LINKING DIGITAL B2B PLATFORM BUSINESS MODELS AND PRODUCT DEVELOPMENT: A BIBLIOMETRIC ANALYSIS AND LITERATURE REVIEW

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ABSTRACT

Developing digital platform business models, especially in business-to-business (B2B) markets, has a high potential for companies who successfully develop their products in generations. The model of SGE - System Generation Engineering describes the development of mechatronic systems on subsystem level. The authors investigate to what extent a comprehensive and unified methodology can be identified, connecting the research areas of product development and digital B2B platform business models. Therefore, this study conducted a bibliometric analysis of scientific data to identify a research gap and a qualitative literature review to affirm the relevance of future research in this research area. The results show a gap between the research areas of digital B2B platform business models and product development. Essentially, several renowned platform researchers suggested performing future research with a methodology that fulfils the following purposes: (1) improve the general understanding of digital platforms, (2) understand their success factors and development, and (3) deal with challenges (e.g., monetization) and loss of valued personal relations in B2B markets through digitization.

Keywords: New product development, Business models and considerations, Research methodologies and methods, digital platforms, SGE - System Generation Engineering

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1 INTRODUCTION

Nearly 35 % of the business models used by the top 20 highest revenue-generating companies are based on digital platforms (Ziegler et al. 2022). The forecast for 2025 predicts digital platforms will account for more than 30 % of the global economy, irrespective of company size (Hasler & Schallmo 2021). Apple Inc's digital platform business model is seen as best practice in the business-to-consumer (B2C) market (Steur & Bayrle 2020). Annually, Apple Inc. launches new product generations, such as the iPhone and iPad. These digital platform business models often only generate customer benefits together with mechatronic systems. The model of SGE - System Generation Engineering describes the development of mechatronic systems on subsystem level. While adaptation takes place through carryover variation (CV), the new development of subsystems occurs through attribute variation (AV) and principle variation (PV) (Albers & Rapp 2022; Albers et al. 2022). Thus, business models in product development can be seen as part of products (Albers et al. 2020). Based on Ropohl's (2009) understanding products are systems. Implementing digital platforms in the business-to-business (B2B) market is becoming more common (Shree et al. 2021), since it is an essential strategy to remain competitive in the advancing digitalisation and adapt to market developments. More and more established companies are trying to enter markets with digital platform business models (Basler de Roca 2022). Although, these companies successfully develop their products in generations, designing and growing digital B2B platform business models tend to be very challenging for practitioners. Current business development processes are designed for pipeline business models and do not grasp the logic of digital platforms business models (Brecht et al. 2021). Therefore, this paper aims to clarify if there is a need for methodological support by investigating the following research question: To what extent can a comprehensive and unified methodology be identified that connects the research areas of product development and digital B2B platform business models? A methodology is the science and doctrine that deals with methods (IPEK 2020b). A bibliometric analysis assessed 3912 scientific articles to confirm the research gap, while a qualitative literature review identified the relevance for future research in this field. The bibliometric analysis extracted a co-occurrence network map visualizing how only a few papers connect the research areas of product development and digital B2B platform business models. Validation was also found in multiple research papers suggesting the necessity of research in this field and a comprehensive methodology to develop digital B2B platform business models according to physical product generation, aimed at providing benefits to practitioners. This study is structured as follows. The following Section introduces the theoretical foundations such as SGE, digital platform business models, and B2B markets. In Section 3, the applied methods of bibliometric analysis and literature review are explained, and the results are presented in Section 4. In the final Section, a conclusion is provided with a summary of the study, revealing its limitations and indications for future research.

2 THEORETICAL FRAMEWORK

2.1 SGE - System Generation Engineering

A new and applicable model for product development is PGE - Product Generation Engineering proposed by (Albers et al. 2015). The underlying hypothesis states that every product development can be traced back to a mapping of the elements of a reference system. This mapping must be suitably assembled using a variation operator with three variation types: PV, embodiment variation (EV), and CV for the subsystems of a new system or a new product generation. Thus, establishing a description model of product development, which allows the variation share of systems to be described on the overall product level and its differentiation according to subsystems (Albers et al. 2015; Albers et al. 2019). In a more recent publication, researchers have shown that the model of PGE can also be adapted and applied for systems development. In this version, the researchers refer to it as the model of SGE - System Generation Engineering, which contains procedures and dependencies in the product development process (Albers & Rapp 2022).

