ADVANCING THE MATURITY OF PROJECT PORTFOLIO MANAGEMENT THROUGH METHODOLOGY AND METRICS REFINEMENTS

By

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A thesis submitted in partial fulfillment of the

requirements for the degree of

Doctor of Project Management (DPM)

Royal Melbourne Institute of Technology,

RMIT University

December 24, 2010

Declaration by the Candidate

I declare that the work presented in this thesis is, to the best of my knowledge, original except where acknowledged otherwise in the text. No part of this document has been previously submitted for a degree of any kind at this or any other academic institution.

The work presented has been carried out during the course of my academic program (as noted herein) but forms part of my on-going professional and research activities in keeping with the aims and objectives of the Doctorate in Project Management (DPM) degree.

Mario Arlt

Princeton, December 24, 2010

Reader's Note

The author of this Doctoral Thesis is a resident of the Unites States of America, employed and supported in his studies by U.S.-based ESI International. As such, spelling, grammar and terminology follow the rules of American English throughout this document. The majority of the literature used for this thesis is English language publications. Several foreign language sources (German and French) have been used; for those non-English sources, short translations of references are provided.

ABSTRACT

ADVANCING THE MATURITY OF PROJECT PORTFOLIO MANAGEMENT THROUGH METHODOLOGY AND METRICS REFINEMENTS

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This thesis presents enhancements to the theory of and practices in project portfolio management, specifically in refinements to methodology, measurement and alignment with strategic planning.

Project portfolio management is the practice for evaluating, selecting and managing in an integrated manner a portfolio, which consist of projects, programs and other related work. Several studies on current practices in portfolio management have indicated a rather low maturity level of organizations in regard to project portfolio management. From the perspective of theory, this appears to be both the result of a relatively immature discipline and a rather technical approach to what is a human decision problem. Whereas salient literature focuses on portfolio management as a constrained optimization problem, it is suggested that it is necessary to define the complexity challenge of portfolio management beyond the mathematical aspect. In this respect, the managerial aspect of dealing with uncertainty and dynamic goals and constraints, the process aspect of an iterative and complex business problem and the behavioral aspect characterized by cognitive limitations, bounded rationality and political bias need to be captured.

This thesis addresses several of these complexity aspects, which are based on knowledge from the project management discipline, as well as other scientific disciplines, specifically decision, behavioral and management science.

Contributions to theory and practice of project portfolio management focus on several areas. The author lays out a five-step approach toward defining the most suitable methodology for the selection of portfolios from the numerous methods and techniques that have been discussed in current literature. Although most of the methods described in the prevailing literature take a project-centric approach toward portfolio evaluation and selection, the author attempts to articulate a more holistic view by emphasizing interdependencies between projects within a portfolio. Following this notion, five types of interdependencies are proposed, and methods and techniques for identifying and addressing these interdependencies are introduced.

A second theme of this thesis is the adequate selection of metrics for both outcomes and process. Even though several debates exist in management science about how, how much and what to measure, little attention has been given to the measurement topic in association with project portfolio management. This is surprising, inasmuch as portfolio management can provide a qualitative and quantitative sanity check for the attainability of strategy, the need for resources and funds to implement certain strategic themes as well as other critical information. Rather than taking a prescriptive approach toward metrics, the author focuses on a simple metrics taxonomy and the tools to develop and evaluate metrics for their relevance, quality and viability.

Lastly, this work discusses the reconciliation of potential misalignments between strategy and project portfolios, and achieving strategic alignment beyond the top-down view of strategic fit.

The five propositions introduced by the author are validated with the help of a case study and a human subject experiment.

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ACKNOWLEDGMENTS

I would like to express my sincere gratitude to Dr. Derek Walker, Professor of Project Management and Director Graduate Research Programs, RMIT University, for his inspiration and guidance in my journey through the Doctorate in Project Management program at RMIT. Furthermore, I would like to thank Dr. Ginger Levin for her coaching through this challenging and exciting thesis effort, together with Dr. Jens Grossklags, Princeton University, for his insightful recommendations and fruitful discussions around the experimental validation, as well as the thesis examiners for their comments and recommendations.

I owe my deepest gratitude to my clients, who I have been privileged to serve as an advisor and coach over the past 15 years and who have been confident and trusting in my ability to assist them in mastering challenging projects, programs and portfolio management improvement efforts.

I am also indebted to my past and present colleagues and my staff, as well as the executives who have supported my doctoral studies over the past six years, especially Dr. Juergen Kazmeier, Vice President of the Software Engineering, Siemens IT Solutions; Mr. Charlie Edwards, CEO and President of Siemens Demag Delaval; and Mr. John Elsey, CEO of ESI International.

Last but not least, I would like to thank my parents and my partner Michelle for their love and immense support through these years of hard work.

LIST OF FIGURES

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ABBREVIATIONS

AHP	Analytical Hierarchy Process
ANP	Analytical Network Process
ANSI	American National Standards Institute
BOCR	Benefits, Opportunities, Costs, and Risks
BSC	Balanced Score Card
CAPM	Capital Asset Pricing Model
CEO	Chief Executive Officer
CMM	Capability Maturity Model®
CMMI®	Capability Maturity Model® Integrated
COCOMO	Constructive Cost Model
COSYSMO	Constructive Systems Engineering Cost Model
CPIC	Capital Planning and Investment Control
CSF	Critical Success Factor
DPM	Doctorate in Project Management
EAC	Estimate at Completion
ECV	Expected Commercial Value
GQM	Goals, Questions, Metrics
IRB	Institutional Review Board for Human Subjects
IRR	Internal Rate of Return
ISM3	Information Security Management Maturity Model
IT	Information Technology
KPI	Key Performance Indicator
MPT	Modern Portfolio Theory
MSP	Managing Successful Programs
NPV	Net Present Value
OCIO	Office of the Chief Information Officer
OGC	Office of Government Commerce (U.K.)
OPM3®	Organizational Project Management Maturity Model
PERT	Program (or Project) Evaluation and Review Technique
PEST	Political, Economic, Social, and Technology

PLESS	Princeton Laboratory for Experimental Social Science
PM	Project Management
PMBOK®	Project Management Body of Knowledge[1]
PMI®	Project Management Institute[2]
PMO	Project Management Office
PMP	Project Management Professional
PPM	Project Portfolio Management
PV	Present Value
R&D	Research and Development
RBS	Risk Breakdown Structure
RMIT	Royal Melbourne Institute of Technology
ROI	Return on Investment
ROM	Rough Order of Magnitude
SDLC	Systems Development Life Cycle
SWOT	Strengths, Weaknesses, Opportunities and Threats
WBS	Work Breakdown Structure

[1] "PMBOK" is a trademark of the Project Management Institute, which is registered in the United States and other nations.
[2] "PMI" is a service and trademark of the Project Management Institute, which is registered in the United States and other nations.

PUBLICATIONS AND PRESENTATIONS

During the course of my participation in the Doctor of Project Management program, my work has been accepted for publication and for presentation through the following peer-reviewed publications, books, one patent and international conferences and professional seminars.

Publications

Walker, D.H.T., Aranda-Mena, G., Arlt, M. and Stark, J. (2008). "E-Business and Project Procurement." in *Procurement Systems: A Cross-Industry Project Management Perspective.* Walker, D.H.T. and Rowlinson, S. (eds.) New York, Taylor and Francis.

Walker, D.H.T., Arlt, M. and Norrie, J. (2008). "The Role of Business Strategy in PM Procurement" in *Procurement Systems: A Cross-Industry Project Management Perspective.* Walker, D.H.T. and Rowlinson, S. (eds.) New York, Taylor and Francis.

Walker, D. H. T., Stark, J., Arlt, M. and Rowlinson, S. (2008). "Introduction and Procurement Fundamentals." in *Procurement Systems: A Cross-Industry Project Management Perspective.* Walker, D.H.T. and Rowlinson, S. (eds.) Taylor and Francis, New York.

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U.S. Patent

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Standards of the Project Management Institute (Contributor Role)

PMI (2008). *The Standard for Portfolio Management.* 2nd ed. Newtown Square, PA, Project Management Institute, Inc.

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Seminars and Other Presentations

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Arlt, M. (2007). Understanding PPM – How to Make the Case for the "Right" Six Sigma Project and Achieve Executive Commitment. Siemens Six Sigma Global Conference Presentation, Siemens AG, Boston, MA, April, 2007.

Arlt, M. (2006). Improving Outcomes of Project Portfolio Management through Refining the Preparatory process Steps Prior to the Portfolio Selection. Second Doctoral Seminar on Research in Strategy, Project and Programme Management. ESC Lille, Lille, France, August, 2006.

1. THESIS INTRODUCTION

1.1 Chapter Introduction and Objective

This introductory chapter provides context for this doctoral research work, including efforts within the author's doctoral studies leading up to this thesis work as part of the Doctor of Project Management (DPM) program as well as other related academic and practitioner experience. This chapter further provides the context and rationale for the topic selection and areas of focus prior to introducing three central research themes and five related propositions that are investigated and validated in subsequent chapters. Furthermore, the research method and approach toward validation of the propositions are explored; and the justification and contribution of the thesis are discussed. The chapter concludes with an explanation of the logical structure of the thesis. Chapter 1 serves the objective of preparing the reader for understanding goals, scope and limitations of the thesis, of explaining the research approach and of justifying it in more general terms as following chapters pursue the arguments in detail.

1.2 Thesis in the Context of the DPM Program

The DPM program of the RMIT University facilitates the transition from understanding of and reflecting on state-of-the-art knowledge in the various project management disciplines to developing new concepts and approaches (Walker, 2008). This is accomplished by providing both knowledge and "tooling" for the research and concept development, which is required in the context of a doctoral thesis. Throughout the curriculum I had the opportunity to develop elements of the conceptual framework, which have been reused in this thesis and have furthermore contributed to research work in collaborative efforts with Dr. Derek Walker, such as the textbook on "Procurement Systems"(Walker and Rowlinson, 2008).

An additional contributing factor has been the thesis work of Dr. James Norrie, a recent graduate of the DPM program, who investigated project portfolio management (PPM) in a public sector setting and provided both insight and inspiration on the topic from a different, yet related, perspective (Norrie, 2006).

As illustrated in Figure 1-1, the ultimate goal of the DPM thesis work is to develop new systems, approaches and tools, by way of enhancement and re-application of concepts in a new context plus the development of novel concepts and performance measurement agents. Two paths toward the goal are feasible: First, from auditing the "as-is" situation, followed by proposing a "to-be" state, to developing a new approach; or second, from the "as-is" situation, through incremental modification or re-contextualization, to the development of a new and enhanced theory. The approach of this thesis predominantly embraces the Q1→Q2→Q4 route, whereas the case for the path Q1→Q3→Q4 could be made for some aspects.

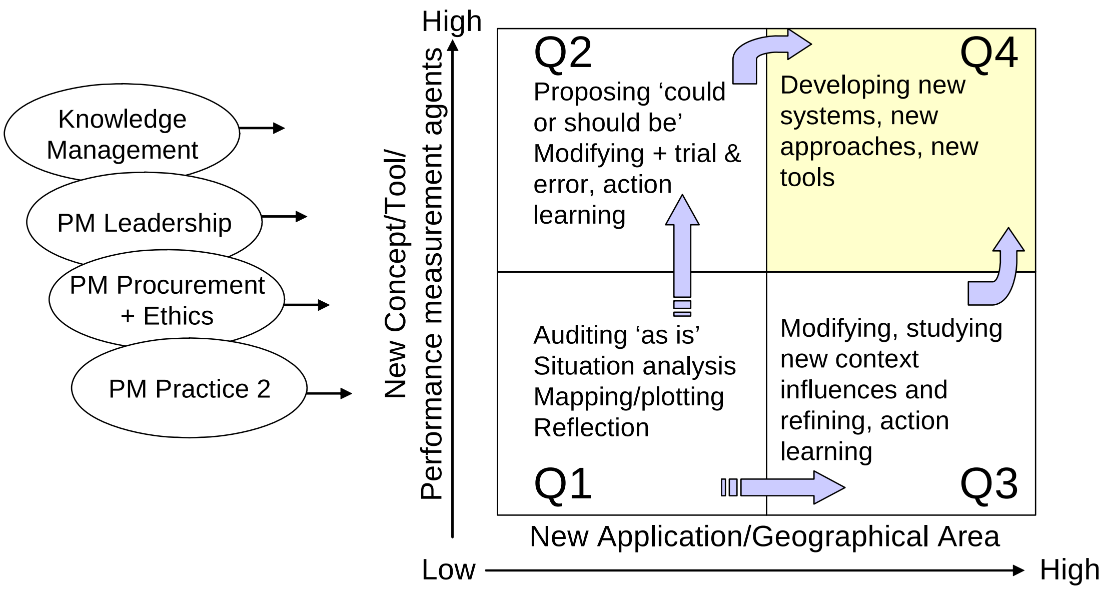

Figure 1-1: Contribution to Practice and Theory (Walker, 2006)

1.3 Professional and Academic Background of the Author

Three pillars have set the foundation for this research effort. First, my academic background: Starting with my earning an M.S. degree in Economics, from the University of Konstanz, a leading German university[3], professional certifications (such as the Project

[3] As of 2009, the University of Konstanz is recognized by the newly established "Excellence Initiative" of the German Federal Ministry of Education and Research and the German Research Foundation as one of the nine leading universities in academic research and education in Germany.

Management Professional (PMP®) and the *OPM3*® Assessor and Consultant from the Project Management Institute), as well as my first years of the DPM curriculum have influenced both this research topic and my approach. Since working on my master's thesis[4], I have been exposed to financial portfolio management, a discipline that has significantly influenced project portfolio selection methods. I have also had the opportunity to contribute to several quantitative research efforts at the Faculty of International Finance at the University of Konstanz. Furthermore, I gained valuable teaching experience in 2007 and 2008 as an instructor in the Master of Science in Project Management program at the University of Wisconsin-Platteville.

Second, five years of applied research in project portfolio management as a Senior Manager at Siemens Corporate Research in Princeton, New Jersey, USA, leading the Siemens' Process and Project Management Group, has contributed valuable insight from both the academic and practitioner perspective. The research work that my team and I conducted was initially inspired by the execution of many organizational project management assessments, which revealed an increasing level of process maturity in the project management domains over time. However, what most of the assessed organizations did not target for improvement were portfolio selection and management processes, which—although not thoroughly assessed—showed strong indications of very low maturity, such as the lack of process definition, conflicting projects, chronic resource conflicts and the frequent choice of projects counterintuitive to organizational objectives. As a result, I made project portfolio management a priority for applied research in order to provide the group's clients with solid recommendations on how to properly approach project portfolio management. One output of the research efforts related to a "System and Method for Improved Project Portfolio Management," was filed as U.S. Patent Application US 2006/0129439 A1 (Arlt and Munoz, 2006). During this time period, I also had the opportunity to contribute to the first and second editions of *The Standard for*

[4] The master's thesis "Risk control systems – Concept and exemplified implementation" elaborated on financial portfolio risk management, control concepts and systems. Original title: "Risikosteuerungs-systeme – Konzept und Umsetzung an einem Beispiel", University of Konstanz, Germany, 1996.

Project Portfolio Management, published by the Project Management Institute (PMI, 2006;2008c).

Lastly, during the past 15 years, I have actively managed and provided consulting services on small- to large-scale projects, programs and project portfolios in the financial services, banking, automotive, pharmaceutical, high technology, retail and energy sectors in Europe and the Americas. The exposure to the financial services and banking sectors, with an emphasis on the management of financial portfolios and portfolio risk management, especially influenced my early thoughts on project portfolio management.

In the years 2007 and 2008 as the Director of Strategy Planning and Implementation at Siemens Energy Services, I had responsibilities for a research and development (R&D) project portfolio. Since 2008, I have been in charge of a project management organization and am providing project and portfolio management advisory services to clients of ESI International, a global training and consulting firm focusing on project management, business analysis and contracting. My academic and professional experience have together contributed the necessary and relevant intellectual property that permit me to reflectively draw upon my close exposure to project, program and portfolio management. Reflective knowledge is used as data in this DPM research thesis and can be compared to having interviewed other experts with similar knowledge of this domain to obtain comparable data and insights (Raelin, 2007).

The three pillars of academic research, applied research and practitioner experience have jointly contributed to the identification of the research problem and the resulting approaches developed in this thesis.

1.4 Context and Rationale for the Selected Area of Research

Project portfolio management has become a significant research area only in the last fifteen to twenty years, while the project management profession has been maturing considerably for more than half an century (Pellegrinelli, 1997; Artto, Martinsuo, Gemünden and Murtoaro, 2009) and has been recognized as a factor with macroeconomic relevance (Cleland, 1999). One indicator for the increasing magnitude of project and portfolio management importance is provided by Hoffmann, Rollwagen and Schneider (2007), who forecasted that in 2020 projects will contribute 17% of the value created in the German economy compared to 2% in 2007.

From the academic perspective, project management "tools of the trade" have been continuously improved over time; however, the real-world implementation success appears to be widely lagging. Having assessed a large number of project management organizations over the past 10 years, the majority of organizations analyzed have exhibited a rather low maturity in respect to project management and portfolio management and, as a result, could be characterized as "initial." This observation is confirmed by surveys, such as the frequently cited CHAOS report of the Standish Group[5], which has bi-annually provided empirical data for project success over the last 16 years for a large number of organizations. According to the most recent report in 2009, only 32% of projects were deemed successful, whereas 44% were considered challenged and 24% were considered failures. It shall be noted that there is significant discussion around the limitations of the CHAOS report, such as its surveying approach and other shortcomings (Sauer, 1993; Gemino, Sauer and Horner-Reich, 2007). However, most of the critique is directed at the sole use of triple constraint measures as a proxy for project success. This topic is further discussed in Section 2.2.1 in the context of the evolution of project management and the measurement of project success.

Project portfolio management can play an essential role in the context of improved success rates: for example, a well-performed PPM process (see Chapter 2, specifically 2.4) guides the selection of those projects, which have a high probability of success, guided by attainable business cases. In the presence of such process, interventions will occur swiftly when a project gets off track. Moreover, project portfolio management can reduce the number of risks that result from dilution of resources—that is, the selection of

[5] The CHAOS report defines project success based on the original "triple constraint" as the successful achievement of project scope, on time and within the given budget. See www.standishgroup.com.

the wrong mix of projects and too many projects are exhibited in many portfolios (Cooper, Edgett and Kleinschmidt, 2001a, p. 73), which in turn leads to resource shortages and misallocations.

1.4.1 PPM Complexity – The Mathematical Aspect

In the project portfolio management context, early research was focused on the "mechanics" of the optimal *project portfolio selection* (Engwall and Jerbrant, 2003), which constitutes a complex managerial problem. Snowden and Boone (2007) found that large numbers of interacting elements, non-linearity of interactions, dynamics and a lack of predictability to be the characteristics of complexity. In line with these findings, the complexity problem in portfolio management is a function of several specifics of PPM, which in most cases makes portfolio decisions exceedingly difficult for those individuals involved. Most recognized in the literature is the mathematical aspect of complexity. A *multitude of goals and constraints* is to be recognized in the portfolio selection (Archer and Ghasemzadeh, 1996). In addition, candidate portfolios can exhibit *large numbers of possible choice sets* that, following the mathematical logic of combinatorics, increase exponentially with the number of projects in a candidate portfolio and that reach a high degree of complexity for even relatively small portfolios. Furthermore, resource and financial *constraints can be complex,* but must be considered, as the availability of funds and adequately qualified staff constitute boundaries for PPM (Cooper et al., 2001a, pp. 21-23).

1.4.2 PPM Complexity – The Managerial Aspect

In addition to the mathematical aspects that relate to the complexity of a constrained optimization problem, managerial aspects come into play as a second set of complexity factors. *Interdependencies* between projects must be taken into account, as projects cannot be considered in isolation (Archer and Ghasemzadeh, 1996). Although little attention in the literature has been directed to project interdependencies in project portfolios (Chien, 2002), such interdependencies must be recognized as an important decision-making factor. In 2009 the author of this thesis conducted a global project portfolio management survey, which provided evidence of several symptoms that are indicative of current portfolio management immaturity (see Section 2.7 for details). Asked whether interdependencies between projects were clearly articulated and well understood, only 38.6% of survey respondents agreed that they were. Furthermore, 71% reported redundancies and conflicts in respect to project priorities. Moreover, future outcomes of projects are by definition *uncertain,* as *the* success of a project is unknown before and mostly during the execution of the project. Lastly, goals and constraints are *dynamic* (Engwall and Jerbrant, 2003)[6], as they may change over time, which may lead to the necessity of changing the portfolio composition.

Both mathematical and managerial aspects of complexity, as summarized in Figure 1-2, lead to the human aspect of complexity in portfolio decisions, such as cognitive limitations of decision makers (to be analyzed in Section 2.2.5). Lastly, the process aspect of complexity is discussed in 2.4.4.

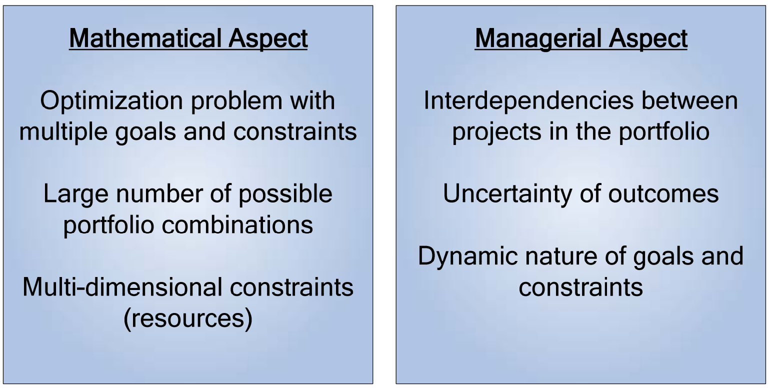

Figure 1-2: PPM Complexity: Mathematical and Managerial Aspects

Early literature on project selection was especially dominated by the discussion of mathematical models for portfolio selection (see Hall and Nauda, 1990). The challenge of selecting portfolios was typically approached as a mathematical problem, which could be "solved" through constrained optimization using numerical models and techniques, with the outcome being an "optimal" portfolio. Numerous methods have been developed,

[6] As Engwall and Jerbrant (2003) point out, only few researchers elaborate on the dynamic nature of portfolio management and how portfolio managers coordinate such dynamic portfolios.

many of them have been coded into software to address the aforementioned mathematical complexity issues and hence to simplify the portfolio selection, which, as stated earlier in this chapter, tends to become overwhelming with an increasing number of choice sets. However, even if complex mathematical algorithms were to be performed with sophisticated software, the framing of the problem and its parameters still remains a challenge. Lastly, intuitive, non-numerical approaches have been introduced and continue to be applied as well (see Chapter 3 for more detail). Most of PPM literature observes existing or proposes new selection methods in theory and practice. However, the questions of which of these countless methods is most suitable for an organization and how to choose the "right" portfolio selection method remains vastly unexplored (Cooper et al., 2001a, p. 15).

The topics of *portfolio management metrics and measurement* at the portfolio level are only peripherally discussed in academic project management literature, mostly implicit with the discussion of selection methods, but hardly as a subject of explicit investigation. For example, although the Project Management Institute recognizes the importance of adequate metrics (PMI, 2008c, p. 18) and other authors propose metrics taxonomies for project and portfolio management (Rad and Levin, 2006), a structured "how-to" approach for defining and selecting those metrics, which best allows the evaluation of both candidate and ongoing projects, does not exist. In addition, little emphasis is given to those metrics, which allow the evaluation of consistent execution and continuous improvement of project and portfolio management processes (Cooke-Davies, 2004).

While practitioners may still be in catch-up mode implementing project management fundamentals, research is progressing toward greater *strategic alignment* of project management with the overall organizational context. In this respect, improvements toward integrating project and portfolio management with organizational strategy are discussed (Pellegrinelli and Bowman, 1994) and the general approach toward project management research has been revisited by some researchers (Cicmil and Hodgson, 2006). One of the main research directions represented by Shenhar, Morris and other academics in the field (discussed in Section 2.3) surrounds the notion of project strategy and the close alignment of projects with organizational strategic intent (Shenhar, Poli and Lechler, 2001a; Morris, 2004; Morris and Jamieson, 2004; Artto, Martinsuo, Dietrich and Kujala, 2008). If validity to strategic project management exists, PPM would need even more to be strategic, because of its role in implementing strategy through the appropriate selection and realization of those projects, which best implement strategy. This thesis aspires to contribute to a more strategic and holistic perspective of PPM than that which is currently found in the literature. In their analysis of trends in project management research, based on key publications in the field, Crawford et al. (2006) identify a strong and increasing interest in the topic of strategic alignment since the mid-1990s and suggest that strategic alignment could form a progressively dominant aspect of project management research.

In an interdisciplinary research effort, Kwak and Anbari (Kwak and Anbari, 2008) analyzed the leading journals in Operations Research, Management Science and Behavioral Science. Although PPM in this project management-centric research study was viewed as an "allied discipline," the study revealed the significance and increased attention to the topics of strategy and portfolio management in the broader literature, that is, beyond project management publications, such as the *Project Management Journal*, the *International Journal of Project Management* and the *International Journal of Managing Projects in Business.* The increased attention to strategy and project portfolio management is illustrated in Table 1-1.

Table 1-1: Journal Publication Trends (Source: Kwak and Anbari, 2008)

Number of articles with reference to—	**1950–1959**	**1960–1969**	**1970–1979**	**1980–1989**	**1990–1999**	**2000–2007**	**TOTAL**
Strategy/PPM	2	10	48	74	78	83	295

In a subsequent publication, Kwak and Anbari (2009) further conclude the growing importance of strategy and PPM toward project management as a discipline.

Although pertinent literature makes a case for the need for strategic project management and strategic alignment of projects, two key questions remain unanswered.

First, does a given portfolio implement the set strategy in full, or do gaps exist? And second, does the project portfolio contain any projects that are not aligned with the current strategy but are in fact justified and the strategy should be amended? The literature in the related discipline of new product development makes the case for recognizing this important gap. Based on the findings from a large-scale survey, Cooper et al. (2001a, p. 11) suggest that many organizations, which defined business and product strategies and articulated strategic areas of focus, did not manage to match R&D resources and funds adequately with goals and strategies.

1.5 Research Themes, Propositions and Rationale

As project portfolio management is maturing as a discipline (Chapter 2 will further elaborate the evolution of the discipline and its current state), empirical evidence suggests that despite these advances, significant opportunity exists for achieving increased benefits from PPM (Cooke-Davies, 2004). This thesis uses a three-pronged approach toward contributing to the improvement of the project portfolio management maturity, based on gaps in literature and deficiencies in today's PPM practice, developed in reflection of the author's research, practitioner work and consulting in the field of project portfolio management. This thesis investigates improvements in project portfolio management in the following areas: (1) refinement of the portfolio selection methodology, (2) consistent and integrated approach to measurement, and (3) tight integration of strategic and portfolio management processes (see Figure 1-3).

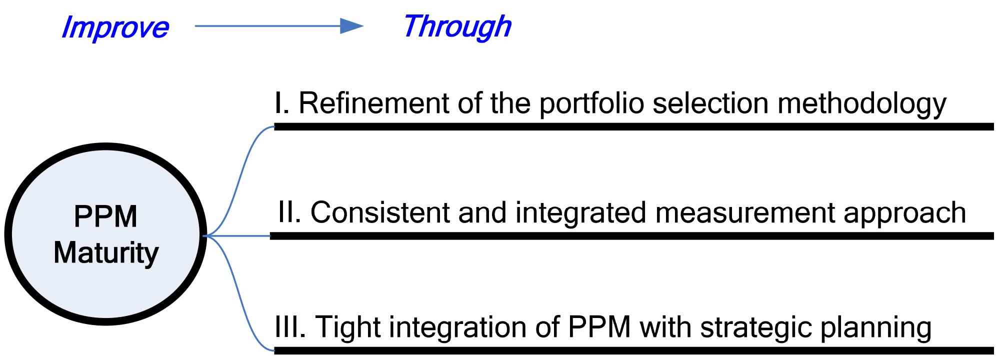

Figure 1-3: Three Research Themes

At this stage it should be noted that these themes relate primarily to the early phases of the portfolio management process. Similar to the project management life cycle, the first critical steps are taken during the preparatory stage, which is where projects are put on track for success or failure through the definition of work scope and attainment of stakeholder buy-in (Arlt, 2009a). The same case can be made for project portfolio management: "[M]anagement teams in successful and innovative companies fully understand that some of the greatest opportunities reside in the fuzzy front end or definition phase… The key to realizing the opportunities that the fuzzy front end presents is to 'tame' the fluid and ambiguous nature of this phase" (Milosevic, Martinelli and Waddell, 2007, p. 40). The term "fuzzy front end," generally accepted as the greatest improvement opportunity in product development life cycles, was coined in the context of the management of new product development projects and programs; but similar to the more general project portfolio management, it covers conceptual development and preparation, including opportunity identification and analysis, idea generation and enrichment, idea selection, and concept definition (Koen, Ajamian, Boyce, Clamen, Fisher, Fountoulakis, Johnson A. and Seibert, 2002).

