Kumulative Dissertation zum Themengebiet:

IT Project Portfolio Selection in the Presence of Project Interactions

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1.1. Motivation

Many firms are operating in highly competitive and globally interconnected business environments where "IT is a key enabler of success in many organizations, providing the requisite tools […] to respond to changing market conditions and evolving business needs" (Bayney and Chakravarti 2012). Thus, the ability to harness information technology (IT) efficiently in order to support, enable, and implement changes in crucial business processes has become a critical success factor in those environments (Heinrich et al. 2014). In this light, it is not surprising that increasingly large sums – an estimated 3.8 trillion US $ world-wide in 2014 alone (Gartner 2014) – are being invested into IT. In many organizations, IT accounts for a significant slice of capital investments, typically ranging from 1.5% to 7% of company revenues (Maizlish and Handler 2005, Bayney and Chakravarti 2012). Both, organizational changes and changes in IT are typically implemented in the form of projects, since most organizations find that "project organisation is better suited to the kind of one-off or temporary problems and opportunities that they have to deal with" (Maylor et al. 2006).

Many companies, however, experience this project proliferation as 'project inflation' (Hirzel et al. 2006), and a cultural change has been observed with more and more companies adopting a 'management-by-projects' approach. Part of the evidence of this change has been a rise over recent years in the membership of professional associations specializing in project management (Praviz and Levin 2006). Nevertheless, the failure rate of IT projects remains high: approximately 20%, according to the Standish Group, result in complete failures, with another 50% of IT projects substantially exceeding their planned schedule or budget (Standish 2009). This is estimated to result in a value destruction of approximately 760 billion US $. These numbers indicate that at this scale of investment "rigor and discipline in investment planning and portfolio selection" is required (Bayney and Chakravarti 2012). It no longer suffices to merely manage single projects well. Rather, managers need to consider projects in unison, choosing the right projects, exploiting synergies between them, and terminating unnecessary projects (Meskendahl et al. 2011). Under the term Project Portfolio Management (PPM), numerous approaches and frameworks are to be found in the literature to provide guidance for handling these types of challenges that companies increasingly have to face.

The main goal of this thesis is to contribute to the knowledge base on IT PPM by thoroughly investigating a crucial, but nevertheless often neglected aspect of IT PPM: project interactions (Santhanam and Kyparisis 1996). Project interactions occur, for example, when projects share

common resources, produce similar or competing outputs, or rely on the results of other projects. These interactions impact not only on an individual project's outcomes, but also on the success of dependent IT projects, and on the overall availability of IT resources in an organization (Buhl 2012). Graves et al. (2003) highlight that IT project portfolios are particularly susceptible to these interactions, due to their high level of resource sharing. As a result, the already complex IT PPM task becomes even more demanding and complex.

This dissertation proposes a common ground for an in-depth discussion of project interactions in the context of IT project portfolios. It comprises five articles that build upon the current body of knowledge, define different types of interactions in IT project portfolios, and highlight several important issues arising from the inadequate treatment of these interactions. This thesis contributes to the literature by providing the necessary concepts and tools to improve on the identification and consideration of interactions in IT PPM. The introduction to this dissertation is structured as follows: In the next section (1.2.) relevant frameworks for PPM are discussed. Section 1.3. proceeds to position the research articles composing this thesis in the context of the literature, identifying research gaps and highlighting the respective contributions made to the literature by each paper. Part 1 of the thesis concludes with summary tables providing an overview of the contributions made by the co-authors, and detailed information about the scientific dissemination that has taken place to date through conference presentations and publications.

1.2. Status Quo of IT Project Portfolio Management

A project can be defined as "a complex effort, usually less than three years in duration, made up of interrelated tasks, performed by various organizations, with a well-defined objective, schedule, and budget" (Archibald 1992). In this sense, "a project portfolio is a group of projects that are carried out under the sponsorship and/or management of a particular organization" (Archer and Ghasemzadeh 1999). Such projects typically compete for scarce resources (people, finances, time, etc.) since there are usually insufficient resources available for each proposed project (Archer and Ghasemzadeh 1999).

1.2.1. Project Management and Project Portfolio Management

When the execution of the aforementioned projects constitutes a larger part of an organizations' business, such an organization typically establishes a function, e.g., in form of a project management office (PMO), with specialized personnel (Levine 2005). The tasks of a PMO include the development of standards and practices to effectively execute projects, usually with respect to the three major metrics *time*, *budget*, and *scope* (Morris and Pinto 2007). In contrast, Operations Management, traditionally consisting of senior managers, is responsible for setting the organization's objectives, as well as strategies to achieve them (Levine 2005). While the various aspects of managing single projects are "generally pretty well understood within the traditional project management

community" (Morris and Pinto 2007), according to Levine (2005), one common problem for many organizations is that there is no connection between Operations Management and the project management functions, and as a result, a lot of effort is invested into 'doing projects right', even if the projects are not the 'right' projects. PPM, therefore, aims to integrate the 'world of projects' in closer alignment with business operations (Levine 2005).

Consequently, and following Meskendahl (2010), the main goals of PPM comprise maximization of the financial value of the project portfolio, linking the portfolio to the firm's strategy, and balancing the projects within the portfolio in consideration of the firm's capacities (Meskendahl 2010). PPM has to be understood as a dynamic decision making process in which a list of active projects is repeatedly updated and revised (Cooper 2001), and in which decisions are reached as part of an iterative process. In this process new projects are constantly being evaluated, selected, and prioritized, existing projects accelerated, terminated, or deprioritized, and resources allocated and reallocated to active projects (Praviz and Levin 2006).

Often, PPM is used synonymously with the term multi-project management (MPM). Pennypacker and Dye (2002) provide a high level comparison between PPM and MPM and distinguish these terms according to their *purpose*, *focus*, *planning emphasis* and *responsibilities* (see table 1). This distinction highlights the core function of PPM to *adequately support the portfolio selection process with respect to the strategic focus of the company*.

