Management Review Quarterly (2022) 72:187–230
https://doi.org/10.1007/s11301-020-00208-3

Innovation portfolio management: a systematic review and research agenda in regards to digital service innovations

Theresa Eckert[1] · **Stefan Hüsig**[1]

Received: 22 May 2020 / Accepted: 5 December 2020 / Published online: 11 January 2021

Abstract
Portfolio Management (PM) for innovation is as relevant as ever before as many incumbent firms undergo massive transformation in response to digitalization and face the challenge to allocate resources for traditional product innovation and service innovation projects more efficiently and effectively. Digital service innovations, regarded as new business fields for many industrial firms are in the forefront of much discussion in practice and academia; nonetheless, it is unclear to what extent existing innovation PM has acknowledged how to manage a portfolio of service and digital service innovations. To address this gap, this work sets out to (1) review and synthesize decades of contributions in the field of innovation PM in a structured way, (2) examine to what extent research has considered and elaborated on innovation PM for services and digital services, and finally (3) provide a research agenda to foster future contributions in this field. We classified relevant findings in innovation PM into four categories (antecedents, consequences, models/frameworks, challenges) and found that literature has acknowledged services more than anticipated, but that still much of today's innovation PM research is focused on physical products. In more recent years, the attention towards services has resulted in a few publications delving into the differences between service and product innovation PM; however, digital service innovations have been overlooked by the research so far. Lastly, we point out how innovation PM for services and digital services may diverge from traditional products and outline a research agenda.

Keywords Innovation Portfolio management · Services · Digital services · Digitalization · Servitization · Literature review · State of the art

✉ Theresa Eckert
theresa.eckert@s2020.tu-chemnitz.de

Stefan Hüsig
stefan.huesig@wirtschaft.tu-chemnitz.de

[1] Technical University of Chemnitz, Thüringer Weg 7, 09126 Chemnitz, Germany

JEL Classification O32

1 Introduction

Emergent digital technologies are changing the way companies create value, the way they interact with their customers, and the way they operate from within. This technology-induced change, referred to as digitalization or the digital transformation is described by Fitzgerald et al. (2014, p. 2) as the *"use of new digital technologies (social media, mobile, analytics or embedded devices) to enable major business improvements such as enhancing customer experience, streamlining operations or creating new business models"*. While certain aspects of new technology introduction replicate transformations of the past (e.g. industrial revolution), the speed and scope of impact suggests that this revolution may impact industries, institutions, and societies in a fundamentally new way. Particularly, Moore's law (Moore 1998) and the concept of zero marginal costs (Rifkin 2014) are among the fundamental forces behind digitalization as the former projects exponential growth of computing capacity and the latter that digital good production often means zero marginal costs without capacity limitations.

In many instances, the advent of these technologies create new business models in the form of novel services or supplement existing product offerings with digital services (Matzner et al. 2018) such as shared vehicle services (Kessler and Buck 2017) or music streaming services (Turetken et al. 2019). Many manufacturing firms (e.g. Apple, General Electric) have moved beyond the simple sale of products, generating an increasing share of revenues from new service offerings (Demirkan and Spohrer 2016; Matzner et al. 2018). This transition from the traditional good-dominant setting where the emphasis is on the delivery of products (Ostrom et al. 2010) to customer-centric service-dominant business models is regarded as servitization (Vandermerwe and Rada 1988). The concept of servitization first appeared in academia by Levitt (1981) but did not find widespread recognition until the article "Servitization of Business: Adding Value by Adding Service" was published by Vandermerwe and Rada (1988). They claim that clear distinctions between traditional manufacturers and service companies will gradually fade and as servitization progresses (Vandermerwe and Rada 1988). Generally, the reasons for servitization are manifold. For some firms, moving towards services is just a natural progression. For others, especially companies in mature industries, have been said to look towards services to extend their product's lifecycle and to seize new growth opportunities (Vandermerwe and Rada 1988; Wise and Baumgartner 1999; Oliva and Kallenberg 2003).

Given the parallels, the business phenomenon of servitization goes hand-in-hand with digitalization and has recently emerged in a number of publications (e.g. Kowalkowski et al. 2017; Vendrell-Herrero et al. 2017; Skylar et al. 2019). Skylar et al. (2019) extend a frequently cited definition of servitization *"the transformational processes whereby a company shifts from a product-centric to a service-centric business model and logic"* (Kowalkowski et al. 2017, p. 7) with the "*utilization of digital tools*" to define digital servitization.

As the number of digital service offerings rise and firms undergo costly transformations in response to digitalization and servitization, there is an inherent pressure to manage product and service innovations efficiently and effectively. Service innovations have been defined as *"a new service or such a renewal of an existing service which is put into practice and which provides benefit to the organization that developed it; the benefit usually derives from the added value that the renewal provides the customers."* (Toivonen and Touminen 2009, p. 893). The prioritization and allocation of resources to different service innovations falls under portfolio management (PM). PM is responsible for *"maximizing the value of the portfolio, seeking the right balance of projects, ensuring that the portfolio is strategically aligned"*, and selecting the right number of projects (Cooper et al. 2001a, p. 3). While PM of innovation, also referred to as new 'product' development (NPD) PM, has been extensively studied, the primary focus lies on physical products. The subject of service PM most prominently appears in information technology research (e.g. Peppard 2003; Queiroz 2009; Kim et al. 2014; Comerio et al. 2015; Schmidt and Freeland 1992). Yet, this stream of research has been developed in isolation to the innovation PM literature as pointed out by Kumar et al. (2008) and Frey and Buxman (2012). It delves into how IT departments manage their portfolio of IT assets (e.g. infrastructure services, help desk support) across the entire lifetime (Leliveld and Jeffrey 2004; Comerio et al. 2015). Service innovations, in contrast, are new services that can be marketed to end-customers (Kumar et al. 2008) and often result in a transformation across multiple dimensions of a business model (e.g. value proposition, revenue streams, customer segments) (Stauss et al. 2010). As such, the degree to which service innovations have been acknowledged and examined in PM thus remains unclear.

Given the widespread assertion that the nature of service and digital services significantly differ from non-digital products (Shapiro and Varian 1998; Menor et al. 2002; William et al. 2008; Nylén and Holmström 2015; Wulf et al. 2017; Vendrell-Herroro et al. 2018), practitioners and scholars alike seek a better understanding of how to manage a portfolio of service/digital service innovations. Leimeister et al. (2014) argue that traditional approaches for designing and delivering products are outdated and incapable for addressing the rapid changes and shorter development cycles in the digital era. Hence, prior to further studies in the realm, we argue that a thorough review of innovation PM literature at this point is necessary in order to gain a more holistic understanding of the state-of-the-art for service and digital service innovations and to lay the foundations for further research in this sphere.

We thereby acknowledge and build upon a previous literature review of innovation PM conducted by Meifort (2015) given its quality and the comprehensive collection of peer-reviewed innovation PM publications until the year 2014. The paper has been cited by many renown scholars in the field (e.g. Kock et al. 2016; Nguyen et al. 2018; Cooper and Sommer 2019) and its research scope to "provide a comprehensive review of innovation PM" replicates ours perfectly. Yet, the paper does not make any inferences to differences in product and service innovation. To our knowledge, our study is the first to investigate and synthesize the innovation PM literature in terms of service and digital services. Further, the innovation PM research field has evolved immensely since Meifort (2015). The field witnessed significantly

more quantitative studies, validating or negating initial findings (i.e. optimal portfolio size) and newer research streams such as agility and entrepreneurial culture in PM (Kock and Gemünden 2016). A more recent review of the previous years is also necessary, as services and digital services are a recent phenomenon in project-level and portfolio-level research. In this paper, we thus set out to synthesize theoretical and empirical contributions in the field of innovation PM until end of 2019. Unlike Meifort (2015), which conceptualizes innovation PM based on different lines of thought, we classify innovation PM research in a way that eases the application of knowledge in practice and the identification of the main research streams and findings for academics. Meifort (2015) refrained from synthesizing literature according to common conclusions because of the abundance of context-specific case study and conceptual research. Yet, given the advancements in the field including a magnitude of wide-scale quantitative studies (e.g. Kock and Gemünden 2016), we synthesize findings and offer a new classification. More specifically, we conceptualize innovation PM based on our exploration of (1) which antecedents are central to innovation PM, (2) which frameworks and models were developed in the innovation PM context, (3) what are the consequences of effective and strong innovation PM, and lastly (4) what challenges result through the entire innovation PM process. Lastly, the research agenda will address to what extent innovation PM needs to be further developed to fulfill digital service specific characteristics.

We pose our research objective in the following questions:

(i) Which antecedents, models/frameworks, consequences, and challenges of innovation PM are discussed in the realm of existing empirical and theoretical research?
(ii) To what extent does existing research investigate innovation PM of services and digital services?
(iii) What future fields of research can be identified in terms of service and digital service innovation PM?

The remainder of the paper is structured as follows. Before presenting the selected methodology, the underlying concepts surrounding PM and digital service innovations will be introduced in Sect. 2. The methodology including the review scope and the search process is then outlined in Sect. 3. Next, the main contribution of our study-the analysis and synthesis of the identified literature-follows in Sect. 4. Thereafter, we suggest an agenda for future research in Sect. 5. Section 6 concludes this paper with a summary of our research contributions and an outline of limitations.

2 Fundamental concepts and their interrelations

This section provides a conceptual background to digital service innovation and portfolio management. More specifically, Sect. 2.1 provides historical context to the development of PM in research and differentiates innovation PM to other streams of PM research. Section 2.2 defines digital services and discusses how they distinguish from physical products and non-digital services.

2.1 Portfolio management

PM is simply put as the management of a portfolio of artefacts. The artefacts can be financial assets, products, projects, business units, customers and more. The concept of PM, however, originated in the financial domain through the seminal work of Nobel Laureate Markowitz (1952). He proved that the risk and return dimensions of a diversified investment portfolio are preferable to a homogenous portfolio. The years following, a few authors examined the idea of applying Markowitz's PM theory to the business domain (Wind 1974; Mahanjan and Wind 1982; Cardozo and Smith 1983; Cardozo and Wind 1985); however, some fellow scholars (Devinney et al. 1985; Bettis and Mahajan 1985) quickly criticized these thoughts. They argue that *"the product portfolio problem is of an entirely different sort and requires a theory that makes quite different assumptions about the nature of investments"* (e.g. limited to only current investments) (Devinney et al. 1985, p. 108).

Distancing itself from the financial portfolio theory, the concept of selecting and prioritizing items in a portfolio did find application in the business domain and experienced tremendous growth in the 1970s (Henderson 1970; Ansoff and Leontiades 1976; Day 1977). The first stream of PM research in the business domain focused on the development of sophisticated mathematical models for optimizing the selection of businesses from a corporate level perspective. Nevertheless, these studies failed to find wide application in practice as models were too complex and time consuming to use (Schmidt and Freeland 1992; Cooper et al. 1999). In the 1970s, the second stream of corporate level portfolio models were introduced to substitute the former. Among the most well-known portfolio models is the Boston Consulting Group Matrix developed by Bruce Henderson (Nippa et al. 2011). While these portfolio analysis tools found widespread application in practice, the development of the research stream has stalled in academia. Untiedt et al. (2012) identify two possible causes for the scholarly domain: (1) criticism concerning inherent flaws or (2) proof that corporate diversification is inferior to market diversification may have made the research stream obsolete.

More recently, a new stream of PM research focused on managing and optimizing innovation portfolios has developed (Cooper et al. 1999, 2001a, b; Chao et al. 2009; McNally et al. 2009, 2013). The rise of innovation PM is also attributed to the increasing relevance of technological innovations and the acknowledgement that effective selection and management is critical to innovation success (Killen et al. 2007). In times of rapidly advancing technology and changing customer demands, firms increasingly rely on PM to help them navigate where to invest in the future. However, Bharadwaj et al. (2013) point out that it is uncertain to what extent today's understanding of innovation PM can be applied to the management of a portfolio of digital services and therefore urges researchers to examine the impact of digital business strategy on innovation PM. Prior research has also already pointed out that most innovation PM literature focuses on tangible products, rather than encompassing services or intangible products (Cooper et al. 2000). The established usage of the term new '*product'* development as synonym to innovation may in part have attributed to misconceptions in the research stream. We question whether the product-focus in innovation PM still remains two decades later, or whether Servitization

has triggered greater interest in services, even if in disguise under NPD portfolio management. Our paper plans to address this query in innovation PM as outlined before.

From here on out, we will refer to innovation PM as PM in line with fellow scholars (e.g. Cooper, Edgett, and Kleinschmidt).

2.2 Digital service

Despite the widespread usage of the term digital service, few explicit definitions are found in literature. Beverungen et al. (2017, p. 784) derived a definition for digital services based on Vargo and Lusch's (2007) definition of services: *"A digital service is the application of digital competencies through deeds, processes, and performance for the benefit of another entity or the entity itself"*. Thereby, Bevergungen et al. (2017) refer to digital competencies as assets and capabilities, which are made available to other parties utilizing information technology. Williams et al. (2008, p. 506) have proposed a slightly different definition for digital services: *"services, which are obtained/or arranged through a digital transaction (information, software models, or consumer goods) over internet protocol"*. The two proposed definitions vary as the latter suggests that for a service to be classified as digital, it must be transacted digitally (e.g. digital platforms Amazon or Facebook), whereas the former definition is broader as it circumferences any service that applies digital competencies to provide a benefit (e.g. digital signage in a travel agency). To gather more acumen, we turn to the digital business model literature, as digital services are a type of digital business model. Bärenfänger and Otto (2015, p. 18) classifies business models as digital if the *"underlying business logic deliberately acknowledges the characteristics of digitalization and takes advantage of them; both in interaction with customers and business partners, and in its internal operations"*.

