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SDG Implementation: Introducing the "SDG Flywheel"

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At the UNs High-level Political Forum on sustainable development (HLPF), at the end of 2023, progress of the Sustainable Development Goals (SDG) implementation at the half-time of the 2030 Agenda for Sustainable Development was reviewed. As a result of the finding that only 15 percent of the SDG targets are on track, bold and transformative actions was called for by the heads of state and governments. Applying science, technology, innovation, and data for transformative action is realized as game changer for scaling up actions to accelerate SDG progress.

The resulting question of "how to support SDG implementation by applying science, technology, innovation and data?" is where our research starts. Based on SDG #17 "Partnerships" and a Service-Dominant Mindset, the research unfolds actor engagement to gradually intensify working together from solidarity over cooperation, collaboration up to value co-creation.

1. Introduction

As early as the first half of the 19th century, Frederic Bastiat (Bastiat & Huszar, 1964, p. 160) pointed out the central economic law that: "services are exchanged for services". Exemplified on the case of two isolated men, he demonstrates that they engage and work to render service and thus positive valuated change to their well-being to themselves. If exchange happens (e.g. Robinson Crusoe hunts and Friday fishes) each renders service to the other and receives an equivalent service from him. If one of the two actor applies natural resources that are also available to the other, that natural resource will not count in the price. What has to be compared is the labour performed not the effort of the nature (Bastiat & Huszar, 1964, p. 160). Bastiat mentions also a disposition that is common among human actor and has an impact on their social practices and exchange behaviour. When, labour being painful, and human being naturally inclined to shun pain, it follows that wherever plunder is less burdensome than labour, it prevails. And thus, that human live and develop, when they can, at the expense of one another (Bastiat & Huszar, 1964, p. 54).

The increase in human knowledge and skills in recent centuries has led to an exponential increase in goods production. Scaling up industrial goods production has evolved into an extensively designed and artificial world in all areas of life (Kozma, 2023; Norman, 2023; Papanek & Fuller, 1972).

The unchanged human disposition, combined with the exponential growth of human capabilities, in addition to the plunder and injustices humans are inflicting on each other, has now severely wounded our planet as a whole of our natural resources and livelihoods. By creating new species of permanent garbage to clutter-up the landscape and the sea, and by choosing materials and practices that pollute the air we breathe the crises of sustainable development have already become a global challenge of energy, food, and water security. And the crisis is being fueled by pandemics, wars, droughts, famines, mass migration, racial inequalities, inequities for women and other symptoms of economic, social and environmental unsustainability. Meeting the needs of humanity and our fragile planet has never been a greater challenge (Alkire et al., 2023; Jeremić & Sachs, 2014; Papanek & Fuller, 1972; Scott & Martin, 2021). To meet this challenge, in 2015 the 17 Sustainable Development Goals (SDGs) have been outlined in the "2030 UN Agenda" as an urgent call to social activism to free humanity from the tyranny of poverty and to want a heal and secure our planet (General Assembly, 2015; United Nations, 2024a, 2024d).

During the "UN High-level Political Forum" at the end of 2023, the status of SDG implementation was assessed at the halfway and the key messages are: "only 15 per cent of the SDG targets are on track", "bold and transformative actions on the SDGs must be prioritized and brought to scale", "transformative action can be pursued through science, technology and innovation (STI). Achievements in enabling technology to act as accelerators of the SDGs, and STI need to be at the front and centre of the SDG action plans" (United Nations, 2023, 2024c). However, applying science, technology, innovation, and data for transformative action is realized as game changer for scaling up actions to accelerate SDG implementation progress.

The resulting question of "how to support SDG implementation by applying science, technology, innovation and data?" is where our research starts.

At the beginning of our work the research problem of SDG implementation is identified, and the value of a solution is justified. Then the “SDG Flywheel” as the findings of our work is presented. The flywheel image is used as framework to describe the concepts and processes to build up momentum and breakthrough for scaling up SDG implementation. This is followed by the elaboration of the “SDG Flywheel” based on Design Science Research Methodology (DSRM).

2. Research Approach and Objectives

Our research design is the overall strategy, procedural plan and analytical approach chosen in order to build and integrate solutions for SDG implementation, in a coherent and logical way (Creswell & Creswell, 2017; De Vaus, 2001; Gioia & Pitre, 1990). The Design Science Research Methodology (DSRM) is applied because it synergistically combines practical relevance and scientific rigor along both the relevance cycle and the rigor cycle that define good design science research

(Baskerville et al., 2018; A. Hevner, 2007; Peffers et al., 2008). Design Science Research embodies three closely related cycles of activities (A. Hevner, 2007). The Rigor Cycle provides the knowledge base for rigorous research based on scientific theories, frameworks, engineering methods, along with domain experiences and knowledge generated with properties and processes found in the application domain. The central Design Cycle supports a tighter loop of research activity for the construction and evaluation of value propositions with the desired properties realized for example as design pattern or design artifacts. The Relevance Cycle tests the artifact regarding suitability for fulfillment of the requirements of the research objectives.

