Openness Indicators for the Evaluation of Digital Platforms between the Launch and Maturity Phase

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Abstract

In recent years, the evaluation of digital platforms has become an important focus in the field of information systems science. The identification of influential indicators that drive changes in digital platforms, specifically those related to openness, is still an unresolved issue. This paper addresses the challenge of identifying measurable indicators and characterizing the transition from launch to maturity in digital platforms. It proposes a systematic analytical approach to identify relevant openness indicators for evaluation purposes. The main contributions of this study are the following (1) the development of a comprehensive procedure for analyzing indicators, (2) the categorization of indicators as evaluation metrics within a multidimensional grid-box model, (3) the selection and evaluation of relevant indicators, (4) the identification and assessment of digital platform architectures during the launch-to-maturity transition, and (5) the evaluation of the applicability of the conceptualization and design process for digital platform evaluation.

Keywords: Digital Platform Openness, Morphological Analysis, Evaluation, Design-Science Research

1. Introduction

Digital platforms (DPs) have garnered significant attention from both companies and research institutions over many years. They are approached from a socio-technical perspective, considering technical components (software and hardware) along with associated organizational processes and standards. Technically, DPs serve as flexible foundations, accommodating third-party modules (software subsystems) to expand their capabilities (De Reuver, Sørensen, and Basole, 2018). Assessing these technical aspects, processes, standards, code base, and subsystems presents methodological complexities. Additionally, evaluating DPs can be undertaken from diverse angles, incorporating both objective and subjective measures while examining their impact on the market and understanding user perspectives. It may also be worthwhile to explore different verticals, such as energy and Industry 4.0, to gain insights (Ullah, Nardelli, Wolff, and Smolander, 2020).

Comprehending the influencing factors driving digital platform changes, especially those related to openness, remains vital. The dynamic nature of these factors makes measurement challenging (Broekhuizen et al., 2021). In this context, researchers like Gawer suggest identifying measurable indicators and characterizing the transition between launch and maturity phases more precisely. Research on digital platform development over time is still evolving (Gawer, 2021). It's essential to explore DPs within the context of their life cycles, spanning birth, expansion, leadership, and self-renewal phases (Jacobides, Cennamo, and Gawer, 2018). Evaluating DPs also raises questions about defining technological parameters, emphasizing innovation and technological quality.

Technological complexity is closely linked to the quality of enabling technology (Gawer, 2021). While developing artifacts for complex DPs may incur higher costs, they tend to exhibit superior quality and can be offered at premium prices. Evaluating digital platform openness in the industrial Internet of Things (IIoT) context is critical for several reasons, such as ensuring interoperability, customization to industrial requirements, and promoting innovation.

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When evaluating DPs, considering influencing factors between companies, DPs, and ecosystem dynamics, along with addressing specific digital platform aspects, is advisable. Ideally, this evaluation should transcend industry-specific boundaries (McIntyre, Srinivasan, Afuah, Gawer, and Kretschmer, 2021). Identifying mechanisms and architectures for comparing DPs is also recommended (Salami and Yari, 2018). To enhance evaluation systems, comprehensive benefit assessment indicators should expand to encompass society, the economy, and technology (Li et al., 2020; Nicolescu, Huth, Radanliev, and De Roure, 2018).

By 2023, international digital platforms, like Amazon Web Services IoT and Microsoft Azure IoT Suite, play a prominent role in shaping the landscape of IIoT applications, driving innovation and connectivity (M. Zhang et al., 2017; Marshall and Lambert, 2018). However, DPs within IIoT companies are experiencing increasing complexity. Operating and utilizing DPs entail unique challenges as they connect with diverse actors and assets on an international scale, facilitating information exchange (De Reuver et al., 2018). These connections span various levels of technical infrastructure, and DPs undergo dynamic changes influenced by both internal and external factors (Bender and Gronau, 2021). Their distributed nature poses challenges for comprehensive analysis (Henfridsson, Mathiassen, and Svahn, 2014). Nevertheless, DPs are gaining significance across multiple industries, including energy and environment, chemicals and raw materials, transport and logistics, and trading.

