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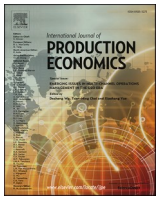

When manufacturers turn into digital platform providers: A transformation model to understand the platformization pathway

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ABSTRACT

Platformization has arrived in manufacturing. However, to enter the digital platform business manufacturers need to make a fundamental shift from product thinking to platform thinking. To master this shift, firms have to take the platformization pathway, which describes the process when manufacturers turn into digital platform providers. However, little is known about platformization on the firm level from a transformation perspective. Our study attempts to close this gap and develops a transformation model that frames the platformization pathway when established manufacturers become platform leaders. For this purpose, we adopt the concept of ambidexterity and develop a theoretical framework to conceptualize and investigate the transformation process as a result of sequential transitions and balancing between explorative and exploitative activities. Moreover, we use interviews from 29 large manufacturers and conduct an inductive case study analysis to identify the different stages, the contextual factors and the dynamics of transformation. By combining the theoretical framework and the results of our case study analysis, we develop a formal transformation model that contributes to understanding the manufacturers' platformization pathway. Our results also aim to support manufacturers in designing their strategies so they can turn into leading digital platform providers.

1. Introduction

The ongoing digitization has continuously increased the pressure on manufacturers to enter the platform business (Pauli et al., 2021). In this respect, Riemensperger and Falk (2020) argue that there is a need within companies to make the shift from product thinking to platform thinking. According to the recent literature, it represents a long-term process driven by overcoming technical and organizational challenges (Pauli et al., 2021), by continuously expanding digital capabilities and resources within the company (Cenamor et al., 2017) as well as by offering data-driven business models complementing physical products for creating added value (Pekkarinen and Ulkuniemi, 2008; Riemensperger and Falk, 2020; Tian et al., 2022). This means that the 'platformization' at the firm level (Reuver et al., 2018; Poell et al., 2019; Weking et al., 2020) can be described not only as a paradigm shift from product thinking to platform thinking, but also as a long-term transformation process that a manufacturer must undergo before becoming a digital platform provider.

Literature presumes, that this challenging transformation is the reason why hardly any platforms have been set up in manufacturing so far, which are home to large digital ecosystems with numerous players due to multi-sided markets and platform-based business models (Riemensperger and Falk, 2020; Pauli et al., 2021). Apart from a few well-known and successful examples, such as Bosch IoT Suite, ABB Ability or BMW ConnectedDrive (Gerrikagoitia et al., 2019; Weiss et al., 2022), the vast majority of industrial firms have difficulties in establishing and successfully operating their own platforms (Lerch and Heimberger, 2022). This begs the so far unaddressed question, namely how precisely established manufacturers turn into leading digital platform providers. In this paper, we contribute to filling this gap by developing an explanatory model that sheds more light on the transformation process of the so-called platformization pathway.

To construct this model, we draw upon the contemporary dynamic perspective of ambidexterity literature, which emphasizes the importance of dynamically balancing the utilization of existing business models' capabilities and resources while simultaneously exploring new possibilities (Luger et al., 2018). This approach, expands the companies' business horizon, enabling them to both exploit their current strengths and explore novel opportunities (O'Reilly III and Tushman, 2008; Raisch and Tushman, 2016; Raisch and Zimmermann, 2017). Using this

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ambidexterity logic, we explain the transformation process of manufacturers as a series of stages resulting from an interplay between sequences of transitions between explorative and exploitative activities (Raisch and Tushman, 2016; Raisch and Zimmermann, 2017). From the practical perspective, it means that manufacturers open new business opportunities by continuously adapting existing business models to new market needs by integrating new or (re-)locating existing resources and capabilities (Teece et al., 1997; Eisenhardt and Martin, 2000; O'Reilly III and Tushman, 2008), for example by using digital technologies for new products and services (Baines et al., 2009). These single transitions characterize in sum a systematic transformation process explaining the pathway manufacturers follow when aiming at becoming digital platform providers.

As a transformation in companies does not occur in an isolated environment, it is necessary to understand the organizational change as a whole when examining the platformization pathway. Studies that look at the process of organizational change often use stages to illustrate the transformation process (Kotter, 1995; Kotter and Cohen, 2002). Stage models describe the fundamental change of an organization (Baines et al., 2020) and characterize specific situations by taking contextual factors into account. Contextual factors are thereby seen as central to shaping the balancing activities between exploration and exploitation (Gibson and Birkinshaw, 2004), and thus the whole transformation, regarding that the behavior of firms is strongly influenced by the particular situation and has to be considered with a view to time (Pye and Pettigrew, 2005). Therefore, we adopt the logic of contextual factors for examining the determinants of the transformation process following the model of Baines et al. (2020), who used it to explain the servitization transformation process, which currently closely relates to platformization.

To summarize, we define the platformization pathway as the transformation process that a manufacturer undergoes to become a digital platform provider. We conclude, that there are three main elements to be explored in order to understand the platformization pathway of manufacturers as a transformation process: (i) single stages of the process from a traditional product provider to a digital platform provider, (ii) dynamics resulting in process flows and thus in single transitions between the stages driven by continuous balancing between explorative and exploitative activities, (iii) contextual factors, determining the process flows and shaping the transformation. Considering this, we target the following research questions for our study:

RQ1 *What are the stages, dynamics, and contextual factors of the platformization pathway of a manufacturer?*
RQ2 *What does the platformization pathway of a manufacturer look like in a formal transformation model?*

Addressing the first research question, we aim at (i) exploring and integrating single stages of the transformation in a process model, (ii) explaining the dynamics resulting in process flows and (iii) systematizing the contextual factors determining the identified process flows. To answer the second research question, we put the three elements in a common context and use it to design a formal transformation model. Therefore, we conduct a multiple cross-case study research based on 29 cases of large-sized manufacturers with different experiences and progresses in terms of platformization. We do so in order to understand the stages and the dynamics of the transformation characterizing the patterns of progress and the speed of individual flows between the single stages. Furthermore, we explain the contextual factors which play a significant role in determining the process flows. We systematize these using the well-known technology-organization-environment (TOE) framework of Tornatzky et al. (1990).

Our study confirms the presumption that a manufacturer has a challenging journey ahead before becoming a digital platform provider and identifies four stages. The two fundamental difficulties are, on the one hand, to generate revenues during each stage in order to drive the platformization forward and not to stall it due to escalating costs and, on the other hand, to develop capabilities in time to meet the technical and organizational challenges that arise along the transformation. The manufacturers we studied usually start the process by equipping their products with smart devices to collect product and customer data. Some manufacturers are already getting into trouble here by failing to provide chargeable service offerings in good time or to renew their analog processes digitally. During the second stage, firms often struggle to connect their isolated IT solutions, which leads to high costs and dead ends. Here, successful cases from our study initially aim to digitize their customer relationships, resulting in greater process efficiency and customer satisfaction. During the third stage, we can observe that successful firms set up digital business models, in some cases generating high revenues, while others fail in their search for suitable value propositions for their customers. Only a few companies in our analysis, however, are starting to expand their platforms into digital ecosystems in order to advance to the final stage and benefit from platform leadership through economies of scale.

We contribute to the literature in three important ways. First, by explaining the stages of the platformization pathway from the perspective of a transformation process representing a new framework for further studies in this context (Baines et al., 2020). Second, our work provides an unparalleled explanation of the intricate dynamics and fluidity observed in the transformation process. Through a continuous interplay between exploration and exploitation activities, we offer a fresh perspective that adds significant value to the evolving field of the dynamic perspective of ambidexterity research (O'Reilly III and Tushman, 2008; O'Reilly III and Tushman, 2013; Raisch and Tushman, 2016; Raisch and Zimmermann, 2017; Luger et al., 2018; Baines et al., 2020). Third, we contribute to the current literature stream that integrates platforms and servitization (Eloranta and Turunen, 2016; Cenamor et al., 2017; Simonsson et al., 2020; Eloranta et al., 2021; Tian et al., 2022; Tóth et al., 2022), as well as the 'contextual' ambidexterity literature (Gibson and Birkinshaw, 2004), by providing a systematization of the technical, organizational and environmental factors that determine the context of the transformation process (Tornatzky et al., 1990).

We structure our paper as follows. First, we describe the theoretical background for our study, which represents the theoretical framework for the transformation model. We then explain the data base of the case studies and the process of data analysis, before we present the results of our study. In the discussion we develop the propositions and provide the formal transformation model of the platformization pathway. The final section summarizes our implications for research and practice and gives an outlook on the need for further research.

2. Theoretical background

To explain platformization at the firm level from a transformation perspective, we rely on insights of the interplay between dynamics, process and context (Pye and Pettigrew, 2005). We explain **dynamics** of the transformation using the ambidexterity theory, which explains the organizational capability to deal with tensions between exploration and exploitation as the main driver of value creation (Dixon et al., 2017). We interpret the **process** and the **context** of the transformation using the literature on digital platforms explicitly focusing on the challenges and specifics of manufacturing (Riemensperger and Falk, 2020; Lerch and Heimberger, 2022) as well as on the topic of the servitization platform approach (Cenamor et al., 2017; Eloranta et al., 2021), which looks at the merging process of platforms and digital business models.

2.1. Ambidexterity: dynamic balancing of exploration and exploitation

It is crucial for companies to continuously reassess their factors of competitiveness in order to ensure their survival. One of the major trade-offs represents the balance between two central strategies, namely

maintaining existing revenue streams and adapting to new requirements and needs (Gibson and Birkinshaw, 2004; Andriopoulos and Lewis, 2009). This calls for companies' capability to exploit old certainties and explore new possibilities, the so-called ambidexterity (March, 1991). Simultaneously engaging in both exploration and exploitation is essential for companies to achieve long-term performance (Tushman and O'Reilly, 1996). For manufacturers, it means the capability to exploit the competence of producing core products and explore new business opportunities by offering innovative products and services (Ardito et al., 2018; Weidner et al., 2023). Currently, digital technologies play a crucial role in this context (Coreynen et al., 2020). Here, companies face the challenge to balance between developing a digital business model while simultaneously maintaining ongoing activities based on existing capabilities (Dixon et al., 2017; Coreynen et al., 2020).

From the resource-based view, ambidexterity means balancing between allocation and re-configuration of organizational resources and capabilities of the company in order to capture existing as well as new business opportunities (O'Reilly III and Tushman, 2008). Consistent, explorative competences refer to new technologies, knowledge, new products and services for new markets and customers, while exploitative competences rely on existing knowledge, existing products and services for existing customers and markets (Jansen et al., 2006). As such, ambidexterity can be seen as a dynamic capability (O'Reilly III and Tushman, 2008), "the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments" (Teece et al., 1997, p. 516).

As none of these two strategies can guarantee long-term success, companies have to continuously maintain the tension between exploration and exploitation (March, 1991; Raisch et al., 2009; Luger et al., 2018; Horvat et al., 2019; Kim et al., 2019). This concept embodies a dynamic perspective on ambidexterity, asserting that organizations constantly oscillate between activities, and that, as time progresses, organizations gradually fortify their ability to strike a balance between exploration and exploitation (Simsek et al., 2009; Luger et al., 2018). On the one hand, exploration paves the way for exploiting novel offerings in the market (Lavie et al., 2010) and thus to gain returns on their explorative investments. However, to avoid falling into a competence trap and succumbing to path dependency, companies are increasingly amplifying their explorative activities to proactively address future value creation opportunities by developing new resources and capabilities (O'Reilly III and Tushman, 2008; Raisch and Zimmermann, 2017). Due to the inherent uncertainty resulting from limited information, companies often adopt a strategy of staged commitment when embarking on new explorative initiatives (Bowman and Moskowitz, 2001). This approach helps them to mitigate risks by gradually committing resources and efforts as they gather more information and gain a clearer understanding of the venture's viability (Raisch and Tushman, 2016). In other words, companies strategically and gradually adapt their activities to meet the evolving demands of exploration and exploitation.