Digital services co-exist with other offering forms such as physical products, e.g. books, cars, furniture, and non-digital services, e.g. theatre, maintenance, consulting (Vendrell-Herroro et al. 2018). Current trends indicate that physical products are being increasingly replaced by digital services because technology enhances their value respective to products (Parry et al. 2012; Peltoniemi 2015). Drawing upon the servitization and digitalization literature, we argue that the nature of digital services can be distinguished to other offering forms-physical products and/or non-digital services-in terms of several unique traits of digital services. The first differential characteristic refers to the concept of zero marginal costs. Digital services can be reproduced infinite times at practically zero marginal cost (e.g. smartphone apps) (Ekeldo and Sivakumar 2004; Remane et al. 2017; Vendrell-Herroro et al. 2018). Second, while for physical products the value is created within a firm and then sold to a customer, for digital services, similarly to non-digital services, the value is realized in the process of consumption (Vargo and Lusch 2004, 2008; Vendrell-Herroro et al. 2018). This captures upon the idea of "value in use". Remane et al. (2017) provides an example of a smartphone, which provides little value to users without its interface to access services (e.g. navigation, mobile payment). Third, traditionally, the provision of services and manufacturing of physical products largely

remained within a firm's boundaries. Digital services, on the other hand, are often a result of co-creation. They rely on an ecosystem of partners, competitors and users (e.g. Apple's Appstore) (Iansiti and Levien 2004; Eaton et al. 2015; Akram 2016; Remane et al. 2017). Fourth, digital services are non-excludable (Barwise and Picard 2015; Vendrell-Herroro et al. 2018), meaning that they can be shared endlessly without reducing the availability of service to others (Vendrell-Herroro et al. 2018). Even more so, many digital services (e.g. Facebook, Airbnb) became exponentially more valuable the more users joined (Shapiro and Varian 1999; Remane et al. 2017). This phenomenon is referred to as network effects. Lastly, digital services have shorter lifecycles and operate in more dynamic environments. As indicated by Moore's law, technologies constantly evolve, generating higher processing capabilities at lower costs. Updates also occur much more frequently as they can be immediately deployed. Yet, these characteristics accumulate to low entry barriers, enabling new competitors to enter the market and reproduce offerings more easily (Menor et al. 2002).

For the sake of this paper, we derive our own definition for digital services based on the ideas discussed above. We define digital services as integrated solutions that deliver other parties value in use by utilizing digital technologies for at least a portion of the interaction. Uber's ride hailing service, for example, is classified as a digital service, as it provides riders value in use by transporting them from point A to B and utilizes digital technologies via transactions among drivers and riders on a digital platform (i.e. Uber's application). In relation to innovation, the introduction of digital services is often inherently classified as service innovations given their newness to the firm and impact on multiple dimensions of their business model. The overwhelming majority of scholars are of the notion that service innovations must only be 'new to a firm', but not necessarily also 'new to the industry or market' (Snyder et al. 2016). The following section, the methodology, outlines the scope of our review and literature search process in detail.

3 Methodology

This study shall use a systematic literature review following the guidelines of Webster and Watson (2002) to identify peer-reviewed articles that have contributed to the PM research, and hence evaluate and discuss the application to services and digital service innovations. The scope of the review will be condensed based on the taxonomy of literature reviews suggested by Cooper (1988) in Sect. 3.1. Next, the search process will be outlined in detail in Sect. 3.2.

3.1 Review scope

In order to specify the research aim of this paper, we outline the scope in accordance to a taxonomy for literature reviews presented by Cooper (1988) and more recently highlighted by vom Brocke et al. (2019). The proposed framework comprises six characteristics, each consisting of further categories, which present the focus areas

Characteristics	Categories			
(1) **Focus**	Research outcomes	Research methods	Theories	Applications
(2) **Goal**	Integration	Criticism	Central issues	
(3) **Organization**	Historical	Conceptual	Methodological	
(4) **Perspective**	Neutral representation	Espousal of position		
(5) **Audience**	Specialized scholars	General scholars	Practitioners/ politicians	General public
(6) **Coverage**	Exhaustive	Exhaustive and selective	Representative	Central/ pivotal

Fig. 1 Taxonomy of literature reviews (following Cooper 1988, p.109)

of this paper (see Fig. 1). The categories displayed gray in the figure present the main focus points of this paper.

The main focus (1) of our contribution lies in examining both research outcomes and theories regarding PM in the innovation domain in order to draw deductions for the management of a portfolio of services/digital service innovations. The overarching goal (2) of the literature review is thereby to first integrate the existing body of knowledge and embody a slightly critical stance of whether the existing contributions remain valid in the context of digital services. Further, the organization (3) of this paper will be concept-centric. The perspective (4) of this paper aims to remain as neutral as possible, although certain degree of subjectivism in the representation of results is nearly inevitable (vom Brocke et al. 2019). As aforementioned, the targeted audience (5) for this paper are scholars in the intersection of PM, servitization, and digital business research communities, as well as practitioners, challenged by the new role of digital services in their organizations. Lastly, the coverage (6) can be regarded exhaustive but selective, as we try to gain a comprehensive overview of all relevant research, but only detail a selection of the contributions in our paper. After providing clarification of our research scope, the next section will outline our literature search process in detail.

3.2 Literature search process

Our literature search process is structured as follows: (1) selection of databases, (2) identification of search terms, (3) definition of inclusion and exclusion criteria and (4) database search and refinement, and lastly (5) backward and forward search. It shall ensure the reliability and reproducibility of our review. Additionally, we will compare and contrast our methodology with that of Meifort (2015) as we plan to incorporate the papers in her literature review to address the second research question. *Selection of databases.* This paper has selected the following three bibliographical databases to facilitate the most exhaustive and reliable collection of publications: Scopus, EBSCO Business Source Complete, and Web of Science. Firstly, Scopus was selected because it is the largest citation database of peer-reviewed literature-scientific journals, books and conference proceedings-with over 23,500

journals that are rigorously vetted by an independent review board (Scopus 2019; IJRVET 2019). As a second source, EBSCO Business Source Complete was chosen as it is regarded as a world-leading scholarly source for research in the business and economic context, providing access to over 3700 peer-reviewed academic journals (EBSCO 2019). Due to the scope of this paper, the business focus of this database deemed appropriate. Lastly, Web of Science was selected to supplement the previous two databases, covering nearly 21,100 journals in a wide array of disciplines (Web of Science Group 2019). Google Scholar was explicitly eliminated as a primary database due to its usability and scope (Bosman et al. 2006; Herrera 2011). While it offers a large variety of search output, many publications are working papers or other non-peer-reviewed articles (Bosman et al. 2006; Bar-Ilan 2008). Meifort (2015), in contrast, only utilized one database-the EBSCO Source Premier-to extract an initial set of relevant papers.

Identification of search terms. Prior to identifying any keywords for the search process, Baker (2000) suggests to consult with publications that provide a thorough overview of the main concepts planned to discuss in the paper in order to uncover relevant search terms (i.e. synonyms and homonyms). In accordance to his recommendation, we identified relevant keywords and further validated these in an iterative process of testing search expressions in different databases to evaluate the resulting collection of publications. We found that there was an inconsistent use of terminology in titles as well as within the text itself for innovation PM (e.g. Hunt et al. 2008; Baptestone and Rabechini 2018; Cooper et al. 2000). Next to innovation PM, the variation included PM for NPD, project PM and product PM. Against this background, we concluded that simplifying the keyword search to one term-portfolio management-in the abstract or title of the article was broad enough to avoid excluding potentially relevant publications from the onset and specific enough as the term is well-established in research. Meifort (2015) also conducts a keyword search in the abstract and titles of the articles, yet unfortunately does not specify which keywords were applied in her search. *Definition of inclusion and exclusion criteria.* To further specify and condense our search output, we applied a set of inclusion and exclusion criteria, as shown in the table below. The inclusion criteria will be applied from the onset in the search string, whereas many of the exclusion criteria will be utilized later to further refine the initial search output. For the same reasoning as noted above, this process was chosen to forgo eliminating relevant publications ex-ante. Next to the main keyword "portfolio management", we supplemented the search string with the inclusion criteria. For example, in *Scopus* the inclusion criteria were depicted as follows: (LIMIT-TO (SRCTYPE, "j") AND (LIMIT-TO (PUBYEAR, 2014–2019) AND (LIMIT-TO (LANGUAGE "German", "English") AND (LIMIT-TO(SUBJAREA, "BUSI") AND (EXCLUDE (KEYWORD "finance"). To secure the quality of findings, we applied the inclusion criteria peer-reviewed journal following Webster and Watson (2002). Dissertations, books, book reviews, and working papers were excluded. The timeframe from 2014 until 2019 was chosen based on the previous literature review by Meifort (2015), which reviewed publications from 1964 until November 2014. The keyword "finance" was excluded from the onset as the sample otherwise consists largely of investment or asset portfolio

Table 1 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Peer-reviewed journal*	Papers that include the term "finance" in the keywords* (in regards to asset/investment portfolio management)
Papers within the time period of 2014 and 2019* (determined by time of last systematic literature review)	Papers not available in full-text
Paper in English or German language* (determined by authors' language skills)	Not ranked or very poorly ranked journals according to Scimago Journal Rank
Papers in the business and management field*	Conference proceedings

*Applied during the initial keyword search

management publications. In terms of exclusion criteria, we disregard all papers that stem from different subject areas (e.g. economics, arts and humanities) and were not available in full-text. Further, for quality reasons, journals were excluded that were not listed or did not steam from high-quality sources according to Scimago Journal Rank (www.scimagojr.com). The inclusion and exclusion criteria applied are summarized in the Table 1.

In comparison, Meifort (2015, pp. 2–3) restricted the results of her keyword search to 20 journals "considered as leading general management journals and leading in the particular field of technology and innovation management" (e.g. Journal of Product Innovation, Management Science, R&D Management, Research Policy, Strategic Management Journal), resulting in 65 publications.

Database search and refinements. Our initial keyword search conducted on October 7–10, 2019 in all of the selected databases yielded 993 articles (see Table 2). Next, we read the titles and abstracts of our initial search output and eliminated publications that did not meet our research scope. This includes remaining papers that do not stem from the business and management field. Further, many eliminated articles thematized financial/asset PM or brand PM. This resulted in the number of publications being reduced to 213. Next, we scrutinized the full texts of the remaining publications and further eliminated publications that proved irrelevant to our research scope. The reasons for elimination varied extensively including an overly strong emphasis on a specific country and/or industry (e.g. electric power utilities in Brazil) or lack of portfolio level view in project management publications. In this step, we also applied the quality criteria by consulting Scimago Journal Rank as stated above. From the resulting 115 papers, we eliminated 75 publications due to duplicates that appeared in multiple databases or already appeared in the literature sample of Meifort (2015). In regards to the review strategy of Meifort (2015), the papers did not undergo further refinement aside from the journal restrictions.

Backward and forward search. After three rounds of refinements, a set of 40 publications remained. Nonetheless, we decided to follow the recommendations of Webster and Watson (2002) and additionally conduct a forward and backward search.

Table 2 Literature search process

Database/Phase	EBSCO	SCOPUS	World of science	Total
(1) Initial keyword search	322	392	279	993
(2) 1st Refinement (Title and abstract review)	51	76	86	213
(3) 2nd Refinement (full text and quality review)	27	46	42	115
(4) 3rd Refinement (Removal and duplicates)	24	15	1	40
(5) Forward and Backward search	34	18	3	52

The backward search analyzes the references of our set of relevant articles in order to identify further publications that were missed in the database search. The forward search, on the other hand, identifies further articles that cited the set relevant articles in this study. For the forward search, we utilized Google Scholar, which offers a tool to identify publications that have been cited in other publications. In line with our review strategy, Meifort (2015) also conducted a backward search to uncover 47 additional publications, yet did not pursue a forward search.

Our final sample consists of 52 publications (see Table 2). In the next section, we discuss and synthesize the findings of our literature review as well as integrate the previous findings of Meifort (2015). Despite the use of different review methods (see Table 3 for summary), the results show (see Sect. 4.1) that the journals largely replicated those in the sample of Meifort (2015) with the *International Journal of Project Management* also being the journal with the most selected publications. This hence provides further basis for the inclusion of Meifort's (2015).