In the IIoT context, DPs are generally defined as software systems facilitating the development of intelligent products and services (Andreev, Balandin, and Koucheryavy, 2012). Platform openness in this context refers to the degree of restrictions imposed on participation, development, or usage, impacting various roles, including developers and end users (Eisenmann, Parker, and Alstyne, 2009). This openness occurs at multiple levels, affecting the demand side, supply side, digital platform provider, or digital platform sponsor (Eisenmann et al., 2009). It plays a significant role in competition within and between ecosystems, encompassing access, authority, and inclusivity across vendors, customers, complementary service providers, categories, and channels (Broekhuizen et al., 2021).

To evaluate DPs and make choices regarding their assessment, a tool for comparing different DPs becomes important. This tool undergoes analysis based on two different categories: (1) the launch phase of digital platform architecture and (2) the maturity phase of digital platform architecture. Section 2.1 provides a detailed definition of these categories and justifies the decision behind the evaluation process.

Research Question: To address the evaluation challenges associated with DPs, it is essential to formulate a specific research question. This paper aims to establish a systematic analysis of digital platform evaluation through the following steps: (1) defining a procedure and (2) designing an evaluation tool to ensure the appropriate design of DPs. The demonstration of the evaluation tool involves deriving a ranking of representative candidates (3). The tool is then empirically validated through expert surveys (4), enabling the selected candidates to serve as a foundation for digital platform evaluation. It is important to note that this paper does not aim to provide an comprehensive description of the technical implementation of the digital platform approach. Instead, it represents an initial effort towards establishing a adequate evaluation foundation.

The research question guiding this study is:

RQ1. What are the relevant openness indicators for the evaluation of digital platforms between the launch and maturity phase?

Paper Structure: In order to address this research question, a design-oriented research approach (Peffers, Tuunanen, Gengler, Rossi, and Hui, 2006) was followed, and the structure of this paper is organized as follows. The first section provides a general introduction, highlighting the motivation behind the study and presenting the research question. In section 2, the requirements for evaluating the digital platform problem are identified, along with the proposed methodological approach. These requirements are addressed through a design that aims to tackle the modeling problem. The design's functionality is demonstrated and evaluated through argumentation in section 3. Finally, section 4 provides a summary of the extent to which the initial modeling problem has been resolved and the research questions have been answered.

Paper Relevance: This research helps address scientific challenges and problems. It provides source-based insights that can help scientific decision makers, companies, and individuals make informed decisions to address problems for evaluating the openness of digital platforms between the launch and maturity phase. Furthermore, this research promotes innovation by broadening the foundation for the development of open digital platforms between the launch and maturity phase. It leads to improvements in existing assessment methods of open digital platforms and the development of new assessment solutions for complex openness indicators. In addition, this research promotes a cycle of continuous improvement.

2. Objectives and Methodology

In accordance with the Design Science Research Methodology (DSRM) approach (Peffers et al., 2006), section 2 outlines objectives that are independent of a specific design. The applied design process is divided into six sequential steps, which are described below. In the first step, a research gap is identified and the research question is formulated in concrete terms. A solution-oriented goal is then formulated, which includes a comparative analysis of previous research and the definition of a research framework. The subsequent model development phase draws on existing literature. In the demonstration phase, the model is presented using openness indicators as a key tool. In the evaluation phase, the results of the model are compared with the predefined objectives. The communication process is effectively achieved through the medium of this paper, among others. A further methodology (Zwicky, 1969) is subsequently introduced to fulfill these methodological objectives. These objectives are distinct from the design itself and its demonstration, allowing for the creation of artifacts that can be evaluated based on their ability to meet the identified requirements. Once the methodological foundation is established, the designed artifacts provide evidence of their functionality through a demonstration.

2.1. Objectives

With the research goal of achieving the evaluation of DPs in mind, section 2.1 introduces a series of requirements that must be taken into account when developing a tool suitable for evaluating the adequate foundation of DPs. The following requirements (R), derived from consensus among 31 practitioners and researchers in the domains of DPs and business applications in expert circles, are identified and presented in Tab. 1.