To provide epistemological evidence for the merit of improvements in these three areas toward the maturing of project portfolio management, five propositions are established and validated. From an epistemological perspective, this thesis attempts to substantiate these propositions as being reasonable and likely to be true.

1.5.1 Theme I: Refinement of the Portfolio Selection Methodology

Current PPM literature provides a large number of project selection methods and techniques. More than 100 methods and techniques[7] for project selection are discussed in the related literature (Hall and Nauda, 1990; Dye and Pennypacker, 1999), and their advantages and disadvantages are debated at length (Ghasemzadeh, 1998; Archer and Ghasemzadeh, 1999a). However, there appears to be little or no guidance on how to

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[7] The terms methodology, method and technique are used rather loosely. A clarification and a systematic approach are provided in the context of Chapter 3.

choose the right selection method for a particular organization or portfolio type. Cooper et al. (2001b) come to the conclusion that "in spite of the many methods proposed in the early days, there was a remarkable lack of follow-up… few authors ever describe attempts to actually implement their methods and to gauge their feasibility" (Cooper et al., 2001a, p. 15). Archer and Ghasemzadeh (1996) summarize their investigation that "no dominant school of thought" has emerged. Cooper et al. (2000) concluded that most project selection tools do not provide the capability to discriminate between projects, and in reality too many projects are executed and fall short of delivering the intended benefits. As a result, Proposition 1 attempts to provide a structured approach toward the choice of methods and techniques, which constitute a portfolio selection methodology:

Proposition 1 – Systematic choice of project selection methods
A structured process for the choice of all methods and techniques, which constitute the portfolio selection methodology, carefully selects from available options and recognizes the influence of organizational culture, maturity and information availability. *The proposition is discussed in Section 4.3.*

Methods and techniques discussed in the literature approach the selection of project portfolios predominantly as project-by-project decisions[8] rather than as a holistic and portfolio-centric decision (Martinsuo and Lehtonen, 2007). The fact that most of the literature uses the term "project selection" instead of "portfolio selection" provides further indication toward this current approach. Although this may appear at first as a semantic difference, in fact little attention is given to linkages between projects in the portfolio, which ultimately impact optimal portfolio choices. The lack of emphasis on interdependencies between projects is recognized by several authors (Schmidt, 1993; Rungi, 2010). Meanwhile, most portfolio selection methods that have been discussed in

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[8] A proper definition of portfolio management is provided in Chapter 2 and entails more than the management of only projects, but also includes programs, sub-portfolios and other related work. As most of the literature refers to the underlying projects only, going forward the term project will be used as a generic definition for the more broadly defined underlying of PPM.

the literature offer a project-centric rather than holistic portfolio view when selecting the choice set of project opportunities to pursue. Proposition 2 builds upon this conclusion:

Proposition 2 – Emphasis on portfolio-centric vs. project-centric selection activities

Understanding the dimensions and characteristics of interdependencies between projects in a portfolio, and further qualifying and quantifying them, will lead to improved outcomes in the selection of portfolios and ultimately greater project portfolio management maturity.

This proposition is elaborated in Section 4.4.

1.5.2 Theme II: Consistent and Integrated Measurement Approach

Performance measurement as a topic area has been widely researched in management science. Many examples of successful companies illustrate how the mastery of analytics does not just empower better decision making and efficiency gains, but can create significant competitive advantage (Davenport, 2006).

Whereas measurement efforts in many organizations used to focus solely on financial metrics, the introduction of the Balanced Scorecard (Kaplan and Norton, 1992) as a tool for organizational goal setting has shifted the direction of measurement to a more diversified picture of financial and non-financial metrics (see Section 6.2 for further elaborations)[9]. Beyond the organizational strategy level, project and portfolio management literature offer a large variety of success factors and corresponding metrics (Fortune and White, 2006); however, a gap exists in regard to a consistent and integrated measurement approach, which entails the selection of those metrics, which ultimately influences portfolio decisions. What applies to the wide range of selection methods can also be said about portfolio metrics. There is an abundance of financial, non-financial and process metrics at the disposal of portfolio managers to be used for proper prioritization of projects and the driving of PPM maturity; however, a consistent approach toward

[9] It should be noted that French engineers in the early twentieth century developed a similar dashboard, the "tableau de bord," which exhibits much similarity with the Balanced Scorecard. A comparison of the two methods can be found in Epstein, M. J. and Manzoni, J. (1997). "The balanced scorecard and tableau de bord: Translating strategy into action." *Management Accounting*. **August 1997**: 28-36.One recent resource on the tableau de bord is Boix, D. and Feminier, B. (2004) *Le tableau de bord facile,* Paris, Livres Outils.

developing and selecting portfolio metrics and an end-to-end measurement process is lacking. Davenport points out the significance of proper management by metrics, establishes a business case for investing in measurement and analytics and outlines how organizations achieve advantages over their competitors by effectively and efficiently collecting, analyzing and acting upon data, such as in the R&D arena, where companies like Yahoo, Novartis and Amazon have managed to consistently improve quality and efficacy of products and services by setting the right "focus on those functions or initiatives that together serve an overarching strategy" (Davenport, 2006, p. 6).

Further evidence is provided by Martinsuo and Lehtonen, who conducted an extensive literature study on PPM success factors and highlight that "studies that combine qualitative and quantitative methods have either explored the relationships or contingency factors between a specific set of success factors and criteria or further investigated project management as a capability for achieving repeated success through projects. As relevant project management related factors, standardization, metrics and measurement and some others have been emphasized" (Martinsuo and Lehtonen, 2007, p. 58). As a result of this thought process, Proposition 3 addresses the following:

Proposition 3 – Choice of effective metrics on strategic, portfolio and project levels

A process guideline to help selecting and defining metrics systematically, in line with organizational goals and cognizant of organizational maturity, increases the focus on achieving the portfolio management goals.

The proposition is discussed in Section 5.3.

The 2009 global PPM survey, discussed in Section 2.7, reconfirmed for portfolio management what I had the chance to observe in numerous project management assessments of organizations[10] of low maturity—a relatively high level of confidence

[10] These CMMI®- and OPM3®-based assessments typically focused on four key elements: (1) appropriate process definition for all phases; (2) adherence to process *and* proper exception handling (a) for those projects that do not meet deliverable/time/cost expectations and (b) in case of a change in strategy, which should trigger portfolio-reshuffle; (3) integration of PM and PPM with other business processes; and (4)

despite clear indications of immaturity: 71% of the participants considered their organizations somewhat mature, mature or very mature. However, the same exact percentage of participants reported significant redundancies and conflicts in project priorities, and fewer than half of the respondents agreed that a consistent approach for screening, prioritizing, selecting and approving projects could be found in their organizations. A possible explanation for these conflicting data points is the cognitive bias of the participants who represent rather immature organizations. As observed in my work at Siemens Corporate Research, assessed organizations would, at a stage of low maturity, tend to overestimate their degree of maturity and would become more self-aware and realistic in their self-assessment as they began to mature. In the search for an explanation for this phenomenon, social psychology provided a likely explanation: the Dunning-Kruger effect supports the notion of illusory superiority of immature organizations or individuals (Kruger and Dunning, 1999). The clear indication of immaturity and the likelihood of cognitive bias of the participants point toward an actual maturity that is *lower* than what is perceived by the survey participants themselves. Another PPM survey conducted by the Center for Business Practices in 2005 appears to confirm the maturity observations, as it concluded that 90% of organizations are immature in respect to PPM (CBP, 2005).

Lastly, authors such as Maizlish and Handler (2005, p. 53) and Cooke-Davies (2004) suggest to pursue—beyond metrics of value delivery—the measurement of process improvement and consciously monitor the effectiveness of the portfolio management process, as little discussion and reference is found in this regard.

Proposition 4 focuses on the measurement of process maturity and success, with the intent to consistently evaluate and consciously drive project portfolio management maturity:

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provision of a feedback mechanism to address "defects" and continuously improve the process. See Section 2.6 for further detail.

Proposition 4 – Use of process metrics to determine and drive PPM maturity

A set of metrics is established to monitor process and continuous process improvement, as well as the fulfillment of the "business case" for performing project portfolio management, in order to achieve and sustain buy-in from the organization and their executives.

The proposition is discussed in Section 5.4.

Bourne (2008) makes the case for further attention and directional considerations regarding the performance measurement topic and reflects on the challenges in the implementation of measurement concepts, such as the Balanced Scorecard. Such challenges include difficulties to design non-financial metrics, the mere adoption of legacy key performance indicators (KPIs) into scorecards, and the disconnect of departmental measurement from overarching strategic goals, which encourages local optimization. Last, but not least, the author recommends the use of cascading measures and suggests that "companies that effectively cascaded their measures down the organization tend to have branch structures … where central resource can create a single set of measures that is rolled out across the network. But in other organizations, the alignment of the measures and the strategic objectives becomes less and less clear the further down the organization you go" (Bourne, 2008, p. 68).

1.5.3 Theme III: Tight Integration of PPM with Strategic Planning

As discussed in Section 1.4, strategic alignment is an increasing area of focus in project management research. Most of the literature defines strategic alignment as the aligning of projects with strategy as a top-down process, and where the "strategic fit" of a project is validated.

As Cooper et al. point out, the validation of the "strategic fit" is still the easiest to implement; however, validating to what degree spending matches the strategic intent is equally important but non-trivial (Cooper et al., 2001a, pp. 106-107). Artto, Martinsuo and Aalto (2001) highlight the need for "vertical integration" between strategy, the management of projects, portfolio management and strategy management.

Figure 1-4 introduces a simplified version of the three stages of the portfolio management life cycle in adaptation of the frequently cited portfolio process model from Archer and Ghasemzadeh (1999b).[11]

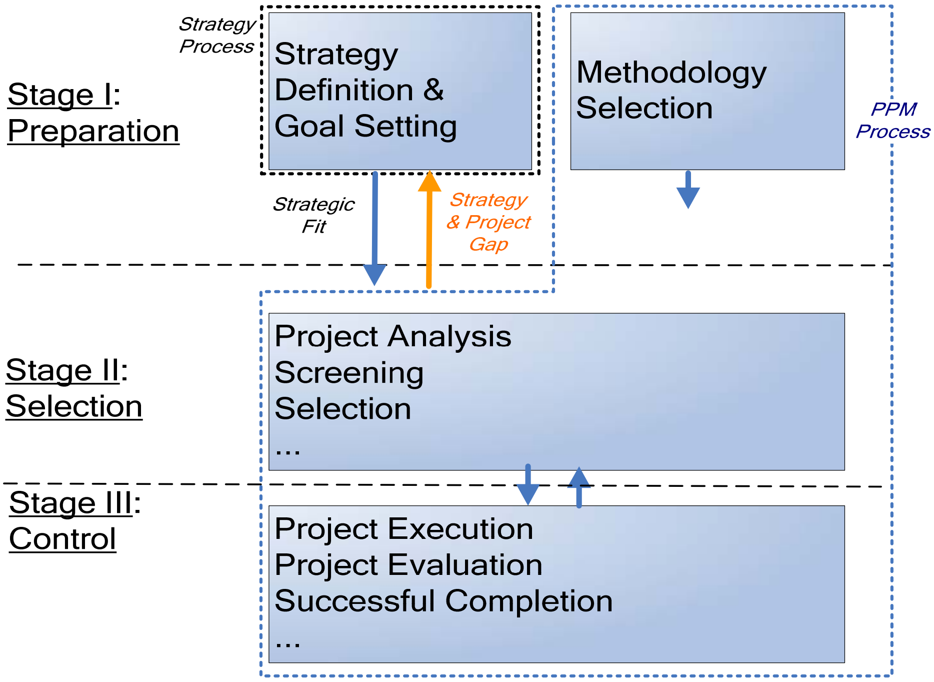

Figure 1-4: Enhanced PPM Life Cycle Model

Although much of the focus of publications to date is directed toward strategic fit, a model for measuring and addressing deficiencies in the project portfolio for a given strategy is introduced. Conversely, the identification of missed opportunities or inconsistencies in the strategy is a contribution that project portfolio management can make to the strategy process (Arlt, 2009a) and a tight integration is proposed as a means to accelerate benefits realization and optimal strategy implementation.

Proposition 5 investigates how to better align strategic planning and portfolio management:

[11] This model, simplified in this introductory Chapter, will be used throughout this thesis as a reference model and serves as the baseline for extension.

Proposition 5 – Reconciliation of misalignments between strategy and portfolio
An enhanced definition of portfolio alignment, including the degree of strategy implementation and the actual strategic contribution of projects, allows understanding the degree the strategy implementation that results from PPM and uncovering gaps in the strategy. *The proposition is discussed in Section 6.3*

The five propositions, which have been introduced in this chapter, are geared toward improving PPM processes and ultimately increasing the maturity of an organization in respect to project portfolio management. The author recognizes that other aspects of improvement of strategic success from PPM do exist. However, the propositions attempt to deliver a contribution toward a more strategic and holistic approach of PPM to deliver increased benefits from project portfolio management. Related topics, which yield merit for further exploration toward PPM improvement, such as portfolio risk management, are touched upon but, given the scope of this work, they are not elaborated in great detail. Other research efforts, such as the ongoing empirical portfolio and multi-project management research at Berlin Technical University, provide significant proof for the correlation between PPM and strategic success.

1.5.4 Summary of Research Themes and Propositions

Enhancements toward the current theory are proposed in the three areas, and are articulated by the themes of (I) refinement of the portfolio selection methodology, (II) a consistent and integrated measurement approach, and (III) the tight integration of PPM with strategic planning.

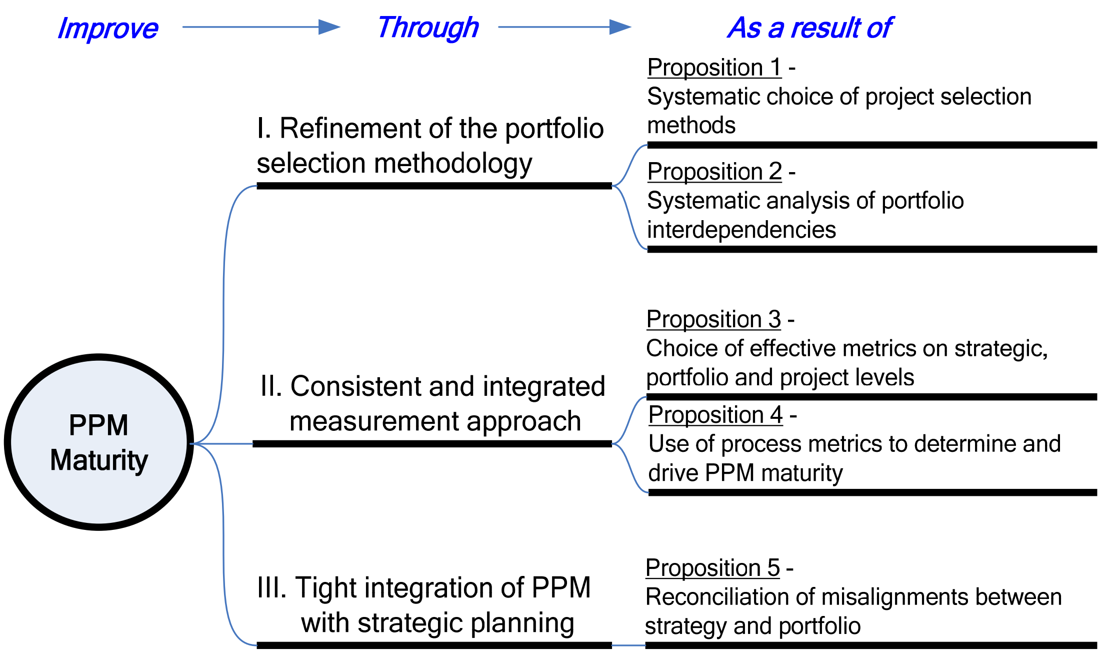

Figure 1-5: Research Themes and Propositions

Figure 1-5 summarizes the approach along the following syntax: Improve PPM maturity through improvement in a specific area of PPM ("Theme") as a result of a new or enhanced activity in the PPM life cycle or change of the process itself ("Proposition").

It should be further pointed out that there are some interrelations between the themes and propositions that further contribute to the improvement of PPM outcomes and maturity. For example, the choice of effective metrics (Proposition 3) feeds into the choice and execution of project selection methods and may amplify the benefit around the corresponding Proposition 1. Lastly, it should be noted that the tighter integration of PPM with strategic planning should help elevate the importance of PPM on the executive agenda, as PPM can provide an effective feedback mechanism and the inputs on the soundness and completeness of organizational strategy.

1.5.5 Literature Discussed

The relevant and salient literature chosen by the author and discussed in Chapter 2, which supports this research effort, is drawn from several areas. Naturally, as a result of the thesis topic, the literature review draws upon the respective research publications in project and program management, such as the *Project Management Journal, International Journal of Project Management and International Journal of Managing Projects in Business*, as well as recognized and industry standards, such as the *Guide to the Project Management Body of Knowledge* (*PMBOK® Guide*) and the *Standard for Portfolio Management* of the Project Management Institute. However, the breadth of the topic area selected, the interdisciplinary nature of the PPM topic and the historic roots of project portfolio management in other related disciplines, including new product development, financial portfolio management and management science, have impacted the choice of relevant literature, which goes beyond project and portfolio management areas. To reach beyond the "technical" perspective that is represented by most of the early literature, the author has made a conscious choice to draw upon research in management, decision and behavioral sciences, which is to acknowledge and emphasize the relevance of strategy and the recognition of PPM as a human decision problem.

As explained in the context of the structure of the thesis (see Section 1.8), the author chose to conduct a subject matter immersion on the three discrete topics of portfolio selection methods, metrics and measurement and strategic alignment at the inception of Chapters 4, 5, and 6 prior to exploring the propositions. Naturally, given the breadth of the topic area selected, the discussed literature cannot be exhaustive and complete; rather, the selection of literature focuses on critical contributions in respect to the physiology of the themes and propositions elaborated in this research effort.

1.6 Research Approach and Validation of Propositions

This research effort commences with a comparative analysis of the relevant literature in the area of project portfolio management, as well as related scientific disciplines in Chapter 2, which establish the foundation in regard to project portfolio management. Whereas Chapter 3 elaborates the theoretical foundation of the research framework used for this thesis, Chapters 4, 5 and 6 present the five propositions discussed in 1.5 and advance the picture of an enhanced portfolio management life cycle, as proposed by the author.

More than one research methodology has been applied in the validation of the five propositions. An initial exploratory survey conducted by the author, for the benefit of this research effort and as part of the author's his PPM advisory role at ESI International, provided topical insight toward PPM challenges and areas of immaturity in the real-world application of project portfolio management; the findings of the survey, which are discussed in Section 2.7, are used to support the case for the respective improvements toward PPM theory and practice.

To validate the five propositions, the author has used two research methodologies: experimental validation and case study research. Propositions 2, 3 and 5 have been validated through experimentation using the Princeton Laboratory for Experimental Social Science at Princeton University to conduct A–B tests with human subjects making portfolio management decisions in a controlled experiment. Propositions 1 and 4, as well as parts of Proposition 3, have been validated through a client case study, based on the author's portfolio management consulting engagement with a large North American client in 2009 and 2010. Lastly, the notion of action research is represented by this thesis as it implicitly or explicitly walks through the elements of the action research cycle—depending on the proposition.

1.7 Justification and Contribution of the Thesis

The above discussion in Sections 1.4 and 1.5 can be summarized by demonstrating the research justification and its intended contribution to the field of project management and, more specifically, the area of project portfolio management.

The identified gaps, as discussed in Section 1.4, led to the selection of three areas of focus: the improvement of portfolio selection; a more systematic approach toward measurement outcomes and process quality in the context of PPM; and the closer integration of PPM and strategy management processes. Through this work the author attempts to make a contribution to knowledge by bridging these gaps. Initial contributions, such as publications, conference papers and book chapters in the context of the DPM program and beyond, have been referenced in "Publications and Presentations," which precedes Chapter 1 (see page xv).

At a personal level, the DPM is designed to help candidates to develop themselves as reflective practitioners, and this thesis and the work it represents has significantly contributed to the personal and professional growth of its author. Research aimed to develop reflective practitioners has been highlighted (Winter, Smith, Morris and Cicmil, 2006). Without detailed discussion at this point, Figure 1-6 provides a preview of the contributions of this thesis through model enhancements and improvements, as a result of the five propositions.

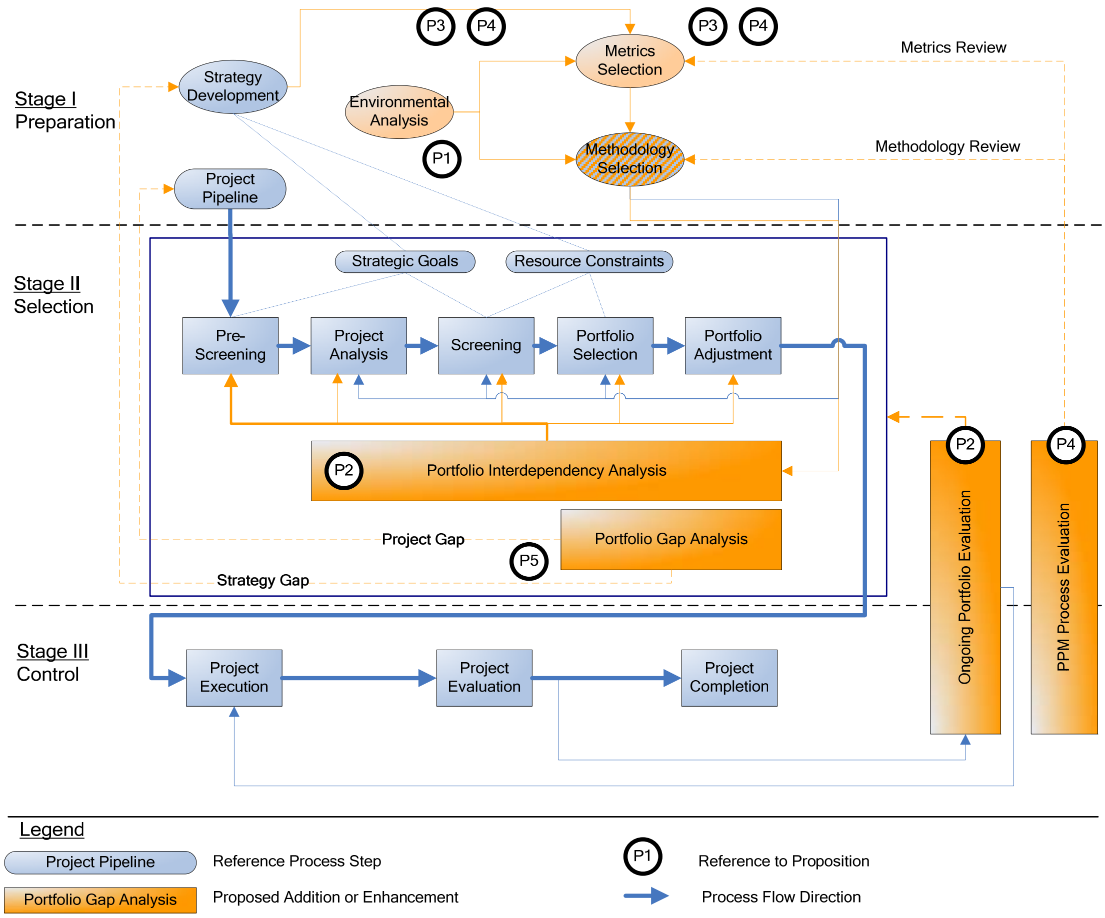

Figure 1-6: Base Model and Contribution to Theory (Preview)

1.8 Structure of the Thesis

After the introduction of this research effort in the context of the DPM program and providing the background of the author, this first chapter has provided both context and rationale for the selected area of research with the project management discipline. Furthermore, Chapter 1 has introduced the three research themes and corresponding propositions and has discussed the context of the pertinent literature of project management and other related research fields and disciplines. Lastly, the first chapter has provided an overview of the research approach and has outlined the epistemological contribution of this effort.

Chapter 2 provides the foundation from both project management literature and other related fields (as introduced in Chapter 1), provides necessary definitions and elaborates on PPM goals, the life cycle model and the concept of maturity, which plays a central role in several propositions.

Each chapter is structured to begin with an overview and to close with a summary. Chapter 3 discusses the research approach and methods used in this thesis. Because of the breadth of topics covered by the three themes and five propositions, Chapters 4, 5 and 6 lead in with an immersion section, which builds on the foundation in Chapter 2, but provides further specifics as a basis for the discussion of the propositions.

Chapter 7 covers both case study and experimental validation, including validation setup and process. Lastly, Chapter 8 provides conclusions and recommendations for further research. Figure 1-7 provides a pictorial summary of the thesis flow against the logical components of research setup, foundational analysis, contribution to the discipline, validation and conclusions.

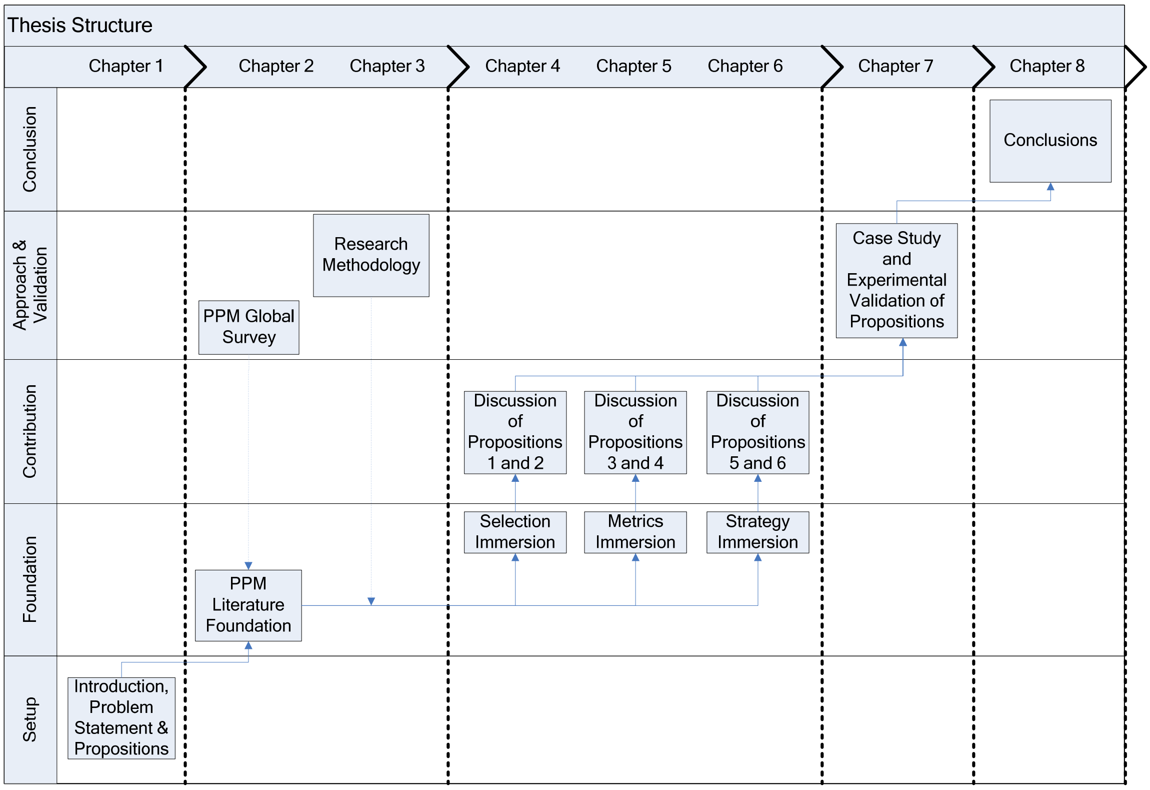

Figure 1-7: Thesis Chapters and Logical Flow

1.9 Chapter Summary

As stated in the chapter introduction, Chapter 1 has served a series of objectives as a setup for the following literature research, elaboration of propositions, validation and conclusions.

