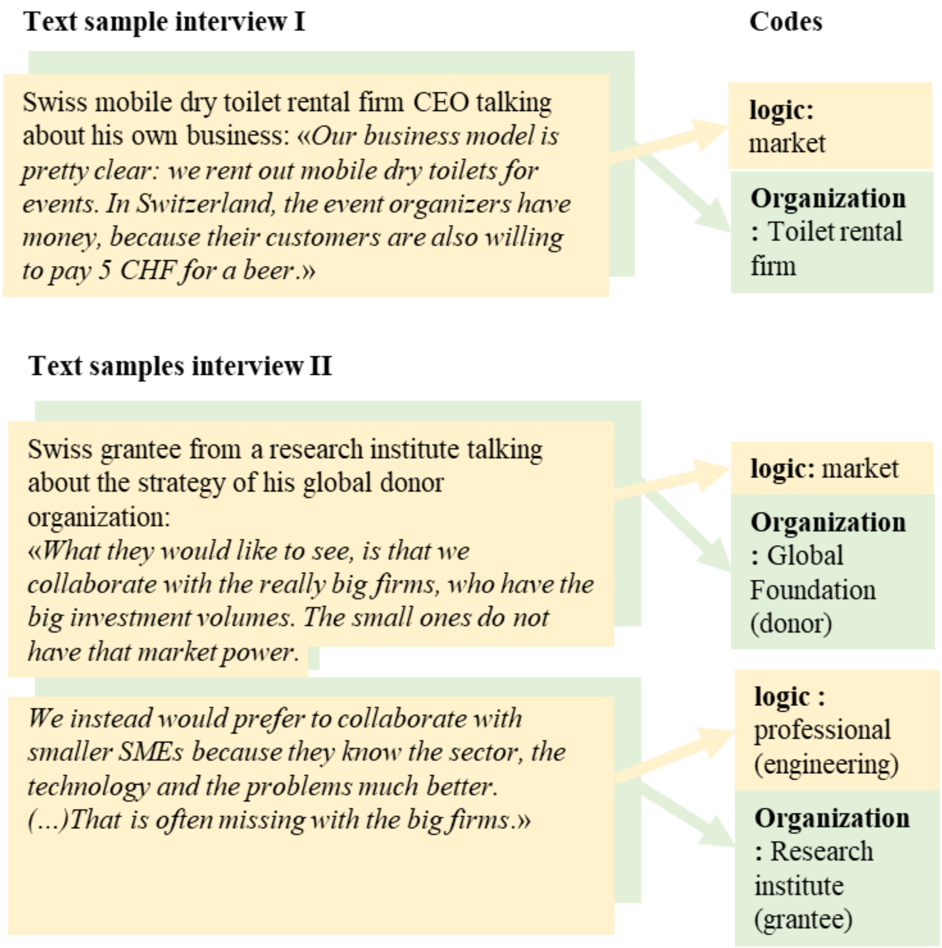


Figure 1: STCA, coding actor – logic affiliations.

Having coded all relationships between actors (here, organizations) and basic logics, we transform these data into an unweighted two-mode (affiliation) matrix, where each row represents an actor and each column represents a basic logic. Unlike more classical social network analysis (Wasserman and Faust, 1994), affiliations are not resulting from jointly attended events but through shared references to logics. Therefore, the cells of the affiliation matrix consist of ones, where actors have been affiliated with a particular logic and zeroes otherwise. To identify value-based proximity, we us a script written in R to project a "one-mode" network of organizations, where links between actors represent shared affiliations with institutional logics (see figure 2 for an intuition for what these affiliations represent). Similarity among actors is then measured by the Jaccard index (following Gower and Legendre, 1986), which is calculated as follows:

$$s = a/(a+b+c)$$
$$where\; n11 = a,\; n10 = b,\; n01 = c \;and\; n00 = d$$

n11 *(a)* represents the overlap of two actors in terms of specific basic logics. In turn, n10 (*b*) and n01 (*c*) represent instances in which one actor was referring to a logic but not the other. Eventually, n00 (*d*) reflects no overlap in terms of specific basic logics among two actors. Thus, the sum of *a, b* and *c* represents the sum of logics that at least one of the two organizations is endorsing. *s* will be 1 if two actors have the exactly same profile of logics. The closer *s* gets to 0, the more dissimilar are the logics they are endorsing.