4 Literature analysis and synthesis

This section provides a descriptive overview of the literature research results, followed by a qualitative content analysis in line with (Mayring 2014). Mayring (2014) proposes a standardized method for qualitative content analysis that

Table 3 Research methodology in comparison to Meifort (2015)

Research methodology of this paper	Research methodology of Meifort (2015)
Database: Scopus, EBSCO Business Source Complete, Web of Science	*Database*: EBSCO Source Premier
Keyword search: Conducted with the term ("Portfolio management")	*Keyword search* but terms not specified
Inclusion/exclusion criteria: See Table 1	*Inclusion/exclusion criteria*: limited to only 20 Journals considered leading in general management and technology/innovation management
Refinements: Elimination based on (1) title and abstract and (2) full text and lastly (3) removal of duplicates	*No further refinements*
Backward and forward search	*Backward search* only

supports the evaluation and classification of large amounts of text. In our paper, we have selected a specific inductive technique of content analysis referred to as summary (Mayring 2014, p. 65ff) in order to reduce the content to its core. We utilized excel to analyze and store information extracted from the databases (e.g. author, title, journal), and supplemented it with further descriptive elements (e.g. methodology, sample) and the key findings for each article.

4.1 Descriptive analysis

As indicated in Fig. 2, the publications of the review stem from a wide variety of academic journals. The most common journals include the International Journal of Project Management (12), the Project Management Journal (5), IEEE Transactions on Engineering Management (4), Journal of Business Research (4), and Journal of Product Innovation Management (4). The wide spread of journals can be explained by the nature of the topic as well by the magnitude of journals in the scope of project and innovation management.

Turning to the number of publications, our review has identified 52 relevant publications in a timespan of only 5 years. This shows that the field has experienced tremendous growth in the last years. The number of publications reached a peak in 2015 with 14 publications, whereas the last two years (2017, 2018) witnessed only half as many (see Fig. 3). This trend may indicate increasing saturation and a maturing state of the art. This is in part also reflected in the research approach. The literature samples indicate a high share of both qualitative and

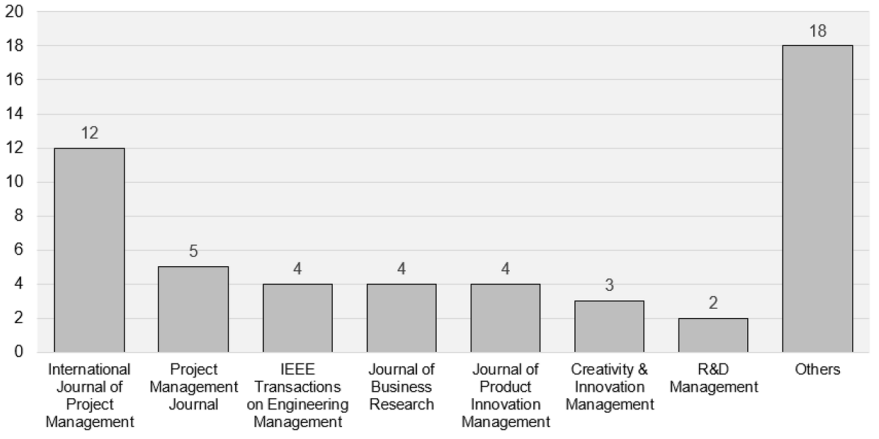

Fig. 2 Distribution of literature across journals

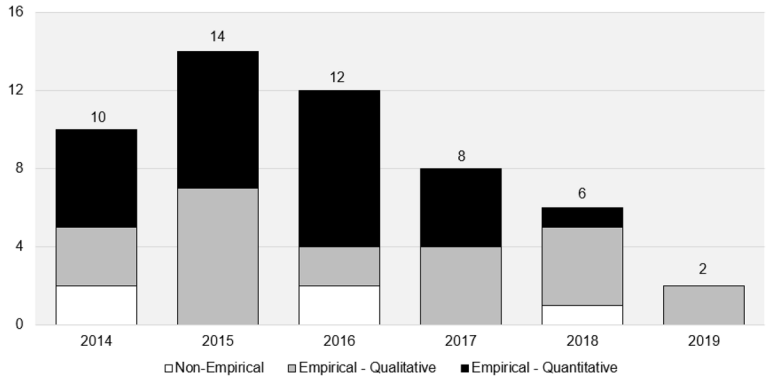

Fig. 3 Distribution of literature across years and research approaches

quantitative empirical research. In comparison to the sample of Meifort (2015), ranging from 1969 until 2014, the number of conceptual papers was still much higher.

4.2 Content-based analysis

In the following, the main findings in regards to (1) antecedents for PM, (2) PM frameworks and models, (3) consequences of PM, and (4) challenges of PM are presented and discussed. Given the amount of quantitative studies in recent years, we chose to classify and synthesize the common findings in innovation PM rather than view the publications from different theoretical lenses as in the previous literature review by Meifort (2015). As commonly proposed in literature reviews (e.g. Raisch and Birkinshaw 2008), we chose to categorize findings into "antecedents" and "consequences". The category "PM framework and models" was supplemented as we found many publications that offered frameworks with the intention to support portfolio managers in different processes, yet did not provide direct evidence for improving portfolio success and as such do not fall into the "antecedent" category. These publications are most commonly in the form of case studies and concord largely with Meifort's (2015) "decision-making perspective". Lastly, "challenges" was selected as an individual category as they occur throughout all stages and dimensions of innovation PM and offer central opportunities for improvements for practitioners and academics alike. The findings are summarized in the Tables 4, 5, 6, 7, 8, 9, 10, 11.

4.2.1 Antecedents for PM

Antecedents for effective and successful PM have been extensively investigated by the selected literature and categorized into five dimensions in this paper: (1) organization & management, (2) portfolio content & structure, (3) external environment, (4) processes and (5) models, tools, and metrics. The dimensions were developed in

Table 4 Organizational and managerial antecedents for PM

	Antecedents	Impact on	Author
Top management	Top management involvement	Portfolio success	Yang and Xu (2017)
	Strong project sponsorship between executives and project managers	Portfolio governance	Too and Weaver (2014)
	Management perception of PM methods and satisfaction on the PM routines in use	Portfolio success	Spieth and Lerch (2014)
	Centralization of the decision making in respect to the approval process of projects	PM → Portfolio performance	Padovani and Carvalho (2016)
	Project visibility (awareness of status, problems, etc.) towards executive sponsors	PM effectiveness	Patanakul (2015)
	Greater number of generations in top management in family businesses; Lower ratio of family members in top management in family businesses	Portfolio performance	Kraiczy et al. (2014)
	Top management oversight at aggregate level of analysis	PM & portfolio strategic fit	In Meifort (2015): Loch and Pich (2001), Unger et al. (2012)
Project manager	High project management competency (capability, knowledge, and responsibility of project managers in terms of PM)	Portfolio success	Yang and Xu (2017)
	Strong authority and responsibility in the organization	Portfolio success	Petro and Gardiner (2015)
	Increasing level of decentralization (greater authority at project manager level)	Portfolio success (inverted-U relationship)	Carbonell and Rodriguez Escudero (2016)
	High accountability or incentives aligned with portfolio	Portfolio success	Kopmann et al. (2017)
	Structured and functional political behavior in PM facilitates flexibility	PM decision-making	Röth et al. (2019)

Table 4 (continued)

	Antecedents	Impact on	Author
Multiple levels	PM involves multiple organizational units at different levels (see Meifort 2015 for different levels); Higher consensus towards a common goal, simultaneous formalization across all levels, information sharing and collaboration	Effective PM	In Meifort (2015): Kissi et al. 2013, Teller et al. (2012, 2014) Teller and Kock (2013), De Maio et al. (1994) etc.
Committees	Involvement of steering committees (positive moderation of project managers with strong authority and responsibility)	Portfolio success	Petro and Gardiner (2015)
Culture	Hofstede's cultural distance dimensions individualism and power distance (positive moderation of degree of decentralization)	Portfolio success (inverted-U relationship)	Carbonell and Rodriguez Escudero (2016)
	Strong innovation climate & open risk culture	Decision-making quality & agility in PM	Kock and Gemünden (2016)
	Risk culture (e.g. venturing & committing resources in uncertain environments)	Portfolio success	Kock et al. (2016)
	Corporate innovation culture (analytical behavior & practices i.e. programs and incentive systems) and national culture should complement each other	Portfolio success	In Meifort (2015): Unger et al. (2014)
	Extensive communication and organizational learning	PM success	In Meifort (2015): Brown and Eisenhardt (1997), Hunt et al. (2008), Herfert and Arbige (2008)

Table 4 (continued)

	Antecedents	Impact on	Author
Internal capabilities & resources	Knowledge of the organizational context including constraints, capabilities, uncertainties, and interdependencies	PM → Portfolio performance	Padovani and Carvalho (2016)
	Adaptability to internal and external changes/ ability to address risks and uncertainties	PM effectiveness	Patanakul (2015)
	High information availability	PM performance	Spieth and Lerch (2014)
	Operational attributes: (1) project visibility to stakeholders, (2) transparency in decision-making, and (3) predictability of performance	PM effectiveness	Patanakul (2015)

Table 5 Portfolio content and structure antecedents for PM

	Antecedents	Impact on	Author
Portfolio size	Large product portfolios	Firm‘s financial performance	Kang and Montoya (2014)
	Increasing portfolio size (positive moderation of front-end success)	Portfolio success	Kock et al. (2016)
	Increasing the number of projects = more complexity (positive moderation of business case control)	Portfolio success	Kopmann et al. (2015)
	Greater resource allocation breadth (creates greater spectrum of projects and thus increases probability of at least some innovation success)	Portfolio performance	Klingebiel and Rammer (2014)
	Selecting the right number of projects	PM	In Meifort (2015): Cooper et al. (2002)
Portfolio Balance	Balancing “mature” and “new” products as well as “first-to-market” and “late-entered” products	Firm‘s financial performance	Kang and Montoya (2014)
	Balancing portfolio from different areas, financial risks or innovation level	PM → Portfolio performance	Padovani and Carvalho (2016)
	Optimal investment mix between risk versus return, maintenance versus growth, and short-term versus long-term innovation projects	PM effectiveness	In Meifort (2015): Cooper et al. (1997a)
Strategic Alignment	Alignment of portfolio with firm’s strategy	PM → Portfolio performance	Padovani and Carvalho (2016)
		Portfolio governance	Too and Weaver (2014)
		PM effectiveness	Patanakul (2015)
		PM effectiveness/success	In Meifort (2015): several authors e.g. Cooper et al. (1997b), Bart and Pujari (2007), Salomo et al. (2008)
	Deliberate strategy implementation and emerging strategy recognition, complement each other in performance effect	Portfolio success	Kopmann et al. (2015)
Project Termination	Timely termination for inappropriate projects so that resources re-allocated to more strategic relevant projects	Portfolio success	Yang and Xu (2017)
	Termination of projects that no longer contribute to business success	Portfolio governance	Too and Weaver (2014)

Table 5 (continued)

	Antecedents	Impact on	Author
Portfolio Interdependencies	Portfolios with more interdependency with other projects (positive moderation of front-end success)	Portfolio success	Kock et al. (2016)
	Component commonality can both be a source of innovation and limitation	Portfolio innovativeness	Korhonen et al. (2016)
	Greater interdependency between projects = more complexity (positive moderation of business case control)	Portfolio success	Kopmann et al. (2015)
	Greater functional integration (promotes effective decision making, as knowledge sharing is strengthened incl. evaluations of technical, managerial, market aspects)	Portfolio performance	Jugend et al. (2016)
Project type	First-to-market new products yield not only an immediate effect, but also persistent long-term effects	Firm‘s financial performance	Kang and Montoya (2014)
	Adoption of green product development practices (substitution of hazardous materials, design for disassembly, reusability and recyclability)	Portfolio performance	Jugend et al. (2017)

Table 6 External environmental antecedents for PM

	Antecedents	Impact on	Author
External environment	High external turbulence-frequent technological breakthroughs in industry and difficult to predict customer needs (positive moderation of business case control)	Portfolio success	Kopmann et al. (2015)
	High external turbulence-frequent technological breakthroughs in industry and difficult to predict customer needs (negative moderation of deliberate strategy)	Portfolio success	Kopmann et al. (2015)
	More turbulent environments-triggered by market and technology changes (positive moderation of controlling intensity and innovative climate) Process formalization becomes less important in turbulent environments	Decision-making quality & agility in PM	Kock and Gemünden (2016)
	External environment (high-velocity, high-growth, turbulent, and unstable environments)	PM (e.g. structure, commitment, emergence, integration)	In Meifort (2015): Floricel and Ibanescu (2008)

Table 7 Procedural aspects

	Antecedents	Impact on	Author
Tasks	11 different PM processes: (1) knowledge of the organizational context, (2) opportunity identification, (3) decision criteria, (4) classification, (5) selection, prioritization, optimization and sequencing, (6) evaluation, (7) balancing, (8) approval, (9) resource allocation, (10) formation of portfolio, and (11) project portfolio management infrastructure	PM → Portfolio performance	Padovani and Carvalho (2016)
Formalization	Well-designed and implemented PM process (activities are organized, scheduled and reviewed regularly, formal and explicit process provides platform for communication and decision-making)	Portfolio success	Yang and Xu (2017)
	Greater formalization (clarification of rules, procedures, and criteria for decision-making in entire portfolio)	Portfolio performance	Jugend et al. (2016)
	Greater formalization of PM processes (clearly specified selection, prioritization, resource allocation and portfolio control)	Decision-making quality & agility in PM	Kock and Gemünden (2016)
	Greater formalization of PM process: clear procedures and consistent application to all projects	PM success	In Meifort (2015): Cooper et al. (1998, 1999, 2001a, b), Perks (2007)
Agility	Greater flexibility in portfolio processes	PM for new services	Aas et al. (2017)
	Implications of agility: (1) more frequent routines (e.g. reviews, standup meetings, (2) structures: agile teams take over aspects of traditional project management, (3) shared idea of how closer interactions between domains could look like should be in place	PM	Stettina and Hörz (2015)