Considering that ambidexterity is a dynamic capability, it explains a continuous balancing process of shifting resources and capabilities between explorative and exploitative activities, which, by generating new business opportunities, might transform the entire company (O'Reilly III and Tushman, 2008; Birkinshaw et al., 2016). The ongoing character of this process points also to its iterative nature. A high-performing firm will be able to continually re-evaluate such demands and draw on the appropriate structural and contextual factors to optimize the balance between explorative and exploitative activities (Dixon et al., 2017). This is akin to the "constant balancing" proposed by Schreyögg and Sydow (2010), as well as the "high sensing high responding" configuration of highly agile firms suggested by Nazir and Pinsonneault (2012). One can consider this from different business perspectives: from the financial perspective, in times of surplus, companies invest in new resources, e.g. new technologies, while in resource-constrained periods they will focus rather on exploiting existing capabilities (Dos Santos et al., 2012). Similarly, from the market perspective, in times of rapidly changing market conditions, because of e.g. disruptive digital services, companies need to reconfigure resources in order to respond effectively to new needs. Hence, the role of the organization in managing ambidexterity is twofold. First, it must see changing opportunities as a result of market turbulences and evolving innovation. Second, it must respond constantly by effectively allocating the suitable resources and capabilities to explore and exploit at the right time. In other words, in order to balance effectively between exploration and exploitation, companies have to consider both, external factors representing environmental contingencies (Stieglitz et al., 2016), and internal factors characterizing organizational arrangements (Gibson and Birkinshaw, 2004).

For our study, we follow the dynamic perspective on ambidexterity (Raisch and Tushman, 2016; Luger et al., 2018) and introduce the transformation of manufacturers resulting from an iterative process of continuous (re-)location of resources and capabilities in order to balance explorative and exploitative activities with the aim to effectively address market changes. With changing needs, caused by either new market conditions or technological development, companies have to invest in new products and services to create value and thereby maintain competitiveness. However, it does not mean that they will automatically cut the ongoing business activity. They will rather use (exploit) it to further generate revenue and at the same time allocate resources to new or added value based on new products and services (explore). By integrating these new products and services into the business model, companies start to exploit them in everyday business, or in other words, they integrate them into the existing routines of the company. However, these new products and services might serve as a basis for further incremental or even radical transformations (Lin et al., 2013; Khanagha et al., 2014). For example, manufacturers can offer even more complex services based on digital solutions and platforms, and thus transform the company from a traditional manufacturer, into a provider of digital platforms. This significantly new value can even change the core of the company's business model from product thinking into platform thinking.

2.2. *Digital platforms in manufacturing*

Although the platformization process (Reuver et al., 2018; Poell et al., 2019; Lerch and Heimberger, 2022) spills over into manufacturing (Riemensperger and Falk, 2020), there is only little research that explicitly deals with digital platforms of industrial firms (Lerch and Heimberger, 2022). Most of the existing articles dealing with platformization focus on systematization of existing platform types for manufacturers (Hartigh et al., 2023) and analyses their business and market effects (Cozzolino et al., 2021), or examine the technical and organizational challenges in the platformization process (Pauli et al., 2021). There is also a general statement in the current literature that the logic of platform business cannot be transferred simply from the consumer to the manufacturing sector, i.e. due to different mechanisms playing a specific role for different sectors (Riemensperger and Falk, 2020; Pauli et al., 2021). In contrast to other sectors in which only few global platforms share the market, there are numerous players in manufacturing operating their own platforms (Gerrikagoitia et al., 2019; Lerch and Heimberger, 2022). Accordingly, network effects do not come into play, which is why platform-based business models cannot fully develop (Riemensperger and Falk, 2020).

A particular feature represents the diversity of platforms, which can be used by manufacturers depending on their purpose (Lerch and Heimberger, 2022). Transaction platforms aim to establish a connection between suppliers and customers with little effort and thus reduce transaction costs (Benner and Tushman, 2015). These not only simplify the match, but also improve it, as a large number of customers and suppliers can interact through networks (van Alstyne et al., 2016). In manufacturing, capacity sharing platforms (Chronéer et al., 2017; Bettoni et al., 2018) or Production-on-Demand platforms (Schor, 2017) can

be found as part of the transaction platforms in addition to the virtual marketplaces (Evans and Gawer, 2016).

Beyond the transaction platforms, however, Industrial Internet-of-Things (IoT) platforms are of particular interest for production (Gerrikagoitia et al., 2019; Hoffmann et al., 2019). These platforms are able to generate and process large amounts of data in order to trigger data-driven solutions for production and Industry 4.0 (Wang et al., 2020). From the provider's point of view, they serve in particular to support innovative value propositions and to generate data-driven business models (Simonsson et al., 2020; Zhou et al., 2023). Consequently, manufacturers face not only one platform logic, but also several, which adds complexity to the process of platformization compared to other sectors.

Challenges for manufacturers in building digital platforms lie in the technical complexity of the system architecture and in the organizational complexity with regard to new business domains and ecosystems (Pauli et al., 2021). On the one hand, the technical complexity arises in particular from the high demands placed on the system architecture of digital platforms (Baldwin and Woodard, 2009). There are numerous components in the form of modules and layers, which have to be interconnected. Due to the great heterogeneity of the individual systems, platforms often use standardized interfaces that also have to be matched (Baldwin and Woodard, 2009). Furthermore, in case of IoT platforms, there is also the challenge of connecting virtual and physical components (Wang et al., 2020). On the other hand, the organizational complexity of digital platforms comes in particular from their ability to involve a large number of third parties (Reuver et al., 2018). This leads to the need to establish new sales processes and build new inter-organizational relationships (Pauli et al., 2021). A large number of new players on digital manufacturing platforms creates also novel two- or multi-sided markets (Rochet and Tirole, 2003; Armstrong, 2006) that do not exist in this form in the traditional logic of manufacturers. The benefit for an individual player grows with the number of other actors or with the size of the network as a whole (Katz and Shapiro, 1985; Armstrong, 2006), which can lead to platform providers being able to scale their business model very quickly to new competitive situations.

Despite these challenges of implementing digital platforms, they open new windows of opportunities for manufacturers by enlarging their business models. A crucial factor for firms to generate value added from their digital platforms is the offering of digital services or data-driven business models (Hein et al., 2019; Naik et al., 2020; Paiola and Gebauer, 2020). A further stream, which analyses the linkage of digital platforms and value creation, has been considered in the servitization literature (Cenamor et al., 2017; Paschou et al., 2020; Simonsson et al., 2020; Eloranta et al., 2021; Fu et al., 2022; Kapoor et al., 2022; Yan et al., 2022). A central argument of this stream is that the use of digital platforms and the offering of digital services and business models go hand in hand from a certain point of transformation.

2.3. The servitization platform approach

The term servitization goes back to Vandermerwe and Rada (1988) and describes the increasing service orientation of manufacturers (Wise and Baumgartner, 1999; Baines et al., 2009). The focus of the investigation is the integration of products and services into product-service bundles or the so-called Product-Service Systems (PSS) (Mont, 2002; Oliva and Kallenberg, 2003). Beyond the base and intermediate services, which are limited to warranty services, spare parts procurement, maintenance or repairs, the so-called advanced services are of particular interest (Baines and Lightfoot, 2014). Advanced services give rise to new types of business models for product manufacturers. Here, the manufacturer is no longer paid for the product itself, but for its use or performance (Tukker, 2004).

Nowadays, servitization has also been looked at from the perspective of digitization. Paschou et al. (2020) define digital servitization as "a new layer of connected intelligence that automates processes, transforms data, and augments the actions of the organizations enabling companies to provide PSS". In this context, the changes that digitization brings to the servitization process are considered in detail. Digitization does not only increase quality, but also reduces the costs of service offerings (Kindström and Kowalkowski, 2014). In addition, digital technologies often enable manufacturers to offer advanced services in the first place (Vendrell-Herrero et al., 2017). This also has significant implications for the service transformation process (Lerch and Gotsch, 2015; Tronvoll et al., 2020; Ciasullo et al., 2021; Favoretto et al., 2022). Digital technologies and data create new and more complex transformation patterns that finally may result in a convergence of digital service offers and Industry 4.0 applications in one company (Frank et al., 2019). From this context, the perspective of a servitization platform approach developed, that seeks to understand how a digital platform "facilitates the implementation of advanced service offerings in manufacturing firms" (Cenamor et al., 2017). So-called 'digital product-service platforms' focus on the offering of new business models (Simonsson et al., 2020) and how to generate value added by digitalization (Kohtamäki et al., 2020). Cenamor et al. (2017) argue that similar skills and competencies will be required in a single company in order to realize digitization and servitization. A platform approach, which links digital platforms and digital product-service offers, thus represents the logical extension of the servitization perspective on the one hand and shows how to leverage the value of digitalization on the other hand (Kamalaldin et al., 2020; Struyf et al., 2021; Jovanovic et al., 2022; Kohtamäki et al., 2022). Moreover, digital platforms are seen as a solution to overcome the service paradox, as they not only contribute to the customization of offerings, but also to greater process efficiency (Kowalkowski et al., 2013). Through modularization and the creation of platform roles, they enable manufacturers to develop, configure and deliver their product-service offerings (Cenamor et al., 2017). In addition, digital platforms with the help of data-driven analysis can contribute significantly to the development of completely new value propositions for manufacturers' digital product-service offerings and business models (Eloranta and Turunen, 2016; Rohn et al., 2021; Tian et al., 2022).

Conceptually, the servitization platform approach closes the gap between servitization and platformization: while digital platforms are seen as technical enablers for advanced service offerings and new business models (Kowalkowski et al., 2013; Baines and Lightfoot, 2014; Cenamor et al., 2019; Naik et al., 2020), these in turn are necessary to leverage the value of platforms at all (Eloranta and Turunen, 2016; Jovanovic et al., 2022). Consequently, a manufacturer on the platformization pathway will at some point move into servitization in order to derive value from its platform activities. We therefore assume that, a manufacturer becoming a digital platform provider will inevitably also develop into a service and business model provider. The fusion and integration of the two topics (Kapoor et al., 2022; Kohtamäki et al., 2022) suggests that platformization and servitization are two sides of the same coin.

3. Research method

We have set the primary research objective of our study to elucidate the intricate transformation process that occurs when manufacturers transition into digital platform providers. Therefore, the study aims to explore and analyze the various stages and dynamics involved in this transformation, as well as the contextual factors that either stimulate or impede the process of platformization. In line with our research objective, we adopt a qualitative, multiple case study approach (Eisenhardt, 1989; Eisenhardt and Graebner, 2007; Yin, 2009). This approach allows us to conduct a comprehensive analysis of the different stages of the process and delve into the interdependencies among them.

Table 1
Case study overview of the selected companies.

