

Association for Information Systems

AIS Electronic Library (AISeL)

Selected Papers of the IRIS, Issue Nr 14 (2023)

Scandinavian (IRIS)

10-14-2023

Portfolio Management of Digital Innovation Initiatives – A Systematic Literature Review

Jukka Salonen

Aalto University, jukka.m.salonen@aalto.fi

Follow this and additional works at: <https://aisel.aisnet.org/iris2023>

Recommended Citation

Salonen, Jukka, "Portfolio Management of Digital Innovation Initiatives – A Systematic Literature Review" (2023). *Selected Papers of the IRIS, Issue Nr 14 (2023)*. 12.

<https://aisel.aisnet.org/iris2023/12>

This material is brought to you by the Scandinavian (IRIS) at AIS Electronic Library (AISeL). It has been accepted for inclusion in Selected Papers of the IRIS, Issue Nr 14 (2023) by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.

PORTFOLIO MANAGEMENT OF DIGITAL INNOVATION INITIATIVES – A SYSTEMATIC LITERATURE REVIEW

Research paper

Salonen, Jukka, Aalto University, Helsinki, Finland, jukka.m.salonen@aalto.fi

Abstract

In increasing proportions, innovation portfolios comprise digital innovations initiatives rather than product innovations, yet resources to invest in digital innovation initiatives are limited and organizations struggle to maximize value from these investments. Innovation portfolio management is a valuable tool for managing the portfolio and supporting realization of value from it, and innovation portfolio management research has a long history; however digital innovation initiatives differ from traditional product innovations and portfolios of these. There is a recognized need for a portfolio management process that speaks directly to the nature of digital innovations and transformation. Reporting on a study employing bibliometric research and a review of published literature, the paper presents the current state of research into portfolio management for digital innovations initiatives. It highlights a disconnection between innovation portfolio management research and studies of digital innovations and transformation. The article describes four themes of existing research and offers conclusions on future areas for research. New research is recommended for addressing digitalization-specific innovation portfolio management, realization of value from digital innovation portfolios and, organizational and executive management requirements for those portfolios' management.

Keywords: Digital Innovations, Digital Transformation, Portfolio Management, Value Realization.

1 Introduction

Use of the digital technologies is constantly increasing in the organizations as they pursue with the digital transformation and invest to digital innovations. Use of the digital technologies creates a portfolio of the investments to digital innovation initiatives, which put demands on the organizations' limited human and financial resources. Organizations seek to realize value in the most efficient way possible from these investments. Innovation portfolio management in general is a combination of practices focused on prioritizing scarce resources, monitoring various innovation initiatives, and controlling that set such that collectively they bring value – i.e., they advance the work toward multiple strategic objectives (Meifort, 2016; Moustafaev, 2017). With a history extending back to the 1950s, innovation-portfolio management has produced a substantial amount of research (Hansen & Svejvig, 2022; Meifort, 2016).

However, digital innovation initiatives differ from traditional innovation initiatives (Nambisan et al., 2017; Yoo et al., 2010), and managing portfolios of them requires an approach different from traditional innovation-portfolio management (Bharadwaj et al., 2013). Their management process demands greater flexibility and agility, less protracted formal processes, and new metrics for the value creation – the old processes are not all effective for measuring digital initiatives' value (Eckert & Hüsigg, 2021). In practice executives are struggling to meet the targets by their investments to digital innovation initiatives (Obwegeser et al., 2020), they even choose wrong initiatives to invest (Barthel et al., 2021), they make wrong prioritization of the initiatives (Rodrigues et al., 2020) and therefore miss to realize value from their investments. Based on recent reviews there is a need in the research to bring theory and practice to support management of digital innovation initiatives portfolio (Eckert & Hüsigg, 2021; Meifort, 2016)

even while scholars have accomplished with broad research on digital transformation (Vial, 2019) and digital innovations (Hund et al, 2021).

Purpose of this paper is to examine how well current research examining portfolio management covers digital innovations, the content of the examination of digital innovation portfolio management, and which aspects of that research should be strengthened. We framed the research questions for our study accordingly:

R1: What is the state of current digital innovation initiatives portfolio management research?

The first research question is formulated according to the guidance by Ranjbar-Sahraei and Negenborn (2017) to present an overview of a research field, find how different subfields are interconnected, and find the potential opportunities for bridging the gaps between subfields.

R2: Which areas could future digital innovation initiatives portfolio management focus on?

Second research question is to analyze further literature and understand prior work in this field, to provide overview of current knowledge in the body of literature and propose potential avenues for future research to stimulate future scientific conversations around that topic (Kraus et al., 2022).

To probe existing research into portfolio management for digital innovations initiatives and how value realization is addressed there, we employed bibliometric research (Mukherjee et al., 2022) and a literature review (Kraus et al., 2022; Okoli, 2015; Webster & Watson, 2002) in combination, using Scopus database material as the source.

The paper is organized such that the following section present background on innovation-portfolio management following by the research methods. Then, the findings from the bibliometric research and literature review are discussed: we present the current state of research into digital innovation initiatives portfolio management and the four themes of scholarship in that area. The final section presents our conclusions on the research's status, and we recommend specific areas for future research based on the conclusions from the literature review.

2 Background

2.1 Innovation portfolio management

Portfolio management has its origins in efforts to manage the financial assets in an investment portfolio (Markowitz, 1952). Two decades later, in the 1970s, portfolio-management science took steps toward supporting the selection of businesses for a company's portfolio of subsidiaries or interests (Ansoff & Leonardides, 1976) by means of mathematical modelling. From the late 1990s onward, portfolio-management research has focused on innovation portfolios' management and critical elements for the success of associated initiatives (Cooper et al., 1997, 1999).

The 2000s' accelerating pace of technology introduction has expanded the research focus to success of innovations and, thereby, to deepening the understanding of portfolio management's impact on value (Killen & Hunt, 2010; Killen et al., 2007). Research into innovation portfolio management has focused on how executives invest a limited set of resources – in most cases, financial ones – to continually build a portfolio of innovation initiatives to reach multiple strategic objectives simultaneously (Hansen & Svejvig, 2022; Meifort, 2016). It has identified several elements that distinguish effective portfolio management, such as it being a continuous, dynamic decision-making process that spans multiple levels of the organization (Meifort, 2016). An important stream of research into innovation-portfolio management has focused on how executives rely on a portfolio of innovation initiatives to arrive at their strategic objectives (Meifort, 2016). Key element in the innovation portfolio management is secure strategic value realization from the portfolio (Martinsuo & Killen, 2014) which means alignment of initiatives goals with the strategy (Dietrich & Lehtonen, 2005).

2.2 Digital innovation initiatives

Digital innovation initiatives have created a new challenge for innovation-portfolio management. Recent research has recognized a fundamental difference between traditional innovations initiatives and digital ones. For instance, Yoo et al. (2010) note three distinct characteristics: reprogrammability, homogenization of data, and the self-referential nature of digital technology. In a report along similar lines, Nambisan et al. (2017) conclude that assumptions under which innovation is a clearly bounded phenomenon focused on fixed products, innovation agency is centralized, and innovation processes form a phenomenon separate from their outcomes do not hold for digital innovations initiatives. Also, researchers regard digital innovation as a dynamic problem-solving process (von Hippel & von Krogh, 2016) wherein the process and outcomes are deeply integrated (Nambisan et al., 2017). Digital transformation 1) extends across silos and organization boundaries and encompasses services, products, and information; 2) manifests rapid scaling via digital technologies, networks, and partnerships; 3) involves high-speed decision-making, brief launches cycles, and use of ecosystems; and 4) exploits information, business models, and networks as new value-creation sources (Bharadwaj et al. 2013).