The corresponding literature streams have brought forth several text books and scientific papers to promote highly valuable PPM frameworks for structuring this complex and recurring decision making process (e.g., De Maio et al. 1994, Archer and Ghasemzadeh 1999, Kendall and Rollins 2003, PMI 2008, Praviz and Levin 2006, Bayney and Chakravarti 2012). The following section presents a selection of important contributions in the field of PPM. In relation to these approaches, the articles in this thesis are positioned in the literature and their contributions to the PPM literature are highlighted.

	PPM	MPM
Purpose	Project Selection and Prioritization	Resource Allocation
Focus	Strategic	Tactical
Planning Emphasis	Long- and medium-term (annual/quarterly)	Short-term (day-to-day)
Responsibility	Executive/senior management	Project/resource managers

Table 1: PPM and MPM (Pennypacker and Dye 2002)

1.2.2. Phases and Frameworks for PPM

The above-cited definition of PPM alone makes apparent that PPM encompasses the full breadth of activities from strategic considerations down to operational management tasks. The strategic implications of PPM are complex and varied (Hax and Majluf 1984), and involve factors that are internal and external to the company, such as the marketplace in which the company operates and its strengths and weaknesses. As a consequence, project portfolio selection (PPS) decisions should be made in this broad context and consider strategic factors and operational factors alike (Archer and Ghasemzadeh 1999). In their seminal article from 1999, Archer and Ghasemzadeh therefore suggest subdividing the PPM process into three process stages: *Pre-Process*, *Portfolio Selection Process*, and *Post Process* (see figure 1). The pre-process stage aims at providing high level guidance to the Portfolio Selection Process. In the Portfolio Selection Process stage, which constitutes the core function of PPM, an optimal portfolio is selected and adjusted to the decision makers' preferences, while in the Post-Process, the portfolio's projects are conducted and managed. In a very similar way to these three process stages PMI (2008) divided the Project Portfolio Management Process into four process groups, a *Strategic Planning Process*, an *Alignment Processes, Monitoring and Controlling Processes*, and *Component Processes*. A consolidated overview over the activities associated with the three process stages following Archer and Ghasemzadeh and PMI (2008) is depicted in figure 1.

	Pre-Process *Strategic planning Processes*	**Portfolio Selection Process** *Alignment Processes*	**Post-Process** *Component and Monitoring Processes*
Characteristics	▪ Rather Unstructured and time consuming process stage ▪ Involves high level management	▪ Logically structured process stage ▪ Frequent repetitions at regular planning intervals	▪ Ongoing management process ▪ Involves project management controlling techniques
Repetition	▪ Occasionally	▪ Every 3 to 12 months	▪ Ongoing
Core tasks	▪ Strategy Development ▪ Goal and category definition ▪ Key performance criteria definition ▪ Resource capacity definition ▪ Methodology Selection ▪ Monitor business strategy change	▪ Identification, categorization and evaluation of individual projects ▪ Rejection of projects which do not meet portfolio criteria ▪ Calculation of common parameters ▪ Rejecting non-viable projects ▪ Optimal portfolio selection: consideration of project attributes, risks, resource constraints and project interactions ▪ Adjustment/Balancing of the portfolio	▪ Execution of projects ▪ Monitoring and controlling of portfolio risks ▪ Reviewing and reporting of portfolio performance

Figure 1 - PPM Process stages and associated core tasks
(Own illustration, adapted from Archer and Ghasemzadeh 1999 and PMI 2008)

Pre-Process

The purpose of the Pre-Process is to formulate the portfolio's strategic plan in alignment with the firm's business strategy, and thereby laying the foundation for PPS. Due to the strategic nature of the decisions made at this point this process typically involves high-level management (Archer and Ghasemzadeh 1999). The development of a portfolio strategy can be a time consuming process, however, once a strategy has been formulated, it generally only requires minor subsequent adjustments. PMI (2008) suggests that a strategic portfolio plan should comprise goals, project categories, key performance criteria, and capacity definitions. To guide this potentially unstructured process, the literature has suggested various techniques such as portfolio analyses (e.g., Applegate et al. 1999), strategic mapping, and cluster analyses. The main outcomes of the Pre-Process include guidelines for the subsequent Portfolio Selection Process stage and the definition of the available resources.

Portfolio Selection Process

The Portfolio Selection Process stage comprises the core activities of PPM and is concerned with selecting a subset of the candidates for the project portfolio; this is repeated every 3 to 12 months. Due to the high importance of this stage, numerous frameworks and approaches can be found in the literature that solely or partially focus on this sub-stage (e.g., De Maio et al. 1994, Praviz and Levin 2006, Bayney and Chakravarti 2012). While not explicitly following the process stages described above, the tasks associated with Portfolio selection are widely congruent across the different frameworks (e.g., see figure 2). The core tasks in this stage typically comprise a pre-screening, or categorization, of the project candidates. Categories like 'must do', 'won`t do, and 'may do' projects may be used (e.g., Bayney and Chakravarti 2012). PMI (2008) suggest defining business relevant categories (e.g., innovation, cost saving, growth) based on the strategic plan developed in the Pre-Process, and grouping projects within the same categories. After categorization, each project candidate is evaluated individually based on predefined indicators. These indicators provide a common set of measures for all project candidates and provide the common ground necessary for a comparison of the project alternatives. Archer and Ghasemzadeh (1999) suggest using a mix of economic return methods (e.g., net present value, internal rate of return, return on investment), benefit/cost ratios and risk analysis techniques. Projects failing to reach certain minimum requirements are rejected. PMI (2008) suggest prioritizing the remaining components and establishing a ranking among the candidates. However, as De Maio et al. (1994) point out, as a major improvement compared to prioritizing the project candidates independently, mathematical optimization provides the necessary tools to model project interactions (e.g., successor/predecessor relationships) and consider them during portfolio optimization. After optimizing the project portfolio, sophisticated prioritization techniques like the Analytic Hierarchy Process (e.g., Saaty 1988,

Schniederjans and Wilson 1991) can be used to prioritize the remaining projects in the optimized portfolio.

During the Portfolio Selection Stage, resource allocation considerations form an integral part of project portfolio selection. Although Pennypacker and Dye (2002) regard resource allocation as belonging to MPM, due to their close connection to PPS, the understanding of PPM in this thesis also comprises resource allocation decisions.

