Innovation Systems for Sustainability

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Synonyms

Innovation system = system of innovation

Definitions

An innovation system has been described as:

> . . . "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies." (Freeman 1987, p. 1)
>
> ... "a system which creates and distributes knowledge, utilizes this knowledge by introducing it into the economy in the form of innovations, diffuses it and transforms it into something valuable, for example, international competitiveness and economic growth." (Gregersen and Johnson 1997, p. 482)

Sustainability in the context of this entry is:

> . . . "the ability to establish continuance as a means for orienting human actions and life toward the threefold relatedness of human existence to contemporaries, future generations, and nature." (Becker 2012, p. 14)

Introduction: The Role of Innovation for Sustainable Development

Successful transformations to sustainability and the achievement of the Sustainable Development Goals (SDG) (United Nations 2015) require fundamental changes in socioeconomic systems. To tackle effectively the global challenges humanity is confronted with, radical changes on a technological, organizational, economic, institutional, sociocultural, and political level are required (Patterson et al. 2017). Carrying on with "business as usual" is no longer an option if humanity is to survive on this planet. As the present encyclopedia impressively shows, a large number of academic, political, and grassroots endeavors from very diverse schools of thought are striving to develop the scientific basis, strategies, and initiatives for achieving sustainable development. The presented approaches within the volume at hand illustrate explorations into research and strategies to promote sustained, inclusive, and sustainable economic growth (as postulated by the eighth SDG).

One general distinction between the approaches concerns the way they value the role of economic growth. Advocates of a purely quantitative consideration of economic growth regard it as the underlying driver of unsustainable developments. They postulate a massive downscaling of our economies, also known as degrowth strategy (e.g., see the article by Robra

W. Leal Filho et al. (eds.), *Decent Work and Economic Growth*,
https://doi.org/10.1007/978-3-319-71058-7_43-1

and Heikkurinen in this encyclopedia). From a Schumpeterian perspective, however, economic growth has a strongly qualitative stance and refers more generally to an enhancement of societal well-being in the sense of economic development (Pyka 2017a). Market mechanisms and structural change are not considered to be part of the problem but need to be part of the solution by supporting qualitative growth toward sustainability (Jacobs and Mazzucato 2016). The success of such a proactive sustainability endeavor heavily depends on human creativity as well as on people's will and their entrepreneurial spirit to find sustainable solutions. In short, sustainable development requires innovation.

Since a considerable part of the current social and ecological problems can be attributed to the technological development within the last two centuries, it can be argued that also the required innovations will have to be of a technical nature. A reduction of the environmental impact of industrialized economies can partly be achieved by efficiency improvements or substitution technologies. However, a mere technical optimization of current ways of production and consumption will not be enough to profoundly improve the prospects of humanity's future living conditions (Frantzeskaki et al. 2012; Schot and Steinmueller 2018). Less tangible, but all the more important, will be changes in coevolving societal and economic practices, values, and attitudes, also referred to as social, ecological, and political innovations (Cajaiba-Santana 2014; Pyka 2017a). This recognition is based on the assumption that current global sustainability challenges are rooted in the underlying structures of societal systems. These problems are persistent, meaning that they are nested in lifestyles and perceptions of the members of societies and therefore impossible to be tackled by technical change alone (Rotmans and Loorbach 2009; Schot and Steinmueller 2018).

Appreciating innovation as motor for the required fundamental change to sustainability brings up two issues: *i* how can innovation be fostered and *ii* how can innovation be directed toward sustainable development. This entry will shed light on these core questions by introducing recent approaches toward combining innovation research with sustainability goals. After an introduction to *innovation systems* research (issue *i*), the *directionality dilemma* (issue *ii*) will be sketched by pointing to the tension between open-ended and uncertain character of innovation versus the normative stance of sustainability. Subsequently, four approaches will be outlined that have been brought forward with the aim of overcoming this dilemma. A final section will draw conclusions.