Digital innovations and the portfolios of them differ from their traditional equivalents anchored in physical products. Also, the innovation process and the characteristics of the inventions differ between the two. There is a recognized need for a portfolio management process that speaks directly to the nature of digital innovations (Bharadwaj et al., 2013; Horlach et al., 2020; Schwarzgruber et al., 2021). Number of initiatives are increasing quickly in the organizations' portfolios and there is growing need for agility (Schwarzgruber et al., 2021) in portfolio management process. Strategic agility in linking operations and strategy in general and specifically in portfolio management is becoming important (Horlach et al, 2020) and need for understanding the fundamentally broader scope of digital transformation (Bharadwaj et al., 2013) is required for portfolio management to realize value from the investments.

In this study we wanted understand how existing research is covering portfolio management of digital innovation initiatives. We carried out bibliometric research and then a review of the most relevant documents found in the first phase. Next, we present that research process in more detail.

3 Methods

3.1 The bibliometric phase

Our bibliometric research was consistent with the recommendations of Mukherjee et al. (2022). The search database was Scopus, and the timeline covered all years indexed, without limitations.

We formed the scope for the research from the following elements: a) *digital transformation*, a fundamental change process enabled by innovative use of digital technologies (Gong & Ribiere, 2021); b) *digital innovation* that creates novel value based on the use of digital technologies (Hund et al, 2021); c) *portfolio of digital innovation initiatives* which consist of all the initiatives where the organization invests resources and uses digital technologies for its digital transformation or for digital innovations; d) *portfolio management of digital innovation initiatives* to maximize the value of the portfolio and to secure alignment with the strategy (Cooper at al., 1998); and e) *strategic value* realized from the portfolio by *successful* alignment of initiatives to the strategy (Dietrich & Lehtonen, 2005). These elements were combined to the search terms to study how portfolio management research and digital innovation/transformation research are interlinked to address specific nature of the portfolio management of digital innovation initiatives. The elements are illustrated in the Figure 1.

We applied the following sets of search terms across the document title, abstract, and keywords:

1. "Digital innovation" AND "portfolio" (combining b and c)
2. "Digital transformation" AND "portfolio" (combining a and c)
3. "Digital innovation" AND "portfolio management" (combining b and d)
4. "Digital transformation" AND "portfolio management" (combining a and d)
5. "Digital innovation" OR "digital transformation" AND "strategic value" (combining a, b and e)

6. “Digital innovation” OR “digital transformation” AND “success” AND “portfolio management” (combining a, b, and d with reference to success as in definition of strategic value).

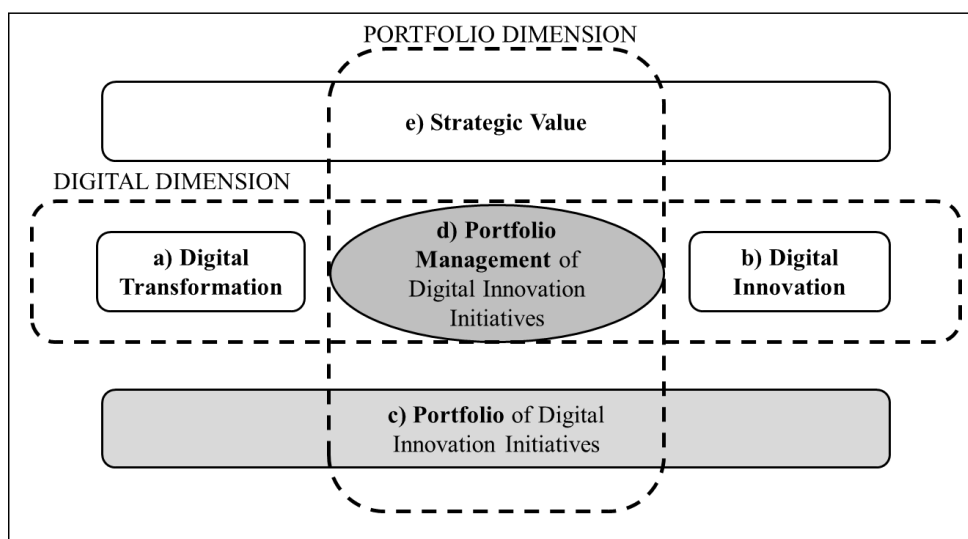


Figure 1. Illustration of the scope of the research and search terms

In total, the bibliometric research returned 228 documents for further attention: we analyzed all these results via the VOSviewer software tool (Ranjbar-Sahraei & Negenborn, 2017). Considering all instances of the keywords found (in the documents’ title, abstract, and keywords), we thus analyzed their co-occurrence, with a threshold of two occurrences of each keyword at minimum. From graphical analysis of all the keywords found, we produced both network- and timeline-based visualizations for each search term, and we performed clustering and network generation related to “portfolio management” and “product portfolio management”. The aim of this analysis was to address research question R1, thus ascertaining the status of digital innovation initiatives portfolio management research. In the findings section we present a cluster visualization of the search terms, which is a suitable manner to show the state of the art in a research field and highlighting the different clusters of the existing research and their interconnections (Ranjbar-Sahraei & Negenborn, 2017). Table 1 presents a statistical summary of the documents found in the searches described above.

| Search terms | 1) ‘Digital innovation’ AND ‘portfolio’ | 2) ‘Digital transformation’ AND ‘portfolio’ | 3) ‘Digital innovation’ AND ‘portfolio management’ | 4) ‘Digital transformation’ AND ‘portfolio management’ | 5) ‘Digital innovation’ OR ‘digital transformation’ AND ‘strategic value’ | 6) ‘Digital innovation’ OR ‘Digital transformation’ AND ‘success’ AND ‘portfolio management’ |
|--|---|---|--|--|---|--|
| Number of relevant documents | 29 | 139 | 8 | 21 | 14 | 17 |
| Published before 2016 | 6 | 1 | 5 | 0 | 2 | 5 |
| Number of keywords (threshold: 2) | 25 | 154 | 3 | 26 | 4 | 10 |
| Conference papers (%) | 35% | 46% | 63% | 62% | 50% | 29% |
| Journal articles (%) | 48% | 35% | 25% | 24% | 43% | 53% |
| Computer science ¹ (%) | 25% | 27% | 25% | 35% | 31% | 20% |
| Business, management and accounting ¹ (%) | 19% | 17% | 7% | 25% | 22% | 14% |

¹ Computer science and Business, management and accounting refer to the Scopus classification of documents.

Table 1. Statistical traits from the bibliometric research.

3.2 The literature review

Then, we conducted the literature review, following the guidance of Kraus et al. (2022), Okoli (2015), and Webster and Watson (2002). This phase began with examining all 228 documents to develop a sound corpus for deeper examination (Figure 2 depicts the literature-selection process). Firstly, we excluded 35 documents overlapping with others in the set. Then, we refined the material related to search term 2, removing 106 documents from further consideration via an inclusion criterion accepting only documents for which the abstract was related to portfolio management of any kind. After this, we filtered out publications that summarize of conference presentations (21 documents) and those papers whose main contribution is not connected directly with digital innovation/transformation or innovation-portfolio management (16 documents). This left us with 50 documents.