2.2 Digital platform business models

Traditional companies are characterized by a linear value chain (Zhao et al. 2020). Within these pipeline companies, value creation takes place successively, starting with the raw material supplier

and continuing through the manufacturer to the end customer (Parker et al. 2017). Contrastingly, the [digital] platform's overriding purpose is not selling services but realizing matches between users (Bünte 2020; Parker et al. 2017). The [digital] platform [business model] provides the infrastructure and acts as an intermediary between the service producer and the consumer (Bünte 2020). In this context, Parker et al. (2017) define a platform as "[...] a business based on enabling value-creating interactions between external producers and consumers" (p.5). Thus, a digital platform is based on a [digital] platform business model acting as an intermediary that offers an interactive ecosystem for exchange to diverse actors from different market sides (Parker et al. 2017; Dahm & Thode 2019).

2.3 B2B markets

In B2B markets, the end customers are companies (Werani 2012). Purchasing decisions usually have a multi-personal character and are often made by the buying center. Hence, sale representatives conduct sales (Rėklaitis & Pilelienė 2019) instead of online marketing channels, which B2C companies commonly rely on. Furthermore, demand is structured more formally by requesting quotations and tendering. Werani (2012) points out that the purchasing process is highly interactive, and the value proposition is more customized (Werani 2012). Brennan et al. (2020) highlight that one cannot between B2B and B2C markets based on product or service features.

3 METHODOLOGY

3.1 Bibliometric analysis

The goal of this bibliometric analysis is to identify and illustrate research gaps in-between the research topics of product development and digital platform business development as part of the product. This method is chosen as it visually represents large amounts of bibliographic data. Co-occurrence analysis uses the counting of paired data within the collection unit to explore patterns and structures of the underlying network (Buzydlowski 2015). VOSViewer, a tool that allows constructing and visualizing bibliometric data, is used in this research (VOSviewer 2022). Other researchers, such as Hasler & Schallmo (2021), have used this approach to identify research areas underrepresented in academic literature and derive a research agenda. Data from Scopus (2022) is collected and merged as a data set for the analysis. Two searches took place in the database; the first regarded the keywords "product generation engineering" and "product develop*"; the second keywords were "digital platform" and "platform business model". The keyword frequencies are displayed in Table 1. Unsurprisingly, the search term "product generation engineering" only occurred twice. One possible explanation could be that related papers usually do not apply this term as a keyword.

Table 1. Overview of most frequently occurring keywords.

Keyword	Occurrences
Product development	656
Product design	450
New product development	249
Digital platform	212
Innovation	148
Commerce	144
Decision making	133
Sustainable development	118
Digital transformation	115
Life cycle	113
…	
PGE - Product Generation Engineering	2
…	

The co-occurrence analysis ran with keywords that occurred at least 30 times. Table 1 provides an overview of the most frequently occurring keywords in the data set. The results of the analysis are described in Section 4.2.

3.2 Literature review

In the second step of this research, the authors aimed to identify literature highlighting the relevance of a methodology to develop digital B2B platform business models. For this purpose, the authors proceeded according to the process recommended by the Technical University of Denmark (Coursera 2022). In this process, the primary tool is the so-called "log book" that helps researchers to structure and record their search for information.

Table 2. Log book search blocks.

Block 1: "B2B market"		Block 2: "future research"		Block 3: "digital platforms"
"B2B" OR "Business to Business" OR "B2B*market" OR "B2B*platforms"	A N D	"research gap" OR "future research" OR "research opportunities" OR "research directions"	A N D	"digital business model" OR "product develop*" OR "platform economy" OR "platform business model" OR "multi-sided markets" OR "two-sided markets" OR "platform markets"

In the first process step, the authors investigated the relevance of future research in developing a methodology for digital platform business models in a B2B market setting. Subsequently, the authors derived several facets relevant to the search, the so-called blocks. The blocks are "future research", "digital platforms", and "B2B market". Initially, the authors included a fourth block named "product development" but linking this block to the others led to no results in Scopus. It hinted at the evidence regarding a research gap in this research area. Next, the authors collected related terms and synonyms for each block. The block "digital platforms" contained, for instance, the terms "digital business model" and "two-sided markets". Afterward, the authors combined the building blocks with the logic operators "and" and "or" and entered them into the databases Google Scholar, Research Gate, Scopus, and Web of Science. The authors limited their search to literature from 2017 to 2022 and articles in English and German. The authors conducted multiple searches from 4 January to 18 March 2022 and continued refining their search terms. The result of this process is presented in Section 4.2.

