Management and Production Engineering Review
Volume 14 • Number 1 • March 2023 • pp. 118–126
DOI: 10.24425/mper.2023.145370

Drivers and Barriers of Digital Transformation in Asset Management

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Received: 06 October 2022
Accepted: 16 November 2022

Abstract
This paper aims to improve understanding of the drivers and barriers to digital transformation in asset management. Accordingly, this paper contributes to the literature by conducting a qualitative Delphi study with 15 experts (including academia, consultancy and industry) to identify, validate, and classify the drivers and barriers affecting digital transformation in asset management. As a result of the experts' interactions, 20 barriers were identified. The main barriers to digital transformation in asset management are the following: Misunderstanding of the strategic importance of asset management, no clear vision/strategy, existing mindset and culture, inadequate asset management system, lack of understanding of digital trends, and lack of employee knowledge and skills. The study also highlights 12 drivers that are critical to the digital transformation of asset management. These include cost reductions, opportunities in condition monitoring of assets, expected benefits in asset management processes, expected benefits in risk management and others.

Keywords
Asset management, Digital transformation, Drivers, Barriers, Delphi.

Introduction

Companies today are facing the development of the fourth industrial revolution, also known as Industry 4.0. Industry 4.0 is inherently related to the digital transformation of manufacturing and other types of industries and aims to advance value creation processes. There is a need to develop systems characterized by greater connectivity, more information and, at the same time, greater flexibility, which will allow companies to have a better overview of their processes and, consequently, improve their performance results (Martínez-Galán et al., 2020). Crespo Marquez et al. (2020a) pointed out that digital transformation is not just about making processes more efficient, but also about creating more sustainable and profitable customer relationships by meeting customers' needs more efficiently. For example, digitalization is creating new opportunities for asset management through the emergence of Cyber Physical Systems (CPS). In this regard, digital twins can be used by companies to determine the performance of their physical assets or to monitor, analyze, and optimize any asset or process. Intelligent asset management systems are becoming increasingly important and are directly related to building new capabilities needed to manage and process data and information (Crespo Márquez et al., 2020b). Therefore, the availability of industrial Internet of Things (IoT), new technologies such as predictive maintenance analytics combined with Big Data, and digital twin simulations are driving the growth of the intelligent asset management (IAM) platforms market (Crespo Marquez et al., 2020b). Technological innovation seems to be a promising landscape for asset management. The IoT as a key enabler of Industry 4.0 as well as Big Data, cloud computing, mobile networks, virtual reality, digital twins, building information modeling (BIM), real-time monitoring of physical assets are some of the trends currently driving the asset management sector and discipline. The digital age poses new challenges to businesses and is enabled by communication between people, machines and resources (Huet et al., 2020; Jasiulewicz-Kaczmarek et al., 2020, p. 4; Kagermann, 2015; Mohammed & Trzcielinski, 2021; Rojek et al., 2021; Tur-

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isová et al., 2021). However, the adoption of digital approaches in asset management is quite challenging. It entails changes in infrastructure related to technology as well as changes in asset management processes. Therefore, for an efficient transition to IAM, it is important to understand the challenges and identify possible solutions.

The ISO 55000 standard provides a good foundation for companies to understand various aspects of the asset management system (ISO 55000, 2014). According to the asset management standard ISO 55000, assets are items, things and entities that have value or potential value for the organization (ISO 55000, 2014). In this regard, companies seek to maximize the value of their assets by investing efficiently in asset management to achieve a better return for their company (Lima et al., 2021; Maletič et al., 2018). This can be achieved by focusing on costs, risks, and performance and optimizing them throughout the asset life cycle (Maletič et al., 2020). Engineering assets are important for creating tangible value for businesses in areas such as manufacturing, energy and water supply, construction, mining, transportation, and various other industries (Almeida et al., 2021). For successful implementation of asset management, it is important to understand the needs of the organization. In addition, aligning the goals of the organization and asset management is critical to the safe, cost-effective, and timely delivery of quality products (Chattopadhyay, 2021) Therefore, an appropriate asset management strategy and plan are critical to creating value from assets and achieving business objectives. In addition, an asset management system can also help organizations achieve better sustainability performance (Maletič et al., 2018; Sandu et al., 2022).