Case	Industry/Business Focus	Size (Revenue/No. of Staff)	Position
Case 1	Manufacturer of Electrical Components	950 M €/5,000–10,000	Head of Digital Marketing Process & Digital Touchpoints
Case 2	Manufacturer of Electric Lamps and Luminaires	1,2 B €/5,000–10,000	Senior eCommerce Digitalisation
Case 3	Provider of networked, environmentally friendly, safe, convenient and cross-material industrial and service solutions	5,5 B €/10,000 and more	Head of eCommerce
Case 4	Agricultural Machinery Manufacturer	3,9 B €/10,000 and more	Teamleader
Case 5	Manufacturer of Door, Window and Security Technology	456 M €/< 5,000	Business Unit Manager Internal Sales
Case 6	Provider Dental Prosthesis Solutions	2 B €/5,000–10,000	Global Head of Digital Marketing & Customer Engagement
Case 7	Manufacturer of Special Glass and Glass Ceramics	2,5 B €/10,000 and more	Sales & Marketing Applications
Case 8	Toy Manufacturer	360 M €/< 5,000	Chief Digital Officer
Case 9	Supplier to the Printing Industry and Ink Manufacturer	2 B €/5,000–10,000	Chief Information Officer
Case 10	Medical Technology	1 B €/5,000–10,000	Product Owner eCommerce
Case 11	Supplier of Technology Products for Thermal Food Preparation for Industrial and Commercial Kitchen	650 M €/< 5,000	Head of eCommerce
Case 12	Producer, Developer and Distributor of Products and Services for Laboratories	1,1 B €/< 5,000	Head of Website Management
Case 13	Producer of Analytical Instruments for Laboratories and Process Analysis Technology and Customized Automation and Robotics Solutions	470 M €/< 5,000	E-Business Manager
Case 14	Manufacturer of Braking Systems for Rail and Commercial Vehicles	6,2 B €/10,000 and more	Manager IT Project Management
Case 15	High Voltage Technology, Metal Fabricator	750 M €/< 5,000	Director Global Order Processing
Case 16	Manufacturer of Lubricant	2,6 B €/5,000–10,000	Chief Digital Officer (Vice President)
Case 17	Manufacturer of Machinery for Agriculture and Farming	354 M €/< 5,000	Business Unit Manager IT
Case 18	Solution Provider for Electrification and Automation	28 B €/10,000 and more	eCommerce Information Systems Lead
Case 19	Manufacturer of Systems for the Mobility of Passenger Cars, Commercial Vehicles and Industrial Technology	38 B €/10,000 and more	Head of Process Management Market Division Industry
Case 20	Manufacturer of Printing Machine	2,3 B €/10,000 and more	Head of IT for Data Integrations & Digital Innovation
Case 21	Manufacturer for Pumps and Pump Equipment	2,3 B €/10,000 and more	Manager Customer, Sales Systems
Case 22	Grain Manufacturer	2 B €/5,000–10,000	IT Projectmanager
Case 23	Development, Manufacturing, Marketing and Sales of Power Tools	4,6 B €/10,000 and more	CRM Program Manager (B2C & B2B)
Case 24	Provider of Digital Farming Systems	44 B €/10,000 and more	Digital Transformation Lead
Case 25	Supplier of Hardware, Software and IT Services	530 M €/< 5,000	Managing Director
Case 26	Supplier for Synthetic Elastomers	302 M €/< 5,000	Head of Marketing Systems
Case 27	Manufacturer of Sanitary Engineering Products	1,1 B €/5,000–10,000	Manager IT Marketing Services
Case 28	Manufacturer of Household, Electrical and Electronic Equipment	627 M €/5,000–10,000	General Manager Business Unit
Case 29	Manufacturer of SMD Placement Machines and Solutions	836 M €/< 5,000	Director Finance Service in Customer Relationship Management

3.1. Selection of case studies

For the case selection, we followed the approach of theoretical or purposeful sampling (Eisenhardt, 1989; Patton, 1990; Seawright and Gerring, 2008), aiming to identify useful cases of transformation on the platformization pathway. We looked for a sample of large manufacturers that can provide an analytical rather than a statistical generalization (Yin, 2009). Following the approach of intensity sampling (Patton, 1990), we targeted companies that can provide us with rich-information manifesting the phenomenon of interest. In a scoping stage we screened 66 potential companies for our case studies. In order to analyze the platformization pathway, we only selected cases that fulfilled the following criteria (see Table 1): manufacturing firms only (precondition), firm size in terms of turnover (comparability), different levels of digitization (variation) and in-depth information on the questions asked (content). Based on these criteria, we finally chose 29 cases for our study.

To select the essential cases, we preferred primarily firms, which possess sufficiently substantial knowledge and experience to assess the questions asked. The assessment of whether a firm has sufficient in-depth knowledge was carried out ex-post. This means that we selected only those interviews for further evaluation, which contained sufficiently substantial answers. Moreover, we considered comparable conditions for developing on the pathway towards becoming a digital platform provider. In order to automatize and digitize operations, processes, production techniques, and advance the digitization of a company, the underlying infrastructure plays a crucial role. Small or medium-sized manufacturers often lack the infrastructural capabilities, which are necessary to achieve a critical degree of digitization and enable digitized products, digital services and the development of digital business models (Ahmed et al., 2022; Rapaccini et al., 2023). This is why we targeted a certain company size in the selection process. There is little evidence in the literature on what is the "right" company size to have a necessary critical infrastructure. Similarly, it is also unclear what exactly a critical digital infrastructure means for the support of the transformation process. Based on the underlying uncertainty, we set an arbitrary company size of at least EUR 300 million in revenue as the critical lower threshold. There is no upper threshold, therefore we considered also large transnational corporations in our selection process. At the same time, this has the effect that we have companies in the case selection that, due to their large network and influence in the value chain, would generally be able to take on the role of a platform leader and consequently could significantly shape a potential platform economy in manufacturing. Finally, to follow the logic of maximum variation sampling (Patton, 1990), we targeted cases with different experiences in terms of platfomization, i.e. they either actively use platforms in their current business models, or they have at least a keen interest to do so in the near future. Similarly, on the one hand we chose cases at the beginning or in the middle of the transformation process, but on the other hand we also selected some companies that have successfully accomplished the transformation process and operate in a digital ecosystem with a variety of digitized products, services and automated processes. In other words, the sampling process ensured that firms with different products, service offerings and business models were sufficiently represented as well as firms at different levels of digitization.

3.2. Data collection

In order to ensure high construct validity based on the data triangulation (Yin, 2009), we used several data collection techniques (Eisenhardt, 1989). Primarily, we conducted interviews in selected companies. We targeted interview partners with substantial knowledge on digital tools and systems used by the company as well as the areas of their application. We assume, for example, that an IT employee might be an expert on the existing digital infrastructure, but would have only limited knowledge on how these tools contribute to the company's business model. We, therefore, looked for persons with an appropriate understanding of the firm's business model and the interlinkages of different business units via the existing digital infrastructure. Furthermore, we addressed employees with significant involvement in developing and implementing new processes and business models within the company, i.e. persons with a broad view of the respective firm's digital transformation path in general. Based on these criteria, we sampled a target group of executives in departments, focusing on digitalization and business as e.g. digital sales units, in business development, digital marketing and distribution and further adjacent departments. Each interview lasted between 45 and 60 min and with the permission of the interview partners we recorded and transcribed the interviews for subsequent coding. For our study, 29 interviews were conducted.

The questionnaire for the interviews consists of six sections: (1) key facts about the company and the corresponding department, (2) description of the current (digital) business model(s), (3) description of the current (digital) customer relation as well as (customer) data usage, (4) digital initiatives for the next two years (including business model and customer relations), (5) activities and measures regarding the digital platform business, (6) trends and challenges facing the company with respect to digital platforms. From these sections, we derived the relevant platform activities of a firm, from which we were able to identify the stages and dynamics of the transformation. Finally, we extracted the contextual factors from the six sections. Here we identified technical and organizational factors that determine the process as well as the environmental factors that provide a framework for the transformation. Here, we followed the TOE-framework of Tornatzky et al. (1990).

Adhering to our interview guideline, we addressed the following requirements. Firstly, the challenge was to ensure that the questions were specific enough to contribute to the research question of the study. Secondly, the questions were to allow for a broad range of responses and digressions, and as such provide a picture of the transformation pathway that is as complete as possible. For those reasons, we chose a semi-structured face-to-face interview format via video conferencing. The surveys took place between July and December 2021. The interview questions were previously tested for validity and reliability in five test interviews before the real field phase. The tests ensured, that the interview questions maintained a balance between accurate and in-depth answers. The guideline for the interview consisted of three categories of questions, which gathered company information along the timeline, i.e. about the company's past, status-quo, and future business models as well as the occurring drivers and barriers. Furthermore, we collected detailed information about different aspects of the business model such as value proposition, sales structure, customer segments, revenue streams and cost structures. In addition, we gathered information about the digital infrastructure and digital tools and systems presently in use, as well as details about currently collected data and its application, the current obstacles and drivers, which the company faces as well as future threats and opportunities for the company. We conducted all face-to-face interviews with at least two researchers. We tape-recorded the interviews and then transcribed them. Both researches discussed and evaluated the protocols in short follow-up meetings after each interview. The written interviews, as well as the ex-post evaluation of each interview form the basis for our primary data source. On average, the written interviews contain approximately 3.560 words each.

To complement this, we relied on secondary data, such as various publicly available company reports and websites. They were gathered separately by one of the researchers. This has two advantages. On the one hand it allowed us to add further supplementary information about the companies such as revenue, number of employees, and detailed information on the business model, product portfolio and customer segments. On the other hand, these secondary data sources allowed us to double-check the assessments made in the interviews and contributed to an in-depth understanding of the development of the companies' business model.

3.3. Data analysis

In order to systematically analyze the collected data, we adopted a qualitative content analysis following the approach of Mayring (2021). Targeting high construct validity, we started our analysis by building the main categories deductively based on our theoretical framework. In this process, we apply the concept of ambidexterity for analyzing exploration and exploitation activities. Based on the servitization and platformization logic, we define the transformation process as the pathway from traditional product providers to digital platform providers and open thus the black box for identifying single stages along the pathway. For exploring and systematizing contextual factors we used the logic of the technology-organization-environment framework (Tornatzky et al., 1990). This framework provides a holistic perspective on technology adoption and implementation by considering the interactions between technological, organizational, and environmental factors. As such, it helps researchers and practitioners to understand the complexities and challenges involved in successful technology adoption and assists in identifying strategies to facilitate the process within organizations.

Using these categories, we identified inductively from the data 1st order codes and formed 2nd order categories representing the single stages, the diverse dynamic effects and contextual factor categories. Finally, we matched the inductively constructed 2nd order categories with the deductively formed primary codes (theoretical framework) in order to explain the platformization pathway in terms of a defined transformation process. The so-developed unified category system following Gioia et al. (2013) (see Table 2) enables further repetition of the research procedure and targets the same results (Yin, 2009). The findings from the 2nd order categories represent the results of the three different aspects of the transformation process presented in chapter 4. These together provide the platformization pathway, which is developed in chapter 5.

4. Results

To present the results of our analysis, we first delineate the single stages along the transformation process as well as the associated explorative and exploitative activities, before we describe the dynamics of the transformation. We then work out the identified contextual factors along the transformation process and systematize them in categories using the TOE-framework (Tornatzky et al., 1990). The findings of these three aspects form the basis for designing a formal transformation model describing the shift from product thinking to platform thinking, which we describe and discuss in chapter 5. To provide evidence to support our findings, we also use representative quotations from the case study interviews.