The context of the research effort has been introduced, and the context and rationale for the topic selection and areas of focus have been introduced. Furthermore, the three research themes and five propositions have been discussed, and the research method, approach toward validation of the propositions and the contribution of the thesis have been elaborated. Lastly, the chapter has provided an outlook on the logical flow of the document.

2. PROJECT, PROGRAM AND PORTFOLIO MANAGEMENT — CONTEXT AND PROCESS

2.1 Chapter Introduction and Objective

The objective of Chapter 2 is to provide the general literature foundation for discussions, elaboration and validation of the research propositions in Chapters 4, 5 and 6. Definitions and terminological clarifications for project, program and portfolio management are provided, and trends in project and portfolio management are discussed. In this context, the author discusses related fields of research and adds perspectives from the research fields of management science, decision science and behavioral science, which have played only a limited role in project and portfolio management literature. Further attention is given to four goals, which define "success" in respect to project portfolio management. This notion of management by objectives is carried forward throughout the thesis. As numerous PPM life cycle models exist today, some prominent examples of these process models are elaborated. The literature review is supplemented with reflective learning elements from the practitioner experience of the author and the topic of process maturity is with the help of the author's 2009 PPM survey.

2.2 Project, Program and Portfolio Management

Project management has been in existence as a formal discipline for about sixty years (Morris, 1994). Formal scheduling methods like Gantt and Program (or Project) Evaluation and Review Technique (PERT) were introduce even earlier[12]. When the Project Management Institute was formed in 1969 as an interest group to represent the emerging profession, project management began to move from a rather ad hoc approach to a managerial discipline. Most of the generally accepted practices of project management were developed in the 1980s, where both the British Projects IN Controlled Environments (PRINCE) standard and *A Guide to the Project Management Body of*

[12] Gantt charts date back to 1911; and PERT analysis started in the 1950s.

Knowledge (*PMBOK® Guide*)[13] were published and subsequently became the de facto standards for project management (Morris, 1994).

An overwhelming number of organizations, public or private, have recognized effective project management as an essential factor to success. This growing attention to project management is confirmed by the rapid increase in publications, and the number of project management certifications and enrollments in associations of project management professionals. For example, the membership enrolment of the Project Management Institute has exceeded half a million[14] as project management is evolving from being a technique to becoming an essential management skill and profession, which is relevant at all hierarchical levels across many domains in public and privately managed organizations. Moreover, project management has been recognized as a life skill and is promoted for example by the PMI's Educational Foundation to students and humanitarian and developmental organizations.

2.2.1 Project Management

With the maturing of the project management discipline, numerous definitions of project management have been articulated by both academics and practitioners. The *PMBOK Guide* (PMI, 1996;2000;2004;2008a) provides a widely accepted and frequently quoted definition of project management as "the application of knowledge, skills, tools and techniques, to project activities to meet project requirements" (PMI, 2008a, p. 6). Similarly, in PRINCE2, project management is characterized as "the planning, monitoring and control of all aspects of the project and the motivation of all those involved in it to achieve the project objectives on time and to the specified cost, quality and performance" (OGC, 2005, p. 4). A third frequently cited definition characterizes project management as "the planning, organizing, directing and controlling of company

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[13] The initial version of *A Guide to the Project Management Body of Knowledge* was published by the Project Management Institute as a white paper in 1987, whereas the first version of the standard was published in 1996.

[14] The Project Management Institute, the largest organization of its kind, currently includes approximately a half million members from more than 170 countries. Updated numbers can be found at www.pmi.org.

resources for a relatively short-term objective that has been established to complete specific goals and objectives" (Kerzner, 2009, p. 4). These three definitions, as well as numerous others, imply that project management aims at a management and control approach that is operational in nature and geared toward the achievement of a pre-defined requirements or goals.

Section 1.4 briefly touched on one of the most discussed questions in project management: the success rate of projects. Project success for the longest time has been based on traditional triple constraint[15] metrics, though such metrics are inadequate or at least insufficient to truly capture a picture of project success. The construction of the Sydney Opera House is an example how misleading triple constraint measures as a proxy for project success can be: At the time of construction, the Opera House was considered a project management disaster, because of significant delays and cost overruns, but later it vastly exceeded expectations by creating an icon for the city of Sydney and initiating the creation of an image of sophistication and culture, which attracted many renowned companies to move regional or global headquarters to the city (Walker, Arlt and Norrie, 2008, pp. 140-141). In retrospective, the "business case" for the Sydney Opera project would certainly deserve a review: even with extended funding and timelines, the economic impact would have very well justified the project.

Project management literature suggests a significant evolution of the discipline since the 1960s (Kloppenborg and Opfer, 2002). With the maturing of the project management research discipline, the discussion on what constitutes project success (Cicmil and Hodgson, 2006; Gemino et al., 2007) has resumed. Although this discussion is still ongoing, one aspect of it is how to distinguish project success from project management and product success (Baccarini, 1999). Atkinson, who refers to the traditional triple constraint as the "iron triangle" principles, had been one of the first

[15] Since its fourth edition, the *PMBOK Guide* does not further utilize the term "triple constraint" but instead refers to "competing project constraints," defined as, but not limited to, scope, quality, schedule, budget, resources and risk (PMI 2008a, p. 6). It is interesting to note, that the concept of benefits management, as articulated in the PMI *Standard for Program Management*, has not been introduced to the *PMBOK Guide* in its 4th edition.

authors to suggest new metrics for project management success (Atkinson, 1999). Cooke-Davies (2004) concludes that "the project management community is starting to relate projects success to business success." Shenhar et al. (2001b) provide a classification of dimensions of project success that entails project efficiency in the sense of the triple constraint, benefit to the customer, (immediate) benefit to the performing organization and strategic benefit to the organization.[16]

However, successfully managing projects is only one element of organizational project success. The definition and selection of projects that deliver the expected benefits to the organization and their proper translation into project objectives and scope is at least equally important. In reality, many organizations have struggled to achieve both of these success factors to organizational project management simultaneously and consistently. As the academic discussion of project success moves beyond the triple constraint, the low percentages of project success measured in traditional triple constraint metrics in the CHAOS report and other studies does however indicate significant room for improvement with respect to project management basics. This notion is further substantiated by Dinsmore and Cooke-Davies, who observe that project success rates have been lagging behind the evolution of project management research and conclude that "a majority of organizational projects fail to deliver even half the benefits they were designed to provide." (Dinsmore and Cooke-Davies, 2006, p. 1).

2.2.2 Program Management

Program management typically addresses the management of multiple, connected projects to achieve benefits from multiple projects beyond the project level. Providing a widely accepted consensus definition that is now recognized by the American National Standards Institute(ANSI), *The Standard for Program Management* (2nd edition) defines program management as "the centralized coordinated management of a program's strategic objectives and benefits" (PMI, 2008d, p. 6). The standard further emphasizes the

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[16] Shenhar et al. use the exact term of "preparing for the future," which is illustrated by examples, such as creating new product lines, markets or technologies.

aligning of multiple projects and optimizing of their integrated cost, schedule and effort as objectives of program management.

However, project and program management are distinctively different functions. Project managers have a more operational role that focused on delivering a defined work product or scope, whereas a program manager's attention is geared toward managing the strategic benefit of a series of projects (Bradley, 2006). Furthermore, stakeholder management becomes more complex in the program management context, because larger numbers of stakeholders are involved, and interests, power and influence of each stakeholder may vary across projects. Lastly, program management requires the coordination of resources for multiple projects and the steering of multiple project managers rather than the hands-on management of projects. Similar to the notion of PMI's program management standard, the Management of Successful Programs (MSP) framework (OGC, 2007), issued by the Office of Government Commerce, a department of the government of the U.K., characterizes programs to deliver outcomes rather than outputs and to include within their lifespan, a series of projects to be initiated, executed and closed. MSP emphasizes the alignment of program management with corporate strategy and the delivery of change, in the context of transitioning project deliverables into business operations.

2.2.3 Multi-Project Management

Several authors have declared that the terms program management and multi-project management are closely related (Elonen and Artto, 2003) and consider a multi-project organization as an environment that manages resource pools for the simultaneous execution of multiple projects (Pellegrinelli, 1997). PMI's *Standard for Program Management* (2nd edition) defines multi-project management as "those aspects of program management associated with initiating and coordinating the activities of multiple projects and the management of project managers" (PMI, 2008d, p. 311). However, other definitions have emerged that consider organizational multi-project management as a broader umbrella term. For example, Gemuenden and Dammer understand multi-project management as an umbrella term for the holistic management of "project landscapes," consisting of portfolio, program, project and functional management-related activities across an organization (Gemünden and Dammer, 2004).[17]

2.2.4 Project Portfolio Management

Artto et al. (2001) define project portfolios as a collection of projects that are carried out in the same business unit sharing the same strategic objectives and the same resource pool. Other definitions extend the scope of underlying components: *The Standard for Project Portfolio Management* of the Project Management Institute (PMI, 2006;2008c), includes beyond projects: programs, sub-portfolios and other related work, as illustrated in Figure 2-1.[18]

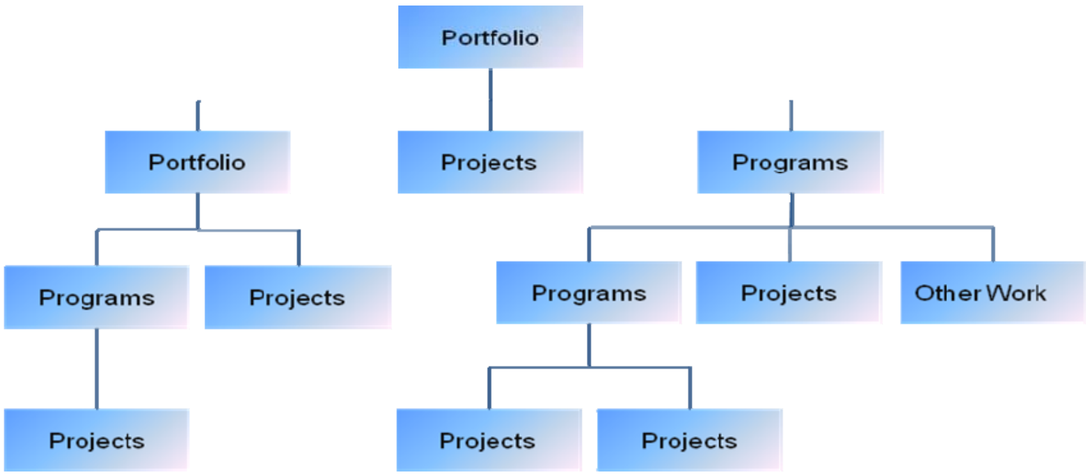

Figure 2-1: Portfolio Composition (Source: PMI, 2006, p. 5)

Many definitions can be found for project portfolio management, and several authors concluded that there is currently no uniform understanding of the term (Morris and Jamieson, 2005; Milosevic and Srivannaboon, 2006; Killen, Hunt and Kleinschmidt,

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[17] Several ongoing research efforts at the Berlin Technical University under Prof. Dr. Gemünden currently analyze portfolio effectiveness in the multi-project management (MPM) context influenced by cultural factors of regional, national and corporate cultures, as well as sector-specific and maturity-related aspects of MPM. At the point of submission of this research work, findings of this study have not yet been published.

[18] As stated in Chapter 1, the term "“project” will be used as a generic term for the underlying of PPM. This terminology is in line with most of most of the PPM literature and simplifies the readability. If particular emphasis is given to programs, sub-portfolios and other related work, then the terms will be explicitly used.

2008). PPM has been characterized by many authors as the bridge or hub function betweens strategy and project management (Levine, 2005). One of the more frequently quoted and elaborate definitions, which emerged in the new product development context, describes PPM as a dynamic decision process in which projects are constantly updated and revised, and existing projects maybe accelerated, decelerated, terminated, or continued according to plan (Cooper et al., 2001a, p. 3). Cooper et al. further define PPM as a decision process under uncertainty with dynamic opportunities, and multiple goals and interdependencies between projects, driven by strategic considerations, steered by multiple decision makers and potentially distributed across multiple locations (Cooper et al., 2001a, pp. 3-4). The *Project Portfolio Management Standard* (PMI, 2008c) further expands the scope of PPM to include one or multiple portfolios consisting of the aforementioned components, and describes PPM as a centralized management process. Furthermore, PPM is aimed at achieving specific strategic objectives through the selection of the portfolio components, based upon their alignment with and contribution to strategy. Another suitable definition describes PPM as “the art and the science of applying a set of knowledge, skills, tools and techniques to a collection of projects to meet or exceed the needs and expectations of an organization’s investment strategy” (Dye and Pennypacker, 1999).

As mentioned earlier, program and project portfolio management are occasionally confused. Table 2-1 illustrates differences between the two: project portfolio management includes a much broader context of both related and unrelated projects, which belong to an organizational entity. Furthermore, portfolio management covers a broader organizational process for the selection, approval, monitoring and control of projects (and programs). Whereas program management monitors and steers the realization of program benefits, project portfolio management achieves benefits management at the strategic level. Lastly, from a timing perspective, portfolio management is an ongoing process (see life cycle discussion in Section 2.5), whereas the duration of programs is finite.

As observed in practice, it may occur under certain circumstances that the program management function is identical to project portfolio management. In this special case, the entire project portfolio equates one program, and no other projects, programs or sub-portfolios exist outside of the respective program; here, the respective manager may exercise both portfolio and program management responsibilities at the same time.

Table 2-1: Program vs. Portfolio Management (Source: Milosevic et al., 2007, p. 20)

Differentiating Factor	*Program Management*	*Portfolio Management*
Process vs. Function	A management function utilized to determine the business and execution feasibility of a selected idea. The idea then turns into an actionable plan that is successfully executed and delivered to the customer.	A process utilized to evaluate, prioritize, select and resource new ideas that best contribute to the attainment of the strategic objectives of an organization
Determining and Obtaining Value	Focused on ensuring that the business value is attained for a single opportunity throughout the development and market introduction process	Focused on determination of the business value of all existing opportunities of the organization
Risk Management	Management of risk across all disciplines involved in the development of a single product, service, or infrastructure capability	Determination of the business and technical risk of each opportunity concept, balancing risk and return for the aggregate portfolio of opportunities
Resource Management	Staffing the Program Core Team, ensuring the project teams are adequately staffed throughout the development life cycle	Aligning resources to opportunities that provide the greatest strategic value to a business

Project management experts are often challenged to qualify the benefits of project management excellence to business executives, the result of an incongruence of objectives and metrics for operations and project management as illustrated in Table 2-2 and the lack of hard quantitative data for the value of project management excellence.

Table 2-2: Drivers of Operations vs. Project Management (Levine, 2005, p. 18)

Operations Management	Project Management
Strategies	Schedule/time
Objectives/goals	Project cost
Business performance	Project performance

Stockholder satisfaction	Stakeholder satisfaction
Project selection and mix	Scope/change control
Resource availability	Resource utilization
Cash flow/income	Cash usage

Beyond such measurement gaps between project and operations management, other potential gaps become apparent, as the management of a portfolio of projects affects financial budgeting and control, procurement, risk management, resource allocation and other aspects of the business. Project portfolio management can serve as an organizational hub, which has an integrative function for the business (Levine, 2005). One of the most intuitive definitions for the bridge or hub function characterizes mature and successful project organizations as efficient by "doing projects right," being effective by "doing the right projects" and being consistent by "consistently doing the right projects, and doing them right" (Cooke-Davies, 2004). [19]

2.2.5 PPM Origin and Related Disciplines

As briefly mentioned in Chapter 1, an interdisciplinary research effort conducted by Kwak and Anbari suggests a strong influence of other disciplines on the project management field of research (Kwak and Anbari, 2008;2009). Among the eight "allied disciplines" identified by the authors, several are relevant to project portfolio management and will be discussed further in this section:

Table 2-3: Allied Disciplines of Project Management (Kwak and Anbari, 2008, p. 5)

1.	Operations Research/Decision Sciences/Operation Management/Supply Chain Management refers to the discipline associated with quantitative decision analysis and management principles.
2.	Organizational Behavior/Human Resources Management refers to the discipline associated with organizational structure.
3.	Information Technology/Information Systems refers to the discipline associated with the use of computers and computer systems to process.
4.	Technology Applications/Innovation/New Product Development/Research and Development refers to the discipline associated with the concepts of making innovative and technological improvements and the research and development of entirely new products.

[19] "Doing the right projects," though not very scientific, is perhaps the most concise definition of the purpose of project portfolio management.

5.	Engineering and Construction/Contracts/Legal Aspects/Expert Witness refers to the discipline associated with the use and application of a broad range of professional expertise to resolve issues related to engineering and construction.
6.	Strategy/Integration/Portfolio Management/Value of Project Management/Marketing refers to the concepts of organizing and managing resources to maximize profit.
7.	Performance Management/Earned Value Management/Project Finance and Accounting refers to the concepts and techniques that measure project progress objectively by combining measurements of technical performance.
8.	Quality Management/Six Sigma/Process Improvement refers to the concepts of improving processes.

Analogous to the findings of Kwak and Anbari, a similar picture can be drawn for project portfolio management and those disciplines, which have been impacting PPM.

2.2.5.1 Project and Program Management

It is evident that project portfolio management is heavily influenced by project and program management, as projects and programs constitute the predominant underlying of PPM. Furthermore, project and program management provide the underlying tools and techniques for managing the projects and programs within a portfolio. However, other disciplines outside project and program management have influenced PPM.

2.2.5.2 New Product Development

Product portfolio management and R&D portfolio management have provided a foundation for both the PPM life cycle and techniques applied in the prioritization and selection of projects. Specifically, the work of Robert Cooper, Scott Edgett and Elko Kleinschmidt (Cooper et al., 2001a; Cooper, Edgett and Kleinschmidt, 2004; Cooper, 2005) have been frequently quoted in the PPM literature and many principles of product portfolio management have been applied to project portfolio management. Earlier R&D project selection approaches (Hall and Nauda, 1990) that were introduced since the 1960s have at least in part been applied to projects beyond R&D in the larger context of project portfolio management. These approaches, which include mathematical programming, benefits measurement and contribution methods, as well as ad-hoc approaches, are the subject of detailed discussion in Chapter 3. Since projects and programs constitute the underlying of the project portfolio management discipline, methods and techniques for the successful implementation of projects and programs, which lead to the successful delivery of their respective outcomes, have influenced PPM. Contextual references for project and program management have been provided previously in this chapter.

2.2.5.3 Financial Portfolio Management

Financial portfolio management is the third discipline that significantly influenced project portfolio management and is frequently referenced in the PPM literature. More specifically, Modern Portfolio Theory (MPT), developed by Markowitz (1952) and refined in the context of the Capital Asset Pricing Model (CAPM) by Sharpe, created the basis for modern finance (Markowitz, 1959; Sharpe, 1964) and established three major paradigms for financial portfolio management. First, a rational investor pursues assets, which maximize returns, while minimizing risk of a portfolio. Second, multiple optimal portfolios may exist and constitute an "efficient frontier." Lastly, diversification leads to (at least in theory) the eliminating of non-systemic risks. Recent controversy in light of the collapse of financial markets, despite what seemed to be proven concepts, should be taken seriously (Colander, Föllmer, Haas, Goldberg, Juselius, Kirman, Lux and Sloth, 2009).[20] The applicability of MPT principles to project portfolios exhibits several limitations: although the general notion of interdependencies between the components of a portfolio can be applied in both cases (see Table 2-4), interdependencies in project portfolios follow different characteristics than asset portfolios.

Table 2-4: Financial vs. Project Portfolio Management (Benko and McFarlan, 2003)

	Financial Portfolio	Project Portfolio
Assets	Various financial instruments with distinct characteristics	Various projects with distinct characteristics
Diversification	Employing multiple financial instruments can reduce risk	Monitoring project variables—scope, approach, vendors, project managers, etc.—can reduce risk
Goals	Income and capital gains	Profitability and growth
Asset Allocation	Invest according to individual investment goals	Invest according to overall organizational intentions
Connections	Correlation	Interdependency

In fact, Markowitz suggested that MPT is of limited use for selecting project portfolios. The nature of projects, which deliver benefits over time and require specific

[20] The paper of Colander et al. exemplifies the discussion on financial risk management and concludes a "systemic failure of the Economics and Finance profession," in light of the 2008/2009 financial collapse.

resources and skills versus the immediate impact of the acquisition of a financial instrument, clearly limits the applicability of MPT to project portfolio management.[21]

Strong alignment of PPM with the school of thought of financial portfolio management can be found in some of the literature. For example, Parkinson suggests that we think of an Information Technology (IT) organization as a "kind of specialized investor employing an asset-allocation strategy" (Parkinson, 2005, p. 27). Furthermore, Sanwal takes an investment-centric approach to what he calls corporate portfolio management and in essence describes the selection and management of all investments that are discretionary in nature (Sanwal, 2007, p. 11). Consequently, Sanwal further suggests the sole application of financial metrics, such as Return on Investment (ROI), Net Present Value (NPV) and Internal Rate of Return (IRR) as the decision criteria for corporate portfolio management. Given the context of Sanwal's work in the financial services sector, this approach appears reasonable, though somewhat limited, as PPM aspects, such as strategic alignment are not addressed, as far as the strategy entails more than the attainment of financial gain. Because of the relevance of financial portfolio management to project portfolio selection, the concept is discussed further in Chapter 4.

2.2.5.4 Management Science

Management science, and more specifically the field of corporate strategy, provides the schools of thoughts for the articulating strategy and providing at least some guidance, toward its implementation. Inasmuch as one of the goals of PPM is to achieve strategic alignment, one proposition of this work relates to the achieving of such alignment. The topic gained traction in the early 1990s with the introduction of the Balanced Scorecard (Kaplan and Norton, 1992). Chapter 6 of this thesis discusses the topic in greater detail.

2.2.5.5 Decision Science

Decision science constitutes another important influence on PPM, which has applied some of its findings and methods. Zachary (1986) provides a comprehensive

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[21] See Harder, P. (2002). A conversation with Dr. Harry Markowitz, www.gantthead.com/article.cfm?ID=119883, Retrieved 1/1/2010.

taxonomy of decision support techniques from a cognitive decision-making perspective, which consists of process and choice models, information control techniques, analysis and reasoning methods, representation aids and human judgment and refinement techniques. Beyond the classification of methods and techniques, Zachary provides a decision decomposition protocol that allows the analysis of decision problems and may support the choice of appropriate methods and techniques in the PPM process. Research at Cambridge University's Manufacturing Systems Research Group "Manufacturing Strategy and Performance Measurement" Project (IFM, 2010) modified and expanded on Zachary's concept. Their taxonomy for modeling and decision support tools is particularly insightful:

Table 2-5: Taxonomy of Modelling and Decision Support Tools and Techniques [22]

Category	Context
1 Information control	Gathering, storage, retrieval, and organization of data, information and knowledge
2 Modeling	a) Paradigm models: paradigms, frameworks or perspectives that help one "get a handle" on the situation
	b) Simulation models: models that enable answers to "what if?" questions
3 Choice models	Techniques/tools that analyze or help to narrow the field of choice
4 Representation aids	Techniques/tools that aid the visualization of data

As stated in Section 2.2.4, PPM can be characterized as a dynamic decision process, influenced and conducted by a broad range of stakeholders across an organization. Artto and Dietrich (2004) as well as Cooper et al. (2001b) describe PPM as a consistent and conscious decision process. Even the most mature processes and tools will only *support* decision making, which elevates the importance of understanding how decisions are made. The existing PPM literature provides several normative aspects of decision theory, which are further discussed in Chapters 3, 4, and 5. Several areas of decision science come to mind: decision making under uncertainty, intertemporal decision making and interaction of competing decision makers and the general aspect of

[22] The complete and detailed taxonomy, including method descriptions is published by the Institute for Manufacturing (IFM) at the University of Cambridge at www.ifm.eng.cam.ac.uk/dstools

irrationality of decisions, both of which lead to the research fields of behavioral science and psychology. As noted earlier, the PPM literature predominantly discusses the mechanics of the PPM process and prescribes a wide array of methods for the selection of portfolios. However, all these methods are tools supporting the selection of an optimal portfolio; yet do not replace actual decisions and judgment calls. Tichy and Bennis stated that a "leader's most important role in any organizations is making good judgments" (Tichy and Bennis, 2007, p. 94). These judgments are an important component of the decision process, and decision theory science provides the relevant frame of reference for the managerial problem related to portfolio decisions.

GOOD LEADER					
PREPARATION PHASE			**CALL PHASE**	**EXECUTION PHASE**	
Picks up on signals in the environment Is energized about the future	Cuts through complexity to get to the essence of an issue Sets clear parameters Provides a context and establishes a shared language	Identifies important stakeholders Engages and energizes stakeholders Taps best ideas from anywhere	Makes a clear yes/no call Thoroughly explains the call	Stays involved during the execution Supports others who are involved Steps clear milestones	Asks for continu-ous feedback Listens to feedback Makes adjustments

Sense & Identify	**Frame & Name**	**Mobilize & Align**	**Call**	**Make it Happen**	**Learn & Adjust**

POOR LEADER					
Cannot read the environment Fails to acknowl-edge reality Does not follow gut instincts	Incorrectly frames the issue Does not define the ultimate goal Remains stuck in an old paradigm	Does not set clear expectations Brings the wrong people on board Does not correct previous mistakes	Dillydallies when it's time to make a call Fails to understand how issues intersect and how the call will play out	Walks away once the call is made Does not gather important information Does not under-stand what good execution requires	Does not measure outcomes Does not respond to resistance in the organization Lacks operating mechanisms to make necessary changes
PREPARATION PHASE			**CALL PHASE**	**EXECUTION PHASE**	

Figure 2-2: Phases of the Decision (Tichy and Bennis, 2007, p. 97).

Decision making in itself is an iterative process with re-do loops, rather than being purely linear (see Figure 2-2). The selection methods and metrics, which are discussed in this thesis, are only the means to accomplish what is the ultimate objective: the making of informed decisions. Selection methods and metrics are relevant at several junctions of the process. As decision makers prepare, judge and execute, environmental signals in the preparation phase, as well as feedback in the execution phase, are provided in the form of metrics and judgment. The usefulness of metrics and approaches under uncertainty is discussed by Courtney, Kirkland and Viguerie (1997), who analyze the impact of uncertainty on strategic action. Courtney et al. suggest that traditional strategic planning only applies for a "clear-enough future," whereas other techniques and especially a more dynamic planning approach are needed for alternate or ranges of futures, as well as true ambiguity. As a result, an understanding of the expected volatility of strategy has an important impact on PPM: In the context of aligning the portfolio with strategy, it is helpful to know the degree of change that a strategy should expect, as portfolio re-alignments may be more or less likely and frequent. Doyle and Thomas (1999) define a decision as "a choice made by some entity of an action from some set of alternative actions" and further characterize "good decisions" as the identification of those alternatives, which are at least as good as other alternatives and maximize the expected utility. This basic concept implies that decisions generate outcomes with an expected utility, which allows calculating the expected utility of an action taken as part of the decision itself. Bazerman (2009, pp. 5-6) summarizes decision making as a six-step process, described in Table 2-6.