4 RESULTS AND DISCUSSION

4.1 Overview about terminology used to define the resulting artifact

When defining the research goal and determining what kind of artifact (e.g., concept, framework, method) should be searched, several terms come to mind. To decide and communicate which artifact the authors want to design with this research, an overview about this terminology is displayed in Table 3. This source for definitions is used as it provides the most common and generic description and avoids definitions from research that do not promote a common understanding. Some terms have multiple definitions in dictionaries. The resulting artifact was defined by the authors as a methodology because it is comprehensive and covers various processes and methods.

Table 3. Overview about terminology.

	Conceptual meaning		Operational meaning		
	Class	Differentiating Characteristics	Class	Differentiating Characteristics	Reference
Concept (Cambridge Dictionary 2022a)	a principle or idea.	-	a concept is a mental construction	intended to support the solution of a problem or the satisfaction of a need.	(Samset 2020)
Framework (Cambridge Dictionary 2022b)	a system of rules, ideas, or beliefs	that is used to plan or decide something.	in computing, a framework is a modular workbench	that provides a set of libraries, tools and conventions that are used in the development of applications.	(Vallet et al. 2018)

Method (IPEK 2020a)	is a goal-oriented procedure	that has a descriptive character and represents the generalized background of certain application cases.	a method is a way of conducting research	that is used in a specific study or type of study	(Whaley 2014)
Methodology (IPEK 2020b)	is the science and doctrine	that deals with methods.	A methodology is a concept	for the development of science, and a concept is a methodology for moving from theory to practice.	(Jabbarova 2020)
Model (IPEK 2021a)	is an abstract description of reality	with depiction feature, reduction feature, and pragmatic feature.	A model is a well-formed, adequate, and dependable artifact	that represents other origin artifacts.	(Thalheim 2017)
Process (IPEK 2021b)	is a description of courses of events	that often specify conditions and timely instances.	A business process is a series of activities	that produces a product or service for a customer.	(Rust et al. 2011)
System (IPEK 2020c)	is a "compilation" of multiple elements	that interact among each other in common.	A system is an arrangement of parts or elements	that together exhibit behavior or meaning that the individual constituents do not.	(Dori et al. 2020)

4.2 Identification of potential research gap via bibliometric analysis

The dataset analysed included 3912 papers from two conducted Scopus searches, one related to keywords about product development and the other on platform development. The papers were published between 2019 and 2022 and had 3786 unique authors. Figure 1 shows the number of papers based on citations, unique authors per year, original document language, and document type. Figure 2 displays the co-occurrence network maps A, B, and C. Map A shows all selected keywords and their connections. Map B focuses on the connections of "digital platforms" to other keywords, while Map C focuses on the connections between "product development" and other keywords. These two keywords were investigated more closely as they are the most dominant in their respective networks. "Product design" is regarded as a part of "product development". The chosen strength is related to how often two keywords are provided in the same paper. Strength ten means that two keywords A and B occurred ten times in the same paper. Only links with a strength of ten or higher were drawn to provide better visualization of clusters and connections between keywords. Lowering the strength would lead to more connections being displayed in the resulting map, which in turn leads to a less interpretable figure. The colour choice has no specific meaning, it only shows the differences in the network map between keywords. From the maps B and C, it is evident that there is no significant connection between the two most common keywords "digital platforms" and "product development" (red and green cluster).
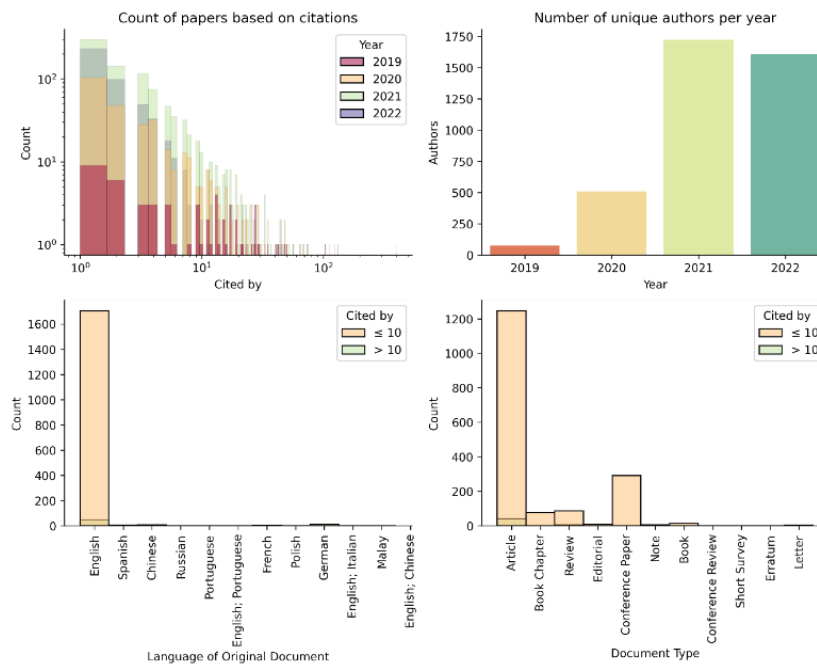
Figure 1 Dataset selection