Innovation Systems

The convention of conceiving innovation as a product of systemic interaction was developed during the 1980s among scholars around Dosi, Freeman, and Nelson (e.g., Dosi et al. 1988; Freeman 1987; Nelson 1993) in response to the desire of policymakers and scholars to better understand and possibly enhance the competitive economic advantage of different nations (Klein and Sauer 2016). At that time, the role of innovation as an economic growth factor – in addition to the traditional factors such as land, labor, and capital – had already been widely recognized. However, it had become obvious that a mere strengthening of new scientific discoveries to trigger innovation did not necessarily result in increased innovative output. As a consequence, innovation economists, sociologists, and also policymakers within the European Union and other OECD countries started to depart from neoclassical linear input-output thinking (Weber and Truffer 2017). Instead, they suggested to regard innovation and innovative capacity of a political or economic entity from a systemic perspective. This requires the observer to include various actors, institutions, and their interrelations as well as feedback within innovation processes (Klein and Sauer 2016).

One way to describe, comprehend, explain, and possibly shape the dynamics and the success factors of a nation's, a region's, or a sector's innovative capacity is the *innovation systems* (IS) approach. The basic assumption of the IS approach is that those actors and institutions that directly promote the acquisition and diffusion

of new knowledge are embedded in a specific socioeconomic system (Lundvall 1992). This involves, for instance, private businesses, state agencies, academia, and consumers as well as regulations, standards, practices, assumptions, and world views. Within this system, "political and cultural influences as well as economic policies help to determine the scale, direction and relative success of innovation" (Freeman 2002, p. 194).

IS have since served as a useful framework for both researchers and policymakers to make sense of the underlying structure and processes inducing the interdependent evolution of technologies, industries, actors, and institutions in an economy (OECD 1997; Sharif 2006). As Lindner et al. (2016, p. 7) argue, for instance, "the systems of innovation heuristic ... continues to be the most influential paradigm within the international innovation policy community." Over the years, IS research and innovation policy across the OECD have coevolved. Findings and theories of IS research have not only provided orientation and strategic guidance for innovation policy but have also been inspired by and quite responsive to policy (Weber and Truffer 2017). Over the course of time, IS concepts have differentiated into several variants, starting from the perspective of national IS to sectoral, regional, or technological IS. Although the latter (TIS) have gained particular importance in sustainability transition research, they will not be covered here. A comprehensive chapter on transitions to sustainability (by Schlaile and Urmetzer), which introduces TIS, is provided in this volume. The aim of this entry is not to introduce its various subforms but rather to illustrate the IS perspective in general and to highlight its relation to transformation processes toward sustainability.

Central Characteristics of IS

The systemic perspective taken by IS originates from the discontent of some scholars and policymakers toward neoclassical accounts of innovation (Gust-Bardon 2014). Especially the following three central characteristics of innovation render the differentiated view and systemic understanding of innovation processes quite plausible:

- Innovation is knowledge-based (Edquist 2005; Lundvall 2010).
- Innovation follows evolutionary trajectories (Cooke et al. 1997).
- Innovation is the outcome of complex processes (Lindner et al. 2016; Weber and Truffer 2017).

Knowledge-Based

The IS framework helps to examine the collective of the actors and institutions involved in innovation and their interactions within defined boundaries. Here, the term interaction can mean a multitude of relations. The most relevant ones for innovation processes are knowledge-based activities like learning, searching, and exploring (Edquist 1997; Lundvall 1992). The aim of the IS approach is to disclose how differences in the configuration and the interactive learning and informing of the included actors and institutions are responsible for certain economic outcomes. For an understanding of the learning processes at the microlevel of the individual firm, it is important to consider certain characteristics of knowledge and the consequences for its acquisition (=learning). Two general assumptions from an evolutionary perspective on knowledge are central: (a) knowledge is more than information and (b) knowledge can be individual and tacit (Polanyi 1959). Instead of regarding economic agents (firms or individuals) as containers to be filled with knowledge that is freely available, the systems approach tries to reveal just how the knowledge can be taken up by the agent. Consequently, a successful IS offers organizations, relationships, and career patterns that promote the acquisition of knowledge and the building of relevant competences. Since the IS itself is also subject to change while adapting to changing environments and circumstances, the specific patterns of collaboration and communication are also dynamic (Lundvall 2007).