Table 2-6: Decision Making (based on Bazerman, 2009)

Decision-making process	Assumption of full rationality and perfect information
Define the problem	Perfect problem definition
Identify criteria	Identification of all criteria
Weight the criteria	Accurate weighting of all criteria
Generate alternatives	All alternatives are known
Rate each alternative on each criterion	Accurate assessment of each alternatives
Compute the optimal decision	Accurate calculation and choice of the alternative with the highest expected utility

In decision theory, as applied in traditional economic theory, for example, the base assumption of the rational behavior of decision makers leads to the assumption of both perfect knowledge and rationality and the assumptions illustrated in the table above.

The understanding of selection, monitoring and control aspects of PPM as a decision problem, are essential to addressing the practical challenges related to "optimal" portfolio selection. Neither the assumptions of rational behavior of the actors involved nor the availability of perfect information about the decision problem and its parameters hold up in the reality of irrationality in decision making and imperfect information. Most of the PPM literature implies rationality of decision making; however, some authors have begun to recognize the irrationality aspect (Eskerod, Blichfeldt and Toft, 2004).

2.2.5.6 Behavioral Science

In addition to the aforementioned challenges of irrationality and imperfect information, cognitive limitations further inhibit the ability of decision makers to achieve optimal outcomes. Simon coined the term "bounded rationality," which concedes irrational decisions as a result of limited cognitive capacity of humans in and lacking information (Simon, 1955). Similarly, Foreman and Selly argue that "decision-making for every complex, crucial decision takes place under constraints of human information-processing limitations" (2002, pp. 6-7) and further explain that both short-term memory limitations and channel capacity lead to degradation in people's performance for choices beyond a set of seven things. The authors further recognize frequently observed cognitive decision rules (a less elegant term would be shortcuts) that are used to cope with cognitive limitations and are likely lead to inferior outcomes (see Table 2-7).

Table 2-7: Cognitive Decision Rules (based on Foreman and Selly, 2002, pp. 8-10)

Cognitive Decision Rule	Explanation
Satisficing	Establishing of an aspiration level and settling for an alternative, which satisfies that level (often the first alternative that meets expectations)
Analogs	Choosing an option that is similar to a prior decision (often regardless of circumstances and outcome of that previous choice)
Nutshell Briefing	Oversimplifying a decision problem, especially common among top executives
Incremental Change	Staying within one's comfort zone rather than considering necessary drastic changes
Consensus	Achieving maximum agreement among decision makers, which may inhibit the choice of a good alternative
Affiliative Decision Rules	Preserving group harmony, party line consensus, suppression of opposition.
Self-serving and Emotive Rules	Making impromptu, "gut" decisions and otherwise irrationally motivated choices.

Doerner, who performed numerous experiments to analyze human ability to manage complex systems, recognized the limited human capacity to anticipate side effects and unintended consequences of actions in complex systems with interdependencies, especially in the absence of immediate and obvious negative effects at the time of a particular decision (Doerner, 1989). In addition, cognitive errors, such as the ignoring of factors or mistaken hypotheses, further reduce the probability of success, even for systems of low complexity, analogous to simple portfolios choice sets. Doerner's experimental research, which confronts highly intelligent and educated study participants with real-world scenarios of relatively low complexity, indicates the challenge that project portfolio management can constitute from the perspective of human cognitive limitation. Doerner's conclusions amplify the need for proper analysis of interdependencies to capture and reflect on the complexity of decision problems as found in PPM. As behavioral science has evolved, researchers have explored patterns of irrationality, which make decision making in the context of bounded rationality increasingly predictable. Ariely observed in his experiments the effects of anchoring[23], the effect of seemingly "free" options, despite their potential adverse effects in context and the role of people's emotional states in decision making (Ariely, 2008, pp. 25-48).

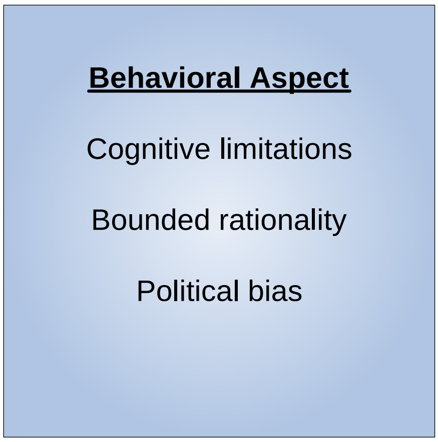

Figure 2-3: Behavioral Aspect of PPM Complexity

Techniques such as the Analytical Hierarchy Process (see discussion in Chapter 4) allow decision makers—at least to some extent—to overcome cognitive limitations and to reveal inconsistencies in choices. Lastly, Figure 2-3 summarizes the behavioral aspect of portfolio management complexity.

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[23] Anchoring describes the comparative approach to purchasing decisions, which can widely impact the perception of the value (or price) of an option.

2.2.5.7 *Summary*

The following map (Figure 2-4) provides an aggregated view of all disciplines that have been or should be taken into account in the PPM context:

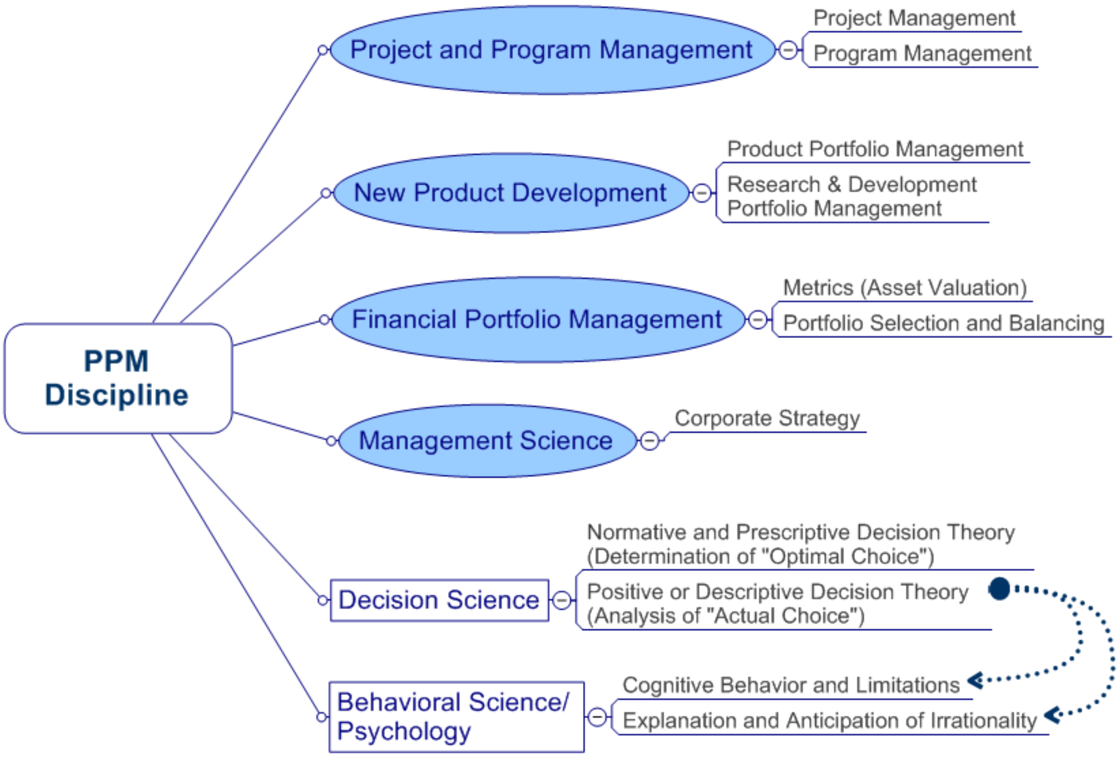

Figure 2-4: Disciplines with Influence on Project Portfolio Management

Project and program management, new product development, financial portfolio management and management science are highlighted, as they are particularly relevant toward the work of this thesis, while decision science, behavioral economics and game theory and organizational psychology are recognized as important and mentioned; however an in-depth analysis would reach beyond the scope of this work.

Although project portfolio management is not new, it is reasonable to expect increased importance of the topic for three reasons. First, organizational project management in many organizations has matured to the degree that the necessary prerequisites for project portfolio management (for example, basic project monitoring and control as well as resource management processes) are in place.

Second, PPM in general, and the management science aspects of PPM, becomes the next challenge on the path to greater maturity, as indicated in several studies that discuss future directions in project management (Cicmil and Hodgson, 2006; Martinsuo and Lehtonen, 2007). As a certain level of maturity in project and program management is achieved, PPM is the next frontier of continuous improvement for many project management organizations (see Section 2.6 for detail on notion of organizational maturity concept).

Third, the attention to PM and PPM are increasing, not just in academia, but as a result of market forces, especially in light of the changed macroeconomic climate. The author had the opportunity to validate this observation in a recent global PPM survey: 70% of the respondents recognized a growing gap between available funds and project deliverables, whereas the same percentage of participants acknowledged that resourcing projects is increasingly difficult and less predictable. Lastly, 58% of respondents observed a greater frequency of changes in strategic direction. These are all indications for significant opportunities to be addressed by project portfolio management (see Section 2.7 for a detailed discussion of the survey findings).

2.3 Strategic Versus Tactical View of Project Management

The term strategic project management has recently gained popularity. However, the interpretation of the term varies widely. Some authors consider strategic project management the management of complex projects through the combination of strategy and project management techniques for the benefit of strategy realization. In other definitions, strategic project management is characterized as an approach that shifts focus from operational measures, such as time and cost, to a more strategic view toward customer needs and market success factors (Shenhar et al., 2001a). Following the later definition of project leadership, Shenhar and Stefanovic (2006) and Artto et al. (2008) advocate the role of project managers to entail strategic and leadership aspects. Some practical reservations toward the notion of strategic project management and leadership at the execution level can be brought forward: Although an effective project manager should understand and implement the strategic intent of a project and assert leadership in his or her operational role as a manager of various stakeholders, his or her primary role is typically operational by definition. In reality, the degree of strategic action is a function of PM proficiency, as depicted in Figure 2-5.

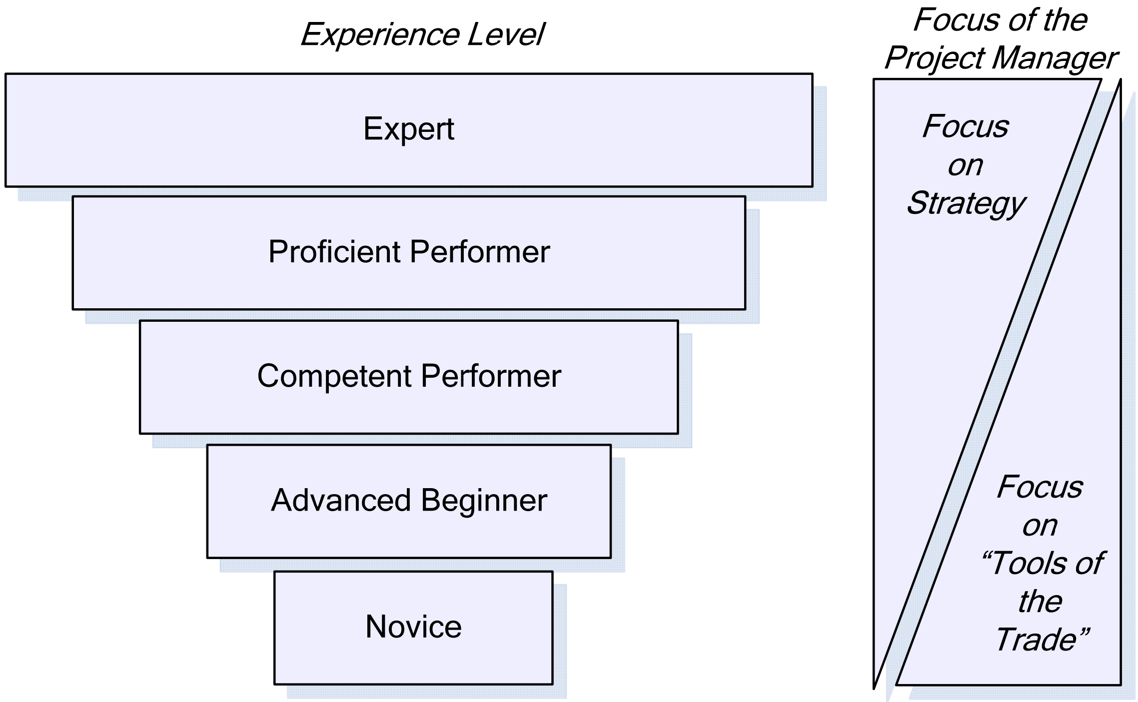

Figure 2-5: Proficiency and Focus of Project Managers (based on Cicmil, 2006)

Strategic decisions with respect to project objectives are provided to or developed with the project manager as part of the strategic management or project portfolio management processes. A project, which is defined as a result of these processes, is to be delivered to balance a series of constraints, such as scope, quality, schedule, budget, resources and risk (PMI, 2008a), as reflected by the aforementioned three project management definitions. The successful management of a project can therefore be equated with achieving the project objectives while adhering to the above constraints.

2.4 Achieving Portfolio Success: The Four Goals of PPM

In the literature of portfolio management in general, and PPM in particular, there are three recurring, distinctive goals under the general objective to maximize organizational benefit from the pursuit of the "optimal" portfolio (Dye and Pennypacker, 1999; Artto et al., 2001; Cooper et al., 2001a). These three primary PPM goals are strategic alignment, portfolio balance and portfolio benefit maximization. Crawford (2008) introduces the more generic term "utility" instead of performance, which is adequate to describe the usefulness or intrinsic value. Because most of the program and portfolio management literature refers to "benefit," this term will be used going forward.

In the following, it is described how these three goals are achieved in the context of the PPM process and what tools are used for the achievement of these goals. In their research on portfolio governance, Müller and Blomquist (2006) have provided evidence for the relevance of these goals from analyzing PPM in high-performing companies. In addition, PPM process maturity is proposed as a fourth goal (Blomquist and Müller, 2004). The effectiveness, efficiency, agility and speed of the execution of PPM and its steps, is addressed throughout this thesis.

2.4.1 Goal 1 – Achieve Strategic Alignment

The criticality of strategy implementation has been discussed in the general strategy literature quite elaborately. For example, Breene, Nunes and Shill (2007) and Bower and Gilbert (2007) analyze the balance of strategic planning and implementation of strategy in organizations. Although the defining of strategy has matured considerably and has been successfully performed in many organizations, the ability to turn strategy into reality varies widely. Portfolio management can be an effective tool in implementing strategy effectively and efficiently. As defined in *The Standard for Portfolio Management* (Second Edition), "a portfolio manager must understand the organization's strategic goals and priorities and how the portfolio supports them…. The portfolio manager typically does not create the organization's strategy, but may participate in the process, depending on the specific organization. However, the portfolio manager does play a key role in implementing the strategy by monitoring execution of initiatives in support of it and by communicating results" (PMI, 2008c, p. 14).

Research in the area of new product development provides the most insight into the aspects of strategic alignment. Cooper et al. suggest investigating three aspects of alignment: (1) strategic fit, as the consistency of projects with the articulated strategy; (2) strategic contribution, as the need to execute certain projects to achieve success with a certain strategy; and (3) strategic priorities, as the dispensing of resources according to strategic importance (Cooper et al., 2001a, pp. 106-107).

The PPM literature typically defines strategic alignment as the linking of project portfolios with organizational and vision and strategy (Cooper et al., 2001b; Artto and Dietrich, 2004). Following the notion of strategic alignment, project portfolios must support the organization's vision and strategy and should be executed in a way that they support and maximize the probability of achieving organizational goals, vision and mission. In the literature, the first of the three aspects of strategic alignment is typically emphasized, if not equated to the notion of strategic alignment. One exception for the acceptance of "rogue" projects is provided by Brady and Davies (2004), who recognize the existence of vanguard projects, which are exploratory in nature and are pursued, even if they are not aligned with the strategy. However, it could be argued that the pursuit of vanguard projects itself constitutes an element of strategy, which would mean their approval would be in line with top-down strategy.

2.4.2 Goal 2 – Maintain Portfolio Balance

Balancing a portfolio is the second primary objective of project portfolio management (Cooper et al., 2001a), and various qualitative and quantitative approaches have been introduced in the literature (Caron, Fumagalli and Rigamonti, 2007). The concept of balance can be found in many aspects of business and daily life, where individuals and organizations balance a range of financial and non-financial goals. However, when conflicting goals exist, decisions about the pursuit of these goals become more complex. For example, rigorous cost savings and strategic technology investments constitute such a goal conflict and require a compromise reflecting the trade-off between these two objectives. A portfolio should also provide a balanced mix of projects, taking into account different time frames and project sizes (Artto et al., 2001). Projects deliver outcomes that are additive, like revenue or costs, but also impact each other positively or negatively, which ultimately impacts the outcome of the project mix. In the end, a portfolio manager should optimize the outcome of the portfolio rather than the particular performance of individual projects. Therefore, "balance" implies the finding of compromises between projects with conflicting parameters or outcomes. Many balancing decisions are characterized by the need to weight trade-offs.

Cooper, Edgett and Kleinschmidt (2001a) discuss portfolio balancing in great detail and propose a range of balancing dimensions to consider, which are shown in Table 2-8.

Table 2-8: Examples of Balancing Dimensions (Cooper et al., 2001a, p. 98)

Risk vs. Reward	Reward: NPV, IRR, benefits after years of launch; market value	By	Probability of success (technical, commercial)
Newness	Technical newness	By	Market newness
Ease vs. Attractiveness	Technical feasibility	By	Market attractiveness (growth potential, consumer appeal, general attractiveness, life cycle)
Strength vs. Attractiveness	Competitive position (strengths)	By	Attractiveness (market growth, technical maturity, years to implementation)
Cost vs. Timing	Cost to implement	By	Time to impact
Strategic vs. Benefit	Strategic focus or fit	By	Business intent, NPV, financial fit, attractiveness
Cost vs. Benefit	Cumulative reward	By	Cumulative development cost

To allow for the recognition of complex trade-offs and to address cognitive limitations that were discussed in Section 2.2.5, several visualization methods are useful, such as bubble charts. These methods are discussed in Section 4.3.1.

2.4.3 Goal 3 – Maximize Portfolio Benefit

Benefits management is at the core of program and project portfolio management. In the case of PPM, benefits are to be maximized both for the individual components, as well as for the entire portfolio. Although the notion of benefits management is straightforward and not subject to debate, the proper qualification and quantification of benefits has constituted a challenge for both academics and practitioners. Similar to the concept of utility in economics, which is highly debated and leads to different utility functions from different perspectives, there is no clear and unified view on how to measure benefits for a portfolio and its components. Most of the literature suggests the use of traditional financial metrics for the determination of benefit, such as net present value, return on investment and internal rate of return, and proposes a risk-adjusted view similar to the CAPM, used for the valuation of financial assets (Archer and Ghasemzadeh, 1999b). It is important to note the limitation of traditional financial metrics in general and the application of models like CAPM in particular: Projects, unlike capital assets, are "unique endeavors," and hence the determination of their value is significantly more difficult (see Chapter 4 for further discussion). The same applies to the determination of risk. Norrie makes the case for a more comprehensive and balanced view of financial and non-financial portfolio benefits and proposes the application of balanced scorecards for the purpose of ranking projects (Norrie, 2006). Williams and Parr add another dimension to the notion of benefits management: both tangible and intangible benefits should be identified, quantified to the degree possible, and managed (Williams and Parr, 2006, p. 173).

2.4.4 Goal 4 –Continuously Improve Process Quality

Although generally the first three goals are discussed explicitly in the PPM literature, the author derives a fourth goal from several sources, which is confirmed by insights from reflective learning as a practitioner. The term agile portfolio management (Krebs, 2009) has been coined and the need for "dynamic capability" of managing portfolios to achieve competitive advantages has been articulated (Killen and Hunt, 2010). However, for most organizations such aspirations remain long-term visions rather than immediate organizational goals, in light of the current PPM process maturity (see Sections 1.4 and 2.6).

A more meaningful paradigm is to continuously improve PPM process quality and increase portfolio management maturity. In this context, Section 2.6 reviews PPM process maturity models, which serve the purpose of determining the current degree of process sophistication as well as the uncovering of deficiencies and opportunities for improvement. A conscious pursuit of increased maturity will drive the improvement of strategic alignment, portfolio balance and portfolio benefits maximization as the primary goals of PPM, in part through the attainment of agility and dynamic portfolio management capability and which constitutes the raison d'être for this fourth goal. The goal of continuously improved process quality is discussed further in the context of portfolio metrics in Chapter 5.

2.5 PPM Life Cycle Models

Both project management and computer science literature provide a wide range of life cycle models (Cooper et al., 2001b; Killen et al., 2008). A prominent example for such life cycle models is the widely implemented systems development life cycle (SDLC), which is used as a project life cycle model to describe the technical phases of a software development effort (Royce, 1970).

The Standard for Project Management (PMI, 2008a) and *The Standard for Program Management* (PMI, 2008d) similarly provide project and program management life cycles, which describe the managerial steps involved to lead and elaborate a project or program from the project or program manager's perspective. An umbrella definition for software development life cycle models could not be found in the literature, despite the emergence of numerous models. However, through the reflection on several of life cycle models from practical application over the last 15 years, the author observed three important commonalities:

1. Depiction of an end-to-end process from inception to closure, consisting of multiple stages and, or process steps
2. Provision of methods for each stage or process step
3. Description of inputs and outputs for each stage or process step

Analogous to software development or project management life cycles, a PPM life cycle describes an end-to-end process, consisting of a series of activities performed in sequence or iteratively, to achieve one or multiple outcomes (PMI, 2008c, p. 23). As PPM is still an emerging discipline, a number of PPM life cycle models can be found in the literature. Although it is generally accepted that a consistent PPM process is meaningful and desirable, neither consensus nor a truly mature process that tightly integrates PPM into the overall business life cycle could be discovered.

2.5.1 Three-stage Model by Archer and Ghasemzadeh

Section 1.5 briefly introduced the life cycle model of Archer and Ghasemzadeh (Archer and Ghasemzadeh, 1996;1999a;2004), which is frequently quoted in the literature.

Figure 2-6 depicts the three-stage model and the authors' alignment of strategy development and methodology selection with the "Preparation" stage, all screening, analysis and selection-related activities in the "Selection" stage and lastly, post-selection, execution, evaluation and close-out activities in the "Controlling" stage.

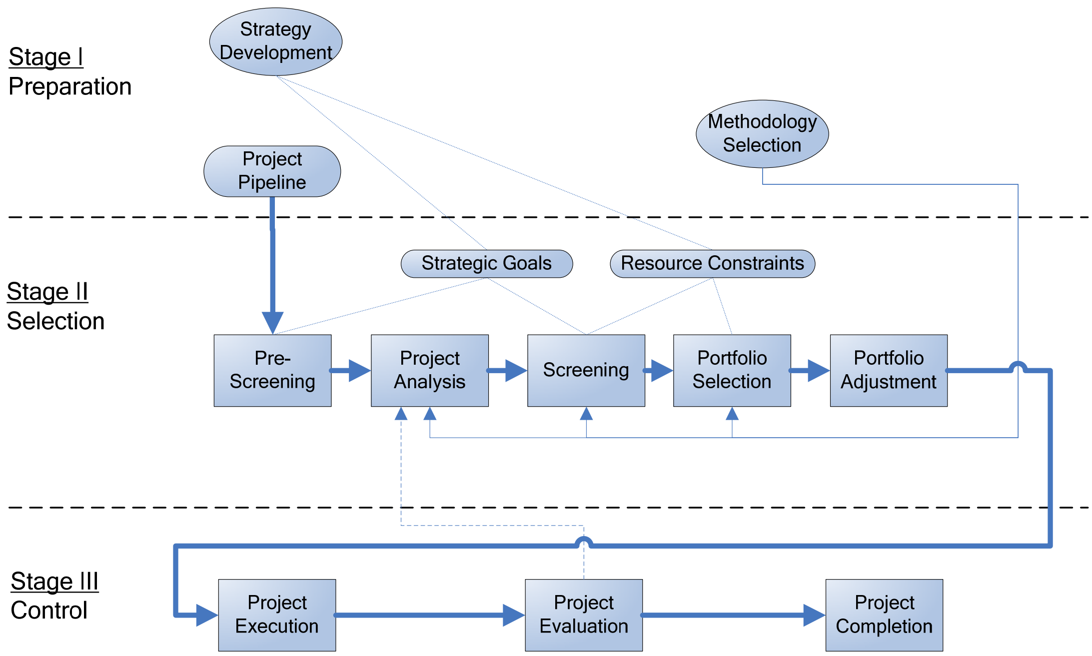

Figure 2-6: PPM Life Cycle Model Based on Archer and Ghasemzadeh (1999b)

The model promotes an integrative approach toward PPM: In Stage I the project selection methodology is determined as a strategic process and a one-time step, not to be repeated, unless another methodology becomes a better choice over time. The outcome of the methodology decision is further described as a function of acceptance by the decision makers, organizational culture, problem-solving style and project environment. Archer and Ghasemzadeh further recognize the importance of strategy development as a precursor to project portfolio selection and acknowledge that the strategic process, which precedes project selection, is often underestimated.

Stage II comprises the actual steps toward the project portfolio selection: pre-screening, project analysis, screening and optimal portfolio selection. Pre-screening, a desirable process step especially for large portfolios, helps to reduce the complexity of the portfolio by excluding inferior and redundant proposed projects from the choice set. Project analysis, screening and portfolio selection lead to the composition of the optimal portfolio, while the process is neutral toward the portfolio selection method.

Lastly, in Stage III, projects are continuously evaluated during the execution and the portfolio selection stage and may be re-started, depending on outcomes of the actual project execution.

2.5.2 Costello's Research Development Project Selection Process

One of the earlier process descriptions in the PPM literature focuses on R&D project selection. The model of Costello, as depicted in Figure 2-7, recognizes and emphasizes the various levels of stakeholders involved and depicts a goal setting and prioritization step (choice and ranking of R&D priorities) as a strategic input to the actual project selection and a parallel process for idea gathering and proposal development, leading into the selection process (Costello, 1983).

The model is unidirectional, and does not contain feedback loops or any explicit monitoring of portfolio or process performance.

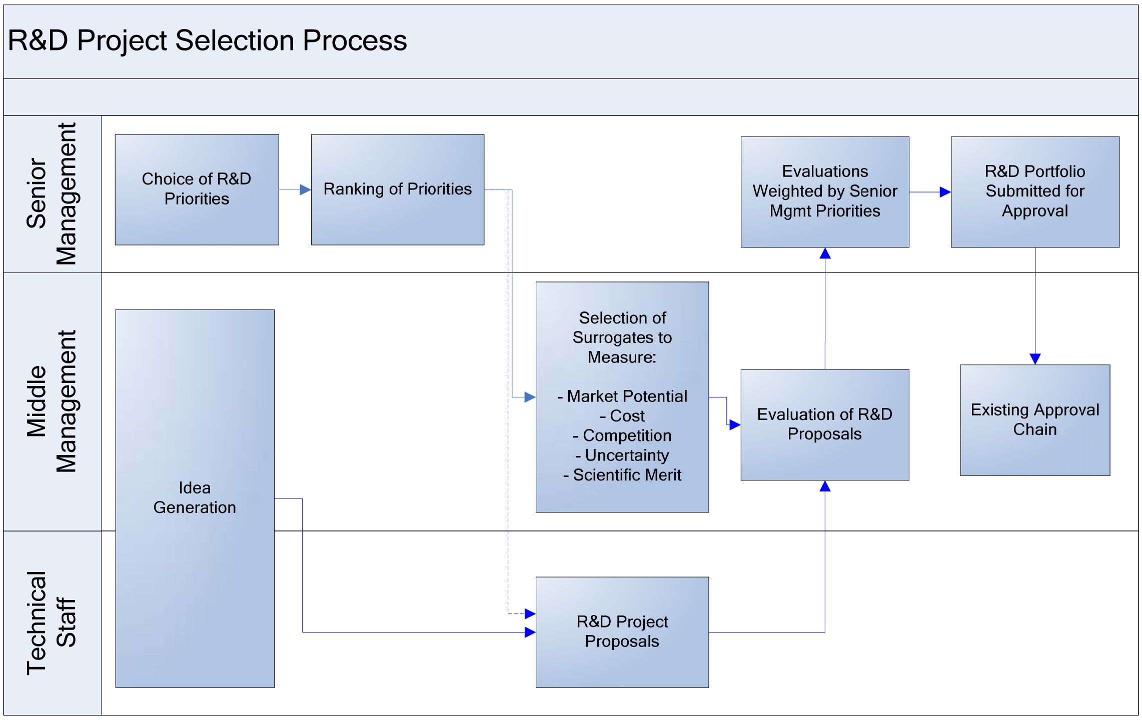

Figure 2-7: R&D Project Selection Life Cycle based on Costello (1983)

2.5.3 Project Portfolio Management Standard of the PMI

Although *The Standard for Project Portfolio Management* provides a process description, which contains the major elements of the PPM process, it may however, deviate somewhat from the terminology of other PPM process descriptions (see Figure 2-8).

