The design of Digital Platform Ecosystem supporting Circular Economy

No Author Given

No Institute Given

Abstract. Circular Economy business models rely on complex data exchange between organizations, which require a supporting digital infrastructure facilitating the circularity-related processes. In a digital platform context, value is generated not by the underlying technologies but by its allied ecosystem: community, users, developers and integrated applications. These ecosystems come with an intrinsically complex inter-organisational structure often overlooked during the development phase, leading to low platform adoption and obsolete platforms in the mid to long-term. Developed through a combined action-research and design science research approach, we propose a framework to support the design and deployment of circular economy ecosystems from a sociotechnical perspective, including practices from the requirements engineering, circular innovation ecosystems and digital platforms literature.

Keywords: Digital Platform Ecosystems · Circular Ecosystems · Sociotechnical Systems Design · Design Science Research

1 Introduction

History shows us that technological revolutions originate new ways of how value can be created and captured, which can also give rise to new forms of organisations [7]. In fact, the digital revolution is ongoing, and there seems to be no end to technological innovation, which places digital platforms (DP) and distributed innovation among the main trajectories for innovation [20]. The digital platform (DP) model is transforming virtually every industry today [19, 21, 2], as their pervasive nature has taken over most of the services we depend on regularly [19]. This happens as well with the so called circular economy (CE).

The concept of CE, particularly promoted by the European Union in several initiatives [15, 5], can be defined as "regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops" [8]. In order to achieve a truly CE, there is a need for a systemic perspective, where both products and processes information flow and sharing are fundamental. This perspective, a truly systems-of-systems one as it involves multiple organisations and value chains, is challenged mostly by the information silos that may be formed between the various phases of the product life cycle (PLC), the lack of interaction between the industrial actors and the poor integration of data and information for effective analytics [27].

The use of DP is as a way to create a circular ecosystem involving industrial actors which collaborate in sharing product and process data and information across the entire PLC chain. By unlocking access to this data and information, organisations can more confidently adopt circular business strategies, leading to more sustainable business practices [13, 17].

In an industrial context, a DP act as both innovation and transaction platforms: these platforms make data available from a large variety of industrial assets and devices that enable complementary solutions to be built upon it; and also offer some type of marketplace structure to facilitate distribution among the industrial actors. Therefore, platforms can perform two central roles: act as a technological foundation and as a market intermediary [20]. These collaborative information systems become, however, rather complex when deployed in industrial environments. Users become large organisations with hundreds, or even thousands, of collaborators, which use these systems as part of established business processes and in the possible creation of new ones [20]. Nevertheless, there is a lack of understanding that a platform's value generation mechanisms lie not on the underlying technologies but on the ecosystem of users, developers and applications it supports [22]. In the case of a DP used to manage data and information to support CE oriented decision-making in the value chain and fostering a CE-oriented ecosystem, the challenges extend from the difficulty of defining a clear value proposition, to the obstacles of technology deployment and adoption.

In this paper, we describe a framework for the design of Digital Platform Ecosystem (DPE) supporting CE that considers the multidisciplinary nature of DP and Ecosystems, facilitating the platform adoption by industrial organisations by shifting the design focus to the surrounding ecosystem. From a sociotechnical perspective, the framework includes guidelines for the deployment of the platform, together with user engagement strategies, the definition of user and organisational profiles and roles, access, security and privacy policies, trust mechanisms and commitment processes. The framework was developed within the CircThread project[1] and validated in three use cases in three different countries.

This paper is divided in the following sections: section 2 focuses on the key characteristics of DP; section 3, defines our work methodology from a Design Science Research perspective; section 4 describes the main results of our research; and section 5 includes lessons learned, as well as topics for future research.

2 Digital Platforms and Ecosystems Design

2.1 Key Characteristics of DP and Ecosystems

DP display a large set of characteristics that explain their attractiveness as a business model [31, 2]. By supporting multi-sided market connections in a seamless and scalable fashion [31], platforms can drastically reduce transaction costs,

[1] H2020-SC5-31-2020 - Building the Digital Thread for Circular Economy Product, Resource & Service Management 2021-2025

which include search, contracting, and distribution [2]. This market discovery is achieved through price discovery mechanisms, which often aggregate data from multiple sources, therefore enhancing the experience for different stakeholders [20, 31]. Another key aspect of DP is their ability to organise and coordinate technological development and innovation through architectural modularity, and appropriate governance structures [29, 28].