Evolutionary

The knowledge-based nature of innovation directly relates to another basic assumption behind the concept of IS. The knowledge flows that promote innovative activities take place within emergent and very specific socioeconomic

systems (Lundvall 1992). This explains why there is usually more than one model that delivers economic success (Hall and Gingerich 2009) – even at the same point in time and state of development. Consequently, the setup of a specific innovation system is hardly a matter of intention and design. History and geography matter as well as coincidence. Small events may provoke unforeseeable feedback effects determining the direction of innovation and development and, thus, shaping the system in a particular way. At the same time, the historical and path-dependent development of IS makes them relatively inert and resistant to (deliberate) quick change and prone to technological lock-in (Edquist 1997; Hekkert et al. 2007).

Considering the evolutionary and unintended nature of innovation systems, it becomes clear that they will never attain perfection but offer an experimental environment which includes failure. Innovation emerges along (experimental) processes of diversity creation and selection (Chaminade and Edquist 2010), rendering notions of optimality irrelevant because "an optimal or ideal system of innovation cannot be specified" (Edquist 2005, p. 185). While the actors are expected to be in constant search for technological and institutional solutions, IS are subject to change on all levels of consideration. Not only do firms change with the emergence of novelties created by themselves or within their sectors, but also institutions, consumers, and policies adapt to new conditions and change or are replaced. This way, new regulation, entry and dropout of firms and organizations, and other events change the character of an IS over time in persistent pursuit of better responses to current problems. Consequently, Hekkert and his colleagues (2007) add a temporal perspective to their IS framework. They suggest to map the dynamics of a system rather than the structure at one point in time. The success of an innovation system does not only depend on the structure of the involved actors and institutions (as initially suggested by the founders of the framework) but also on the activities inducing change. This analytical detail, of course, takes better account of the evolutionary nature of IS.

Complex

The framing of innovation processes as being knowledge-based and evolutionary obviously increases the complexity of innovation research tremendously: an effective flow of knowledge depends on the very distinctive characteristics of knowledge itself (e.g., whether it is tacit or codified) as well as on the equally distinctive characteristics of the agents who create, use, and diffuse this knowledge (e.g., how well they can absorb the knowledge) (Urmetzer et al. 2018). In addition, the evolutionary nature of innovation introduces characteristics such as nonlinearity, path dependency, and uncertainty to innovation processes. While neoclassical economics and many conventional management and policy designs base their conceptualization of innovation upon linear technology-push and demand-pull models, IS approaches explicitly welcome the complex nature of innovation processes. From the IS perspective, innovation is a collective endeavor: the sources of innovation are dispersed, learning is reciprocal, and novelties are created in networks rather than by individual actors (Lindner et al. 2016).

The ultimate benefit of the IS perspective is that it provides "a counter narrative to the one of methodological individualism prevalent in neo-classical economics and vast strands of the management or public policy literature. The latter would as a rule look for the decisive elements as factors for explaining innovation success. IS approaches instead emphasize that the constellation of factors and their development over time give rise to qualitatively new properties; they focus much more on interaction terms" (Weber and Truffer 2017, p. 112).

IS Meets Current Challenges

The IS concept originally emerged at the policy-academia interface. The scientific contribution to provide conceptual orientation and strategic guidance for innovation policy was twofold: while Freeman's approach provided the opportunity to compare innovative performance of nation states, Lundvall was more interested in the micro-foundations of IS and scrutinized the interactions between users and producers (Sharif 2006). Both

approaches contributed to a more systematical mapping of the determinants of innovation and facilitated a precise evaluation and comparison of the innovative performance of nations. Based thereon, other scholars provided concepts for translating these insights into concrete policy targets by relating the configuration of their components (i.e., actors, networks, and institutions) to their performance. Several researchers have worked on approaches to enhance the consultative power of IS research for policy by making explicit the various functions, activities, or determinants of innovation in IS (Bergek et al. 2008; Edquist 2001; Hekkert et al. 2007; Jacobsson and Bergek 2011).