Table 7 (continued)

	Antecedents	Impact on	Author
Controlling & Reviews	Improving governance controls (through feed-forward anticipatory control)	Innovation decision-making & cash margins	Baker and Bourne (2014)
	Strategic control at portfolio level (positive moderation of deliberate and emerging strategy)	PM success	Kopmann et al. (2015)
	Controlling intensity (effort and quality of continuous screening and monitoring to react to changes)	Decision-making quality & agility in PM	Kock and Gemünden (2016)
	Business case control (encompassing planning monitoring, reporting, taking necessary corrective action, and re-planning) across 3 stages: initial review, ongoing monitoring during project execution, post-project tracking	Portfolio success	Kopmann et al. (2017)
	Greater involvement of steering committees with managers from different functional areas in portfolio decision making for services	PM for new services	Aas et al. (2017)
	Portfolio governance (also regarded as dynamic capability)	PM quality → Portfolio success	In Meifort (2015): Urhahn and Spieth (2014)
	Frequent project reviews	PM success	In Meifort (2015): McDonough III and Spital (2003), Mohr et al. 2008
	Increased risk management (composed of risk transparency and risk coping capacity) at both project and portfolio level; becomes more important under environmental turbulence and dynamics	Portfolio success	In Meifort (2015): Teller and Kock (2013), Teller et al. 2014

Table 8 Methods, tools and metrics

	Antecedents	Impact on	Author
Methods	Greater usage of methods (e.g., financial methods, scoring, ranking, checklists, maps, graphs and diagrams)	Portfolio formalization	Jugend et al. (2016)
	Method usage (Yet, certain methods e.g. strategic bucket approaches, team decision making, checklists impact management perception and satisfaction positively, thus fostering PM performance indirectly)	No significance on PM performance	Spieth and Lerch (2014)
	Visual representation through network mapping, matrix and tabular displays (network mapping strongest impact)	Decision-making quality → Portfolio success	Killen (2017)
	Increased usage of proactive lineage (planning a roadmap of future projects) and reactive lineage (using learning from the past) practices	Portfolio performance	Kock and Gemünden (2019)
	Use of effectuation-a dynamic decision-making logic stemming from the entrepreneurship context	Portfolio decision-making	Nguyen et al. (2018)
Tools	Greater usage of certain decision/planning tools within specific contexts (yet, not in all contexts)	Portfolio decision-making quality	de Villiers, Woodside & Marshall (2016)
	Shift from purely financial to strategic PM tools; Use of multiple methods/tools	Portfolio success	In Meifort (2015): Cooper et al. (1998, 1999, 2001a, b), Szwejczewski et al. (2006), Killen et al. (2008)
	Less usage of specific tools to assess the value of non-financial effects for new services. Instead, business cases with financial calculations were the most common tool	PM for new services	Aas et al. (2017)

Table 8 (continued)

	Antecedents	Impact on	Author
Metrics	(1) Derivation of selection criteria from firm's strategic goals → (2) information requirements across all projects, → (3) alignment with information requirements → (4) adequate structural alignment (timely, efficient delivery of high-quality information) →	PM success	Kaiser et al. (2015)
	Greater consideration of the expected value (financial & non-financial) of the projects in the portfolio	PM effectiveness	Patanakul (2015)
	Focus of decision-making on strategic fit and criteria profitability and return on investment, less importance of tools. Intuition played a role, when lack of relevant information	PM	Baptestone and Rabechini (2018)
	Focus on four key attributes when exploiting an innovation project: (1) financial returns, (2) demand uncertainty, (3) competitive advantage, (4) risk	PM	Behrens (2016)
	Non-financial criteria complemented new service portfolio decisions to higher degree	PM for new services	Aas et al. (2017)

Table 9 Models and frameworks in PM

	Models and frameworks	Author
Portfolio selection	Portfolio selection model-a fuzzy possible attractiveness rating (FPAR)-by considering both favorable factors (e.g. project value and strategic fit) and unfavorable factors (e.g. projects risks) while using a fuzzy weighted average	Lin and Yang (2015)
	Portfolio selection model that uses a fuzzy weighted average approach for ranking new product projects and utilizes artificial neural networks for estimating project performance more precisely	Relich and Pawlewski (2017)
	Decision-making framework-combination of modeling, simulation, and optimization techniques to provide the best portfolio possible. Further provision of a rich set of analysis and visualization tools for decision makers to use in exploring the suggested portfolios and applying their intuition to make the final selection	Sampath et al. (2015)
	Comparison of two mathematical modeling frameworks that reflect different managerial attitudes (risk-aware and risk-seeing) towards upside risk in the context of R&D portfolio selection	Wang and Thiele (2017)
	Framework to assist decision makers in designing a set of strategic buckets in R&D project selection, consisting of four strategic constructs, namely technology, market, capabilities, and organizational processes (+external environment). Research showed that the design of buckets should be a dynamic process and individual to each firm	Santiago and Soares (2018)
	Governance framework for improving NPD decision making in complex product portfolios with short product life cycles	Baker and Bourne (2014)
Portfolio optimization	Proposition of mathematical model that helps define product optimization and scheduling of individual product development activities across various stages of product development in resource-constrained environment	Dash et al. (2018)
	Framework for integrated portfolio selection and adjustment that goes beyond supporting the portfolio selection process by offering an objective way for adjusting projects and portfolios	Barucke Marcondes et al. (2018)
	A resource management process framework that organizations can use to manage the resources across multiple NPD projects in a dynamic NPD portfolio is proposed	Abrantes and Figueiredo (2015)
Sustainability	Framework for integrating sustainability in the innovation project portfolio management process	Brook and Pagnanelli (2014)

Table 10 Consequences of PM

	Consequences	Of	Author
Innovation performance	Innovation performance	PM → Dynamic capabilities	Sicotte et al. (2015)
	Innovation performance (measured through NPD success net profit, sale growth rate)	PM success	Yang and Xu (2017)
	Firm's innovation success (measured through impact of new products or services, impact for process innovation satisfaction with innovation performance)	PM	Tidd and Thuriaux-Alemán (2016)
	Innovation project performance (measured through budget and schedule adherence, project customer satisfaction) Firm's innovativeness (relative newness of total portfolio)	PM performance	Spieth and Lerch (2014)
	Innovation performance (measured through technology and market, firm-internal and environment-related aspects)	Portfolio performance	In Meifort (2015): Schultz et al. (2013)
Innovation speed	New product development speed and competence development	PM	In Meifort (2015): Acur et al. (2010)
Firm performance	Firm performance (measured through customer satisfaction, market effectiveness, and financial performance)	PM performance	Spieth and Lerch (2014)
	Firm's financial performance (measured through perceived share, profit, and adaptability)	Portfolio performance	Hermano and Martín-Cruz (2016)
	Firm's financial performance (measured through a variety of items)	Proficient PM	In Meifort (2015): Killen et al. (2008), Salomo et al. (2008), Schultz et al. (2013), Urhahn and Spieth (2014), Kester et al. (2014)

Table 11 Challenges of PM

	Challenges	Author
Portfolio Balance	Objective of "balancing" a portfolio most challenging to fulfill due to commonly overly strong focus on incremental innovation and consequently little focus on long-term, radical innovation	Jugend et al. (2016)
Decision- making	Ambiguity in decision making → decisions makers typically prologue decision and allow ideas to be further developed	Gutiérrez (2014)
	Optimism bias from decision-makers → own managerial efforts can still reduce cost or time of project that is already over budget/time	Meyer (2014)
	Challenging resource allocation decisions because (1) unknown contingencies, (2) uncertainty about economic estimates, and (3) require constant corrective action	In Meifort (2015): Loch and Bode-Greul (2001)
Termination	The decision to terminate a project-The attention to strategic alignment and balance during termination decisions is strengthened when past project failure experience is high and involvement of top management greater (vs. middle management). On the other hand, it is deferred when the firm's growth rate is high.	Behrens and Patzelt (2015)
	Factors that significantly reduce termination decision quality at portfolio level: (1) dysfunctional executive advocacy behaviors (bias towards personal goals while sacrificing organizational goals; in favor of "pet projects") (2) weaknesses in project initiation (front-end) (3) weak project management process (4) weak termination decision processes (e.g. tools, stakeholders)	Lechler and Thomas (2015)
Optimization models	Implementation of optimization models difficult due to data requirements, analytical complexity, and hard interpretation Not possible to develop one tool applicable for all organizations, very specific Inability to incorporate strategic needs	In Meifort (2015): Baker (1974), Loch and Pich (2001), Kavadias and Chao (2007)

retrospect to reviewing the publications and their main findings and grouped based on commonalities.

Organizational and managerial aspects. Organizational and managerial aspects in regards to antecedents refer to the characteristics and attributes of an organization (e.g. structures, culture, capabilities and resources) and management (e.g. hierarchy, management involvement). First, managerial aspects were found to cover primarily two stakeholders-the top management and the project managers. In regards to the former, a high transparency and involvement of top management supported portfolio success (Too and Weaver 2014; Meifort 2015; Patanakul 2015; Yang and Xu 2017). If the top management is highly involved in PM, it is more likely that the firm will conduct regular reviews to align the portfolio with the firm's strategy (Yang and Xu 2017; Cooper et al. 1999). Project visibility of the status and potential problems enables management to react quicker and lead necessary measures in the way (Patanakul 2015). Padovani and Carvalho (2016) further found that centralization in approval processes increases the effectiveness of PM and hence portfolio performance. In regards to project managers, the review found that in contrast to Carbonell and Rodríguez-Escudero (2016) that decentralization, giving greater authority at project manager level, increases the portfolio success until a certain threshold is reached (inverted-U relationship). From there on out, further decentralization, decreases portfolio success. The latter research indicates that a balanced authority among top management and project managers leads to the best results. Petro and Gardiner (2015) also point out that project managers with strong authority and responsibility in the organization lead to better results in terms of portfolio success. The relationship was further positively moderated by involving a steering committee (Petro and Gardiner 2015). Generally, good project managers have strong capabilities, knowledge, and take responsibility in terms of PM (Yang and Xu 2017). Further, portfolio success heightened when project managers incentives were aligned with the portfolio's objectives. Another quite central organizational aspect are the multiple levels (e.g. corporate, business-unit, portfolio, project, and technology level, etc.) involved in PM as addressed in Meifort (2015). PM in a large part is about managing these multi-organizational levels and achieving consensus about the portfolio's future direction. Cultural aspects of the firm such as extensive communication, organizational learning, innovation power, and adverseness to risk played a key role in portfolio success throughout a series of research papers (Meifort 2015; Kock and Georg Gemünden 2016; Kock et al. 2016). A strong innovation climate is characterized through managerial support and autonomy to pursue creative ideas, whereas risk culture is demonstrated by venturing and committing resources to projects uncertain of the outcome or environment (Kock and Gemünden 2016; Kock et al. 2016). Nonetheless, the key towards quality decision-making is that measures for containing risk are implemented and risk is openly communicated (Kock and Gemünden 2016). Lastly, in regards to internal capabilities and resources, the research indicated that information availability belongs to the key drivers to PM performance. PM effectiveness and success are further dependent on (1) maintaining an overview of the firm's constraints, capabilities, uncertainties, and interdependencies (Padovani and Carvalho 2016) as well as (2) the ability to adapt quickly to these

type of internal/external changes (Meifort 2015; Patanakul 2015). To conclude, our review demonstrates that the maturity of organizational and managerial antecedents is already quite advanced.

Portfolio Content & Structure. Next to organizational and managerial aspects, antecedents in terms of the portfolio itself are discussed next. Selecting the right number of projects is part of Cooper et al. (2002) objectives for portfolio management. Yet, there is academic discourse to what the right number of projects is. Is the wider breadth of resource allocation, consequently larger portfolios, more successful than smaller, more focused portfolios? Kang and Montoya (2014) and Klingelbiel and Rammer (2014) agree that larger portfolios (or greater resource allocation breadth respectively) are more successful in terms of financial and portfolio performance. They argue that the greater the number of projects, the greater the chance of one of the projects becoming successful. Kock et al. (2016), Kopmann et al. (2015) and Teller et al. (2012), on the other hand, find that an increasing number of projects also inflicts more complexity. Also in line with Cooper, further research found that portfolios should be balanced (e.g. different levels of risk and innovation) and strategically aligned with the firm's strategy (Kang and Montoya 2014; Too and Weaver 2014; Meifort 2015; Patanakul 2015; Padovani and Carvalho 2016). Moreover, Kopmann et al. (2015) analyzed the effect of strategy formulation on portfolio success. They found that both the implementation of (1) deliberate strategies, strategy that cascades from corporate strategy to project level, as well as (2) emerging strategies, strategy that emerges from PM conditions, significantly improves portfolio success. The implementation of both further enhances this relationship. Further, the strategic decision to terminate projects that are no longer in line with a firm's strategy or no longer contribute to business performance is also regarded central to managing successful portfolios (Too and Weaver 2014; Yang and Xu 2017). In terms of portfolio interdependencies, Kock et al. (2016) and Kopmann et al. (2015) found that just as with portfolio size, the greater the interdependency among projects, the greater the complexity. Jugend et al. (2016), however, suggested that greater integration of projects may even improve decision-making when knowledge sharing takes place. Korhonen et al. (2016) also suggested that component commonality can act as a source of innovation in the beginning-trying to optimize product design. In later stages, when subsequent projects use already established design, it may hinder innovation. In regards to the type of projects in a portfolio, Kang and Montoya (2014) advocate to focus more on first-to-market projects as they result in the best financial results in the short and long-term, and Jugend et al. (2017) suggest to adopt green products for stronger portfolio performance. We find that the type of projects is still in early development in terms of its impact on portfolio success. Further research could for example investigate the influence of cooperation projects or projects with shorter versus longer development cycles on portfolio success.