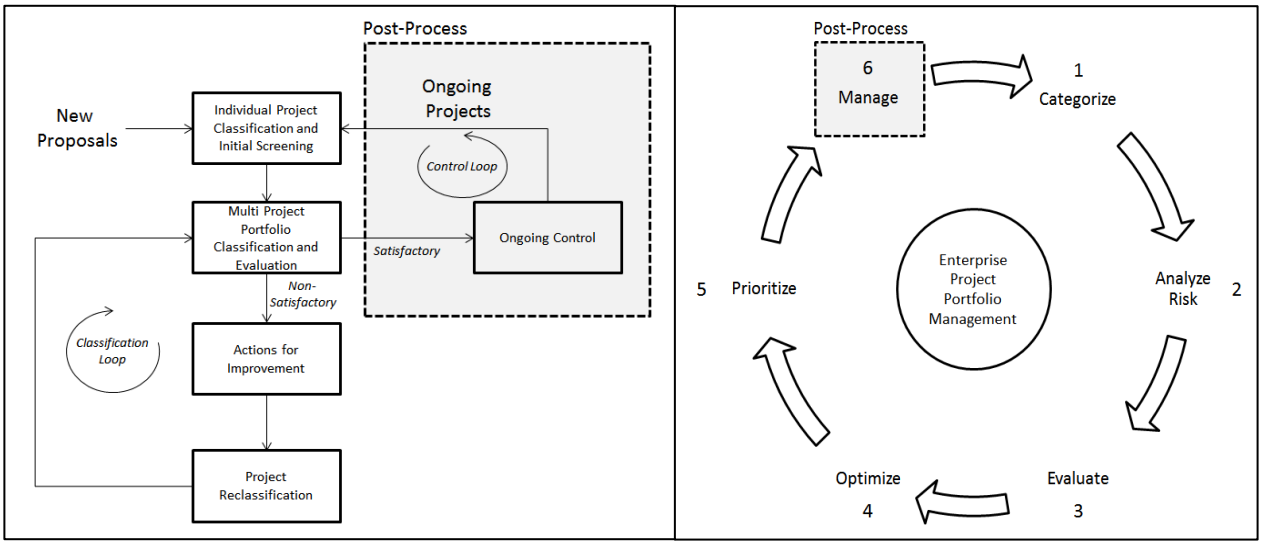

Figure 2 - PPM process (De Maio et al. 1994) **CREOPM: PPM cycle**
(Adapted illustrations, in line with De Maio et al. 1994, and Bayney and Chakravarti 2012)

Post-Process

The Post-Process stage comprises activities and processes that are located in the downstream of portfolio selection. PMI (2008) also refers to these processes as monitoring, controlling and component processes. In this stage, the projects that have been selected into the project portfolio are conducted, managed and periodically re-evaluated. Monitoring and controlling processes resemble ongoing activities like monitoring the portfolio risks or reviewing and reporting the performance of portfolio components. Changes in business strategy are monitored as well, and in case of substantial changes, the Pre-Process activities might have to be conducted again. Ideally, a project database with relevant project data is maintained that can be used to improve future iterations of the portfolio selection process. Typically, classical project management and controlling methods are applied during this stage.

1.2.3. Consolidated PPM Framework

Based on the different frameworks in the literature and on the considerations described above, figure 3 shows a consolidated PPM framework. It is grounded in the well-known framework suggested by Archer and Ghasemzadeh (1999) and comprises the core activities related to all three stages of the PPM process. The framework has been matched with, and extended by the frameworks suggested by De Maio et al. (1994), PMI (2008), Praviz and Levin (2006), and Baney and Chakravarti (2012). (See figures 4 to 8 in the Appendix of this thesis).

