

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/352461615>

# Towards Visualizing and Simulating Business Models in Dynamic Platform Ecosystems

Conference Paper · June 2021

CITATION

1

READS

342

2 authors:



**Christian Vorbohle**

Universität Paderborn

4 PUBLICATIONS 3 CITATIONS

[SEE PROFILE](#)



**Sebastian Gottschalk**

Universität Paderborn

21 PUBLICATIONS 55 CITATIONS

[SEE PROFILE](#)

Some of the authors of this publication are also working on these related projects:



Business Models for On-The-Fly Computing (CRC901) [View project](#)

Association for Information Systems

**AIS Electronic Library (AISeL)**

---

ECIS 2021 Research-in-Progress Papers

ECIS 2021 Proceedings

---

6-14-2021

## **TOWARDS VISUALIZING AND SIMULATING BUSINESS MODELS IN DYNAMIC PLATFORM ECOSYSTEMS**

Christian Vorbohle

*Paderborn University, vorbohle@mail.upb.de*

Sebastian Gottschalk

*Paderborn University, sebastian.gottschalk@uni-paderborn.de*

Follow this and additional works at: [https://aisel.aisnet.org/ecis2021\\_rip](https://aisel.aisnet.org/ecis2021_rip)

---

### **Recommended Citation**

Vorbohle, Christian and Gottschalk, Sebastian, "TOWARDS VISUALIZING AND SIMULATING BUSINESS MODELS IN DYNAMIC PLATFORM ECOSYSTEMS" (2021). *ECIS 2021 Research-in-Progress Papers*. 55. [https://aisel.aisnet.org/ecis2021\\_rip/55](https://aisel.aisnet.org/ecis2021_rip/55)

This material is brought to you by the ECIS 2021 Proceedings at AIS Electronic Library (AISeL). It has been accepted for inclusion in ECIS 2021 Research-in-Progress Papers by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact [elibrary@aisnet.org](mailto:elibrary@aisnet.org).

# TOWARDS VISUALIZING AND SIMULATING BUSINESS MODELS IN DYNAMIC PLATFORM ECOSYSTEMS

*Research in Progress*

Christian Vorbohle, Paderborn University, Paderborn, Germany, christian.vorbohle@upb.de

Sebastian Gottschalk, Paderborn University, Paderborn, Germany,  
sebastian.gottschalk@upb.de

## Abstract

*Platform-based business models underlie the success of many of today's largest, fastest-growing, and most disruptive companies. Despite the success of prominent examples, such as Uber and Airbnb, creating a profitable platform ecosystem presents a key challenge for many companies across all industries. Although research provides knowledge about platforms' different value drivers (e.g., network effects), companies that seek to transform their current business model into a platform-based one lack an artifact to reduce knowledge boundaries, collaborate effectively, and cope with the complexities and dynamics of platform ecosystems. We address this challenge by developing two artifacts and combining research from variability modeling, business model dependencies, and system dynamics. This paper presents a design science research approach to develop the platform ecosystem modeling language and the platform ecosystem development tool that support researcher and practitioner by visualizing and simulating platform ecosystems.*

*Keywords: platform ecosystems, platform ecosystem modeling language, platform ecosystem development tool, business models, design science*

## 1 Introduction and Motivation

Companies with digital platform-based business models have grown substantially in number and size and increasingly determine daily life by changing consumption, interaction, communication, and socialization habits (Evans et al., 2016; McAfee and Brynjolfsson, 2017). Establishing a digital platform was recently proposed as a promising digital transformation strategy for achieving high profits and market leadership (Parker et al., 2017; Teece, 2018). In contrast to pipeline businesses (see van Alstyne et al., 2016, p. 4), platforms create an ecosystem of complementors as platforms profit from the success of the exchanges (e.g., of content, products, or information). Prominent examples of platform ecosystems are mobile application platforms (e.g., Apple's App Store) and social media platforms (e.g., Facebook), where participants are turning the value creation into a joint value creation process (Parker et al., 2017). Platform ecosystems are organized around a central platform-based business model that serves as a mediator for the ecosystem to offer complementary products or services (Kapoor, 2018). In platform ecosystems, value creation critically depends on the interplay between the involved business models (Wirtz, 2020). Many studies have suggested that the origin of value creation is found in the relationships among these business models (e.g., Dyer, 1997; Foss and Saebi, 2017). To be successful, digital platforms must facilitate joint value-creating mechanisms (Jacobides et al., 2018). This facilitation includes setting suitable incentives for all the different groups of participants to join as well as aligning and implementing regulations for orchestrating interactions in the ecosystems (Tiwana, 2014; Hein et al., 2020; Reuver et al., 2018). Given the value of leading global companies and their underlying platform business models (The Innovator, 2019), many companies and institutions want to emulate this success and pursue their own platform strategies. Examples range from the automotive industry (Volkswagen AG, 2020), to software providers, such as DATEV (Datev eG, 2020); electric

cars (Handelsblatt, 2020), On-The-Fly (OTF) computing (Karl et al., 2019) and virtual reality (Schuir et al., 2020). However, enabling different business models to interact within a platform ecosystem is a collaborative and complex task. In a recent BCG Henderson Institute case study, managers across multiple companies have consistently found “ecosystem strategy to be the most challenging: Only 18% succeeded versus an AI opponent, versus 71% in the classical strategy.” (Fuller et al., 2019, p. 9). Consequently, a recent study estimated that more than 80% of all digital platforms fail within a few years (Yoffie et al., 2019).

Visual languages have been considered to be a promising approach to guide the design and evaluation of business models (John et al., 2017; Täuscher and Abdelkafi, 2017). The main advantage associated with these artifacts is that they establish a common language within an organization (Eppler et al., 2011). However, existing business model modeling languages provide little value in the context of inter-organizational collaboration as they are limited to a static and intra-business model perspective while omitting dependencies and joint value creation mechanisms with other organizations (Schwarz and Legner 2020; John et al., 2017; Boßelmann and Margaria, 2017). With the increased interest in digital platforms, a current research gap exists regarding how business models can be co-designed on platform ecosystems. Previous research has not attempted to design for collaboration among different business models. In this design science research approach, we argue for conceptualizing business model modeling languages and business model development tools as boundary objects (Star and Griesemer, 1989) that are the “artifacts, documents, terms, concepts, and other forms of reification around which communities of practice can organize their interconnections” (Wenger, 1998, p. 105). Boundary objects support collaboration, form a foundation for joint value creation, and are artifacts that enable different groups to resolve the knowledge boundaries separating them (Carlile, 2004).