The large amount of data that these platforms can aggregate and generate is usually made available to a set of independent third-party complementors which can develop new applications and services by making use of standard interfaces provided by the platform's core [20], allowing the platform's firm to achieve economies of scale and scope [7]. These services are then made available to users usually through an app store or marketplace [20]. Platforms are also at the heart of a phenomenon known as network effects [19, 6]. Network effects are feedback loops that can cause exponential growth (positive network effects) as more users make use of the platform and become part of their ecosystem, or shrinking (negative network effects) as if users and value are not correctly governed and filtered, it may cause other users to abandon the platform due to not capturing enough value [19].

Theres is an ambiguity that hovers over the DP research [2, 21] as the terms "Platforms" and "Ecosystems" are used interchangeably [22].The term "Ecosystem" is a metaphor originating from biological systems comprising interacting organisms that make up an habitat [10]. However, it is also used in a management context to define a business structure and strategy [1, 12]. [10] states that recent literature on digital platforms have been analysed from single paradigms such as economics, technical, business and social. Therefore, it suggests a shift in perspective by combining the intra-organisational technical perspectives on digital platforms and the inter-organisational economic, business and social perspectives on ecosystems. It then conceptualises Digital Platform Ecosystems (DPE) as comprising a platform owner that implements governance mechanisms to facilitate value-creating mechanisms on a digital platform between the platform owner and an ecosystem of autonomous complementors and consumers.

2.2 Digital Platforms and Ecosystems Design Frameworks

If a platform strategy is the motor of shared innovation and value co-creation, then Architecture – as the conceptual blueprint that describes the structure of technological solution [28], – and Governance are the two gears [28]. We can look at architecture as a tool for simplifying and precisely describing the interconnections between parts of the ecosystem and to reduce structural complexity [28]. Furthermore, ecosystem architecture encompasses both the platform architecture and the architecture of complementary applications [28]. The issue of how to govern DPE has been a continuing subject of study [21]. The main goal of good ecosystem governance by a platform owner is not to direct the behaviour of an ecosystem but to shape and influence it [30], while simultaneously respecting the autonomy of users and complementary developers. Therefore, the platform owner must create ecosystem orchestration mechanisms that ultimately allow it to leverage and manage the generative nature of the ecosystem.

Even after the fact that the literature around DP and Ecosystems have not generated much design theory (knowledge) [21], there have been a few attempts to create frameworks, methods and models to design these sociotechnical artefacts. We give some examples below within the circular economy domain. From their participation in a circular ecosystem project, [14] have developed 3 groups of Circular Innovation Ecosystem principles. [3] also states that there is little guidance and methodical support for designing ecosystems. It then performs a great effort in synthesising the current literature from multiple perspectives in order to introduce specific types and characteristics of DPE as a basis for a future comprehensive modelling framework. The framework aims to support ecosystem construction by organising the modelling of ecosystems in three aspects, goal modelling, ecosystem modelling and platform modelling. From the effort and results of the Ecosystem Modelling framework [3] and its application in designing Industrial Symbiosis Platforms [4], the Digital Industrial Symbiosis Ecosystem framework has been developed [16]. More generic models outside the scope of circular ecosystems have also been developed, such as the Ecosystem Pie Model [26] and the Platform Design Toolkit [24, 23].

3 Methodology

3.1 Research context and case studies

The framework for the design of DPE supporting CE was developed within the CircThread project. This project aims create a Industrial Digital Platform (IDP) to support circular produt life cycle decisions by implementing a digital thread specific for circularity oriented infomation. In simple terms a Digital Thread is related to the flow and linking of the information generated during the product lifecycle. CircThread DIP enables the capturing, linking, combination, and sharing of product data and information covering product status logs and materials, resources, critical raw materials, substances, product lifespan, environmental, social, and end-of-use options, that will be linked to circularity strategies, from products maintenance and lifespan extension, furthered by refurbishment, repair, reuse, remanufacturing, and finally recycling for secondary raw materials use. This IDP can be characterised as a multi-sided platform, where the value exchanged is product information and the participants' roles are information providers, consumers, and variation of these (see Section 4). The new model of a CE presents large opportunities for Europe, which is not yet fully exploitable in the absence of Digital Technologies (DT) with associated decision making support across the PLC among various stakeholders. The CircThread project is contributing to such digital infrastructure through a DP architecture that can be instantiated in particular value chains to unlock access to product data between stakeholders that is now in silos and to use it for enhanced CE decision making across the extended PLC.