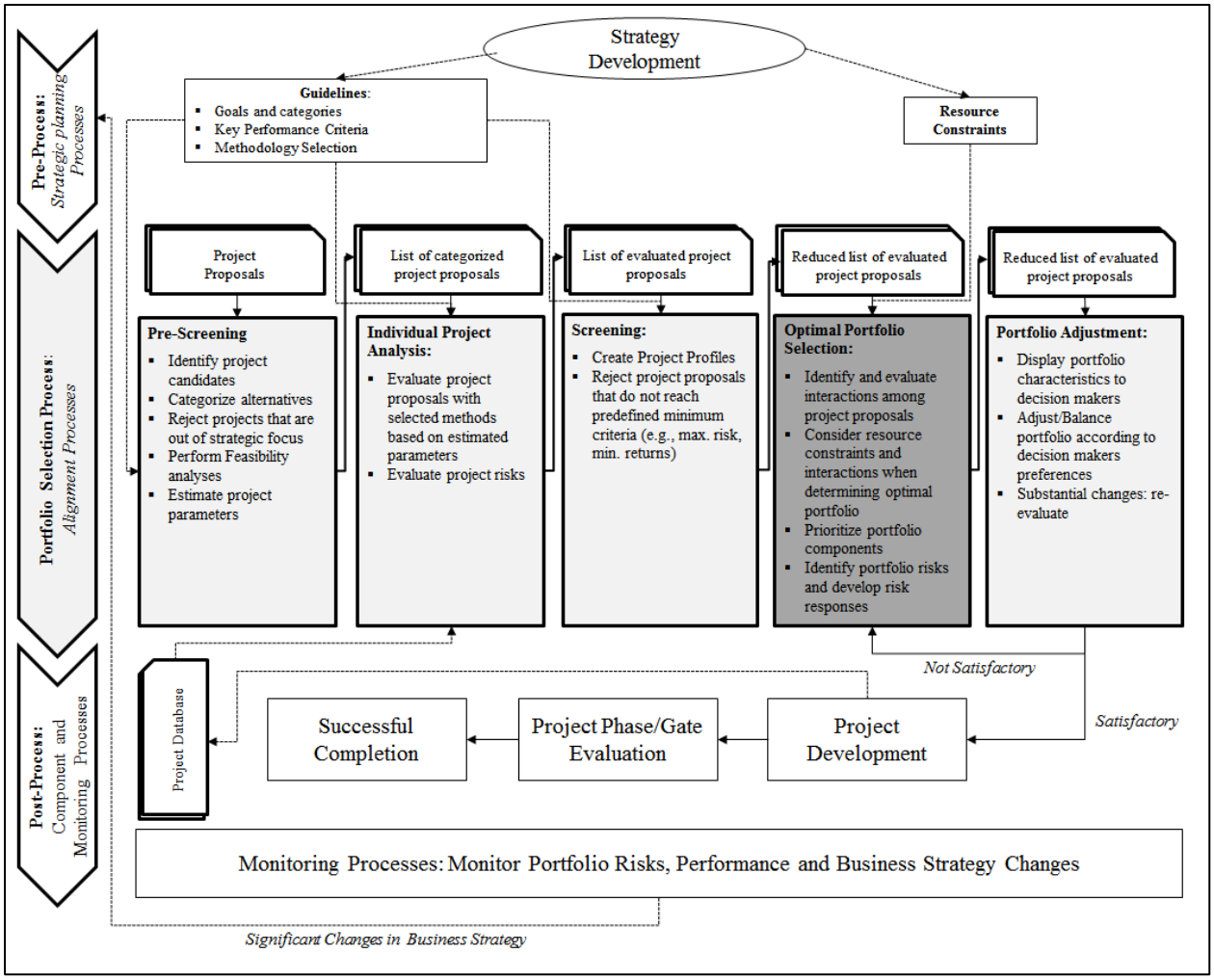

Figure 3 - PPM process (own illustration, based on Archer and Ghasemzadeh 1999, adapted and extended in line with De Maio et al. 1994, PMI 2008, Praviz and Levin 2006, and Baney and Chakravarti 2012)

1.3. Optimal Portfolio Selection in the Presence of Project Interactions

"*If we don't let the wild horse out of the corral, we don't have to go and chase it back*"
(Levine 2005)

It becomes apparent that selecting an adequate project portfolio is one of the core responsibilities of PPM. In this context, Levine (2005) states that the "primary and unique aspect of PPM is what it does to formalize and assist in the selection of projects". This selection task has become an increasingly "important and recurring activity in many organizations" (Archer and Ghasemzadeh 1999). To improve on this core responsibility of PPM, the thesis at hand contributes to the literature by focusing on the Portfolio Selection Process stage, and more specifically, on the Optimal Portfolio Selection sub-stage.

Based on the value and costs determined in the previous sub-stages, the goal of the Optimal Portfolio Selection sub-stage is to select the subset of project candidates that have the potential to deliver the highest benefits under the given resource constraints. What sets this sub-stage of project portfolio selection (PPS) apart from prioritizing individual projects in isolation is the presence of multiple types of interactions that may occur among projects. For example, if a similar database server is needed in more than one project and each project only temporarily needs this server, it may be shared among the projects and thus has to be procured and installed only once. Thereby, valuable cost synergies may be leveraged. Thus, an isolated project selection and management is not sufficient (see, e.g., Hierzel et al. 2006, Santhanam and Kyparisis 1996) and "it is widely accepted that organizations must be able to understand the [inter]dependencies […] in their portfolio in order to make appropriate project decisions for the best portfolio outcomes" (Killen and Kjaer 2012). Not accounting for such interactions when planning a project portfolio may not only result in unleveraged cost synergies, but rather can represent a source of risk for the overall project portfolio. In a survey conducted with 100 IT directors in the UK and Ireland, CA Research identifies issues of interactions and conflicts between multiple projects as one of three major reasons for IT budget over spending (CA Research 2007).

Due to the high relevance of considering interactions during portfolio selection, a number of sophisticated approaches have been developed over the last five decades (for an overview over the most prominent contributions, see table 2).

Authors (year)	Summary	Considered interactions
Weingartner (1966)	The article surveys the techniques available to deal with interactions (e.g. mutual exclusion and inter-dependence). The reviewed techniques include linear and integer programming, dynamic programming, and a discrete optimizing procedure.	▪ Mutual exclusion interdependencies ▪ Contingent/Compound projects ▪ Pair-wise second order effects ▪ Interrelation in success probability
Aaker and Tyebjee (1978)	A model for dealing with three types of interdependencies among projects is developed. In identifying the necessary inputs, the model also encouraged cross-functional interaction and communication in the organization.	▪ Overlap in resource utilization ▪ Technical interdependence ▪ Effect interdependence
Gear and Cowie (1980)	The authors explored the distinction between internal and external relationships. An example of modeling external interrelations was presented and analyzed.	▪ Internal relationships (resource, benefit) ▪ External relationships
Fox et al. (1984)	The article proposes a framework and a resulting model in which present value interrelations could be assessed indirectly by explicitly modeling item impact on profitability.	▪ Cost interaction ▪ Outcome interaction ▪ Benefit interaction (impact interaction and present value interrelation)
Nelson (1986)	A method for prioritizing manufacturing modernization projects is presented. Extending classical capital budgeting analysis, the model addresses complexities of non-economic criteria, project interdependence, and uncertainty. Interdependencies are modeled as conditional probabilities.	▪ Overlap interdependencies ▪ Technical interdependencies ▪ Effect interdependencies
De Maio et al. (1994)	The article suggests an interpretative model that explains firms' dynamic behavior in Multi-Project Management of new product development. A visual representation for depicting interactions in a portfolio is provided.	▪ Resource interdependencies ▪ (Input/Output): Commonality, System integration, Technological prerequisites, Market interactions
Santhanam and Kyparisis (1996)	An IS project selection model is developed that models benefit, resource and technical interdependencies among projects. The model is formulated as a nonlinear 0-1 programming problem and is among the first to consider higher order interactions.	▪ Resource interdependencies ▪ Benefit interdependencies ▪ Technical interdependencies
Lee and Kim (2001)	The authors suggest an integrated approach for interdependent IS project selection problems using Delphi, Analytic Network Process concept and Zero-One Goal Programming.	▪ Resource interdependencies ▪ Benefit interdependencies ▪ Technical interdependencies
Klapka et al. (2002)	In the article, a multi-criterial decision support system that supports project portfolio selection for large project landscapes is presented. The model considers pairwise and third-order interactions.	▪ Synergistic effects ▪ Contingency between projects ▪ Benefit interdependencies ▪ Risk interactions
Bardhan et al. (2004)	The authors provide a nested real options approach to support the selection of IT project portfolios. The effect of interactions on the projects values (in terms of NPV) is investigated.	▪ Soft dependencies ▪ Hard dependencies
Doerner et al. (2006)	The paper describes a heuristic approach for optimizing a set of interdependent project proposals. It combines ILP preprocessing and an ant colony heuristic to efficiently solve large portfolio selection problems.	▪ Synergistic effects ▪ Cannibalization effects
Eilat et al. (2006)	A methodology for the construction and analysis of efficient, effective and balanced portfolios of R&D projects with interactions is developed and presented. Dependency matrices are used to value interdependencies between pairs of projects.	▪ Resource interactions ▪ Benefit interactions ▪ Outcome interactions
Liesiö et al. (2008)	The paper presents a multi-objective zero-one linear programming problem for portfolio selection to construct robust project portfolios with interactions.	▪ Mutual exclusivity, follow-up projects ▪ Synergistic effects ▪ Cannibalization effects
Carazo et al. (2010)	A multi-objective binary programming model for obtaining efficient portfolios as well as project scheduling is proposed.	▪ Synergistic effects ▪ Cannibalization effects
Lourenco et al. (2012)	The authors suggest a model for selecting a robust portfolio of projects in the context of limited resources, multiple criteria, different project interactions and several types of uncertainty	▪ Mutual exclusivity, follow-up projects ▪ Synergistic effects