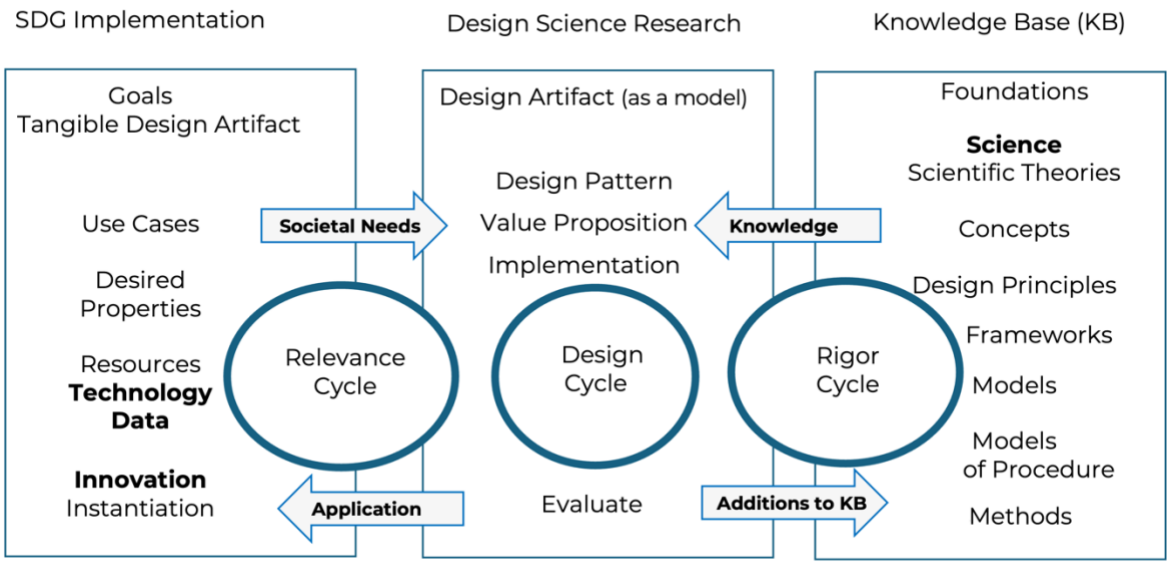

Figure 1 Design Science Research Cycles (A. R. Hevner, 2007) adapted to SDG Implementation

Referring to (Gregor et al., 2020; Hevner & Chatterjee, 2010) the DSR process includes six activities which are presented in the following briefly. In activity (1), the research problem is identified and the value of a solution, e.g. a design artifact, is justified. Activity (2) defines the knowledge base and derives design principles as generalized outcomes and properties that should be represented by a solution. As shown in figure 1 science as part of the STI is assigned to this activity.

In activity (3) design patterns as reusable solutions for the common parts of the design problems are derived from the knowledge base and the design principles. Creating the patterns includes determining and demonstrating the desired functionalities and its architecture. Activity (4) represents these patterns as the results of specific research-related design decisions, they are classified as design artifact as a model. In activity (5), a tangible design artifact is instantiated. Finally in activity (6) the findings in reference to the research question of "how to support SDG implementation by applying science, technology, data and innovation?" are presented and communicated.

In our research we strive to use the interplay and mutual reinforcement of the three DSR cycles to build up step by step momentum and breakthrough to empower the implementation of the SDGs this we call the "SDG Flywheel".

3. The Need for Momentum in SDG implementation

In 2012 Oxfam Discussion Papers, Raworth - inspired by Rockström (Rockström et al., 2009) - established a framework with two rings shaped like a doughnut to visualize a safe and just space in which humanity can act sustainable between planetary and social boundaries. The mantra here is that sustainable development can only succeed if social foundations and planets life-giving systems are pursued together (Raworth, 2012, 2017). Visualized as the doughnuts inner ring the social foundations set the basics for meeting the minimum standards for a dignified life. These basics of life include e.g. sufficient food, clean water, healthcare, access to education or a minimum income. Below the Doughnut's social foundation lie shortfalls in human well-being, faced by those who do not receive the minimum standards. Beyond the outer ring, the ecological ceiling, lies an overshoot of environmental degradation and critical planetary deterioration such as climate change and the consequences such as heat waves, drought, floods. But between these two boundaries lies an "sustainable action arena" - shaped like a doughnut - which represents the space for ecologically safe and socially just action for humanity (Raworth, 2017, p. 45). Acting in the "sustainable action arena" makes it possible to meet "the needs of the present without compromising the ability of future generations to meet their own needs" (Handl, 2012).

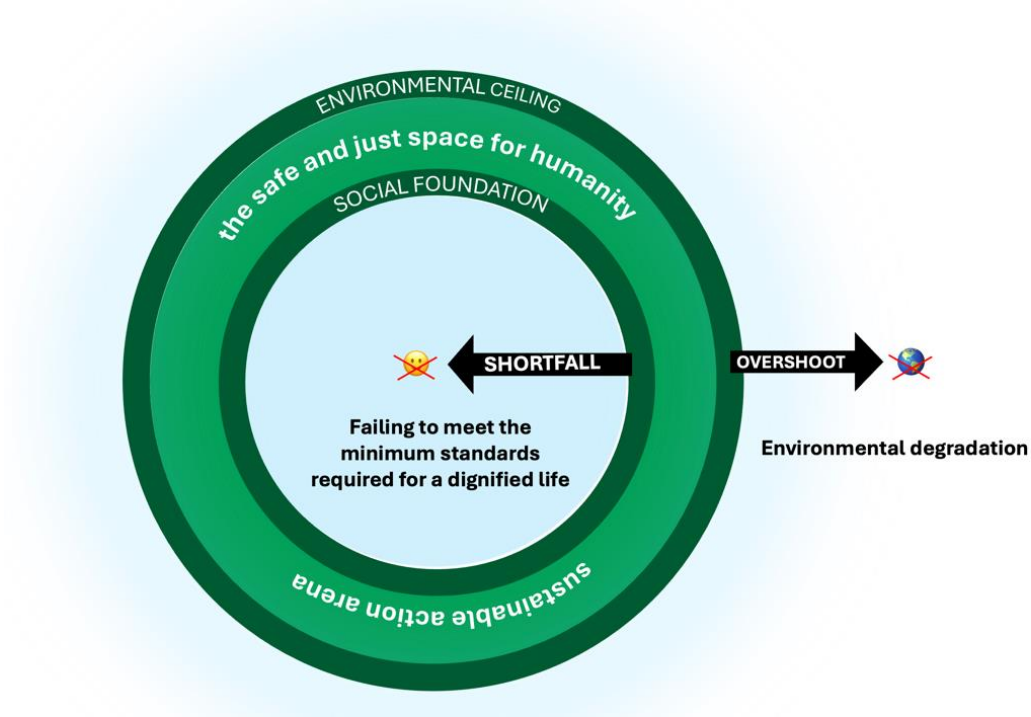

Figure 2 The Doughnut as context for social and economic practices based on (Raworth, 2012, 2017; Rockström et al., 2009)

In 2015, the doughnut image had impact in fostering new ways of thinking during the UN process of negotiating the 2030 Agenda for Sustainable Development. 17 Sustainable Development Goals (SDGs) as plan of action for people and planet are seen as integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental (General Assembly, 2015; United Nations, 2024a, 2024d). Table 1 shows examples of SDGs and their mission statements (United Nations, 2024b).