For the elaboration of our framework, we have adopted the Design Science Research framework which focuses on guaranteeing the utility and truth of an information system (IS) artefact [11]. Relevance is guaranteed by extracting the business needs from a certain environment, which, in this case, is the *CircThread* project. On the other hand, DP and IS literature served as a knowledge base for our artefact. The framework building process itself is a creative process with multiple iterations, each one consisting of a development/building phase and a justification/evaluation phase. Figure 1 consists of an instance for the Design Science Research methodology regarding this particular research. The pragmatic nature of the design science research (DSR) framework allowed us to contribute with a potential solution to the application domain and maintaining rigorousness to make a valid contribution to the knowledge base. The result of this effort

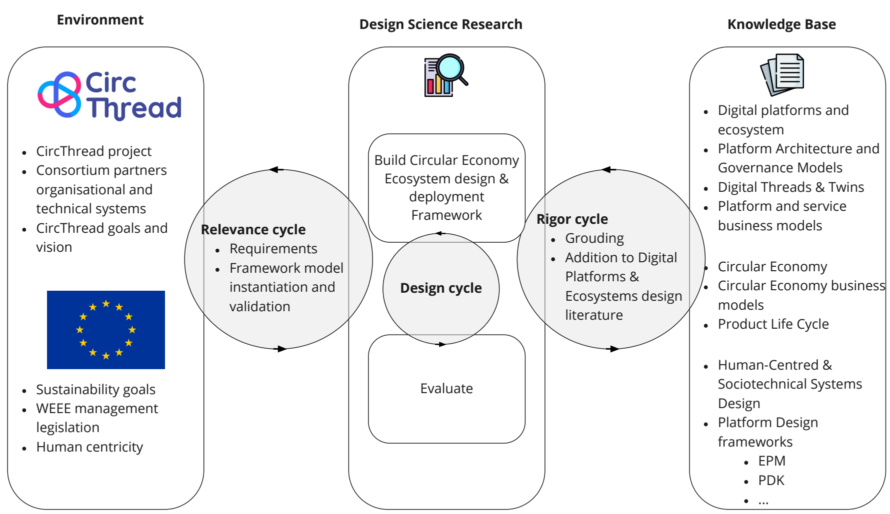

Fig. 1: Design Science Research approach for the Circular Economy Ecosystems design and deployment framework artefact

was an artefact – defined as a framework – to be applied in the deployment of CE industrial ecosystems. This framework includes models, which will be used to represent real world industrial scenarios and ecosystems, and methods which define processes on how to solve problems by more accurately searching the solution space. At the same time it combines models for ecosystem and value constellation modelling in order to build a conceptual macro perspective of DPE dynamics between the multiple industrial actors and roles, as well as micro scenarios where requirements can be elicited, validated, and formally modelled into business processes. At the same time, we will provide processes to create these models and understand industrial environments to better guide the requirements engineering (RE) process from a sociotechnical systems (STS) perspective.

The framework was developed using an action-research approach with the participation of the industrial organisations that formed three pilots in the CircThread project in Spain, Slovenia and Italy. Each of these pilots is comprised of one or more organisations, in the sectors of home appliances (dishwashers, washing machines and boilers), industrial batteries and photovoltaic panels. The pilots where used as requirements sources and for the framework validation.

3.2 Research design

The approach to the user-centred design and specifying deployment requirements of the framework was centred around the use of scenarios in a three-step process of actions and resulting artefacts (see Figure **??**). Departing from previously identified personas and user stories, together with the knowledge gained from the scientific literature, an initial scenario the CircThread DPE use was developed. The goal was to acquire knowledge of the partner's organisational needs (who will interact with the system, when, what is the goal of this interaction, and what comes after specific actions). By focusing on the who, what and when we could iterate and improve the scenario and further detail it.

With detailed scenarios of future platform usage, we could begin to formally document platform interactions from an intra-organisational perspective by modelling internal business processes, as well as an inter-organisational perspective by modelling and understanding ecosystem dynamics and informational dependencies between actors and product lifecycle stages. Finally, having the organisational dependencies and needs of the ecosystem and the individual organisations, we were able to provide recommendations on a conceptual DPE architecture and governance model, as well as deployment strategies to achieve a minimum viable ecosystem.

Pilot interactions were mostly composed of 1-hour long semi-structured interviews. During scenario elaboration, we came across some questions regarding specific organisational roles and platform interactions. These doubts were transformed into questions to conduct the interviews. However, we did not enforce a specific interview process, as we had come to the conclusion that partners have a tendency to focus on their particular needs and vision for the future without much need for guiding questions. Nonetheless, some of the more open guiding questions focused on organisational needs and vision for governance models.