Table 2 - Literature overview (based on and adapted from Kundisch and Meier 2011a, Chien 2012, and Müller et al. 2015)

These approaches already provide highly valuable foundations for describing and modeling interactions in IT Portfolios, but research in this area is still far from complete. Even a cursory glance at column 3 in table 2 suggests the need for a common terminological basis which can bring together the diverse strands of this fragmented research field and thereby enable the development of a cumulative research tradition. This thesis prepares a common ground for a thorough discussion of interactions. Furthermore, while the numerous sophisticated approaches found in the literature (see table 2) already provide valuable modelling and problem solving techniques for PPS problems, the literature takes a somewhat methodological perspective, focusing on algorithms for optimizing portfolios (Kaiser et al. 2015). Often, the necessary input data for the models and approaches is not widely available in companies (Fox et al. 1984, Cho and Kwon 2004). What seems to be widely missing is support for identifying and assessing different types of interactions as well as a thorough investigation of the economic impacts of interactions on portfolio costs and benefits. Comprising five research articles, this dissertation aims at contributing to closing these gaps as outlined in table 3.

Paper	Contribution to PPM Sub-stage and Tasks	Research Questions
Kundisch and Meier (2011a)	(Pre-Process), (Optimal Portfolio Selection)	*How are project interactions treated in different literature streams?* *What are the different types of interactions among IT projects and how do they affect IT project portfolios?*
Kundisch and Meier (2011b)	Optimal Portfolio Selection	*How can resource interactions among IT projects be adequately identified?* *How can the identified resource interactions be adequately incorporated into the selection decision of IT project portfolios.*
Meier (2014)	Optimal Portfolio Selection	*How can the identification of potential output interactions in IS project portfolios be adequately supported by semantic clustering?*
Meier, Kundisch, and Willeke (2015)	Optimal Portfolio Selection	*How can the identification and evaluation of potential economically relevant resource interactions among projects be adequately supported?* *How much effort should be invested in the assessment of those resource interactions?*
Meier, Zimmermann, and Nicolau (2015)	Individual Project analysis/Optimal Portfolio Selection	*How does human resource sharing influence IT project risk?*

Table 3 - Overview: Positioning and Research Questions

The first article, *Kundisch and Meier (2011a)*, comprises a comprehensive literature review and contributes to the unification of the terminology and the semantics of interactions among IT projects used in the literature. It constitutes the starting point for the other four articles and future research in this field. The articles *Kundisch and Meier (2011b)*, and *Meier (2014)* explore, to what degree interactions are already incorporated into technically models and methods for portfolio selection in the literature. A lack in the literature concerning the availability of the necessary input data is identified and the articles contribute to closing this gap by structuring and supporting the identification process of resource and output interactions. Further, algorithmic tools are provided to support the consideration of the identified types of interaction when selecting an optimal project portfolio. The article *Meier, Kundisch and Willeke (2015)* identifies a trade-off between, on the one hand, the effort involved in identifying and assessing interactions in greater detail and, on the other hand, realizing the benefits of their consideration in the planning process, which is so far unaddressed in the literature. Utilizing concepts from information value theory (Howard 1966) the article suggests an approach to answer the question of how much effort should be invested in the assessment of those interactions. Finally, the article *Meier, Zimmermann, and Nicolau (2015)* empirically investigates the relationship between resource interactions (in form of resource sharing) and portfolio risk.

The following pages contain a short summary of the articles included in this dissertation. After each of the summaries, the theoretical contributions as well as the managerial implications of each paper are briefly outlined. At the end of the section tabular overview provides detailed information about each of the articles regarding the contributions made by the respective co-authors, and their scientific dissemination on conference presentations and publications.

1.4. Overview and Contributions

Summary of Kundisch and Meier (2011a)

The multi-faceted nature of PPS may explain the fragmentation of research in this area, as well as the absence of a common terminology and of a guiding structure for gathering the existing knowledge on the manifold types of interactions and their effects. In line with Benaroch's and Kauffman's' argument that "a major challenge for IS research lies in making models and theories that were developed in other academic disciplines usable in IS research and practice" (Benaroch and Kauffman 1999), the paper draws upon insights from disciplines as diverse as Capital Budgeting, Research and Development (R&D), Operations Research (OR), and Information Systems (IS). Based on a comprehensive literature review, *Kundisch and Meier (2011a*) contributes to the unification of the terminology and the semantics of interactions by identifying three relevant classification dimensions and systematically developing a classification framework for interactions in IT PPS. Based on the findings in the literature, three different types of interactions, namely *resource interactions*, *output-resource interactions*, and *output interactions*, are defined in an empirical-to-conceptual research approach (Nickerson et al. 2012). For each of the different types of interactions, examples are presented and their effects on a transformational and an economic level discussed. Further, the paper highlights valuable avenues for future research in this field.

