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Value-driven IT Project Portfolio Management: Process Model, Evaluation Framework, and Decision Support

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Abstract

Companies must optimize their information technology (IT) project portfolio to achieve goals. However, IT projects often exceed resources and do not create their promised value, for example, because of missing structured processes and evaluation methods. Continuous IT portfolio management is thus of importance and a critical business activity to reach value-driven goals. Guided by Design Science Research with literature reviews and expert interviews, we develop, evaluate, and adjust an IT project portfolio management process model, a holistic IT project evaluation framework, and implement a decision support system prototype. Our results and findings synthesize and extend previous research and expert opinions and guide decision-makers to make more informed and objective IT project portfolio management decisions aligned with optimal value creation. Furthermore, we deduce new research opportunities for IT project portfolio management process models, decision tools, and evaluation frameworks.

Keywords: IT project portfolio management, process model, evaluation framework, decision support system, value contribution, design science research

Introduction and Motivation

Information technology (IT) impacts a company's long-term performance and competitiveness and forms a critical success factor (Bezdrob et al. 2020). Thereby, IT projects are characterized by complexity, cross-functionality, dynamics, non-routine, temporality, and uncertainty. These make IT project portfolio management (ITPPM) a challenging task (Chiang and Nunez 2013; Kester et al. 2011). Selecting the "right" IT projects is essential to create optimal value. Nevertheless, ITPPM is often unstructured and decisions are made ad hoc instead of long-term planning. Thus, many IT projects deviate from their defined objectives, are not completed, or completely fail (Varajão and Trigo 2016). According to the Project Management Institute (PMI 2017a), roughly $97 million US Dollars per $ 1 billion investments in IT projects are wasted. Similarly, Lee et al. (2021) refer that on average 66% of implemented IT projects are more expensive and 33% require longer as planned. Failed IT projects due to weak ITPPM processes lead to resource losses and exceedances (e.g., Hershey: $150 in lost sales, 19% drop in earnings), project abandonment (e.g., Dell: $200 million), or bankruptcies (e.g., FoxMeyer) (Fadlalla and Amani 2015; Hughes et al. 2017). Thus, companies need adequate and resilient methods for the critical business activity of ITPPM. Considering existing interdependencies and constraints, these methods ensure that selected IT projects fit the company's strategy and create value (Chiang and Nunez 2013; Kester et al. 2011). If departments and functions are aligned to strategy, IT projects are more likely to be completed successfully

(PMI 2017a). Additionally, uniform IT guidelines stabilize the performance of IT projects (Martin 2006). However, many decisions are motivated by subjectivity, personal experiences and perceptions. Often uniform ITPPM methods, evaluation and selection criteria, and their consistent usage are missing (Varajão and Trigo 2016). An ITPPM tool can further support decision-makers (DM) to ensure efficient, transparent, and consistent decisions more rapidly (Caniëls and Bakens 2012; Killen et al. 2020).

Even though ITPPM is considered to be a structured process, besides best practices for PPM (e.g., PMI 2017b) only few ITPPM process models exist in literature which are rather perfunctory. Mostly, existing models encompass three (Ajjan et al. 2016) to five main phases (Archer and Ghasemzadeh 1999). Typically, they include activities such as the definition of baseline conditions (Alaeddini and Mir-Amini 2020), IT project identification (Montgomery 2007), evaluation (Chiang and Nunez 2013), selection (Ajjan et al. 2016), and monitoring with adaptions (Miller 2002). Other than that, existing models vary in their phases and activities. Moreover, the procedure is mostly sequential with no or few re-cycles between and within phases. To address this and better meet IT project characteristics, we propose an integrated ITPPM process model that allows an objective and value-driven ITPPM. To do this, we synthesize existing process models and expand them with expert interviews. It comprises activities from different models combined within an integrated one. Unlike many existing models, it also allows re-cycles between and within individual phases and allows to address peculiarities of IT projects. It enables, e.g., a flexible reaction to changes and uncertainties and a discussion between stakeholders. In addition, IT project evaluation, prioritization, and selection are critical activities (Varajão and Trigo 2016). Several methods have been researched on this topic ranging from rather simple financial project selections (Rosacker and Olson 2009), and balance scorecard approaches (Asosheh et al. 2010), to more advanced optimization models (Cho and Shaw 2013) and fuzzy programming (Heidary et al. 2020), among others (Mohagheghi et al. 2019). In rather simple methods, IT project decisions are often based only on the evaluations. In more advanced methods, several constraints are considered, however, the project evaluation is often already available and not described in more detail (Archer and Ghasemzadeh 1999). We combine both approaches and develop a holistic scoring framework that enables a quantification of subjective estimations and thus an objective evaluation of IT projects of different types and sizes. The scoring results then serve as an input for our decision support system (DSS) prototype. It allows to select from a large number of IT project proposals those that maximize the value proposition, considering interdependencies and limitations. In doing so, we mitigate disadvantages resulting from the sole use of scoring approaches (Mohagheghi et al. 2019) and decisions are not made on an individual project level but consider other factors such as resource constraints and dependencies. Our main contributions are our three artifacts, an integrated ITPPM process model, a holistic scoring framework, and our DSS prototype. These Level 1 and Level 2 artifacts (Gregor and Hevner 2013) support ITPPM and enhance and contribute to the knowledge base. We provide knowledge to increase transparency and objectivity to make more informed IT portfolio decisions and thus decrease IT project failure rates, minimize subject manipulations, increase value creation, and goal achievement. We follow a Design Science Research (DSR) process (Hevner et al. 2004) to address the following research questions (RQ):

RQ 1: What activities constitute a value-driven ITPPM process?
RQ 2: How can IT projects (and proposals) be uniformly evaluated to generate a value-driven IT portfolio?
RQ 3: How can a DSS support IT project selection and scheduling?

First, we describe the theoretical background of ITPPM. Then, we motivate our DSR-oriented research design. Afterwards, we present our results and findings of our literature reviews and expert interviews, including an ITPPM process model and a scoring framework. Then, we introduce our DSS prototype and provide an applicability check. Finally, we discuss our results and findings, their implications, deduce recommendations for theory and practice and a research agenda, present limitations, and conclusions.

IT Project Portfolio Management

An IT project portfolio consists of various IT projects carried out under a company's management. Its goal is to create value while all IT projects share and compete for the same scarce resources (Archer and Ghasemzadeh 1999; Linhart et al. 2020; PMI 2017b). Aligning with previous studies, we define ITPPM as a continuous and dynamic process to identify IT projects and proposals and to (re-)score, (re-)prioritize, (re-)select, and (re-)schedule them, taking into account interdependencies, limitations, and stakeholder interests to optimize value creation and fit to company goals (e.g., Kester et al. 2011). Uncertainties, unknowns, changing information, dynamic opportunities, and multiple goals are core elements of the

ITPPM process. Considering all these aspects, ITPPM is challenging (Mohagheghi et al. 2019). At the same time, IT is marked by a duality. In addition to expenditures on IT projects, a large proportion is also spent on IT-related routine processes. As a result, IT project decisions have far-reaching consequences (Bezdrob et al. 2020). Controlling the whole portfolio, ITPPM improves objective achievement, minimizes uncertainties, and realizes benefits (Daniel et al. 2014). Not integrated and overlapping IT projects, neglecting resource availabilities, unclear roles and responsibilities, missing feedback, and projects that are not stopped despite deviations are major problems in ITPPM (Too and Weaver 2014; Trigo and Varajão 2020). Due to the increased competitive pressure and influence on success, it is crucial to know the individual activities along an ITPPM process and establish them within a company (Ajjan et al. 2016). An integrated process model can address these activities and structure ITPPM to increase portfolio success (Martin 2006). Literature and practice have already introduced some portfolio process models. Ajjan et al. (2016) proposed a sequential model with pre-implementation structures, an implementation process, and post-implementation outcomes. Chiang and Nunez (2013) structure their sequential ITPPM process model along three swim lanes corresponding to involved stakeholders. It involves 10 activities that can be summarized into four superior steps: identification, evaluation, selection, and monitoring. Montgomery's (2007) process model includes an overarching enterprise strategic planning process and four other phases: pre-select, select, control, and evaluate. Archer and Ghasemzadeh (1999) created a framework for portfolio selection that includes the five main phases of pre-screening, single project analysis, screening, optimal portfolio selection, and portfolio adjustments, with additional activities before, during, and after these phases. In existing process models, IT project evaluation and selection activities are usually addressed while other activities differ and re-cycles are often not possible. Thus, we build on the existing models, expand them, and synthesize different phases into a comprehensive and integrated ITPPM process model.