4 Results

4.1 Framework Components Overview

In this section we will go over the constructs of the developed framework, presented in Figure 2. *Ecosystem.* The ecosystem, delimited by dotted lines in Figure 2 is the set of technical and organisational artefacts and the different roles of

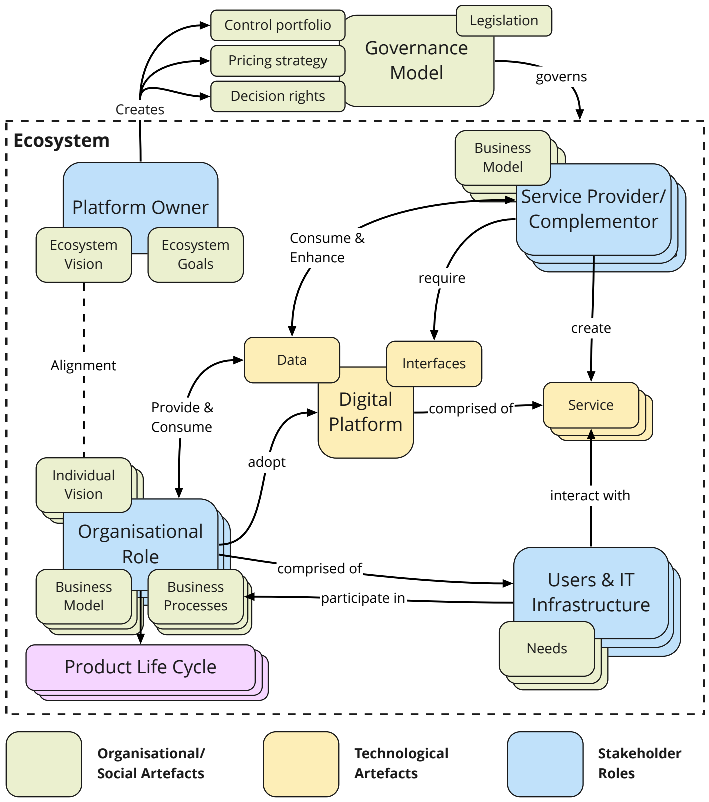

Fig. 2: Circular Economy Ecosystems design framework

stakeholders. In this context, the ecosystem is platform-based, as we can see the presence of a DP in the centre.

Digital Platform. The DP is at the centre of the ecosystem, functioning essentially as the orchestrator by providing the means of stakeholder value co-creation. The platform functions as the technological infrastructure and is made up of data, which is shared between the multiple stakeholder roles, and interfaces which are used by service providers to interact with the data and build and integrate new service offers. At the same time, the DP contains services which can either be proprietary or developed by service provider stakeholders.

Platform Owner. The platform owner role is responsible for designing and maintaining the ecosystem. This role can be filled by a single entity, such as a group of people or organisation or a consortium of organisations that have a common interest in building and deploying the digital ecosystem. This common interest is defined in the ecosystem goals, which are the high-level objectives for which the ecosystem is being designed. In a Circular Economy ecosystem, the goals are mostly circularity and environmental sustainability-related. Lastly, an ecosystem vision must be collaboratively created and aligned with the platform-adopting organisations.

Organisational Role. Organisational roles are the organisation archetypes that will adopt the DP into their business processes, with the goal of enhancing or even creating new business models. Each role has their own ecosystem vision, which must be elicited and aligned with the Platform Owners for a shared vision and design vocabulary. These archetypes are often related to their business model and/or product life cycle acting phase.

Product Life Cycle. The product life cycle phase is a specific state in which the product can be in. Usually, an organisational role can have its business model and processes in one or multiple product life cycle phases. Identifying these phases is extremely important, as it will allow the ecosystem designer to more accurately create models and organisational roles, which will improve the quality of the design. In the case of CircThread, with the help of consortium partners, we were able to document the life cycle phases, as well as the transition between them, in which a dishwasher, washing machine, battery, boiler and photovoltaic panel can be in. This allowed us to understand the actors in each product life cycle phase, the informational needs and closed loop paths.

Users & IT Infrastructure. This role represents the actual users of the DP inside adopting organisations. These users can be anyone or anything that interacts with the system, from workers to IoT sensors, IT infrastructure or even software, which have individual needs. Identification of these stakeholder roles is a crucial task that falls under the responsibility of the ecosystem designer.

Service Provider / Complementor. This role is responsible for enhancing the generative nature of the DPE by using the platform's resources - data and interfaces - to create and integrate new services which can be easily deployed into the current DP instance of adopting organisations. This role has its own business model, which must be taken into consideration when designing the governance model. The role of the ecosystem designer in this role is to incentivise the service provider / complementor participation in value-enhancing activities.