Theoretical Contributions of Kundisch and Meier (2011a)

This paper contributes to the literature on project interactions by being among the first to provide a comprehensive classification and discussion of the different types of interactions and their effects among IT projects. To facilitate a cumulative research tradition, a unification of the terminology and semantics of interactions among IT projects has been conducted. A conceptual framework has been suggested that may serve as a starting point to extend existing models and approaches, and to develop new ones that consider all of the identified types of interactions. Further, it highlights important avenues for future research in the field.

Practical Implications of Kundisch and Meier (2011a)

Practitioners may capitalize on the insights derived from this article to identify and select appropriate models for application from this fragmented and rather unwieldy body of knowledge. Further, the different types of interactions identified and described in the article could be used to raise awareness amongst decision-makers about the existence and potential effects of interactions.

Summary of Kundisch and Meier (2011b)

Kundisch and Meier (2011b) focuses on resource interactions – interactions caused by the simultaneous utilization of scarce resources – as one of the most prominently discussed types of interaction in the literature. A lack of support in the identification and assessment of resource interactions is identified, which severely hampers the applicability of those models in business practice. To address this gap, the prevailing definitions of resource interactions in the literature are extended by introducing *allocation*, *performance* and *sourcing interactions*, depending on specific properties of different types of resources. Using this finer grained definition of resource interactions, a structured identification process for resource interactions among IT projects is presented.

Theoretical Contributions of Kundisch and Meier (2011b)

This article conceptually contributes to the understanding of resource interactions by providing a thorough discussion of different types of resource interactions so far unrecognized by the literature. Based on the conclusions it derives from the literature, the prevailing definitions of resource interactions are extended by allocation, performance, and sourcing interactions. The article further contributes to the literature by methodically defining a structured identification process for resource interactions among IT projects. As changes in PPS typically require adaptations in an organization's overall project culture, the necessary requirements to apply the presented approach are discussed. The article further contributes to the literature by presenting a tailored mathematical decision model that accounts for the newly defined sub-types of resource interactions.

Practical Implications of Kundisch and Meier (2011b)

For practitioners, the presented identification process may serve as a tool to incorporate resource interactions into their portfolio decisions in a (more) structured and still pragmatic way. The structured information gathering process described in this article may highlight the importance of some resources for an organization, which previously may not have been recognized explicitly. Additionally, the procurement of required resources may be improved due to the identification of the described resource interactions. Thus, the overall portfolio decision may be based on a broader information base gained from the identification process.

Summary of Meier (2014)

Meier (2014) focusses on output interactions, as defined in *Kundisch and Meier (2011a)*. The article identifies anecdotal as well as first empirical evidence in the literature for the existence of output interactions and their economic effects. While few empirical studies in the literature (Aral et al. 2006, Engelstätter 2009) find ex-post evidence, no research has been conducted so far that aims at the ex-ante identification of output interactions. *Meier (2014)* identifies a lack of techniques in the literature of how to identify output interactions early in the portfolio's planning stage. Considering the reported effects and their potential business value impact, an ex-ante consideration of output interactions could substantially affect the portfolio selection decision. In contrast to resource requirements, which usually have to be quantified when proposing a project in a proposal document, project outputs and goals tend to be formulated in a rather textual and less structured form. However, indications about possible connections among similar or competing goals among two or more projects may already be found within the informal linguistic information of the textual descriptions in the project proposals, at the time of the portfolio is being planned. The article contributes to filling the identified gap by conferring semantic clustering, a technique originating in the text mining literature, to the field of IT project portfolio selection to automatically identify potential output interactions based on the textual goal descriptions found in project proposals. As a proof of concept, a first performance evaluation (Hevner et al. 2010) of the developed prototype is conducted on a standard test set for semantic clustering approaches.

Theoretical Contributions of Meier (2014)

In this paper, a starting point for a more detailed ex-ante identification of output interactions within IT project portfolios is provided by applying LSA to the domain of IT PPS. Thus, the main contribution of this paper is the development of a prototypical Decision Support System that confers well established concepts from the text mining and information retrieval domain to the field of IT PPS. In a cumulative research tradition, the developed prototype is based on semantic clustering presented by Kuhn et al. (2005), which uses LSA for the identification of semantic topics in source code. The approach is adapted to the new conditions arising from the application domain of IT PPS.

Practical Implications of Meier (2014)

The developed tool can support practitioners in identifying output interactions in a structured manner and to include them into their portfolio decisions. The hierarchical representation of potential output interactions in this paper may highlight relationships within an organization's project landscape which previously may not have been recognized explicitly.

Summary of Meier, Kundisch, and Willeke (2015)

While the ability to identify and consider interactions in a project portfolio's planning stage is regarded as highly important in the literature, in *Meier, Kundisch, and Willeke (2015)* we argue that there is a trade-off between, on the one hand, the effort involved in identifying and assessing interactions in greater detail and, on the other hand, realizing the benefits of their consideration in the planning process. In this context Lee and Kim (2001) state that the "cost of [the] difficulty in data gathering […] is not as critical as the risk in selecting the wrong project without considering the interdependencies". In contrast, Phillips and Bana e Costa (2007) conclude that only the strongest interactions have an effect on decision making and therefore, only those should be considered. The articles *Kundisch and Meier (2011b)* and *Meier (2014)* provide an original and valuable contribution by improving the identification of resource and output interactions and, thereby, potentially lowering the costs associated with identifying interactions. However, assessing the effects of all the identified interactions is a demanding task even if only a handful of project proposals are available for selection. In larger project environments the potential complexity is likely to increase dramatically. Therefore, a question that has not previously been raised in the literature is whether it actually pays off to identify and evaluate all possible interactions that may occur among a set of projects. Moreover, the literature lacks adequate tools that support the identification of the most influential interactions (as mentioned by Phillips and Bana e Costa 2007). By focusing on resource interactions in a first step, *Meier, Kundisch, and Willeke (2015)* contributes to closing this research gap in two ways: First, a technique to support the automated identification and evaluation of potential economically relevant resource interactions is suggested. Second, based on information value theory (Howard 1966) a decision model for the calculation of a theoretical upper bound for the effort that should be invested in improving estimates for the identified interactions is presented.