4.1. Transformation stages

As we do not know much about the single stages of companies' platformization process, and we have very few examples such as those taken from Riemensperger and Falk (2020)'s study, we rely strongly on an inductive approach aiming at exploring and describing the transformation stages as the starting point of our empirical research. In this

Table 2
Category system of the qualitative content analysis.

Primary codes (Theoretical framework)			(Platformization pathway)	2nd order categories (Stages, dynamics and contextual factors)		
Dynamic balancing between exploration, exploitation	Transformation process undefined	Contextual factor categories (technological, organizational, environmental)	**Transformation process defined**	Stages (1, 2, … n)	Dynamic principles (1, 2, … n)	Contextual factor categories (1, 2, … n)

explorative process, we firstly identified the key characteristics in our data, which characterize the crucial features of single stages on the platformization pathway: 'customer relationship', 'business model' and 'market' (see Table 3). These characteristics determine significantly the differences in a manufacturer's platform activities along the transformation process, and, therefore, they also seemed to us to be suitable for the distinction of single stages. In order to ensure a precise mapping of all 29 cases to a specific stage, we defined thresholds for each stage, including several criteria, all of which a manufacturer must fulfill. Finally, with the objective of verifying the identified stages, we assigned each case to a specific stage. In an iterative process of exploration, we modified the identified stages using various category syntheses approach (Mayring, 2021), until each company was a fit for a stage (compare Fig. 1), leading us to a final list of four clearly distinguishable stages. In order to explain further the interlinkages between the stages, we simultaneously strove to understand explorative and exploitative activities in each identified stage individually. In distinguishing exploration and exploitation, we differentiated according to whether a manufacturer's activities were predominantly progress-oriented and cost-driven (exploration), or whether the activities were focused on optimization and a revenue orientation (exploitation). In some cases, we observed that manufacturers were active across stages. This was the case, however, only one or two criteria of the threshold for the next stage were met. If there was a balancing of explorative and exploitative activities, we assigned these manufacturers to both stages, leading to a so-called stage transition (see section 4.2). According to our analyses, the criteria of each threshold go hand in hand, no case was represented in our study that fulfilled several criteria across three or four stages and thus could not be clearly assigned.

In the sense of Riemensperger and Falk (2020), the naming is done according to the predominant thinking paradigm of the respective stages: (1) Product thinking, (2) Sales thinking, (3) Value thinking, (4) Platform thinking. Table 3 provides an overview of the four stages and defines the explorative and exploitative activities for each stage by means of our case study analysis. The focus of the company during the respective stage is also listed and the three key characteristics of 'customer relationship', 'business model' and 'market' are shown with their respective specifications. The main logic behind this taxonomy is that a manufacturing firm goes through different stages and changes from a 'Traditional Product Provider' (stage 1), through a 'Digitalized Product Provider' (stage 2), over a 'Digital Business Model Provider' (stage 3) to the 'Digital Platform Provider' (stage 4) by exceeding the required thresholds in each case.

At the first stage, Traditional Product Providers **(product thinking)** largely maintain their traditional environment and offer their customers predominantly analog products and services. Although they start to use digital standard solutions for their processes and offerings, complex digital solutions are rare. *Explorative activities* during this stage relate to the development of new products or the improvement of existing ones. In some cases, initial digital components are coupled with the physical product to improve product functions. *Exploitation* for manufacturers during this stage consists of optimizing the existing product portfolio, although complementary standard services are offered, some of them are handled via simple digital processes. In general, Traditional Product Providers show a conventional customer relationship based predominantly on analog channels. The most important business model of these companies has traditional sales and distribution structures, and complementary business models that are offered in addition to products are rare. Likewise, manufacturers at this stage focus predominantly on traditional markets and on an already existing customer base, while these companies find it hard to develop completely new markets.

> *"We are in the process of delivering digital added value, digital information on the products. These services are being considered. We already have pilot customers, but these products are not being sold yet. 99.5% is still earned by the sales of physical products".* (case C7).

> *"We offer a preventive and maintenance service as well as training and qualification, which are urgently required in the pharmaceutical industry. […] At the moment we do not offer any of these services in our web shop, but we plan to do so. […] The only thing we have is the possibility to offer software for our instruments. This we started recently like two weeks ago."* (case C13)

> *"Our sales model is still carried that we sell through dealers. […] In addition, we also have a spare parts distribution, we have a lifetime warranty for our machines. This is also mapped through our dealer network."* (case C17)

> *"We try to deliver added value by equipping our electric motors with sensors that collect data and anticipate when our product might fail. We try to create additional business by evaluating additional data for customers and offering added value."* (case C25)

Manufacturers who have largely exhausted their analog product portfolio and standard service offerings are beginning to *explore* digitization potential along their interface with the customers during the second stage. Here, Digitalized Product Providers **(sales thinking)** are starting to integrate formerly unconnected IT-systems such as CRM or ERP and to establish their own system architecture. This proves to be one of the first key challenges in platformization, as digital networking often appears to be more complex than initially assumed by the firm. Hereby, Digitalized Product Providers are beginning to build up digital customer relationships and at the same time gradually reduce their analog interaction processes with the customer. These explorative activities during stage 2 go partly along with increasing investments for the companies and may lead to a significantly delayed transformation.

> *"We have a new director that is responsible for digitalization […] we are using the cloud and introduce more of our own web stores and CRM tools, so that everything is handled more electronically and automated so that efficiency is increased."* (case C14)

> *"The customer still writes an email or clarifies things on the phone. Many colleagues do not understand the added value. […] There is only a portal for the after-sales market where the customers can log in and get their services there."* (case C19)

> *"The customers want to collect a lot more digital data about our products. We are doing that to some extent. We also want to monetize that and bring it to the customer. We are faced with the decision of keeping the data and offering customers access the data for money, or going to a larger instance where there are multiple vendors or companies so the customer can have an overall dashboard."* (case C22)

In order to capitalize on opportunities more effectively, many companies establish transaction platforms, such as online stores, and integrate them with their existing system architecture. Additionally, they frequently incorporate self-service options and chatbots into their online

Table 3
The four stages of the platformization pathway.

	1. Product thinking (Traditional Product Provider)	2. Sales thinking (Digitalized Product Provider)	3. Value thinking (Digital Business Model Provider)	4. Platform thinking (Digital Platform Provider)
Exploration	Developing new or improving existing (physical) products, partly adding digital components for improving product features	Digitizing customer interfaces and establishing digital customer relationships by integrating formerly unconnected systems as e.g. CRM or ERP	Connecting physical products to the internal system architecture by coupling them with smart devices (one-sided IoT) as well as experimenting with (digital) business model offerings	Establishing multi-sided markets and integrating third party players in the network beyond the firm's own customer base (for transaction and IoT platform)
Exploitation	Optimizing existing (physical) product portfolio, adding complementary standard service offerings supported by digital components	Optimizing the established system architecture, increasing process automation and efficiency as well as establishing one-sided marketplaces	Optimizing existing (digital) business models and developing complementary offerings as well as expanding to existing customer base	Expansion of existing business models into multi-sided, platform-based business models, use of network effects and scaling of the platform by growing or linking
Focus	(Physical) Product driven	Efficiency driven	Value added driven	Ecosystem driven
Customer Relationship	Conventional analog sales structures and customer relationships	Digital customer relationship including customer value co-creation	Digital customer relationship including customer value co-creation	Digital customer relationship including customer value co-creation
Business Model	Product sales partly with complementary standard services	Digitalized product sales, using online-shops, product configurators, direct selling	Digital Product-Service bundles, not selling the product, but the usage or result by digital business models	Platform-based business models (multi-sided) with Digital Product-Service bundles as the core
Market	Conventional customer base and conventional customer acquisition	Conventional customer base and digital addressing of potential customers	Conventional customer base and digital addressing of potential customers	Multi-sided market, including third parties beyond the conventional customer base
Threshold	Manufacturing physical products	Establishing or using online stores and automated processes, coupled with internal IT systems, collecting data, offering digital services	Establishing or already using the IoT, products equipped with smart devices, offering digital business models	Establishing or already using multi-sided markets (beyond customer base and suppliers), offering platform-based business models

stores to automate processes and enhance efficiency. Furthermore, companies employ product configurators to enable customization, and introduce direct selling as an additional sales channel. Thus, the customer is increasingly involved in the value creation processes as part of the exploitative activities. Although Digitalized Product Providers still have a traditional business model, focusing on product sales and on their traditional markets, a digital customer relationship can not only increase customer satisfaction and process efficiency, but also make it easier to acquire new customers.

"In addition, we have a web store where customers can purchase products or access digital services such as order histories or stock and price situations. […] We use a classic B2B platform to populate the sales channel and we use platforms such as social media channels." (case C1)

"Our customer store should support the customers in the way that they can configure their systems themselves and order all their complementary products there." (case C5)

"*We produce paint. So in that sense, we have relatively few digital services. It's always something physical in 99% of the cases."* (case C9)

"We offer a very wide range of services that are provided for free. These include equipment instruction after the customer has purchased the equipment. These other services that I mentioned with […] planning, workflow, process optimization, these are all paid services." (case C11)

During the third stage **(value thinking)**, Digital Business Model Providers focus on generating added value through new business models. The *explorative activities* are initially characterized by coupling the physical products with smart devices and linking these with the system architecture, whereby the firms begin to establish their own IoT platform, resulting in hybrid platforms. At the same time, they are beginning to experiment with digital business models, which they usually offer to their customers free of charge. For example, customers can book digital add-on services via apps or use further digital upgrades that extend the functions of the products or increase their performance. During this stage, the Digital Business Model Providers invests again, while hardly any new turnover is generated.

"This is pure digitization of existing business relationships […]. We have extremely different processes where we work with large quantities under time pressure. There we have everything completely digitalized, the customer has our printing ink in a tank with a sensor. If the sensor falls below a certain quantity, we deliver a truck with new ink. So there's no more [in person] communication." (case C9)

"In parallel, there are still digital business models where we are working with 3D technology. […] They are working intensively on how data will be collected in the future. They are working more and more with individual solutions. 3D printing means that you don't do mass production, but can print a solution for a customer." (case C10)

"It's about having the vision of the digital lab to offering lab works as a service. […] We also have to see how we can provide our offerings, which are interesting for customers, not by selling them products, but by selling them services." (case C12)

"This is an application that you can download to your cell phone, where we bundle all our services. Warranty extension, that you can easily register the product, but also that you can easily replace a product. But we also offer other services, such as always knowing where the product is by equipping it with wireless technology. In other words, all the services around it to strengthen the bond." (case C23)

The *exploitative activities* at this stage focus on optimizing the existing business model portfolio and on adding further digital business models. Now, offerings such as predictive maintenance pay per use, flat rate models, availability guarantees, or everything that is a service become common. The shift from free add-on services to paid business models also frequently begins here, significantly increasing turnover for the first

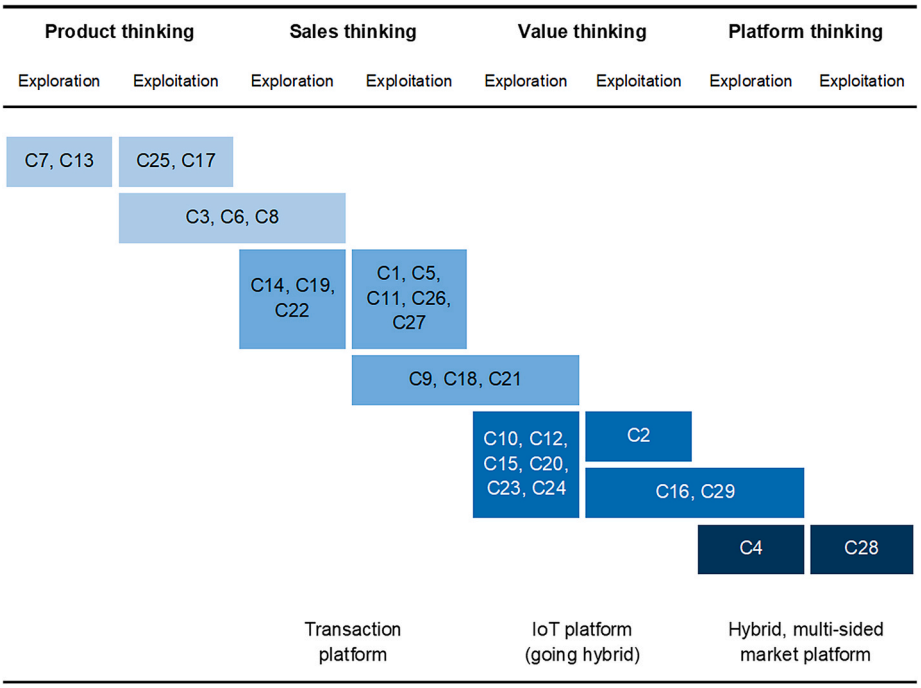

Fig. 1. Cross-case mapping for the transformation status.

time in the platformization process. A central challenge at this stage is the creation of new types of value propositions and suitable payment modes that generate added value for both the customer and the manufacturer. Successful digital business models are gradually extended all over the customer base.