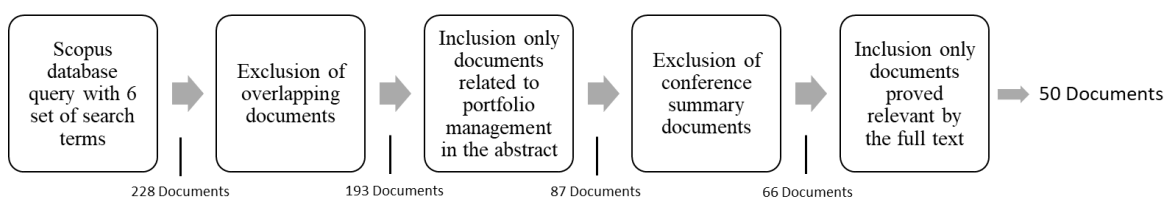


Figure 2. An outline of the selection process for the literature review.

These 50 documents were coded for first- and second-level categories based on their central contribution. A preliminary iteration, handled by NVivo automated coding functionality, provided an overview of the documents' content. For example, while automatic coding identified the main codes "portfolio" and "value", these categories were sparsely populated in comparison to the other main codes. After this iteration, which identified 21 main codes and 133 sub-codes, we performed manual coding focused on the focus and contribution of each document. We found 14 focus areas and ultimately refined the set to 11 areas of focus by excluding codes such as "digital innovation hubs" (DIH), which are related more closely to specific initiative such as the European DIH network supporting small and medium-size companies' digitalization. We then organized these 11 focus areas under four themes characterizing the research at a general level. This analysis was designed to create a foundation for firm conclusions pertaining to prior research and, thereby, for an answer to research question R2, on potential areas for fruitful future research into portfolio management of digital innovation initiatives.

4 Findings

4.1 Bibliometric results: the current research landscape

4.1.1 Portfolio management of digital innovation initiatives

The first set of search terms produced 29 documents and set 2 yielded 139 results. Nearly half of these were conference papers, and only one in four was related to computer science (in Scopus classification) which we call after this in the paper as information system science. For the former set, VOSviewer analysis did not find the keyword "portfolio management" at all with our threshold set at 2 occurrences, as the visualization presented in Figure 3, below, attests. This demonstrates that the existing research does not connect portfolio management with digital innovations. Figure 4 presents the keywords for search 2. There, "digital transformation" is quite distant from "portfolio management", "product portfolio management", "project management", and "project portfolio management". The analysis found the "portfolio management" network connected more closely to "project management", "investments" and "financial data processing", and "project management" than to digital transformation.

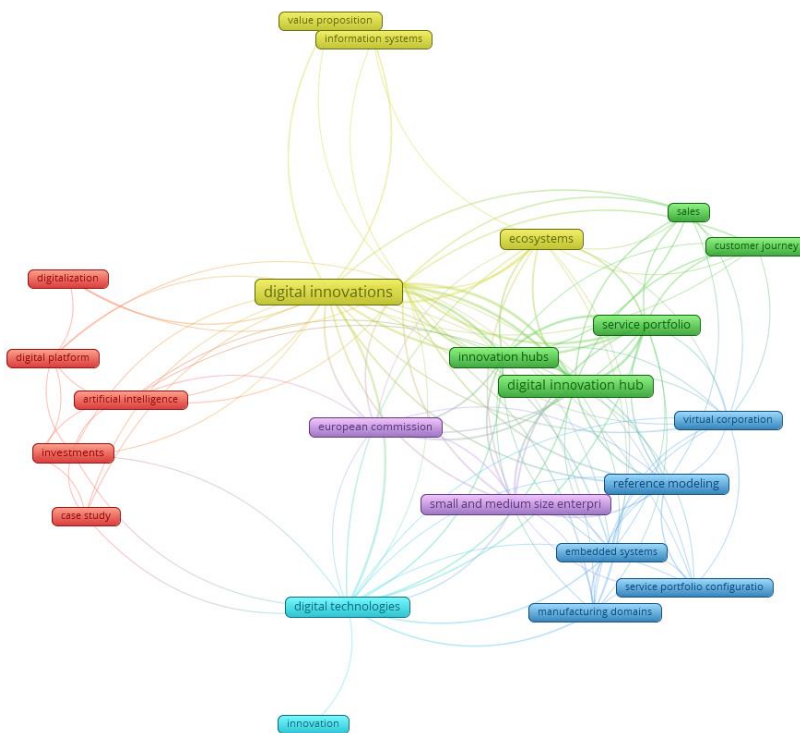


Figure 3. A cluster visualization for 'digital innovation' and 'portfolio'. (Colors presents the clusters of the existing research, lines present interconnection of the keywords and distance presents gaps between them.)

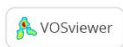
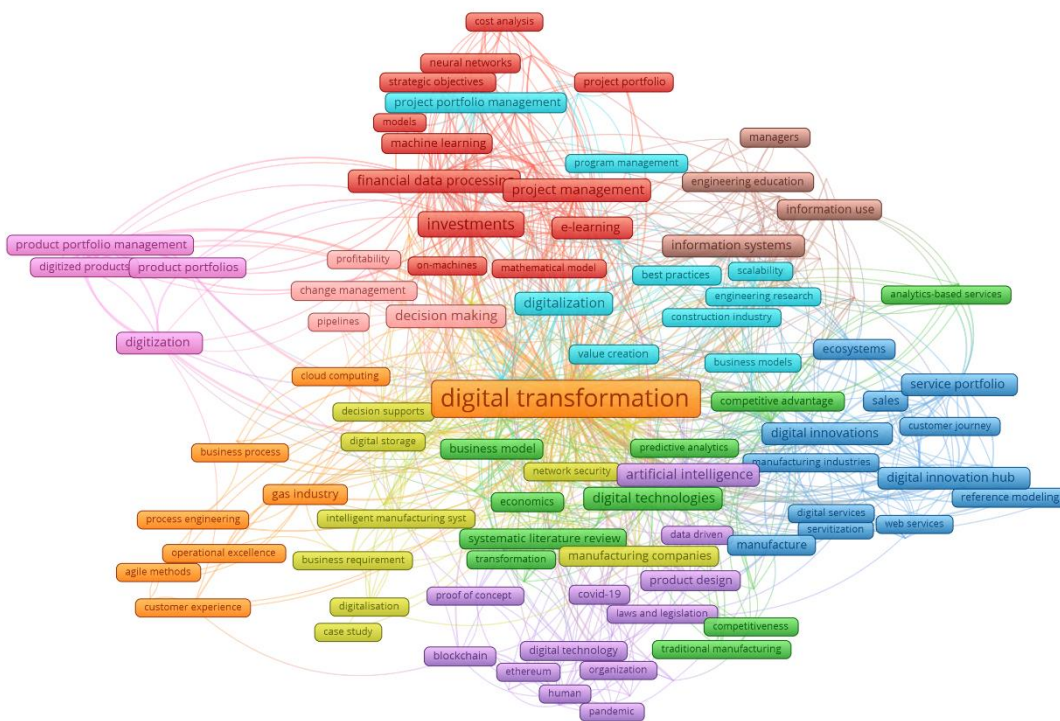


Figure 4. A cluster visualization for 'digital transformation' and 'portfolio'.