Table 1 SDGs Short Titles and Mission Statements (excerpt)

SDG #	SDG short title	Mission statement
1	No poverty	"End poverty in all its forms everywhere"
2	Zero hunger	"End hunger, achieve food security and improved nutrition, and promote sustainable agriculture"
3	Good health and well-being	"Ensure healthy lives and promote well-being for all at all ages"
7	Affordable and Clean Energy	"Ensure access to affordable, reliable, sustainable and modern energy for all"
17	Partnerships for the goals	"Strengthen the means of implementation and revitalize the global partnership for sustainable development"

At the end of 2023, the status of SDG implementation was assessed, and a recap was made. The key messages are: "only 15 per cent of the SDG targets are on track" (United Nations, 2023). This proves that mankind continues to act outside the "sustainable action arena" and is heading further to abyss of the shortfall of human wellbeing by failing the minimum standards. Thus, to better implement and enforce the SDGs are needed more urgently than ever to save humanity and the planet, or as the UN states: "bold and transformative actions on the SDGs must be prioritized and brought to scale", "transformative action can be pursued through science, technology and innovation (STI). Given the scale of the challenges and the diversity of the SDGs a successful SDG transformation cannot consist of just a few measures; rather, the measures e.g. STI must interact, interplay and reinforce each other. This has led us to the image of the flywheel, which is the common thread running through our work.

4. Findings - The "SDG Flywheel"

The term flywheel is a powerful metaphor used by James Watt over 200 years ago in his steam engine. The flywheel is characterized as highly efficient at capturing, storing and releasing energy. To unlock the dynamics of a flywheel and to make the flywheel spin fast it is necessary to build up force and minimize friction. The more force is added and the more friction is eliminated the faster it spins and makes the breakthrough from inertia to dynamics (Halligan, 2018; Nance, 1996). Collins has transferred these characteristics of the flywheel to transformations: In creating a good-to-great transformation, there’s no single defining action. Rather, it feels like turning a giant, heavy flywheel. Pushing with great effort, you get the flywheel to inch forward. Then at some point breakthrough! The flywheel flies forward (Collins, 2019).

In this sense we visualize the findings of our work in figure 3 using the image of the "SDG Flywheel". The "SDG Flywheel" is characterized by building up momentum out of the individual parts. Step by step the parts like knowledge base, design principles and design patterns build up momentum. Turn by turn capabilities evolve that feed the "SDG Flywheel". Figure 3 shows that there is no miracle moment rather the process pushing the "SDG Flywheel" in one direction. The process elaborated in this paper is based on the three DSR cycles, the utility and novelty of the design patterns and the design artifacts first as a model and after verifying that the properties are suitable for the specific task in the context of SDG implementation as a tangible

instance of a digital service platform. This service platform facilitates momentum by resource integration and building resource density as precondition for unbundling and rebundling of resources and thus for service innovations as new combinations of resources. Service innovations that as value propositions are applied by (inter-) actors in the process of service for service exchange and in this way establish new and sustainable social and economic practices. Practices designed for improving SDG implementation and within the "sustainable action arena". And then, breakthrough. At some point the momentum hurls the "SDG Flywheel" forward, the momentum is working for acting in the "sustainable action arena" without "pushing harder" or the necessity to build up much more resources or capabilities. Like the flywheel with tremendous power and on its own heavy weight the "SDG Flywheel" as a digital service platform flywheel has achieved a level of resource density facilitating that the creation of further sustainable value propositions goes faster and faster. The tremendous power is the result of continued improvement, of incremental steps in the parts at first and of the fit into the context of an overall (construction) plan that will work. The interplay and mutual reinforcement of the various capabilities of the "SDG Flywheel" is made possible by the duality of structure (Giddens, 1984), by the construction plan of the digital service platform applied as medium and output of practices. The structural properties of Service Dominant Architecture, as construction plan for collaborative creation of value propositions on service platforms, are both, medium and output for the practices they recursively organize. As demonstrated by the example of the SDA service systems, this structure enables all actions and processes to interact and reinforce each other. SDA is both the medium for planning the processes and sustainable value propositions as well as the output and result of the physical implementation, the digital service platform.