Table 1. Requirements for the tool

ID	Requirement
R1	Adequate base (methode and system)
R2	Digital platform architecture lauch phase
R3	Digital platform architecture maturity phase
R4	Digital platform analysis (not subjective)
R5	Digital platform identification (ranking)

The following section provides a detailed explanation of these requirements. Firstly, it is of importance to systematically and methodically identify a suitable set of indicators (R1) that will serve as the basis for the design process. When considering digital platform architectures within the launch phase (R2), it becomes crucial to evaluate the available options comprehensively. In the context of the maturity phase, different digital platform architectures (R3) should be taken into consideration. In order to ensure an objective analysis, the evaluation of 31 experts in the domains of DPs and business applications (R4) becomes an important aspect of the digital platform assessment, assisting in mitigating subjective biases. A ranking-based approach (R5) is essential for a clear and understandable evaluation of DPs. By adhering to these requirements, the objective is to establish a methodological framework that incorporates morphological analysis and design-oriented artifact creation, thereby providing a methodological foundation.

2.2. Morphological Analysis

In adherence to the Design Science Research Methodology (DSRM), the steps outlined by Zwicky are followed in order to design an artifact. To explore all relevant solutions for a multidimensional and non-quantified complex problem across different domains, morphological analysis proves to be a suitable tool (Zwicky, 1969). This method has been recognized and applied in various fields such as anatomy, geology, botany, and biology, employing different morphological techniques (Ritchey, 2006). The process begins with a general morphological analysis and involves constructing a morphological box known as the Zwicky box, which is accomplished through five iterative steps (S) (Zwicky, 1966). The construction of the Zwicky box can be observed in detail in Tab. 2.

Table 2. Construction of morhological box in five iterative steps (Zwicky, 1966)

ID	Step
S1	Definition of problem dimension
S2	Definition of indicator categories
S3	Construction of the morphological box
S4	Evaluation of relevant solutions
S5	Application of the adequate solution

First Step (S1): The problem dimensions are accurately defined, taking into consideration their relevance and practical applicability to support problem-solving.

Second Step (S2): Parameters are established, representing a range of values for each dimension. These parameters typically represent different approaches to addressing the problem within each dimension.

Third Step (S3): The morphological box is constructed by arranging the parameters in an n-dimensional matrix. Each cell in this box represents a specific parameter of the problem, and selecting one parameter per dimension creates a unique configuration that represents a potential solution to the problem. In our case, an empirical investigation was conducted to determine the most favorable configuration with the highest acceptance.

Fourth Step (S4): This step involves examining and evaluating relevant solutions based on their intended purpose. In our context, the goal is to identify an adequate foundation for the design. Through workshop sessions involving 31 research and consulting experts in the domains of DPs and business applications, individual responses were gathered for guidance questions related to the digital platform tool. The experts were selected to participate in this process based on their expertise and experience. Participants include four PhDs who have particular expertise due to their extensive educational backgrounds. The participation of nine PhD students further enriches the discussions with insights from their advanced research. Two professors are also part of the group and bring their extensive academic experience to the initiative. In addition, six practitioners from software companies contribute valuable insights from their practical industry experience. Finally, one participant is an IT security manager and brings a critical perspective in this critical area. In addition, there are nine students who bring new and innovative viewpoints to the project. The collective contribution of these 31 experts forms a well-rounded team that ensures a comprehensive and insightful evaluation process. m The evaluation process considered selected dimensions, and the architectures were divided into two clusters: platform architectures within the launch phase of production companies and platform architectures within the maturity phase of production companies. The best architectures for each cluster were determined based on evaluations from the 31 domain experts in the final stage.

Fifth Step (S5): This step involves the practical application of the adequate solution, namely the morphological box. Insights gained from previous steps are taken into account during this application phase.

2.3. Design

In accordance with the DSRM (Peffers et al., 2006), this section 2.3 introduces artifacts that have been designed to address the modeling problem. The design of a systematic evaluation of relevant tools for implementation is explained, followed by the presentation of a design that outlines the technical aspects. A visually accessible form of representation is designed. To systematically capture the requirements across different indicators, a morphological box was constructed. The following indicator categories (IC) have been identified based on consensus among 31 practitioners and researchers in the domains of DPs and business applications in expert circles. These categories, as shown in Tab. 3, encompass a comprehensive set of indicators that facilitate the evaluation and assessment of the proposed tool.