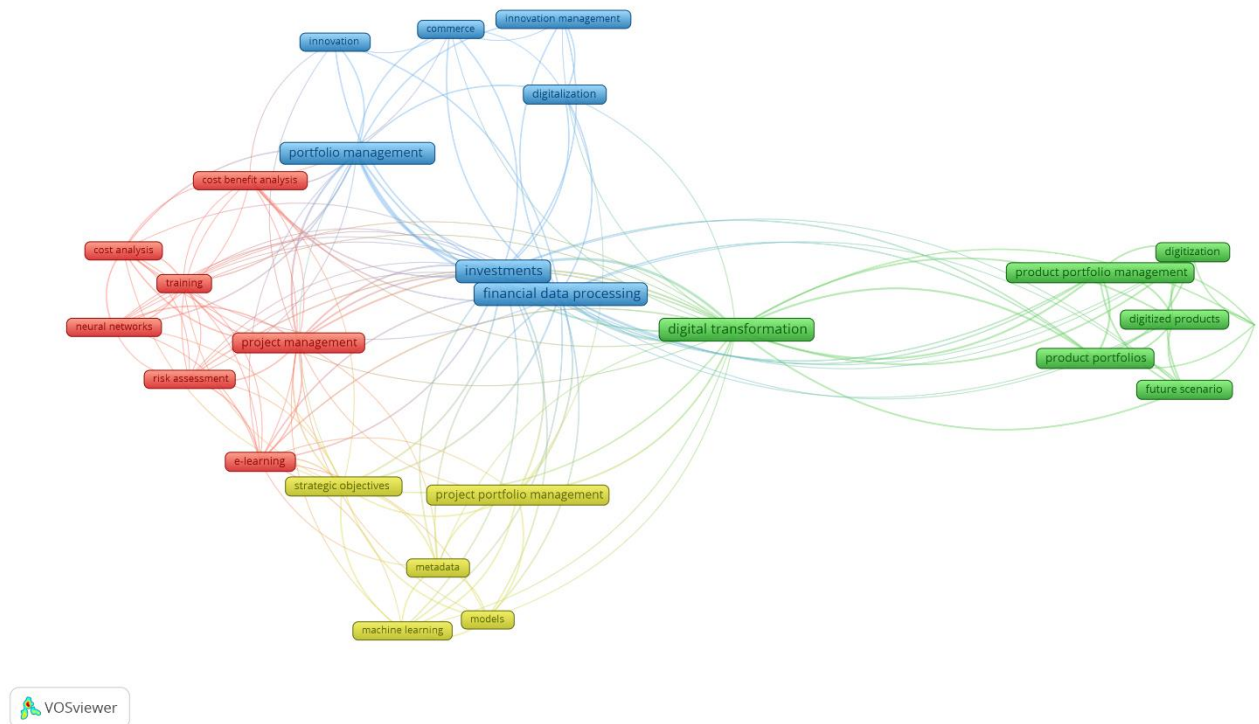


Figure 5. A cluster visualization for 'digital transformation' and 'portfolio management'.

The next two sets of documents, from search 3's "digital innovation" AND "portfolio management" and search 4's "digital transformation" AND "portfolio management", together consisted of only 29 pieces in all, with more than 60% being conference-only papers (a quarter of them were published in journals). A third lie in the information system science domain, and most are recent, produced after 2015.

VOSviewer analysis found only three keywords for the search term 3: "digital innovation", "financial data processing", and "investments". There was no "portfolio" nor "portfolio management" keywords and by that no connections to them. Search 4 showed more connections, which are presented in Figure 5. In this figure, "portfolio management" displays a close connection to "investments" and "financial data processing". Then "project management", "project portfolio management", and "product portfolio management" form distinct, separate clusters. Key word "digital transformation" is connected only to "product portfolio management". These results highlight the weakness of the link between digital innovations/transformation and portfolio management in the research thus far.

4.1.2 Value from digital innovation initiatives portfolios

The remaining 31 documents fall under the final two sets of search terms (5: "digital innovation" OR "digital transformation" AND "strategic value"; 6: "digital innovation" OR "digital transformation" AND "success" AND "portfolio management"), fewer than half of which were published as journal articles. Here too, only a quarter of the documents are related to information system science. Most of these documents were published after 2015. For the two sets of search terms, respectively, VOSviewer recognized only four and 10 keywords, without "portfolio management" featuring among them.

The focus in these documents is on value created via business models or on organizational factors. They encompass case studies and literature reviews contributing to work on strategic value related to digital business models for various types of organizations. For searches 5 and 6, we found only one document related to portfolio management focused on project management (Anshin & Bobyleva, 2021). Research

of strategic value generated by management of portfolios of digital innovation initiatives is not covered by the existing research.

4.1.3 The state of the existing research

The bibliometric research found portfolio management to be most prominent in the research domain as a project, financial, and risk management tool. Project management, product portfolio management, and product portfolios' digitalization have formed the center of scholarly attention. Investment and financial data processing show a close connection to portfolio-management research while the link to from portfolio management research to digital innovations or to digital transformation is far weaker. Value realization by portfolio management is not linked to digital innovations/transformation in the existing research. The literature review took our analysis further, as is detailed below. We elaborate on both phases' findings together in the closing section of the paper.

4.2 The literature review – research themes

Table 2 offers a summary of the literature review's analysis, which identified 11 focus areas and four underlying themes as it was explained in Section 3.2. These are discussed in the following sections.

| Theme | Focus | Studies |
|----------------|---|---|
| Organization | Learning | Gallico, 2021; Jarrahi et al., 2022; Lokuge et al., 2019; Robert et al., 2020 |
| | Human-resource management | Nicolás-Agustín et al., 2022; Van Doorn et al., 2022 |
| | Agility | Horlach et al., 2020; Schwarzgruber et al., 2021 |
| Process | Project selection | Gertzen et al., 2022; Holmes et al., 2022; Heberle et al., 2017 |
| | Product portfolio management | Bibaud-Alves et al., 2019; Chen et al., 2021; Dülme et al., 2020; Echterfeld and Gausmeier, 2018a, 2018b, 2021; Münch et al., 2019; Richard et al., 2021 |
| | Project management | Anshin and Bobyleva, 2021; Bandara et al., 2021; Bierwolf et al., 2018; Lappi et al., 2019 |
| Digital tools | Digitalization of innovation | Huesig and Endres, 2019; Keller, 2019; Nylén and Holmström, 2015; Schneckenberg et al., 2021 |
| | Machine learning, AI, and neural networks | Diaz, 2022; Diaz et al., 2020; Fabac, 2022; Marchinares and Aguilar-Alonso, 2020; Marchinares and Rodriguez, 2021 |
| Business model | Industry 4.0 transformation | Bouncken et al., 2021; Brodeur et al., 2022a, 2022b; Teixeira et al., 2022; Yang, 2021 |
| | Strategic value | Alhammadi and Lataifeh, 2022; Giannelia, 2020; Gray et al., 2013; Järvenpää and Tuunainen, 2013; Li, 2020; Pisoni, 2021; Shalamanov et al., 2021; Tesla et al., 2020; Volkenborn et al., 2021; Zhang et al., 2023 |
| | Customer value | Ho and Hsu, 2022; dos Santos et al., 2022; Mayer 2019 |

Table 2. Existing research themes and focus, identified from 50 documents.

4.2.1 The organization-related theme

Learning: We found that scholars regard organizational learning as an important part of digital transformation and as vital for digital innovations. Learning communities can support organizations' learning in project and program management and can decrease the likelihood of transformation programs failing (Robert et al., 2020). Robert and colleagues recommend enhancing organization-level learning by means of five focus groups, under the following themes: governance, risk management, relationships, culture, and leadership. The papers pinpoint learning as a foundation for business transformation, with artificial intelligence able to function as a tool for the process (Jarrahi et al., 2022), and they offer evidence that design thinking and use of e-learning platforms support both learning and knowledge-sharing in the digital innovation process (Gallico, 2021). The authors found also that organizations' readiness for digital innovation has a substantial impact on innovation-implementation success, with Lokuge et al. (2019) citing seven aspects of that readiness: resource readiness, IT readiness, cognitive readiness, partnership readiness, innovation valance, cultural readiness, and strategic readiness.