However, the circumstances and expectations for innovation are changing. Along with the groundbreaking developments in digitalization and virtualization, the process of innovating has become much faster, more collaborative, and more global. A growing number of actors such as public administration, end users, and civil society are increasingly involved in idea creation and testing, thereby influencing, shaping, and speeding up the innovation process (Weber and Truffer 2017). System borders, sectors, and agency are becoming more difficult to pin down and thus challenge a clear delineation of IS, today.

These might be some of the reasons why policymaking still struggles with the consequent deployment of IS thinking. Yet another issue calls for immediate attention: the sustainability imperative. Except from a few quite recent endeavors, which will be introduced in the subsequent section, political and scientific debates about more effective IS are often focusing on the question of how innovation can be achieved and fostered, treating innovation as a purely positive phenomenon, inevitably and automatically solving our problems (Blok and Lemmens 2015). However, faced with the persistent sustainability challenges, these premises no longer hold, and a continued "blind" innovation policy aimed at increased economic competitiveness is short-sighted and highly irresponsible (Schlaile et al. 2017).

As the preceding elaborations show, the first set of challenges to IS research refers to issues such as the increased number of involved actors, globalization, and digitalization. They do not necessarily touch the core of the IS conceptualization and might thus be technically solvable. The second set of challenges, however, directly points to more intangible qualities of the concept and questions whether the IS framework possesses the normative power necessary to contribute to innovation activities tackling the societal, environmental, and developmental challenges (Weber and Truffer 2017). The following section will explore the suitability of the IS framework to frame and inform processes of transformative change toward sustainability (Daimer et al. 2012; Lindner et al. 2016).

Sustainability in IS

Sustainability is a truly normative issue, and the existence of norms, values, and desired goals recognizing the necessity for change and its direction is deemed essential for successful intentional change toward sustainability (Urmetzer et al. 2018). The following section will first concretize the term sustainability in the context of transformations and then relate it to general concepts of directionality in IS research.

While a fixed definition of sustainability has not distilled throughout the literature, the most common definition refers to *sustainable development* and has been brought forward by the World Commission on Environment and Development (WCED) in their so-called Brundtland report in 1987: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, p. 43). Since then, many attempts have been made to clarify and concretize the concept of sustainability to better guide human action. Approaching the matter from an ethical perspective, Becker (2012) has come up with a rather anthropocentric definition: "[S]ustainability is the ability to establish continuance as a means for orienting human actions and life toward the threefold relatedness of human existence to contemporaries, future generations, and nature" (p. 14). Becker's definition may be considered suitable from an

IS perspective, because it refers to the relations of humans among each other, with future generations, and to the environment – a truly systemic approach.

Some innovation scholars have ventured the attempt to understand and guide transformations to sustainability – building, among others, on the IS framework (e.g., see the article by Schlaile and Urmetzer in this encyclopedia). While the IS perspective continues to successfully guide science, technology, and innovation policies around the world to increase economic competitiveness and innovative performance, sustainability issues often remain a decorative add-on and are seldom considered genuinely in political strategies. Innovation, progress, and future well-being are often conceived in purely economic terms and expected to be driven by technological advances. This world view has historical roots: until the mid-nineteenth century, economic growth was associated with a quantitative expansion of production factors (land, labor, and capital). A radically new school of research then demonstrated that technical change was responsible for the largest part of economic growth (Abramovitz 1956; Solow 1957). The new discipline of innovation research was concerned with the question if and to what extent innovation drives economic progress. The recognition of innovation as a necessary motor for development and well-being brought forth an overly positive perception of innovation. This "pro-innovation bias" (Rogers 2003) ultimately led to strategic search heuristics that were very much confined to answering the question of how to propagate innovation (issue *i*, see Introduction) (Godin 2015). Concerning the second issue above (*ii* how to direct innovation toward sustainability), innovation research in general and IS specifically do currently not provide analytical or conceptual orientation for innovation policy (Lindner et al. 2016).