Table 3. Indicator categories of morphological box

ID	Indicator category
IC1	Objective openness indicator
IC2	Access to supplier indicator
IC3	Access to customer indicator
IC4	Additional service providers indicator
IC5	Product category indicator
IC6	Company delivery channel indicator

For each indicator, corresponding attributes were compiled and supported by relevant guiding questions, such as ”What is the total amount of diverse product categories and wide range of items that are currently offered and available on the DPs marketplace?” These attributes were then assessed using different scales, including options such as marketshare. Consensus was sought to identify any mutually exclusive conditions within the scales. The scales were evaluated through a survey conducted with 31 experts in the domains of DPs and business applications to determine the configurations with the broadest acceptance for each indicator. The resulting best configuration of the morphological box can be seen in Tab. 4.

2.4. Demonstration

This section 2.4 utilizes the designed artifact to demonstrate its usage and evaluate whether the initial research problem has been addressed. It also showcases the application of the morphological box to identify a suitable foundation for the evaluation of DPs.

As of 2023, prominent international industrial Internet of Things digital platforms employing these architectures include Amazon Web Services IoT and Microsoft Azure IoT Suite (M. Zhang et al., 2017; Marshall and Lambert, 2018). In German-speaking countries, Siemens Xcelerator and SAP Leonardo are notable players as digital platforms (Gurcan and Taentzer, 2021). These digital platform providers in the manufacturing domain aim to bring together multiple user groups and leverage network effects. They

Table 4. Morphological box with best general openness indicators

Indicator	Guidance Question	Scale	Reference
IC 1	Are digital platform changes on the market measured through market share?	Market share	Broekhuizen et al., 2021 Thomas, Autio, and Gann, 2014
IC 2	What is the access and activity strategy for digital platform suppliers? What is the extend and degree of access that suppliers, who are not part of the platform, have to a platform, and what permissions are granted to them?	Restrict control strategy/ Facilitate enable strategy	Broekhuizen et al., 2021; Boudreau, 2010 Hagiu and Wright, 2019 Van Alstyne, Parker, and Choudary, 2016a Van Alstyne, Parker, and Choudary, 2016b Parker and Van Alstyne, 2018 Eisenmann, Parker, and Alstyne, 2009
IC 3	What is the scope and magnitude of the customer access granted to a digital platform, and what activities are they authorized to perform within the features and functionalities of the digital platform?	Niche market segment/ Mass market appeal	Broekhuizen et al., 2021; Cui and Wu, 2016 Mačiulienė and Skaržauskienė, 2016 J. Zhang, Cao, and He, 2018 Cennamo and Santaló, 2015 Balka, Raasch, and Herstatt, 2014 Thiel and Masters, 2014
IC 4	With what strategy are external service providers, that enhance the digital platform's products granted access and authority into the platform? What is the degree and extent of access and authority, and integration granted to external service providers that complement the platform's products?	Tighten restrict control strategy/ Liberate facilitate enable strategy	Broekhuizen et al., 2021; Kannan, 2017 Jacobides, Cennamo, and Gawer, 2018 Hagiu and Wright, 2019 L. Zhang et al., 2014 Gebregiorgis and Altmann, 2015 Ondrus, Gannamaneni, and Lyytinen, 2015 Suarez and Cusumano, 2009 Eisenmann, Parker, and Alstyne, 2009
IC 5	What is the total amount of diverse product categories and wide range of items that are currently offered and available on the DPs marketplace?	Category amount/ Specific amount	Broekhuizen et al., 2021 Kumar, George, and Pancras, 2008 Oppewal and Koelemeijer, 2005 Sirohi, McLaughlin, and Wittink, 1998
IC 6	What is the total amount through a variety of communication, delivery, distribution, engagement, user experience, and interaction streams? How many distinct multi-channels are available to enhance user engagement?	Coperate stream amount/ delivery channel amount	Broekhuizen et al., 2021 De Haan, Kannan, Verhoef, and Wiesel, 2018 Saghiri, Wilding, Mena, and Bourlakis, 2017 Emrich, Paul, and Rudolph, 2015 Wang, Malthouse, and Krishnamurthi, 2015 Verhoef, Neslin, and Vroomen, 2007

establish participation rules and framework conditions within their digital platform. The impact of DPs on business and organizational models and their influence on economies have been explored in various studies (Tiwana, Konsynski, and Bush, 2010; Evans and Schmalensee, 2008; Parker, Alstyne, and Choudary, 2016; Bender, 2020).