Three issues, in particular, are insufficiently addressed by existing business model modeling languages to serve as a valuable artifact for designing successful collaborations in platform ecosystems. First, business model modeling languages with pure reporting and documentation functions have little value in the context of platform ecosystems (Schwarz and Legner, 2020). To create a useful artifact, flexibility should be considered as well as the possibility of adapting the business model rapidly. Accordingly, business model developers must view business models through a systemic lens to prevent undesired consequences due to their design choices (Boßelmann and Margaria, 2017; Osterwalder et al., 2005). Second, platform ecosystems need a collective strategy, which requires the collaboration of all business models within the ecosystem. Several articles have discussed the structural interdependencies (e.g., the cost structure depends on key resources) of business model components (e.g., Cosenz and Noto, 2018; Krumeich et al., 2013). However, the number of uniform dependency visualizations that can be comprehended at a time is limited by humans’ working-memory capacity. When this limit is exceeded, a state of cognitive overload ensues, and comprehension degrades rapidly (Miller, 1956). Business model modeling languages will benefit from incorporating dependency types that help to identify different types of dependencies between business models. Third, to guide the design and assessment of business models, the business model visualizations often view the components implemented statically while neglecting changes over time (Bouwmann et al., 2020; Täuscher and Abdelkafi, 2017). To address static business modeling, dynamic business modeling approaches have been introduced (e.g., Abdelkafi and Täuscher, 2016; Cosenz and Noto, 2018). System dynamics (SD; Forrester, 2007), which is a mathematical modeling technique for understanding the non-linear behavior of complex systems, has gained attention in business model research with acceptance from researchers (e.g., Zsifkovits et al., 2016; Cosenz and Noto, 2018). However, SD often results in overwhelming models, which practitioners refuse to use (Stadtländer et al., 2021). For these reasons, a modeling language for platform ecosystems must be joined with a straightforward software tool that supports the development of platform ecosystems.

Design science helps create novel artifacts that are appropriate for developing new improvements and solutions for known problems (refer to Gregor and Hevner, 2013). Therefore, we present a design science research approach following the methodology of Peffers et al. (2007) to develop a platform ecosystem modeling language and a platform ecosystem development tool. We based our research proposal on Peffers et al.’s (2007) six-step methodology and present preliminary results for the first four

steps. Inside this approach, we identified three main objectives to address the current shortcomings for platform ecosystem modeling. First, we facilitated the possibility of variability modeling to enable flexibility. Second, we facilitated the usage of various business model dependency types to address joint value creation. Third, we facilitated dynamic changes through to modeling with SD. Moreover, we will create a development tool as an instantiation of the platform ecosystem modeling language.

By investigating business model modeling languages and development tools as boundary objects, we contribute to research by strengthening the theory base underlying the usage of modeling languages and development tools in the context of business model collaborations and joint value creation. Information systems (IS) research will benefit from systematically exploring and analyzing the contributions that conceptual modeling and tools can make to business model design and innovation research (Bouwman 2020; Veit et al., 2014). Furthermore, our research provides insights into the business model requirements of modeling languages to surmount the boundaries between different interest groups (Carlile, 2004). Our two artifacts are designed to support collaboration and allow different platform ecosystem participants to develop common interests and overcome knowledge boundaries. We aim to improve the collaboration of different business models on platform ecosystems and contribute to practice by providing a platform ecosystem modeling language and a usable platform ecosystem development tool.

## **2 Background and Related Work**

A business model describes the essence of how a company creates, delivers, and captures value (Osterwalder and Pigneur, 2010). The business model is a detailed explanation of the firm's strategy (Casadesus-Masanell and Ricart, 2010) and acts as an intermediary between the business strategy and business processes of a company (Al-Debei et al., 2010). The process of business model development is a continuous and challenging task that requires creativity and collaboration between different stakeholders (Eppler et al., 2011). We divide those approaches into static and dynamic business model modeling. Moreover, we introduce the theory of boundary objects with respect to the theoretical contribution of our approach.

### **2.1 Static Business Model Modeling**

The static visualization of business models can be supported with different business model modeling languages proposed in the literature (John et al., 2017). The most prominent example of these languages is the Business Model Canvas (BMC), which structures a single company's business model within a fixed canvas structure (Osterwalder and Pigneur, 2010). The BMC is also the foundation for many software tools in use (Szopinski et al., 2019). While the BMC works independently of any application domain, there are also modeling languages for platform ecosystems. The Platform Canvas (Sorri et al., 2019) and Platform Business Model Canvas (Eisape, 2019) use the concept of canvas models to visualize platform ecosystems. The Business Variability Model introduced the concept of modeling different variants of business models for software ecosystems, a subset of platform ecosystems, based on the BMC (Gottschalk et al., 2019). More flexible is a formalization approach for software ecosystems (Boucharas et al., 2009) that enables different participants (e.g., companies, customers, suppliers, and distributors) and relationships to be modeled in the form of flows (e.g., product and money). More generalized is the platform ecosystem modeling language (Pauli et al., 2020), which provides an abstract and concrete syntax to model platform ecosystems with their included participants, proposed value propositions, and resource-transferring links. Nevertheless, with pure visualizations of platform ecosystems, it is impossible to cover the dynamic behavior within and among the participants.