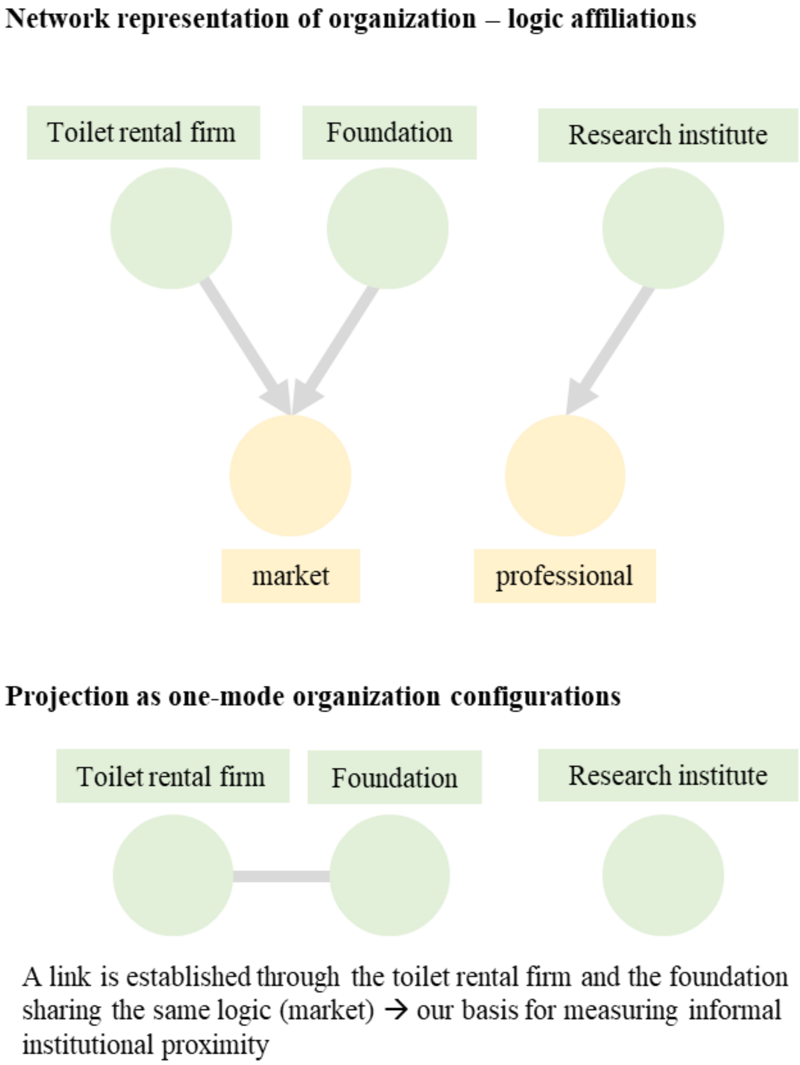


Figure 2: STCA network intuition, from affiliations to one-mode projection.

While at the node-level, we identify value-based proximities among specific organizations, at the field-level, we can identify groups of organizations based on value-based proximity. Following Fuenfschilling and Truffer (2014), we identify overarching field logics by distinguishing groups of actors sharing high value-based proximity within the group and showing low proximity among the different groups. This is a typical application case for clustering methods. We opted for Ward's method, an agglomerative clustering algorithm, which starts from each node as a cluster and then iteratively merges actors into higher level clusters by minimizing the squared distance from the centroid of the newly merged 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 and by this a hierarchical tree of possible groupings is provided. The analyst may then choose the step in the aggregation process (cutvalue) where an "optimal" number of groups were identified. A simply way to judge 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). In our application case, the clusters were analyzed according to their combinations of basic logics, as well as various aggregated attributes of the organizations belonging to them, including their collaboration patterns across field logics and geographical scales, as well as their technological foci.