Following the fifth step of the morphological analysis outlined in section 2.2, the previously determined best configuration of the morphological box is applied to identify a suitable basis for the evaluation of DPs. The closer a parameter of a tool performs to the adequate values within a particular dimension, the more suitable the tool is as a foundation. The preferred tools (PT) are those that exhibit proximity to the previously established optimum. The analysis and evaluation of the tools can be seen in Tab. 5.

Objective quantitative openness indicator (IC1): The objective quantitative openness indicator, as proposed by Boudreau (Boudreau, 2010), is a valuable tool for evaluating the impact of actual changes in platform openness on market outcomes. It's important to note that during the initial launch phase, market effects are typically not observed, primarily due to the inherent challenges in measuring the platform's influence at such an early stage. However, as the platform progresses into the maturity phase, meticulous efforts are made to measure and assess its effects on the market. This evaluation involves a examination of the market shares. By scrutinizing these outcomes, it is possible to gain a deeper understanding of the extent to which digital platform openness influences the market landscape. To illustrate, as of the first quarter of 2023, Amazon Web Services IoT commanded a substantial 32%

Table 5. Tool analysis digital platforms between the launch and maturity phase

ID	Amazon WS IoT		Microsoft Azure		Google Cloud		Siemens Xcelerator	IBM Maximo
	Launch	Maturity	Launch	Maturity	Launch	Maturity	Launch	Launch
IC1	0	32	0	23	0	10	1	3
IC2	Enable	Enable	Control	Enable	Control	Enable	Enable	Control
IC3	Mass	Mass	Niche	Mass	Mass	Mass	Niche	Mass
IC4	Enable	Enable	Control	Enable	Control	Enable	Enable	Control
IC5	7	7	3	7	5	13	13	16
IC6	50	886	266	851	27	141	215	324
PT	**Yes (84%)**		**Yes (58%)**		**Yes (68%)**		**Yes (68%)**	**No (65%)**

market share within the competitive cloud infrastructure market, while Microsoft Azure secured a noteworthy 23% share, showcasing the practical application of this openness indicator in assessing real-world market dynamics.

Access of supplier or vendor indicator (IC2): The access of supplier or vendor indicator refers to the level of access and permissions granted to external suppliers who are not part of the platform. It determines their capabilities and actions within the digital platform (Van Alstyne, Parker, and Choudary, 2016a; Van Alstyne, Parker, and Choudary, 2016b). DPs like Amazon Web Services IoT and Siemens Xcelerator adopt an enabled authority approach, offering opportunities to suppliers beyond the platform. This fosters collaboration, innovation, and mutually beneficial partnerships, enabling suppliers to contribute their expertise, resources, and services to enhance the platform's offerings and overall value proposition.

Access of customer or client indicator (IC3): The access of customer or client indicator pertains to the access and entitlements provided to customers on a digital platform. It involves explicit criteria-based restrictions and implicit target market pre-selection (Mačiulienė and Skaržauskienė, 2016). DPs such as Amazon Web Services IoT and Siemens Xcelerator employ an enabled authority approach to serve these markets. They empower customers to actively contribute to value creation by engaging in production and delivery phases, including collaborative production, product adaptation, participation in delivery, and sharing feedback.

Additional service provider indicator (IC4): The additional service provider indicator relates to the degree of access and authority granted to external service providers that complement the core platform product (Kannan, 2017). These providers form a broad group often referred to as "Complementary Service Providers," "Sponsors," or "Interoperable Platforms" (Gebregiorgis and Altmann, 2015). DPs like IBM Maximo adopt a restrictive authorization strategy for these vendors. These restrictions are designed to ensure the security and quality of the services provided while allowing access to external service providers.