### **2.2 Dynamic Business Model Modeling**

The dynamic behavior can be covered with dynamic business modeling (Moellers et al., 2019). One of the earliest examples is the e3-value model (Gordijn and Akkermans, 2001), which can be used to model a value network containing different participants to calculate the financial assessments based on a

software tool. Over time, other concepts, such as scenario planning, agent-based modeling, or SD for decision support systems, have been transferred to the domain of dynamic business modeling. Scenario planning, which identifies critical uncertainties for calculating different future scenarios (Lindgren and Bandhold, 2003), is used to calculate outcomes of various services platforms (Zoric, 2011), which are a particular type of platform ecosystem. Agent-based modeling, which simulates the behavior of autonomous but interconnected participants (Kiesling, 2012), has been transferred to business modeling (e.g., Nakagawa et al., 2012; Lagemann et al., 2015). In recent years, SD has been used by an increasing number of modeling approaches in the literature (e.g., Zsfikovits et al., 2016; Cosenz and Noto, 2018; Moellers et al., 2019). SD models the business model as a complex system with non-linear behavior and can be based on canvas structures (Cosenz and Noto, 2018) or flexible structures (Abdelkafi and Täuscher, 2016). While these approaches can be used with standard SD software tools, special software tools are designed for dynamic business modeling. These software tools are referred to as business model development tools (BMDTs) and can guide business models' visualization and simulation (Szopinski et al., 2019). Augenstein et al. (2018) proposed the design principles of a software tool for a business model decision support system, including the variability modeling of different business models. Design principles for a software tool were also developed by Athanasopoulou et al. (2018). In contrast to Augenstein et al., the authors focused on Internet-of-Thing platform business models, which constitute a particular form of platform ecosystems. Nevertheless, most approaches focus on single business models instead of networks of interrelated business models. They also tend to focus either on business models in general or on specific platform ecosystems. Finally, most approaches do not provide an accessible software tool that researchers, practitioners, and regulatory authorities can use to model instances of platform ecosystems. To the best of our knowledge, no approach adequately addresses platform ecosystems with their complex network of relationships, combining a flexible modeling language and an accessible tool for researchers and practitioners.

### 2.3 Boundary Objects Theory

The theory of boundary objects supports our underlying hypothesis that collaboration and a shared understanding of knowledge can be supported by design. The term boundary object was first defined by Star and Griesemer (1989). The fundamental idea is that scientific work is heterogeneous and requires collaboration among different participants to be successful (Star and Griesemer, 1989). In the case of collaboration, however, each participant has different knowledge, demands, and concerns that arise from different communities of practice (Carlile, 2004). Boundary objects form a foundation for a working relationship and enable participants to bridge knowledge boundaries. Moreover, boundary objects fulfill different roles in cross-disciplinary collaborations. According to Nicolini et al. (2012), boundary objects serve three different activities: (1) they motivate collaboration, (2) they allow participants to work across different types of boundaries, and (3) they represent the fundamental infrastructure of collaborative activities. However, the significance of boundary objects for the design of IS artifacts has gained only marginal attention so far.

## 3 Research Approach

IS research uses design science to create artifacts that solve an existing problem or fulfill an opportunity. We adhere to this approach by using a scientific method to improve the collaboration experience of researchers and practitioners for platform ecosystems. Design science research methods are widely accepted in IS research and have been used for developing artifacts in research disciplines as diverse as the Internet-of-Things (Turber et al., 2014), smart city initiatives (Ojo et al., 2015), and blockchain-based artifacts designed to overcome financial fraud (Hyvärinen et al., 2017). Hevner et al. (2004) describe design science research as a build-and-evaluate process with the goal of producing novel artifacts. Our main goal is to create and evaluate two artifacts that support the co-design of business models on platform ecosystems. Our research approach follows the design science methodology of Peffers et al. (2007). The methodology suggests a process to conduct design science research in ISs. It consists of six phases: (1) identification of the problem and motivation, (2) definition of the objectives,

(3) design, (4) demonstration, (5) evaluation, and (6) communication. We follow the design science methodology illustrated in Figure 1 and have selected a problem-centered initiation as our research entry point. The problem of business model collaboration is derived from a project in which we developed business models for a complex software ecosystem. We discuss the use case and the generalizability in the discussion chapter of this paper. In the remainder of this chapter, we present our current research state involving the first four phases, followed by future research directions for the remaining steps.

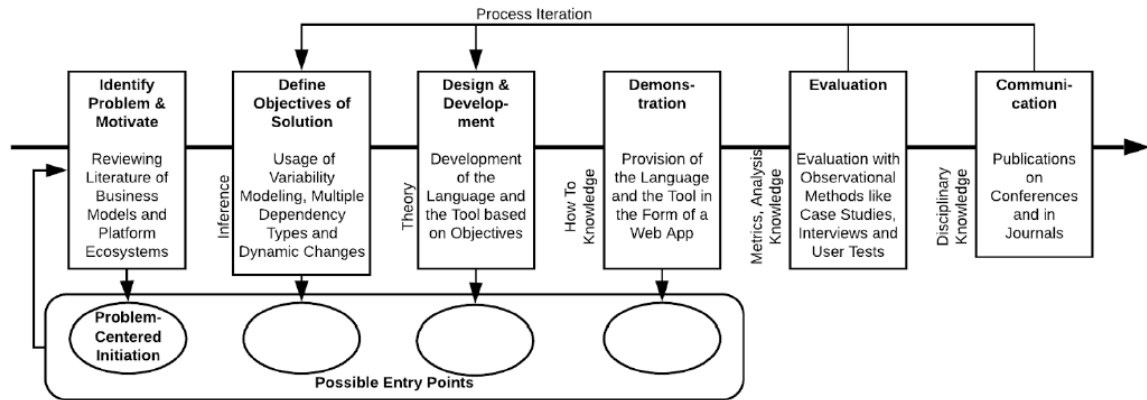


Figure 1. Design Science Research Methodology (Adapted from Peffers et al., 2007).

### (1) Problem Identification and Motivation:

Platforms are omnipresent phenomena transforming industries with high speed and changing everyday life (Evans and Gawer, 2016). Based on an extensive analysis of static and dynamic business model modeling research and literature related to boundary objects (see Research Background), our study started with an awareness of a significant problem: the lack of useful artifacts to co-design business models on platform ecosystems. No approach to modeling the complexity and dynamics of platform ecosystems, which enable collaboration and create joint value creation mechanisms, currently exists. Thus, our motivation was to develop two artifacts that support researchers and practitioners. To provide a solution and justify our design decisions, we built on the theory of boundary objects. We achieved rigor in our research endeavor by examining existing knowledge and applying it to our solution objectives.