The evaluation and selection of IT projects and proposals are connected with challenges, as it is necessary to consider both quantitative and qualitative parameters (Archer and Ghasemzadeh 1999; Asosheh et al. 2010). Companies and researchers have developed various methods, tools, and models for a common approach. They all try to reflect the reality of ITPPM while reducing complexity and handling manifold and potentially conflicting interests and goals. Those methods range from financial to non-financial solutions (Mohagheghi et al. 2019). Decisions are often based on a project level in traditional evaluation and selection methods. These include, e.g., cost/benefit analyses, scoring models with multiple criteria, or basic optimization models (Chiang and Nunez 2013). However, existing interdependencies and synergies between IT projects are neglected here. Decisions based on these methods mostly do not lead to optimal results. Rather, they are widely used because of their simple application (Chiang and Nunez 2013; Cho and Shaw 2013). In recent literature, more advanced optimization models emphasize integer linear programming, multi-criteria selection, fuzzy programming, and mixed-integer linear programming, among others. Mohagheghi et al. (2019) give an overview of different studies that introduced or applied these methods and approaches. We build on existing methods and models and combine qualitative and quantitative evaluation criteria within one scoring framework. It then serves as an input for a mathematical optimization model and DSS. Thus portfolio decisions are not made solely at the individual IT project level based on IT project evaluations but also take into account interdependencies and constraints.

There are many commercial tools to support ITPPM, however often not accessible without charges. They encompass general programs to specific ITPPM solutions, which differ in their functionalities and target groups. Functionalities include, e.g., capacity planning, portfolio monitoring, risk management, reporting, IT project evaluation, and prioritization. The latter is done, for example, with Gantt charts, Kanban boards, company-specific criteria, or top-down planning (e.g., Planview 2022; KeyedIn 2022). Caniëls and Bakens (2012) showed that using a project management information system (IS) enhances decision quality, reduces times for decisions, and improves resource allocations and monitoring. According to Killen et al. (2020), visualizations enhance decision-making and the portfolio outcome. Due to the limited access, we developed a DSS that optimizes IT portfolio value creation and illustrates it in a Gantt chart (Trigo and Varajão 2020). We thus increase ITPPM objectivity, decision quality, and reliability (Chiang and Nunez 2013).

Research Design and Methods

To address our research questions, we developed an integrated ITPPM process model, a holistic evaluation framework, and a DSS prototype. Therefore, we conducted a DSR-oriented research design following Hevner et al. (2004) and Hevner (2007). DSR is a problem-solving paradigm that aims to enrich human knowledge by creating artifacts and generating design knowledge through innovative solutions for real-world problems (Drechsler and Hevner 2018; Hevner 2007; vom Brocke et al. 2020). Therefore, DSR often relies on parts of already existing (design) knowledge and solutions and combines, extends, or revises them. According to Hevner (2007), DSR consists of three closely connected activity cycles: the rigor- (scientific knowledge base), relevance- (environmental perspective), and design cycle (building and evaluating artifacts). We decided to apply DSR to solve practical problems that researchers and practitioners experience in ITPPM, building on existing knowledge and extend it. Aligning with Gregor and Jones (2007), we contribute to the existing body of knowledge and provide relevant solutions for the predominant problem settings (cf. Sections 1 and 2) through systematical development and evaluation of new artifacts and further derive generalized implications for IS research. Accordingly, we applied various research steps in the rigor-, relevance-, and design cycles, see Figure 1. In the first step, we identified the research problem and opportunity already outlined in Sections 1 and 2. Following the problem specification, we performed a systematic literature review to identify existing process models for ITPPM. Further, we conducted 24 expert interviews to get an overview and practical insights into this topic. We derived an ITPPM process model based on the gained insights, evaluated it with further seven experts, and revised it. During the process, we noted that the phases of IT project (re-)evaluation and selection/prioritization are essential for an IT portfolio's success and analyzed these further in the next iterations. Therefore, we performed another literature review and conducted 14 expert interviews. Based hereon, we quantified relevant IT project evaluation categories, derived a holistic scoring framework for IT projects (proposals), evaluated our artifact, and revised it. We further used the inputs and gained knowledge from scientific literature and expert interviews to continually develop an IT project portfolio DSS prototype to support and automatize ITPPM. Once developed, we evaluated our scoring framework and DSS prototype with an applicability check. As outlined by Arnott and Pervan (2012), many existing DSR research has not applied an evaluation of their artifact. Thus, we improve conventional DSR processes and strengthen our artifacts' worth, effectiveness, and usefulness with our evaluation iterations.

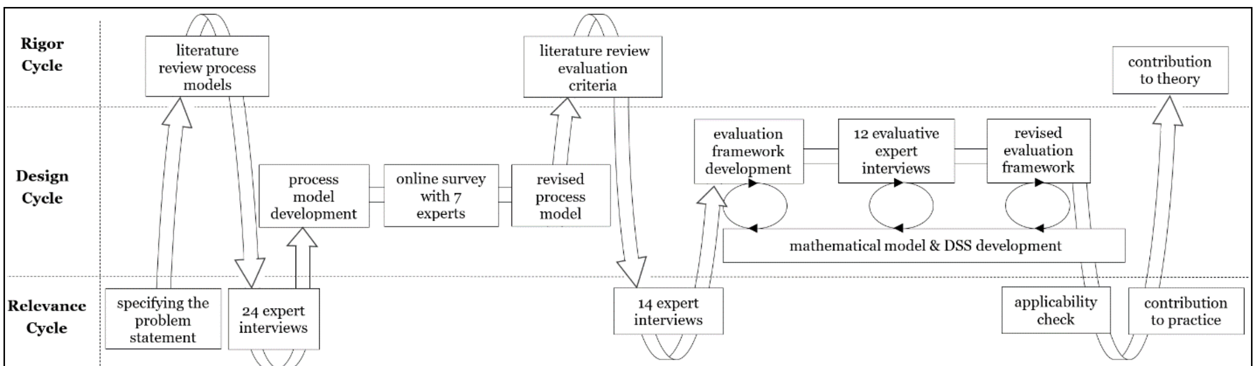

Figure 1. Research Design with Iterations

Results and Findings

Cyclic Process Model

Gathering Knowledge from Scientific Literature and Experts

To identify existing ITPPM process models, we considered the knowledge base and performed a literature review, and the environmental perspective by performing 24 expert interviews. For the literature review, we followed the guidelines proposed by vom Brocke et al. (2009, 2015), Webster and Watson (2002), and Watson and Webster (2020). We searched in six databases (AISeL, Science Direct, ACM, IEEE, Web of Science, Springer Link), the International Journal of Project Management, and Project Management Journal using a keyword search string (("IT project selection" OR "IT project evaluation" OR "IT portfolio selection" OR "IT portfolio evaluation" OR "IT portfolio management") AND ("framework" OR "process model" OR "procedure model" OR "cycle")) and identified 989 relevant publications. We considered peer-reviewed, full-text, and completed research articles in German or English and excluded duplicates, with 328 articles remaining. For them, we reviewed keywords, abstracts, and titles and excluded 236 articles.