Human-resource management: Managing human resources is another key organizational factor studied in connection with digital transformation. In today's new digital environment, companies and other entities must adopt a set of human-resource-related practices favoring innovative employee behavior that aids in digitally transforming their business (Nicolás-Agustín et al., 2022), such as teleworking, teamwork, and employee engagement. These are crucial to fostering innovative behavior and a successful digital transformation process. Digital revolution also is affecting managerial roles, thus influencing middle managers' strategic role in the organization (Van Doorn et al., 2020).

Agility: Agile organization and work methods is the third angle covered by the literature. For today's volatile environment of digital transformation, agility is required of the innovation portfolio management (Horlach et al., 2020). To this end, the papers identify six design principles for agile portfolio management: customer-solution-driven portfolio management, employing a multi-level cross-function portfolio-governance body, well-aligned autonomous decision-making, short and synchronized portfolio cycles, portfolio management's alignment with adjoining strategic management processes, and extension toward innovation management capabilities' mutual integration (Horlach et al., 2020). Among the requirements cited for agile innovation portfolio management are transparency, versatility, collaboration, alignment with strategy, changes' adaptiveness, and effectiveness (Schwarzgruber et al., 2021).

4.2.2 The process theme

Project selection: Project selection is one of the key elements in portfolio management, and the scholars found that companies use traditional selection criteria (revenue, new customers, and strategic alignment) alongside some digital-transformation-specific criteria (e.g., customers' migration to digital channels, upskilling, and digital capabilities' development) to measure the value of a digital transformation project (Gertzen et al., 2021). They apply various types of support tools for their selection of projects. A system engineering (SE) approach is especially prominent, for guaranteeing innovation flow from idea generation to proof of concept and onward to the minimum viable product with suitable prioritization and selection (PAS) (Holmes et al., 2022). Another approach that has been proposed is use of "digitalization canvas" to identify most promising digital innovation projects with limited resources and know-how (Heberle et al., 2017).

Product portfolio management: Scholars have concluded that product portfolio digitalization, as part of digital transformation, demands portfolio management. Studies of manufacturing companies found it especially crucial to align the portfolio strategically with digitalization and ensure a continuous stream of digital product innovation, if one is to stay competitive (Echterfeld & Gausmeier, 2018a). Methodology for digitalizing product portfolios includes portfolio analysis to ascertain the appropriate extent of digitalization, portfolio alignment, feature identification for digital products' design, and creation of a digital portfolio roadmap (Echterfeld & Gausmeier, 2018a, 2018b, 2021). The corpus stresses the importance of selecting, prioritizing, and managing the interdependence of diverse digital initiatives in line with corporate objectives (Richard et al., 2021); both Dülme et al. (2020) and Münch

et al. (2019) present a process for building roadmaps for digitalizing product portfolios. At the same time, traditional new-product development demonstrates a vital link to digital transformation, through process and knowledge management (Bibaud-Alves et al., 2019). In the realm of digital transformation, it has been recognized that, while product portfolio diversity improves the success of a firm's new-product success to a certain degree, it is design iteration combined with a distinct approach to strategy-by-doing that underpins a new product's continual attractiveness to users (Chen et al., 2021).

Project management: The literature recognizes a need for further development of project-management practices and theories, prompted by digital transformation (Bierwolf et al., 2018). One important adjustment entail developing new models and theories that shed light on the complexity of the projects and their management. In this connection, Bierwolf et al. cited Winter et al. findings (2006) pertaining to the changes needed in project management: shifting from a focus on deliveries to emphasis on value creation, moving from treating projects as instruments toward handling them as social processes, and applying a broader conceptualization of projects. According to the Bierwolf team, learning is a crucial aspect of this development. The publications also indicate that companies amid transformation must evaluate the strategic alignment between the digital transformation program and the individual projects (Anshin & Bobyleva, 2021) and base their resource allocation on this assessment. Another component cited as important for digital transformation projects' success is stakeholder involvement and connections to technicians (Bandara et al., 2021).

4.2.3 The theme of digital tools

Digitalization of innovation: The digital innovation process is harder to control than a traditional product innovation one, so organizations need dynamic tools to support the innovation process (Nylén & Holmström, 2015). Per the corpus, a framework for the digital innovation process should address the following areas: assessing the product from the user-experience and value-proposition angle both, scanning the environment for innovation opportunities, developing an understanding of the organization's skills (especially its learning), and providing sufficient space and time for innovation (Nylén & Holmström, 2015). The scholars found the digital innovation process to be an especially pressing issue for software vendors, who should be able to manage their innovation process such that they propose and create value for the clients (Schneckenberg et al., 2021). Accordingly, Schneckenberg et al. (2021) concluded that these companies' digital innovation process can benefit from cloud computing. Various software tools have been developed to support innovation and render it more efficient. The benefits of innovation management software (IMS) hinge on how well innovation managers adopt it, with the key drivers cited for greater adoption rates being the functions' support for idea evaluation and for portfolio management (Huesig & Endres, 2019). The papers point also to SAP's Intelligent Enterprise Framework, which supports numerous classes of innovation scenarios (Keller, 2019).

Machine learning, AI, and neural networks: Various digital decision-making tools exist for portfolio management and project management, and machine learning is already seeing use to improve project portfolio management (Marchinares & Aguilar-Alonso, 2020) and project selection (Marchinares & Rodriguez, 2022). Researchers have found that machine learning can facilitate selection of suitable projects, reduction of planning costs, and organizational learning (Marchinares & Aguilar-Alonso, 2020). Among the techniques employed is using artificial neural networks (ANNs) and Monte Carlo simulation modelling to capture risk effects and quantify investment priorities. Per the scholars (Diaz, 2022; Diaz et al., 2020), this method enables applying the principles of portfolio management theory to real-world measurement and optimization of the digitalization project portfolio's performance. Another tool considered is a Digital Balanced Scorecard (BSC) system that, by interpreting a digital strategy, assists organization leaders in successfully formulating and coordinating all the necessary activities and projects (Fabac, 2022). While such work clearly is relevant for digital transformation, Fabac (2022) is the only scholar identified who has focused purely on digital innovation projects.

4.2.4 The business models theme

Industry 4.0 transformation: Manufacturing companies receive particular attention, as more and more of them undergo digital transformation. Scholars have found several factors crucial for their success: mutually aligned digital and business strategy, leadership displaying digital skills, work across function boundaries, understanding of organizational readiness, communication, teamwork, employee learning, a unified culture, project-management skills, and strategic focus on continuous improvement (Brodeur et al., 2022b). Also, collaboration among small and medium-sized companies in their digital transformation projects has improved the success of the transformation (Brodeur et al., 2022b). Benefits of and risk has been studied for industry 4.0 transformation and human-technology interactions are recognized as an important factor on that (Teixeira et al., 2022). Meanwhile, studies have not yet considered digital innovation portfolio management as a driver for value realization.