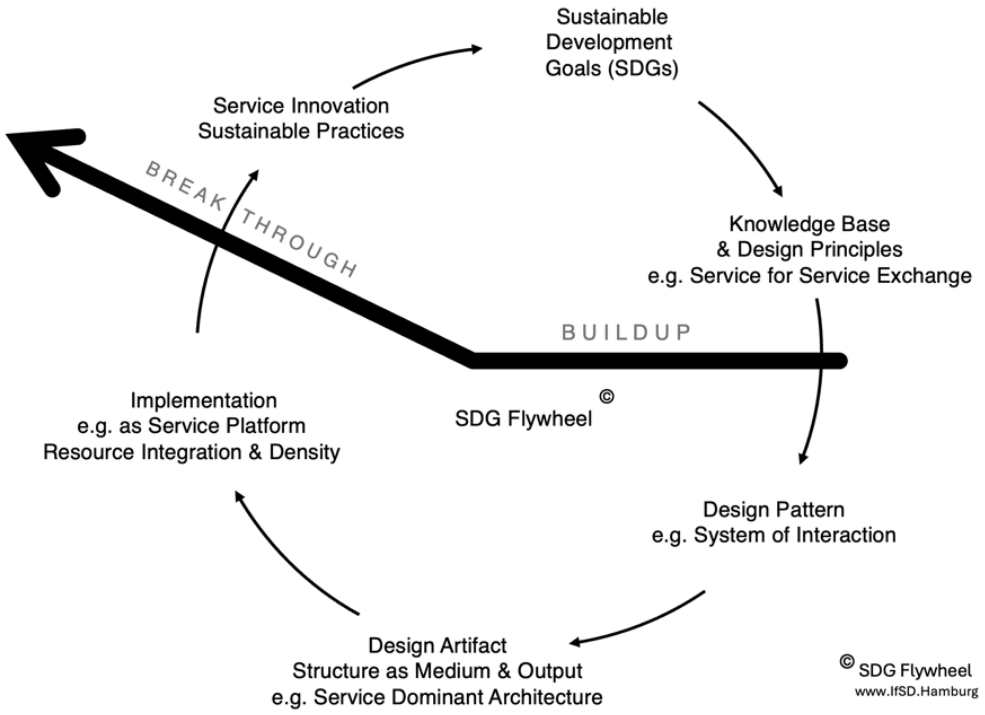

Figure 3 The "SDG Flywheel" (by IfSD.Hamburg)

5. Buildup Momentum - Knowledge Base, Design Principles and Design Patterns

As shown in figure 3 the "SDG Flywheel" starts building up momentum with a justificatory knowledge base as general, overarching foundation to achieve generalized outcomes, so called design principles. Design principles are formalized through explicating aim, context and mechanism and play an important role as means of accumulating knowledge and for its transfer to artifacts and real life situations (Gregor et al., 2020; Sein et al., 2011). For building a knowledge base as precondition for deriving the design principles of a solution for better SDG implementation, service is chosen as the central concept. We put the service lens and different perspectives on service like mindset, logic (or mental model), science, or architecture at the core of our work: because service, understood as the application of resources (e.g., knowledge, data, technology) for the benefit of another, is connected to every other concept. Service is the basis of social and economic exchange and at the core of partnerships (SDG #17), cooperation and value cocreation (Bastiat & Huszar, 1964; Spohrer et al., 2022, p. 12; Vargo & Lusch, 2004). We pick the service lens because zooming into the properties and mechanisms of co-creation and service for service exchange is central for analyzing the aspects of actor engagement, the treatment of resources (e.g. technology or data), and the creation of innovations as core elements of transformational social and economic practices. Accordingly, this work is part of transformative service research (TSR), that centers on creating uplifting changes and improvements in the well-being of individuals, communities and the ecosystem" (Anderson et al., 2013; Rosenbaum et al., 2011).

To this end, we outline below the core elements and mechanisms of S-D Logic, Service Science, Institutional Analysis and Development Framework (IAD), the Regenerative Service Economy Framework and Service Innovations to derive design principles.

5.1.1. Service-Dominant Logic (process of value co-creation)

According to Vargo et al. (Lusch & Vargo, 2008; Spohrer et al., 2022; Vargo & Lusch, 2008) a logic is a conceptual lens for observing the world and understanding how it works. It is also sometimes referred to as a mental model. Over the past centuries the logic or mindset of economic exchange was based on the creation of goods as manufactured output, it was goods-dominant. This Goods-Dominant Logic views service(s) as a modification of goods production and distribution as transactional exchange practices. The mental model of Goods-Dominant Logic is that one actor creates value, through production and other actors destroy it through consumption and then returns to the producer for more value laden products. The dominance of this linear "make-buy-destroy-rebuy" mental model and the continual disposal of goods is at the root of the sustainability problem. It promotes the idea that value and economic activity centers on the production of value-laden goods by firms (Vargo, 2021, p. 258).

In contrast Service-Dominant Logic as an alternative mental model is focused on service provision at the core of value and social and economic activities. Value is understood as benefit provided by service and can be provided independently from the sale of products. Resources are obtained by service for service exchange. The

beneficiary is always the primary resource integrator and all actors are both provider and beneficiaries in the process of service for service exchange (Vargo, 2021). The value chain associated with Goods-Dominant Logic becomes a service ecosystem understood as two actors in a vast network of resource integrating, service providing and service receiving actors (Vargo, 2021, p. 259). Service-Dominant Logic is about the process and outcome of actors (e.g., people and organizations) "applying resources, such as knowledge, for the benefit of others in exchange for others providing service for them" (Bastiat & Huszar, 1964; Spohrer et al., 2022; Vargo & Lusch, 2004). The process of value co-creation according to Service-Dominant Logic is focused on the relation and interaction of networked human and non-human actors (Lusch & Vargo, 2008). Service-Dominant Logic considers service as part of relationship building and management and as a process of using one´s resources for the benefit and in cooperation with another party. The interactive relationship and cooperation during the process of value co-creation results in added value that improves one's well-being (Vargo & Lusch, 2016). In this process actors e.g. companies as carrier of operant and/or operand resources engage by acting on (integrated) resources (Löbler, 2013). Operant resources, such as knowledge or competences, are those that act upon other resources to create value. Operand resources are resources which must be acted on to be beneficial, such as natural resources and money (Constantin & Lusch, 1994; Vargo et al., 2010).

In the process of co-creating value resource-integrating actors (human and non-human) engage and connect by sharing institutional arrangements through service for service exchange. That way they are forming institutionally coordinated service (eco) systems (Vargo & Lusch, 2016, 2018). In this service (eco) system structures actors are aligned by value propositions and need to interact in order for a focal value proposition to materialize (Adner, 2017).

The mental model of Service-Dominant Logic demonstrates that value is understood as benefit provided by service and can be provided independently from the sale of products (Vargo, 2021, p. 258). Accordingly, circular economy, in which parts of discarded products are reused to create new products, has indeed intuitive appeal for goals of sustainability. But, it also partially perpetuates a mental model of economic activity that is at the root of unsustainability (Vargo, 2021, p. 257). This shift toward understanding value as benefit provided by service and independent of the sale of products, for example, the selling of entertainment (e.g., music and videos) digitally, opens opportunities for the reconceptualization of circularity and "beyond circularity" to strengthen sustainability (Vargo, 2021).