The introduction of Industry 4.0 enables companies to collect and process a large amount of data over the entire life cycle of an asset. It therefore offers the opportunity to digitize and automate interactions between different stakeholders, reduce errors, and improve the performance of asset management processes. For example, Industry 4.0 can provide insights on how to improve asset maintenance using predictive analytics. In addition, the large amount of data on assets and asset management also provides opportunities for the future development of asset management using new technologies. Digital transformation in asset management should therefore ensure that the right business information and operational technology data is available at the right time, across the system, and throughout the asset life cycle. A prominent example is IAM, which represents a shift from traditional preventive maintenance to new condition-based and predictive maintenance concepts. There is also a growing shift toward prescriptive approaches that enable organizations to make actionable recommendations for assets (e.g., asset maintenance decisions, operations, and other life-cycle management activities).

Asset-intensive companies need to understand and operate within the changing context. The successful implementation of an asset management strategy must be fully aligned with the company's digital strategy, and both must flow from the company's strategic objectives (Trindade & Almeida, 2018). They must manage their adaptation to change to better fit their strategic priorities. Thus, a digital strategy in asset management is a key enabler of data-driven decision making, which is indeed a key enabler of asset management and an important contributor to an efficient and effective asset management system.

On the one hand, there is still a great deal of uncertainty among manufacturers about what the implementation of Industry 4.0 really requires of them - and many are still finding it difficult to even get started. On the other hand, most technology vendors have been relatively quick to transition their portfolios to Industry 4.0 (Industry 4.0, 2016). Adopting new technologies can help companies be be more responsive in the market-place. Accordingly, companies should also consider these aspects when building an asset management system. Very few executives have the commitment and fortitude required to bring about the kind of long-term change needed to equip organizations for the digital future. The goal of this paper is to identify the underlying factors that are either facilitating or hindering, or even halting, digital transformation in asset management. Drivers can be understood as factors and forces that lead organizations to initiate and implement activities related to the digitalization of asset management. On the other hand, barriers can be understood as factors that hinder the success of asset management digitalization. In this respect, this paper contributes to the literature and to practice by providing answers to what experts consider to be the key drivers and barriers of digital transformation in asset management. Therefore, this paper attempts to make several contributions to the literature, of which we can highlight the following: 1) First, this study identifies relevant drivers and barriers to the digitalization of asset management. The identified drivers and barriers can serve as a foundation that comprehensively covers potential challenges and issues related to the effective adoption and implementation of digital asset management strategies. 2) Second, as a contribution to theory, this study provides a benchmarking framework to help managers

formulate critical strategies for effective asset management in the context of digitalization.

The remainder of this paper is divided into four sections. The Methodology section describes the procedure of the Delphi study. The following Analysis and Discussion section contains the interpretation of the results. The paper concludes with the Concluding Remarks, Limitations and Future Work section.

Methodology

This section sets out the methodological background and research process relevant to our study design and implementation. In the absence of extensive empirical data, this study used a structured approach to elicit expert insight on the drivers and barriers to digital transformation in asset management. The collection of literature, the selection of barriers and drivers, and the applicability of the research methodology are related to the purpose of this work. This paper is based on a study among experts from Slovenian manufacturing companies, consultancies and universities. We grounded our research framework and its related processes on certain guidelines suggested by Delphi method. Delphi method is used as a group technique aiming to achieve the reliable consensus by surveying a panel of experts (Landeta, 2006). In the Delphi technique, responses to questionnaires from a panel of experts are evaluated in multiple iterations to reach consensus on a particular topic; multiple iterations (rounds) give participants an opportunity to reflect on feedback on their responses to statements in earlier iterations (Hsu & Sandford, 2019). Delphi method is useful and has been widely used in many areas of management. Indeed, the Delphi method has already been used in various works on the subject of digital transformation, for example as a tool for identifying consensus in digital trans-formation as a disruptive innovation (Roblek et al., 2021). However, some challenges arise in implementing this method, such as selecting panel of experts, designing the survey questions, maintaining the number of panel of experts and their commitment, and achieving a satisfactory level of agreement (Okoli & Pawlowski, 2004). In this paper, we rely on the procedure as proposed by Worrell, Di Gangi, and Bush (2013) and divide the process into three blocks, namely: (1) sampling of experts, (2) literature review and brainstorming, (3) narrowing down alternatives and ranking (see Fig. 1). Each step of the research approach is grounded on the literature support and verified through expert feedback.