**(2) Solution Objectives:**

The artifacts should facilitate making decisions about business models and enable interactions and collaborations among different participants by “providing a common language in which to have a strategy conversation” (Spee and Jarzabkowski, 2009). We identified three main requirements for a common language (see Figure 2). The first requirement is *Variability Modeling*, which is used to represent different configurations of business models within a single modeling structure. Based on this structure, it will be possible to dynamically switch between different configurations at runtime without changing the underlying model. In the past, taxonomies (Osterwalder, 2005), as well as customized structures (Gottschalk et al., 2019), have been presented to model these different configurations. However, these approaches are limited in combining structuring flexibility with constraints for configuration. Therefore, we decided to use feature models (Apel et al., 2013) as our representation structure for variability modeling. The second requirement is *Multiple Dependency Types*, which are needed to model all interactions between business models within the platform ecosystem (Basole et al., 2015). Recent business model research has criticized the lack of bundled knowledge in describing essential archetypes of business model dependencies (Foss and Saebi, 2017; Massa et al., 2017; Wirtz et al., 2020). Consequently, we included a comprehensive analysis of business models with the objective of conceptualizing dependencies through a derived taxonomy. The third requirement is *Dynamic Changes*, whose objective is to simulate outcomes of the platform ecosystem under predefined conditions (Abdelkafi and Täuscher, 2016). The simulation is performed by modeling the complex behavior of the platform ecosystem at the time of design and setting the parameters of possible

configurations during the runtime. Different approaches to agent-based modeling (e.g., Nakagawa et al., 2012; Lagemann et al., 2015) and SD (e.g., Cosenz and Noto, 2018; Moellers et al., 2019) have previously been proposed. Our approach used SD as it can model the platform ecosystem as a complex system with non-linear behavior. This system uses stocks to save the current state of different measurements, which are connected by flows. Moreover, time delays and feedback loops can be used to enhance the modeling possibilities (Forrester, 2007).

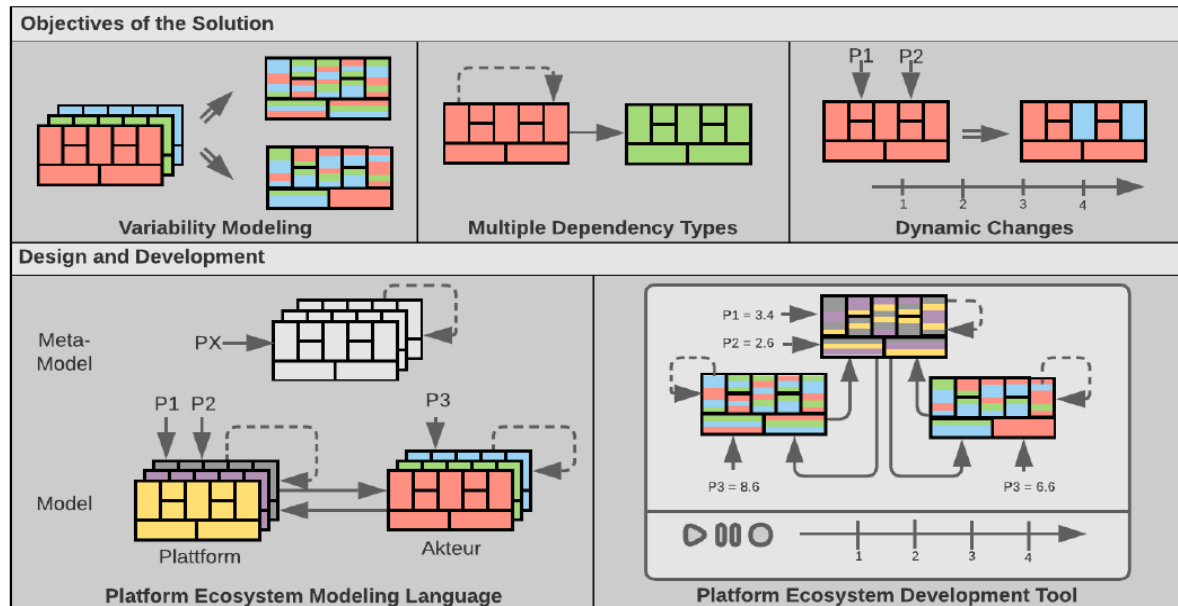


Figure 2. Steps 2 and 3 of the Design Science Research Cycle.

### (3) Design and Development:

At the design stage, we used the identified solution objectives from step (2) to develop first the *Platform Ecosystem Modeling Language* and subsequently the *Platform Ecosystem Development Tool* (see Figure 2). To cover *Variability Modeling*, we used feature models (Apel et al., 2013) that originally described a compact representation of all the products of a software product line. A feature model splits a product into a hierarchy of mandatory and optional features with required and excluding dependencies. From this feature model, concrete products can be instantiated. In Gottschalk et al. (2019b), we applied feature models to the modeling of individual business models. The next goal was to extend this approach for modeling the variability of platform ecosystems within the platform ecosystem modeling language. For the *Multiple Dependency Types*, we conducted a large-scale literature review and empirical validation to create a taxonomy of essential business model dependencies. The preliminary results of the literature review have already been documented (Vorbohle et al., 2020). The taxonomy was developed using the method proposed by Nickerson et al. (2013). To cover the aspects of *Dynamic Changes*, we used SD (Forrester, 2007), which is a mathematical modeling technique for understanding the non-linear behavior of complex systems. We added support for SD to our platform ecosystem modeling language. In addition, we interpreted the features of the feature models as stocks and defined the flows between those features that can be associated with dependency types. Moreover, we defined the parameters for each feature at the time of design, which can be changed at the runtime using the platform ecosystem development tool. Based on these three solution objectives, we develop a domain-specific modeling language following the engineering method proposed by Frank (2013). A domain-specific modeling language incorporates concepts that represent domain-level knowledge. The modeling language consists of a meta-model (see Bork et al., 2020) that defines variability aspects, multiple dependencies, and dynamic changes. This meta-model can be used to design instances of possible platform ecosystems. The design and analysis of these platform ecosystems were made available by extending our own BMDT provided in a previous study (Gottschalk et al., 2020).