5.1.2. Service Science (structure of service systems)

Referring to Spohrer et al. (Spohrer et al., 2022) science can be interpreted as a knowledge creation service. Science is about better models of the world´s natural and social systems. Service Science grounds the nature, scientific understanding, and management principles needed to understand and improve service and service innovation (Maglio & Spohrer, 2008; J. C. Spohrer et al., 2008).

With the service system a new perspective of analysis is introduced by Service Science. Referring to the mutually character of service that involves at least two actor - one applying competence and another integrating the applied competences - these interacting responsible actors or service system entities. Service systems are defined as dynamic value co-creation configurations of resources, including people,

organizations, knowledge (language, laws, measures, methods), and technology, all connected internally and externally to other service systems by value propositions (J. C. Spohrer et al., 2008). From Service Science perspective service (eco) systems can be described as networks and structures of interconnected responsible actors (service system entities). This perspective (Vargo & Lusch, 2016) offers potential insights into the dynamics of how actors coordinate their intentions and actions to be able to have cooperative trade through markets" (Vargo et al., 2017). Hence, service systems as open systems are (1) capable of improving the state of another system through sharing or applying resources and (2) capable of improving their own states by acquiring external resources. Economic exchange depends on reciprocal value creation (Kieliszewski et al., 2018; Spohrer et al., 2007). Thus service (eco) systems can be observed as dynamic structures of interconnected responsible actors. Each actor engagement e.g. resource integration or service provision changes the nature of the service system to some degree and thus the context for the next iteration and determination of value creation (Spohrer & Maglio, 2008; Vargo & Lusch, 2011).

5.1.3. Institutional Economics and the IAD Framework (rules)

The IAD framework (Ostrom, 2005, 2010; Ostrom et al., 1994) is structurally detailing action situations relevant to actors as participants in specific situations. As shown in figure 4 the framework is structured in the three areas “exogeneous variables”, “action arena” and “interactions & outcomes”. Starting on the left in the framework are the exogeneous variables that affect the actions of an action arena. The exogeneous variables include three categories of variables (Kiser & Ostrom, 1982): 1. The attributes of states of the planetary and the resources acted upon, e.g. the physical possibilities of actions and the producibility of outcomes (Ostrom et al., 1994). 2. The attributes of a community as all aspects of the social mindset and cultural context (McGinnis, 2013). 3. The third category that specifies the values of the working components of an action arena relates to the rules specifying positions, set of actions or outcomes (McGinnis, 2013; Ostrom et al., 1994).

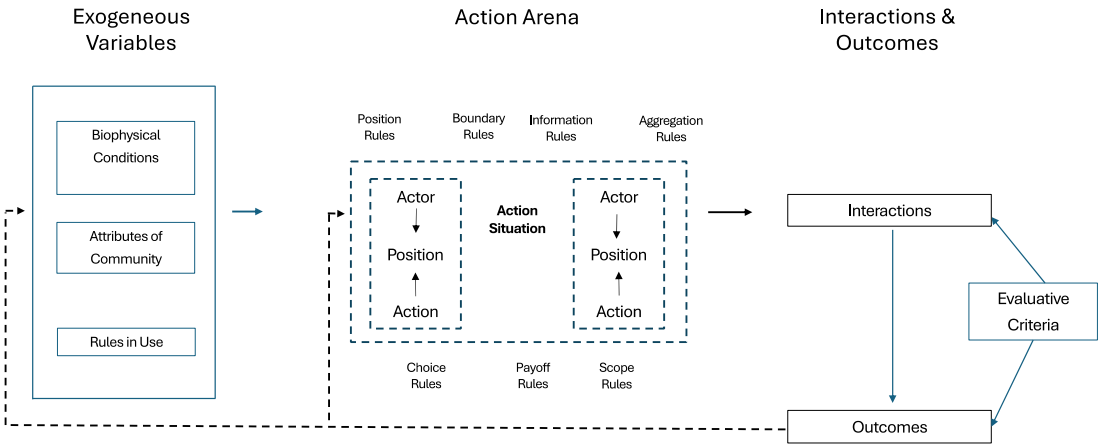

Figure 4 Ostrom`s Institutional Analysis and Development (IAD) framework (Kiser & Ostrom, 1982; Ostrom, 2005; Ostrom et al., 1994)

Zooming into the action arena shows that the action situation relevant to actors as participants in specific situations is linked to a systematic set of rules. Thus, the IAD framework helps to analyze rules and action situations and how they organize themselves recursively (Giddens, 1984; Li et al., 2016; Ostrom, 2005). The IAD

framework describes rules (Aligica, 2006; McGinnis, 2013; Ostrom, 2005; Ostrom et al., 1994) like e.g. position rules that specify a set of authorized actions; boundary rules that specify how participants enter or leave the positions in the action arena or information rules that specify the information available in the respective position. These rules become institutions by actor engagement and through the constitution of regularized patterns of interaction. In this way institutions coordinate resource integration and service exchange among actors (Edvardsson et al., 2014; Vargo & Lusch, 2016, 2018).

5.1.4. Regenerative Service Economy Framework (missing services and transformative action)

As a global human service nonprofit ServCollab intends to elevate the human experience to improve well-being and enable well-becoming through service research collaborations. It is a call to action for service researchers to support the sharing economy, including effective service intermediaries to ensure less production and thus less waste is created (Fisk et al., 2020; Fisk et al., 2024; Russell-Bennett, Polonsky, et al., 2024, p. 39; Russell-Bennett, Rosenbaum, et al., 2024). Based on a literature review of more than 200 articles the Regenerative Service Economy Framework is proposed from one of these collaborations. The conceptual framework aims to sustainably manage natural and physical resources for all humans without harming the planet (Russell-Bennett, Polonsky, et al., 2024). It is built on four key components (Russell-Bennett, Polonsky, et al., 2024):

1. As fundamental principle mutualism as reciprocal beneficial relationships between organisms (Alkire et al., 2023, p. 12) enables a sustainable life on planet earth. The need for mutualism in ecosystems also means that services cannot focus on a single actor without considering the impact or input of other actors.