We independently analyzed the remaining papers and excluded the ones without a focus on process models and mathematical articles only. We performed a backward-, forward-, author-, and similarity search for the remaining ones. Finally, we identified 24 relevant publications and independently analyzed them regarding their process activities, and compared and discussed our results until final agreement, see Table 1.

In a next step, we performed expert interviews to embed practical knowledge. We contacted potential participants relying on projectmanagement.com and our practice and academic network. Potential participants were specialized in ITP(P)M, consultants within this domain, have in-depth expertise on ITP(P)M processes, and ideally long working experiences. We recruited interviewees from various positions, industries, and company sizes to get a diverse view and ensure our results' reliability, validity, and generalizability. An overview of the final interviewees' profiles is provided in online Appendix 1. For the interviews, we created a guideline with open-ended questions and conducted a pretest with professors and research assistants to validate its comprehensibility and suitability. As all rated it as comprehensible and suitable, no changes were necessary. During the interviews, we discussed ITPPM processes, used approaches, and best practices. After 24 interviews, we reached saturation (Corbin and Strauss 2014). Depending on the expert's location, the first author conducted the interviews in person (n=4) or by telephone (n=20) and they varied in their length from 32 to 85 minutes. All interviews were performed in German or English, recorded, transcribed, and analyzed qualitatively according to Corbin and Strauss (2014), supported by the software MAXQDA 2020. Therefore, both authors independently coded the transcripts deductively following the identified categories from literature and then inductively analyzed the transcripts again to iteratively identify new activities not mentioned in literature (Wiesche et al. 2007). Once finished, both authors compared their results, discussed them, made adaptions until agreement, and clustered all activities into eight phases. Table 1 shows identified ITPPM activities and compares them with selected process models from literature and best practices. Further, it displays how often identified activities were named in all identified literature and expert interviews.

Phase (P)	Activity \ Authors	Ajjan et al. (2016)	Alaeddini and Mir-Amini (2020)	Archer and Ghasemzadeh (1999)	Chiang and Nunez (2013)	Ghannadpour et al. (2021)	Miller (2002)	Montgomery (2007)	PMI (2017b)	British Standards Institution (2015)	Number of experts	Number of literature
P1	Define roles, tasks, and responsibilities	x	x		x				x		-	10
	Determine resource availabilities	x		x*			x		x	x	2	9
	Decide on evaluation & selection method	x	x	x*			x		x	x	2	11
	Determine evaluation (sub) categories		x	x*			x	x	x	x	3	14
	Determine the criteria's importance		x		x		x				4	6
	Define thresholds			x*					x		1	2
	Establish ITPPM policy	x		x*							7	9
P2	Identify IT project proposals	x	x	x*	x	x	x	x	x	x	10	10
	Define mandatory projects	x		x							2	3
P3	Check the IT project's eligibility			x					x		1	3
	IT project (re-)evaluation	x	x	x	x	x		x	x	x	6	20
	Discussion of the results	x						x			8	3
	Top management involvement	x			x			x			1	3
	Final evaluation							x			-	2
P4	Define interdependencies			x	x		x		x	x	4	8
	DSS usage / optimization model			x							2	6
	Optimal IT portfolio			x	x						-	4
	Scenario & sensitivity analysis		x	x	x		x		x		2	3
P5	Discussion of the "optimal" results	x	x		x				x		8	4
	Prioritization/selection	x		x	x	x		x	x	x	3	18
	Authorizing	x			x			x		x	1	5
	Portfolio adjustments	x		x				x	x	x	-	5
	Final IT portfolio composition	x	x	x							1	5
P7	Periodically review of IT portfolio	x			x	x		x	x	x	5	5
	Measures in case of deviation	x			x	x	x	x	x	x	5	5
P8	Performance measurement			x*				x	x	x	4	4
	Knowledge generation	x		x*				x		x	3	3
	Lessons learned	x						x			6	10

* Pre/post activates; not included in main ITPPM phases

Table 1. Literature Overview of Activities within an ITPPM Process

We propose a cyclic ITPPM process model consisting of eight phases and 28 activities (cf. Table 1) based on the existing body of knowledge and findings from our expert interviews.

Phase 1 - Initialize/continue/adapt ITPPM processes and policies: The first phase is very general and defines baseline conditions for the upcoming phases. The senior management, board of management, and the chief executive officer are particularly involved in this process, as (strategic) decisions are made for the subsequent phases (Expert2 (Exp2); Exp9; Exp16). Decisions in this phase are usually long-term and will be applied to future IT portfolio decisions, unless top management (TM) and DM identify alternatives that are better suited to achieve company objectives or react to uncertainties and changes (Archer and Ghasemzadeh 1999). One task during this phase is to define the planning horizon, roles, tasks, and responsibilities of employees (Alaeddini and Mir-Amini 2020; Gadatsch 2009). This includes, for example, responsibilities for submitting IT project proposals, the (re-)evaluation of IT projects, and final decisions for the IT portfolio (Heidary et al. 2020). In addition, the resource availabilities for the IT project portfolio in the macro planning period must be defined (Dewi 2019; Exp4). This encompasses the availability of human resources, especially bottleneck employees, financial, and infrastructure resources (De Reyck et al. 2005). They restrict later decisions and prevent resource overloads. Another task within this phase is to determine the IT project evaluation and selection method (Kornfeld and Kara 2011; Exp16). Examples include, i.e., portfolio matrices, scoring models, Analytic Hierarchy Procedure, and optimization models (Archer and Ghasemzadeh 1999; Mohagheghi et al. 2019). Once the evaluation method has been defined, (sub)criteria, concrete values, and their importance must be set to enable an IT project evaluation with respect to the company strategy and consider the IT maturity (Heidary et al. 2020; Exp11; Exp16). Also, minimum requirements are defined that an IT project at least must have before it is evaluated in more detail (Exp14; Archer and Ghasemzadeh 1999). Once the ITPPM processes and policies are defined, they must be communicated and established throughout the company (Dewi 2019; Gadatsch 2009). If all involved employees are familiar with them and understand their purpose and goal, the IT portfolio process is more transparent and it supports to reduce misinterpretation, subjectivity, and rejection (Kornfeld and Kara 2011). Especially TM involvement improve the ITPPM policy adaption and ultimately an IT portfolio's success (Alaeddini and Mir-Amini 2020).

Phase 2 - Collect IT project (proposals): In this phase, IT project ideas are systematically collected, mainly by the departments (Chiang and Nunez 2013; Exp10). This is preliminarily done with pre-studies, project profiles, or business cases (Exp2; Exp14). Then, the requirements and scope of each IT project (proposal) are defined, risks named, planned duration set, and responsibilities and roles defined (Exp10; Exp19). In addition, "must" projects need to be identified. These will be part of the IT portfolio regardless of their goal contribution or resource requirements. They result, e.g., from national and international regulatory requirements (Archer and Ghasemzadeh 1999; Exp2; Exp14). At the end of this phase, all IT project proposals and their relevant information are systematically collected.