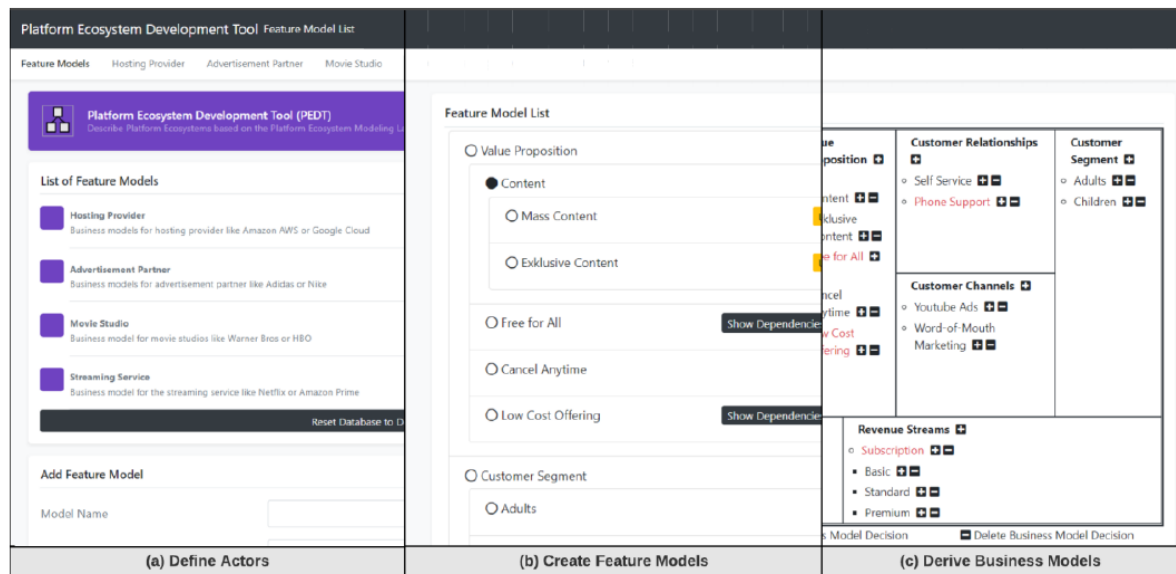


Figure 3. Overview of the Platform Ecosystem Development Tool.

#### (4) Demonstration:

IS design science literature advocates that artifacts should be subject to the demonstration because after generalized design knowledge is proposed, it must be “brought into being” (Gregor and Jones 2007, p. 328). We will demonstrate the utility of the proposed artifacts in two steps. First, we will present our implemented prototype of the *Platform Ecosystem Development Tool* (see Figure 3), which instantiates the proposed design solution, namely the *Platform Ecosystem Modeling Language*. We plan to make both artifacts accessible to every researcher and practitioner by building a web application of the tool so that no additional software needs to be installed. Second, the artifacts will be applied to solve one or more instances of a given problem (Peffer et al., 2007). We will demonstrate the utility of the proposed artifacts by reporting on our software ecosystem from our collaborative research center, On-The-Fly Computing (Karl et al., 2019). Figure 3 depicts the current state of our software tool applied to the use case of developing a streaming service. At the beginning (see Figure 3 [a]), we define all the participants we want to consider in our platform ecosystem (e.g., *Streaming Services*, *Movie Studios*, *Hosting Providers*, and *Advertisement Partners*). Next (see Figure 3 [b]), we define for each participant a feature model that contains possible configurations of their business model (e.g., choosing between *Free for All* and *Cancel Anytime* policies as *Value Propositions*). In the end (see Figure 3 [c]), we can use those feature models to derive configurations of business models (e.g., for *Netflix* as a *Streaming Service*). Moreover, we can check the conformance between the business model configuration and the feature model (e.g., *Subscription* as *Revenue Stream* conflicts with *Free for All* as a *Value Proposition*). We will extend the tool with the previously defined objectives to visualize multiple dependencies among the participants and simulate the behavior of the platform ecosystem over time.

#### (5) Evaluation:

Following the design science objective of building and evaluating artifacts, it is generally prescribed that the development of new artifacts requires analyzing their usefulness. An evaluation employs formal measurement instruments and empirical observations to determine how well an artifact solves a problem (Peffer et al., 2007) and positively impacts the intended application purpose (Peffer et al., 2012). The lack of knowledge about the new artifacts is unlikely to generate user enthusiasm. Introducing a new modeling language not only involves learning effort but also requires relinquishing the use of the modeling language users are familiar with. Hence, new modeling languages threaten to challenge existing competencies and reputations. For this reason, to evaluate our artifact, we will adapt the evaluation criteria from Becker et al. (2013), who conducted a Delphi study to identify evaluation criteria for tool-based workshops. They identified seven criteria, including time efficiency, productivity, and communication between participants. Our evaluation will be separated into ex-ante and ex-post

evaluations. First, we will question domain experts about their expectations of the effects of the platform ecosystem development tool based on the evaluation criteria. Subsequently, we will conduct a series of workshops in which the platform ecosystem development tool will be used in real-world scenarios. After each workshop, we will interview the participants and ask them to rate the workshop quality in terms of the evaluation criteria. Finally, we will compare the ex-post workshop evaluations with the ex-ante expectations provided by the domain experts. The results from the evaluation procedure could trigger another analysis or a redesign of the problem or the artifact.

#### **(6) Communication:**

We will communicate the artifact through detailed research contributions to academic conference proceedings and journals. Ultimately, we will provide the artifact to practitioners and publish the source code of the platform ecosystem development tool together with the specifications of the platform ecosystem modeling language so that anyone can use and extend it.