Governance Model. As previously discussed, by adopting the governance dimensions referred by [28], the ecosystem designer should be able to more accurately design and describe the governance model. In addition, it is essential to take into account the legislation surrounding circular economy and the linked products.

4.2 Information Ecosystem and Roles

The definition of roles, both from an informational perspective as well as from a PLC stage perspective, is a crucial component for the efficient mapping of a DPE. This mapping leads to a macro perspective of the entire ecosystem dynamics, by learning who performs what action in what stage of the PLC. An informational role is a role involving specific tasks related with the creation, modification or use of information. Six types of informational roles where identified and characterised: *provider/producer, consumer, complementor, disseminator, regulator, enhancer.* These informational roles are fundamental in a DP where information is the maisn exchange value and differ from platform roles as they elaborate on how information is processed and used in a given stage of the PLC. Therefore, each platform role can have multiple informational roles. For example, a manufacturer can provide information during the product design and manufacturing stages, yet consume information provided by recyclers (another platform role) during the recycling stage. Roles are further classified based on 5 characteristics: (i) main interest: what are the main interests for each role in using the platform; (ii) specific context: if there is any specificity to how they use, and get value from, the platform; (iii) PLC conditions: what are the necessary PLC chain conditions for the platform to be used; (iv) skill requirements: what are the necessary sociotechnical requirements to participate in the ecosystems; and (v) dependencies: how different roles complement each other and value is exchanged.

4.3 Using the framework for deploying and configuring a DPE

Characterisation of organisational and user roles The first step in the design process using the framework is to identify who is responsible for designing and governing the platform (Platform Owner) and who will interact with the platform (Organisational and User Roles). The platform owner is responsible for defining the goals of the platform, designing its business models and the initial ecosystem. By initial ecosystem, we understand both the adopting organisation as well as the core services that make up the initial value proposition of the DPE. Organisational roles are based on their business models and product life cycle stages. It is important to understand that the adoption of a DP will most likely allow for the creation of business strategies that have not been possible due to the lack of a digital infrastructure. Therefore, business (platform-based) model design should be a process where the ecosystem designer can work on the ecosystem's value proposition for each organisational role. It is crucial to have a complete list of all the stages that the product will be in, as data - in addition to physical resources - will be produced in each phase, which, given the principles of the Circular Economy framework, will be consumed in another product phase, closing the product loop. User roles are characterised by their individual needs inside the adopting organisation. We have to learn and document how their current work is done and how it could be enhanced by the adoption of the DP. One popular way of doing such a task is through the use of user stories, which represent frequently primary requirements artefacts and units of functionality of the project [18].

*Creation of shared ecosystem vision and business processes*With the identified organisation and user roles, we can now create a shared ecosystem vision from the multiple perspectives of the adopting organisations and learn about their internal business processes and data needs. The alignment of ecosystem vision between stakeholders is imperative as it sets the foundation for discussion by aligning how the system under design should behave in the future. There is also the need to place the platform users and their needs in context. Therefore, it is essential to characterise the adopting organisation's business processes which will be enhanced by platform adoption. By creating descriptive scenarios of platform usage, we can create both a shared system vision and categorise the platform interactions that make up the business processes. Depending on the granularity of these scenarios, it might be necessary to detail the business processes and platform interaction further. The use of a formal notation, such as Business Process Model Notation [9], is undoubtedly a plausible solution. With the detailed system usage scenarios and diagrams, we are now aware of the data and information needs of these organisations.