Phase 3 - Request (re-)evaluations from responsibles and check them: This phase starts with an evaluation of identified IT project proposals and a re-evaluation of already ongoing ones applying the defined method and (sub)criteria (P1) (Ajjan et al. 2016; Exp8; Exp11). Before the IT projects are evaluated in more detail, they must meet the minimum requirements (Archer and Ghasemzadeh 1999; Exp14). In first evaluation iterations, mostly the business units, the IT project manager, and the project management office (PMO) are involved (Exp8; Exp16). The further procedure then depends on the size and importance. As the scope and importance of an IT project increase, the employees' number and importance also increase (Exp22). Exp1 and Exp23 note that evaluations are often done independently by multiple responsible for many IT projects. "[...] it helps to diversify the bias if you bring other people's perspectives in [...]" (Exp23). After the first iteration, the evaluation is already final for smaller and less important IT projects. For the remaining ones the evaluation results are further discussed (Gadatsch 2009; Exp19; Exp24). "Being able to kind of blindly score it, so that you're not influencing each other. But when it comes to the gather at the end, you have a way of kind of reviewing the scoring and come to consensus on what that means" (Exp23). This activity usually involves IT project managers, department heads, and the PMO (Exp10; Exp24). In case of disagreement or ambiguity, the employees responsible for the initial evaluation have to justify and defend their different evaluations (Exp13). Depending on the results, a re-cycle into the previous (re-)evaluation activity is necessary to adjust the initial evaluation results (Exp23). These iterations end when a consensus is reached among those responsible for evaluation. This can either be a commonly accepted value or a range of values (Exp1). For medium-sized and important IT projects, this evaluation is then final. The evaluation results are presented to the TM for large IT projects that are particularly important (Exp2; Exp16). They can then ask further questions and change the evaluations (Exp18). In the end, all IT projects (proposals) are (re-)evaluated and their evaluations are authorized.

Phase 4 - Build an "optimal" IT project portfolio: Based on the final and approved evaluations of the third phase, all information that serves as a basis for decision-making for an IT portfolio composition is complete. Phase 4 is a multi-step process to create the "optimal" IT portfolio. A first compilation can be based on mathematical optimization models and decision support tools (Ajjan et al. 2016; Kornfeld and Kara 2011; Exp11). A DSS thereby facilitates the evaluation and selection process, reduces the amount of information, and enables to focus on the relevant ones (Archer and Ghasemzadeh 1999). Before that, as a first step, the interdependencies among the IT project (proposals) need to be identified (Belarbi 2016; Exp1; Exp16). However, Exp11 adds that it is difficult to identify them all. Those between large IT projects are mostly identified and often overlooked on smaller ones. Therefore, PMO or portfolio boards that overview the IT projects (proposals) must be involved in this process. Afterwards, all IT project-specific data must be entered or uploaded into a DSS. This includes, e.g., interdependencies, resource requirements and availabilities, and evaluation results (Archer and Ghasemzadeh 1999). The "optimal" IT portfolio composition is determined based on, e.g., a mathematical optimization model or expert rules while respecting all existing restrictions. According to Exp11 and Exp14, it is also possible to determine several scenarios, e.g., best-, worst-, and normal cases, and perform sensitivity analyses. At the end of Phase 4, all interdependencies are identified and proposals for an "optimal" IT portfolio composition are made.

Phase 5 - IT project selection and scheduling: The results from the fourth phase form a basis for discussion and decision-making on which IT projects to include in an IT portfolio (Ajjan et al. 2016; Exp14). TM, PMO, head of departments, and the portfolio board are usually involved in this process (Exp5; Exp18). Exp14 and Exp17 emphasize that the results from the DSS of Phase 4 are only intended to support decision-making. "Whether an IT project is implemented in the end is then left to the decision-maker, which then probably discusses the DSS' results" (Exp17). Ultimately, all final decisions are always made by a team of DM (Exp16). Based on the DSS output and the discussions between the DM, IT projects are prioritized for an IT portfolio composition, selected, and planned for a defined planning horizon (Chiang and Nunez 2013; De Reyck et al. 2005). Again, this must be approved and authorized by the TM (Montgomery 2007; Exp9; Exp12). Portfolio adjustments are necessary if the TM requests adaptions. If many changes occur, a re-cycling into previous phases is necessary (Archer and Ghasemzadeh 1999). After possibly several iterations within this Phase 5, an IT project portfolio with its IT projects and their scheduling is defined.

Phase 6 - IT project management and operation: In this phase, the management of the selected IT projects occurs. Most recently, Iriarte and Bayona (2020) and Trigo and Varajão (2020) identified updated critical success factors for IT project management. In addition, Wiener et al. (2016) propose a framework to support IT project control. In literature, there are many different activities associated with this phase. Most of them include five ones: project initiation, project planning, project execution, project monitoring and controlling, and project closure (PMI 2017b). There is already a lot of research and best practices for the IT project management and operation phase. Therefore, the analysis of the single activities is out of our scope and we have not considered them further.

Phase 7 - Continue/end/freeze/hold IT projects: After starting the implementation of the selected IT projects, a review of the IT portfolio is carried out periodically (Beringer et al. 2012; Exp1; Exp18). This enables adjustments during the planning periods (Exp18). The project team members and the project manager must present the current IT project status (Exp12). This is compared with the planned evaluations of Phase 3 and, if necessary, adjustments are possible (Montgomery 2007; Exp16). "Does this project, even though we've started it, does it continue to make sense to move down that path, or do we pick something else because it's no longer returning the value we thought it would?" (Exp23). If necessary, the DM and TM can temporarily freeze, change priority, hold, or even terminate IT projects (Exp12). Otherwise, all IT projects continue as planned in Phase 5.

Phase 8 - Knowledge sharing and lessons learned: This phase occurs after an IT portfolio's completion. Exp15 emphasizes that IT project completion meetings are used less to point out occurred errors and more to report on successes. However, a completion meeting must also allow constructive criticism and not make individual employees responsible for problems. This way, problems and their causes can be identified and measures derived to avoid them in the future (Belarbi 2016; Kornfeld and Kara 2011; Exp4). Exp4 and Exp14 also agree that problems do not necessarily have to result from the IT projects themselves but are often a consequence of a lack of TM support, unrealistic timelines, or intermediate tasks that consume the

IT project employees' time resources. In addition, after an IT portfolio has been completed, an evaluation of it must occur in which the target and current status are observed about the evaluation carried out in Phase 3 (Gadatsch 2009; Montgomery 2007; Exp13). The same is possible for individual IT projects' planned and actual prioritization to identify re-prioritization carried out during the planning period (Exp14). The IT project data generated by the uniform ITPPM approach can also be aggregated in an IT project database (Too and Weaver 2014). After several IT portfolios have been carried out, weak points of the individual processes can be identified, measures against them be initiated, and future processes be optimized (Ajjan et al. 2016; Exp3). Exp13 adds that this can identify categories, especially in IT project (re-)evaluation, that are regularly over- or under-evaluated. "A uniform approach to project identification, evaluation, and selection allows experience to be gained in these processes" (Exp4) and to implement a knowledge management. After an IT portfolio's planning horizon ends and all phases are completed, a new ITPPM cycle starts. Phase 1 thereby only needs to be reviewed and updated in case of changes and not with every new IT portfolio.