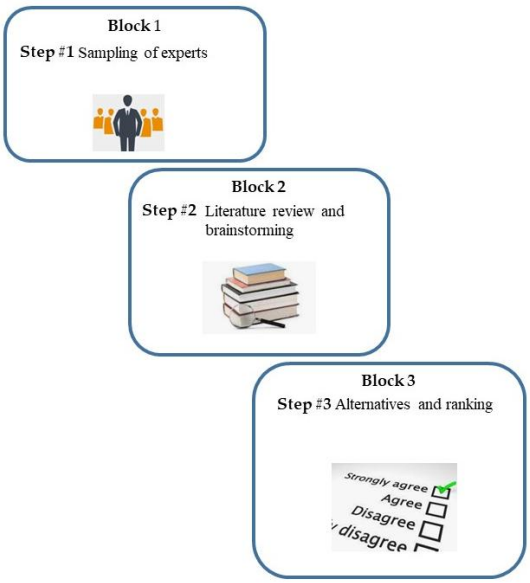

Fig. 1. Research approach

Participants

It is argued that the selection of suitable experts within the Delphi study is of particular importance. Since the number of participants (i.e. experts) is limited, they must have sufficient knowledge and experience of the topic to be discussed so that they can represent a variety of perspectives. The Delphi panel consisted of Slovenian academics and practitioners working in the field of asset management, as well as representatives of asset management solution providers. Many of the experts involved are members of various European and international bodies and societies in the field of asset management. In order to meet the methodological requirements of the Delphi study, the sample of suitable experts was selected on the basis of various criteria, i.e. different ages and years of professional experience, different working positions and levels of education. A total of 15 experts were included in the study (see appendix, Table A1).

Delphi study design

The survey was conducted in two rounds. The first round of the Delphi survey includes open-ended questions on drivers and barriers to digital transformation in asset management. In the second round, the questionnaire created with the 1KA tool (https://www.1ka.si/d/en) was sent to participants with a request to rate each of the options (drivers and barriers) on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). All terminologies, factors and types of information were explained and defined

in the survey. Experts were contacted individually if further explanation was needed or they encountered technical difficulties. A deadline of four weeks was set for the collection of responses. In addition to the evaluation of the questionnaire, experts had an option to add additional drivers and barriers, which were not identified in previous interactions.

The questionnaire was initially developed based on the literature review. The summarized results are presented in Table 1. Based on the literature review and the qualitative analysis of the responses from the first round of the Delphi study, 20 barriers and 12 drivers for digital transformation in asset management were finally formulated.

Table 1
Identified drivers and barriers in management literature – summarized literature review

Authors	Research method/focus	Drivers/Barriers
Stentoft et al., 2021	Questionnaire-survey (drivers and barriers for Industry 4.0 readiness)	*Drivers*: legislation/standards, strategy, workforce, public advisor system *Barriers*: lack of knowledge about the new digital technologies, lack of standards, more focus on operation at the expense of developing the company, lack of data protection (cybersecurity), lack of qualified employee, lack of employee readiness, requires continued education of employees, lack of understanding of the strategic importance of the new digital technologies, lack of understanding of the interplay between technology and human beings, too few financial resources, too few human resources (manpower).
Liere-Netheler et al., 2018	Qualitative research approach	*Drivers*: process Improvement, workplace improvement, vertical integration, management support, horizontal integration, cost reduction
Osmundsen et al., 2018	Literature review	*Drivers*: customer ehaviour and expectations, digital shifts in the industry, changing competitive landscape, regulative changes
Cichosz et al., 2020	Multiple case studies (barriers, success factors and leading practices)	*Barriers*: Complexity of the logistics system and underlying processes, lack of resources including skilled resources, technology adoption, resistance to change and data protection.
Schroeder et al., 2019	Interviews, focus group, Delphi-based inquire (conceptualization of the industry 4.0 context)	*Barriers*: Inhibiting culture, lack of digital exchange standards, business value uncertainty, resource limitations.
Peillon & Dubruc, 2019	Literature review and case studies (barriers to digital servitization)	*Barriers*: Digital transformation and servitization are not considered as strategic goals.
Trappey et al., 2017	A review of essential standards and patent landscapes (for the Internet of Things)	*Barriers*: Lack of standards

Analysis and discussion

The results of the study are presented in this chapter. Therefore, the final ratings according to the 5-point Likert scale are presented in concurrence with the interpretation and discussion of the study findings. As highlighted in the previous section, 15 experts agreed to participate in the study. Drivers and barriers identified from the literature review were rated on an aforementioned five-level Likert scale by the panel of experts. The threshold of 3 (on a 5-point Likert scale) was chosen to decide which factors should be preserved. This is consistent with previous studies that have also used the mean as a selection criterion (Gajic & Palcic, 2019). During the research process, experts added drivers and barriers in addition to those

identified in the literature. The identified drivers for digital transformation in asset management are shown in Table 2.