A dedicated innovation path in the light of current sustainability challenges calls for a new mode of fostering and handling innovation. While the unambiguous significance of innovation for advancing humankind can hardly be denied, the full reliance on random novelty creation and competitive forces that shapes current paradigms must be challenged. But how can innovation – a process also found to be characterized by true uncertainty – be harnessed to serve sustainability-related solutions?

The Directionality Dilemma

In traditional IS concepts, the direction of change or the purpose of the innovation is rarely addressed (Daimer et al. 2012; Tödtling and Trippl 2018). From the systemic perspective on innovation, the determination of direction is difficult to conceptualize. Mainly due to their complexity and evolutionary characteristics, Edquist (2005) argues that IS emerge on the basis of multiple and interacting processes. This renders a centralized control of IS impossible. The long-term ambition for sustainable development, as expressed, for instance, in the SDGs, stands in stark contrast to the conceptualization of innovation as an open-ended and highly uncertain process (Knight 1921; Pyka 2014). The direction of change has generally been understood to be defined by "the market" and attempts to determine direction otherwise (e.g., by the state) were associated with a compromise of openness and creativity resulting in reduced innovativeness (Aghion et al. 2009). Furthermore, the standard measures of sustainability are ambiguous and regularly contested (Smith et al. 2010). Social and environmental improvements in one region, for instance, may cause a decline of conditions elsewhere or in the future. In contrast to the global agreement on the 17 relatively generic SDGs, specific sustainability-related norms, values, and narratives are products of diverse and often conflicting and changing world views (Blok et al. 2015; de Witt 2015). However, considering the relational nature of sustainability (as elaborated in the previous subsection), it may not even be so important – and virtually impossible – to define globally effective norms and values (a predefined sustainability paradigm) as an overarching goal of future innovations. Instead, within IS for sustainability, decision-makers should be enabled to "apply, negotiate and reconcile norms and principles based on the judgements of multiple stakeholders" (Blok et al. 2015, p. 12), a process that depends on the cultural context and that will change over time.

On the other hand, the globally palpable urgency of transformative change, as recently been affirmed, for instance, by the IPCC in their special report "Global Warming of 1,5°C" (IPCC 2018), requires a reconsideration of determining a direction of change toward socially desirable ends. Weber and Rohracher (2012) legitimize top-down policy intervention in IS toward a certain direction with the responsibility of the state to set collective priorities for innovation to solve societal problems that would otherwise remain unaddressed. Mazzucato (2016) brings up several examples of historical state interventions that enabled the development of crucial technologies of societal importance, such as space travel and the internet. Such mission-oriented policies have been, on the other hand, suspected to be biased toward only a small number of technologies and industries, thus crowding out others that might become of relevance later (Ergas 1987).

While Fagerberg (2018) deems the knowledge base of innovation (systems) research very well equipped to inform policies about tackling global societal challenges, other scholars do see the necessity for some adaptations to IS. Smith et al. (2010), for instance, recommend (a) to consider innovation along the whole life cycle of a problematic technology (including sources, user practices, and disposal) and (b) to introduce institutional factors to the analysis of innovation processes, such as search routines and knowledge capabilities of the system actors as well as prevailing paradigms and regimes (Smith et al. 2010). Bryden and Gezelius (2017) see the need for IS to better account for ethical principles. Drawing on the triple bottom line accounting (i.e., sustainability-sensitive business accounting), they suggest a human rights-based design of IS by empowering especially the underprivileged stakeholders to actively participate in innovation processes. From their point of view, this is the only way to achieve robust and just solutions for the entire society. For the same reason, Andersen and Andersen (2017) recommend the inclusion of a wide variety of stakeholders early in the innovation strategy planning. Such IS foresight mechanism will be indispensable not only for successful innovation but also for directing innovation toward solutions to sustainability problems (Andersen and Andersen 2017).