Evaluated and Adjusted Cyclic Process Model

We evaluated our ITPPM process model with online surveys. We relied on five experts from the initial pool (Exp2; Exp5; Exp11; Exp21; Exp23) and included two new ones (Exp25; Exp26) to determine whether our results are saturated, i.e., new experts bring only limited new ideas. Our primary goal was to evaluate our artifact's practical applicability and completeness with the target stakeholders (Sonnenberg and vom Brocke 2012). Following Hevner et al. (2004) and Sonnenberg and vom Brocke (2012), we evaluated the process model's comprehensibility, relevancy, usability, completeness, functionality, fit with the company, and added value. The online questionnaire thus consisted of questions to cover these assessment criteria. Following Corbin and Strauss (2014), both authors independently analyzed the answers deductively according to the assessment criteria and then compared, discussed, and adopted their results until agreement. We followed the evaluation strategy for design science research proposed by Venable et al. (2016) and adjusted our ITPPM process model relying on the experts' feedback. Figure 2 shows the adapted model with all phases and activities. The experts confirmed that all individual phases and activities are understandable and relevant. Most experts agreed that no activities should be added, deleted, or combined, with some exceptions. We included technology & business roadmaps (P1) and change management (P7) as additional inputs. Regarding the adaptability to a company, the experts were dissenting opinions. Some thought it is adaptable, while others suggested it is more applicable to larger companies and IT projects.

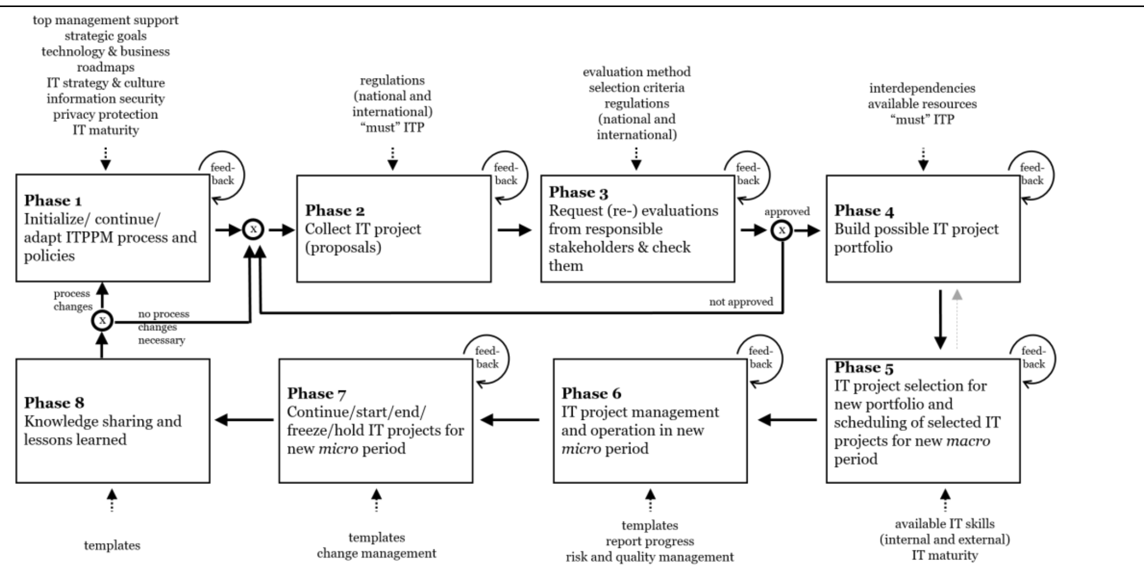

Figure 2. Cyclic ITPPM Process Model

Our findings from literature and expert interviews (cf. Table 1) show that the activities of IT project (re-)evaluation (P3) and prioritization/selection (P5) were often mentioned. Different stakeholders with different interests are involved in this process and try to manipulate it to their individual benefit (Beringer et al. 2013). It requires consistent and transparent methods relevant to all stakeholders for these activities. Therefore, and to answer our RQ2 and RQ3, we analyzed how IT projects (proposals) can be evaluated uniformly and how a DSS can be designed to provide a basis for selection decisions in the next sections.

Scoring Framework for IT Projects

Gathering Knowledge from Scientific Literature and Experts

We performed another literature review to identify commonly used IT project evaluation criteria. For this we have proceeded as with the first literature review. We identified articles by an explorative database search of German and English literature in peer-reviewed academic journals (AIS Scholar Basket, Journal of Project Management, International Journal of Project Management) and used keyword combinations of IT, project portfolio management, selection criteria, in combination with scoring, and tool-based. We reviewed abstracts and titles for the search results and applied inclusion and exclusion criteria. For the key articles, we then performed a backward-, forward-, author-, and similarity search to identify additional scientific articles. For the final sample, we independently developed a concept matrix (Webster and Watson 2002) analyzing named and described IT project evaluation criteria and discussed it. Based hereon, we clustered similar criteria in seven evaluation categories with 22 sub-categories, see online Appendix 2.

After considering the knowledge base, we identified further IT project evaluation categories used in practice based on expert interviews. We relied on experts from the first interviews (Exp1, 4, 6-8, 10-12, 15, 16, 18-20, 22) and followed the same procedure and methods. The topics included questions about an evaluation's responsibility, used evaluation categories, interdependencies, and ITPPM tools. After 14 performed expert interviews, we reached saturation. Depending on the expert's location, the first author performed the interviews in person (n=4) or by telephone (n=10), transcribed them, and they varied in their length from 37 to 72 minutes. Then, both authors independently analyzed all transcripts, first deductively based on the identified (sub)categories from literature and then inductively using open coding (Corbin and Strauss 2014; Wiesche et al. 2017) to iteratively expand the (sub)categories with MAXQDA 2020 support. Then, we compared and discussed the results and made adoptions until agreement. Again, we used a concept matrix (Webster and Watson 2002) to structure our results (see online Appendix 3).

Finally, we consolidated eight categories with several sub-categories based on our literature review and expert interviews: **Complexity** describes the associated changes inherent with an IT project implementation (Sweetman and Conboy 2019). Besides the General sub-category (e.g., Cho and Shaw 2013), it encompasses the number of business departments involved in an IT project's implementation. With increasing numbers, the degree of complexity of an IT project's execution rises (e.g., Sweetman and Conboy 2019). We identify the occurring number of changes along with an IT project's implementation as a further sub-category as employees are only capable of a limited number of changes in their daily work (e.g., Chiang and Nunez 2013). "An organization should not overstretch itself and run too many projects at the same time. [...] Too many changes at the same time can cause reactions that are no longer manageable" (Exp19). **Efficiency** refers to an IT project's economic efficiency, meaning its cost relative to its benefits (e.g., Cho and Shaw 2013). Besides, literature here addresses the impact of an IT project's selection on growth rates, and economic returns (e.g., Chiang and Nunez 2013). Except for the cost/benefit analysis, the experts' opinions differ in the sub-categories to be evaluated. Some only consider a possible cost reduction associated with an IT project implementation (Exp6; Exp12). One expert expands this additionally with maintenance requirements (Exp1). Other experts rather focus on the benefit for internal and external customers or growth related to an improved market position or business diversification (Exp8; Exp16). **Interdependencies** encompass the relationship between two or more IT projects (e.g., Ahmadi-Javid et al. 2020). In addition to the General sub-category (e.g., Sweetman and Conboy 2019; Exp15; Exp19), literature mentions different interdependencies. IT projects and proposals can be mutually exclusive or time-dependent (e.g., Chiang and Nunez 2013). The latter occurs when successor IT projects are dependent on their predecessors. They can only start once their predecessors are completed (e.g., Kock and Gemünden 2019). There is no uniform agreement among the experts on identifying, analyzing, and evaluating these. Some use structured methods like strategy roadmaps (Exp12; Exp15) or consider them in their business roadmap to prevent the execution of redundant IT projects (Exp8; Exp16). Others consider interdependencies not in a structured way (Exp6). They rely on portfolio managers who know them and consider them when prioritizing IT projects (Exp7). Identifying and considering dependencies can reduce the portfolio's complexity and make it more easily manageable (Exp18; Exp19). **Resource limitations** refer to the limited availability of different resources (Chiang and Nunez 2013). Literature mainly considers and assesses financial and human resources (e.g., Chen et al. 2020; Chiang and Nunez 2013). The experts often mention the availability of human resources (Exp4; Exp19). The necessary internal and external resources for an IT project execution are often evaluated based on their resources and time efforts (Exp7; Exp22). In many IT projects, employees with special skills, qualifications, and knowledge are required for implementation (Exp8; Exp19).