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 the major potential conflict lines and the overall degree of harmony/conflict among the field logic clusters in the current technological 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 (Fig. 3).

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. Lessons were learned about its acceptance, but the project 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 firm 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 f 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 “Reinvented 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 problem through a high-tech pathway (for example fully integrated systems based on supercritical water oxidation), sidelining 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 should at some point, commercialize the technologies (Interviews In21, In16, In5, In20, In3). In parallel to these developments around the BMGF, the Western-Swiss cooperative Equilibre developed two more 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 cooperatives in the German-speaking part largely failed due to technological challenges

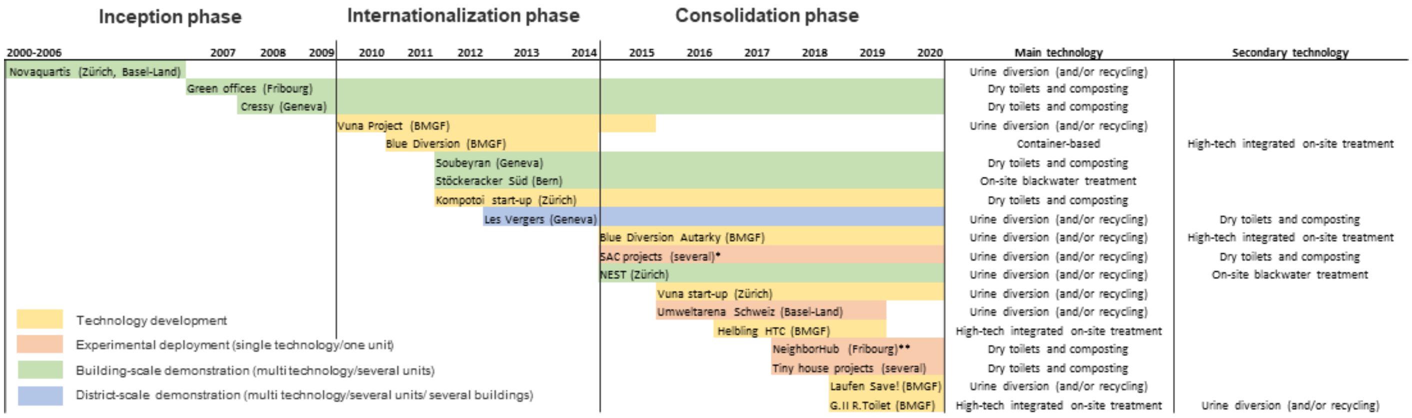


Figure 3: Timeline of major projects in the Swiss innovation system.

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 different actors lacking any serious connection.

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 test platform, the "NEST", at Eawag starting in 2015 (Interviews In12, In10), and by Vuna 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 4 shows the 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 actor engagement around modular water technology

[1] Including all important organizations involved in the projects in figure 3

projects. The closer the organization nodes are placed to each other in the graph, the stronger is their value-based proximity. To strengthen the visual interpretation, we chose to set the edge width proportional to proximity. 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 distinguishable.[2]

Analyzing the distribution of basic logics in each of these clusters (see bar chart at the right hand of Figure 4) enables to interpret three aggregated field logics. Cluster A seems to be dominated by actors 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