## **4 Discussion and Expected Contribution**

Researchers and practitioners' great interest in platform-based business models is undisputable. Given the financial value of leading global companies, many companies want to transform their business model to be platform-based (Parker et al., 2017; Teece, 2018). However, the interactions of different business models on such platforms often lead to a collaborative and complex challenge that current business model modeling languages and development tools cannot surmount (Schwarz and Legner, 2020). Therefore, based on the theory of boundary objects (Star and Griesemer, 1989), we have presented a design science research approach to enhance the knowledge of visualizing and simulating platform ecosystems. To this end, we identified three primary issues that must be addressed: (1) flexibility, (2) joint value creation, and (3) dynamic modeling. These issues formed the basis for building the main objectives of the variabilities of different business model configurations (i.e., variability modeling), the visualization of varying dependency types within and among business models (i.e., multiple dependency types), and the dynamic changes during the simulations (i.e., dynamic changes). We derived these objectives from our collaborative research center, On-The-Fly Computing (Karl et al., 2019), where we develop business models for OTF computing markets. In this software ecosystem, individual software is composed of small software services that are traded over globally accessible markets. In this market, the different perspectives of the OTF service providers (who develop the small software services), the OTF market providers (who manage repositories of those services), the OTF providers (who compose individual software out of the services in the market and make them accessible to users), and OTF computing centers (which execute the composed software) are evident. The end users then use the composed software. Every participant in the ecosystem has a business model, which interacts with other models and leads to an interdisciplinary and complex view of the software ecosystem.

On the basis of boundary objects theory and three solution objectives, we developed a platform ecosystem development language and a platform ecosystem development tool. While the development language is the primary artifact, its instantiation and usage are supported by the development tool. Both artifacts can help researchers and practitioners to visualize and simulate platform ecosystems. Researchers will benefit from the ability to analyze existing platform ecosystems, including the value creation mechanisms and complementor interactions. Practitioners will benefit from the ability to collaboratively design a new platform and systematically compare ecosystems different possibilities to innovate all business models collectively. By evaluating both artifacts, we aim to contribute to the bounded objects theory regarding how different participants can collaborate in the platform ecosystems' business model development. We used a modeling language to derive a common understanding of the platform ecosystem where each participant can model their viewpoints. Moreover, we used a software tool to allow the participants to collaborate in the viewpoint modeling.

## **Acknowledgments**

This work was partially supported by the German Research Foundation (DFG) within the Collaborative Research Center "On-The-Fly Computing" (CRC 901, Project Number: 160364472SFB901).

## References

- Abdelkafi, N. and K. Täuscher (2016). "Business Models for Sustainability From a System Dynamics Perspective" *Organization & Environment* 29 (1), 74–96.
- Al-Debei, M. M. and D. Avison (2010). "Developing a unified framework of the business model concept" *European Journal of Information Systems* 19 (3), 359–376.
- Apel, S., D. Batory, C. Kästner and G. Saake (eds.) (2013). *Feature-Oriented Software Product Lines*. Berlin, Heidelberg: Springer Berlin Heidelberg.
- Athanasopoulou, A., Haaker, T., and de Reuver, M. (2020). "Designing digital tooling for business model exploration for the Internet-of-Things". In: *DESRIST 2018 - 13th International Conference on Design Science Research in Information Systems and Technology*, Springer, Cham (2018).
- Augenstein, D., C. Fleig and A. Maedche (2018). "Development of a Data-Driven Business Model Transformation Tool". In: S. Chatterjee, K. Dutta and R. P. Sundarraj (eds.) *Designing for a Digital and Globalized World*, pp. 205–217. Cham: Springer International Publishing.
- Basole, R. C., M. G. Russell, J. Huhtamäki, N. Rubens, K. Still and H. Park (2015). "Understanding Business Ecosystem Dynamics" *ACM Transactions on Management Information Systems* 6 (2), 1–32.
- Becker, J., D. Beverungen, R. Knackstedt, M. Matzner, O. Müller, and J. Pöppelbuß (2013). "Designing Interaction Routines in Service Networks: A Modularity and Social Construction-Based Approach," *Scandinavian Journal of Information Systems* 25 (1), 37–68
- Boßelmann, S. and T. Margaria (2017). "Guided Business Modeling and Analysis for Business Professionals". In: M. A. Pfannstiel and C. Rasche (eds.) *Service Business Model Innovation in Healthcare and Hospital Management*, pp. 195–211. Cham: Springer International Publishing.
- Bork, D., D. Karagiannis and B. Pittl (2020). "A survey of modeling language specification techniques" *Information Systems* 87, 101425.
- Boucharas, V., S. Jansen and S. Brinkkemper (2009). "Formalizing software ecosystem modeling". In: *Proceedings of the 1st international workshop on Open component ecosystems - IWOCE '09*. Ed. by R. Di Cosmo, P. Inverardi. New York, New York, USA: ACM Press, p. 41.
- Bouwman, H., M. de Reuver, M. Heikkilä and E. Felt (2020). "Business model tooling: where research and practice meet" *Electronic Markets* 30 (3), 413–419.
- Carlile, P. R. (2004). "Transferring, Translating, and Transforming: An Integrative Framework for Managing Knowledge Across Boundaries" *Organization Science* 15 (5), 555–568.
- Cosenz, F. and G. Noto (2018). "A dynamic business modelling approach to design and experiment new business venture strategies" *Long Range Planning* 51 (1), 127–140.
- DATEV eG. (2020). *DATEV Ecosystem*. URL: <https://www.datev.com/news/datev-ecosystem/index-2.html> (visited on: 18.11.2020).
- Dyer, J. H. (1997). "Effective interim collaboration: how firms minimize transaction costs and maximise transaction value" *Strategic Management Journal* 18 (7), 535–556.
- Eisape, D. (2019). "The Platform Business Model Canvas a Proposition in a Design Science Approach" *American Journal of Management Science and Engineering* 4 (6), 91.
- Eppler, M. J., F. Hoffmann and S. Bresciani (2011). "NEW BUSINESS MODELS THROUGH COLLABORATIVE IDEA GENERATION" *International Journal of Innovation Management* 15 (06), 1323–1341.
- Evans P.C., Gawer A (2020). *The Rise of the Platform Enterprise A global Survey*. The Center of Global Enterprise.
- Forrester, J. W. (2007). "System dynamics—the next fifty years" *System Dynamics Review* 23 (2-3), 359–370.
- Foss, N. J. and T. Saebi (2017). "Fifteen Years of Research on Business Model Innovation" *Journal of Management* 43 (1), 200–227.
- Fuller, J., Jacobides, M. G., & Reeves, M. (2019). "The myths and realities of business ecosystems." *MIT Sloan Management Review*, 60(3), 1-9.