Strategic and customer value: The literature reviewed addresses value's realization from digital business models both from the customer standpoint and from a company-strategy perspective. However, the corpus does not highlight the connection between the value produced and either digital innovations or innovation portfolio management. Strategic value overall has been examined in settings of higher-education institutions (Shalamanov et al., 2021; Teslia et al., 2020), health care (Gray et al., 2013), religious organizations (Giannelia, 2020), personal identification (Alhammedi & Lataifeh, 2020), creative industries (Li, 2020), insurance (Pisoni, 2021), the energy and oil industry (Volkenborn et al., 2017), information technology (Järvenpää & Tuunainen, 2013), and more generally to incumbent firms (Zhang et al, 2023). In turn, the customer value yielded via digital transformation has been studied in such contexts as convenience stores (Ho & Hsu, 2022), air travel (Mayer, 2019), and the public sector (dos Santos et al., 2022).

5 Conclusions

Digital innovation initiatives form an increasing part of organizations investments. Executives are struggling to realize value from their investments to digital innovation initiatives. Research of portfolio management, product portfolio management, and project portfolio management have an extensive history. Similarly, there is a large body of research on digital innovations and digital transformation. Research has identified that digital innovation initiatives differ from traditional innovation initiatives and managing portfolios of them requires specific approach. In our study we wanted to analyze how well current research address the issues of portfolio management of digital innovation initiatives.

Proceeding from the bibliometric research conducted to answer research question *R1: What is the state of current digital innovation initiatives portfolio management research*, our analysis led us to the following main conclusions about the state of portfolio management of digital innovation initiatives research:

- Portfolio management has a noticeably weak presence in research into digital transformation and digital innovation. Studies specific to digital innovation initiatives portfolio management seem entirely absent.
- Researchers examining value from digital transformation or from digital innovations have not focused on digital innovation initiatives portfolio management; portfolio management manifests itself instead as a financial and risk management tool in relation to digital transformation and digital innovations.
- Scholars have articulated only a tentative connection between portfolio management and value realization from digital innovation initiatives.

Hence, these findings led us to the conclusion that there is need for information systems science to direct attention to digital innovation initiatives' portfolio management, and thereby support the cultivation and actualization of value from investments to digital innovation initiatives.

Our analysis then identified four research themes based on the 50 documents examined in the literature review, related to the organization, process, digital tools, and business model. From these themes and the 11 areas of focus found, we outlined the following main dimensions to current research:

- **Business models and the value dimension:** The research strongly connects realization of value from digital transformation to digital business models. The associated work loosely links portfolio management (as a tool) to building a digital innovation initiatives portfolio that supports value creation.
- **Digital transformation and the organization dimension:** The second constellation of research found addresses digital transformation's requirements for organizational readiness, learning, management, attention to human resources, and agility. The last of these is a broad concept, and agile portfolio management is quite prominent in the relevant literature. Organizational learning and human resources are identified as important for innovation portfolio management, while value realization is not covered on this dimension.
- **Innovation portfolios and the process and tools dimensions:** The final focus of research covers product portfolio digitalization, project selection, portfolio management, and digital tools for decision-making in portfolio management. This research deals with product portfolios and digital portfolios both. The value realized by means of the portfolio is not given focus in these studies.

Although all of these are important areas of study, they don't address the issue of specific characteristic of digital innovations in innovation portfolio management and the challenge of realizing value from a portfolio of digital innovation initiatives. The literature review led us to the conclusion that both digital innovation initiatives portfolio management and the value realized by means of it have received quite limited research attention. This is consistent with findings presented in some earlier surveys. From their literature review, Eckert and Hüsigg (2021) concluded that digital and service innovation portfolio management is an under-researched topic. They also highlighted the value-realization dimension as ripe for additional research, and their review points to models and frameworks for digital innovation portfolio management as holding potential for future research into digital innovation initiatives.

The literature review formed a foundation for answering the second research question *R2: Which areas could future digital innovation initiatives portfolio management focus on.* Our review underscores the importance of digital-portfolio-specific research and of research looking directly at value realization via digital innovation initiatives portfolios. We identified the following two areas in particular for potential streams of research:

1. **Requirements that digitalization imposes for innovation portfolio management:** Researchers could explore which characteristics particular to digital innovations and digital transformation the portfolio management frameworks and practices must consider. Other key questions are what kind of portfolio management process digital innovation initiatives requires and how these processes could support addressing digital innovations' unique characteristics. Further research would also study which are main principles of portfolio management of digital innovation initiatives. These questions are in practice especially important for the product companies moving to the digital services in their business models.
2. **Realization of value from digital innovation initiatives portfolios:** While Eckert and Hüsigg (2021) recognized the importance of value realization, they did not cite it specifically as meriting future research. Our study, in contrast, articulated this need clearly. Several research questions can be identified: How are organizations' strategic values defined and then connected to the digital innovation initiatives portfolio, what methods and tools foster creating this connection in the portfolio management process, how can one measure the digital innovation initiatives portfolio's success, and what accountability structures does the process need?

These questions lead also to two consequent research questions related to organizational requirements and executives' role in the portfolio management of digital innovation initiatives:

3. **Organizational requirements for digital innovation initiatives portfolio management:** While prior research does address the organizational dimension of digital transformation, further studies could fruitfully tackle several central questions from a portfolio-management perspective: What does digital innovation initiatives portfolio management require from an organizational and leadership perspective? What organizational design principles are needed for governance of that management?
4. **Executives' role in digital innovation initiatives portfolio management:** Digital innovation initiatives portfolio management don't appear in this study as a task for executive management even their bear the highest responsibility of realized value of the investments to the portfolio. Further studies would investigate how executives in the best way design and implement portfolio management of digital innovation initiatives, how portfolio management governance should be connected to overall governance of the firm and what kind of executive roles are needed.

Naturally, some limitations accompany our conclusions. Selecting authors' original keywords for the search terms influenced both the bibliometric research and the literature review's findings and conclusions. Other search terms may well have led to other sorts of conclusions, but we also tested several search terms and after that concluded the scope of the study and final search term selection. Also, though we tested our searches with Google Scholar too, Scopus was the only database source. Notwithstanding these caveats, we believe that the analysis and results contribute significantly to understanding the state of research into digital innovation initiatives portfolio management aimed at realizing value.

References

- Alhammedi, A., & Lataifeh, M. (2022). Examining the influence of national digital identity and smart pass platform on accelerating the processes of digital transformation. In *Proceedings of the 2022 IEEE International Conference on Communications, Computing, Cybersecurity and Informatics*.
- Anshin, V., & Bobyleva, A. (2021). The digital transformation program management in medium-sized businesses: A network approach. *Serbian Journal of Management*, 16(1), 147–159.
- Ansoff, H., & Leontiades, J. (1976). Strategic portfolio management. *Journal of General Management*, 4(1), 13–29.
- Aoufi, A., Schoeman, M., & Turner, N. (2021). How to outsource Agile projects effectively: Suppliers and client advisors need to work closely with client organizations to ensure key enablers are in place to increase success when outsourcing Agile projects. *Research Technology Management*, 65(1), 59–66.
- Bandara, W., Gable, G., Tate, M., & Rosemann, M. (2021). A validated business process modelling success factors model. *Business Process Management Journal*, 27(5), 1522–1544.
- Barthel, P., Perrot, C. M., Benlian, A., & Hess, T. (2021). Towards a method for Evaluating Digital Innovation Projects. ECIS.
- Bharadwaj, A., El Sawy, O., & Pavlou, P. (2013). Digital business strategy: Toward a next generation of insights. *MIS Quarterly*, 37(2), 471–482.
- Bibaud-Alves, J., El-Haouzi, H., Thomas, P., & Boucinha, V. (2019). Toward a sustainable new product development approach based on industry 4.0 assets. *Studies in Computational Intelligence*, 803, 156–167.
- Bierwolf, R., Romero, D., Pelk, H., & Stettina, C. (2018). On the future of project management innovation: A call for discussion towards project management 2030. In *International Conference on Engineering, Technology and Innovation, ICE/ITMC 2017, Madeira Island, Portugal, June 27–29, 2017* (pp. 689–698).
- Bouncken, R., Kraus, S., & Roig-Tierno, N. (2021). Knowledge- and innovation-based business models for future growth: Digitalized business models and portfolio considerations. *Review of Managerial Science*, 15(1), 1–14.