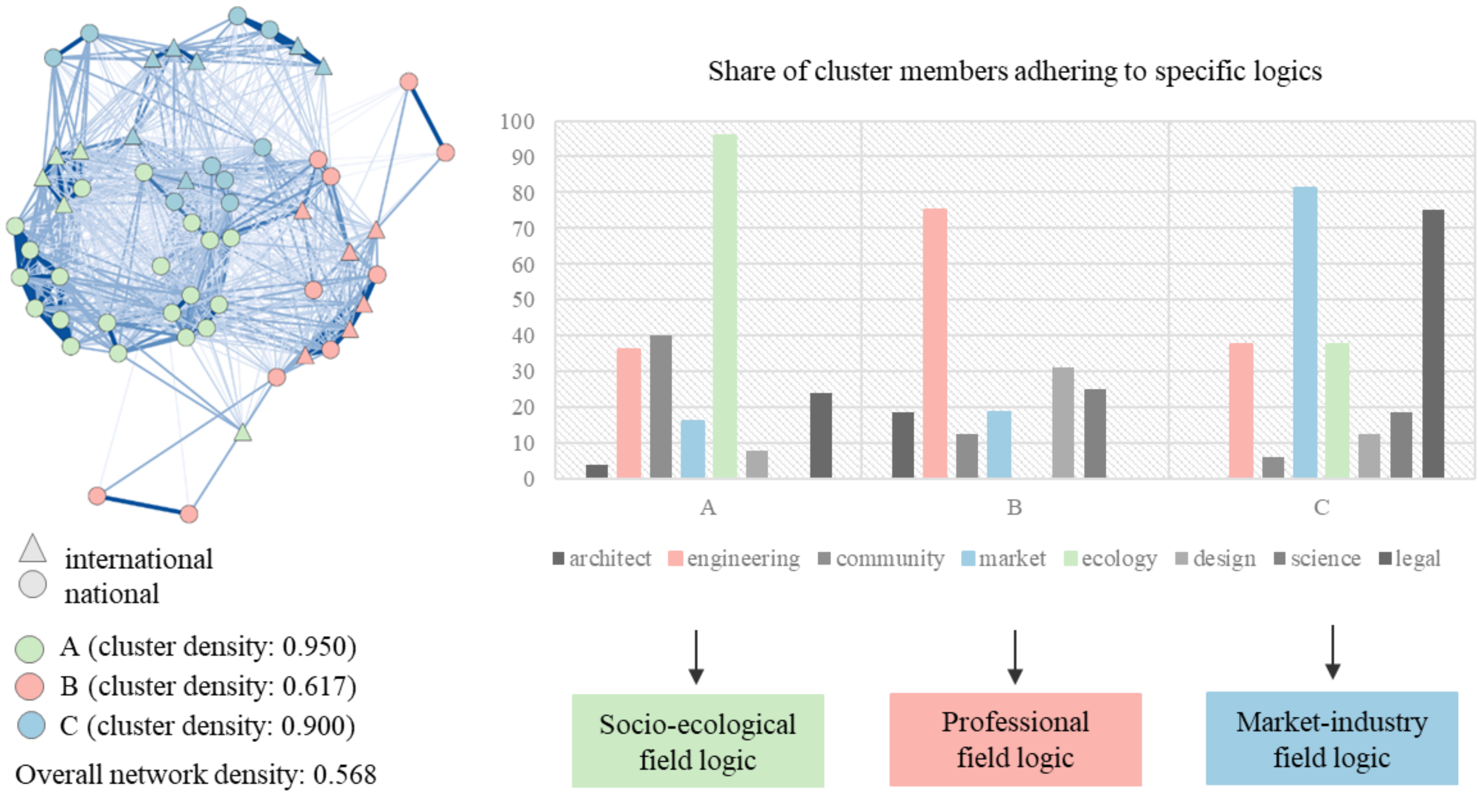


Figure 4: Network graph of institutional proximity, modularity cluster, and within cluster composition of institutional sector logics.

[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).

market-industry field logic**.** Both the network topology and the clustering algorithm identify rather clearly distinct groups of actors, which depict rather homogenous profiles in terms of value orientations. Furthermore, from the network graph, a rather clear center-periphery structure emerges with a center populated by some actors following a diversity of basic logics, whereas most of the actors are located in rather peripheral realms of the graph, indicating adherence to very 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 5 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 derive 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 of a specific field logic, 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, indicating whether the technical field as a whole might easily be delimited at the national or some sub-national regional scale or whether it has a more international reach.