Risk encompasses the evaluation of negative and positive uncertainties along with an IT project's execution (e.g., Ahmadi-Javid et al. 2020; Exp4). However, it is often addressed without a specification of actions and measures. Literature agrees to avoid too many hazardous IT projects to balance the overall risk within an IT portfolio. Used sub-categories are the available experience of an IT project's leader (e.g., Chen et al. 2020) and potential occurring risks and their consequences of a non-performance (e.g., Chiang and Nunez 2013; Exp6). This category also considers IT project synergies. IT projects can positively or negatively impact the implementation or value of other IT projects (e.g., Cho and Shaw 2013; Exp19). **Strategy** defines an IT project's contribution to the company's strategy, i.e., the long-term vision to achieve objectives and competitive advantages (Asosheh et al. 2010). For one expert, this category is one of the most important (Exp11). Commonly used sub-categories involve an IT project's impact on a company's competitive advantage, market share increase (e.g., Irani and Love 2002), contribution to strategic goals (e.g., Sweetman and Conboy 2019), and customer benefit or loyalty increase (Exp16). However, the experts also indicate difficulties in quantifying strategic contributions. The effects of IT projects are often only immediately apparent and only provide a basis for further projects that then address the strategic objectives (e.g., Exp15). **Urgency** refers to the consequences of an IT project's or proposal's rejection (Rosacker and Olsen 2008). Regulatory requirements and the need for renewal need to be considered (Exp1). This includes the evaluation of expected consequences of non-compliance with regulatory requirements, the need to modernize, replace, or supplement existing systems towards their end of lifecycle, and the IT project's support to keep the daily business running (Rosacker and Olsen 2008; Exp1; Exp12). Additionally, one expert indicates that various IT projects are driven by, e.g., expiring maintenance contracts, new security or network requirements (Exp4). In some companies, such IT projects often represent a significant part of a portfolio (Exp4; Exp6) and are partly regarded as mandatory due to their importance (Exp15; Exp18). **Company politics** defines subjective decisions by executives instead of objective criteria (Chiang and Nunez 2013). Some experts indicate that specific IT projects are chosen based on political influences rather than objective categories (Exp4). Thus, some IT projects are executed and resources assigned due to having a high position within a company.

Evaluated and Adjusted Scoring Framework for IT Projects

We merged the identified categories into one holistic scoring framework that allows a uniform and value-adding IT project (re-)evaluation (P3). It defines a sub-criterion's specifications to get a certain score using a verbal scale. We decided to exclude resource limitations and politics even though they were mentioned in literature and by experts. In the case of political IT project decisions, selections are made irrespective of their value creation. Resource constraints are critical to consider to prevent resource overload. So we claim that both categories do not directly influence an IT project's (proposal's) value creation and thus consider them in additional constraints in our DSS prototype. We further merged the interdependency category into the complexity category. Only the number of interdependencies is considered. Specific ones are further classified within the DSS. A first version of the scoring framework is available in online Appendix 4. All IT projects and proposals P are individually scored according to each sub-criterion using an integer one to five scale. This allows to quantify qualitative and quantitative criteria within one quantitative score. Parameter v_{isc} denotes the results of the scoring value of IT project i in the sub-criterion s of the evaluation criterion c. An overall score can thus be determined using Equation (Eq) 1 and Eq2 for each IT project (proposal).

$$a_i = \sum_{c \in C} \left(w_c \frac{\sum_{s \in N_c} v_{isc}}{\sum_{s \in N_c} 1} \right) \quad \forall\, i \in P \quad \text{(Eq1)} \qquad \text{subject to} \qquad \sum_{c \in C} w_c = 1 \quad \text{(Eq2)}$$

Eq1 defines an IT project's (proposal's) individual score. Thereby, the factor w_c denotes the individual weighting of criterion c, i.e., its relative importance. The second factor in Eq1 determines the average score of an IT project (proposal) for a criterion. It is calculated by an IT project's sum of scores for all sub-criteria s of criterion c divided by the number of sub-criteria s of this criterion c. N_c denotes the set of sub-criteria of evaluation criterion c. Then the average score of criterion c is multiplied by the first factor, the criterion's individual weight w_c. The individual IT project (proposal) score a_i of an IT project (proposal) i is then calculated summing up all weighted scores of all criteria. The auxiliary condition in Eq2 normalizes the criteria's weightings and ensures that the sum of all weights is equal to one. We restricted the usage of an outer weighted sum to prevent more manual effort. Company-specific, an inner weighted sum can be added, too. Then, for each sub-criteria s of criterion c an additional weight has to be defined.

(Sub-)Criteria		Score Value 1	Score Value 2	Score Value 3	Score Value 4	Score Value 5
Complexity	Involved business departments	numerous	many	several	individual	IT department specific
	Change management impact on teams/individuals	significant changes	considerable changes	isolated changes	minor changes	no changes
	Interrelation with other IT projects	numerous	many	several	individual	none
	Ease of implementation	very complex	complex	medium	simple	very simple
	IT architecture fit	significant customizations	considerable customizations	isolated customizations	minor cus-tomizations	no customizations
Efficiency	Investment recovery periods	very long	long	moderate	short	very short
	Long-term cost savings	no effects	barely noticeable	noticeable	considerable	highly significant
	Impact on the growth rate	no effects	barely noticeable	noticeable	considerable	highly significant
	Employee performance improvement	none	barely noticeable	noticeable	considerable	highly significant
Risk	Risk profile	very high	high	moderate	low	very low
	Similar (un)successful past IT projects of leader/ team	in-experienced	little experienced	medium experienced	experienced	highly experienced
	Positive interrelation with other IT projects	none	barely noticeable	noticeable	considerable	highly significant
	Negative interrelation with other IT projects	highly significant	considerable	noticeable	barely noticeable	none
Strategy	Short-term business goals support	none	barely noticeable	noticeable	considerable	highly significant
	Long-term business goals support	none	barely noticeable	noticeable	considerable	highly significant
Urgency	Non-compliance with regulatory requirements	none existing	short-term disruptions	considerable disruptions	legal con-sequences	sanctions
	Needed to keep daily business processes running	no need	for few processes	for several processes	for many processes	for core processes
	Need for modernization	next 6+ years	next 5 years	next 4 years	next 3 years	next 2 years

Table 2. Adjusted Scoring Framework for IT Projects (Proposals)

After developing the scoring framework, the first author performed twelve additional expert interviews from the initial pool of experts to evaluate it (Exp2, 3, 5, 9, 11, 13, 14, 16, 17, 21, 23, 24). Again, we applied the methods and procedures from the first interviews and evaluated the scoring framework's practical applicability based on the same assessment criteria as the process model (Hevner et al. 2004; Sonnenberg and vom Brocke 2012). Thus, the interview guide consisted of questions to cover these assessment criteria. We interviewed experts from Germany (n=5), the United States (n=4), Canada (n=2), and France (n=1). The interviews lasted between 32 and 72 minutes. We performed them online in either English or German, recorded and transcribed them, and independently analyzed them deductively according to the assessment criteria, following Corbin and Strauss (2014) with MAXQDA 2020 support, and discussed our results.