2. Intergenerational Custodian Mindset: Humans need to be custodians of natural resources. This begins with an intergenerational mindset of human-environmental interactions characterized by respect, relevance, reciprocity, and responsibility.

3. Regenerative Service Economy: Drawing on Raworth´s Doughnut Economy (Raworth, 2017) and circular and non- circular flow concepts (Vargo, 2021) it aims to create value through service ecosystems, where the balance between the consumption and regeneration of resources ensures sustainable growth.

4. Service Thinking Practices: These practices are seen as manifestation of a service thinking mindset that drives action in a service (eco) system that benefits people an planet (Alkire et al., 2023; Spohrer & Maglio, 2008).

5.1.5. Service Innovation (resource density -> breakthrough)

Lusch & Nambisan (Lusch & Nambisan, 2015) offer a conceptualization of service innovation. They consider service innovations as the rebundling of diverse resources that create novel resources that are beneficial to some actors in a given context. Grounded in S-D logic it emphasizes innovation as collaborative process within actor-to-actor networks. Service as fundamental basis of exchange is understood as application of tangible and intangible (e.g. knowledge) resources. The capacity to

create innovations is unleashed by increasing resource liquefaction and resource density. Thus resource integration is seen as core element in the process of rebundling existing resources and each innovation (new bundle of resources) can be combined with other resources for even more innovative possibilities (Arthur, 2009; Lusch & Nambisan, 2015; Vargo et al., 2015). In their conceptualization Lusch & Nambisan (Lusch & Nambisan, 2015) advise implications for entrepreneurial opportunities in digital ecosystems. It can be interpreted as a call to action for effectual actors to create and act on emergent opportunities and thereby to design new pattern of innovation. In this process they draw on (1) service ecosystem as an emergent actor-to-actor networks; (2) service platforms for enhancing level of resource density; and (3) value co-creation as a resource integration process. The dual role of technology is emphasized: as an operand resource technology is enabler and as operant resource technology is actor on resources and initiator of service innovations. With the evolving digitization the emerging role of technology as practical application of knowledge and as integral component of innovation is depicted (Capon & Glazer, 1987; Lusch & Nambisan, 2015, p. 157).

5.1.6. Design Principles and Design Patterns

To build up further momentum for the "SDG Flywheel" and In line with DSRM design patterns are derived from the design principles. Table 2 depicts these patterns as systems to generalize the design principles in a way that can be reused for recurring problems, challenges and tasks in the context of our solution and SDG implementation. A system is defined as a configuration of resources, including at least one operant resource, in which the properties and behavior of the configuration is more than the properties and behavior of the individual resources (Spohrer et al., 2008).

Table 2: Knowledge Base(d) Design Principles

Knowledge Base	Design Principle	Design Patterns
SDG #17 partnerships & mindset - partnerships - openness - performance - generative culture - mutualism	- value co-creation - action situations - relational exchange - actor networks - actor & resource coordination - reciprocal relationships - value propositions	- system for connecting actors - system for resource integration - system for co-creation - system for interactions
service - value - value co-creation (process) - service (eco) system (structure)	- service for service exchange - resource integration - institutions - process of value co-creation - structure of service systems	- system for actor coordination - system for resource coordination
outcome - SDG implementation - resource density	- transformative services - resource density - resource un- & rebundling	- system of knowledge - system of combining resources

- service innovation - change in practices	- new combinations of resources	

6. Breakthrough - Design Artifact, Resource Density and Service Innovations

In this section it is elaborated how breakthrough within the "SDG Flywheel" (figure 3) is achieved by design patterns that are transformed and operationalized in a design artifact (figure 1). First in a design artifact as a model and then as tangible representation of the design pattern. Subsequently the properties of the design artifact are evaluated in terms of relevance for the implementation of the SDG. While analysing the eight design patterns (table 2) derived from the design principles, we discovered that these eight systems correspond in content, properties and mechanism to the five systems and design patterns of the Service Dominant Architecture (SDA). And that SDA consequently covers the design principles deduced in the front section. SDA is derived from the core mechanisms of S-D Logic and Service Science and a subject of continuous design theorizing (Spohrer et al., 2022; Warg & Engel, 2016; Warg et al., 2015; Warg et al., 2016; Warg et al., 2019; Warg Markus et al., 2016; Weiß et al., 2023; Weiß et al., 2018). In the following (figure 5) the five purposed systems of Service Dominant Architecture (SDA) are described as value statements. This serves to compare the SDA value statements against the solution requirements of SDG implementation.

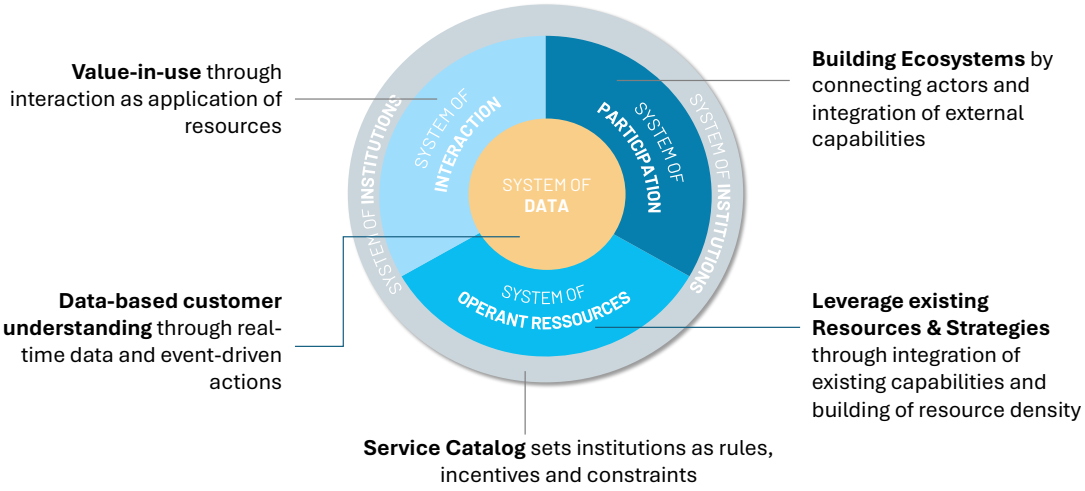

Figure 5: Overview Service Dominant Architecture (SDA) and aims of the five purposed systems (Spohrer et al., 2022; Warg & Frosch, 2023)