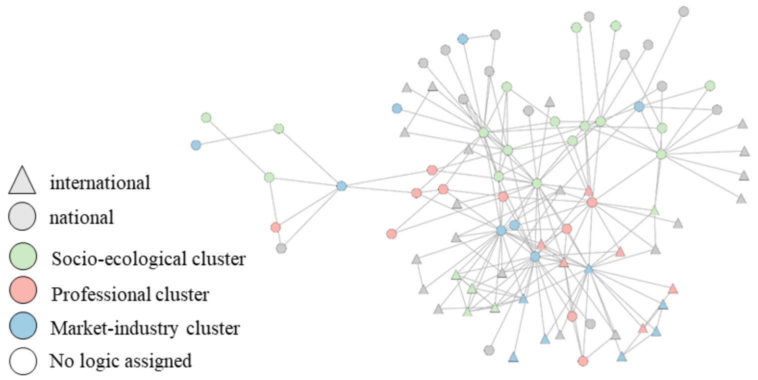
To answer these questions we will report the following network statistics (I1-I5) derived for the field network as a whole and the different sub-networks of field logic clusters. For answering the first question, we report the indicator of the “average degree” (I1) of actors in each field logic cluster. It counts how many collaborations each actor has on average in a given field logic. To answer the second question, we introduce two complementary indicators. One measures the intensity of collaborations among actors 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 actors of a specific field logic collaborate with actors 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 actors from a given field logic to collaborate with international partners. It is given as a percentage share of connections of actors from a specific logic to actors from outside their home country compared to all collaborations (I4). And a second one, reporting per field logic cluster on the cross-regional collaborations inside Switzerland by the percentage share of collaborations of Swiss actors 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 actors adhering to the professional field logic have more potential to find synergies with other actors. Regarding the openness of actors 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 outside 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 logics. 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 actors 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 actor 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

[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.

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 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



	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**

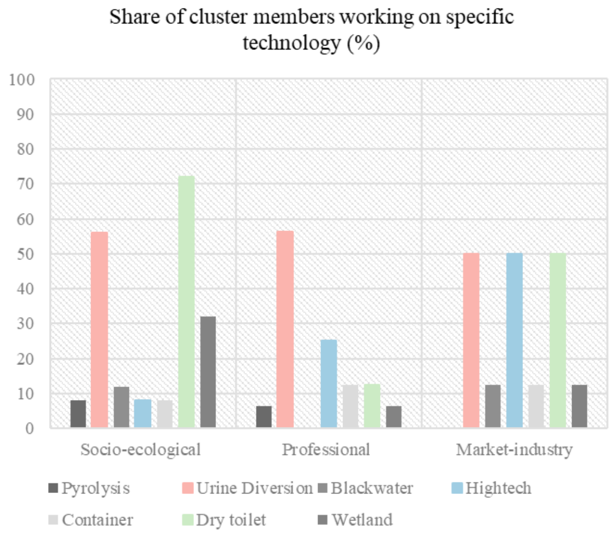


Figure 5: Analysis of collaboration networks and technological foci at the level of cluster members.

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 any implications on the likely direction of innovation activities different actors 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.

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

Mapping out these topologies of value positions among actor groups might be largely inconsequential if they just represent different motivations, rationales and mobilizing visions that guide a diversity of actors 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 actor groups and whether any substantial conflicts might appear when actors 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.

Tab 2: Conflict dimensions among Swiss modular water field logics. Own figure

	Core values	Vision of growth/ uptake/ 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	STI: scientific knowledge	Passive adopters	technocratic
Market-standardization field logic	Economic efficiency, rationalization	Risk investment by large players and increasing consumer demand	STI: scientific, design, market knowledge	Consumers	capitalist
Socio-ecological Field logic	Environmental sustainability, liveability	Diffusion among friends and other grassroots initiatives	STI & DUI: practical, hands-on & scientific knowledge	Active adopters, innovators, producers	ecological

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 and an STI mode of knowledge generation focused on scientific publications and lab-based prototypes, members of the ecological field logic engage much more strongly in a DUI 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 STI vs. DUI modes of knowledge. Eventually, these statements further reflect different philosophical stances to 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.