External environmental aspects. Research regarding the influence of the external environment on PM proved to be limited and where mostly considered only as moderators for PM success. The external environments under investigation were defined as turbulent with frequent technological and customer-induced changes.

In environments with high turbulence, the value of business controlling becomes more imperative, whereas a deliberate strategy and process formalization becomes less important as a firm needs to constantly adapt its strategy to the changing environment (Kopmann et al. 2015; Kock and Georg Gemünden 2016a). Moreover, Kock and Georg Gemünden (2016) also found that in the context of turbulent environments, a firm's innovation climate becomes more impactful to making quality decisions and agility in PM. They reason that under highly turbulent environments, the motivation to innovate becomes stronger among project managers. The external environment is still in an early stage of development and further research could expand along the lines of Floricel and Ibanescu (2008) and examine the direct influence of external factors on portfolio success rather than being utilized as a moderator.

Procedural aspects. In this paper, antecedents of processes refer to best practices in terms of ways of doing, managing, coordinating innovation portfolios. Padovani and Carvahlo (2016) identify eleven procedural tasks that are relevant to PM and in turn positively influence a portfolio's performance (see Table 7). Yang and Xu (2017), Jugend et al. (2016), Kock and Georg Gemünden (2016), and Meifort (2015) explored the formalization of PM processes and found that greater formalization-clear rules, criteria and procedures-lead to higher portfolio decision-making quality and performance. Aas et al. (2017), who explore the distinction between service and product portfolios, find that PM for services, however, requires greater flexibility to account for high degree of heterogeneity in service portfolios. Stettina and Hörz (2015) also suggest implementing agility into PM. Regardless of formalization or agility, controlling and reviews are critical to both portfolio management approaches. The controlling intensity of PM, demonstrated through continuous monitoring and reporting, displays a positive relationship with decision-making and portfolio success as it enables a firm/portfolio manager to respond quicker to changes (Kopmann et al. 2015; Meifort 2015; Kock and Gemünden 2016; Kopmann et al. 2015). The review demonstrates that procedural aspects, especially formalization and review have been extensively studied. Yet, agile portfolio management and question of how firms can best implement agility in their processes is still in an early development stage and calls for future investigation (Tables 8, 9, 10, 11).

Methods, tools & metrics. This section covers methods, tools and metrics that have yielded to greater decision-making and portfolio performance. In regards to methods, the research displays mixed results. Jugend et al. (2016), Killen (2017), and Meifort (2015) find that greater usage of methods such as scoring models, checklists, or network mapping supports formalization or decision-making quality, respectively, and hence improves portfolio performance. Spieth and Lerch (2014), on the other hand, examined the direct effects of method usage on PM performance and found no significant effect. Yet, they also found certain methods (e.g. strategic buckets, team decision making, checklists) to have significant effects on management perception and thereby indirectly foster PM performance (Spieth and Lerch 2014). De Villiers et al. (2016) tested the efficacy of a range of tools (e.g. BGC Matrix, devil's advocate) and found that it leads to better product portfolio decision making

only in certain contexts, and that over reliance can lead to decision incompetence. Turning to metrics and selection criteria, Kaiser et al. (2015) outline that metrics should be derived from the firm's strategy and access to high quality information should be secured for achieving PM success. Further, Patanakul (2015), Baptestone and Rabechini (2018), Relich and Pawlewski (2017) and Behrens (2016) explore which type of selection criteria firms should consider for effective PM. Patanakul (2015) found that firms should emphasize more on the expected value (financial and non-financial) of projects in portfolio selection. Baptestone and Rabechini (2018) found strategic fit as well as profitability and return on investment are the most central selection criteria. Lastly, Behrens (2016) finds that managers find four selection attributes most relevant: (1) financial returns, (2) demand uncertainty, (3) competitive advantage, and (4) risk. In terms of services again, Aas et al. (2017) find that the role of non-financial criteria is much higher than for products. To conclude, despite extensive research and development of many different tools and methods, we still find discrepancies among scholars regarding their influence on portfolio performance. Metrics, for portfolio selection and performance measurement, should also be further developed to determine which key performance indicators forecast portfolio success best.

4.2.2 PM models and frameworks

Next to the aforementioned antecedents for portfolio success, the research sample consisted of a number of models and frameworks that were developed to support managers in (1) the portfolio selection process, (2) the continuous portfolio optimization, and (3) the implementation of sustainability. Models and frameworks are widely addressed in PM research and as such a review of all would push the boundaries of this paper. In this section, we thus supplement key contributions since 2014 (see Meifort (2015) for prior publications). In contrast to similar aspects (i.e. tools and decision criteria) discussed in the antecedents, research in this section does not provide direct evidence for improving decision-making or portfolio success. The papers in this category are primarily conceptual by nature and illustrated through the use of case studies. They are also more specific; detailing individual components and the usage of the proposed frameworks. Findings in the antecedents are broader and, for example, delve into whether certain criteria (i.e. non-financial criteria) or the greater usage of tools supports the performance of PM.

To support managers in the portfolio selection process, Lin and Yang (2015) and Relich and Pawlewski (2017) have developed 'fuzzy' weighted portfolio selection models (based on estimates/imprecise data) that help rank projects and estimate portfolio performance. Sampath et al. (2015) combine different modeling, simulation, and optimization techniques for portfolio selection, illustrated in a case study of Intel Corporation. Wang and Thiele (2017) propose two mathematical decision-making models for R&D projects that take the large upside risk of radical innovations into account. Baker and Bourne (2014) extend NPD stage gate processes by proposing a governance framework-feedforward anticipatory control (FAC)-for improving decision-making in complex product portfolios with short life-cycles. The FAC is derived from a combination of feedforward controls such as planning

and forecasting for go/kill decisions (Cooper 1990) with management's validation of targets. Based on case studies in the sports and apparel industry, Baker and Bourne (2014) demonstrate that FAC help balance control and creativity in the portfolio as well as drive productivity and profit growth. Lastly, Santiago and Soares (2018) propose a framework that helps decision-makers in the design of strategic buckets. The next set of models and frameworks concern the continuous optimization of portfolios. Dash et al. (2018) propose a framework for product optimization and scheduling of activities across various lifecycle stages. Marcondes et al. (2018) propose a framework that goes beyond the realm of portfolio selection and specifies how to adjust existing portfolios, and Abrantes and Figueiredo (2015) provide a framework for optimizing the allocation of human resources across projects in dynamic environments. Lastly, Brook, and Pagnanelli (2014) provide managers with a step-by-step framework of how best to incorporate sustainability practices (e.g. ecological, social, and economic) into the PM process.

4.2.3 Consequences of PM

The consequences of PM are referred to as the output resulting from effective PM. The research in our literature sample, indicates that successful PM leads to (1) greater innovation performance (Spieth and Lerch 2014; Meifort 2015; Sicotte et al. 2015; Yang and Xu 2017), (2) innovation speed (Meifort 2015), (3) greater firm innovativeness (Spieth and Lerch 2014; Tidd and Thuriaux-Alemán 2016), and (4) better firm performance (Spieth and Lerch 2014; Meifort 2015; Hermano and Martín-Cruz 2016). The items utilized to explore these relationships varied slightly; however, the number of studies exploring the relationship of PM with innovation and firm performance within the relatively short period is quite large and thus solidifies the importance of PM.

4.2.4 Challenges of PM

The challenges of PM are much less explored than the antecedents for PM. Challenges are, however, often inherently related to antecedents. For example, while having a balanced portfolio is an antecedent for successful portfolios, this objective is often times quite challenging for firms to fulfill because they tend to overly focus on incremental innovation (less risk, less effort), and consequently focus too little on long-term, radical innovation (Jugend et al. 2016). However, the most commonly identified challenge among the publications occurs during the decision-making process. Gutiérrez (2014) identifies ambiguity in the decision-making, which results in portfolio managers to allow ideas to be further developed until they grasp a better understanding of the purpose/benefits and can construct better judgements. This prolonged decision, however, requires additional resources that could be assigned to another project. Meyer (2014) identifies a further challenge in decision-making-optimism bias. This occurs when managers believe that the predicted cost or time of a project can be reduced through their own managerial efforts. Bias in decision-making was also identified by Lechler and Thomas (2015), who examined challenges related to termination decisions. They argue that managers often times display bias

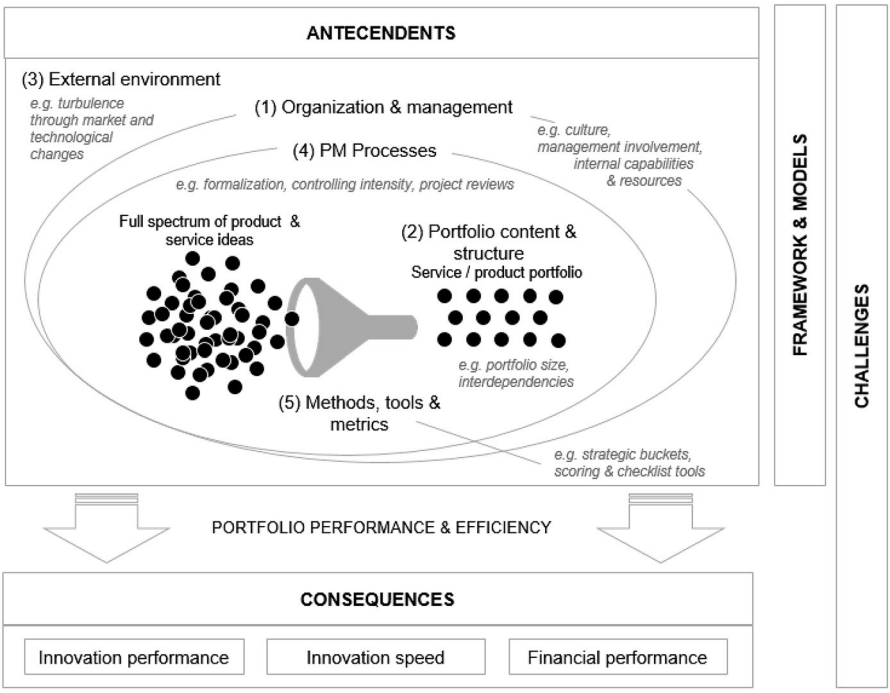

Fig. 4 Classification framework of PM research

towards personal goals (or so-called "pet projects") and thereby potentially sacrificing organizational goals. In Meifort (2015), Loch and Bode-Greul (2001) also specify the challenges involved with resource allocation decisions-lack of consistent and reliable information and continuous adaption required. Lastly, optimization models were formerly dismantled because they were unable to grasp the complexities of PM e.g. project interdependencies (Meifort 2015). With today's technology such complexities can be incorporated, yet these models still have strong information requirements and decrease transparency for project managers (Loch and Pich 2001 cited in Meifort 2015).

To conclude this section of literature synthesis, our classification of PM research is summarized and visualized in the Fig. 4.

4.3 Exploration of services and digital services in current innovation PM research

In this section, we address the second research question and explore to what extent the current PM research has acknowledged services and digital services. We cross-examined the papers in our sample [52 papers] as well as the totality of papers presented in Meifort (2015) [112 papers] to create a complete picture. We classified empirical papers based on their research sample, and conceptual papers based on the degree to which the paper acknowledged and thematized services. While some

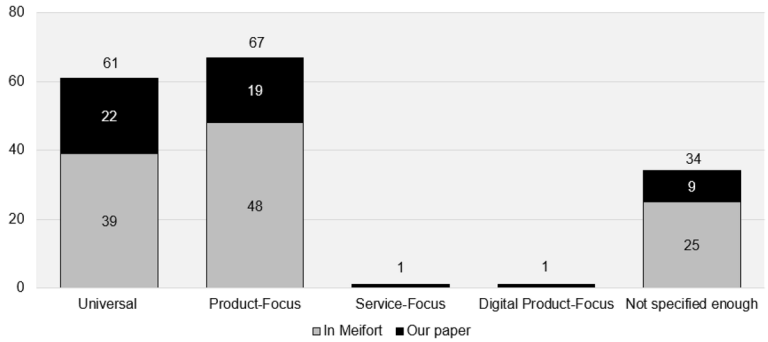

Fig. 5 Distribution of PM literature with product and/or service focus

authors consider new product development to consist of both products and services, many studies, especially early PM papers, have a strong focus on R&D in manufacturing intensive industries and as such their research is not applicable to services. The findings of the papers categorized as 'universal' are applicable to both services and products, whereas the findings of product-focused papers do not necessarily remain valid for services. Papers that did not specify their scope sufficiently (e.g. whether NPD includes services), and/or the research sample provided no further indication, were classified as 'not specified enough' (Fig. 5).