- Brodeur, J., Pellerin, R., & Deschamps, I. (2022a). Collaborative approach to digital transformation (CADT) model for manufacturing SMEs. *Journal of Manufacturing Technology Management*, 33(1), 61–83.
- Brodeur, J., Pellerin, S., & Deschamps, I. (2022b). Operationalization of critical success factors to manage the Industry 4.0 transformation of manufacturing SMEs. *Sustainability (Switzerland)*, 14(14).
- Chen, L., Wang, M., Cui, L., & Li, S. (2021). Experience base, strategy-by-doing and new product performance. *Strategic Management Journal*, 42(7), 1379–1398.
- Ciriello, R., Richter, A., & Schwabe, G. (2018). Digital innovation. *Business & Information Systems Engineering*, 60, 563–569.
- Cooper, R. G., Edgett, S. J., & Kleinschmidt, E. J. (1997). Portfolio management in new product development: Lessons from the leaders – I. *Research Technology Management*, 40(5), 16–28.
- Cooper, R. G., Edgett, S. J., & Kleinschmidt, E. J. (1998). Portfolio management for new products. Addison-Wesley Reading.
- Cooper, R., Edgett, S., & Kleinschmidt, E. (1999). New product portfolio management: Practices and performance. *Journal of Product Innovation Management*, 16, 333–351.
- Diaz, R. (2022). Strategic digital shipbuilding project portfolio configuration and optimisation. *International Journal of Simulation and Process Modelling*, 18(2), 140–154.
- Diaz, R., Smith, K., Landaeta, R., & Padovano, A. (2020). Shipbuilding supply chain framework and digital transformation: A project portfolios risk evaluation. *Procedia Manufacturing*, 42, 173–180.
- Dietrich, P., & Lehtonen, P. (2005). Successful management of strategic intentions through multiple projects—Reflections from empirical study. *International Journal of Project Management*, 23(5), 386–391.
- dos Santos, S., Capellin, F., Trentin, M., Bortoluzzi, S., & de Lima, E. (2022). Digital transformation in the public sector: Enabling technologies and their impacts. In *Industrial engineering and operations management* (Springer Proceedings in Mathematics and Statistics series, 400) (pp. 101–113).
- Dülme, C., Echterfeld, J., Gausemeier, J., & Hannes, L. (2020). Digital transformation of product portfolios – future-oriented consolidation as key enabler. In *26th International Association for Management of Technology Conference, IAMOT 2017* (pp. 111–128).
- Echterfeld, J., & Gausemeier, J. (2018a). Digitising product portfolios. *International Journal of Innovation Management*, 22(5).
- Echterfeld, J., & Gausemeier, J. (2018b). Pattern based digitization of product portfolios. In *Towards sustainable technologies and innovation – proceedings of the 27th Annual Conference of the International Association for Management of Technology, IAMOT 2018* (pp. 680–699).
- Echterfeld, J., & Gausemeier, J. (2021). Digitising product portfolios. In *Digital disruptive innovation*, pp. 349–378.
- Eckert, T., & Hüsig, S. (2021). Innovation portfolio management: A systematic review. *Management Review Quarterly*, 72(1), 187–230.
- Fabac, R. (2022). Digital Balanced Scorecard system as a supporting strategy for digital transformation. *Sustainability (Switzerland)*, 14(15).
- Gallico, D. (2021). E-learning design thinking and design driven innovation. In *15th International Conference e-Learning, EL 2021 – held at the 15th Multi-Conference on Computer Science and Information Systems, MCCSIS 2021* (pp. 91–98).
- Gertzen, W., van der Lingen, E., & Steyen, H. (2022). Goals and benefits of digital transformation projects: Insights into project selection criteria. *South African Journal of Economic and Management Sciences*, 25(1).
- Giannelia, T. (2020). Digital religion: How religious organizations derive value from technological innovations. In *Proceedings of the 41st International Conference on Information Systems, ICIS 2020, Making Digital Inclusive: Blending the Local and the Global, Hyderabad, India, December 13–16, 2020*.
- Gong, C., & Ribiere, V. (2021). Developing a unified definition of digital transformation. *Technovation* 102, 1–17.
- Gray, P., El Sawy, O., Asper, G., & Thordarson, M. (2013). Realizing strategic value through center-edge digital transformation in consumer-centric industries. *MIS Quarterly Executive*, 12(1).

- Hansen, L., & Svejvig, P. (2022). Seven decades of project portfolio management research (1950–2019) and perspective for the future. *Project Management Journal*, 53(3).
- Heberle, A., Löwe, W., Gustafsson, A., & Vorrei, Ö. (2017). Digitalization Canvas – Towards identifying digitalization use cases and projects. *Journal of Universal Computer Science*, 23(11), 1070-1097.
- Ho, S., & Hsu, Y. (2022). Paving the way for digital transformation: Investigate customer experiences of using mobile apps. *Pacific Asia Journal of the Association for Information Systems*, 14(1), 18–39.
- Holmes, R., Zhang, Z., Saldaña, S., Mallison, B., & Francis, J. (2022). Systems engineering for innovation portfolio management in the energy industry. *Advances in Transdisciplinary Engineering*, 28, 197–206.
- Horlach, B., Schimer, I., & Drews, P. (2020). Agile portfolio management: Design goals and principles. In *Proceedings of the 27th European Conference on Information Systems*.
- Huesig, S., & Endres, H. (2019). Exploring the digital innovation process: The role of functionality for the adoption of innovation management software by innovation managers. *European Journal of Innovation Management*, 22(2), 302–314.
- Hund, A., Wagner, H. T., Beimborn, D., & Weitzel, T. (2021). Digital Innovation; Review and Novel Perspective. *Journal of Strategic Information Systems* (30), 1-39.
- Jarrahi, M. H., Kenyon, S., Brown, A., & Donahue, C. (2022). Artificial intelligence: A strategy to harness its power through organizational learning. *Journal of Business Strategy*.
- Järvenpää, S., & Tuunainen, V. (2013). Theoretical elaboration of IT enablement model in the era of customer and community digital innovation. In *ECIS 2013 – proceedings of the 21st European Conference on Information Systems*.
- Keller, B. (2019). Digital innovation to drive intelligent utility enterprise. In *2019 IEEE International Conference on Energy Internet* (pp. 484–486).
- Killen, C. P., & Hunt, R. A. (2010). Dynamic capability through project portfolio management in service and manufacturing industries. *International Journal of Managing Projects in Business*, 3(1), 157–169.
- Killen, C., Hunt, R., & Kleinschmidt, E. (2007). Managing the new product development project portfolio. In *PICMET '07 – Portland International Conference on Management of Engineering and Technology* (pp. 1864–1874).
- Kraus, S., Breier, M., Lim, W., Dabić, M., Kumar, S., Kanbach, D., Mukherjee, D., Corvello, V., Piñeiro-Chousa, J., Liguori, E., Palacios-Marqués, D., Schiavone, F., Ferraris, A., Fernandes, C., & Ferreira, J. (2022). Literature reviews as independent studies: Guidelines for academic practice. *Review of Managerial Science*, 16, 2577–2595.
- Lappi, T., Aaltonen, K., & Kujala, J. (2019). Project governance and portfolio management in government digitalization. *Transforming Government: People, Process and Policy*, 13(2), 159–196.
- Li, F. (2020). The digital transformation of business models in the creative industries: A holistic framework and emerging trends. *Technovation*, 2020(92–93).
- Lokuge, S., Sedera, D., Grover, V., & Dongming, X. (2019). Organizational readiness for digital innovation: Development and empirical calibration of a construct. *Information and Management*, 56(3), 445–461.
- Marchinares, A., & Aguilar-Alonso, I. (2020). Project portfolio management studies based on machine learning and critical success factors. In *Proceedings of [the] 2020 IEEE International Conference on Progress in Informatics and Computing, PIC 2020* (pp. 369–374).
- Marchinares, A., & Rodriguez, C. (2021). Online solution based on machine learning for IT project management in software factory companies. In *Proceedings of the 2021 13th International Conference on Computational Intelligence and Communication Networks* (pp. 150–154).
- Markowitz, H. (1952). Portfolio selection. *Journal of Finance*, 7(1), 77–91.
- Martinsuo, M., & Killen, C. P. (2014). Value management in project portfolios: Identifying and assessing strategic value. *Project Management Journal*, 45(5), 56-70.
- Mayer, C. (2019). Digital passengers: A great divide or emerging opportunity? *Journal of Airport Management*, 13(4), 335–344.
- Meifort, A. (2016). Innovation portfolio management: A synthesis and research agenda. *Creativity and Innovation Management*, 25(2), 251–269.