Development of collaborative networks, ecosystem dynamics and initial governance model This third step is responsible for identifying ecosystem dynamics, and dependencies between organisational roles and creating the initial ecosystem governance model. The first course of action in this step is understanding ecosystem dynamics by mapping the ecosystem. By adopting this wide ecosystem lens, we understand that organisational roles have their own business processes, which require using platform-provided services and act on one or more product life cycle phases. These phases produce or consume information that must be integrated into the platform for future use. With organisational and informational roles defined, together with the categorised product life cycle phases, we can map the ecosystem dynamics and ultimately answer the question: "What and how is information processed, when and by whom?". We suggest the creation of an Information Ecosystem model, which takes into consideration the multiple dimensions of ecosystem dynamics to represent information dependencies between actors and the various stages of the product life cycle. Figure 3 can be viewed as a meta-model for creating instances of Information Ecosystem models that fit the needs of the ecosystem designer. With this model, the ecosystem designer is able to extract the organisational actors and the consumed information from the product life cycle phases and should now focus on collaboratively developing the ecosystem's governance model. In our particular framework instance, we have decided to adopt [28]'s governance dimensions. Finally, industrial ecosystems like CircThread are often heavily regulated, such is the case for WEEE regulations. The platform designer should include someone with regulatory expertise to aid in the creation of a Circular Economy governance model. *Development of platform governance and conceptual architecture*Having defined the core services that make up the initial platform value proposition, the design effort must now be shifted to the conception of technical interfaces that allow third-party developers and service providers to integrate their service offers into the platform's ecosystem. This will increase the ecosystem's value proposition which will most likely stimulate network effects between organisational actors and service providers. Lastly, there is the need to further define the degree to which services and data belong to the developer or to the platform. A general rule is that the more open the platform is regarding its governance model for outside innovation the more inviting it is [14], increasing the chances of network effects exploitation. However, platform openness also reduces the influence of the platform owner, which in return might cause the platform and its surrounding ecosystem to shift to different industries that were unforeseen in the early design stages. Depending on the nature and goals of the platform, governance models can be more or less open and must be carefully and collaboratively designed.

Development of platform deployment strategies Existing strategies provide useful insight for ecosystem designers to collaboratively develop a deployment strategy that functions as an effective adaptation for DPE. [25, 19] have gone through great effort in presenting the most common strategies for platform deployment: (i) single target group, focus on a particular target group or segment of the market; (ii) subsidising strategy relies on incentives to increase the mass of a single side of the market in order to create value for another, up until value is naturally generated and exchanged and subsidising is no longer needed; (iii) platform envelopment that leverages relationships with other established platforms and ecosystems by combining its own services and functionalities with the target platform bundling a more complete offering; (iv) exclusivity agreements by signing exclusivity agreements on one market side can be sufficient to attract other users on both market sides; and (v) side switching where a two-sided platform market is turned into a one-sided platform market by developing a launch strategy that fills both market's needs at the same time.

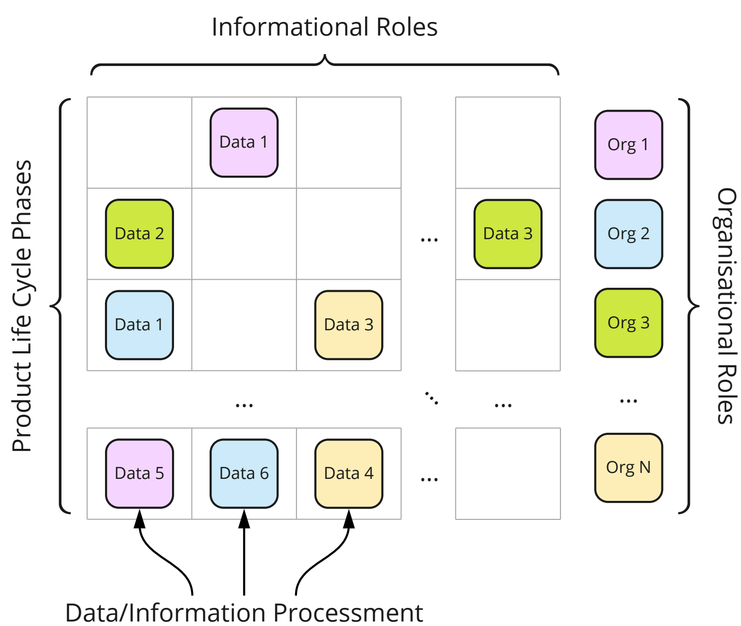

Fig. 3: Information Ecosystem model creation tool

5 Conclusion & Future Work

The lack of insights from the literature into the design of DP and DPE lead to a state-of-the-art where industrial platforms and platform services have become ephemeral, contributing to the lack of adoption. The growing adoption of circular practices in the industry can become the impulse that platform-based business models need to solidify their stay in business-to-business markets further. From this perspective, and by relying on a combined action-research and design ccience research approaches, we presented a framework that is both rigorous and flexible to serve as reference for platform owners and developers to guide the early development stages of thriving DP-based Ecosystems. This description is necessarily incomplete, as the framework includes many other details that could not be accomodated in the space of this paper.

Regarding future work, we can identify that there is still space to accommodate more constructs to cater to specific industries. The Circular Economy ecosystem design and deployment framework was initially validated in the same environment it was created in, the CircThread project. It would be ideal to follow other Circular Economy DP-based Ecosystem development projects to validate further the many components of the framework, feeding the cycle of build design and evaluation.