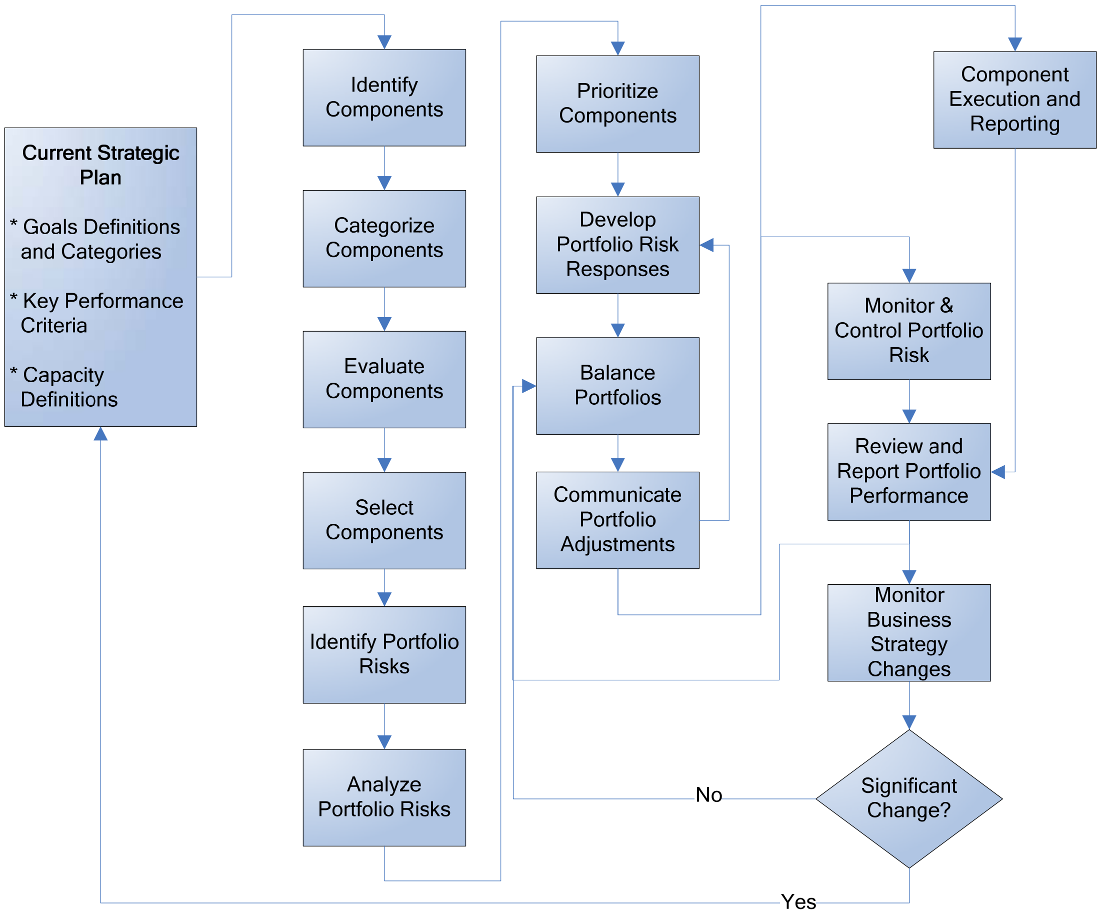

Figure 2-8: PPM Life Cycle recommended by PMI (PMI, 2008c)

Starting with the *identification* of components, PMI's generic description for the pipeline or backlog of project and program candidates, an initial *categorization* (a grouping of components into strategic categories) is performed. Each component is assigned to one category, similar to the strategic bucket approach in product portfolio management (Cooper et al., 2001a). In the subsequent *evaluation*, an initial recommendation is elaborated after a ranking and visual comparison (e.g. bubble charts) are performed. In the next step, which is rather mislabeled as *selection*, the candiate components or the entire portfolio are defined, prior to another step that is labeled as *prioritization*. In this step, components are ranked within the established categories, and some supporting evidence is collected.

PMI's standard further defines *portfolio balancing* as the finalization of the project selection, which leads to the formulation of the portfolio, which in turn best achieves the strategic objectives of an organization. Lastly, the *authorization* steps assign the necessary financial and human resources and communicate the desired outcomes. Some aspects of the PMI standard have been critiqued, mostly in regards to inconsistencies and gaps and the standards level of refinement in comparison to the *PMBOK® Guide* standard (Hanford, 2009), which, in the author's opinion, is one more indication for the early maturity state of the PPM discipline.

2.5.4 The Capital Planning and Investment Control Model

The model introduced in this section is widely used in the U.S. public sector and as a recommendation of the Office of the Chief Information Officer (OCIO) for the information technology departments in the U.S. government and its branches. The Capital Planning and Investment Control (CPIC) model, which were developed as a result of the 1996 Clinger-Cohen Act that mandates federal agencies to make more targeted IT investments, typically entails three phases: Select, Evaluate and Control (Logan, 2006). Although there are several implementations of CPIC across the U.S. government, the guideline issued by the Department of the Interior appears to be one of the most detailed and comprehensive (OCIO-DOI, 2005). Some implementations extend on the basic model and use five phases: Pre-Select, Select, Control, Evaluate, and Steady State.

The CPIC process models of the respective departments prescribe in detail the required entry and exit criteria and provide process flows for each phase, as well as tools and templates (see Figure 2-9).

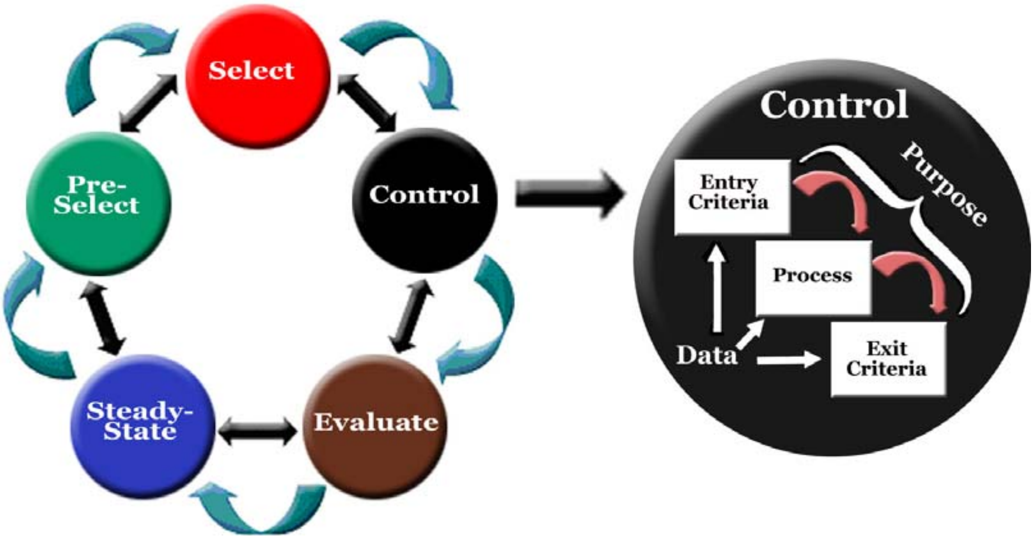

Figure 2-9: CPIC Process Model (OCIO-DOI, 2005)

While at this stage numerous adaptations of CPIC exist across departments, the degree of PPM success in the public sector is still perceived as low; supporting evidence for this statement is provided in Section 2.7.

The introduced life cycle models exhibit several characteristics that contribute to the complexity to the PPM: Models consist of multiple stages or phases, and they are in some way iterative. The understanding of and adherence to defined processes, an aspect of maturity discussed in the next chapter, are a third component of the process aspect, summarized in Figure 2-10.

Process Aspect

Multi-stage / multi-phase projects

Iterative process

Process understanding and adherence

Figure 2-10: Process Aspect of PPM Complexity

2.6 PPM Maturity

Maturity models have emerged in computer science, specifically for the evaluation of software development, through the introduction and spread of the Capability Maturity Model (CMM®) and its extension, the Capability Maturity Model Integration (CMMI®) (SEI, 2010). CMM dates back to the mid-1980s and was initially created to evaluate software development capabilities. The model was later extended to accommodate maturity evaluation for other domains, such as acquisitions and services. Today countless maturity models, both published and proprietary, are in existence and in use. The author's research efforts at Siemens Corporate Research, plus hands-on experience from managing, executing and analyzing a large number of maturity assessments, has led to the observation of the following main characteristics of these maturity models:

Table 2-9: Characteristics of Maturity Assessments

Characteristic	Explanation
Two-dimensionality	Maturity models are defined by discrete levels, associated with maturity characteristics for certain process areas or components.
Trade-off between maturity and cost	An increase in maturity is achieved by applying certain practices or principles, which lead to an intended positive outcome (reduced cost, lower error rates, increased quality etc). Although the objective of the continuous improvement process is to advance from one level to the next in either one particular or all process areas, costs are associated with achieving greater maturity, which may outweigh the benefits. Typically, a decreasing marginal rate of return can be observed and negative returns may occur beyond level 3.
Continuous improvement vs. degradation	The increase in maturity is a result of a continuous improvement process. Maturity may degrade, if no further attention is spent to process maintenance and improvement.
Notion of "best practices"	Maturity models are to a degree prescriptive and recommend certain action, based on generally accepted "best practices."
Maturity is a function of process definition and application	Both the documentation (theory) and application (practices) are relevant for demonstrating maturity; process maturity can be observed only if processes are both well documented and consistently applied. A consistent measurement and control process ensures process is both adequately defined and applied.

Although numerous maturity models have been introduced for evaluating project management organizations (Pennypacker and Grant, 2003), fewer models exist for PPM. PM Solutions' Project Portfolio Management Maturity Model (Pennypacker, 2005) is a typical two-dimensional model that follows the notion of maturity levels, as per CMMI and is characterized by five process maturity levels (initial, structured, institutionalized, managed and optimized) for six PPM process areas or components (portfolio governance, project opportunity assessment, project prioritization and selection, portfolio and project communication management, portfolio performance management and portfolio resource management). Jefferey and Leliveld (2004) introduced a similar two-dimensional portfolio management maturity model for information technology articulating multiple characteristics for the stages “defined,” “managed” and “synchronized.”

PMI’s *Organizational Project Management Maturity Model* (*OPM3)* (PMI, 2003;2008b) constitutes a more complex maturity model and, in the authors’ opinion, the most advanced model at this point. *OPM3* is suited to evaluate the organizational project management domains project, program and portfolio management for four process improvement stages (standardize, measure, control and continuously improve) across five process groups for program and project management (Initiate, Plan, Execute, Control, Close) and two process groups for the portfolio management domain (Aligning and Monitoring Process Groups), as illustrated in Figure 2-11.

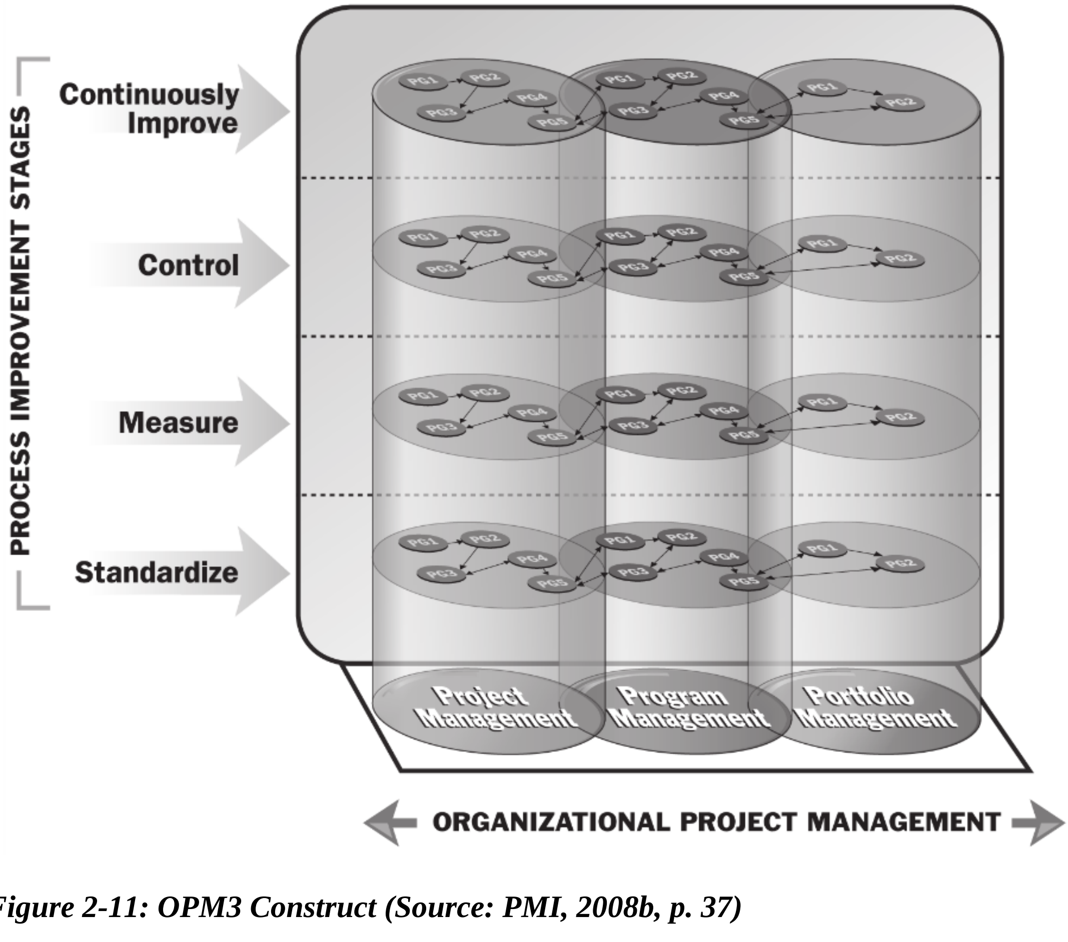

Figure 2-11: OPM3 Construct (Source: PMI, 2008b, p. 37)

Furthermore, *OPM3* analyzes—beyond the scope of project, program and portfolio management processes—an array of organizational enablers, such as organizational policy and vision, sponsorship, organizational structures and project success criteria. The model deserves attention, as it indirectly ties Key Performance Indicators (KPIs) to the achievement of those best practices, which make up the accomplishment of the aforementioned stages. Figure 2-12 demonstrates how the *OPM3* construct can be decomposed; the maturity corresponding to a process stage is a function of achieving a number of "best practices," which *OPM3* describes as an industry-acknowledged way to achieve a stated goal. A best practice is achieved when one or multiple capabilities are demonstrated, where the capabilities describe specific organizational competencies.

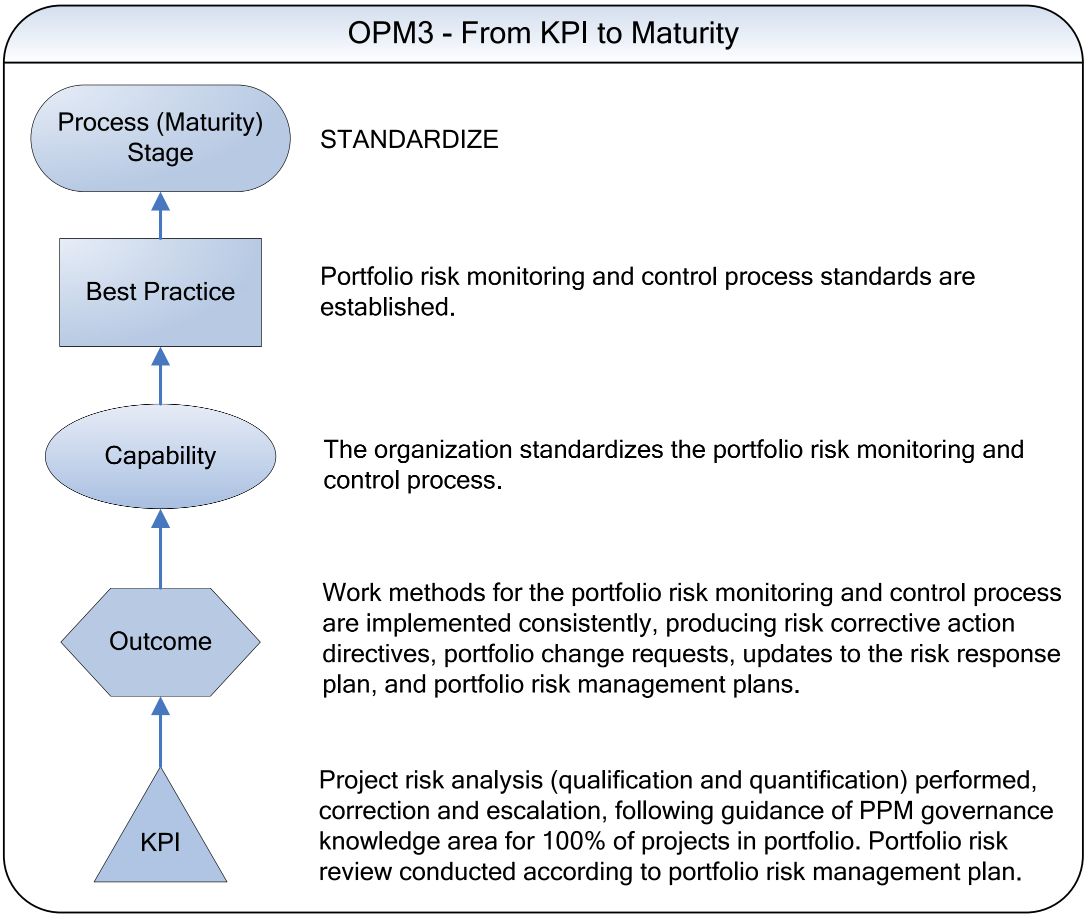

Figure 2-12: OPM3 Multi-Dimensional Model (based on PMI, 2008b, p.26)

A capability exists when certain outcome of such capability can be observed in either tangible or intangible form. A KPI serves as a measurement of a qualitative or quantitative degree of achievement of an outcome.

Like most maturity models, the aforementioned examples provide some metrics for maturity, and it is commonly assumed that a greater degree of process maturity will have a positive impact on the business, whereas the achievement of greater maturity is tied to implementation effort and hence cost.

The reason why the PPM maturity concept is discussed, is its relevance for the selection of suitable metrics. Immature organizations will focus on different metrics than organizations with higher maturity. This is a result of:

- Different focus both in regard to portfolio management objectives and goals surrounding the PPM process
- Varying degree of availability and quality of PPM (process)-related data.

Process metrics that allow determining and driving maturity and support the achieving of benefits from PPM, such as process effectiveness and adherence, efficiency, cycle time and agility are discussed in the context of Proposition 4 in Section 5.4.

At least since the discussion of achieving return on investment from project management improvements, introduced by Ibbs and Kwak as PM/ROI (Ibbs and Kwak, 1997; Kwak and Ibbs, 2000), the topic of benefits from greater project management maturity has been discussed by practitioners and academics. The study on the very topic, commissioned by the Project Management Institute, provided much qualitative indication for value of project management, whereas only limited quantitative evidence could be found (Thomas and Mullally, 2008).

2.7 PPM Survey – State of Maturity and Challenges

2.7.1 Introduction

In 2009, the author conducted a global project portfolio management survey with ESI International's global client base with the objective to explore PPM maturity, current PPM challenges and the impact of the current recession on PPM (Arlt, 2009b). This survey was targeted at various management levels in project businesses and served the objectives to understand—

a) The level of portfolio management maturity from the practitioner perspective of the project and program managers,
b) Challenges and failure points, and
c) Specific PPM-related challenges, in light of the economic recession.

The participants were asked about their perception of the quality of the PPM process from their perspective.

2.7.2 Survey Demographics

Participants from commercial clients in financial services, telecommunication, IT, energy, pharmaceutical and healthcare industries, professional services, manufacturing and other sectors public sector[24] clients were asked to respond to 14 questions using an online survey. The geographic coverage of the survey included the U.S., U.K., Europe, and Asia for commercial clients, as well as government organizations in the U.S. The 467 respondents reported project portfolio sizes ranging from less than 10 to greater than 1,000 projects per year. Not all respondents answered every survey question. Participants of the survey remained anonymous.

Survey participants were asked to identify themselves as project managers, program managers, PMO heads, line of business managers or executives. On average, about half of the participants identified their role as project or program managers. PMO heads, line of business managers and executives where slightly underrepresented among survey participants in the U.S. commercial region (13.4%), while the Asia region showed the highest percentage of these middle- and upper management participants job classes with 37.5% of survey respondents. For all geographies, both the executive and project and program management perspective of PPM maturity was adequately represented. Survey participants from the U.S. commercial sector represented mostly large

[24] Because of differences in terminology between the private and public sectors, the government version of the survey was slightly modified to accommodate the appropriate language, whereas the structure and content of the survey was identical.

organizations with more than $1bn in revenues (51.9%), while large organizations of this magnitude only made up about one third of the data represented for the other geographies. Lastly, survey participants were asked, at what level portfolio decisions would be made - while numbers indicated that U.S. clients would make such decisions to a lesser degree at the corporate than the divisional or departmental level, this finding can be explained with the aforementioned difference in organizational size, as large organizations typically delegate portfolio decision to their rather sizable divisions or departments. More detailed data from this survey are provided in Appendix A.

2.7.3 Findings

Findings of the survey supported assumptions stated earlier in regard to the early maturity stage of PPM in practice. Redundancies and conflicts in project priorities were reported by 71% of the respondents, and fewer than half of the respondents observed a consistent approach for screening, prioritizing, selecting and approving projects, both defined and implemented in their organizations.

One indication in the direction of both general state of immaturity and the lack of adequate understanding for interdependencies, especially in regard to project timelines and resources, was provided by the following survey finding: Resource conflicts and work overload for critical resources were reported by 73% of respondents, with the U.S. commercial sector reporting 85.6%. Lastly, only 29% of respondents consider their organization mature or very mature, in respect to their PPM process. Figure 2-13 provides an overview of the key findings for the commercial sector participants of the survey.

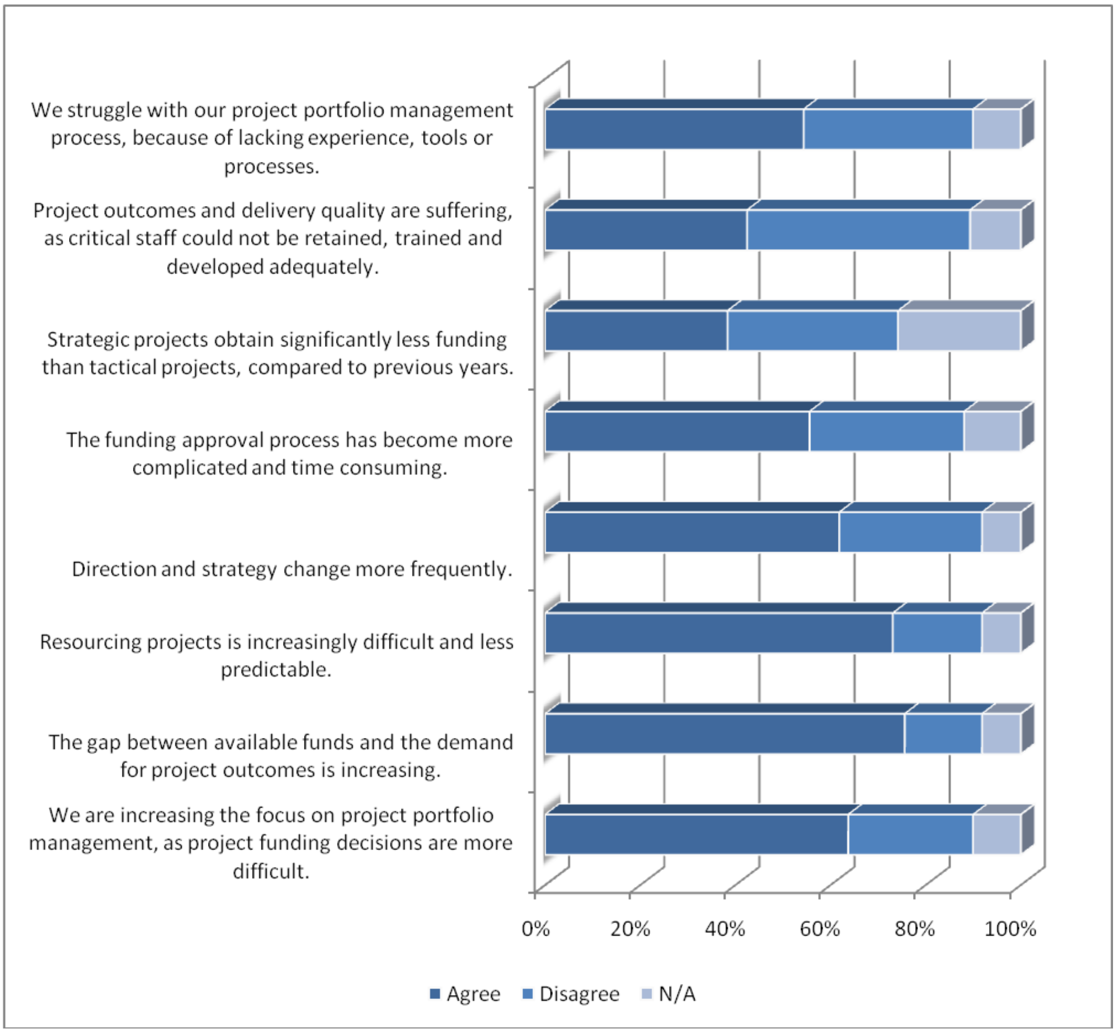

Figure 2-13: Key Findings – U.S. Commercial Sector

For the government sector, maturity ratings appear to be even lower than in the commercial sector (see Figure 2-14). Although 28% of U.S. commercial sector respondents describe PPM in their organization as “mostly ad-hoc and informal,” 54% of U.S. public sector respondents have the same conclusion.