We see that the different value positions generate a rather diversified tension field for establishing a mutual understanding, strategic coordination and even shared goals of what a joint TIS could really be all about. Therefore, we would conceptualize a harmonic TIS in which misalignments between the basic dimensions in table 2 are rather minor and can be translated into a shared set of strategies among all actors. The stronger specific value conflicts are, the more we would expect to find competing directionalities being pushed by different actor constellations competing over scarce resources like internal resource mobilization, external funding or public legitimacy. Instead of the co-construction of systemic resources, we would see a division of resources and a more competition-oriented development of a technological field.

5. Discussion

What can we conclude in terms of development potentials for the analyzed Swiss modular water technology field? 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 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. The different value-based proximities may give rise to manifold conflicts among actors, which might stand in the way of further consolidating a "Swiss" TIS. This has implications for how to identify system failures, how to set adequate geographical system boundaries, and ultimately, the kind of policies that are needed to support technological development in a sustainable direction.

The analysis of value-based proximities among the actors in the Swiss field showed 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 which rules, norms and visions actors in the TIS would have to agree on in order to further consolidate the maturation of a nationally bounded TIS. At least initially, proponents of modular technologies followed rather different technological avenues depending on the dominant field logic they adhered to (low-tech dry toilets vs. high-tech fully integrated systems), with initially 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.

As the present study represents merely a snap-shot of the most recent constellations, we have to investigate development trends that could lead into one or another direction. In terms of the technology portfolio, certain technological components could 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.

This leads us to asking how actors changed their position in the field of value-based proximities over time. 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. For investigating these moves, we added three colored circles to fig. 5 to identify actors that subscribe to the basic logics of ecology (green), market (blue) and professional engineering (red) (see fig. 6). Overlap areas depict exactly those actors with combinations of two or even three corresponding logics.[4] The central realm where all circles overlap identifies those actors that could potentially serve as intermediaries in the field because they relate to all three core basic logics. Drawing on individual actors history of the past 20 years, we may trace how core actors moved towards the center or whether we see a rather stagnant or even centrifugal dynamics in the field. In organizational studies, these processes have been framed as whether or not we observe a hybridization of institutional logics in a field (Greenwood et al., 2011).

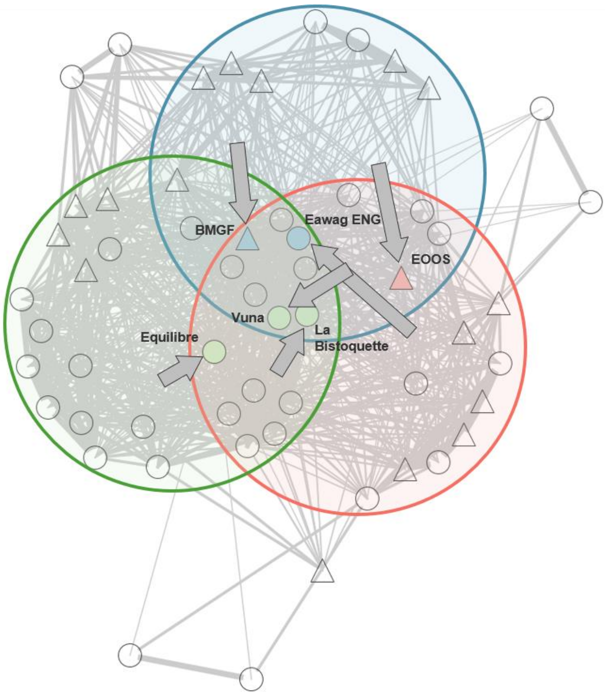


Figure 6: Hybridization dynamics. Red circle: organizations following basic logic of professional engineering, green circle: organizations following basic logic of ecology, blue circle: organizations following basic logic of market. Node colors of highlighted nodes: field logic cluster membership. Arrows indicate moves of actors in the value field during the time of analysis.