Secondly, although we present a step-by-step explanation of user roles and the framework's internals, as well as pragmatic methods to extract knowledge and validate requirements from the ecosystem participants, we encourage the creation of different practical Requirements Engineering methods and models that might serve as an improved fit in other projects. A transparent and efficient model to create, document and validate governance models and deployment strategies would also be an excellent addition to this framework.

References

1. Adner, R.: Ecosystem as structure. Journal of Management **43**, 39–58 (1 2017). https://doi.org/10.1177/0149206316678451, http://journals.sagepub.com/doi/10.1177/0149206316678451
2. Asadullah, A., Faik, I., Kankanhalli, A.: Digital platforms: A review and future directions. In: PACIS 2018 Proceedings (2018), https://aisel.aisnet.org/pacis2018/248/
3. Benedict, M.: Modelling ecosystems in information systems - a typology approach. In: Multikonferenz Wirtschaftsinformatik (3 2018)
4. Benedict, M., Kosmol, L., Esswein, W.: Designing industrial symbiosis platforms – from platform ecosystems to industrial ecosystems. In: PACIS 2018 Proceedings (2018), https://www.researchgate.net/publication/325397155
5. European Commission and Directorate-General for Research and Innovation, Breque, M., Nul, L.D., Petridis, A.: Industry 5.0 Towards a sustainable, human-centric and resilient European industry. Publications Office (2021). https://doi.org/10.2777/308407, https://op.europa.eu/en/publication-detail/-/publication/468a892a-5097-11eb-b59f-01aa75ed71a1/language-en

6. Gawer, A.: Bridging differing perspectives on technological platforms: Toward an integrative framework. Research Policy **43**, 1239–1249 (2014). https://doi.org/10.1016/j.respol.2014.03.006
7. Gawer, A.: Digital platforms and ecosystems: remarks on the dominant organizational forms of the digital age. Innovation pp. 1–15 (9 2021). https://doi.org/10.1080/14479338.2021.1965888, https://www.tandfonline.com/doi/full/10.1080/14479338.2021.1965888
8. Geissdoerfer, M., Savaget, P., Bocken, N.M., Hultink, E.J.: The circular economy – a new sustainability paradigm? Journal of Cleaner Production **143**, 757–768 (2 2017). https://doi.org/10.1016/j.jclepro.2016.12.048, https://linkinghub.elsevier.com/retrieve/pii/S0959652616321023
9. Group, O.M.: Business process model & notation™ (bpmn™). https://www.omg.org/bpmn/ (2022), https://www.omg.org/bpmn/, last accessed on 2022-05-22
10. Hein, A., Schreieck, M., Riasanow, T., Setzke, D.S., Wiesche, M., Böhm, M., Krcmar, H.: Digital platform ecosystems. Electronic Markets **30**, 87–98 (3 2020). https://doi.org/10.1007/s12525-019-00377-4, http://link.springer.com/10.1007/s12525-019-00377-4
11. Hevner, A.R., March, S.T., Park, J., Ram, S.: Design science in information systems research. MIS Quarterly **28**, 75 (2004). https://doi.org/10.2307/25148625, https://www.jstor.org/stable/10.2307/25148625
12. Jacobides, M.G., Cennamo, C., Gawer, A.: Towards a theory of ecosystems. Strategic Management Journal **39**, 2255–2276 (8 2018). https://doi.org/10.1002/smj.2904, https://onlinelibrary.wiley.com/doi/10.1002/smj.2904
13. Kalmykova, Y., Sadagopan, M., Rosado, L.: Circular economy – from review of theories and practices to development of implementation tools. Resources, Conservation and Recycling **135**, 190–201 (8 2018). https://doi.org/10.1016/j.resconrec.2017.10.034, https://linkinghub.elsevier.com/retrieve/pii/S0921344917303701
14. Konietzko, J., Bocken, N., Hultink, E.J.: Circular ecosystem innovation: An initial set of principles. Journal of Cleaner Production **253**, 119942 (4 2020). https://doi.org/10.1016/j.jclepro.2019.119942, https://linkinghub.elsevier.com/retrieve/pii/S0959652619348127
15. Korhonen, J., Honkasalo, A., Seppälä, J.: Circular economy: The concept and its limitations. Ecological Economics **143**, 37–46 (1 2018). https://doi.org/10.1016/j.ecolecon.2017.06.041, https://linkinghub.elsevier.com/retrieve/pii/S0921800916300325
16. Kosmol, L., Leyh, C.: A conceptual design for digital industrial symbiosis ecosystems. In: The Next Wave of Sociotechnical Design. pp. 362–374. Springer International Publishing (2021). https://doi.org/10.1007/978-3-030-82405-1$_3$5, $https://doi.org/10.1007/978-3-030-82405-1_35$
17. Kristoffersen, E., Blomsma, F., Mikalef, P., Li, J.: The smart circular economy: A digital-enabled circular strategies framework for manufacturing companies. Journal of Business Research **120**, 241–261 (11 2020). https://doi.org/10.1016/j.jbusres.2020.07.044
18. O'hEocha, C., Conboy, K.: The role of the user story agile practice in innovation. In: Lean Enterprise Software and Systems. vol. 65, pp. 20–30. Springer Berlin Heidelberg (2010). https://doi.org/10.1007/978-3-642-16416-3$_3$, $http://link.springer.com/10.1007/978-3-642-16416-3_3$