> *"We have services, solutions and even smart solutions for building monitoring. We have, for example, IoT services up to service contracting, light as a service, financing of light. This is how the warehouses of large key account customers are equipped. They are continuously supported and thus receive additional services in addition to the core product."* (case C2)

> *"Today, we can no longer sell a machine without a software solution. […] In addition, we don't sell individual machines, but entire lines, and this is primarily about communication between the machines. […] now we are moving in the direction of Software as a Service, which is basically a subscription model. The customer gets the software (for running the machines) and we guarantee that the software is available and the customer always gets the current version."* (case C29)

At the final stage **(platform thinking)**, the company's focus is on building multi-sided markets resulting in digital ecosystems. During the exploration phase, Digital Platform Providers embark on a progressive expansion of their hybrid platforms, actively forging connections with other platforms to enhance their overall ecosystem. While continuing to focus on their own customer base, third parties are also integrated, leading from an originally one-sided market to multi-sided markets. Not only additional providers or even competitors are taken into account, but also intermediaries, system integrators and new customer groups. The challenges at this stage lie in particular in ensuring the technical interoperability of the company's own platform with external platforms, but also in creating an incentive for third parties to join the own platform.

> *"The IT landscape of our merchants and commercial partners will be significantly professionalized. For us, the topic of direct integration into ERP systems is of great importance. This integrative idea will be much more strongly developed across the entire value chain. By this, I mean order entry, order confirmation, delivery notification and also "track and trace" […] There is the project at our company that creates a digital ecosystem. But I am not allowed to tell you more about that."* (case C4)

> *"E-commerce solutions focus on direct access. This involves catalogs, transparency, […] safety data sheets, simplified reordering, simplified overview of interfaces, order tracking and additional materials. […] We are developing a lubricant-centric platform that will also allow customers to manage their own lubricants, maintenance and operations. That will be available via app and computer. This is also a service for which you have to pay to access our platform."* (case C16)

The *exploitative activities* for Digital Platform Providers lie in equipping the existing digital business models with new value configurations so that multi-sided, platform-based business models are created that deliver benefits for all parties. The resulting network effects scale the platform and create a digital ecosystem with numerous players who create both demand and supply. The Digital Platform Provider generates revenue not only via the transaction platform, but also via data-driven business models based on the IoT.

> *"We are moving more and more in the solution business. We no longer simply offer high-quality products, but we also moved into the cloud with our products. If the customer is connected accordingly [to the ecosystem], based on the processed data, we offer various digital services […] The final stage of this development is offering Light-as-a-Service. You only buy the light, not the hardware."* (case C28)

4.2. Dynamic principles of the transformation

Having described the transformation stages that frame the platformization pathway, we now focus on the dynamics of transformation. By the dynamics, we understand the dynamic principles (DP) of transformation, which determine the progress of transformation and explain individual flow speeds. In the analysis of our interviews, we therefore looked for elements that describe the way the stages run with respect to the platform business and strove to understand the reasons for different speeds of transformation. We then clustered the elements according to

similar patterns based on the same dynamic principle. For a better understanding of the dynamic principles in combination with the stages, we present in Fig. 1 the transformation status achieved for all 29 cases.

With our cross-case analysis, we were able to identify four dynamic principles (Table 4). First, it seems that the companies go through the stages sequentially and in the same order (DP-1). In our cases, we could not find any evidence that stages were omitted. In some interviews, it was emphasized that a time sequence exists in the expansion of the platform business.

> "We are currently building a tool, which will allow profit sharing, E-commerce, and predictive maintenance where an artificial intelligence processes data. A highly connected IoT platform is required for this, and we have had that for over 10 years." (case C20)

> "We don't have a simple web shop anymore, but a complex platform. I'm talking about e-business, not e-commerce. E-commerce is just a building block. We sell the overall project, and that comes more and more often via the online order button. So the e-commerce store is really just one element of it." (case C28)

In two cases, an attempt was made to directly build a platform with multi-sided markets. However, the attempt failed and the companies restarted at an earlier stage. Furthermore, there is no case that has passed through the stages in a different order. Nevertheless, what we observed is that two stages can run simultaneously. This takes place especially at the time of a stage transition (DP-2). Hereby, the exploitative activities of the lower stage run simultaneously with the explorative activities of the higher stage (see C3, C6, C8, C9, C16, C18, C21, C29 in Fig. 1), before the activities at the lower stage are ultimately stopped and the stage transition is completed.

> "Historically, we are a German manufacturing company. However, nowadays we define ourselves more and more through software solutions. Today, we don't sell a machine without a sensible software anymore. We are no longer a simple manufacturing company, but also a software company, which offers manufacturing services. Over time, our company has become very digital. That's why we've become a solution provider." (case C29)

> "The business model has changed significantly because we are drastically cutting back on service for all commodity products. We used to have significantly more sales force, more technical support, significantly more technical service. At the moment we even make customers pay for a call. That's pure digitization of existing business relationships." (case C9)

Likewise, it appears that the transformation process also may come to a standstill for a longer time, which corresponds to a stage stagnation (DP-3). During the exploitative stages, companies skim off their revenues and focus on optimizing existing offerings and processes. Here, firms often do not see the need to move on to the next stage, or, in some cases, do not recognize the possibilities of a step into the next stage. During the explorative stages, however, companies may make high investments, but at the same time their activities terminate in dead ends and exploitative activities seem far away, whereupon the transformation process is (temporarily) interrupted. Stage stagnation can therefore occur during both explorative and exploitative activities.

> "We aim for centralization for 20 or 25 years. A lot of our business and B2B-Platforms that we have today are used to some extent for customers and their outdated technology. When we look at this, it makes no sense to innovate these technologies. We get a really complex architecture which we built over the years to connect our customers to our product. Trying to integrate the customer in a way that makes sense for a [digital] product is the biggest trouble which we have." (case C18)

> "We have built remote condition monitoring for 40 years. All our critical equipment has all kinds of sensors. They are fully wired so you can capture everything. Data sharing is the holy grail but no one really knows what to do with the data. You can capture all the data you want, but as long as we don't build a business model out of it, it's useless." (case C18)

Moreover, we can state that the implementation of the different platform types seems to follow the same pattern for our cases (compare chapter 4.1): At sales thinking, firms introduce transaction platforms that are at least managed as online stores (stage 2). Afterwards, during value thinking, manufacturers implement IoT platforms that focus on their own customer base (stage 3) and combine it with their transaction platforms, resulting in so-called hybrid platforms. Finally, at platform thinking, the hybrid platform is extended to multi-sided markets turning into a digital ecosystem (stage 4). Accordingly, no company in our case studies has an IoT platform without also operating at least a basic transaction platform. Therefore, we conclude that the platform progress runs in this specific pattern and leads to hybrid platforms in the end.

> "Although we expect revenue gains via our existing platform, it will be the case that merchant structures and its IT landscape will become significantly more professional. The issue of direct integration with ERP systems will be more important than having a big, fancy e-commerce platform. This integrative thought will be much stronger and more fleshed out, and not just for order entry but across the entire value chain." (case C4)

> "Today's offline business (emails, personal meetings) is being supplemented, and in some cases replaced, by digital channels and digital touchpoints. The extent is probably still a low single-digit percentage. But it is still relevant. For example, e-commerce will be add-on business, or it will be substitution. If you don't do that, you will lose market share." (case C3)

4.3. Contextual factors

Following Baines et al. (2020), we define contextual factors as determinants shaping the transformation process of an organization. In order to gain a first impression of relevant contextual factors for the platformization process as a guideline for further inductive research, we firstly reviewed the relevant contextual factors examined in recent studies, like for instance the internal factors of technical and organizational complexity used by Pauli et al. (2021). Subsequently, we researched such determinants in our interview data and were able to

Table 4
Overview of the identified dynamic principles.

	Dynamics of transformation			
Dynamic principle	Stage sequence (DP-1)	Stage transition (DP-2)	Stage stagnation (DP-3)	Platform stages (DP-4)
Identified effect	The individual stages run through one after the other, sequentially in the same order and iterative between explorative and exploitative activities. Skipping individual stages does not seem possible.	Simultaneous activities of exploitation and exploration of two subsequent stages, resulting in a stage transition, after exploitative activities are ultimately stopped.	Delays or standstills during a stage, as indicated by dead ends of explorative activities or by successful skimming of sales from existing offerings in exploitative activities.	Transaction platforms are implemented first (stage 2), followed by and combined with IoT platforms (stage 3). As a hybrid platform, multi-sided markets are added last (stage 4).

identify various relevant internal and external factors in our case studies. Internal factors are characterized by the fact that they can be shaped by the company itself. In our case studies, we observed that the complexity of an internal factor also rises with progress of the transformation. Accordingly, the requirements on a company to overcome these challenges increase over time, as well. In contrast, external factors describe the environment in which a manufacturer is situated. Despite their significant role for the transformation process, they can hardly be influenced by any company. In addition, they remain largely stable over time and change rather slowly.

In order to systematize the factors, we adopted the TOE-framework from the technology adoption literature (Tornatzky et al., 1990) and used its three building blocks, technology-organization-environment, to cluster the inductively identified internal and external factors. Using this combined deductive-inductive approach, we were able to identify contextual factors with respect to technical, organizational and environmental complexity. Since we identified a significant difference in the role of market and business, it was logical for us to subdivide the environmental context into market and business environment. While the market environment includes determinants shaping the entire market related macro environment of a company, the business environment characterizes the micro environment covering predominant business logic, i.e. business model, as well as key product-service features. Hence, we synthesized the identified contextual factors into the following four categories: (1) technical complexity, (2) organizational complexity, (3) market environment and (4) business environment (see Table 5).