Theoretical Contributions of Meier, Kundisch, and Willeke (2015)

In terms of addressing the identification and assessment of resource interactions, the key contribution of *Meier, Kundisch and Willeke (2015)* is twofold. First, we develop a technique for identifying potential economically relevant resource interactions in a semi-automatic process. Second, we present a concept for calculating a theoretical upper bound for the effort that should be invested in improving the estimates for the interactions identified. The concepts developed in this article may be incorporated into new research approaches or provide input for the development of new methods and models that account for resource interactions in greater depth.

Practical Implications of Meier, Kundisch, and Willeke (2015)

For practitioners, the article may improve the incorporation of resource interactions into their portfolio decisions in a more structured but also pragmatic way. While a certain process maturity level is required to make full use of the insights that can be gained from the approach, it may substantially

reduce the potentially high effort inherent in the identification and evaluation of economically relevant resource interactions. As an additional benefit, the structured process of information gathering may highlight the importance of at least some of the (key) resources to the company in question, which may previously not have been recognized explicitly. As a result, potential bottlenecks may be identified before they are able to occur, and procurement strategies for the corresponding resources may be improved at an early planning stage to reduce the risk of resource shortage during portfolio implementation.

Summary of Meier, Zimmermann, and Nicolau (2015)

The exploitation of resource interactions among human resources is a highly relevant topic in IT project portfolio management. On an economical level, exploiting resource interactions by sharing resources among two or more IT projects may translate into cost synergies and, thereby, reduced portfolio costs (Gear and Cowie 1980, Lee and Kim 2001, Santhanam and Kyparisis 1996, Heinrich et al. 2014). In contrast, sharing human resources among projects also introduces risk factors into an IT project portfolio. A systematic analysis of these risks and their potential impact on project success to date is scarce in the literature (Heinrich et al. 2014). In particular, there has not been any empirical research to date that investigates how human resource sharing might affect project success. This paper attempts to fill this gap in the literature. We find first evidence that projects that share a large amount of their human resources with other projects are more likely to fall short in their planned scope. More specifically, a 1% higher degree of human resource sharing is associated with a decrease of 3.4% in the odds that a project will be in scope, as evaluated by the project owner. Further, and rather surprisingly, our results indicate that projects that share their human resources are more likely to comply with their initially planned timeline.

Theoretical Contributions of Meier, Zimmermann, and Nicolau (2015)

The article is among the first to empirically observe the relationship between human resource sharing, a typical form of resource interaction, and different project risk measures. *Meier, Zimmermann, and Nicolau (2015)* uses concepts from Modern Portfolio Theory (Markowitz 1952) and conceptually contributes to the literature by providing a theoretical research model that conceptualizes the relationship of human resource sharing and project risk measures. Further, our analyses partially confirm findings from Standish (2013), who state that increases in experienced and training of project management professionals can be tied directly to increases in success rates. In this regard, we find evidence that with increasing project manager experience the likelihood that a project can hold its initially planned timeline increases as well. However, there are several limitations that have to be considered when interpreting the results of this study. First of all, due to the characteristics of the data set only correlations for the observed variables can be reported. Thus, we cannot conclusively show that resource sharing is the driving mechanism behind the identified relationships. In future research,

the causal relationships between human resource sharing and project success have to be further investigated.

Practical Implications of Meier, Zimmermann, and Nicolau (2015)

The findings of our study indicate that practitioners should be aware that human resource sharing practices, which can be seen as widely applied business practice, potentially come at a cost. Not considering the resulting risk effects may diminish project success and lead to inferior project results. It might prove beneficial to identify potential resource bottlenecks and to include adequate capacity buffers already during resource allocation planning.

Together, these five articles make an original contribution to the knowledge base by improving the understanding of project interactions and their effects on IS PPS. The dissertation makes three types of contributions: On a conceptual level it contributes to the literature by providing a framework for classifying interactions and the definition of different types of interactions and their effects. Methodologically, the dissertation contributes to the knowledge base by proposing innovative tools to deal with the problem of identifying and evaluating different types of interactions. Third, a first empirical approach to the investigation of the effects of resource sharing on project performance is presented. For researchers, the results of this dissertation may provide a valuable starting point to facilitate a better understanding of the different types of interactions and their effects on project portfolio selection decision. Researchers are enabled to extend and improve on existing models and approaches through identifying the different types of interactions, and the conceptual framework developed may help to identify interesting, so far unaddressed areas for future research in this field. This dissertation supports practitioners by lowering the barriers and providing a better access to the hitherto fragmented, but highly valuable body of knowledge. Further, the proposed concepts and tools can aid in developing strategies to improve portfolio selection under consideration of interactions at an early stage of decision making, and thus, to avoid unfavorable portfolio decisions. In addition, the implementation of the developed approaches in business practice can help to identify so far unrecognized resource bottlenecks and improve the overall understanding of interactions on PPS decisions in practice.

Contributions to Presentations and Scientific Dissemination of Studies Submitted as Parts of this Dissertation

Publication	**Kundisch, D., Meier, C., 2011.** IT/IS Project Portfolio Selection in the Presence of Project Interactions - Review and Synthesis of the Literature, *Wirtschaftsinformatik Proceedings, Zürich*.
Contribution to joint work with co-authors	Co-authorship with Prof. Dr. Dennis Kundisch (60% C. Meier, 40% D. Kundisch) - Literature review by C. Meier - Positioning of the Paper together with D. Kundisch - Framework development by C. Meier, comments and corrections by D. Kundisch - Concretization of the contributions together with D. Kundisch - Write-up of the paper by C. Meier. Feedback, comments and corrections by D. Kundisch
Conferences/ Workshops/ Seminars	The paper was presented at the following conferences, workshops, and seminars: - Department Research Seminar Business Information Systems, Paderborn, 2011 - Internationale Tagung Wirtschaftsinformatik, Zürich, 2011
Scientific Dissemination	The work on this paper started in January 2010. A short version of the Paper has been published in Lecture Notes in Informatics 2010 and has been presented at the GI Jahrestagung INFROMATIK 2010 in Leipzig, Germany. The full paper was finally accepted for presentation at Internationale Tagung Wirtschaftsinformatik 2011 in Zürich, Switzerland and for publication in the conference Proceedings (VHB Jourqual Ranking 3: C, Orientierungslisten der Wissenschaftlichen Kommission Wirtschaftsinformatik: A) on November 22nd 2010.