19. Parker, G.G., Alstyne, M.W.V., Choudary, S.P.: Platform Revolution. W. W. Norton & Company, Inc. (2016)
20. Pauli, T., Fielt, E., Matzner, M.: Digital industrial platforms. Business & Information Systems Engineering **63**, 181–190 (4 2021). https://doi.org/10.1007/s12599-020-00681-w, http://link.springer.com/10.1007/s12599-020-00681-w
21. de Reuver, M., Sørensen, C., Basole, R.C.: The digital platform: A research agenda. Journal of Information Technology **33**, 124–135 (6 2018). https://doi.org/10.1057/s41265-016-0033-3, http://journals.sagepub.com/doi/10.1057/s41265-016-0033-3
22. Silva, H.D., Soares, A.L.: From digital platforms to ecosystems: A review of horizon 2020 platform projects. In: Camarinha-Matos, L.M., Afsarmanesh, H., Ortiz, A. (eds.) Boosting Collaborative Networks 4.0. pp. 111–120. Springer International Publishing, Cham (2020). https://doi.org/10.1007/978-3-030-62412-5$_{9}, http : //link.springer.com/10.1007/978 - 3 - 030 - 62412 - 5_{9}$
23. SRL, B.: Pdt platform design toolkit - boundaryless. https://boundaryless.io/pdt-toolkit/ (2021), https://boundaryless.io/pdt-toolkit/, last accessed on 2022-06-01
24. SRL, B.: The platform design toolkit user guide. https://boundaryless.io/pdt-toolkit/ (2021), https://boundaryless.io/pdt-toolkit/, last accessed on 2022-06-01
25. Stummer, C., Kundisch, D., Decker, R.: Platform launch strategies. Business & Information Systems Engineering **60**, 167–173 (4 2018). https://doi.org/10.1007/s12599-018-0520-x, http://link.springer.com/10.1007/s12599-018-0520-x
26. Talmar, M., Walrave, B., Podoynitsyna, K.S., Holmström, J., Romme, A.G.L.: Mapping, analyzing and designing innovation ecosystems: The ecosystem pie model. Long Range Planning **53** (8 2020). https://doi.org/10.1016/j.lrp.2018.09.002, aditional information -https://www.ecosystempie.com/guidelines.pdf
27. Tao, F., Cheng, J., Qi, Q., Zhang, M., Zhang, H., Sui, F.: Digital twin-driven product design, manufacturing and service with big data. The International Journal of Advanced Manufacturing Technology **94**, 3563–3576 (2 2018). https://doi.org/10.1007/s00170-017-0233-1, http://link.springer.com/10.1007/s00170-017-0233-1
28. Tiwana, A.: Platform Ecosystems. Morgan Kaufmann (2014). https://doi.org/10.1016/C2012-0-06625-2, https://linkinghub.elsevier.com/retrieve/pii/C20120066252
29. Tiwana, A., Konsynski, B., Bush, A.A.: Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics. Information Systems Research **21**, 675–687 (2010). https://doi.org/10.1287/isre.1100.0323
30. Williamson, P.J., Meyer, A.D.: Ecosystem advantage: How to successfully harness the power of partners. California Management Review **55**, 24–46 (10 2012). https://doi.org/10.1525/cmr.2012.55.1.24, http://journals.sagepub.com/doi/10.1525/cmr.2012.55.1.24
31. Zutshi, A., Grilo, A.: The emergence of digital platforms: A conceptual platform architecture and impact on industrial engineering. Computers & Industrial Engineering **136**, 546–555 (10 2019). https://doi.org/10.1016/j.cie.2019.07.027, https://linkinghub.elsevier.com/retrieve/pii/S0360835219304188