Some recent endeavors of explicitly coupling the IS concept with sustainability aspirations include s*ustainable systems of innovation* (Segura-Bonilla 1999, 2003), *sustainability-oriented innovation systems* (Altenburg and Pegels 2012; Stamm et al. 2009), *reflexive innovation systems* (Lindner et al. 2016), and *dedicated innovation systems* (Pyka 2017a, b). They will be introduced in the following.

Sustainable Systems of Innovation

One proposal to consider sustainability issues within the IS framework has been made by Segura-Bonilla who brought forward the concept of sustainable systems of innovation (SSI) (Segura-Bonilla 1999, 2003). By extending Lundvall's (1992) IS definition, he conceptualized SSI as being "constituted by human and natural elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge" (Segura-Bonilla 2003, p. 378). The SSI perspective has been developed and empirically tested with innovations in the forest sector. SSI do not only consider social rules and the interactions of anthropogenic system components such as firms, organizations, policymakers, individuals, and institutions; it rather adds the ecosystem as another systemic actor. Corresponding to the factors that influence the performance of IS (the institutional setup, the knowledge infrastructure, the specialization pattern, the public and private demand structure, and the government policy; see Gregersen and Johnson 1997), SSI are expected to be strongly affected by the human-environment relationships, too. Segura-Bonilla argues that the new attention to natural system elements and their interaction with the socioeconomic system will prompt political and economic actors to "start to think in long-term competitiveness" (2003, p. 378).

Sustainability-Oriented Innovation Systems

Building upon Segura-Bonilla's SSI (Segura-Bonilla 1999, 2003) and others, Altenburg and

Pegels (2012) have further developed Stamm's et al. (2009) concept of sustainability-oriented innovation systems (SoIS). Based on Freeman, they understand SoIS as "networks of institutions which create, import, modify and diffuse new technologies that help to reduce environmental impacts and resource intensity to a level commensurate with the earth's carrying capacity" (Altenburg and Pegels 2012, p. 10). The overall goal of SoIS is the acceleration of environmentally sustainable technological innovations through a paradigm shift toward sustainability. Altenburg and Pegels emphasize the central role of governments to politically enforce the disruption of unsustainable trajectories by incentivizing industry to develop environmentally sustainable technologies. Although their policy recommendations do involve consumer information and education, the suggestions for policies on the basis of SoIS remain largely technology-centered and only partially consider the systemic character of innovation. Examples for suggested policy instruments include command-and-control measures and pricing instruments: public support for basic and applied research, the removal of entry barriers to sustainable technologies, and support for new "green" technologies until they become cost competitive and are able to substitute conventional technologies (p. 17). The role of the civil society in innovation processes is reduced to consumption and policy legitimization. The active role of users in IS as innovative agents is neglected. It remains open whether and how the postulated top-down shift in agenda setting of currently unsustainable technological dynamics will prompt the desired paradigm shift toward sustainability.

Reflexive Innovation Systems

Going the decisive step further, Lindner et al. (2016) expand the responsibility of the paradigm shift to the collective of all societal actors: they propose to improve the normative heuristic of IS by integrating the formerly exogenous strategy formulation into the framework. From the perspective of so-called reflexive innovation systems (ReIS), policymakers as well as the other system agents are enabled to reflect upon (a) the analysis of the system, (b) goal formulation, and (c) strategy development. Thus, the entire system potentially will work more effectively and robustly toward sustainable ends, since the collective decisions will increase the sense of ownership and legitimacy (Lindner et al. 2016). Similarly, Bajmócy and Gébert (2014) propose to extend the scope of the IS approach by questioning its implicit goals of economic growth, productivity growth, and employment. Based on the capability approach (e.g., Sen 1993), they call for the recognition and exploitation of knowledge, values, and norms that are scattered among all societal actors to encourage a debate on the socially desired objectives of the respective IS. There is ample evidence on collective action and the willingness and ability of humans to cooperate in small groups, though one of the major problems seems to remain the scalability of cooperative behavior and positive feedbacks (e.g., through local norms and trust) beyond those small groups (Carattini et al. 2017; Ostrom 2000).