The findings show that the majority of papers are either 'universal' [61] or 'product-specific' [67]. Only one paper was classified as 'service-specific' (Aas et al. 2017) and one more as 'digital-specific' (Echterfeld and Gausmeier 2018). The remaining papers [34] are not specified enough to classify, but are likely to fall into the product-specific category, if detailed more.

The number of 'universal' papers is surprising given the assumption that services have been widely ignored by innovation PM literature up to date. Yet, we found that many of the 'universal' papers were categorized based on whether their sample included services (e.g. financial services, consultancy) and did not necessarily extensively address services. Still, we present and briefly discuss these publications as they offer valuable insights in regards to what extent services have been acknowledged in innovation PM. The 'universal' papers that explored both product and service innovation PM are mostly found in the research stream antecedents for PM. The findings in terms of (1) organization and management (e.g. top management involvement, risk culture) and the (3) external environment are particularly well explored with only few exceptions (Kraiczy et al. 2014). In terms of (2) portfolio content and structure, "balanced, strategically aligned, and interdependent" service portfolios are found to have a positive relationship to portfolio performance (Spieth and Lerch 2014; Too and Weaver 2014; Kopmann et al. 2015; Patankul 2015; Kock et al. 2016; Padovani and Carvalho 2016). Further, likewise to products, services require further research to resolve contrary findings in regards to portfolio size. The remaining antecedents (4) PM processes and (5) methods, tools and metrics are far less explored in terms of services. In a case study including the examination of service firms (i.e. insurance, telecommunication services), Patanakul (2015) finds that

greater attention to the expected value both financially and non-financially associates with greater PM effectiveness. Kasier et al. (2015), who included construction service firms in their sample found that metrics derived from the firm's strategy and high quality information associate with greater PM success. Unlike solely product-focused research (Jugend et al. 2016; Killen 2017), Spieth and Lerch (2014), who included services in their definition of innovation projects investigated the method usage (e.g. strategic buckets, checklists, etc.) found no significant impact on IPM performance.

Next to antecedents, service providers are also widely considered in research regarding PM consequences. The literature shows that successful PM in services leads to greater innovation performance, greater firm innovativeness, and better firm performance (e.g. Spieth and Lerch 2014; Sicotte et al. 2015; Tidd and Thuriaux-Alemán 2016). Yet, innovation speed in services remains unexplored. Lastly, the categories 'models and frameworks' and 'challenges' are uniformly product-focused and as such reveal no insights in regards to services.

In Meifort (2015) and our literature review, four papers explored the distinction between services and products in detail (Killen et al. 2008; Koh and Crawford 2012; Sicotte et al. 2015; Aas et al. 2017). In retrospect, we identified three additional papers (Storey and Hughes 2013, Calantone et al. 2010; Killen and Hunt 2010) that display a high relevancy for our paper but were disregarded in Meifort (2015). Their findings will also be discussed here. Killen et al. (2008) found that PM practices among services and products are similar to a large extent, but have specific challenges. Service-firms operate in environments with dynamic markets and technologies, shorter lifecycles, and greater ease of service imitation. Manufacturing-intensive firms, on the other hand, are less flexible in dynamic competitive environments and are increasingly challenged to move towards greater service integration (Killen and Hunt 2010). Further differences were found: services have shorter development and business planning processes, require greater flexibility and collaborative approaches to account for the high degree of heterogeneity in service portfolios, and focus on more non-financial criteria and less on specific tools (Killen et al. 2008; Calatone et al. 2010; Koh and Crawford 2012; Storey and Hughes 2013; Aas et al. 2017). Similar to products, Storey and Hughes (2013) found that superior performing service firms do not spread their resources across too many projects, too thinly. They also 'kill' projects that are no longer relevant, strive for a well-balanced portfolio (not too risk adverse) and conduct periodic reviews (monthly or quarterly) so that it does not become too late to correct potential problems (Storey and Hughes 2013).

Although the concept of PM was applied to services much later, Killen et al. (2008) found that the use of portfolio methods among service organizations are just as mature (measured in terms of formality, decision-making, performance measurement, and methods used) as for product organizations. Storey and Hughes (2013) in contrast finds that only 8% of service firms (financial services) have well-executed PM, in comparison to 21% found in studies of product-centered firms (Cooper et al. 2001b). Storey and Hughes (2013) states that service services do not yet have PM in their strategic focus. Methods originally developed for products were utilized for services. Yet, the findings that service firms invest a higher percentage of their

revenues in the development of services, but product-focused firms report significantly more profit from new products, may also suggest that PM processes are not yet optimized for services.

5 Research agenda

Our literature review demonstrates that the PM of services and digital services are under-researched. While there has been research regarding service innovation (e.g. de Brentani 1991; Kelly and Storey 2000; Storey and Kelly 2001; Storey and Hughes 2013; Storey et al. 2016; den Hertog et al. 2010) and digital service innovation (e.g. Eaton et al. 2015; Chowdhury 2015; Nylén and Holmström 2015; Akram 2016) on project level, the research on portfolio level remains narrow for services and non-existent for digital services. Given the growing significance of services, in particularly of digital services, to developed economies and the inherently different nature of digital services, we argue that there is a high relevance to examine how the design and execution of PM should optimally look like. In the following, we outline potential areas for future research in the context of services/digital services.

1. In product PM, research has found that PM processes with greater formalization in terms of clear rules, criteria and procedures improve decision-making quality and portfolio performance. A case study paper from Aas et al. (2017) suggests that service portfolio processes are often more flexible but they do not investigate the influence of formalization or agility on performance. Given that digital services compete in much more dynamic environments with shorter lifecycles, formal processes may need to shorten and allow for greater flexibility. We urge researchers to investigate the role of formalization and agility on the performance of services and digital services.
2. Similar to the previous research suggestion, the utilization of portfolio methods and tools for service portfolios is also an interesting and under-researched area. The literature sample indicates that greater usage of tools and methods yields higher performance for product portfolios. We suggest investigating the utilization on service/digital service portfolio performance as well. Along these lines, it would also be essential to know which tools or methods work in the context of services best and to what extent established tools may need to be adapted. Digital services inherently offer new possibilities of collecting and analyzing data, thus potentially improving the accuracy and usefulness of tools applied in portfolio selection.
3. New selection criteria and performance indicators are needed as most have originated on the basis of product-orientated business models (Baines et al. 2006, 2009; Martinez et al. 2010). In the context of digitalization, traditional metrics are no longer fundamentally effective. This is because a large majority of assets in the digital world are intangible (e.g. user experience, algorithms) and thus more difficult to identify and quantify (Bughin and Manyika 2013). Digital traction metrics (e.g. daily active users, engagement rates) and metrics capturing the financial impact of acquiring, retaining and monetizing customers become critical

(Fleming 2015) and as such should also be considered when allocating resources to different digital services and measuring their performance.

4. Kopmann et al. (2015), Korhonen et al. (2016), and Jugend et al. (2016) investigate the relationship between product portfolio interdependencies and performance, yet further research is required for a coherent stance. We reckon it would be interesting to examine this relationship also for services because cost savings from synergies can be immense, especially for digital services, where back-ends can be more easily standardized.
5. The next potential area of research covers models and frameworks for PM. The existing research is mostly of conceptual nature (illustrated through case studies) and developed under product-intensive contexts. Further research could illustrate and validate these frameworks in the context of services/digital services as well as develop models and frameworks that consider the unique nature of services/digital services. Such a contribution would be highly relevant for practitioners in service fields.
6. In our literature review, we identified challenges across the dimensions decision-making, termination, and the use of optimization models and found that these papers were also developed with a strong product-centricity. Future research could investigate not only further service-specific challenges but also examine to what extent these challenges apply to services. For example, investigating termination decisions for digital services would be interesting, as we expect digital service-specific factors (e.g. shorter lifecycles, co-creation with partners, marginal-zero costs, etc.) to influence the decision-making process significantly. If the cost of offering an additional unit does not result in nearly any costs, the decision to terminate a digital service may be deferred. Also, digital services may alleviate the challenges in optimization models as they inherently capture data and as such can deliver sufficient information for complex models.
7. As addressed in the introduction, the subject of service PM has mostly appeared in the information technology domain and has been developed in isolation to innovation PM. Until recently, IT service PM primarily focused on prioritizing infrastructural IT investments (e.g. networks, servers) and gave little attention to IT projects that offer business value (Trastour and Christodoulou 2009). Yet, as IT organizations seek to grasp a more complete picture of IT-related investments, they have extended existing IT portfolios with IT services that generate more and more value towards the end-customer. Even though the scope of digital services can often only be partially reflected in IT services, future research could explore whether and how to merge these two research streams.

6 Conclusion

In this paper, we conducted a systematic literature review to understand the state of innovation PM research in general as well as for services and digital services specifically, and highlight potential areas for future research. The literature review covered 52 empirical and conceptual papers in peer-reviewed journals and incorporated further 112 papers from a prior literature review of innovation PM conducted

by Meifort (2015), covering in total a timeframe from 1969 until 2019. We classified the literature along the categories (1) antecedents, (2) models & frameworks, (3) consequences, and (4) challenges with the objective to create a structured and exhaustive overview of existing PM research areas. Our review revealed that while the product-centricity is still high in innovation PM research, in more recent years, services have been considered more frequently. Digital service innovations, however, have not been investigated in any research papers up to date. Given that the characteristics of digital services significantly distinguish from traditional services and products and its increasing significance in today's economy, we suggest research concerning the management and steering of a portfolio of digital services.

Our paper results in several contributions to theory and practice. In academia, our paper addresses scholars in the intersection of innovation PM, digitalization and servitization and offers relevant theory contributions. First, by supplementing and incorporating the work of Meifort (2015), our review offers a complete and coherent synthesis of innovation PM research up to date. Our categorization including antecedents and consequences of successful innovation PM is in alignment with many relevant conceptual contributions. Unlike Meifort (2015), who explores PM along different theoretical lenses (e.g. strategic, decision-making perspectives), our categorization lays out the core developments such as what factors lead to successful PM, how differences in PM effects firm performance, and how the successful implementation of PM can be supported. Additionally, in contrast to Meifort (2015), we further grouped findings (i.e. portfolio size, formalization, top management) within a category (i.e. antecedent) and presented the main finding of a study in regards to the category. Meifort (2015) structured papers according to the author and published year in a given category and presented a brief summary rather than the main findings of each paper. Our structure intends to enable researchers to quickly identify existing research streams and for future research, especially in terms of services and digital services, to incorporate findings across the identified categories. The second main contribution of this study includes the investigation of the service and digital service perspective in existing innovation PM research. Due to the established usage of the term new 'product' development, it remained unclear to what extent services and digital services have been investigated without immediate recognition. Our study explored the scope and research sample of all our selected papers including the papers gathered in Meifort (2015) to identify potential contributions in terms of services/digital services. We found that significantly more studies have acknowledged services in innovation PM than anticipated. In the last years, publications on the antecedents and consequences of PM have largely acknowledged both products and services, but only few explicitly dive into specific differences between managing a portfolio of services and products (Killen et al. 2008; Calatone et al. 2010; Killen and Hunt 2010; Koh and Crawford 2012; Storey and Hughes 2013; Sicotte et al. 2015; Aas et al. 2017). Other research streams such as PM models and frameworks or challenges of service PM also remain widely unaddressed. Further, we found that digital services, despite their imminent importance to firms and in research, have not been taken up in PM research so far.

Thirdly, we identified potential areas of discrepancy between product-focused and service or digital service focused PM, which call for further examination. We

propose that several aspects such as formalization and standardized procedures that resulted in superior performance in the product-centered world, do not necessarily remain valid for services and digital services given their unique characteristics (i.e. shorter lifecycles).

In regards to practitioners, we address portfolio managers and product strategists firstly by offering state-of-the-art insights to PM that shall support them in the design and optimization of their portfolios. As mentioned above, we specifically chose to classify PM research differently than Meifort (2015), to ease translation and utilization of research by practitioners. Our conceptual framework is structured in a way that allows managers to quickly identify how PM processes and the adjacent environment (e.g. culture, management, external environment) should to be organized to successfully manage portfolios and how successful PM can benefit the firm. It also provides an overview of frameworks developed by academia to support portfolio management activities (e.g. prioritization) and points out key challenges to look out for. Secondly, it provides first insights to what extent the PM of services/digital services differ to products, which is especially relevant for historically product-orientated firms transitioning more towards services. Yet, further empirical investigations that offer guidelines for service providers, in particularly, for digital service providers are still outstanding.

Yet, our research contains certain limitations. Firstly, the keyword-based search may have excluded relevant papers that were not identified through our search term in the title, abstract or keywords. Especially, given the lack of a consistent terminology to describe PM of innovation. Researchers referred to it as new product development PM (e.g. Easingwood 1986; Chao et al. 2009), project PM (e.g. McDonough III and Spital 2003) or product PM (e.g. Kang and Montoya 2014; Dash et al. 2018) at times. Yet, we tried to overcome this limitation as much as possible through a broad search term and by supplementing the database search with a backward and forward search. Secondly, the selected time frame of the search yields some limitation. We selected papers from the year 2014 onwards to extend Meifort's (2015) review, which cut off in 2014. Yet, we found that in Meifort's review sample, some relevant papers were missing (e.g. Calantone et al. 2010; Killen and Hunt 2010; Storey and Hughes 2013). Thirdly, the development of the categories (e.g. antecedents-organizational and managerial aspects) and the classification of papers into these categories was completed by the authors and thus inherently creates limitations. Lastly, our research only selected papers written in English or German, which entails the risk of disregarding relevant papers in other languages.