- Frank, U. (2013). "Domain-Specific Modeling Languages: Requirements Analysis and Design Guidelines". In I. Reinhartz-Berger, A. Sturm, T. Clark, S. Cohen and J. Bettin (eds.) *Domain Engineering*, pp. 133–157. Berlin, Heidelberg: Springer Berlin Heidelberg.
- Gordijn, J. and H. Akkermans (2001). "Designing and evaluating e-business models" *IEEE Intelligent Systems* 16 (4), 11–17.
- Gottschalk, S., F. Rittmeier and G. Engels (2020). "Hypothesis-driven Adaptation of Business Models based on Product Line Engineering". In: *2020 IEEE 22nd Conference on Business Informatics (CBI)*: IEEE, pp. 134–143.
- Gottschalk, S., F. Rittmeier and G. Engels (2019). "Business Models of Store-Oriented Software Ecosystems: A Variability Modeling Approach". In: B. Shishkov (ed.) *Business Modeling and Software Design*, pp. 153–169. Cham: Springer International Publishing.
- Gregor, S. and A. R. Hevner (2013). "Positioning and Presenting Design Science Research for Maximum Impact" *MIS Quarterly* 37 (2), 337–355.
- Gregor, S. and D. Jones (2007). "The Anatomy of a Design Theory" *Journal of the Association of Information Systems* 8, 312–335.
- Handelsblatt (2020). *Zulieferer-Trio um Bosch greift etablierte Autobauer an*. URL: <https://www.handelsblatt.com/technik/thespark/baukasten-fuer-e-autos-zulieferer-trio-um-bosch-greift-etablierte-autobauer-an/25630510.html?ticket=ST-801123-y3PrsmCZwKcNth5Zfpaf-ap2> (visited on: 18.11.2020).
- Hein, A., M. Schreieck, T. Riasanow, D. S. Setzke, M. Wiese, M. Böhm and H. Krcmar (2020). "Digital platform ecosystems" *Electronic Markets* 30 (1), 87–98.
- Hevner, March, Park and Ram (2004). "Design Science in Information Systems Research" *MIS Quarterly* 28 (1), 75.
- Hyvärinen, H., M. Risius and G. Friis (2017). "A Blockchain-Based Approach Towards Overcoming Financial Fraud in Public Sector Services" *Business & Information Systems Engineering* 59 (6), 441–456.
- Jacobides, M. G., C. Cennamo and A. Gawer (2018). "Towards a theory of ecosystems" *Strategic Management Journal* 39 (8), 2255–2276.
- John, T., D. Kundisch and D. Szopinski (2017). *Visual Languages for Modeling Business Models: A Critical Review and Future Research Directions*.
- Karl, H., D. Kundisch, F. Meyer auf der Heide and H. Wehrheim (2019). "A Case for a New IT Ecosystem: On-The-Fly Computing" *Business & Information Systems Engineering* 84 (3), 488.
- Kapoor, R. (2018). "Ecosystems: broadening the locus of value creation" *Journal of Organization Design* 7 (1), 39.
- Kiesling, E., M. Günther, C. Stummer and L. M. Wakolbinger (2012). "Agent-based simulation of innovation diffusion: a review" *Central European Journal of Operations Research* 20 (2), 183–230.
- Krumeich, J., Werth, D., and Loos, P. (2013). "Interdependencies between Business Model Components - A Literature Analysis" In: *Nineteenth Americas Conference on Information Systems (AMCIS 2013)*, Chicago, Illinois, USA.
- Lagemann, H., M. Boßlau and H. Meier (2015). "The Influence of Dynamic Business Models on IPS2 Network Planning – An Agent-Based Simulation Approach" *Procedia CIRP* 30, 102–107.
- Massa, L., C. L. Tucci and A. Afuah (2017). "A Critical Assessment of Business Model Research" *Academy of Management Annals* 11 (1), 73–104.
- McAfee, A. and E. Brynjolfsson (2017). *Machine, platform, crowd. Harnessing our digital future*. New York: W.W. Norton & Company.
- Miller, G. A. (1956). "The magical number seven, plus or minus two: some limits on our capacity for processing information" *Psychological Review* 63 (2), 81–97.
- Moellers, T., L. von der Burg, B. Bansemir, M. Pretzl and O. Gassmann (2019). "System dynamics for corporate business model innovation" *Electronic Markets* 29 (3), 387–406.
- Nakagawa, H., A. Nagai and T. Ito (2012). "A Framework for Collaborative Business Development Based on Middle Agent Model". In: D. Hutchison, T. Kanade, J. Kittler, J. M. Kleinberg, F. Mattern, J. C. Mitchell, M. Naor, O. Nierstrasz, C. Pandu Rangan, B. Steffen, M. Sudan, D. Terzopoulos, D. Tygar, M. Y. Vardi, G. Weikum, H. Jiang, W. Ding, M. Ali and X. Wu (eds.)