Overall, the experts rated the scoring framework with its (sub-)criteria as valuable support for ITPPM. "It gives a framework in which to be kind of consistent in the way you evaluate projects" (Exp23). We revised our artifact based on the experts' feedback. We firstly adopted some changes in the wording of the (sub-)criteria to concretize them to avoid misunderstandings. Secondly, we extended the scoring framework with additional sub-criteria. For example, we made some wording changes for the complexity criterion and added two additional sub-criteria: IT architecture fit and ease of implementation. In summary, our holistic scoring framework for IT project evaluation now consists of five criteria with 18 sub-criteria, see Table 2. An IT project's impact and value creation increase with rising score values. Applying Eq1 and Eq2, it is then possible to calculate an IT project's (proposal's) overall value creation.

Decision Support System Prototype and Applicability Check

Parallel to our scoring framework development, evaluation, and revision, we used the gained knowledge from literature and expert interviews to continually develop a mathematical optimization model (see online Appendix 5) based on Archer and Ghasemzadeh (1999) and an DSS prototype to automatize ITPPM selection and scheduling(P4). After finishing Phases 1 and 2, all IT projects get evaluated based on the identified qualitative and quantitative scoring criteria (cf. Table 2, P3). This evaluation can be done directly in the DSS and the individual IT project score is calculated, which quantifies qualitative and quantitative parameters into one quantitative score. Then, the DSS maximizes the overall portfolio value creation by adding up the IT project's individual scores. Thereby, it includes the categories we excluded from our scoring framework and considers different constraints, interdependencies, and resource limitations. Overall, our DSS's application allows DM to insert scenario-dependent IT project data. Based hereon, our DSS solves the mathematical optimization model, selects and schedules IT projects into a portfolio, illustrates it in a Gantt chart, and shows the total optimized IT portfolio score. The DSS prototype ensures that IT projects are only selected once into the portfolio and that mandatory IT projects are included (cf. criterion of company politics; Exp4; Exp6) irrespective of their value creation. For each type of restricted resource, an exceedance in every planning period is prevented. This includes inter alia monetary (e.g., Sweetman and Conboy 2019; Exp10) and human resource limitations (e.g., Chen et al. 2020; Exp7). Our DSS prototype also considers IT project interdependencies. In case individual or groups of IT project(s) are mutually exclusive to each other (e.g., Chiang and Nunez 2013; Exp8), it ensures that at most one (group) of these is selected and scheduled. Given that an IT project (group) has a predecessor IT project (group), the DSS prototype considers these temporal interdependencies (e.g., Alaeddini and Mir-Amini 2020; Exp20). It ensures that a successor IT project is not selected without its predecessor(s). For scheduling, the DSS also considers that a successor IT project cannot start before its predecessor is finished.

Once we implemented and extensively tested our DSS prototype with its underlying constraints, we performed an applicability check using a generic IT project portfolio selection problem to show the DSS's applicability (Rosemann and Vessey 2008). We considered different scenarios that consisted of four planning periods and 80 IT projects (proposals). All required one to four periods for their implementation, with their earliest starting period spread over the planning horizon. We further considered temporal interdependencies and mutual exclusiveness. We used our scoring framework for IT project evaluation. Based on the importance to reach a company's goal, we defined strategy and urgency as the most important criteria (w_c= 0.3), risk with a weight of 0.2, and the remaining complexity and efficiency criteria with 0.1 each. As for limiting factors, we considered general external resources (e.g., consultant, soft- & hardware costs), general internal resources (e.g., project team), and internal domain-specific resources (e.g., key employees). The scenarios differed in their resource availability. While we considered the whole IT project budget for the first scenario, we gradually decreased it by five percent for the other scenarios. We used a standard laptop (Intel Core i7-8665U, 1.9 GHz CPU with 16 GB RAM) to conduct the calculation with MATLAB (version R2020b) and CPLEX (Studio1210). For the first scenario with normal resource availabilities, 22 IT projects were selected and scheduled with an optimized value creation of 74 (cf. online Appendix 6 (left)). Decreasing all resource availabilities gradually by five percent, we found a decrease in the IT portfolio's value creation by roughly the same share. Taking the example of a 25% resource decrease, 16 IT projects were selected and scheduled with an optimized value creation of 56 (cf. online Appendix 6 (right)). So the portfolio value decreased by 25%. For our generic example, our DSS prototype thus allows to anticipate the decrease in value creation inherent with resource changes.

Discussion, Implications, and Recommendations

Literature and practice acknowledge the importance of uniform and flexible ITPPM processes but are limited (Martin 2006; Varajão and Trigo 2016). Therefore, we developed a structured ITPPM process model that provides a step-by-step approach to support company decision-making. Accordingly, ITPPM is aligned to eight phases with 28 activities, see Table 1 and Figure 2 and thus differs from other models with three (Ajjan et al. 2016), four (Montgomery 2007), or five (Archer and Ghasemzadeh 1999) main phases. Our ITPPM process model compromises many phases and activities that can be found in others, but we synthesize conceptual and empirical knowledge into a fully comprehensive and integrated model. Further, it describes individual activities within each phase in more detail than existing models (e.g., Alaeddini and Mir-Amini 2020). ITPPM is an iterative process and cannot always be processed straightly. Rather, (re-

)turns are possible between and within individual phases and activities. Unlike existing models in literature (e.g., Archer and Ghasemzadeh 1999; Chiang and Nunez 2013), our ITPPM model has a basic sequential order, however, with many feedback possibilities and re-cycles within and between activities and phases. These enable better communication between individual stakeholders and allow to react to uncertainties and dynamics to make adaptions. When evaluations and reviews only occur once or twice a year, failures can only be found late, leading to non-preferable outcomes and resource waste (Sweetman and Conboy 2019). In our interviews, we discussed used ITPPM approaches and best practices with many experts. Thus, we indirectly integrated this knowledge into our ITPPM process model. As a result, there is great consistency between our model and best practices in terms of the individual phases, activities, and the re-cycles. In general, IT project identification, evaluation, selection, and monitoring activities were addressed in almost all models in literature and best practices (e.g., Ajjan et al. 2016; British Standards Institution 2015). However, the activities threshold definition and check for eligibility, policy establishment, mandatory IT project definition, discussion of results, TM involvement, and DSS usage have only been scarce considered.

Our process model enables to meet various characteristics of IT projects. After each ITPPM cycle is finished, adaptations can be made in line with future ITPPM process cycles. This way, the non-routine of IT projects can be addressed and processes are only temporary and can be adapted. In addition, defining roles and tasks allows stakeholders from different departments to be involved in the ITPPM process to consider a cross-functional view. The interdependencies analysis and IT project evaluation using the identified criteria also enable to address the complexity and cross-functionalities of IT projects. With our DSS, sensitivity-, and scenario analyses, it is possible to evaluate the effects of changing parameters before IT projects are implemented. It offers the opportunity to minimize uncertainties associated with IT projects. Continuous analyses of current IT portfolios and measures taken as a result of deviations make it possible to react to uncertainties and mitigate dynamic developments through non-routine. Moreover, we identified a high degree of agreement between the relevant ITPPM phases and activities in literature and practice (cf. Table 1). The individual activities' mentions are fairly balanced across all phases. However, scientific literature focuses much more on Phase 1 than the experts. The activities IT project (re-)evaluation and prioritization/selection are addressed by 20 respective 18 papers out of the identified 26 ones by our literature review. This again underlines the importance of these phases and also the further focus of this paper on them. In contrast, threshold definition and scenario analysis are addressed less in literature.