Publication	**Kundisch, D., Meier, C., 2011.** A new Perspective on Resource Interactions in IT/IS Project Portfolio Selection, Proceedings of the European Conference on Information Systems, Helsinki.
Contribution to joint work with co-authors	Co-authorship with Prof. Dr. Dennis Kundisch (70% C. Meier, 30% D. Kundisch) - Positioning of the Paper together with D. Kundisch - Literature review by C. Meier - Concretization of the research questions joint with D. Kundisch - Definition of Types of resource interactions and development of identification process together with D. Kundisch - Development and formulation of mathematical decision model by C. Meier - Write-up of the paper by C. Meier. Feedback, comments and corrections by D. Kundisch
Conferences/ Workshops/ Seminars	The paper was presented at the following conferences, workshops, and seminars: - European Conference on Information Systems (ECIS), Helsinki, 2011 - Department Research Seminar Business Information Systems, Paderborn, 2012
Scientific Dissemination	Work on this paper started in July 2010. The paper was finally accepted for presentation as a research in progress paper at European Conference on Information Systems 2011, Helsinki, Finland and for publication in the conference Proceedings (VHB Jourqual Ranking 3: B, Orientierungslisten der Wissenschaftlichen Kommission Wirtschaftsinformatik: A, acceptance rate ~31%) on March 3rd 2011.

Publication	**Meier, C., 2014.** Identifying Output Interactions Among IS Projects – A Text Mining Approach. Working Paper, University of Paderborn.
Contribution to joint work with co-authors	Single authored paper.
Conferences/ Workshops	The paper was presented by C. Meier at the following conferences and workshops: - Department Research Seminar Business Information Systems, Paderborn, 2013 - European Conference of Information Systems (ECIS) 2013, Utrecht, Netherlands
Scientific Dissemination	Work on this paper started in March 2012 - Earlier versions of this paper have been published as a research in progress paper in the Proceedings of the European Conference of Information Systems, Utrecht, Netherlands, 2013 (VHB Jourqual Ranking 3: B, Orientierungslisten der Wissenschaftlichen Kommission Wirtschaftsinformatik: A, Acceptance Rate: 30%) - Current Version: November 2014

Publication	**Meier, C., Kundisch, D., Willeke, J. 2015.** Is it worth the Effort? – A Decision Model to Evaluate Resource Interactions in IS Project Portfolios**.** Working Paper, University of Paderborn.
Contribution to joint work with co-authors	Co-authorship with J. Willeke and D. Kundisch (65% C. Meier; 20% J. Willeke, 15% D. Kundisch) - Joint development and concretization of research question - Positioning of the paper by C. Meier and D. Kundisch - Literature review by C. Meier, supported by J. Willeke - Development of the decision Model by C. Meier and J. Willeke - Development of procedural approach by C. Meier, supported by J. Willeke - Write-up of the first draft by C. Meier. Feedback, comments and corrections by D. Kundisch - Write-up of the first paper revision for *Business & Information Systems Engineering* by C. Meier. Feedback, comments and corrections by D. Kundisch - Write-up of the response to the reviewers and revision of the paper for first round of review at *Business & Information Systems Engineering* by C. Meier. Feedback, comments and corrections by D. Kundisch and J. Willeke
Conferences/ Workshops	Mini-Poster presentation at Internationale Tagung Wirtschaftsinformatik 2013, Leipzig, Germany.* *: Presentation by a co-author.
Scientific Dissemination	- Work on this paper started in December 2011 - First draft: July 2012, accepted for Mini-Poster presentation at Internationale Tagung Wirtschaftsinformatik 2013, Leipzig, Germany - Current version: June 2015, currently under review for publication in *Business & Information Systems Engineering Journal* (VHB Jourqual Ranking 3: B, Orientierungslisten der Wissenschaftlichen Kommission Wirtschaftsinformatik: A), 3rd and final review round, accepted with minor revisions.

Publication	**Meier, C., Zimmermann, S., Nicolau, V. 2015**. The Impact of Human Resource Sharing on IT Project Risk. Working Paper, University of Paderborn.
Contribution to joint work with co-authors	Co-authorship with S. Zimmermann and V. Nicolau (75% C. Meier; 20% S. Zimmermann, 5% V. Nicolau) - Acquisition and construction of the dataset by V. Nicolau - Literature review by C. Meier, supported by V. Nicolau - Concretization of the research question and positioning of the paper by C. Meier and S. Zimmermann - Hypotheses development, statistical modelling and conduction of all statistical analyses by C. Meier, supported by S. Zimmermann - Write-up of paper by C. Meier. Feedback, comments and corrections by S. Zimmermann
Conferences/ Workshops	Submitted as completed research Paper to International Conference on Information Systems 2015, Fort Worth, USA.
Scientific Dissemination	Work on this paper started in December 2014. The paper has been accepted for publication in the proceedings of the International Conference on Information Systems 2015. (VHB Jourqual Ranking 3: A, Orientierungslisten der Wissenschaftlichen Kommission Wirtschaftsinformatik: A)

1.5. Erklärung zu Arbeiten in Koautorenschaft

Ich, Christian Meier, erkläre hiermit, dass keine der als Teil dieser Dissertation vorliegenden Studien Gegenstand eines anderen laufenden oder abgeschlossenen Promotionsverfahrens der Fakultät für Wirtschaftswissenschaften an der Universität Paderborn ist.

Paderborn, den …….. …….

(Unterschrift Christian Meier)

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