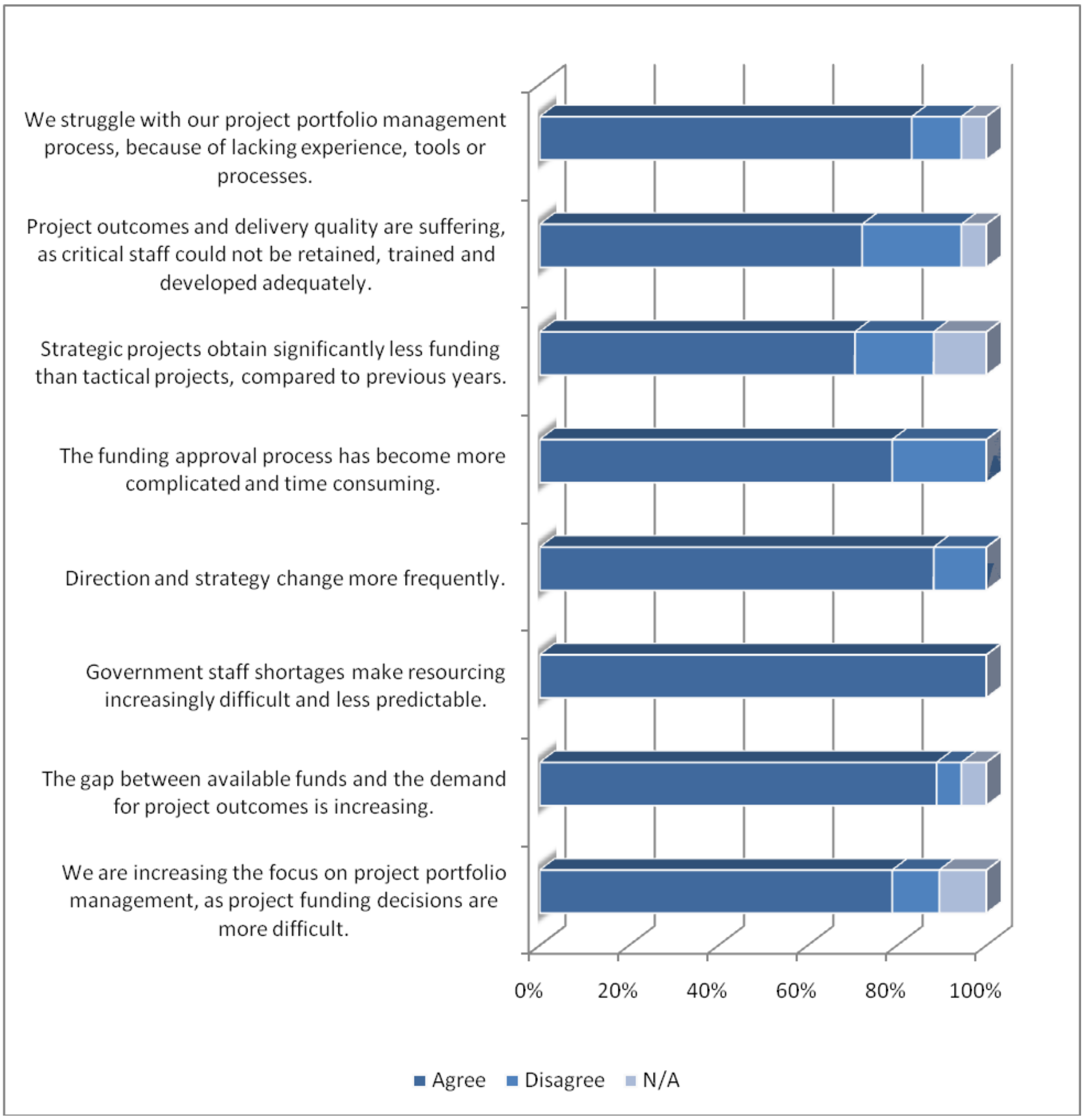

Figure 2-14: Key Findings – U.S. Government Sector

Whereas most of the questions related to aspects of the portfolio selection, the survey further provided interesting insight in the monitoring and control phase and led to the conclusion that frequently basics of management projects are overlooked, as a considerable number of organizations do not perform any project reviews. Specifically 17.1% of U.S. commercial respondents reported no project reviews are performed. However, 39% of respondents stated that corrective action is taken quickly as a result of the project review process. For the government sector participants, responses are even more alarming: 50% of the participants declared that no corrective action is taken.

The survey also revealed an increasing importance of project portfolio management in a time of economic distress in the commercial sector, as funds are increasingly scarce, while the demand for project outcomes is increasing. In line with economic stimulus efforts by the government, this applies to a lesser degree to the public sector, at least at a federal level; instead, the government is facing severe shortages of resources to adequately deliver the intended portfolio benefits. In light of the sheer size and complexity of the portfolio managed by the federal government, PMI's CEO called for creating a chief portfolio officer position in the government to accelerate benefits realization and eliminate waste (Balestrero, 2009).

The following findings and implications can be summarized:

- In general, PPM maturity is perceived to be low – further research towards appropriate PPM methodologies to increase PPM maturity appears warranted. Several symptoms suggest that the actual maturity is even lower than perceived by the participants, which was anticipated (see discussion in Section 1.5.2).
- Resource conflicts and work overload, reported by 73% of the survey participants provide a strong indication that interdependencies within portfolios are not sufficiently understood and managed.
- The importance of PPM is increasing, as commercial organizations face the dilemma of having fewer funds available to satisfy growing expectations for project deliverables. Conversely, government organizations need to demonstrate quicker impact with available resources. This finding implies the need for understanding of strategic alignment and strategic contributions of projects.

2.8 Chapter Summary

Chapter 2 provided the literature foundation with definitions for project, program and portfolio management and analyzed origins and related disciplines of PPM, making the case for a broader view on PPM and assigning greater emphasis to management, decision and behavioral science aspects of portfolio management.

In line with the pertinent literature, three organizational goals for project portfolio management have been articulated, and the case for a fourth goal, the continuous improvement of PPM process quality, has been made. Several PPM life cycle models have been discussed, including the model of Archer and Ghasemzadeh, which will serve as the baseline model for the subsequent chapters. The concept of PPM maturity has been discussed and illustrated with findings from the PPM literature and the survey conducted by the author.

3. RESEARCH METHODOLOGY

3.1 Chapter Introduction and Objective

Chapter 1 indicated the need for further discussion about the research framework that underlies this thesis. The theoretical foundation of the research framework including research philosophy and methodologies and the application of the research framework to this thesis are discussed. As the terms methodology, method and technique are frequently used in the literature, these terms are defined in this chapter. Furthermore, validity of findings and limitations of the approach, as well as ethical issues, are elaborated.

3.2 Research Framework

The research framework that is discussed in this section follows taxonomy introduced by Saunders, Lewis and Thornhill (2003), which consists of research philosophy, approach, methodologies, time horizon and techniques and procedures applied in a research effort, as illustrated in Figure 3-1. The "research onion" of Saunders et al. (2003) shall be "unpeeled" to provide the baseline for the discussion of the research framework that underlies this thesis.

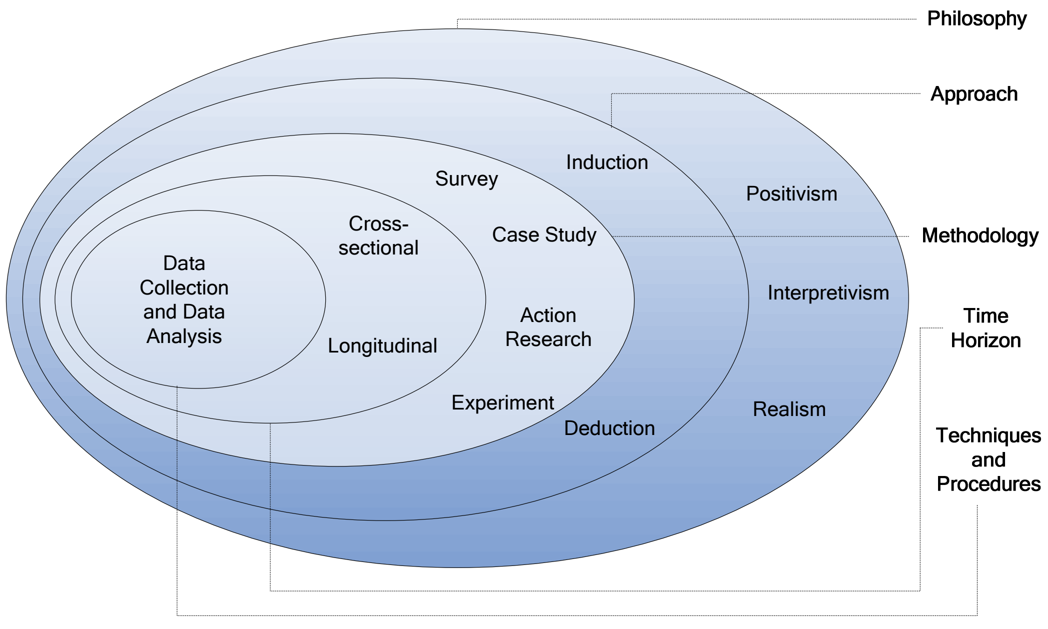

Figure 3-1: The Research Onion (Simplified; Based on Saunders et al., 2003, p. 132)

3.2.1 Research Philosophy

Research philosophies or paradigms provide the framework to “the development of knowledge” (Saunders et al., 2003, p. 83) and manifest how data should be captured and analyzed (Levin, 1988). Several philosophical paradigms are recognized and used in the scientific literature; and the most common philosophical approaches, which are summarized in Table 3-1, are briefly discussed in Sections 3.2.1.1 through 3.2.1.3.

Table 3-1: Research Philosophies

Research Approach	Attempts to Understand
Positivism	Objective reality
Interpretivism	Subjective reality (as perceived by subjects studied)
Realism	Reality in the context of observable hidden root causes

3.2.1.1 Positivism

The positivist research philosophy is typically applied in natural sciences and aims at validating the truth of a hypothesis with the observing and interpreting of mostly quantitative data (Saunders et al., 2003, p. 84). Saunders et al. further characterize the perspective of the positivist researcher as an independent and objective analyst who “… interprets data that have been collected in an apparently value-free manner” (Saunders et al., 2003, p. 83). Generalizing findings from a positivist is rather unproblematic. However, a positivist research philosophy contributes rather incrementally to an existing body of knowledge (Stiles, 2003). Positivist researchers typically, but not necessarily, rely on quantitative data. The inherent shortcoming of positivism lies in the limitation of a researcher (as a human subject) to perceive the *objective reality* 100% objectively.

3.2.1.2 Interpretivism

The interpretivist research paradigm focuses on the observing and interpreting of *subjective reality*, that is, the reality as it is perceived by the studied subjects. Consequently, it is possible that multiple subjective views of the same reality exist. The interpretivist point of view plays a particular role in social sciences, as often individuals and their perspective on reality are studied (Saunders et al., 2003). Both experimentation and surveys are common tools to support interpretivist research.

3.2.1.3 Realism

Although realism–similar to positivism—also follows the logic of natural science, it takes a different interpretative direction. Realist theory reaches beyond observable phenomena and attempts to capture a more holistic view of reality that includes underlying mechanisms that cannot necessarily be observed directly (Taylor and Bogdan, 1998). It needs to be recognized, however, that realists implicitly use a subjective definition of reality that may diverge from the absolute reality (Riege, 2003). Case studies, interviews and some quantitative methods are used to support realist research (Perry, Riege and Brown, 1999).

3.2.2 Research Approach

Following the research framework of Saunders (2003), the most common research approaches, induction and deduction, both entail the collection of data and development of theory. Table 3-2 illustrates the characteristics of both inductive and deductive research approaches. Whereas inductive research observes qualitative or quantitative data and draws conclusions, deductive research defines a theory (articulated as a hypothesis) and validates it qualitatively or quantitatively.

Table 3-2: Research Approaches (Source: Babbie, 1993)

Purpose	Explanation
Deductive approach	Identifies relevant theory, developing hypotheses, making observations relevant to testing the hypotheses and comparing the hypotheses and observations
Inductive approach	Begins by making observations about a set of relevant data and then seeks to discover patterns that may point to more general theories

It is typical for many research efforts that both inductive and deductive approaches are applied (Hyde, 2000). A balanced use of induction and deduction—rather than a sole inductive research approach—is advocated in the literature, because it leads to flexibility in the research and balanced perspectives (Hyde, 2000; Saunders et al., 2003).

3.2.3 Research Methodology

Research methodologies are at the core of the research framework. Several qualitative methodologies and specifically one quantitative research methodology shall be discussed here, as they are relevant to this thesis. Survey, case study, experimental and action research methodologies are to be introduced and discussed, as well as action research, which have been applied in this research effort.

3.2.3.1 Survey

According to Neuman and Kreuger (2003), survey research is the most common research methodology used in social sciences. Surveys can be used to support either inductive or deductive research, as they allow proving theories or hypotheses (deduction) or the observing of data and identification of patterns that leads to establishing a theory (induction). This thesis made use of the survey methodology for the stage setting and the supporting of the research propositions articulated and validated in this thesis. The application of the survey methodology for the purpose of exploratory research allows researchers to expose issues and better understand them (Sekaran, 1992).

3.2.3.2 Case Study

The case study method as formally discussed by Yin (1984;1994) has become a generally accepted research methodology in social sciences. Eisenhardt (1989) defines case study research as a methodology that “focuses on understanding the dynamic present within a single setting,” highlights the ability of the methodology to capture both qualitative and quantitative information and “provide[s] description, test theory or generate theory” (Eisenhardt, 1989, p. 534).

3.2.3.3 Action Research

Action research constitutes an iterative, reflective research methodology that aims at progressively evolving an organization toward a goal. This approach gained significant popularity in the social sciences (Kemmis and McTaggart, 1988; McNiff and Whitehead, 2000; McKay and Marshall, 2001). Figure 3-2 illustrates the basic principle of action research.

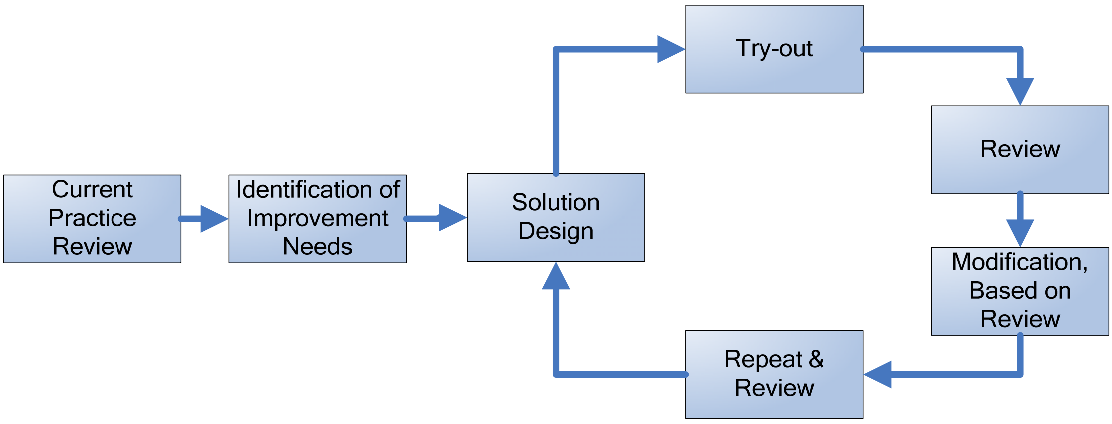

Figure 3-2: Action Research Cycle (Based on McNiff and Whitehead, 2000)

Nogeste (2006) discusses the diverse definitions of action research and summarizes the characteristics of action research as follows:

- Involvement of the researcher as a genuine and active participant
- Concurrent research and action
- Iterative nature, as successive research cycles are executed
- Reflection after each iteration
- Convergence toward the research objective with each iteration
- Preceding exploratory steps for purposes of stage setting
- Partnering of researcher and research subject
- Collection of real world data throughout the research cycle

3.2.4 Time Horizon

One critical question for any research venture is to define whether a research effort is to observe a research problem at a specific point in time or over a defined duration (Saunders et al., 2003). The decision whether to choose a longitudinal or cross-sectional study further relates to the choice of research methodologies. If a researcher decides to use a survey, this choice typically implies a cross-sectional time horizon, whereas action research may take a longitudinal perspective.

3.2.5 Data Collection

A researcher has the option to collect qualitative data, quantitative data or both. Although the use of both quantitative and qualitative data is established and credible, qualitative research is typically associated with inductive research. Table 3-3 summarizes the characteristics of both data collection approaches.

Table 3-3: Quantitative vs. Qualitative Research (Kumar, 2005, pp. 17-18)

Difference with respect to—	Quantitative Research	Qualitative Research
Approach to inquiry	Structure/rigid/predetermined methodology	Unstructured/flexible/open methodology
Main purpose of investigation	To quantify extent of variation in a phenomenon, situation, issue, etc.	To describe variation in a phenomenon, situation, issue, etc.
Measurement of variables	Emphasis on some form of either measurement or classification of variables	Emphasis on description of variables
Focus of inquiry	Narrow focus in terms of extent of inquiry, but assembles required information from a greater number of respondents	Covers multiple issues but assembles required information from fewer respondents
Dominant research value	Reliability and objectivity (value-free)	Authenticity, but does not claim to be value-free
Dominant research topic	Explains prevalence, incidence, extent, nature of issues, opinions and attitude; discovers regularities and formulates theories	Explores experiences, meanings, perceptions and feelings
Analysis of data	Subjects variables to frequency distributions, cross-tabulations or other statistical procedures	Subjects responses, narratives or observation data to identification of themes and describes these
Communication of findings	Organization more analytical in nature, drawing inferences and conclusions, and testing magnitude and strength of a relationship	Organization more descriptive and narrative in nature

The following Section 3.3 applies the introduced research framework to the approach taken in this thesis.

3.3 Selection and Discussion of Research Methods

The author used more than one research methodology for the validation of the propositions that have been introduced in Section 1.5. All methodologies used in this thesis shall be discussed in this section.

3.3.1 Literature Research and Initial Survey

Section 1.5.5 discussed the rationale for the selection of both standard project management journals and recognized publications in other adjacent and relevant disciplines. The author made the case for expanding the literature review (see Chapter 2 and immersion sections 4.2, 5.2 and 6.2) beyond the typical scope of literature in the context of the PPM topic, which includes project and program management, new product development, financial portfolio management and management science literature. In addition, the author explored decision science and behavioral science literature to investigate aspects of choice in the decision process, as well as cognitive behavior and its limitations.

To further substantiate perceived gaps from the literature, an exploratory survey was conducted by the author. The dual-purpose survey, which served both information needs of ESI International and the research objective of this thesis, investigated the current PPM maturity of organizations, pain points and additionally, PPM-related issues specific to the 2008/2010 economic downturn and was targeted at the project manager and program manager audiences. Participants were asked about their perception of the quality of the PPM process from their perspective as project and program managers. This allowed the surveying of a large participant base and an insightful bottom-up perspective on prevalent PPM challenges.[25] A base version for commercial sector survey participants was slightly modified to accommodate government-specific terminology in order to survey public sector participants as well. The survey was structured as follows:

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[25] Further research is planned for late 2010 to compare the bottom-up with the top-down view of an executive decision maker audience for purposes of comparative analysis.

Table 3-4: Structure of the Exploratory Survey

Theme	Objective	Content Summary of Questions
PPM Maturity – Perceptions and Symptoms	Understand perceived maturity and evaluate actual maturity, based on PPM maturity symptoms	Q1. Perceived degree of consistency of organizational PPM process Q2. Frequency of portfolio evaluation Q3. Frequency of project review Q4. Action taken as result of project review Q5. Degree of tool support Q6. Perceived overall maturity of PPM process Q7. PPM process quality observations (eight sub-questions, based on expert discussion) Q8. Challenges of PPM process (eight sub-questions, based on expert discussion)
Organizational PPM Setup	Understand roles, portfolio size and process ownership, in the context of the survey participant's perspective	Q10. Organization size Q11. Level at which portfolio decisions are made Q12. Portfolio size Q14. Process ownership
Participant Information	Gather contextual information about survey participant to understand process role and perspective	Q9. Job title of participant Q13. Role in PPM process

From an epistemological perspective, the survey was aimed at validating the author's observations as a practitioner in the field regarding the perception of relative immaturity of the PPM domain and taking—beyond a positivist view—an interpretivist view on the reality of PPM, as perceived by the 467 survey respondents. The exploratory survey used an inductive research approach to explore general PPM maturity, as perceived by the survey participants and symptoms for PPM immaturity.[26] Data gained from the survey were mostly quantitative in nature; some additional qualitative data provided for commentary were not mined for the purpose of this thesis.

3.3.2 Case Study

The author conducted a longitudinal analysis in the context of a project with a large business and IT organization. Findings and data from interviews throughout the project where summarized in a case study. It shall be pointed out that the actual project exhibited

[26] Since the dual-purpose survey served objectives beyond the purpose of this thesis, not all findings and conclusions are discussed in this work, but rather only those that were deemed relevant by the author.

characteristics of action research, as discussed in Section 3.2.3.3, as the organization was supported throughout a one-year period of time and multiple improvement iterations and calibration exercise were performed. In these iterations, solutions were designed, tested, reviewed and modified as needed. This cycle was repeated a number of times for several topic areas (see Figure 3-3). Throughout the project lifecycle, interviews notes, qualitative and quantitative data have been collected to be used in the subsequent case study.

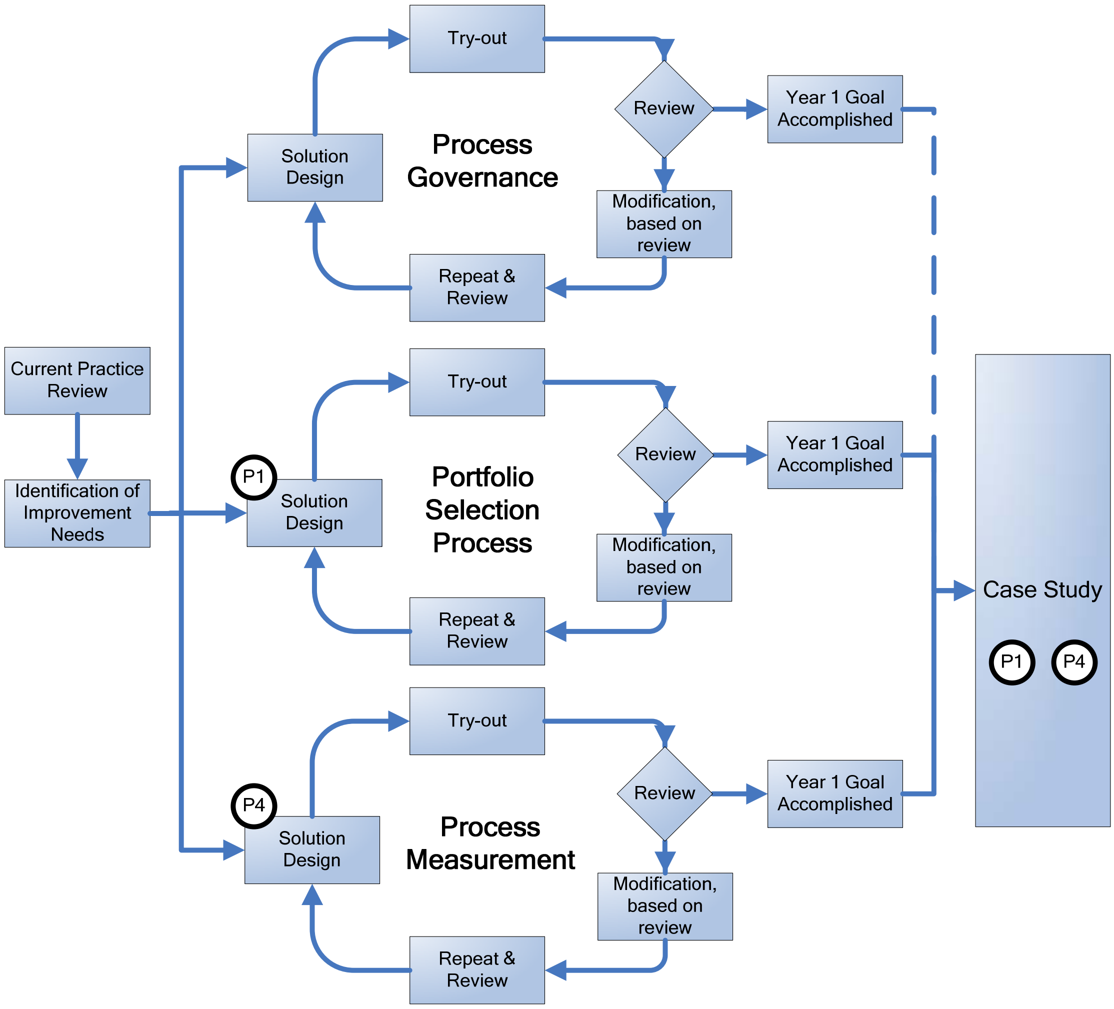

Figure 3-3: Project Life Cycle Toward Case Study

As this reflective process was repeated numerous times for establishing a PPM governance process, the actual project selection process and the process measurement process, reflective learning exercises were performed. The case study was compiled at the conclusion of the improvement cycle to capture a retrospective view on application of the techniques and methods and ultimately to validate the proposed approaches for the choice of portfolio selection methods (Proposition 1) and the selection and application of process metrics (Proposition 4). Further details of the case study are discussed in Section 7.3.

3.3.3 Experimentation

As per the introduction of the research approach in Section 1.6, the author used experimentation for the validation of Propositions 2, 3 and 5. The application of experimental validation of results was one of the author’s ambitions to pursue in the context of this work with several objectives in mind. First, due to the author’s background in economics, the application of methods that have proved to add value in the field of economics, especially in the context of bounded rationality, was both intriguing and relevant to the discussion. This approach also follows the notion of re-application of existing methodology from other fields in the context of the DPM program, as discussed in Section 1.2. Second, applying a methodology that provides quantitative experimental data with statistical significance for purposes of validating the propositions had particular appeal. Lastly, introducing a proven research methodology to the field of project portfolio management that could be beneficial for further research (see Chapter 8) added to the benefits.

Most of the experience for this approach is drawn from behavioral economics, which addresses the aspect of bounded rationality (Gigerenzer and Selten, 2001), as discussed in Section 2.2.5.6. Grossklags (2007) summarizes several principles from the literature on experimental economics to be applied to successful experiments, which have been adopted for the experiment conducted for this thesis work.

First, the experiment has been designed to exhibit *realism*, as the setup should be comparable to a real-world decision-making situation. The scenario selected for the experiment consisted of a hypothetical yet realistic portfolio for a software development company that was selected (but modified and anonymized) based on a portfolio of an organization with which the author had previously worked. Most of the modification related to the second experimental design principle: *simplicity.* A balance between realism and simplicity is of critical importance for a behavioral experiment, which was designed to provide clear instructions (tested on a sample population) and an easy-to-use, single-screen simulation tool for the actual portfolio selection. The experiment, which consisted of two iterations (see Section 7.2) was deemed stable after a test round, as participants had virtually no questions for clarification in the actual four lab sessions. A third aspect, *provision of incentives* was treated as less important than what would be required in the context of competitive simulation scenarios, where performance pay rather than flat fee awards as chosen in this experiment would be of greater value. Although participants were provided with one hour to complete the two iterations of the experiment, time to completion ranged between 35 and 70 minutes. And although it was not discussed in detail, the author did not find a correlation between time spent and optimality of outcomes.

Although the experimental setup is discussed in great detail in Section 7.2, the approach nevertheless shall be briefly outlined here. The work breakdown structure for the experiment included four key elements: experimental planning and design, test run and calibration, experiment and analysis of results.

3.4 Validity of Findings and Limitations of the Approach

As discussed in Chapter 1, both case study and experimentation have served the purpose of validating the five propositions as being reasonable and likely to be true.

Yin (1998, pp. 242-243) identifies construct validity, internal and external validity, as well as reliability as the four elements to confirm the validity of case study research. Several of these validation elements have been applied in the context of this case study and are explained in Table 3-5.

Table 3-5: Testing the Validity of Case Study Research (based on Yin, 1998, p.243)

Tests	Case Study Tactic	Research Phase in which tactic occurs	Tactic applied in this research effort
Construct validity	Use multiple sources of evidence.	Data collection	Series of interviews and quantitative data (five metrics)
	Establish chain of evidence.	Data collection	Notes from interviews and discussions throughout the project and data collection
	Have key informants review draft case study report.	Composition	Comprehensive review by portfolio manager (key source)
Internal validity	Do pattern matching.	Data analysis	Not applicable for single case study
	Do explanation building.	Data analysis	Causalities have been identified and discussed
	Do time series analysis.	Data analysis	Not performed in this case study
	Do logic models.	Data analysis	Not performed in this case study
External validity	Use rival theories within single cases.	Research design	Not performed, due to lack of comparable theory
	Use replication logic in multiple-case studies	Research design	Not applicable for single case study
Reliability	Use case study protocol.	Data collection	Simple case study protocol established and applied.
	Develop case study database.	Data collection	Collected interview notes and metrics data

In this context, limitations of the approach shall be discussed. Eisenhardt and Graebner (2007, p. 27) state "while single-case studies can richly describe the existence of a phenomenon, multiple-case studies typically provide a stronger base for theory building. …[T]he theory is better grounded, more accurate, and more generalizable (all else being equal) when it is based on multiple case experiments. Multiple cases enable comparisons that clarify whether an emergent finding is simply idiosyncratic to a single case or consistently replicated by several cases," The author consciously abstained from a multi-case study option, as efforts involved for a single case study were already considerable and the time frame for measurement of success would have varied for multiple cases, due to varying cycle times and inconsistent maturity. Although the case study approach seemed suitable overall, the combination of case study for those propositions, which required both induction and deduction from a real-world PPM process with experimental validation, was deemed a good mix of validation techniques for the verification of the propositions brought forward.