The strongest connection occurs between "digital platforms" to "product design" (map B), and "product development" to "commerce" and "innovation" (map C). A connection between "digital platforms" and "product development" is absent, revealing limited research in how digital platforms are derived from product-based companies focused on product developments or PGE. In this research, the search term "product generation engineering" was used to identify research with this keyword. The network did not represent this keyword because it did not surpass the threshold of 30 occurrences (see Section 3.1).
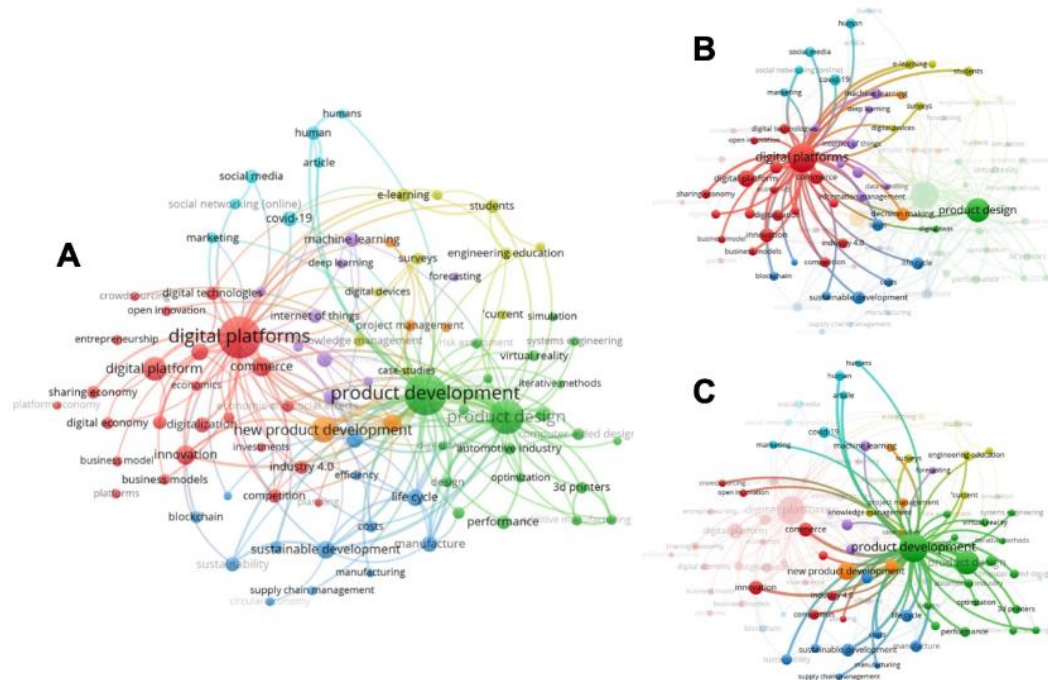

Figure 2. Co-occurrence network maps.

4.3 Relevance analysis of a methodology based on scientific literature

In this section, the results from the information search based on the procedure described in Section 3.2 are presented. The search resulted in a total of 16 articles that the authors deemed relevant to different

degrees. Following a paired comparison approach the authors came together in workshops to estimate the relevance of the given articles to the research question similarly to existing research (Miranda 2001). The relevance was expressed through a numerical rating of 9 (highest), 6 (base), and 3 (lowest). Three articles are considered valuable in the search for evidence of a relevant methodology with the purpose of digital B2B platform business model development. The ranking of the selected 16 articles is based on how fitting the scientific paper are regarding the topic of digital B2B platform business development and future research suggestions. Table 4 shows the details regarding the articles with relevance rating 9. The authors name the respective article, the provided keywords, a short summary from the respective paper, and the suggested research. All three articles, including their title and keywords, are concerned with method developments to improve digital platform development. The first two papers synthesize existing research in the field of digital platforms by applying methods like bibliometric analysis.

Table 4. Identified research papers with rating "9" and the respectively derived questions.