Dedicated Innovation Systems

The preceding illustrations reveal that a paradigmatic shift from a purely economic to a sustainability paradigm, as requested by the proponents of SoIS (Altenburg and Pegels 2012), will not occur unless the entirety of innovative actors shift their predominant focus on economic competitiveness to sustainable solutions (Lindner et al. 2016). Consequently, the integration of such normative dimension requires a redefinition of the dedication of search heuristics inherent in IS. While the creation, diffusion, and use of knowledge in IS aim at innovation for enhancing international competitiveness and economic growth (Gregersen and Johnson 1997), dedicated innovations shall improve sustainability performance such as the continuity of ecological systems, inter- and intragenerational justice, or the quality of life (Schlaile et al. 2017). Such dedicated innovation systems (DIS) have been recently coined by Pyka (2017a, b) and can be thought of as IS that explicitly go beyond their traditional orientation by allowing for paradigmatic change toward sustainability. As with all IS, such dedicated systems

cannot be consciously designed or planned, and their setup and output are generally not very responsive to intentional influence (Edquist 2005). Instead, IS can be said to emerge on the basis of the collective of underlying paradigmatic principles that guide the agents in their (inter) actions. Such principles build on knowledge, which represents a fundamental element of IS in general and of DIS in particular. In fact, this recollection of the centrality of knowledge in IS may represent the unique feature of DIS among other propositions. This resonates with recent findings regarding possible points to intervene in systems, i.e., leverage points (Meadows 1999): Abson et al. (2017) demonstrate that a change in the ways how knowledge is created and used is one of a few quite effective realms of inducing change in systems. Without going too deep into this issue, it is important to mention that not only the processes of knowledge creation and use must change but also that the kind of knowledge requires reassessment: in light of a dedication to sustainability, the focus on economically relevant knowledge production must be complemented by a consideration of other types of knowledge. This includes the ability to comprehend systemic interrelations, the competence to detect and formulate normative objectives and understand trade-offs between them, as well as knowledge about how to induce change (Urmetzer et al. 2018).

Conclusion

This entry has provided an overview of the contribution and limitations of the IS framework in the context of sustainability transformations. Since its very origins in the 1980s until today, IS research has continued to evolve by responding to critique and reacting to new trends in politics, economics, and society. It can be concluded that the knowledge-based, evolutionary, and complex conceptualization of IS offers a prolific basis for understanding and inducing change processes of normative orientation.

During the past decade, researchers have built upon the IS framework to develop different conceptualizations of IS for sustainability on different systemic levels – be it the incorporation of the natural ecosystem as one system element (Segura-Bonilla 1999), be it the empowerment of central authorities with a strict normative endowment (Altenburg and Pegels 2012), or the integration of the formerly exogenous strategy formulation into the framework (Lindner et al. 2016). It has become apparent that IS for sustainability requires a systemic dedication to sustainability values (Pyka 2017a). This can also be expressed as a collective understanding or a common paradigm of sustainability to which the majority of innovative actors commit themselves. Such sustainability paradigm will inevitably alter search heuristics and trajectories from purely economic perspectives to integrated and sustainability-oriented ones. One typical shortcoming of IS approaches to sustainability transformations seems to be that they provide little opportunity to consider the complexity of the normative value systems (Blok et al. 2015; Lindner et al. 2016): most of the current approaches either presume consensus about the scale and importance of sustainability-related issues or trust in top-down control of the IS. However, to acknowledge and exploit the potential accumulated in the diverse knowledge and value base of actors and their interrelations contributing to innovation (as accomplished by the very recent proposals of ReIS and DIS) will be fundamental to successfully advance IS concepts for sustainability.

Cross-References

- Biobased Economy
- Green Economy
- Responsible Research and Innovation
- Sustainable Innovation
- Transitions to Sustainable Development

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