Different trends of hybridization can be observed by following the position of a number of key actors in this field (see arrows in Fig.6). 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 founding a consultancy based on the experiences already collected in Geneva. Vuna, the Eawag spin-off from a BMGF funded research project, moved from a strong professional value base and increasingly embraced elements of an ecology logic. The engineering research department at Eawag learned to increasingly adapt to the market-logic based requirements set by the BMGF funding terms. In parallel, 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.

[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.

These exemplary re-positioning processes of individual actors show that some consolidations and bridging attempts have taken place in the technological field. Actors that currently reside in the center of the network graph may therefore the role of "system intermediaries" (Kivimaa et al., 2019) able to bridge "structural holes" (Burt, 1992) and therefore contribute to the formation of a TIS. Nevertheless, value-based conflict lines still persist and it remains open, which of the logics and directionalities will prevail in the end, and which form of sustainable urban water management has eventually the potential to contribute to a sustainability transition of the urban water management sector.

This leads us finally to answers to the questions of appropriate geographical boundaries of a potentially emerging modular water TIS and what role industrial policies can play to promote sustainability transitions. First, as we have seen in the analysis, 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 networks and 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 real "Swiss TIS" is emerging or whether the national boundary only represents one among many contexts for occasional encounters and for raising specific resources.

This directly leads to the question of what role national science, technology, innovation policy may play to support the developments in a sustainable direction. First, national industrial policy-making needs to consider the different field logics that co-exist in the emerging technological field, or it will run the risks of enforcing collaborations among actors against their proper 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 social and institutional embedding of these technologies in Switzerland. Rather than solving local water and resource issues, policy would then potentially be perceived as supporting industry formation for global markets and thus spending tax-payers' money for non-local benefits.

6. Conclusion

We started this paper by diagnosing a flagrant absence of actors' value considerations in 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. 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. All this enables to systematically discuss alternative directionalities of this field and therefore connects TIS dynamics with grand challenge oriented policies.

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 or a lack of resources. Value considerations, mismatches in goals and visions, or differences in perceiving 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 more basic agreements cannot be achieved. This might even impact capability failures, because typically actors following different logics also differ in their specific stocks of expertise. And finally, institutional failures may also occur among the TIS actors if they cannot agree on shared visions, standards and ways to proceed, which will hamper their ability to access resources 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 to set system boundaries, 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 TIS 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. Setting the system boundaries in technological and spatial terms therefore becomes a key question where value positions have to be considered.

In a sense, we merely 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 conceptually grounded set of proximities, which encompasses the rather intuitive list originally provided by Boschma (2005): 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, however, able to provide further arguments how certain combinations of value dispositions 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 coincide in a territory without generating too strong conflicts. We maintain that our degree of harmony might also be used to identify the relative importance of spatial proximity for a given technological field.

Third and finally, all these considerations have definite implications on what policy makers can do to promote innovation success, especially in terms of how they will generate solutions for 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. The second generation focused primarily on economic success while the third one taking into account the dealing with grand challenges and broader value concerns. 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 framework (Markard and Truffer, 2008)

Finally, we see the presented approach as very 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 theory building, which is mandatory in innovation and socio-technical systems research (Furnari et al., 2020, Weber and Truffer, 2017)

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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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Environmental Social Sciences
Eawag - Swiss Federal Institute of Aquatic Science and Technology
Contact person: Johan Miörner
Überlandstrasse 133, 8600 Dübendorf, Switzerland
Tel.: +41-587-656493
E-Mail: johan.miorner@eawag.ch
https://www.eawag.ch/en/department/ess/

Department of Geography and Regional Research
University of Vienna
Contact person: Michaela Trippl
Universitätsstraße 7/5/A0528, 1010 Vienna, Austria
Tel.: +43-1-4277-48720
E-Mail: Michaela.trippl@univie.ac.at
https://humangeo.univie.ac.at/