To conclude, while our research identified a few papers that investigate how to manage service portfolios, further research regarding how to design PM for firms with a portfolio of digital services is strongly recommended to support managers in the context of the digital economy. We believe that the value contribution of digital services in firms and the economy will continuously growth through advancements in technology and growing customer expectations for on-demand and individualized offerings.

References

Aas TH, Breunig KJ, Hydle KM (2017) Exploring new service portfolio management. Int J Innov Manag 21(6):913

Abrantes R, Figueiredo J (2015) Resource management process framework for dynamic NPD portfolios. Int J Project Manag 33(6):91

Acur N, Kandemir D, Weerd-Nederhof PC, Song M (2010) Exploring the impact of technological competence development on speed and NPD program performance. J Prod Innov Manag 27(6):915–929

Akram A (2016) Value network transformation–digital service innovation in the vehicle industry, Doctoral dissertation, University of Goeteborgs

Ansoff HI, Leontiades JC (1976) Strategic portfolio management. J General Manag 4(1):13–29

Baines TS, Lightfoot HW, Benedettini O, Kay JM (2006) The servitization of manufacturing; a review of literature

Baines T, Lightfoot H, Peppard J, Johnson M, Tiwari A, Shehab E, Swink M (2009) Towards an operations strategy for product-centric servitization. Int J Oper Prod Manag 29(5):494–519

Baker NR (1974) R&D project selection models: an assessment. IEEE Trans Eng Manag 21:165–171

Baker MJ (2000) Writing a literature. Mark Rev 1(2):219–247

Baker M, Bourne M (2014) A governance framework for the idea-to-launch process: development and application of a governance framework for new product development. Res Technol Manag 57(1):82

Baptestone R, Rabechini R (2018) Influence of portfolio management in decision-making. J Ind Eng Manag 11(3):53

Bärenfänger R, Otto B (2015) Proposing a capability perspective on digital business models In: 2015 IEEE 17th conference on business informatics, vol 1, pp 17–25

Bar-Ilan J (2008) Which h-index?—a comparison of WoS, Scopus and Google Scholar. Scientometrics 74(2):257–271

Bart C, Pujari A (2007) The performance impact of content and process in product innovation charters. J Prod Innov Manag 24:3–19

Barwise P, Picard RG (2015) The economics of television: excludability, rivalry, and imperfect competition. Handbook Econ Media 29:165–187

Behrens J (2016) A lack of insight: an experimental analysis of R&D managers' decision making in innovation portfolio management. Creat Innov Manag 25(2):239–250

Bettis RA, Mahajan V (1985) Risk/return performance of diversified firms. Manag Sci 31(7):785–799

Beverungen D, Matzner M, Janiesch C (2017) Information systems for smart services. Inf Syst E-Bus Manag 15(4):781–787

Bharadwaj A, El Sawy OA, Pavlou PA, Venkatraman N (2013) Digital business strategy: toward a next generation of insights. MIS Q 3:471–482

Bosman J, van Mourik I, Sieverts E, Verhoeff H (2006) The coverage and functionality of the citation database Scopus, including comparisons with Web of Science and Google Scholar

Brook JW, Pagnanelli F (2014) Integrating sustainability into innovation project portfolio management-a strategic perspective. J Eng Technol Manag 34:21

Brown SL, Eisenhardt KM (1997) The art of continuous change: linking complexity theory and time-paced evolution in relentlessly shifting organizations. Adm Sci Q 42:1–34

Bughin J, Manyika J (2013) *Measuring the full impact of digital capital*. McKinsey and Company https://www.mckinseycom/industries/high-tech/our-insights/measuring-the-full-impact-of-digital-capital

Calantone RJ, Harmancioglu N, Droge C (2010) Inconclusive innovation "returns": a meta-analysis of research on innovation in new product development. J Prod Innov Manag 27(7):1065–1081

Carbonell P, Rodríguez-Escudero (2016) The individual and joint effects of process control and process-based rewards on new product performance and job satisfaction. BRQ Bus Res Qy 19(1):26–39

Cardozo R, Smith DK (1983) Applying financial portfolio theory to product portfolio decisions. An empirical study. J Mark 47(2):110–119

Cardozo RN, Wind J (1985) Risk return approach to product portfolio strategy. Long Range Plan 18(2):77–85

Chao RO, Kavadias S, Gaimon C (2009) Revenue driven resource allocation: funding authority incentives, and new product development portfolio management. Manag Sci 55(9):1556–1569

Chowdhury S (2015) Service logic in digitalized product platforms: a study of digital service innovation in the vehicle industry. Doctoral dissertation, University of Gothenburg

Comerio M, Batini C, Castelli M, Grega S, Rossetti M, Viscusi G (2015) Service portfolio management: a repository-based framework. J Syst Softw 104:112–125
Cooper HM (1988) Organizing knowledge syntheses: a taxonomy of literature reviews. Knowl Soc 1(1):104
Cooper RG (1990) Stage-gate systems: a new tool for managing new products. Bus Horiz 33(3):44–54
Cooper RG, Sommer AF (2019) New-product portfolio management with Agile. Res Technol Manag 63(1):29–38
Cooper RG, Edgett SJ, Kleinschmidt EJ (1997a) Portfolio management in new product development: lessons from the leaders-I. Res Technol Manag 40(5):16–28
Cooper RG, Edgett SJ, Kleinschmidt EJ (1997b) Portfolio management in new product development: lessons from the leaders-II. Res Technol Manag 40(6):43–52
Cooper RG, Edgett SJ, Kleinschmidt EJ (1998) Best practices for managing R&D portfolios. Res Technol Manag 41(4):92
Cooper RG, Edgett SJ, Kleinschmidt EJ (1999) New product portfolio management: practices and performance. J Prod Innov Manag 31(4):333–351
Cooper RG, Edgett SJ, Kleinschmidt EJ (2000) New problems, new solutions: making portfolio management more effective. Res Technol Manag 43(2):18
Cooper RG, Edgett SJ, Kleinschmidt EJ (2001a) Portfolio management for new products
Cooper RG, Edgett SJ, Kleinschmidt EJ (2001b) Portfolio management for new product development: results of an industry practices study. R&D Management 31(4):91
Cooper RG, Edgett SJ, Kleinschmidt EJ (2002) Optimizing the stage-gate process: what best-practice companies Do-II. Res Technol Manag 45(6):81
Dash B, Gajanand MS, Narendran TT (2018) A model for planning the product portfolio and launch timings under resource constraints. Int J Prod Res 56(15):5081–5103
Day GS (1977) Diagnosing the product portfolio. J Market 41(2):29–38
De Brentani U (1991) Success factors in developing new business services. Eur J Mark 25(2):33–59
De Maio A, Verganti R, Corso M (1994) A multi-project management framework for new product development. Eur J Oper Res 78(2):178–191
de Villiers R, Woodside AG, Marshall R (2016) Making tough decisions competently: Assessing the value of product portfolio planning methods, devil's advocacy, group discussion, weighting priorities, and evidenced-based information. J Bus Res 69(8):2849–2862
Demirkan H, Spohrer J (2016) Emerging service orientations and transformation. Inf Syst Front 18(3):407–411
Den Hertog P, Van der Aa W, De Jong MW (2010) Capabilities for managing service innovation: towards a conceptual framework. J Serv Manag 21(4):490–514
Devinney TM, Stewart DW, Shocker AD (1985) A note on the application of portfolio theory: a comment on Cardozo and Smith. J Market 49(4):107–112
Easingwood CJ (1986) New product development for service companies. J Prod Innov Manag 3(4):264–275
Eaton B, Elaluf-Calderwood S, Sorensen C, Yoo Y (2015) Distributed tuning of boundary resources: the case of Apple's iOS service system. MIS Q Manag Inf Syst 39(1):217–243
EBSCO (2019) Business source complete magazines and journals. https://www.ebscohostcom/titleLists/bth-journalspdf
Echterfeld J, Gausmeier J (2018) Digitising product portfolios. Int J Innov Manag 22(5):81
Ekeldo I, Sivakumar K (2004) The impact of E-commerce on entry-mode strategies of service firms: a conceptual framework and research propositions. J Int Mark 12(4):46–70
Fitzgerald M, Kruschwitz N, Bonnet D, Welch M (2014) Embracing digital technology: a new strategic imperative. MIT Sloan Manag Rev 55(2):1
Fleming M (2015) Digitalization changes everything: improving economic measurement in an Era of radical innovation and transformation. Monthly Lab Rev 138:92
Floricel S, Ibanescu M (2008) Using R&D portfolio management to deal with dynamic risk. R&D Management 38(5):452–467
Frey T, Buxmann P (2012) IT project portfolio management-a structured literature review
Gutiérrez E (2014) Managing ambiguity when evaluating and selecting new ideas in project portfolio management. Int J Innov Technol Manag 11(5):1
Henderson BD (1970) The product portfolio. Boston Consult Perspect 66:11–97
Herfert KF, Arbige MV (2008) Aligning an R&D portfolio with corporate strategy. Res Technol Manag 51:39–46

Hermano V, Martín-Cruz N (2016) The role of top management involvement in firms performing projects: a dynamic capabilities approach. J Bus Res 69(9):3447–3458
Herrera G (2011) Google scholar users and user behaviors: an exploratory study. College Res Libr 72(4):316–330
Hunt R, Killen CP, Christiansen JK, Varnes C (2008) From models to practice: decision making at portfolio meetings. Int J Quality Reliab Manag 25:97
Iansiti M, Levien R (2004) The keystone advantage: what the new dynamics of business ecosystems mean for strategy, innovation, and sustainability. Harvard Business Press, Harvard
IJRVET (2019) Indexing. International journal for research vocational training and education. https://journalssubuni-hamburgde/hup2/ijrvet/Indexing
Jugend D, da Silva SL, Salgado MH, Miguel PAC (2016) Product portfolio management and performance: Evidence from a survey of innovative Brazilian companies. J Bus Res 69(11):5095–5100
Jugend D, Rojas Luiz JV, Chiappetta Jabbour CJ, Silva SLA, de Lopes SJAB, Salgado MH (2017) Green product development and product portfolio management: empirical evidence from an emerging economy. Bus Strat Environ 26(8):1181–1195
Kaiser MG, El Arbi F, Ahlemann F (2015) Successful project portfolio management beyond project selection techniques: understanding the role of structural alignment. Int J Project Manag 33(1):28
Kang W, Montoya M (2014) The impact of product portfolio strategy on financial performance: the roles of product development and market entry decisions. J Prod Innov Manag 31(3):516–534
Kavadias S, Chao RO (2007) Resource allocation and new product development portfolio management. In: Handbook of new product development management, Routledge, pp 151–180
Kelly D, Storey C (2000) New service development: initiation strategies. Int J Serv Ind Manag 11(1):45–63
Kessler T, Buck C (2017) How digitization affects mobility and the business models of automotive OEMs. In: Phantom ex machina, Springer, Cham, pp 107–118
Kester L, Hultink EJ, Griffin A (2014) An empirical investigation of the antecedents and outcomes of NPD portfolio success. J Product Innov Manag 31(6):51
Killen CP (2017) Managing portfolio interdependencies. Int J Manag Projects Bus 10(4):856–879
Killen CP, Hunt RA (2010) Dynamic capability through project portfolio management in service and manufacturing industries. Int J Manag Projects Bus 3:1.
Killen CP, Hunt RA, Kleinschmidt EJ (2007) Managing the new product development project portfolio: a review of the literature and empirical evidence. In: PICMET'07-2007 Portland international conference on management of engineering and technology, pp 1864–1874
Killen CP, Hunt RA, Kleinschmidt EJ (2008) Project portfolio management for product innovation. Int J Qual Reliab Manag 25(1):43
Kim Y, Choi JS, Shin Y (2014) A decision model for optimizing the service portfolio in SOA governance. In: 4th World congress on information and communication technologies (WICT 2014), pp 57–62
Kissi J, Dainty A, Tuuli M (2013) Examining the role of transformational leadership of portfolio managers in project performance. Int J Project Manag 31:485–497
Klingebiel R, Rammer C (2014) Resource allocation strategy for innovation portfolio management. Strat Manag J 35(2):246–268
Kock A, Georg Gemünden HG (2016) Antecedents to decision-making quality and agility in innovation portfolio management. J Prod Innov Manag 33(6):670–686
Kock A, Gemünden HG (2019) Project lineage management and project portfolio success. Project Manage J 50(5):587–601
Kock A, Heising W, Gemünden HG (2016) A contingency approach on the impact of front-end success on project portfolio success. Project Manag J 47(2):41
Koh A, Crawford L (2012) Portfolio management: the Australian experience. Project Manag J 43(6):33–42
Kopmann J, Kock A, Killen CP, Gemünden HG (2015) Business case control in project portfolios—an empirical investigation of performance consequences and moderating effects. IEEE Trans Eng Manag 62(4):529–543
Kopmann J, Kock A, Killen CP, Gemünden HG (2017) The role of project portfolio management in fostering both deliberate and emergent strategy. Int J Project Manage 35(4):557–570
Korhonen T, Laine T, Lyly-Yrjänäinen J, Suomala P (2016) Innovation for multiproject management: the case of component commonality. Project Manag J 47(2):130–143