- Moustafaev, J. (2017). *Project portfolio management in theory and practice: Thirty case studies from around the world*. Taylor & Francis.
- Mukherjee, D., Lim, W., Kumar, S., & Donthu, N. (2022). Guidelines for advancing theory and practice through bibliometric research. *Journal of Business Research*, 148, 101–115.
- Münch, J., Trieflinger, S., & Lang, D. (2019). DEEP: The product roadmap maturity model. In *Proceedings of the 2nd ACM SIGSOFT International Workshop on Software-Intensive Business: Start-ups, Platforms, and Ecosystems, co-located with ESEC/FSE 2019* (pp. 19–24).
- Nambisan, S., Lyytinen, K., Majchrzak, A., & Song, M. (2017). Digital innovation management: Reinventing innovation management research in a digital world. *MIS Quarterly*, 41(1), 223–238.
- Nicolás-Agustín, Á., Jiménez-Jiménez, D., & Maeso-Fernandez, F. (2022). The role of human resource practices in the implementation of digital transformation. *International Journal of Manpower*, 43(2), 395–410.
- Nylén, D., & Holmström, J. (2015). Digital innovation strategy: A framework for diagnosing and improving digital product and service innovation. *Business Horizons*, 58(1), 57–67.
- Obwegeser, N., Yokoi, T., Wade, M., & Voskes, T. (2020). 7 key principles to govern digital initiatives. *MIT Sloan management review*, 61(3), 1-9.
- Okoli, C. (2015). A guide to conducting a standalone systematic literature review. *Communications of the Association for Information Systems*, 37.
- Pisoni, G. (2021). Going digital: case study of an Italian insurance company. *Journal of Business Strategy*, 42(2), 106-115.
- Ranjbar-Sahraei, B., & Negenborn, R. (2017). *Research positioning & trend identification: A data-analytics toolbox*. Delft University of Technology.
- Richard, S., Pellerin, R., Bellemare, J., & Perrier, N. (2021). A business process and portfolio management approach for Industry 4.0 transformation. *Business Process Management Journal*, 27(2), 505–528.
- Robert, I., Bierwolf, E., & Frijns, P. (2020). Digital transformation and learning communities in the practice of project management. In *Towards the Digital World and Industry X.0 – proceedings of the 29th International Conference of the International Association for Management of Technology, IAMOT 2020* (pp. 495–507).
- Rodrigues, C. M., Deschamps, F., de Freitas Rocha Loures, E., Cestari, J. M. A. P., & de Freitas, I. H. (2020, 2020/). Digital Transformation Project Portfolio Selection/Prioritization: Literature Review and Future Directions. *Proceedings on 25th International Joint Conference on Industrial Engineering and Operations Management – IJCIEOM*, Cham.
- Schneckenberg, D., Benitez, J., Klos, C., Velamuri, V., & Spieth, P. (2021). Value creation and appropriation of software vendors: A digital innovation model for cloud computing. *Information and Management*, 58(4).
- Schwarzgruber, S., Rueckel, D., & Krumay, B. (2021). Requirements for agile project portfolio management for diversified companies. In *27th Annual Americas Conference on Information Systems* (proceedings volume, Paper 6).
- Shalamanov, V., Matern, S., & Penchev, G. (2021). Digitalization and cyber resilience model for the Bulgarian Academy of Sciences. *Studies in Big Data*, 84, 77–92.
- Teixeira, E. L. S., Tjahjono, B., Beltran, M., & Julião, J. (2022). Demystifying the digital transition of remanufacturing: A systematic review of literature review. *Computers in Industry*, 134, Article 103567.
- Teslia, I., Yehorchenkova, N., Khlevna, I., Kataieva, Y., Latysheva, T., Yehorchenkov, O., Khlevnyi, A., & Veretelnik, V. (2020). Developing a systems engineering concept for digitalizing higher education institutions. *Eastern-European Journal of Enterprise Technologies*, 6(2–108), 6–20.
- Van Doorn, S., Georgakakis, D., Oehmichen, J., & Reimer, M. (2020). Opportunity or threat? Exploring middle manager roles in the face of digital transformation. *Journal of Management Studies*.
- Vial, G. (2019). Understanding Digital Transformation: A review and Research Agenda. *The Journal of Strategic Information Systems* 28(2), 118-144.

- Volkenborn, A., Lea-Cox, A., & Wei, Y. (2017). Digital revolution: How digital technologies will transform E&P business models in [the] Asia-Pacific. In *Society of Petroleum Engineers – SPE/IATMI Asia Pacific Oil and Gas Conference and Exhibition 2017*.
- von Hippel, E., & von Krogh, G. (2016). Identifying viable ‘need–solution pairs’: Problem solving without problem formulation. *Organization Science*, 27(1), 207–221.
- Webster, J., & Watson, T. (2002). Analyzing the past to prepare for the future: Writing a literature review. *MIS Quarterly*, 26(2), xiii–xxiii.
- Winter, M., Smith, C., Morris, P., & Cicmil, S. (2006). Directions for future research in project management: The main findings of a UK government-funded research network. *International Journal of Project Management*, 24, 638–649.
- Yang, L. (2021). Research on intelligent monitoring and maintenance of [a] civil air defense alarm system based on [the] Internet of Things. In *BDSIC 2021: 2021 3rd International Conference on Big-Data Service and Intelligent Computation* (pp. 66–77).
- Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). The new organizing logic of digital innovation: An agenda for information systems research. *Information Systems Research*, 21(4), 724–735.
- Yoo, Y., Boland, R., & Majchrzak, A. (2012). Organizing for innovation in the digitized world. *Organization Science*, 23(5), 1398–1408.
- Zhang, Z., Jin, J., Li, S., & Zhang, Y. (2023). Digital transformation of incumbent firms from the perspective of portfolios of innovation. *Technology in Society*, 72, Article 102149.