Product category or detail indicator (IC5): The product category or detail indicator refers to the digital platform's willingness to offer a variety of product categories and items. It involves decisions on assortment composition, including breadth, depth, and category relationships. Managing category openness enables platforms to provide diverse product options while optimizing customer choices and satisfaction (Sirohi, McLaughlin, and Wittink, 1998). For example, Amazon Web Services IoT offers seven categories within the IoT segment, including "Applications," "Analytics," "Device Security," "Device Connectivity," "Device Management," and "Smart Home and City." Microsoft Azure has expanded to include seven categories: "IoT Connectivity," "IoT Solutions," "IoT Analytics and Data," "IoT Security," "IoT and IIoT Platforms," "IoT Core Services," and "IoT Edge Modules."

Company delivery channel indicator (IC6): The company delivery channel indicator refers to the accessibility of a digital platform through multiple communication and distribution channels (Saghiri, Wilding, Mena, and Bourlakis, 2017). DPs can enhance channel openness by offering a range of digital and physical channels, facilitating user transitions. For example, IBM Maximo and Siemens Xcelerator are still in the launch phase, as they were released in 2021 and 2022, respectively. Consequently, no data for the maturity phase are available and could not yet be evaluated.

Preferred tools (PT): The preferred tools were selected based on their alignment with optimal solutions identified by 31 experts in DPs and business applications. Amazon Web Services IoT emerged as the top choice, with 84% preference rate, followed by Microsoft Azure at 58%, and both Google Cloud and Siemens Xcelerator at 68%, showcasing their competitive standing. Notably, 65% of the experts did not favor IBM Maximo, indicating a misalignment with their preferred toolset. Amazon Web Services IoT's appeal stems from its market leadership, versatility, and extensive access for external vendors. Despite being in its launch phase since mid-2022, Siemens Xcelerator garnered expert recognition for its unique offerings in a niche market, highlighting its potential to compete effectively in specialized domains. These preferences underscore the dynamic nature of the digital platform landscape and the importance of tailoring tool selections to specific industry needs.

3. Evaluation

In subsection 3.1, this section examines the fulfillment of requirements for a suitable tool to evaluate digital platforms (DPs) based on the demonstration evaluation. The subsection 3.2 explains the experiences collected from the demonstration, specifically focusing on the insights shared by the 31 experts in the domains of DPs and business applications. In subsection 3.1, the evaluation of the demonstration goes beyond providing a comprehensive assessment of the identified requirements for a digital platform evaluation tool. It also assesses the extent to which these requirements have been fulfilled. This analysis ensures that the tool meets the necessary criteria for evaluating DPs effectively. Furthermore, subsection 3.2 delves into the perspectives and insights gained by the 31 experts during the demonstration, shedding light on their valuable experiences and observations.

3.1. Requirement Fulfillment

In accordance with the DSRM (Peffers et al., 2006), section 3.1 evaluates the demonstration presented in section 2.4 to determine if the requirements outlined in section 2.1 have been fulfilled. The results of this evaluation can be found in Tab. 6. The following paragraphs explain the fulfillment of each requirement:

Table 6. Requirement fulfillment of the tool

ID	Requirement fulfillment	
R1	Adequate base (methode and system)	yes
R2	Digital platform architecture launch	yes
R3	Digital platform architecture maturity	yes
R4	Digital platform analysis (not subjective)	yes
R5	Digital platform identification (ranking)	yes

R1 has been satisfied through the utilization of the morphological analysis methodology to create a tool capable of analyzing different types of tools and assessing their suitability as a foundation for evaluation. By employing the empirically validated morphological box and obtaining consensus from 31 experts in the domains of DPs and business applications, a systematic and methodical identification of an appropriate set of tools has been achieved. Moreover, the evaluation process has reduced subjectivity (as per R4) by relying on the informed judgments of diverse domain experts.

R2 and R3 have been satisfied by considering representatives identified in the literature and through expert consensus for analysis within each category. For example, Amazon Web Services IoT represents the maturity phase, while Siemens Xcelerator represents the launch phase. These platforms not only exemplify different stages of development and adoption but also offer valuable insights into the factors contributing to their positions. Studying these platforms allows researchers to gain a deeper understanding of the dynamics and outcomes associated with different stages of platform development and adoption.