Before we summarize the identified factors using our four categories in the following paragraph, we want to highlight some general findings concerning the mechanisms of contextual factors. First, our analyses show that the individual contextual factors emerge for the first time at a particular stage and then become relevant to a manufacturer. However, since the stages build on each other, the contextual factors remain relevant for the following transformation stages as well. For example, the 'capability of customers to accept new business models' becomes relevant for the first time during value thinking. However, this capability is still required in a more complex form in platform thinking. The same is true for the other contextual factors. Second, we see in our data that the same contextual factor can have an accelerating or a decelerating effect on the transformation process, depending on its configuration. For example, in the case of 'human resource capacity', extensive human resources have a positive effect on the transformation progress, while low human resources have a negative one. Third, the influence of a single contextual factor also depends on the transformation status of a company. This can be illustrated, for instance, by the factor 'customer needs and requirements'. Here, at the beginning of the transformation process, manufacturers are rather pulled by customers requiring digital communication and distribution channels. In contrast, companies at a more advanced transformation stage are often hindered by their customers lagging behind digital development to make further progress.

Technical complexity refers in particular to system architecture and data processing (Pauli et al., 2021). With regard to system architecture, it is crucial how many systems are linked with each other, how efficiently they are linked and how smoothly the communication between them is. With respect to data processing, the main issues are whether crucial data is at the firms' disposal and whether they are able to realize the business potentials of the available data. It also depends on the company's capability to process data and use it analytically resulting in future business cases.

> "We get a really complex architecture which we built over the years to connect our customers to our product. Trying to integrate the customer in a way that makes sense for a [digital] product is the biggest trouble, which we have." (case C18)

> "The data we collect from various sources enables us to offer new values for our customers […] we are now able to create insights on how our customers use our products so that we can create better products, and also services." (case C4)

Organizational complexity comprises all intra- and inter-organizational relationships (Pauli et al., 2021), as well as the capability of a firm to manage them. The complexity and efficiency of the internal processes play a key role for platformization. Here, it is crucial, how well the internal processes can be digitized and integrated. Moreover, the availability of human resources is critical for the transformation of a company. Firms that have not managed to hire employees, who possess the necessary digital skills, impede their transformation and thereby often lag behind.

> "[…], it is necessary to bring together the systems and platforms that have evolved over time, and to design end-to-end processes […] this is also a matter of organization and how we can integrate it with our technical systems." (case C1)

> "We are still lacking certain skills in the teams. Something like data analysis or something like that, people are in demand everywhere right now and it is not that easy to find good staff. So, we're also looking for more people to build up the know-how […] but we also

Table 5
Overview on the contextual factors with stage references.

Contextual factors				
First time appearance	Internal factors		External factors	
Stage	Technical complexity	Organizational complexity	Market environment	Business environment
Product thinking	• Data availability of products and customers • Data collection potential • Complexity of the structure of collected data	• Human resource capacity • Intra-organizational process complexity • Intra-organizational structure	• Number of competitors • Market power of the manufacturer vis-à-vis customers • Customer needs and requirements	• Complexity and batch size of the product • Length of the product life cycle • Investment volume of the product
Sales thinking	• Complexity of existing system architecture • Number and variety of interconnected systems	• Type of customer connectivity • Complexity of integrating customers and suppliers to digital platform	• Capability of customers to accept new relationships • Complexity of distribution structure • Legal framework	• Level of service orientation • Level of customer orientation
Value Thinking	• Data processing capabilities • Capability for big data analytics	• Capability to adapt new business models in an old environment	• Capability of customers to accept new business models	• Complexity of the predominant business model
Platform thinking	• Capability to establish technical interoperability with other platforms	• Business foresight capabilities • Capability for platform thinking	• Capability of third parties to follow a new market	• Number of (in parallel) existing business models • Number of business segments

invest a lot into further training of our workforce to be able to keep up with digital development." (case C25)

The category 'market environment' covers all market forces influencing the platformization pathway of a firm. These include the market power of the manufacturer vis-a-vis its customers as well as the customer needs and requirements, which differ from market to market. Moreover, the type and number of competitors is crucial, as well as the legal environment, which prevails in a certain market. The capability of customers or third parties to join a digital ecosystem and enter the platform business is also important.

"We are highly digitally organized, but we operate in a non-digital business environment. It's not a good idea for our sales representative to go to a customer with a tablet to sell him ink that the customer uses to print newspapers. The customer won't like the idea that we use tablets, which can be used to read newspapers digitally. The customer earns money by printing newspapers. We are operating in a traditional environment with highly digital processes." (case C9)

"One the major issues for us is the ever-changing legal framework which influences our strategies […] this is also crucial for digitalization in context of our potential new business models; think of data and privacy issues for example" (case C5)

The final category of contextual factors is the so-called 'business environment'. For companies that have many business segments, for example, it is more difficult to make progress with digitization than companies with a few business segments. In addition, the product life cycle and the product complexity play a central role here. Long-lived and complex capital goods, for example, hold more potential for offering digital business models than short-lived ones. In addition, the fundamental service orientation of a market or sector is important, because a more service-friendly environment helps when introducing new business models.

"We are a traditional machine manufacturer and therefore do transactional business. But of course, like almost all machine manufacturers, we want to move into recurrent revenue business models. For this reason this department was founded." (case C20)

"How much will our business depend on digitization? Very much so, because our strategy is that we will not sell products in the future, but solutions [for customer problems]." (case C24)

5. Discussion

Our study explores the platformization pathway of manufacturers from a transformation perspective. In depth, our research provides insights into (i) what the stages of transformation are and how they can be characterized using explorative and exploitative activities, (ii) how the dynamics of the transformation process occur through the lens of dynamic balancing between exploration and exploitation activities, and (iii) what contextual factors are critical to the progress of the transformation and individually shape the platformization pathway. In our study we follow the approach of inductive, multiple case study research according to Eisenhardt (1989). Therefore, in this chapter, we first formulate some central hypotheses on the platformization pathway of manufacturers in the form of propositions and reflect on these with the help of the literature to date. These address the first research question *'What are the stages, dynamics, and contextual factors of the platformization pathway of a manufacturer?'*. Afterwards, we develop the formal transformation model based on our propositions as well as in light of our second research question *'What does the platformization pathway of a manufacturer look like in a formal transformation model?'*. The chapter concludes with a practical reflection of the formal model by briefly illustrating and reviewing the transformation process of BMW, Hewlett Packard and Apple.

5.1. Reflection and propositions

A number of papers exist that explicitly focus on digital platforms in manufacturing (Lerch and Heimberger, 2022). However, none of these papers puts its findings about platformization on the firm level in a chronological order, or provides evidence of a step-by-step expansion of manufacturers' platform business. Therefore, a conceptual finding of our paper is to develop an understanding about the platformization of manufacturers through the lens of a transformation process. Here we can state that the platformization on the firm level describes the shift from product thinking to platform thinking (Riemensperger and Falk, 2020). As the literature shows, manufacturers undergo this shift because platformization creates new opportunities for value added, which ensures the competitiveness of the company (Arnold et al., 2016; Cenamor et al., 2017; Coreynen et al., 2017; Riemensperger and Falk, 2020). However, these opportunities also come with technical and organizational challenges that must be mastered for progress (Gerrikagoitia et al., 2019; Pauli et al., 2021):

Proposition 1. *The platformization pathway addresses the shift from product thinking to platform thinking and describes the underlying transformation process that a manufacturer undergoes to become a digital platform provider.*

Moreover, we can state that a transformation process with respect to organizational change takes into account the aspects of dynamics, process and context, as well as their interplay (Pye and Pettigrew, 2005). This is what we interpret in the platformization pathway as stages, dynamic principles and contextual factors, following the approach of Baines et al. (2020). The stages determine the state and activities of a manufacturer along the platformization pathway. In addition, the dynamic principles and the contextual factors as well as their interplay define the individual progress and the framework conditions of the transformation process.

Proposition 2. *The individual state of a firm along the platformization pathway is characterized by stages, while the dynamic principles and contextual factors define the progress and framework conditions of a manufacturer's transformation.*

The third finding refers to the theoretical foundation of the transformation process, which follows the logic of ambidexterity understood as a dynamic balancing act between exploration and exploitation (Raisch and Zimmermann, 2017; Luger et al., 2018). Although digital platforms and servitization have already been considered in conjunction with ambidexterity (Cenamor et al., 2019; Coreynen et al., 2020), the understanding of the platform business that evolves over time has been missing up to now. Therefore, we draw on the dynamic approach of ambidexterity and consider it a process of continuous transitions between exploration and exploitation. Following Luger et al. (2018), O'Reilly III and Tushman (2013) and Raisch and Zimmermann (2017), we regard transitions between explorative and exploitative activities of a company as iterative processes that repeat continuously driving thereby the entire transformation process. By applying this theoretical framework to the transformation process of the platformization pathway, the dynamic approach describes the balancing act by manufacturers exploiting conventional product-service offerings and maintaining their revenues, on the one hand, and deploying resources for new opportunities of digital platform offerings, on the other. This transitioning and balancing act runs iteratively throughout the entire transformation process enabling thereby the platformization pathway:

Proposition 3. *The platformization pathway is driven by a sequence of transitions between explorative and exploitative activities of a firm. It describes the ongoing balancing act of manufacturers between exploiting their current product-service offerings, and exploring new platform business opportunities.*

One of our key findings represents the four stages of the

transformation process, which are in particular characterized by the predominant thinking paradigm. For a manufacturer, this originally lies in product thinking and ends as a digital platform provider in platform thinking (Riemensperger and Falk, 2020). By our case study analysis, we are now able to complement these two paradigms by so-called sales thinking and value thinking, as well as to integrate them into a continuous process. The thinking paradigm of the manufacturer defines the focus on the platform business for each stage, which interacts with its explorative and exploitative activities. The focus ranges from a strong product orientation (product driven), to improving the efficiency of customer processes (efficiency driven), to adding more value for the customer and manufacturer through new business models (value added driven), to creating an ecosystem with third-party providers (ecosystem driven). This finding leads us to our next proposition:

Proposition 4. *The platformization pathway consists of four thinking paradigms framing the stages* (1) *product thinking*, (2) *sales thinking*, (3) *value thinking*, (4) *platform thinking*, *which determine the focus and activities of a manufacturer's platform business*.

Moreover, the focus of the platform business has a concrete impact on the change of organizational structures and processes. Here we identified three key characteristics, which change from stage to stage and are also mentioned in the existing literature (Arnold et al., 2016; Riemensperger and Falk, 2020; Broekhuizen et al., 2021); namely 'customer relationship', 'business model' and 'market'. Nevertheless, we are also able to characterize them from a dynamic perspective and at the same time, these define the thresholds that a manufacturer must overcome to move on to the next stage. The shift in the customer relationship takes place primarily during stage 2 and transforms the customer relationship from an analog one into a digital one (Kamalaldin et al., 2020) including automated customer processes, transaction platforms such as web shops and digital service offerings. A manufacturer's business model initially changes from traditional product-service sales to digital business model offerings with the help of an IoT at stage 3 (Haaker et al., 2021; Paiola et al., 2021). Subsequently, the digital business models develop into platform-based business models, which are characterized by their multi-sided value propositions to the various stakeholder groups (Şimşek et al., 2022; Tian et al., 2022) (stage 4). The manufacturers' market does not change during the first three stages and focuses largely on the traditional and already existing customer base. It is not until stage 4 that the shift occurs, when manufacturers equip their hybrid platforms with multi-sided markets to integrate third party players and ensure interoperability between platforms (Hein et al., 2020; Broekhuizen et al., 2021).