For the experiment, one – at least theoretical – epistemological challenge is known as the Duhem-Quine problem, that is, the impossibility to test a hypothesis or proposition in complete isolation, as it is impossible to isolate a single hypothesis or proposition (Smith, 1994). However, as Grossklags (2007, p. 2) points out, "economic experimentalists aim for a more local form of external validity test called parallelism in which they evoke a more narrow relationship between small-scale experiments and realistic markets. Given main characteristics of the economic environment observed in the field and modeled in the laboratory they argue that observations from the experiment will then carry over into these closely related real world institutions and can be further validated by field data."

The selection of subjects for an experiment, typically drawn from student populations at universities to simulate the behavior of portfolio managers is a lesser concern. If key criteria for experimental setup, as discussed in Section 3.4, are implemented, student populations can be expected to behave similar to managers (Ball and Cech, 1996).

As stated in Chapter 1, the author consciously chose the introduction of propositions and to prove them as reasonable in the proposed context.

3.5 Ethical Issues

Ethical issues are particularly relevant when performing experiments with human subjects, as performed by the author at the Princeton Laboratory for Experimental Social Science (PLESS). Similar to the guidelines at RMIT, human subject experiments at Princeton University follow strict ethics guidelines and regulations that require the documentation of appropriate ethics training and the approval of experiments by the Institutional Review Board for Human Subjects (IRB). Strict regulations and guidelines have been established in light of controversial human subjects experiments, such as the Stanford prison experiment conducted at Stanford University in 1971 (Zimbardo, 2007). As the principal investigator, the author and his advisors filed a formal application with the IRB and provided a record of successful completion of the training course "Protecting Human Research Participants" by the U.S. National Institute of Health. The application, which contains the certificates, can be found in Appendix C. Other aspects, such as deception (for example, through withholding of relevant information), not only conflicts with ethics standards but also creates potential mistrust of the participants and may negatively impact on the results of the study (Bonetti, 1998).

3.6 Methodology, Methods and Techniques

Throughout the project and portfolio management literature, the terms method and technique are used rather interchangeably. However, a closer look at the terms yields benefits for the further analysis and the intent of a conscious choice of the most suitable selection method. A technique (derivative from the ancient Greek word τεχνικός, technikos) describes a (scientific) procedure, whereas a method (derived from μέθοδος, methodos) constitutes a systematic process of accomplishing something. *The American Heritage Dictionary of the English Language* (Picket, 2006), defines a technique as "the systematic procedure by which a complex or scientific task is accomplished." The dictionary further defines a method as "a means or manner of procedure, especially a regular and systematic way of accomplishing something" *or* "the procedures and techniques characteristic of a particular discipline or field of knowledge." Lastly, a methodology may be comprised of multiple methods, practices and procedures. One of the most conceptually clear differentiations between the terms can be borrowed from educational research: Anthony defines approach, method and technique as a "trio of terms," as hierarchically linked, whereas one or multiple techniques carry out a method, which is consistent with an approach (Anthony, 1963). Anthony's logic can be easily translated to project portfolio management.[27] As shown in Figure 3-4, techniques and methods contribute to a cohesive methodology for the entire PPM life cycle, in the sense of a "portfolio" of methods.

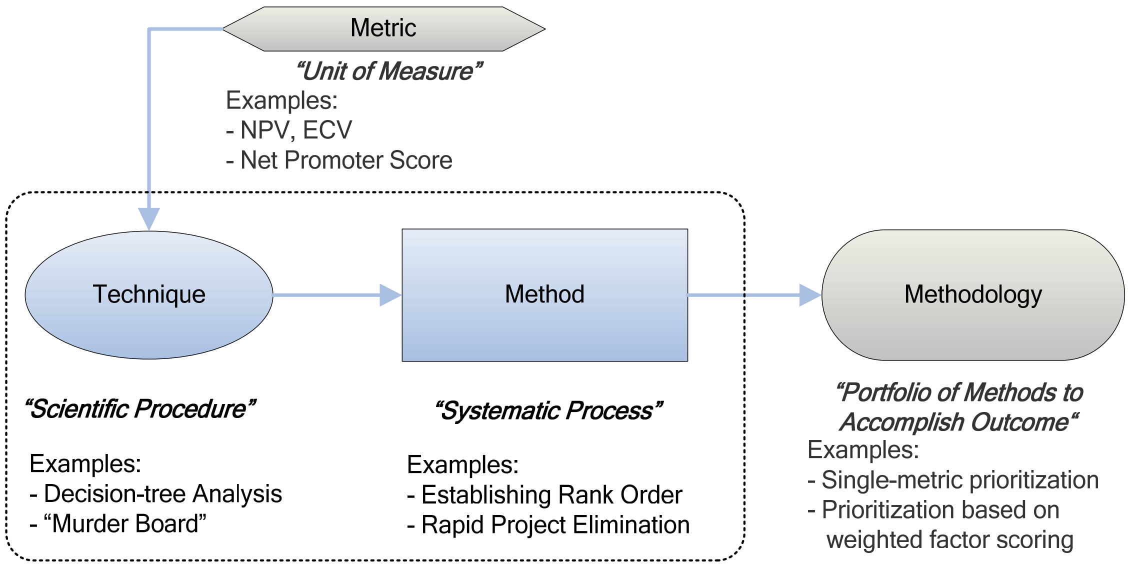

Figure 3-4: Techniques and Methods in the PPM Context

3.7 Chapter Summary

Chapter 3 provided the research framework, as a contextual foundation for the three-pronged validation approach, consisting of exploratory survey, case study and experimental validation, which have been further explained. Although findings of the survey had been introduced in Chapter 2 for the purpose of analyzing gaps in the existing theory as well as practitioner challenges, experimental validation and case study validation are discussed in Chapter 7 in great detail. Lastly, validity of findings and limitations of the approach, as well as ethics-related concerns were discussed.

[27] Without further discussing semantics, the terms technique, method and methodology are used going forward. Methodology is used as a synonym for Anthony's term approach, because of the better fit to the project portfolio management context.

4. DETERMINING THE PORTFOLIO SELECTION METHOD

4.1 Chapter Introduction and Objective

Section 2.5 introduced the three-stage life cycle model, comprising the "Prepare," "Select" and "Control" stages. Section 4.2 provides a further immersion into portfolio selection methods and techniques. Sections 4.3 and 4.4 discuss model enhancements in regards to Theme I, the conscious choice of the portfolio selection method, and they elaborate on Propositions 1 and 2. The objective of this chapter is to provide two model extensions, in respect to a more systematic recognition of interdependencies within the portfolio and a process for choosing the appropriate selection methods throughout the "Select" stage of the PPM life cycle.

4.2 Immersion – Portfolio Selection

4.2.1 Portfolio Selection – Definition and Characteristics

Ghasemzadeh (1998) describes portfolio selection as a simultaneous project comparison on particular dimensions with the outcome of a ranking, which allows for the selection of the top-ranked projects, subject to resource constraints. Ghasemzadeh further distinguishes portfolio selection methods and techniques in a more narrow sense from strategic techniques, which support the strategic alignment of projects in the portfolio, and from benefits measurement techniques, which allow the evaluation of projects (Ghasemzadeh, 1998, pp. 8-12). Regardless of specific methods and techniques applied, three aspects, which through reflection on my experience have shown to be essential, shall be discussed here as the lead-in to Propositions 1 and 2.

4.2.1.1 Portfolio-centric Selection

Throughout the literature, the terms project selection and portfolio selection are used inconsistently and often interchangeably. However, there is more than a semantic difference to these terms. Most of the literature describes the selection as a process that moves from insular project evaluation to combining the selected projects in a portfolio after establishing a rank order that is based on strategic goals and a subsequent elimination of those projects in the ranked list, which would lead to exceeding resource constraints. Although this *project selection* approach leads to choosing the individually most beneficial projects, it may fall short of composing the optimal portfolio (Chien, 2002). *Portfolio* selection, if performed properly, leads to the optimal portfolio that addresses the aforementioned PPM goals of achieving strategic alignment, portfolio balance and maximum portfolio benefits. In order to take this holistic view, interdependencies between projects need to be included in the selection process, in addition to analyzing individual projects, their contribution and resource use. The analysis of interdependencies needs to be started at the onset of the evaluation process and is discussed in Section 4.4.

4.2.1.2 Recognition of the Complexity Aspects of the Portfolio Selection

As previously discussed in Chapters 1 and 2, portfolio selection constitutes a complex process. To avoid scope creep, the author did not further investigate the field of complexity theory, which could yield interesting insights for the field of PPM. Identifying the degree of complexity and corresponding response strategies from a decision perspective could yield interesting insights for portfolio decision makers (Snowden and Boone, 2007). As recognized in the literature, complexity leads to inferior decisions, especially in at the front-end of the decision process (Miller and Olleros, 2000). Figure 4-1 summarizes the four aspects of portfolio

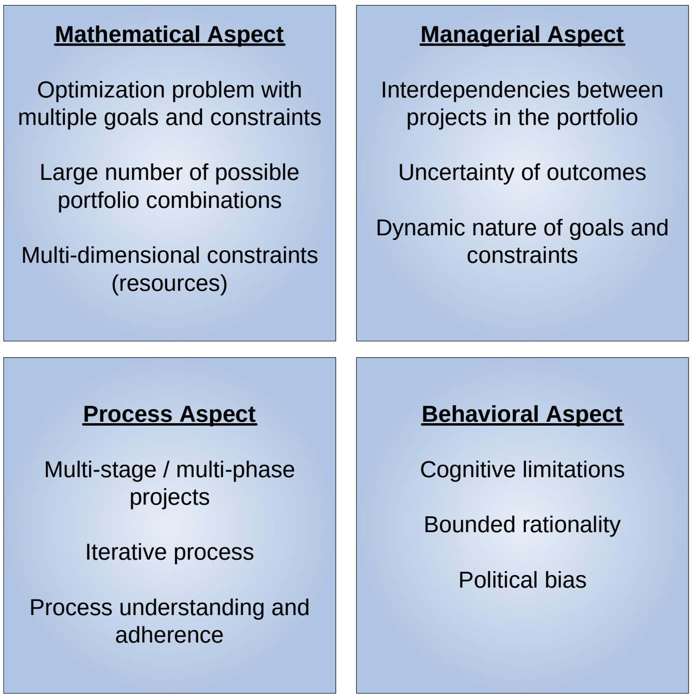

Figure 4-1: Four Aspects of Portfolio Complexity

complexity, which have been introduced. Although all aspects of complexity are discussed to some degree, this chapter places emphasis on the managerial aspects, especially the interdependencies, in the context of Proposition 2.

Another aspect of complexity is the dynamic nature of the process. Although only peripherally mentioned in the literature, selection processes are continuous and iterative in two respects, which are discussed in this section.

(A) Project interdependencies

The need for identifying interdependencies before projects are eliminated or prioritized has been acknowledged in the R&D portfolio management literature. The complexity of portfolio selection is discussed and explained by several authors. Danilovic and Sandkull (2005) tie complexity to the number of independencies in a portfolio and their change over time. Verma and Sinha (2002) provide multiple case studies and identify resource and technology interdependencies. Lycett et al. (2004), in the context of program management, identify the improved management of interdependencies, especially program benefit and project goal interdependencies as critical. As the author's survey suggests that the sharing of resources is one of the most critical operational challenges of PPM[28], discussions around resource interdependencies are most prevalent (De Maio, Verganti and Corso, 1994). As Chien points and other authors recognize, projects should be earmarked as independent or interdependent (Chien, 2002; Archer and Ghasemzadeh, 2004). Some of the literature also recognizes—at least in part—the different dimensions of interdependencies, such as resource interdependencies, which result from the sharing of resources between projects. It can be argued that the identification and addressing of interdependencies in the selection process is one aspect that distinguishes a portfolio-centric selection approach from a project-by-project perspective. Proper identification, qualification and—if applicable—quantification of interdependencies allow for a true portfolio view of all interrelated activities. Proposition 1 focuses on different types of such interdependencies and is discussed in Section 4.4.

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[28] See Appendix A for detailed survey data on this issue.

(B) Uncertainty of outcomes

During the project analysis, project requests or formal business cases for projects are typically reviewed and evaluated. In this context, an equitable comparison of projects in the subsequent steps requires a common set of metrics (Archer and Ghasemzadeh, 2004), which must be estimated or calculated for each project. In practice, the availability of data is a significant challenge; the need for relevant, quality and viable data is discussed in the metrics requirements in Section 5.3.1. Data accuracy, which is one aspect of the quality requirement, constitutes a particular challenge; most of the data is subject to uncertainty, as the future outcome of a project is uncertain, and the difficulty to estimate outcomes is amplified by the characteristics of projects as "unique endeavors" and hence the lack of comparables or historical information in many cases. Project estimating as a discipline has vastly advanced, and models for the estimating of complex projects. Estimating techniques can be found in the *PMBOK Guide* (PMI, 2008a) other standards, such as *The Practice Standard for Scheduling* (PMI, 2007). Domain-specific estimating models, such as the Constructive Cost Model (COCOMO) and the Constructive Systems Engineering Cost Model (COSYSMO) have delivered significant improvements in the accuracy of estimates in software and other engineering disciplines (Boehm, Abts, Brown, Chulani, Clark, Horowitz, Madachy, Reifer and Steece, 2000; Valerie, 2005). Lastly, Flyvbjerg, Bruzelius and Rothengatter (2003) suggest the reliance on historical data from reference projects for estimating, especially for large projects, which have exhibited significant budget and schedule overruns in the past.

Most of the attention in the literature on estimating is dedicated to parametric and other estimating models. In addition, some authors have empirically demonstrated that the aspect of accountability of project managers strongly impacts the accuracy of estimates (Lederer and Prasad, 2000). The related research typically elaborates on cost and time estimates; however, the aspect of accountability can be applied to project benefits as well. In this context, the notion of accountability can be extended to cover a performance commitment in a broader sense: project performance—accountability for benefits achievement and strategic contribution and project management performance—

accountability for the management success, in the context of cost, time, scope and other project management criteria.

Creating incentives for good estimates and benefits prognoses, as well as repercussions for poor estimates or politically motivated manipulation of business case data, is critical to the achievement of quality input data for an optimal portfolio selection. As previously stated in Section 1.5, much of the PPM literature to date focuses on project-centric analysis rather than portfolio-level analysis. More so, project portfolio management may attempt comparing projects in the ideation phase with others that have gone through a more or less elaborate business case process, with projects that have completed feasibility or engineering studies, and yet others that are in various stages of delivery. As a result, the reliability of estimates, as well as the willingness to potentially abandon prior investments, varies across the portfolio of such projects.

The difference in accuracy in estimates is recognized by the project management profession and has been reflected in the literature, such as PMI's *PMBOK Guide*. The *PMBOK Guide* suggests, for example, that cost estimates in the project initiation phase could exhibit a rough order of magnitude estimate with an accuracy of ±50%, whereas estimates later in the process may reach ±10% accuracy (PMI, 2008a). Although the mechanics of estimating shall not be elaborated further in this context[29], three types of estimates may apply (PMI, 2008a, p. 138):

1. *Rough Order of Magnitude (ROM) estimate*, typically a parametric estimate, as the aforementioned parametric models COCOMO and COSYSMO, with a -25 to +75% variance
2. *Top-down estimate*, or budget estimate, practically an estimate based on comparables (that is, historical information of similar projects), with a variance of -10 to +25%, and

[29] A draft of the "Practice Standard for Project Estimating" has been completed by the Project Management Institute, but it has not yet been published at the date of the completion of this thesis.

3. *Bottom-up estimate*, an estimate based on activity-level estimating, which requires the development of a full work breakdown structure.

In the context of the project analysis, estimating accuracy is of great importance. Understanding the role of the portfolio manager as a risk manager (in part) for the entire portfolio, it is important to understand the risk of individual projects to adequately manage the risk of the entire portfolio. The acknowledgment of the uncertainty of outcomes for different projects and at different life cycle stages feeds into the selection of metrics; and the discussion is resumed in Chapter 4.

(C) Dynamic nature of goals and constraints

Portfolio selection (and portfolio management more generally) can be characterized as a dynamic and iterative process that is repeatedly executed over time. There are two aspects to the iterative nature of PPM. First, within the "Select" stage, portfolio decision makers may run through multiple iterations of phases in order to reach an optimal portfolio. For example, the prioritize, select, optimize and approve phases may each be performed several times as the participants are going through a learning process and as decision models are "calibrated." Such re-do loops, as introduced in the discussion on decision science in Section 2.2.5.5, though not discussed in the PPM literature, can be found in practice and are an element of the discussion of Proposition 1 and part of the case study validation.

Second, expected project outcomes change over time, as projects may or may not achieve the intended benefits and deliver them within the given funds, resource and time constraints. Furthermore, strategic objectives and constraints maybe changing, for example as a result of environmental changes. Both types of variances of these stochastic variables lead to the requirement of a repeat of the selection process over time. This may happen within or outside the budget cycle that organizations typically follow, or at least require that adjustments need to be made (as displayed in the illustration as "repeat cycle," where a Stage III event triggers the repeat of Stage II, or a Stage II event leads to a strategy review in Stage I). Both re-do loops and repeat cycles are shown in Figure 4-2.

Aspects of PPM as a dynamic process are revisited and further discussed in the context of Propositions 4 and 5.

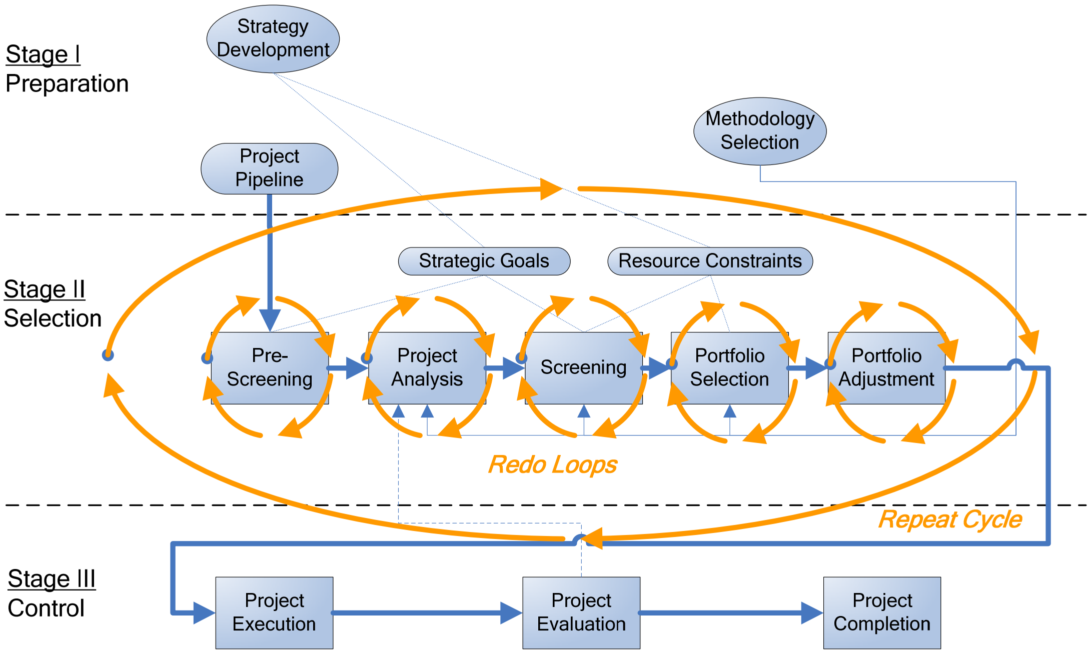

Figure 4-2: Redo Loops and Repeat Cycles

4.2.1.3 Establishment of Portfolio Governance

The earlier discussion on leveraging decision and behavioral science shall be resumed here. As mentioned before, much of the portfolio selection literature treats the actual portfolio selection as a mathematical optimization problem. However, some authors point out that PPM is a managerial decision process after all (Bayart, Bonhomme and Midler, 1999; Ghasemzadeh and Archer, 2000; Foreman and Selly, 2002). As such, portfolio decisions can be *supported* by mathematical models and computational tools, but can by no means be replaced by them. As a result, a portfolio selection methodology needs to entail clearly articulated governance guidelines, defining how decisions are made (decision process) and what rules apply in the event that stakeholders are not in agreement on certain choices (decision rules). This is particularly relevant, because the decision process in any larger organization is typically steered and influenced by multiple decision makers and is distributed across multiple functions, legal entities locations and hierarchy levels. The decision process needs to articulate which stakeholder is involved in which process step and in what role. Furthermore, decision rules need to spell out the voting rights and voting power of individuals, as well as what majorities would be required to move past a decision gate.

Research has been conducted in respect to portfolio governance and in line with the PPM objectives stated in Section 2.4. Müller states the following governance aspects to be relevant specifically for project portfolio management (Müller, 2009, pp. 49-54):

- Effective communication
- Effective provision of information and PPM-relevant data
- Defined roles and authorities of PPM stakeholders and assignment of roles to suitable individuals in the organization
- Knowledge management (collection of artifacts and learning projects)

4.2.2 Portfolio Selection Methods in Theory and Practice

As stated previously, an extensive choice set of methods for project portfolio selection is offered in the project portfolio management literature. From the perspective of the author's reflection on experience in the area of PPM, this does appears to be perfectly reasonable, because project selection in itself is a multi-step process, specific to the organizational purpose (or mission), specific organizational goals, the culture of decision making and the maturity of an organization. In this Section, four project selection frameworks are discussed. Furthermore, portfolio selection techniques are defined and classified as well.

4.2.2.1 Taxonomies of Project Portfolio Selection Methods and Techniques

The literature provides a number of taxonomies for classifying project portfolio management selection methods; the most frequently quoted are to be discussed in this context. Hall and Nauda (1990) provide the most comprehensive summary of R&D project selection methods based on the early literature on the topic, which are applicable to project portfolio management in general. Dye and Pennypacker (1999), Cooper et al.

(2001a) and Archer and Ghasemzadeh (2004) expand on the taxonomy from Hall and Nauda (1990), as illustrated in Table 4-1:

Table 4-1: Portfolio Selection Methods in the Literature

Method Type	Method	Source
Mathematical Programming (Constrained Optimization)	Integer Programming Linear Programming Non-Linear Programming (Goal Programming/Dynamic Programming)	Hall and Nauda (1990)
Benefits Measurement	Benefits Contribution (Economic Models) - Cost-Benefit - Risk Analysis - (Single) financial metric-based selection (net present value, discounted cash flow, internal rate of return, return on investment, payback period, expected value, as well as techniques like productivity index approach and real options valuation) Comparative Approaches - Q-Sort - Ordinal Ranking Consensus - Normative Models - Paired Comparison - Interactive Group Scoring Model - Multiple Criteria - Single Multiple Attribute - Analytical Hierarchy Process	Hall and Nauda (1990) Archer and Ghasemzadeh (2004) Hall and Nauda (1990) Hall and Nauda (1990)
Ad hoc	Top-down Methodologies Genius Award Systems Approaches	Hall and Nauda (1990)
Strategic Planning	Cognitive Emulation - Regression - Decision Trees - Expert Systems Portfolio Maps Cluster Analysis	Hall and Nauda (1990) Cooper et al. (2001a)
Marketing Research	Consumer Panels Focus Groups Perceptual Maps Preference Mapping	Dye and Pennypacker (1999)

Meredith and Mantel (1999) provide a different classification and distinguish between numeric and nonnumeric selection models. Among the non-numeric approaches, the authors discuss the following project types that will lead to prioritization and selection of the respective projects over others:

- “Sacred cows” (projects that are carried by the political sponsorship from one or multiple executives),
- “Operating necessity” (projects required to sustain an operation, e.g. the protecting of assets from imminent weather damage), and
- “Competitive necessity” (projects that are necessary to maintain competitiveness)

Maizlish and Handler (2005) use a similar taxonomy, consisting of scoring methods, standard financial models, non-numerical models, and they expand on advanced modeling and simulation approaches, including Monte Carlo simulation (Levine, 2005), real options analysis (Wang and Hwang, 2007), scenario planning, and decision trees. Frame (1999) adds several methods to the inventory of selection methods, such as the murder board, a diverse panel that scrutinizes project proposals with the objective to “tear them apart.” Furthermore, project proposals in government and academic institutions often go through peer reviews, which may yield in the assignment of a score.[30] Lastly, Aalto (2001) proposes a series of “portfolio decision tools,” such as expected commercial value, a productivity index and dynamic rank ordered list. The five types of methods are further analyzed and discussed.

4.2.2.2 Mathematical Programming

Mathematical programming describes the optimization of one or multiple objective functions, subject to specific constraints. Numerous PPM software solutions provide the functionality for constrained optimization, which is complex or cumbersome to perform without computational aid, especially for large portfolios. As a result of the optimization, one or multiple optimal solutions are determined, which are characterized by the greatest (risk-adjusted) value under the given resource constraints. Financial portfolio management first applied the concept to investment portfolios and defined the concept of

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[30] For example, the National Science Foundation requests peer assessments for project proposals and include the evaluation of a project’s technical merits, the competence of the key participants and other value criteria on a 1 to 5 scale (Frame, 1999).

the efficient frontier, which contains all optimal solutions (Merton, 1972), whereas all other solutions below the efficient frontier are deemed sub-optimal (see Figure 4-3), as a result of a lower risk-adjusted value for a given amount of resources (A preferred over B), or conversely, as a result of higher resource usage for a given risk adjusted value (C preferred over D), as illustrated. As pointed out in the literature (Hall and Nauda, 1990; Cooper et al., 2001b), constrained optimization is an attractive approach, however, with limited applicability. Some of the disadvantages include the high level of expertise required to understand and properly use such models and the need for detailed and accurate quantitative data (Meredith and Mantel, 1999), as a prerequisite to "solve" the system of equations. As a result of lacking quantitative data, the system of equations may remain under-determined, and the optimization cannot be performed. Furthermore, most variables are stochastic rather than deterministic and the determining of probabilities in the context of project outcomes, as discussed, is subjective and very problematic.

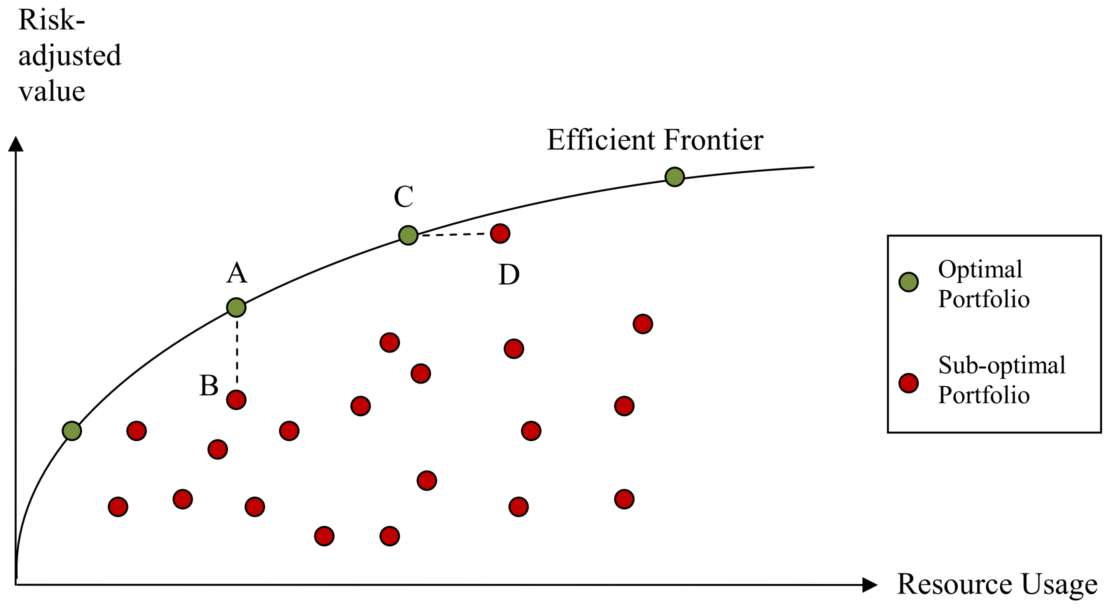

Figure 4-3: Portfolio Efficient Frontier

4.2.2.3 Benefits Measurement Methods and Techniques

Benefits contribution models are most frequently cited in the literature (Archer and Ghasemzadeh, 1999a; Frame, 1999; Cooper et al., 2001a) and typically use one or multiple relative or absolute measures for economic return (for example, ROI, NPV[31]) or benefits-cost relationships. When taking a closer look and with the definitions of Section 3.6 in mind, benefits measures constitute metrics rather than methods and techniques and are used as inputs for ranking or scoring. As metrics are being discussed and are only one parameter (the unit of measure) for a portfolio selection methodology, these shall be further discussed in the context of metrics in Chapter 5. As an example for *comparative methods*, Q-Sort stands out as the most intuitive approach and can be used for large portfolios[32]. The following example illustrates the use of the method: a deck of cards, of which each card represents a candidate project, is divided into two smaller, decks of equal size, one for high-level benefit and for low-level benefit projects. This process is repeated as follows: the high-level deck is further divided into very high-level and high-level, whereas the low-level deck is split into very low-level and low-level (see Figure 4-4).