1. System of Operant Resources: The system of operant resources represents the workbench, where the various resources and capabilities are brought together for building value propositions dependent on the achievable level of resource density. A high resource density positively impacts the possible resource combinations and thus the emergence and creation of innovative value propositions. 2. System of Interaction: The system facilitates value in use and value in context by enabling the application of resources bundled in value propositions. Interaction enables resource integration and service exchange in the process of value co-creation between actors.

3. System of Participation: The system enables actor-to-actor orientation and the integration of resources of other actors in the process of co-producing value propositions. 4. System of Data (Data Lake): Data received and generated by interacting with other actors (e.g. customer) should be systematically recorded and evaluated in real time. In this way, data and knowledge e.g. about the preferences and the context of other actors like customers can be build up continuously in the system of data.

5. System of Institutions (Service Catalog): As rules, institutions enable the coordination of actors and the access to and use of resources. In conjunction with design patterns, institutions enable the coordinated creation of value propositions.

6.1. Design Artifact (as a model) - New Forms of Collaboration in Energy Supply for achieving SDG #7

In line with DSRM the design artifact represents a specific implementation of the design patterns. We have chosen SDG no. 7 to demonstrate the design artifact as a model and to validate the SDA properties within the actor network of energy producers, consumers and infrastructure providers. SDG #7 emphasizes ensuring access to affordable, reliable energy services. Key targets include substantially increasing the share of renewable energy, improvement in energy efficiency, enhancing cooperation to facilitate access to clean energy technology, and expanding infrastructure and upgrading technology for sustainable energy services (United Nations, 2024b).

Figure 6 displays how the SDA systems foster value co-creation. External capabilities, e.g. smart meters, sensors, software for the energy consumption estimation, are integrated via System of Participation. Existing capabilities (System of Operant Resources) e.g. for forecasting energy demands or operational data from solar and wind energy suppliers are leveraged. Based on data regarding e.g. energy demand, supply forecasts, utilization as well as weather forecasts (System of Data) sustainable value propositions are offered via interaction (System of Interaction) from e.g. energy providers, brokers, spot markets, smart meters. Actors and capabilities are coordinated via rules defined in and based on the System of Institutions. In this way the SDA design artifact demonstrates how service innovations facilitate transformative practices for energy supply where new technologies and renewable energy sources getting more and more dominant.

One of the most relevant aspects is the leading role of governmental or public institutions as responsible actors e.g. for setting the rules for the coordination of actors and resources. By this they can authorize or restrict contributors and capabilities for innovative solutions and business models needed to fight climate change. Once public stakeholders have set the System of Institutions, new solutions as combinations of resources can be bundled in the System of Operant Resources and applied via the System of Interaction. SDA based service innovations will especially cover: 1. Private and Business Customer Solutions with flexible tariffs tailored to their specific consumption and needs, e.g. based on weather conditions or spot market energy prices. These solutions foster a more efficient energy use, supporting the goals of SDG.
2. Collaborative efforts between governments, private sectors and businesses are accelerating the adoption of renewable energies. Based on the System of Data all

parties can e.g. utilize a centralized repository for energy production and consumption data. New services will be composed out of existing services like metering services for households, to enable new market models. 3. Power Purchase Agreements (PPAs, understood as contracts between a power producer and a power purchaser) are crucial for targeting SDG #7. SDA based PPAs can be designed particularly for the renewable energy sector, involving producers such as operators of photovoltaic or wind power plants. PPAs will be a major contributor for the "SDG Flywheel" because of services for highly individualized pricing and contracts or services for delivery and power distribution. 4. New partnerships and collaborations of private sector, public sector, business sector and financial sector drive the development of smart grids, energy storage systems, car charging operators or advanced metering infrastructures.

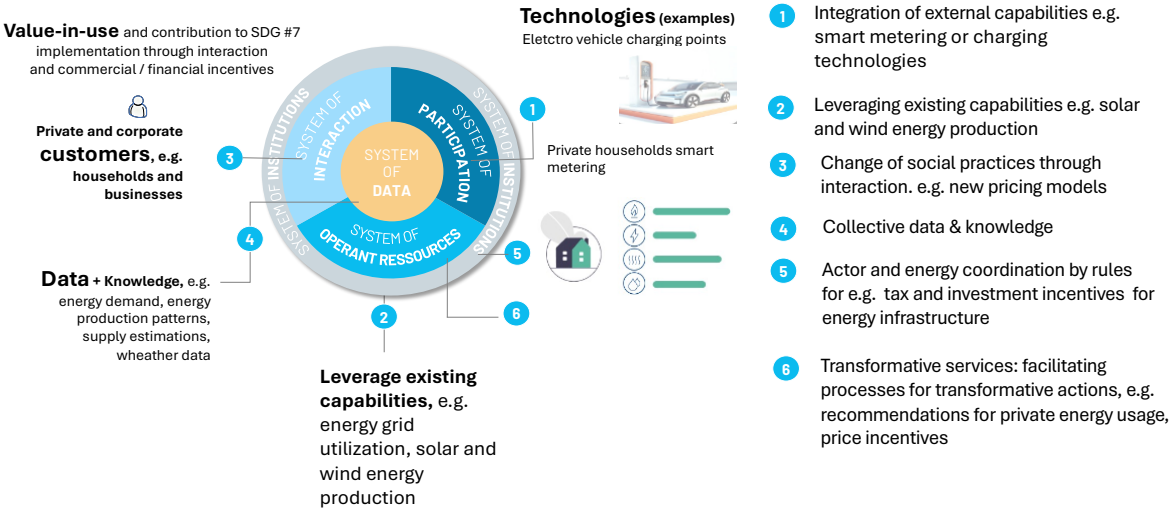

Figure 6 Design Artifact as a Model for Implementing SDG #7 "affordable and clean energy"