- Advanced Research in Applied Artificial Intelligence*, pp. 679–688. Berlin, Heidelberg: Springer Berlin Heidelberg.
- Nickerson, R. C., U. Varshney and J. Muntermann (2013). “A method for taxonomy development and its application in information systems” *European Journal of Information Systems* 22 (3), 336–359.
- Nicolini, D. (2013). *Practice Theory, Work, and Organization. An Introduction*. First edition. Oxford: Oxford University Press.
- Ojo, A., Curry, E., Janowski, T., & Dzhusupova, Z. (2015). Designing Next Generation Smart City Initiatives: The SCID Framework. In M. P. Rodríguez-Bolívar (Ed.), *Transforming City Governments for Successful Smart Cities* (pp. 43–67). Cham: Springer International Publishing.
- Osterwalder, A. and Y. Pigneur (2010). *Business model generation. A handbook for visionaries, game changers, and challengers*.
- Osterwalder, A., Y. Pigneur and C. L. Tucci (2005). “Clarifying Business Models: Origins, Present, and Future of the Concept” *Communications of the Association for Information Systems* 16.
- Parker, G. G., M. W. van Alstyne and S. P. Choudary (2017). *Platform revolution. How networked markets are transforming the economy - and how to make them work for you*. New York: W. W. Norton & Company.
- Pauli, T., Marx, E., Dunzer, S. and Matzner, M. (2020). Modeling Platform Ecosystems. In: *ER Forum, Demo and Poster 2020*.
- Peffer, K., M. Rothenberger, T. Tuunanen and R. Vaezi (2012). “Design Science Research Evaluation”. In: D. Hutchison, T. Kanade, J. Kittler, J. M. Kleinberg, F. Mattern, J. C. Mitchell, M. Naor, O. Nierstrasz, C. Pandu Rangan, B. Steffen, M. Sudan, D. Terzopoulos, D. Tygar, M. Y. Vardi, G. Weikum, K. Peffer, M. Rothenberger and B. Kuechler (eds.) *Design Science Research in Information Systems. Advances in Theory and Practice*, pp. 398–410. Berlin, Heidelberg: Springer Berlin Heidelberg.
- Peffer, K., T. Tuunanen, M. A. Rothenberger and S. Chatterjee (2007). “A Design Science Research Methodology for Information Systems Research” *Journal of Management Information Systems* 24 (3), 45–77.
- Reuver, M. de, C. Sørensen and R. C. Basole (2018). “The Digital Platform: A Research Agenda” *Journal of Information Technology* 33 (2), 124–135.
- Schuir, J., J. Vogel, F. Teuteberg and O. Thomas (2020). “Understanding the Augmented and Virtual Reality Business Ecosystem: An e3-value Approach”. In: B. Shishkov (ed.) *Business Modeling and Software Design*, pp. 240–256. Cham: Springer International Publishing.
- Schwarz, J. S. and C. Legner (2020). “Business model tools at the boundary: exploring communities of practice and knowledge boundaries in business model innovation” *Electronic Markets* 30 (3), 421–445.
- Sorri, K., M. Seppänen, K. Still and K. Valkokari (2019). “Business Model Innovation with Platform Canvas”. 1-13 Sider / *Journal of Business Models*, Årg. 7 Nr. 2 (2019): *Journal of Business Models* / *Journal of Business Models*, Årg. 7 Nr. 2 (2019): *Journal of Business Models*.
- Spee, A. P. and P. Jarzabkowski (2009). “Strategy tools as boundary objects” *Strategic Organization* 7 (2), 223–232.
- Stadtländer, M., T. Schoormann, and R. Knackstedt, (2021). “Capturing the Dynamics of Business Models: Towards the Integration of System Dynamics and Reference Modeling.” In: *Proceedings of the International Conference on Wirtschaftsinformatik (WI)*, Duisburg-Essen/virtual, Germany
- Star, S. L. and J. R. Griesemer (1989). “Institutional Ecology, ‘Translations’ and Boundary Objects: Amateurs and Professionals in Berkeley’s Museum of Vertebrate Zoology, 1907–39” *Social Studies of Science* 19 (3), 387–420.
- Szopinski, D., T. Schoormann, T. John, R. Knackstedt and D. Kundisch (2019). “Software tools for business model innovation: current state and future challenges” *Electronic Markets* 60 (11), 2794.
- Täuscher, K. and N. Abdelkafi (2017). “Visual tools for business model innovation: Recommendations from a cognitive perspective” *Creativity and Innovation Management* 26 (2), 160–174.
- Teece, D. J. (2018). “Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world” *Research Policy* 47 (8), 1367–1387.

- TheInnovator (2020). *The Platform Economy*, URL:<https://innovator.news/the-platform-economy-3c09439b56> (visited on: 18.11.2020).
- Tiwana, A. (2014). *Platform ecosystems. Aligning architecture, governance, and strategy*. Waltham, MA: MK.
- Turber, S. & Smiela, C. (2014). "A Business Model Type for the Internet of Things." *Twenty Second European Conference on Information Systems*, Tel Aviv.
- van Alstyne, M., G. Parker and S. P. Choudary (2016). "Pipelines, platforms, and the new rules of strategy" *Harvard business review : HBR* 94 (4), 54–62.
- Veit, D., E. Clemons, A. Benlian, P. Buxmann, T. Hess, D. Kundisch, J. M. Leimeister, P. Loos and M. Spann (2014). "Business Models" *Business & Information Systems Engineering* 6 (1), 45–53
- Volkswagen AG (2020). *Volkswagen develops the largest digital ecosystem in the automotive industry* URL:<https://www.volkswagenag.com/en/news/stories/2018/08/volkswagen-develops-the-largest-digital-ecosystem-in-the-automot.html> (visited on: 18.11.2020).
- Wenger, E. (2018). *Communities of practice. Learning, meaning, and identity*. 23rd printing. Cambridge: Cambridge University Press.
- Wirtz, B. W. (2020). *Business Model Management. Design - Process - Instruments*. 2nd ed. Cham: Springer International Publishing AG.
- Yoffie, D. B., Gawer, A., & Cusumano, M. A. (2019). "A study of more than 250 platforms a reveal why most fail." *Harvard Business Review*.
- Zoric, J. (2011). "Connecting business models with service platform designs: Exploiting potential of scenario modeling" *Telematics and Informatics* 28 (1), 40–54.
- Zsifkovits, M., G. Barbeito, S. Pickl and G. Pauli (2016 - 2016). "System Dynamics Modeling for Analyzing Business Model Innovation". In: *2016 5th IIAI International Congress on Advanced Applied Informatics (IIAI-AAI)*: IEEE, pp. 749–754.