Paper	Summary based on cited authors	Suggested research
Digital platforms for business-to-business markets: A systematic review and future research agenda (Shree et al. 2021).	"The evolution of digital platforms has transformed the way businesses operate. Digital platforms have become popular and common in Business-to-Business (B2B) markets, thereby leading to increased interest of researchers. This review presents a synthesis of the last ten years of research on digital platforms in B2B markets. the current study identifies the technological, organizational, and environmental context-based factors that play a major role in adoption of digital platforms in B2B markets" (Shree et al. 2021).	"The adoption of the platform in B2B context is an emerging research area, and it is yet to gain more attention of researchers" (Shree et al. 2021). "[…] need for stronger theoretical frameworks to better understand the adoption of digital platforms in B2B context" (Shree et al. 2021). "Value co-creation […] not been given sufficient attention in the context of B2B platforms which are more complex in nature" (Shree et al. 2021). " […] explore both strategies from the platform service provider perspective and the implications on stakeholders and their response mechanisms" (Shree et al. 2021).
Bibliometric Analysis of Digital Platforms: Current State and Future Research (Hasler & Schallmo 2021).	"We identified the major research streams and clustered them with a co-citation network analysis. For example, academic literature has mainly focused on B2C (Business-to-Consumer) platforms, with research on B2B (Business-to-Business) platforms being sparse. Furthermore, academic literature has yet to develop guidelines and procedures for establishing digital platforms in general and to improve knowledge transfer to practitioners" (Hasler & Schallmo 2021).	"Investigate what effective communication measures via digital platforms look like and how they affect marketing and business strategy" (Hasler & Schallmo 2021). " […] examine what factors beneficially influence adoption of digital platforms in companies of different sizes" (Hasler & Schallmo 2021). "Smaller companies, especially, struggle to find their role in platform-driven digital ecosystems. Further research could address questions on how to facilitate knowledge transfer on digital platforms from research to practitioners, helping with the make-or-join decision" (Hasler & Schallmo 2021). Further research could build upon this with the goal of creating more comprehensible structural and procedural models for digital platform development in a B2B context. It would also be interesting to consider the role of grey literature in this context if there are no theoretical models available" (Hasler & Schallmo 2021).

Platform Patterns - Using Proven Principles to Develop Digital Platforms (Drewel et al. 2021).	"Small and medium-sized enterprises (SMEs) are already facing the threat of losing direct consumer contact and becoming exchange-able executers. In order to prevent this, it is important to anticipate at an early stage which strategic options exist for the future platform economy and which adjustments to the product program should already be initiated today. Basically, medium-sized companies in particular lack a strategy for an advantageous entry into the future platform economy. We show how we derived a catalogue with 37 identified platform patterns. The catalogue has a generic design and can be customized for a specific use case" (Drewel et al. 2021).	"Further approaches, such as specification techniques to describe platforms, are needed to support companies in coping with the transformation from pipeline to platform markets" (Drewel et al. 2021). "Moreover, we were able to gain some additional theoretical insights, e.g., (a) platform categories are often taken up in the scientific discussion but a uniform differentiation does not exist yet. (b) Besides technical knowledge gaps, companies often do not know how to earn money with platforms. (c) The manufacturing industry is particularly concerned about the loss of consumer access due to digital platforms" (Drewel et al. 2021).

The results displayed in Table 4 highlight a need for a methodology that fulfils the following purposes: (1) improve the general understanding of digital platforms (Shree et al. 2021), (2) understand their success factors and development (especially in B2B markets) (Hasler & Schallmo 2021), and (3) deal with challenges (e.g., monetization) and loss of valued personal relations in B2B markets through digitization (Drewel et al. 2021). These future research suggestions are also visible in the last column.

5 CONCLUSION AND OUTLOOK

The results of the bibliometric analysis and literature review have shown a research gap for a methodology in the development of digital B2B platform business models in product development. The evidence is only based on scientific literature only, revealing one research limitation. The model of SGE according to Albers (2022) describes the development of new systems. Future research should investigate the methodological relevance for digital B2B platform business model development has in mechatronic systems. Therefore, the authors suggest conducting a survey or interviews with experts in digital B2B platform business model development in the product development context. Future research should investigate what requirements the methodology should meet to make it applicable and relevant in practice. The study results can be used for the investigation, for example, by constructing survey and interview questions based on the literature findings. Consecutively, future research should apply and test the developed methodology in a real-life setting and draw comparative conclusions regarding other methods and tools currently used to support digital B2B platform business model development.

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