6.2. Design Artifact (tangible)

SDA as architecture enables the dualism of structure as medium and output of the practices it recursively organizes (Giddens, 1984, p. 25). The properties of SDA are both the process (medium) and the output (tangible structure) of planning, designing and constructing (Alexander, 1977; Gamma, 1995; Warg & Deetjen, 2021). Figure 7 shows the plan-build roadmap of instantiating a service platform. The five SDA systems are represented as microservices in software modules. The modules can be instantiated and extended (e.g. use case based) to build a digital service platform.

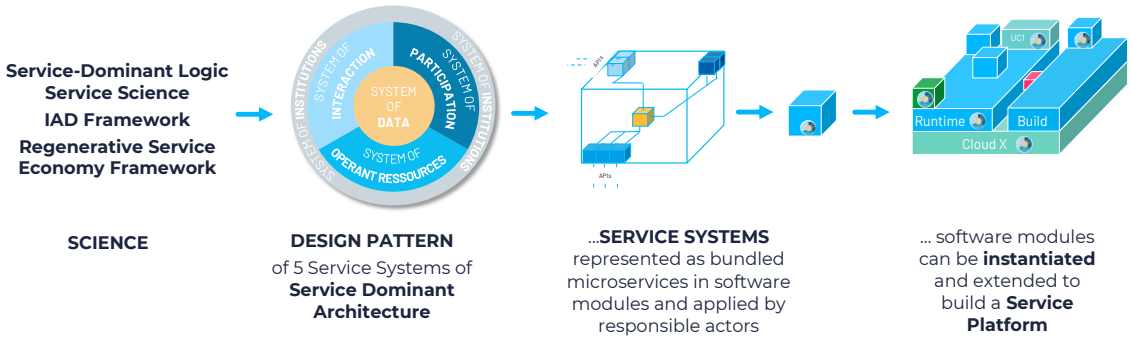

Figure 7 Design Patterns as Medium (Plan) and instantiated Output (Structure)

7. Contributions to Theory and Practice

This paper contributes to the development of knowledge in the research fields of DSRM and TSR. In the context of DSRM the "SDG Flywheel" builds knowledge about the interrelation and interplay of the three circles as parts of a comprehensive design science research. It is demonstrated that beyond a distinct and iteratively interacting throughout the research process DSRM is also suitable for a continuous interplay. Accordingly, in analogy to dynamic systems, the state of the three circles is not static but dynamic. Changes in one circle thus have an impact on the other two circles. The interplay of the three DSRM circles offers a field of future research.

In practice, digital service platforms with patterns and properties such as SDA enable resource density and new value propositions. This is discerned to promote service for service exchange and digital, resource-saving "as a service" models in the course of and beyond circularity. For practice SDA patterns offer standard solutions for problems that occur repeatedly and can be applied for use cases again and again. This helps organizations and market players to focus on their new business models and contributing to SDG goals, e.g. optimizing energy supply by renewable energy sources, instead of reinventing existing software. In parallel, governmental or public institutions can set directions for those market players by enabling a framework or construction plan. As visualized in figure 7 the SDA patterns are recursively applied as construction plan and output for developing software stacks, preconfigured with the five SDA systems as bundles of microservices. Watermann et al. (Waterman et al., 2015) denote this as "Emergent Architecture"; an architecture in which the team makes only the minimum architecture decisions up-front, such as selecting the technology stack and the highest-level architectural styles and patterns. By making only the minimum architecture decisions up-front, such as selecting the SDA design patterns and the technology stack, the architecture emerges with each use case as demonstrated by the SDG #7 example. We define this approach as "Agile Emergent Service Dominant Architecture" (Warg & Frosch, 2023; Waterman et al., 2015; Weiss, 2023). Focal advantages are time and cost savings. Hence an agile mindset opts against "Big Requirements Up Front" approaches which try to understand all future requirements well up front often realize at process end that the requirements, technologies, users etc. have changed substantially (Bradley, 2018). Agile emergent architectures make use case based quick starts possible and technology decisions

only have to be made at the last moment this allows the latest and best technological knowledge to be utilized.

8. Summary and Conclusion

Introducing the image of the "SDG flywheel" (figure 3) the paper demonstrates how bold and transformative actions for SDG implementation can be realized and scaled up by applying STI and data resources.

In line with DSRM (figure 1) a service lens as core of the knowledge base is taken to model the properties and mechanisms of value co-creation and thus of SDG #17 "Partnerships for the goals". Design principles are derived, and patterns and artifacts are demonstrated to be suitable to model the properties of partnerships, cooperations and value co-creation. By applying Service Dominant Architecture (SDA) and associated design patterns, S-D logic, Service Science and the presented justificatory knowledge (design theorizing) are implicitly supplied. SDA as structure for implementing these properties and mechanism as a digital service platform is demonstrated. By integrating and applying resources (e.g. STI and data) into the platform resource density as momentum and precondition for scaling up service innovations and thus SDG implementation is realized. The breakthrough point is reached when resource density and the parts of the "SDG Flywheel" interplay and reinforce each other and enable innovations e.g. as new sustainable value propositions and transformative services ever more quickly and easily without pushing harder the integration of further resources.

A Service-Dominant Mindset for the process of value co-creation and the provision of service independently from the ownership and possession of physical products; service systems thinking and Service Dominant Architectures for SDG implementation (e.g. via service platform) have proven to be suitable foundations for transformative actions and practical SDG implementations within and beyond the circular economy.

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