By deriving rankings for tools within each cluster based on the fulfillment of the best dimensions and parameters, the evaluation has identified the top candidates within each cluster (Digital platform architecture launch phase / Digital platform architecture maturity phase). This approach ensures comprehensibility and fulfills R5.

As all requirements (R1 to R5) have been satisfied, it can be concluded that the creation of an evaluation and analysis tool has been successfully accomplished in accordance with the principles of the DSRM.

3.2. Demonstration Experiences

During workshops and panel discussions with 31 experts, the evaluation and analysis tool proved to be valuable and useful. The tool assisted experts in evaluating digital platforms (DPs) by identifying the most attractive candidates within each category. This enabled experts to make informed decisions and select DPs in their respective areas of interest. The tool facilitated discussions among the experts, allowing them to compare the strengths and weaknesses of different DPs and rank alternative options in conflict situations. The summarized percentages provided in brackets in Tab. 5 transparently represented the decisions made by the experts.

Through the analysis of various DPs, the evaluation and analysis tool revealed a research gap in the performance of DPs. It became evident that no single representative showed good performance across all categories. However, *Amazon Web Services IoT* emerged as the best-performing platform overall. By selecting the most attractive digital platform in each category, the experts compiled a set of DPs that holds the most promise for developing a digital platform approach. Future research endeavors can build upon this evaluation.

Furthermore, the analysis and evaluation tool provided a structured framework for assessing the performance of digital platforms and identifying areas for improvement. By engaging the expertise of 31 experts and facilitating collaborative discussions, the tool enhanced the accuracy and reliability of the evaluation process. It also deepened the experts' understanding of the complex dynamics and intricacies underlying digital platforms. The insights gained from this evaluation can serve as valuable input for enhancing existing platforms and devising effective strategies for future digital platforms.

4. Conclusion and Future Research

The research question regarding relevant openness indicators for the evaluation of digital platforms between the launch and maturity phases has been addressed through a morphological analysis. This analysis involved conducting a literature review and consulting 31 experts to identify the parameters necessary for evaluating digital platforms (DPs). The relevance of these parameters was estimated through empirical research, leading to the identification of the best configuration for the dimensions and the creation of a morphological box. By demonstrating the constructed morphological box, a selected set of DPs was analyzed. Based on the evaluation, the best DPs were identified within each category. In the maturity phase category, Amazon Web Services IoT emerged as a prominent candidate, while Siemens Xcelerator represented the launch phase category. These selected DPs serve as a novel and suitable basis for the development of digital platforms. In summary, the research question was answered by employing a morphological analysis that involved expert input, literature research, and empirical estimation of parameter relevance. The resulting morphological box and the identified DPs provide valuable insights and form a solid foundation for further digital platform development.

Future research: While the principle of integration has been practically validated, there is a need to provide technical proof and validate it in real-world scenarios to ensure its applicability.

Moreover, this study focused on key dimensions such as access to suppliers, customers, additional service providers, product categories, and company delivery channels. Expanding the set of dimensions would provide a more comprehensive understanding of tool identification, including the exploration of more advanced digital platforms.

The disparity in the scales used for the various openness indicators continues to be a challenge because they come from different studies. This discrepancy makes cross-category data aggregation difficult. To enable meaningful comparisons, this problem needs to be addressed by standardizing indicators. Future research could focus on creating a standardized framework for openness indicators. This would not only facilitate accurate cross-category aggregation, but also lead to a comprehensive overall indicator of openness that would improve the depth and applicability of future studies.

Additionally, this study relied primarily on the morphological box and interviews as research methods. To enhance the robustness of the evaluation results, future research should incorporate additional research methods. This would allow for validation and interpretation of the findings, further strengthening the overall analysis.

Investigating the potential for further development of morphological boxes is an intriguing area of scientific research. The practical application of our morphological box in the context of digital platforms can contribute to the advancement of this field from a practical standpoint.

The performance assessment and development of digital platforms are also promising areas for future research. Research endeavors should focus on implementing and refining digital platforms for industrial use cases, which would contribute to the advancement and practicality of these platforms.

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