We identified critical IT project evaluation (sub)criteria and merged them in our scoring framework. In existing research, cost/benefit analysis (e.g., Asosheh et al. 2010), economic returns (e.g., Chiang and Nunez 2013), risk assessment (e.g., Ahmadi-Javid et al. 2020), and strategic alignment (e.g., Sweetman and Conboy 2019) are mainly addressed as critical whereas interdependencies, urgency, complexity, experience, and synergies are less considered (cf. online Appendix 2). However, some identified (sub)criteria are already known from existing selection problems from other fields (e.g., Konys 2019) and are comparable with some balance scorecard perspectives (Asosheh et al. 2010). Applying our scoring framework, subjectivity can be reduced, although not eliminated. Aligning with Exp23, employees with an advantage of an IT project's implementation must not be the only ones in charge of an IT project (re-)evaluation. Rather, companies must prefer multiple scoring from different stakeholders. Using our approach, each IT project is evaluated using the identified criteria. However, this simplifies reality and assumes that IT project benefits are deterministic. According to, e.g., Sweetman and Conboy (2019) and Exp15, IT projects' impact often can neither be estimated before implementation nor directly deliver their value creation. Often, IT projects have indirect value creation, e.g., improving other processes that create value.

Using the one to five scoring scale, the scoring framework quantifies qualitative and quantitative evaluation criteria in one quantitative score. Besides resource limitations, interdependencies and further constraints, the scoring results serve as one input into our DSS which then get optimized. Thus, despite previous work, we do not only use either a scoring method or a mathematical model, but a combination of both, as suggested by Mohagheghi et al. (2019). When using only the scoring framework, IT projects can be selected based on, e.g., their scoring rank until all resources are exhausted. This process becomes complex and unfeasible with increasing IT projects, periods, and resources. As our applicability check shows, IT projects are not only selected into the portfolio based on their ranking. Lower-scored are also selected to use all resources efficiently. It thus requires automated support to ensure reliable and timely decisions (Killen et al. 2020). According to Caniëls and Bakens (2012), a DSS can improve decision quality. The possibility of sensitivity and scenario analysis allows DM to analyze their decisions' effects. Critical thresholds for, e.g., resource reductions and their impact on the IT portfolio composition become immediately apparent.

Our results and findings have several practical implications. Companies can adapt our process model to their structures and needs and implement a company-specific ITPPM process. However, as some experts noted, adapting the process model is mainly possible for larger companies and IT projects and requires rigid discipline. Our evaluation framework enables to consistently and transparently evaluate each IT project (proposal) aligning a company's strategy and objectives. This also makes a comparison between existing IT projects and proposals possible. To apply our framework, the scoring scale needs to be defined company-specific with concrete values to avoid subjective interpretations. It also enables organizational learning, reporting, and eases data collection. Companies can further adapt and individualize the scoring framework by applying weights to the criteria. Here it is crucial to agree on weights that do not over- or underrepresent individual scoring criteria or departments. The DSS prototype assists companies to prioritize and select IT projects that optimize value creation, thus providing a rational basis for IT portfolio decisions and making this process more efficient and faster. It enables impact analysis before decisions are made to assess their consequences. However, the DSS's results are not to be seen as fixed but offer an orientation to what IT portfolio composition and schedule optimize the company's value creation. In the end, experienced senior executives should always make the final IT portfolio decisions. Therefore, the DSS provides realistic values to increase objectivity, decision quality, accountability, and fairness to make results more reliable. DM can use our artifacts to supplement or replace company-specific approaches. Once our three artifacts are implemented and accepted company-wide, IT portfolio decisions are more transparent and comprehensible. This also allows to explain to employees why their IT project (proposal) is not included in the IT portfolio. In addition, IT project employees are involved early in the ITPPM process and are not put ahead of completed IT portfolio decisions to increase their acceptance (Bhatti and Qureshi 2007).

Further, we contribute to ITPPM theory and synthesize conceptual and empirical ITPPM knowledge by developing an ITPPM process model, IT project evaluation framework, and DSS prototype. Our research design shows how to derive an ITPPM process model, critical scoring criteria, an evaluation framework for IT projects, and a DSS for IT portfolio decisions. Hence, we extend and contribute to the ITPPM knowledge base. For that, we used literature reviews, expert interviews, and an online survey. Referring to Gregor and Hevner (2013) our developed DSS represents a Level 1 artifact. It is still limited in its functionalities and scope, only tested with an applicability check, and thus provides less mature knowledge. With our ITPPM process model and scoring framework, we developed Level 2 artifacts with more mature and abstract knowledge that can partly be transferred to other project or portfolio types. Our three artifacts reduce ITPPM complexity, increase transparency and objectivity, and serve as decision support for ITPPM decisions while considering value driven and strategic orientation. Researchers can use or enhance our process model using further theories and case studies. Moreover, Table 1 reveals research opportunities on important ITPPM activities. Further, our results and findings enhance the understanding of critical scoring criteria and IT project evaluation to be more objective and prevent subject manipulations to support a fair IT project evaluation. The proposed evaluation framework allows to evaluate IT projects of all sizes and types according to the same five criteria and 18 sub-criteria (see Table 2) to enable comparability. It improves IT project evaluation and selection and generates new opportunities to improve ITPPM. Both, the process model and scoring framework serve as a starting point for further theory development, design theories, and evaluations regarding process models and decision frameworks in ITPPM. We further merged conceptual and empirical knowledge in our DSS. Together with our scoring framework, we add to the existing literature and combine an evaluation and selection approach within one solution. Our DSS's design specifications, constraints, and implementation provide a foundation for further improvements and solutions. For our three artifacts, we demonstrated their functional feasibility (proof-of-concept). Thus, they all provide a basis for future analysis of their value on IT portfolio performance (proof-of-value) and as a part of the stakeholders' daily work routine (proof-of-use) (Nunamaker et al. 2015).

Moreover, we developed a research agenda with six research directions to contribute to the knowledge base and complete the rigor cycle (Watson and Webster 2020). Within the ITPPM process model, characteristics of the individual activities differ in their maturity. A maturity model for ITPPM process models can support companies to assess themselves better and enables to derive measures to improve ITPPM processes. *(1) How can a maturity model for ITPPM process models be designed*? We demonstrated our artifacts' proof-of-concept but cannot make a general statement about their successful usage in a real-life company. Further research can analyze our three artifacts' actual proof-of-value and proof-of-use, using, e.g., laboratory experiments with real world data. (2) *How can our artifacts improve the decision-making quality and influence a DM's behavior? (3) What influences do the artifacts have on an IT portfolio's* *performance?* Our research showed that IT portfolio selection decisions vary between companies. While some make manual selections, others use software tools. However, these differ in their functionalities, scopes, purposes, and maturity. *(4) What are theoretically grounded and empirically validated elements of ITPPM tools? (5) How can a maturity model for ITPPM tools be designed?* Besides two analyzed best practices for PPM, we only considered them more indirectly through interviewing experts that work with them and shared their experiences. Further research can systematically analyze and evaluate existing best practices in more detail. *(6) How do process models for (IT)PPM in literature differ from best practices?*

Limitations and Conclusions

Given increasing IT expenditures and high failure rates, ITPPM is crucial to create value and achieve goals (Bezdrob et al. 2020). DSR-oriented, we developed an ITPPM process model, a scoring framework, and implemented a DSS prototype. However, as with all research, ours has some limitations. Activities within the ITPPM process model and (sub)criteria included in the scoring framework reflect the current state of research and practice, which must be reviewed and updated regularly. The results of our qualitative studies reflect the interviewees' subjective perceptions and can be biased. To overcome this, we combined findings with scientific literature. Despite the positive feedback through the evaluations and confirmed applicability, our scoring framework is still quite general and must be specified to company needs. Depending on the company, it still needs adoptions, e.g., regarding the internal market risks. Nevertheless, our results and findings offer various capability improvements in ITPPM and provide applicable knowledge for researchers and support practitioners in ITPPM, providing comprehensive and simplified decision-making.

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