Proposition 5. *The platformization pathway consists of three key characteristics that define the thresholds a manufacturer must overcome to reach the next stage*: *'customer relationship'*, *'business model' and 'market'*.

From our cross-case analysis, we derived four dynamic principles that determine the progress of transformation and thus the generic patterns in the process. First, our analysis shows that the stages run through sequentially, whereas omitting stages does not seem possible (DP-I). This result is in line with research on comparable transformation processes (Baines et al., 2020) and can also be justified from the stepwise, iterative process of exploration and exploitation (O'Reilly III and Tushman, 2008). Stage transitions occur when a company simultaneously engages in explorative and exploitative activities of two subsequent stages (DP-II). This is the driver of the transformation process and goes hand in hand with the balancing strategy of ambidexterity (Luger et al., 2018). In contrast, the transformation process is slowed down if explorative activities lead to dead ends or if exploitative activities are too attractive to meet the challenges of the next stage. In this case, (temporary) stage stagnation occurs (DP-III). We derive our next proposition from these three dynamic principles:

Proposition 6. *The platformization pathway is characterized by a sequential run of stages in a specific order*. *Progress depends on whether a manufacturer has exhausted its activities and is scaling back* (*stage stagnation*), *or is moving forward with the activities of the next stage* (*stage transition*).

The fourth dynamic principle describes the specific order in which the different digital platform types are implemented (DP-IV). At the end of the platformization pathway, when a relevant ecosystem is established, we could only identify hybrid platforms in our case studies. Lerch and Heimberger (2022) also come to the same result, however, our findings now allow us to draw conclusions about how this state comes about at the end of the transformation process. As we can see, manufacturers establish first transaction platforms during sales thinking (stage 2), which are supplemented with IoT platforms and thereby resulting in hybrid platforms during value thinking (stage 3). Up to this point, however, firms are dealing with one-sided platforms that only address their own customer base. It is not until platform thinking, that the hybrid platform is further developed and expanded into a platform consisting of multi-sided markets (stage 4). The fact that the stage of platform thinking is characterized by digital ecosystems goes hand in hand with the findings of Riemensperger and Falk (2020). Consequently, this fourth dynamic principle leads to our next proposition:

Proposition 7. *In order to follow the platformization pathway*, *manufacturers first establish transaction platforms*, *which they later complement with IoT platforms to create hybrid platforms*. *Finally*, *these are equipped with multi-sided markets turning into digital ecosystems*.

Contextual factors represent a crucial aspect for the individual shape and progress of the transformation process (Baines et al., 2020) and define the framework conditions. In our cross-case study analyses, we were able to identify various contextual factors and group them into four categories. Two categories, consisting of internal factors, so-called 'technical complexity' and 'organizational complexity', which are already mentioned in the literature (Gerrikagoitia et al., 2019; Riemensperger and Falk, 2020; Pauli et al., 2021), can not only be confirmed by our analyses, but also supplemented by additional insights. Moreover, we were able to identify two further categories of external factors that have not been mentioned in the literature to date. The categories 'market environment' and 'business environment' largely determine the shape of the transformation process and describe the environment in which a manufacturer operates. The four categories were derived and adapted from the TOE-framework, which was developed by Tornatzky et al. (1990) for describing technology adoption in firms.

Moreover we can state, that the two categories of internal factors become more and more challenging as transformation progresses. The individual progress of platformization of a single firm, therefore, is largely determined by its capability to overcome the technical and organizational challenges (Pauli et al., 2021). In contrast, the two external categories remain stable along the platformization pathway and define the framework conditions of the transformation. Consequently, a firm's transformation process is shaped by its own technical and organizational capabilities as well as its external environmental factors. Our last proposition is hence as follows:

Proposition 8. *The platformization pathway consists of four categories of contextual factors*: *technical and organizational complexity* (*internal factors*), *determining the progress over time*, *and market and business environment* (*external factors*), *shaping the framework conditions of the transformation*.

5.2. A transformation model for the platformization pathway

The findings from our study deliver the basis for building a formal transformation model, which represent the manufacturers' platformization pathway. For this purpose, we use (a) the theoretical framework that we have developed using ambidexterity as the theoretical

foundation combined with servitization and platformization literature, and (b) the empirical findings including the propositions from our cross-case study analysis. If we combine these theoretical and empirical aspects, a formal transformation model of the platformization pathway of manufacturers emerges as illustrated in Fig. 2.

The platformization pathway model explains the transformation of a manufacturer turning into a digital platform provider as an ambidextrous organization or company. The environmental factors set out the individual framework conditions for the transformation of a company covering micro and macro aspects. These can hardly be influenced by the manufacturer and remain largely stable during the transformation process. The dynamic balance between exploration and exploitation describes the continuous transitions between those activities, which run as iterative processes driving thereby continuously the transformation across the single stages. This iterative process does not only take time, but also leads the manufacturer to ever higher levels of platformization, which in turn bring increasing challenges but also opportunities.

The challenges go hand in hand with the internal contextual factors. These are technical and organizational in nature, change over time, and become increasingly challenging along the transformation. Consequently, the progress of the transformation depends to a large extent on how a company can overcome these challenges. In contrast, opportunities are largely represented by the four transformation stages. At the second stage, these usually involve efficiency increases through process optimization, while added value is created through additional offerings at the third and fourth stage. Therefore, the challenges and opportunities go along with the continuous expansion of the platform business, which starts with the implementation of transaction platforms and ends with hybrid, multi-sided platforms in the sense of digital ecosystems.

The four stages describe a manufacturer's predominant thinking paradigm, which largely determines its respective explorative and exploitative activities. Depending on the individual strategy, a firm focuses either more on exploring new platformization opportunities or on exploiting existing product-service offerings, which may result in stage transitions or (temporary) stage stagnations. To sum up, we can observe that two aspects are crucial for the individual transformation progress of a manufacturer: the way in which explorative and exploitative activities are balanced as well as a firm's capability to master the technical and organizational challenges that come with the transformation. These two strategic elements combined with the external factors shape a manufacturer's individual platformization pathway.

5.3. Practical reflection of the transformation model

The pathways of some well-known companies provide a practical reflection on the transformation process. These also illustrate the relevance of capability development (ambidexterity) and the dynamics of a changing environment (business and market) as well as how this shapes the individual transformation of manufacturers turning towards digital platform providers. The examples also show that the platformization pathway does not always have to be fully completed.

In the automotive industry, for example, the environment has in recent decades been slowly but continuously shifting towards a digital service market (Gaiardelli et al., 2014). BMW, as one of the pioneers in this sector, started offering telematics services at the end of the 1990s (leaving product thinking). Over the years, BMW has expanded its digital service offering and added, e.g. traffic information, services for navigation, communication and infotainment and introduced digital channels, such as Amazon, for the sale of products and services (reflecting sales thinking) (Kukkamalla et al., 2021). Meanwhile, the

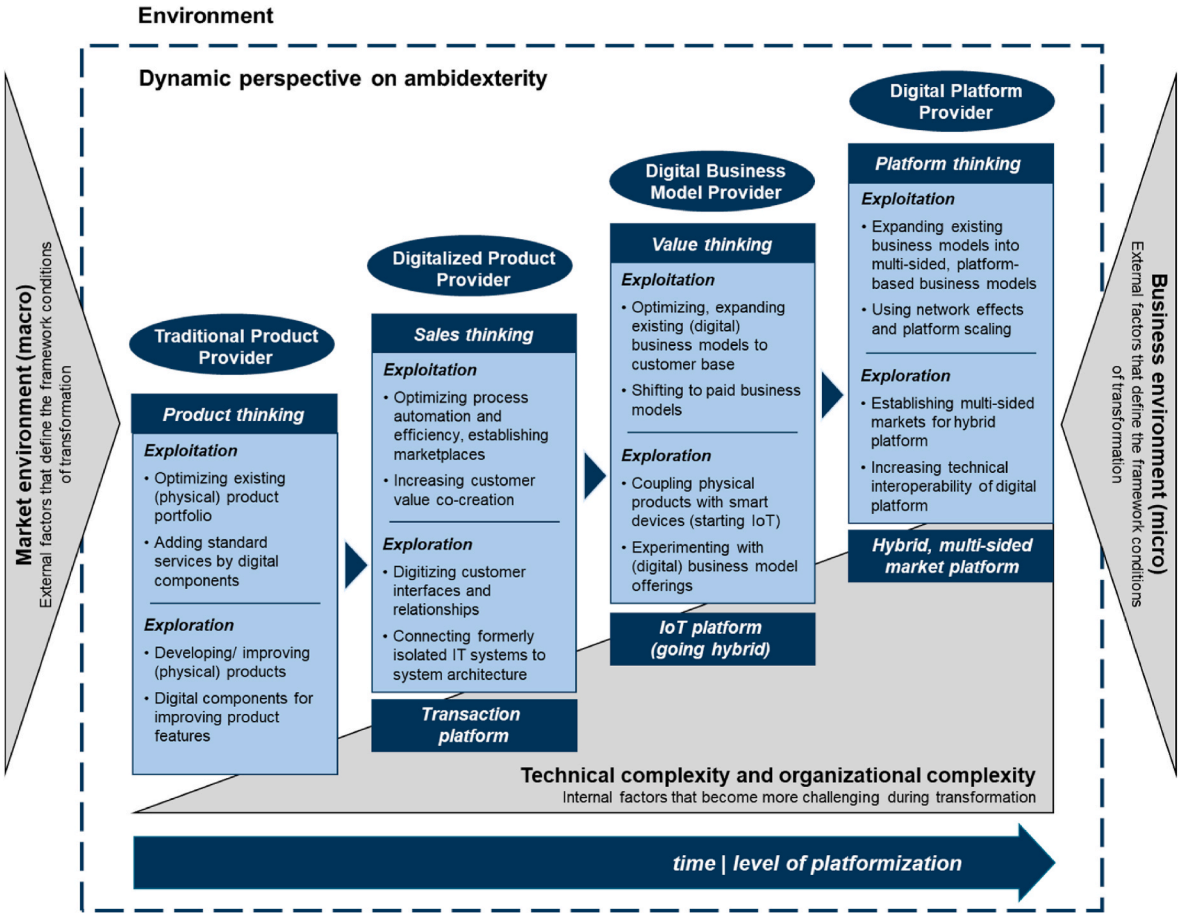

Fig. 2. Transformation model for understanding the platformization pathway.

automotive sector regards the car itself as a digital device. BMW developed the OS7.0 digital platform from 2016, which enables the modular use of apps in the car, and launched it in 2018. There were already 20 apps available at the launch; BMW develops the apps itself and customers can book and use them via the ConnectedDrive system. Additional services such as parking space search, music streaming and others are offered for a fee (comparable to value thinking), in the form of a subscription (Weiss et al., 2022).

In contrast, the computer and software industry has experienced a very turbulent environment in recent decades. Hewlett Packard (HP) and Apple are two companies that had a comparable starting point but went through the transformation process in different ways. As manufacturers of printers (HP) and computers with operating systems (Apple) respectively, both were device manufacturers (reflecting product thinking) in this sector (Hacklin et al., 2018). HP, like most of its competitors, used the razor and blade model to sell its printers and cartridges for decades (comparable to sales thinking). Later in the 1990s, printers were equipped with digital devices, which made the pay-for-print model and further service offerings possible (Visintin, 2014). However, HP was not able to significantly increase its profits, and at the same time failed to develop software expertise and roll out its own digital platform structure (Hacklin et al., 2018). As a result, the digital service offerings (representing value thinking) remained a complementary business model to the actual primary business model, which focuses on the hardware.