Table 2
Drivers for digital transformation in asset management

Drivers	Mean value
Cost Reduction	4.67
Opportunities in condition monitoring of assets	4.60
Expected benefits in asset management processes	4.53
Expected benefits in risk management	4.53
Expected benefits in decision making	4.53
Opportunities in advanced analytics: support for better decision making	4.47
Agility and response to change	4.20
Expected benefits in value-creation	4.13
Increased competition	4.13
Technological changes	3.93
Expected benefits in investment decisions	3.80
Legal requirements and changes in legislation	3.27

Table 3 presents the identified barriers to digital transformation in asset management.

To our knowledge, there is no current stream in the asset management literature that addresses the drivers/barriers to digital transformation in asset management. To address this gap, we reviewed the current general management literature on this topic and combined it with the findings from the case analysis. The alignment of literature reports and expert perceptions resulted in a list of drivers/barriers to digital transformation in asset management.

It could be argued that some organizational factors, such as the perceived benefits of asset management, intrinsically function as drivers that move companies toward digital transformation. From an internal perspective to the organization, experts pointed out expected benefits of asset management and related processes as key drivers of the digital transformation in asset management. It is probably the perceived strategic benefits of digitalization in asset management, such as improved process efficiency or lower operating costs, that encourage companies to decide to implement it. Technological innovation is undoubtedly driving companies to change the traditional way of working in asset management through digitization, with the expectation that this change will help manage risk and improve costs and performance. However, companies are likely to face obstacles along the way. The results of our study are consistent with previous research (Maletič et al., 2022; Stentoft et al., 2021), which shows that barriers related to legislation, management, and the workforce hinder the digital transformation process. However, in addition to what can be found in the management literature, our study highlights the importance of taking a strategic view of asset management. Furthermore, the results suggest that companies should establish an asset management system if they want to succeed in digital transformation. This is in line with studies (Gavrikova et al., 2020) that highlight that com-

Table 3
Barriers to digital transformation in asset management

Barriers	Mean value
Misunderstanding the strategic importance of asset management	4.53
No clear vision/strategy	4.47
Existing mindset/thinking and culture	4.40
Inadequate asset management system	4.33
Lack of understanding of digital trends	4.33
Lack of knowledge and skills of employees	4.33
Misalignment of business and asset management objectives	4.07
Lack of management support	4.00
Inadequate hierarchy of physical assets.	3.80
Lack of understanding of the organization's key success factors.	3.73
Lack of understanding and knowledge of processes	3.60
Insufficient human resources	3.47
Lack of innovation potential	3.47
Current IT structure	3.33
Inflexibility of processes	3.27
Lack of employee readiness	3.14
Insufficient financial resources	3.13
Insufficient data protection (cyber security)	3.20
Dependence on other technologies	3.13
Rigidity of regulatory bodies	3.06

panies should recognize the need for a strategic approach to asset management. It is also known that an asset management system helps organizations achieve better performance outcomes (Alsyouf et al., 2021; Maletič et al., 2018, 2020). In addition, strategy is often seen in the literature as an important driver of digital transformation (Stentoft et al., 2021). Similarly, asset management strategy ensures the alignment of asset management processes with the strategic goals of the organization in order to achieve business objectives (Lima et al., 2021). Since digital transformation should be aligned with the broader business strategy, it is important that the asset management strategy reflects the digital transformation goals of the business. Therefore, the asset management objectives included in the strategic asset management plan (SAMP) must be aligned and consistent with the business objectives (ISO 55000, 2014). This means that not having SAMP in the organization is a barrier to digital transformation in asset management. SAMP is also the starting point for developing asset management strategies, goals, and plans that lead to an optimal combination of asset lifecycle activities – based on criticality, condition, performance, and risk level. SAMP is therefore essential for laying the groundwork for implementing new strategies and technologies. Although the asset management industry can benefit from advances in digital technology, this task would be rather difficult to implement without a clear strategy and focus on establishing an asset management system and processes. The main task of asset management is to preserve the value of assets in order to achieve business objectives (Lima et al., 2021). However, misalignment of business and asset management objectives prevents the organization from realizing the value of assets at the desired level. This is also true for digital transformation. There is often a lack of critical understanding of how digitalization will impact the business and how to effectively plan and deploy the required capabilities. In such cases, it can very quickly happen that asset management goals with regard to digital transformation are not aligned with strategic goals. Digital does not just mean "remote." For example, machine learning can be used to analyze textual information in maintenance messages and suggest appropriate failure modes. Therefore, it is critical to understand digital trends and develop digital skills and knowledge. Asset management requires competencies that meet the requirements for knowledge, skills, experience, behaviors, attitudes, and attributes related to asset management (ISO 55001, 2014). New capabilities in asset management are needed to implement digital transformation. Management must therefore create an environment in which asset managers can become excellent professionals who are able to make the right decisions based on and with the help of data analysis. A lack of knowledge and support from top management is therefore an obstacle on the path to digitization in asset management.