Kowalkowski C, Gebauer H, Kamp B, Parry G (2017) Servitization and deservitization: overview, concepts, and definitions. Ind Mark Manag 6:4–10
Kraiczy ND, Hack A, Kellermanns FW (2014) New product portfolio performance in family firms. J Bus Res 67(6):1065–1073
Kumar R, Ajjan H, Niu Y (2008) Information technology portfolio management: literature review, framework, and research issues. Inf Resour Manag J 21(3):64–87
Lechler TG, Thomas JL (2015) Examining new product development project termination decision quality at the portfolio level: consequences of dysfunctional executive advocacy. Int J Project Manag 33(7):1452–1463
Leimeister JM, Österle H, Alter S (2014) Digital services for consumers. Electron Mark 24(4):255–258
Leliveld I, Jeffrey M (2004) Best practices in IT portfolio management. MIT Sloan Manag Rev 1:79
Levitt T (1981) Marketing intangible products and product intangibles. Cornell Hotel Restaur Adm 22(2):37–44
Lin C-T, Yang Y-S (2015) A linguistic approach to measuring the attractiveness of new products in portfolio selection. Group Decis Negot 24(1):145–169
Loch CH, Bode-Greuel K (2001) Evaluating growth options as sources of value for pharmaceutical research projects. R&D Manag 31:231–248
Loch CH, Pich MT (2001) Selecting R&D projects at BMW: a case study of adopting mathematical programming models. IEEE Trans Eng Manag 48:70–80
Mahanjan V, Wind J (1982) Integrating financial portfolio analysis with product portfolio models. University of Pennylvanina, Marketing Department, Wharton School
Marcondes GAB, Leme RC, Carvalho MM (2018) Framework for integrated project portfolio selection and adjustment. IEEE Trans Eng Manag 3:71
Markowitz H (1952) Portfolio selection. J Finance 7(1):77–91
Martinez V, Bastl M, Kingston J, Evans S (2010) Challenges in transforming manufacturing organisations into product-service providers. J Manuf Technol Manag 21(4):449–469
Matzner M, Büttgen M, Demirkan H, Spohrer J, Alter S, Fritzsche A, Jonas JM (2018) Digital transformation in service management. J Serv Manag Res 2:97
Mayring P (2014) Qualitative content analysis: theoretical foundation, basic procedures and software solution Klagenfurt https://nbn-resolvingorg/urn:nbn:de:0168-ssoar-395173
McDonough EF III, Spital FC (2003) Managing project portfolios. Res Technol Manag 46(3):40
McNally RC, Durmusoglu SS, Calatone RJ, Harmancioglu N (2009) Exploring new product portfolio management decisions: the role of managers' dispositional traits. Ind Mark Manage 38(1):127–143
McNally RC, Durmusoglu SS, Calatone RJ (2013) New product portfolio management decisions: antecedents and consequences. J Prod Innov Manag 30(2):245–261
Meifort A (2015) Innovation portfolio management: a synthesis and research agenda. Creat Innov Manag 25(2):251–269
Menor LJ, Tatikonda MV, Sampson SE (2002) New service development: areas for exploitation and exploration. J Oper Manag 20(2):135–157
Meyer WG (2014) The effect of optimism bias on the decision to terminate failing projects. Project Manag J 45(4):7–20
Mohr R, Pacl H, Hartmann M (2008) Realize hidden value through timely portfolio. Dec Res Technol Manag 51:44–50
Moore GE (1998) Cramming more components onto integrated circuits. Proc IEEE 86(1):82–85
Nguyen NM, Killen CP, Kock A, Gemünden HG (2018) The use of effectuation in projects: the influence of business case control, portfolio monitoring intensity and project innovativeness. Int J Project Manage 36(8):1054–1067
Nippa M, Pidun U, Rubner H (2011) Corporate portfolio management: appraising four decades of academic research. Acad Manag Perspect 25(4):50–66
Nylén D, Holmström J (2015) Digital innovation strategy: a framework for diagnosing and improving digital product and service innovation. Bus Horiz 58(1):57–67
Oliva R, Kallenberg R (2003) Managing the transition from products to services. Int J Serv Ind Manag 14(2):160–172
Ostrom AL, Bitner MJ, Brown SW, Burkhard KA, Goul M, Smith-Daniels V (2010) Moving forward and making a difference: research priorities for the science of service. J Serv Res 13(1):4–36
Padovani M, Carvalho MM (2016) Integrated PPM process: scale development and validation. Int J Project Manag 34(4):627–642

Parry G, Bustinza OF, Vendrell-Herroro F (2012) Servitisation and value coproduction in the UK music industry: an empirical study of consumer attitudes. Int J Prod Econ 135(1):320–332
Patanakul P (2015) Key attributes of effectiveness in managing project portfolio. Int J Project Manag 33(5):1084–1097
Peltoniemi M (2015) Cultural industries: product–market characteristics, management challenges and industry dynamics. Int J Manag Rev 91:41–68
Peppard J (2003) Managing IT as a portfolio of services. Eur Manag J 21(4):467–483
Perks H (2007) Inter-functional integration and industrial new product portfolio decision making: exploring and articulating the linkages. Creat Innov Manag 16(2):152–164
Petro Y, Gardiner P (2015) An investigation of the influence of organizational design on project portfolio success, effectiveness and business efficiency for project-based organizations. Int J Project Manag 33(8):68
Queiroz, M, Moura A, Sauve J, Bartolini C, Hickey M (2009) A model for decision support in business-driven IT service portfolio management using SLA-dependent criteria and under uncertainty. In: Proceedings of the international conference on management of emergent digital ecosystems, pp 274–281
Raisch S, Birkinshaw J (2008) Organizational ambidexterity: antecedents, outcomes, and moderators. J Manag 34(3):375–409
Relich M, Pawlewski P (2017) A fuzzy weighted average approach for selecting portfolio of new product development projects. Neurocomputing 231:19–27
Remane G, Hanelt A, Nickerson RC, Kolbe L (2017) Discovering digital business models in traditional industries. J Bus Strat 38(2):41–51
Rifkin J (2014) The zero marginal cost society: the Internet of Things, the collaborative commons, and the eclipse of captialism. Palgrave Macmillan, London
Röth T, Spieth P, Lange D (2019) Managerial political behavior in innovation portfolio management: a sensegiving and sensebreaking process. J Product Innov Manag 36(5):57
Salomo S, Talke K, Strecker N (2008) Innovation field orientation and its effect on innovativeness and firm performance. J Prod Innov Manag 25:560–576
Sampath S, Gel ES, Fowler JW, Kempf KG (2015) A decision-making framework for project portfolio planning at Intel Corporation. Interfaces 45(5):13
Santiago LP, Soares VMO (2018) Strategic alignment of an R&D portfolio by crafting the set of buckets. IEEE Trans Eng Manag 8:63
Schmidt RL, Freeland J (1992) Recent progress in modeling R&D project-selection process. IEEE Trans Eng Manag 39(2):189–201
Schultz C, Salomo S, Talke K (2013) Measuring new product portfolio innovativeness: how differences in scale width and evaluator perspectives affect its relationship with performance. J Prod Innov Manag 30:93–109
Scopus (2019) Scopus data | curated connected complete scopus. https://www.elseviercom/__data/assets/pdf_file/0017/114533/Scopus_GlobalResearch_Factsheet2019_FINAL_WEBpdf
Shapiro C, Varian H (1998) Information rules: a strategic guide to the network economy. Harvard Business Press, Harvard
Sicotte H, Drouin N, Delerue H (2015) Innovation portfolio management as a subset of dynamic capabilities: measurement and impact on innovative performance. Project Manag J 45(6):29
Skylar A, Kowalkowski C, Tronvoll B, Sörhammer D (2019) Organizing for digital Servitization. A service ecosystem perspective. J Bus Res 5:83
Snyder H, Witell L, Gustafsson A, Fombelle P, Kristensson P (2016) Identifying categories of service innovation: a review and synthesis of the literature. J Bus Res 69(7):2401–2408
Spieth P, Lerch M (2014) Augmenting innovation project portfolio management performance: the mediating effect of management perception and satisfaction. R&D Manag 44(5):498–515
Stauss B, den Hertog P, van der Aa W, de Jong MW (2010) Capabilities for managing service innovation: towards a conceptual framework. J Serv Manag 81:14
Stettina CJ, Hörz J (2015) Agile portfolio management: an empirical perspective on the practice in use. Int J Project Manag 33(1):140–152
Storey C, Hughes M (2013) The relative impact of culture, strategic orientation and capability on new service development performance. Eur J Mark 47(5/6):833–856
Storey C, Kelly D (2001) Measuring the performance of new service development activities. Serv Ind J 21(2):71–90
Storey C, Cankurtaran P, Papastathopoulou P, Hultink EJ (2016) Success factors for service innovation: a meta-analysis. J Prod Innov Manag 33(5):527–548

Szwejczewski M, Mitchell R, Lemke F (2006) A study of R&D portfolio management among UK organisations. Int J Manag Dec Making 7:604–616
Teller J, Kock A (2013) An empirical investigation on how portfolio risk management influences project portfolio success. Int J Project Manag 31(6):817–829
Teller J, Unger BN, Kock A, Gemünden HG (2012) Formalization of project portfolio management: the moderating role of project portfolio complexity. Int J Project Manag 30(5):596–607
Teller J, Kock A, Gemünden HG (2014) Risk management in project portfolios is more than managing project risks: a contingency perspective on risk management. Project Manag J 45(4):20
Tidd J, Thuriaux-Alemán B (2016) Innovation management practices: cross-sectorial adoption, variation, and effectiveness. R&D Manag 46:1024–1043
Toivonen M, Tuominen T (2009) Emergence of innovations in services. Serv Ind J 29(7):887–902
Too EG, Weaver P (2014) The management of project management: a conceptual framework for project governance. Int J Project Manag 32(8):98
Trastour D, Christodoulou A (2009) Towards robust IT service portfolio management. In: International workshop on distributed systems: operations and management, Springer, Berlin, Heidelberg, pp 152–163
Turetken O, Grefen P, Gilsing R, Adali OE (2019) Service-dominant business model design for digital innovation in smart mobility. Bus Inf Syst Eng 61(1):9–29
Unger BN, Gemünden HG, Aubry M (2012) The three roles of a project portfolio management office: their impact on portfolio management execution and success. Int J Project Manag 30:608–620
Unger BN, Rank J, Gemünden HG (2014) Corporate innovation culture and dimensions of project portfolio success: the moderating role of national culture. Project Manag J 45:38–57
Untiedt R, Nippa M, Pidun U (2012) Corporate portfolio analysis tools revisited: assessing causes that may explain their scholarly disdain. Int J Manag Rev 14(3):263–279
Urhahn C, Spieth P (2014) Governing the portfolio management process for product innovation—a quantitative analysis on the relationship between portfolio management governance, portfolio innovativeness, and firm performance. IEEE Trans Eng Manag 61(3):522–533
Vandermerwe S, Rada J (1988) Servitization of business: adding value by adding services. Eur Manag J 6(4):314–324
Vargo SL, Lusch RF (2004) Evolving a new dominant logic for marketing. J Market 68(1):1–17
Vargo SL, Lusch RF (2007) From goos to service(s) divergences and convergences of logics. Ind Mark Manag 37:254–259
Vendrell-Herrero F, Bustinta O, Parry G, Georgantzis N (2017) Servitization, digitization and supply chain interdependency. Ind Market Manag 60:69–81
Vendrell-Herroro F, Gomes E, Collinson S, Parry G, Bustinza O (2018) Selling digital services aboard: how do extrinsic attributes influence foreign consumers' purchase intentions? Int Bus Rev 27(1):173–185
vom Brocke J, Simons A, Niehaves B, Riemer K, Plattfaut R, Cleven A (2019) Reconstructing the giant: on the importance of rigour in documenting the literature search process. ECIS 9:2206–2217
Wang S, Thiele A (2017) A comparison between the robust risk-aware and risk-seeking managers in R&D portfolio management. Comput Manag Sci 14(2):114
Web of Science Group (2019) Web of science core collection. Web of Science Group https://clarivatecom/webofsciencegroup/solutions/web-of-science-core-collection/
Webster J, Watson R (2002) Analyzing the past to prepare the future writing a literature review. MIS Quart 26:93–993
William K, Chatterjee S, Rossi M (2008) Design of emerging digital services. A taxonomy European. J Inf Syst> 17:505–517
Wind Y (1974) Product portfolio: a new approach to the product mix decision. Comb Proc 6:460–464
Wise R, Baumgartner P (1999) Go downstream. Harvard Bus Rev 77(5):133
Wulf J, Mettler T, Brenner W (2017) Using a digital services capability model to assess readiness for the digital consumer. MIS Q Exec 16(3):171–195
Yang Y, Xu D (2017) A methodology for assessing the effect of portfolio management on NPD performance based on Bayesian network scenarios. Expert Syst 34(2):91