As opposed to HP, Apple changed the value proposition of its primary business model very early on, proactively addressing the market with innovative offerings and adapting to the rapidly changing environment of the software industry. The early understanding of recognizing hardware as a digital device for software offerings led to a rapid transformation from computer manufacturer to streaming provider with the help of the MP3 player, which resulted in very high profits, the rapid expansion of digital capabilities (Hacklin et al., 2018) and hence, in a very intensive transformation process (fast through sales and value thinking). This business model, based on subscription and pay per use offerings, was later continued and expanded by means of mobile phones and apps. By opening up its own digital platforms to third-party app providers in particular, network effects were generated, allowing the multi-sided platform to scale quickly and become the dominant business model (representing platform thinking). Apple is now a technology and software provider for whom the production of physical goods merely serves as a vehicle for offering digital business models based on software and via digital ecosystems (Hacklin et al., 2018).

6. Conclusions

In our paper, we shed light on the transformation process established manufacturers undergo to become digital platform leaders and thus contribute to a better understanding of platformization at the firm level. So far, there is a general recognition in the literature that manufacturers need to initiate the shift from product thinking to platform thinking (Riemensperger and Falk, 2020), but the underlying process is not yet understood. To close this research gap, we developed a theoretical framework and combined it with the findings of our case study analysis with the aim of designing a transformation model that gives an in-depth understanding of the platformization pathway. Our research provides some theoretical as well as practical implications, but at the same time points to future research opportunities.

6.1. Theoretical implications

As we state at the outset of our paper, to date there has been no research on the platformization of manufacturers from a transformation perspective on a firm level. Therefore, the main purpose of our paper is to develop a formal transformation model that explains the platformization process of manufacturers. We are thus answering the call to explore the needed shift from product thinking to platform thinking in more detail (Riemensperger and Falk, 2020). Based on our inductive case study analysis (Eisenhardt, 1989), our study provides a number of theoretical implications.

Using the formal transformation model, we provide a concept that explains how the continuous expansion of the platform business of large manufacturers takes place. Due to the different states of development the analyzed firms were in during our study, we were able to identify the transformation stages of the platformization pathway. Using multiple case study analyses, we elaborated several dynamic principles that, together with contextual factors, explain the individual transformation progress of firms. With this conceptual approach, we cover three crucial aspects, dynamics, process, and context, which are necessary to describe organizational change (Pye and Pettigrew, 2005; Baines et al., 2020). Thus, we are able to distinguish the transformation stages that frame the pathway from those forces that influence the progress of the transformation: the dynamic principles and contextual factors. This provides not only deeper insights into the transformation, but also explanations for the different progress in platform business between companies. Therefore, together with the propositions, the formal transformation model forms a basis for further research work.

In our study, we employ the theory of ambidexterity, specifically focusing on the recent process-based approach that emphasizes a dynamic balance between exploration and exploitation (Raisch and Tushman, 2016; Raisch and Zimmermann, 2017; Luger et al., 2018), in the real-world company context. The literature to date which deals with this topic has been largely theoretical in nature and calls for additional explanations for the evolution of firms' exploration-exploitation balance (Luger et al., 2018). Furthermore, contemporary research has underscored the significance of examining ambidexterity through the lens of dynamic capabilities (O'Reilly III and Tushman, 2013; Farzaneh et al., 2022). In this paper, we elucidate the platformization pathway of manufacturing companies through a series of successive transitions between diverse exploration and exploitation activities as part of the transformation process' single stages. These transitions facilitate the acquisition of valuable resources and capabilities (O'Reilly III and Tushman, 2008), ultimately shaping the platformization process for coping with technological and market changes (Poell et al., 2019; Lerch and Heimberger, 2022). Additionally, considering the relevant technical, organizational, and environmental factors, our results facilitate the comprehensive understanding of the underlying causes behind single stage transitions and stage stagnations during transformation. This sheds light on the varying speeds observed within the overall flow process. These findings make a significant contribution to the existing ambidexterity literature in two ways. Firstly, they provide further insights into why companies change their focus or transition between exploration and exploitation within specific contexts or stages of development (Simsek et al., 2009; Raisch and Zimmermann, 2017). Secondly, they shed light on the dynamic evolution of manufacturing companies over time. Specifically, they clarify how the ongoing interplay between exploration and exploitation, through iterative balancing and continuous transitioning, can result in transformative effects on a company's resources and capabilities. Consequently, our application of a dynamic perspective on ambidexterity to a real-world problem provides an appropriate approach that future research can use for analyzing similar transformation processes on the firm level.

Furthermore, our study contributes to the literature examining the interplay between servitization and digital platforms (Eloranta and Turunen, 2016; Cenamor et al., 2017; Simonsson et al., 2020; Eloranta et al., 2021; Fu et al., 2022; Tian et al., 2022). However, this literature mostly focusses on how platforms can be used to improve service offerings and processes (Kowalkowski et al., 2013; Kindström and Kowalkowski, 2014), leveraging value due to digitization (Cenamor et al., 2017), offer IoT-based or platform-based business models (Paiola and Gebauer, 2020; Haaker et al., 2021; Şimşek et al., 2022), or realign customer relationships (Kamalaldin et al., 2020). These contributions

provide valuable information for platformization at the firm level, but still follow a servitization logic. However, our study not only allowed us to locate the various findings along a platformization pathway in time and systematize them on the basis of a formal transformation process, but also to view the topic from a platformization logic. The firm level perspective of platformization can also be used to guide further work and incorporate other literature streams and theories.

6.2. Practical implications

Our transformation model shows manufacturers a pathway for platformization with several stages including explorative and exploitative activities in which they can position themselves. In this context, our model helps large-sized manufacturers to develop an understanding of the platformization process and map a pathway to platform leadership. Our formal transformation model presented in Fig. 2 and practically reflected by well-known cases (BMW, HP, Apple) thus supports the transformation management of manufacturers in successfully mastering the shift from product thinking to platform thinking.

Our findings can be used to work out recommendations that support the platformization pathway from the beginning to the end (cross-stage recommendations) and relate to the two strategic elements of manufacturers during the transformation (see section 5.2): (1) Companies should redesign their organizational structures and establish digital business capabilities in order to master technical and organizational challenges. Creating responsibilities and establishing new capabilities is one of the most important factors to achieve progress in the platformization pathway and traditional structures are mostly not designed for this (for example, case C14 received help as they established a new board member responsible for digital business). (2) One of the biggest challenges of the transformation is the platformization cost trap, which means that costs explode and at the same time there is no monetization of the platform business. This leads to stage stagnation or even a complete standstill of the process. In order to make progress in the platformization pathway, a balancing of explorative and exploitative activities in terms of costs and revenues should be maintained right from the start (i.e. case C11 and C22 made an early transition to monetization as they continuously introduced new paid services and only offered their traditional services for free).

Depending on the stage, various challenges can be identified in advance, which helps to better master the transformation process and thus to drive it forward more successfully (stage-specific recommendations): At the beginning of the transformation, in *product thinking*, a key success factor is to equip the firm's own, previously largely analog products with digital components and, building on this, to offer the first digital services (case C7 e.g. started with pilot customers to test the services initially). Standard solutions should be used here, for example RFID chips and mobile devices, but also conventional ERP and CRM systems. These already enable initial digital networking and provide a basis for business models beyond product sales (i.e. case C25 used sensors to collect information on when products were likely to fail). Right from the start, care should be taken to ensure that additional digital services are offered exclusively for a fee in order to accustom customers to the value of services. At the same time, this leads to an initial return on investment in the platformization pathway (not as case C29 did when moving into platform thinking after customers were used to free services and never had paid for them before; more like cases C11 or C22, which during earlier stages prepared the transition to paid services through mixed offers). *Sales thinking* is mostly about successfully driving forward the digital networking of isolated IT solutions within the company, such as CRM or ERP, and awaken customers' interest in new digital processes. To make this possible, the focus should be on simplifying and increasing the efficiency of processes for the customer and connecting the necessary systems with each other (e.g., case C14 aimed from the beginning at higher process efficiency for the customer when purchasing). Automated process flows, such as the use of chatbots, but also online stores or self-services are helpful. Moreover, complementary business models such as direct selling or product configurators also help to increase customer satisfaction (this approach was chosen by cases C1, C5, C19 for example). The aim of this second stage should be to establish digital customer relationships. At the *value thinking* stage, the crucial challenge for manufacturers is to develop attractive value propositions for customers in order to monetize their digital business models. Here, in-depth customer analyses can initially help to identify the needs of the customer base. When offering digital business models, specially developed apps can be used as well as new payment modes should be introduced to ensure monetization of the platform (i.e. case C28 with Light as a Service, C29 with subscription models, or C16 with process optimization via apps). At this stage, the focus should be on developing and offering several complementary digital business models based on IoT. The success factors in *platform thinking* lie in establishing technical interoperability with other digital platforms and creating incentives for new third-party providers. This makes it possible to exploit economies of scale and open up new markets beyond the traditional business. For this purpose, attractive value propositions should be developed for all participating players, while at the same time strengthening the manufacturer's capabilities in business analytics. The aim of the final stage is to develop a digital ecosystem and build a digital platform with multi-sided markets to reach platform leadership (case C28, which managed to integrate third party providers and build a digital ecosystem with data exchange).

6.3. Limitations and future research

As with any qualitative research, the limitations of our case study analysis, point to opportunities for future research. First, our analysis uses case studies consisting of interviews conducted at a specific point in time during the transformation process. As a result, we were not able to observe the transformation process of most companies until the end, but only until the respective current point in time when the interviews were conducted. Accordingly, future research could focus on following one or more companies throughout the entire transformation process and analyze them in depth. Such a long-term analysis could provide even more comprehensive insights into the entire transformation process, from beginning to end.

Second, our study provides insights into the platformization of manufacturers through an explorative approach based on inductive case study analysis. Hence, it is not possible to draw conclusions for any given firm in manufacturing or to make representative statements about platformization in general. Our results are expressed by hypotheses in form of propositions which require further verification. Therefore, future research could use large-scale surveys to investigate the topic of platformization of manufacturers by quantitative methods. The advantage would be not only to get an impression of the general progress of platformization in manufacturing, but also to investigate correlations with other issues by means of statistical analyses.

Third, the selection of companies in our qualitative analysis only shows a sample of manufacturing industries. The reason for this situation is that we have only included large companies in our case study analysis, each of which employs several thousand people, with the aim of observing the activities of potential platform leaders. However, small and medium-sized firms are not included in our study, they encounter certainly other opportunities but also challenges on the platformization pathway. They themselves usually do not have the resources to build their own digital platforms, but rather have to join platforms of larger companies in order to participate in the platform business. All the large companies in our study tackle the platform business exclusively through developing and operating own digital platforms. For small and medium-sized companies in particular, however, it is important to know how they can join other digital platforms and still participate in platformization in their specific way. Future analyses should therefore also deal with the platformization pathway of small and medium-sized companies and, in particular, with the question of what further transformation

pathways might look like beyond those of large companies that rely on their own digital platforms.

CRediT authorship contribution statement

Christian M. Lerch: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. **Djerdj Horvat:** Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Johannes Jasny:** Data curation, Investigation, Methodology, Writing – original draft.

Data availability

The data that has been used is confidential.

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