Furthermore, the present study shows that the current IT structure, data protection and insufficient financial resources are also barriers that hinder digital transformation in asset management. Previous literature (e.g. von Leipzig et al., 2017) has shown that insufficient IT structures, lack of technical skills, inadequate business processes, and high implementation risks and costs are frequently cited as barriers.

Concluding remarks, limitations and future work

This section outlines some conclusions, practical implications and limitations of the study. This paper aims to contribute by providing answers to the question of what experts consider to be the main drivers and barriers to digitalization in the field of asset management. Empirical data on this phenomenon was developed through a Delphi study with an expert panel of 15 experts from manufacturing companies, consulting firms and universities. Therefore, this work can be useful for any organization interested in digital transformation in asset management. Nowadays, companies cannot escape the opportunities of digitalization. Asset management is no exception. Integrating digital technologies into the asset management space fundamentally changes the way you operate and realize value from assets. However, many barriers can arise when a company decides to embark on the digital transformation journey. This study identified 20 barriers related to management, workforce legislation and other aspects. Beyond the obstacles, this study provides insight into the drivers and identifies 12 drivers that are essential to moving forward in the digital transformation of asset management. According to the findings, cost reduction, opportunities in condition monitoring of assets, expected benefits in asset management processes, expected benefits in risk management, expected benefits in decision making are the most influential drivers from viewpoint of experts. Among the barriers, the following received the highest scores: misunderstanding the strategic importance of asset management, no clear vision/strategy, existing mindset/thinking and culture, inadequate asset management system, lack of understanding of digital trends and lack of knowledge and skills of employees. Based on the results, some practical implications

for companies could be outlined. First, there is often a lack of clear understanding of the term "asset management." Companies should understand the importance of asset management and its strategic relevance. At the same time, it is important for companies to assess the current state of asset management and the level of digital maturity. This understanding helps companies to grasp the complexity of asset management digitalization. In this context, a clear digitalization roadmap can be crucial to outline what goal a company actually wants to achieve and to identify the digital initiatives that can be used to achieve the goals of asset management digital transformation. One of the most important areas is improving organizational culture. It should promote openness to change and willingness to adopt new technologies. It is critical to understand the role that leadership and workplace culture play in implementing change to improve an organization's asset management capabilities. It should be emphasized that companies need sufficient drivers to engage in the digitization of asset management and that the outcome is highly dependent on the extent to which asset management problems and challenges can be transformed into business opportunities.

Limitations and future research directions are presented below. This research proposes a Delphi-based analysis according to the experts' feedback. Therefore, the results of the study are based on the experts' assessments, which must be done very carefully. In this work, 20 barriers and 12 drivers are proposed in relation to the digitalization of asset management. It should be noted that the identification of drivers and barriers could be further explored. The Delphi-based analysis is also not able to illustrate the relationships between drivers and barriers and their causal relationship with the outcomes of asset management digitalization. In addition, this Delphi-based study could be extended by involving experts from other countries and comparing results from different contexts. Accordingly, it is possible to compare drivers and barriers in terms of dimensions and attributes such as country of origin, industry type, company size, etc. In addition, a case study research approach is proposed that aims to develop a deeper, multi-faceted understanding of the topic under study in its real-world context. Further, future studies could expand our research by identifying enablers as those factors that make digitalization in asset management possible to achieve. The latter would allow for more intensive theoretical contributions in the field of asset management implementation and its digitalization. Finally, the link between digital transformation in asset management and an organization's performance outcomes, and the role of drivers and barriers in this, could be another future direction to further advance the understanding of digital transformation in asset management.

Appendix

Table A1
Demographic data of experts

Age Group	Number of experts
31–40	3
41–50	4
51–60	4
Over 60	4
$\sum$	15
Education	
Short-cycle higher vocational	1
University degree (Professional Bachelor's)	1
Second cycle (Master's), University degree (pre-Bologna)	3
Specialisation after university degree (pre-Bologna)	1
Master of Sciences (pre-Bologna)	5
PhD	4
$\sum$	15

Acknowledgments

This research was supported by the Slovenian Research Agency; Program [No. P5-0018 – Decision Support Systems in Digital Business].

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