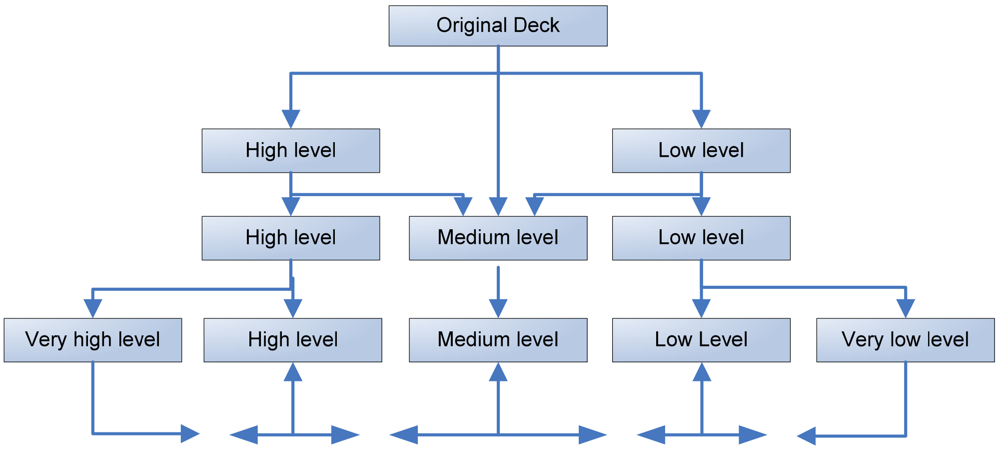

Figure 4-4: Q-Sort (Meredith and Mantel, 1999)

If at this point a reasonably small amount of projects (eight or less projects) remains in each of the four decks, the decision maker ranks all projects within each deck;

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[31] See Chapter 5 for definitions.

[32] Methods like AHP and ANP are not practical for large portfolios (see discussion in Section 4.2.2.3).

and after final validation of the sorting and ranking decisions, the sorting of all projects by benefit is completed (Meredith and Mantel, 1999).

Scoring models are used by many practitioners and constitute the core of most PPM noteworthy software solutions.[33] The popularity of scoring models results primarily from their ease of use based on standardized weighting of priorities and objectives, and the potential to include both qualitative and quantitative criteria. In addition, risk (that is, probability of technical feasibility or commercial success) can be incorporated in the scoring criteria. Lastly, users of scoring models can adjust weights and other parameters, which enables the performing of what-if analyses and simulations (Meredith and Mantel, 1999).

Multi-factor scoring consists of several steps. In the first step, organizational goals are being defined in a three-level goals hierarchy. Five primary strategic objectives (cost reduction, improvement of project management, increased dedication to customer, infrastructure and team development) are established by the organization and further broken down into more granular, tactical goals. The very detailed goals at the third level of the goal hierarchy enable a more meaningful judgment of strategic contributions from projects to the achieving of organizational goals.

In a second step, the relative importance of all goals versus the other goals at the respective level is determined. Levine demonstrates a very similar approach to scoring, based on a weighted hierarchy of objectives that expands beyond financial criteria and entails a multitude of non-financial objectives used by AOL and emphasizes the benefit of synthesizing quantitative data with qualitative judgment (Levine, 2005). In a third step, projects are evaluated in regard to their contribution to the organizational goals. All projects should find at least one strategic goal to which they contribute. Otherwise, it is

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[33] The Gartner Group annually issues the "Magic Quadrant Report" comparing the most relevant PPM software solutions in the marketplace and ranks, among other criteria, their functional and technical capabilities. Since this thesis research effort excludes tool-specific discussions, software implementation aspects of PPM will not be further discussed.

possible that a project is not contributing to the organization's strategy, or a meaningful strategic goal may not be articulated (see Chapter 6). A project can contribute to more than one goal. The realization of the benefits of a single project can contribute to the achievement of one or multiple strategic objectives. A single project can fully or partially realize a strategic objective or not at all contribute to it[34]. As an exact quantification of the contribution percentage is not always possible or requires too much effort to estimate, the following heuristic values for contribution have been applied in the following example: 16% for a minor contribution to a project to a goal, 33% for a significant contribution, 66% for a major contribution, and 100% for the full realization of the goal through successful realization of the project (Arlt and Munoz, 2004).

After the goal contributions for all projects are determined, the calculation of the value for the strategic importance, which yields the total project scores, as per the definition of this example, is straightforward, because for every project goal contributions are multiplied with their corresponding weights, and the sum of all goal contributions for a project constitute the "strategic importance"[35] (see at the bottom of table in Figure 4-5), which establishes the value for the rank order of the projects (Arlt and Munoz, 2004).

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[34] While, it is also possible that a project has a negative impact on a strategic goal, such adverse effects shall not be discussed at this point.

[35] The strategic importance of a project i is calculated as follows: $S[i] = \sum_{j=1}^{G} P[i][j] \cdot G[j] \quad \forall \quad i = 1..P$, whereas P[i][j] = contribution of project i to goal j, G[j] = strategic weight of goal j, G = total number of goals, P = total number of projects.

L1	L2	weight	#	L3 Goal	weight	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	Contribution to goal
Reduce Cost (17%)	Refine Supplier Selection	8	33	Establish Vendor Mgt Strategy	4					66	16							82
			18	Make or buy conscious decisions	3				16		66							82
			16	consciously subcontract special development	1						100							100
	Eliminate Redundancies	6	34	consolidate vendors	2					100								100
			38	consolidate responsibilities	2				16									16
			23	eliminate overlapping services	2		16											16
	Unattach low value high-cost activities	3	32	offer self-support	1													0
			14	Phase out maintainence-intense legacy systems	2													0
Improve Project Execution (30%)	Planning	7	29	better planning of large scale efforts	5			66	16									82
			3	kill losing projects earlier	2			66										66
	Improve PM	20	27	prioritize high value projs.	5			16										16
			1	implement PM model	10				66									66
			35	enforce std. Risk managmnt.	5				16									16
	Knowledge/Information Management	3	30	improve proj. reporting	2				66									66
			31	decrease rework	1				33									33
Increase focus on customer (38%)	Look into the future: be ready for the customer	15	26	define technological roadmaps	2	66			16									82
			25	anticipate tech. Requirements	2	100												100
			7	better relationship managmntl	7													0
			21	evaluate potential service provision	1	33												33
			6	better understand cust. Demands	3		16							66	33			115
	Listen more carefully to the customer	15	36	communication with business	7		66											66
			13	differentiate prices by value offered	4		100								16			116
			22	identify capabilities	4		16											16
	Make more enticing offerings to the customer	8	10	increase visibility to customer	3													0
			5	cost-competitive services off-shore	1													0
			9	emphasize non outsource able services	4									33	66			99
Improve Infrastructure (10%)	Scalable and flexible	6	37	more scalable and flexible architecture	6							100						100
	Standard and accessible	2	8	enforce standard architecture	2							16						16
	Secure	2	24	maintain security	2								100					100
AccelerateTeam development (5%)	Company-Employee Alignment	2	4	better direction for staff	2											100		100
	Personal Development	1	19	improve career paths for tech. Staff	1											16	100	116
	Skills development	2	28	increase business competency of tech. Staff	1											16	16	32
			20	customize skill development plans	1												33	33
Sum		100			100													
				Strategic Importance		365	1006	542	1097	464	362	632	200	330	427	232	149	
				Normalized Strategic Importance		0.33	0.92	0.49	1	0.42	0.33	0.58	0.18	0.3	0.39	0.21	0.14	
				Project Rank		7	2	4	1	5	8	3	11	9	6	10	12	

Figure 4-5: Example for Multi-Factor Scoring Model (Arlt and Munoz, 2004)

The *Analytic Hierarchy Process* (AHP) and the *Analytic Network Process* (ANP), a generalization of the AHP, provide advancements in scoring to improve decision making and provide a robust mathematical support to the human ability to make comparisons. In the 1980s, Saaty published techniques to structure complex problems into decision models and to derive ratio scale weights in order to identify the most suitable decision. The first theoretical method conceived by Saaty was the Analytic Hierarchy Process (Saaty, 1980;1982), which helps to configure problems in a hierarchical model; subsequently the author has continuously improved the methodology and developed the Analytic Network Process. The ANP follows the same conceptual rules of the AHP, but it allows representing the problem in a network structure, without imposing hierarchical composition (Saaty, 1996a; Saaty, 1996b). In order to understand the rationale behind these methods, it is helpful to summarize the common procedural structure of the two and the related five steps that the decision makers are supported to perform. Both the AHP and ANP enable the decision maker to—

1. ***Structure the Decision Model***: Both methods guide the decision makers to construct a hierarchy (AHP) or a feedback network (ANP) of the decision model, including the global goal, strategic objectives and sub-objectives, evaluation criteria, and alternatives (potential decisions).
2. ***Perform Pair-wise Comparisons***: The decision makers evaluate the factors in the model, to make judgments on pairs of elements (numerical, graphical and verbal pair-wise comparisons). In order to avoid introducing larger errors in judgments, paired comparisons should be made between elements that do not differ by more than an order of magnitude. (Both AHP and ANP typically use an absolute numerical scale that ranges from 1 to 9—that is, one order of magnitude.)
3. ***Evaluate, and If Needed, Reduce Inconsistency***: The rigor of the analytics behind the methodology keeps track of the consistency of the judgments, guiding the decision maker to identify the most inconsistent areas of the model and revisit criteria and judgments. The inconsistency ratio of the entire model should be lower than 10%; otherwise a review of the model is recommended.
4. ***Prioritize***: The methodologies consent to synthesize the model, identifying a priority of decisions (or the “best” decision).
5. ***Optimize***: Decision makers are enabled to perform sensitivity analyses to examine the solution and comprehend the chosen sensitivity to changes, which may occur to the decision model (adjustments into the model structure, judgment revisions, addition/removal of alternatives, etc.). Moreover, decision makers can make adjustments in order to optimize their decisions.

(A) The Analytical Hierarchy Process – AHP

The AHP enables the decision maker(s) to build a hierarchical model of goals and criteria, identifying an overarching goal (top level of hierarchy) and a structure of objectives (second level), sub-objectives (third level), and so on. The lowest level of the hierarchy is represented by the alternatives, the set of potential decisions (see Figure 4-6).

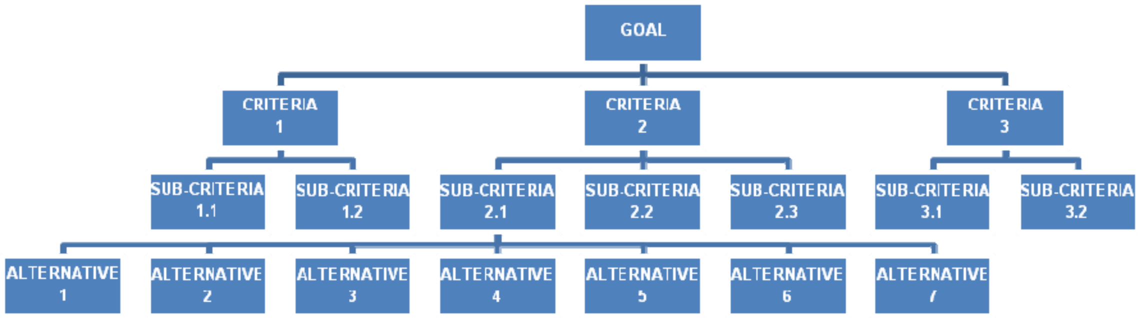

Figure 4-6: Example of AHP Decision Model

After the hierarchical decision model is designed, the AHP provides a framework for setting priorities—the weighting system—on each level of the hierarchy. The AHP uses pair-wise comparisons between elements at a given level of the hierarchical model, in terms of relative importance of the pair of elements with respect to their parent node in the hierarchy. With the AHP, a decision maker is asked to perform pair-wise comparisons by answering questions such as the following: Given a criterion at the upper hierarchical level, which of two elements of the lower hierarchical level is more relevant with regard to the criterion considered? Similar to scoring models, one of the advantages of the AHP is its ability to manage quantitative and qualitative factors using the same logic, however, without forcing the adoption of an imposed physical/numerical scale with a unit, but yet taking advantage of the human brain capacity to express judgments in the form of comparisons, and deriving a scale of priorities from pair-wise comparison. Enabling group decision making, the AHP enables consensus building and the aggregation of diverse perspectives.

Another property of the AHP concerns the absence of a forced transitivity of the judgments, which means that a lack of consistency in the set of judgments is tolerated in the model. The AHP does not force a full consistency of the model, but rather provides the ability to represent intransitive and inconsistent relationships as they occur in the real world and are comprehended by the human mind, while, at the same time, a measure of the inconsistency is provided. Although a low degree of inconsistency is desirable, it is not sufficient to conclude that a good decision is made. As Foreman and Selly (2002) state, it is possible to be consistently wrong, so it is better to be accurate than consistent.

Figure 4-7 depicts a practice example used by the author, which applies the AHP to the prioritizing of five strategic objectives. The 5x5 matrix in the example requires ten pair-wise comparisons, as the matrix is symmetric. For example "Accelerate Team Development" is much more important than "Reduce Cost," represented by the value 9; hence "Reduce Cost" must be much less important than "Accelerate Team Development," represented by the value 1/9. The normalized data[36] allow for analyzing the consistency of the data, and the inconsistency ratio allows revisiting choices, if the degree of inconsistency is too high.

The advantage of the AHP over scoring models and the inherent ability of AHP to address aspects of complexity, such as cognitive limitations and political bias in the choice between several options becomes apparent, as inconsistencies are revealed and can be reduced to an acceptable minimum through performing re-do loops in the pair-wise comparison of project alternatives until a desired consistency ratio is reached[37].

---

[36] Normalized values are calculated by dividing the array value $x_{i,j}$, where *i* represents rows and *j* represents columns by the column vector sum ($x_{1,j}$; $x_{5,j}$).

[37] Saaty recommends that the inconsistency ratio should not exceed .1 (or 10%).

Strategic Success Factors (N=5)		Reduce Cost	Improve Project Execution	Increase Customer Focus	Improve Infrastructure	AccelerateTeam Development		Rank (Relative position of factor in comparison to other factors)
		1	2	3	4	5		
1	Reduce Cost	1	3	1/7	1	1/9		4
2	Improve Project Execution	1/3	1	1/9	1/3	1/9		5
3	Increase Customer Focus	7	9	1	5	1/5		2
4	Improve Infrastructure	1	3	1/5	1	1/9		3
5	AccelerateTeam Development	9	9	5	9	1		1

Normalized Data

		1	2	3	4	5	Avg.	Consistency
1	Reduce Cost	0.05	0.12	0.02	0.06	0.07	0.06	5.06
2	Improve Project Execution	0.02	0.04	0.02	0.02	0.07	0.03	5.13
3	Increase Customer Focus	0.38	0.36	0.15	0.30	0.12	0.26	5.52
4	Improve Infrastructure	0.05	0.12	0.03	0.06	0.07	0.07	5.16
5	AccelerateTeam Development	0.49	0.36	0.76	0.54	0.61	0.55	6.05

Consistency Index	CI	0.10
Random Index	RI	1.12
Inconsistency Ratio	ICR	0.09

Legend

Factor in the **row** is

Much more important than factor in the **column**	**9**
Somewhat more important than factor in **column**	**5**
Equally important	**1**
Much less important than factor in the **column**	1/9
Somewhat less important than factor in the **column**	1/5

Random index table

n	RI
2	*0.00*
3	*0.58*
4	*0.90*
5	***1.12***
6	*1.24*
7	*1.32*
8	*1.41*
9	*1.45*
10	*1.51*

Notes

RI is the random index representing the consistency of a randomly generated pair-wise comparison matrix.

*To calculate the inconsistency ratio, the consistency index is tabluated by the size of the matrix (ICR=CI * RI)*

Figure 4-7: Pair-Wise Comparison and Consistency Analysis

(B) The Analytical Network Process – ANP

The ANP keeps unaltered all qualities and capabilities of the AHP, as stated above, without the restrictive assumptions about a hierarchical composition of the decision model (Saaty, 2004).. Instead, the ANP articulates the decision problem building up a network of elements, grouped by clusters. Whereas with the AHP, interdependencies between elements are by definition top-down in the hierarchic structure, the ANP allows influences and relationships connecting any components of the network, building (n:m) non-linear networks of priorities in any direction (see Figure 4-8).

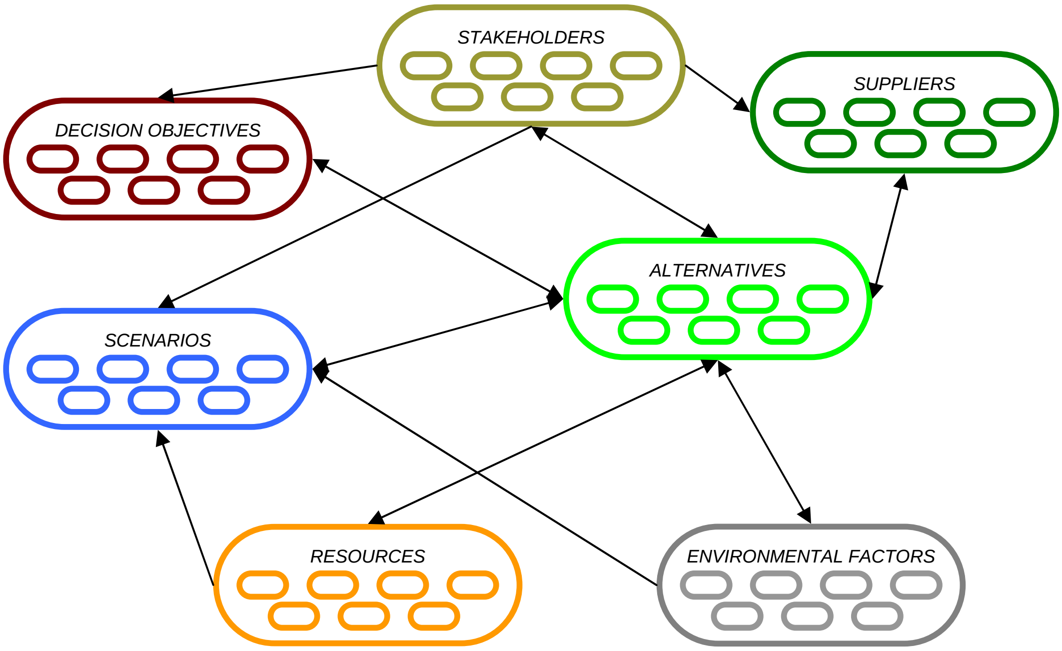

Figure 4-8: Example of ANP Decision Model

As in the AHP, the key concept of the ANP is the pair-wise comparison between elements and their relative magnitude of influence on a given criterion. However, unlike the AHP, the ANP allows feedback between and within clusters (outer and inner interdependencies, respectively) throughout the whole network of elements, which means that decision makers are capable of making all possible and potential pair-wise comparisons between elements regardless hierarchical levels. Adopting the ANP, decision makers make judgments by replying to two different questions: Given a criterion (no matter which level), which of two elements (somehow related) of the network is more relevant with regard to the criterion? Which of the two elements has higher influence, with regard to the criterion, on a third (related) element of the network?

As highlighted by the previous questions, key drivers for assessing comparisons between elements are not the hierarchical levels (as for the AHP), but the given criteria under discussion. Decision makers accomplish their evaluations focusing on the crucial areas of the decision model without depending on the structural disposition of the elements within the model. The ANP fully exploits the concept of the *control criterion.* Using a system of control criteria helps to structure the decision model through significant perspectives of the area under investigation, to guide paired comparisons (shaping proper questions), and to synthesize the model through the same key points of view.

The ANP theory further provides instructions on how to adopt valuable and effective control criteria systems, providing guidance on benefits, opportunities, costs and risks (BOCR). Decision makers can approach a decision focusing on BOCR, seeking to identify, elaborate and utilize several strategic control criteria and sub-criteria for each of the four merits (Saaty, 2004). At first, decision makers structure the decision model building a network of elements (that is, decision objectives, stakeholders, scenarios, environmental factors, alternatives, etc.) and specify a number of strategic control criteria (for example, economic, social, and political) for each one of the four BOCR merits. Now, the four merits and the related control criteria can be easily prioritized adopting the AHP method in order to weight the importance of each merit and of the control criteria (for each merit). Each merit receives a ratio (generally b, o, c, and r, with $b + o + c + r = 1$, that weighs the relative importance in relation to the decision making. After that, dealing with one merit at a time, decision makers can formulate appropriate pair-wise comparisons between elements of the decision network with regard to each control criterion of the merit under discussion.

Subsequently, the pair-wise comparisons are synthesized in order to rate the entire network with regard to each BOCR merit, and in particular, to prioritize the alternatives.

By adopting the BOCR merits system, the ANP becomes an efficient predictive tool, which is due to its excellent modeling capabilities. My experience suggests that the ANP provides an impressively flexible methodology, capable of considering and analyzing a wide range of environmental issues (such as risks and opportunities), enabling decision makers to manage complex decisions in a robustly scientific way without forcing them to make restrictive structural assumptions or to adopt limiting perspectives.

4.2.2.4 Ad-hoc Methods

Ad-hoc methods, such as profiles (Archer and Ghasemzadeh, 1999a) are a simplified version of scoring, where projects that do not meet certain criteria are eliminated from the choice set. Although this can be efficient, the applicability of such techniques is limited, for example, to the elimination of projects that are violating compliance or other business rules. Because of the interdependent nature of projects in a portfolio, particular care is needed, as profiling may exclude projects that do not meet a pre-defined threshold, but may be required as a prerequisite for a crucial other project. Another example for an ad-hoc approach is the "genius award," which simply allocates funds to proven managers or staff. Although Hall and Nauda claim that this approach may be just as effective as complex analytical approaches (Hall and Nauda, 1990), many organizations —for reasons such as the scarcity of funds and resources, redundancy and conflict of efforts—avoid the use of ad-hoc approaches.

4.2.2.5 Strategic Planning

Portfolio maps are one of the most commonly used visual tools for balancing portfolios. More widely known as bubble charts (Cooper et al., 2001a, pp. 74-104), they are typically used as a graphical representation of the balance of portfolios in regard to mostly two-dimensional trade-off relationships. Balancing decisions and simulations are further supported by the ability of such charts to display additional characteristics, as illustrated in Figure 4-9. Whereas bubble size characterizes budget, color specifies department and red shading symbolizes mandatory projects, other attributes, such as shape could be used to capture additional, decision-relevant attributes.

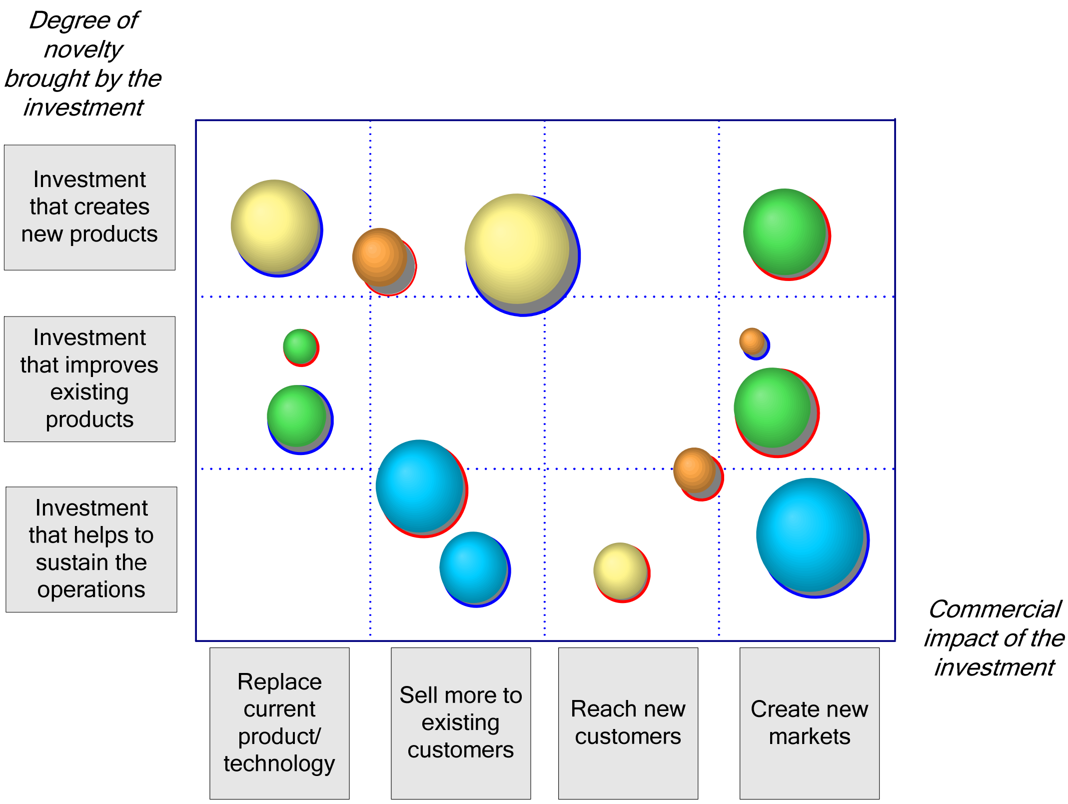

Figure 4-9: Balancing the Portfolio with Bubble Charts (Arlt and Martyniuk, 2006)

Although bubble charts are the default visualization tool introduced in the context of strategic portfolio planning, other useful tools can be found in the literature. To reduce complexity, as discussed in 4.2.1, large numbers of components could also be visualized in tree maps to support balancing decisions for large portfolios. The concept introduced by Johnson and Shneiderman (1991) uses tiling algorithms to divide a rectangle into smaller rectangles, where size, positioning and color are allowed to reflect various attributes of data. The concept has been applied to the monitoring of portfolios, as demonstrated by Cable, Ordonez, Chintalapani and Plainsant (2004) and is illustrated in Figure 4-10. Projects are depicted as rectangles and clustered by life cycle phase. The attributes project size (size of the rectangle) and project health status (red color) manifests underperforming projects, based on the selected metric cost performance index.

Figure 4-10: Portfolio Visualization with Tree Maps (Source: Cable et. al., 2004, p. 4)

This technique can be equally used to support the selection of portfolio, which consists of large numbers of projects and different attributes can be used.

Lastly, the strategic balancing of portfolio components with a focus on multiple attributes could make use of other visualization techniques. As an example, Chernoff faces could be used to visualize multivariate data (Chernoff, 1971;1973) and support the balancing across multiple dimensions. This technique allows a graphical representation of such data, using the picture of a face for each project (see Figure 4-11). Facial characteristics, such as eye size, pupil position, curvature of the eyebrows, nose line, head shape, etc. represent specific project metrics. Chernoff faces could be used in multiple ways:

- To review the consistency of project business cases (aesthetic analysis for each face),
- For comparison of projects (side-by-side comparison of faces or pattern analysis) based on single or multiple attributes, and
- For comparison of single or multiple faces over time (face changes)

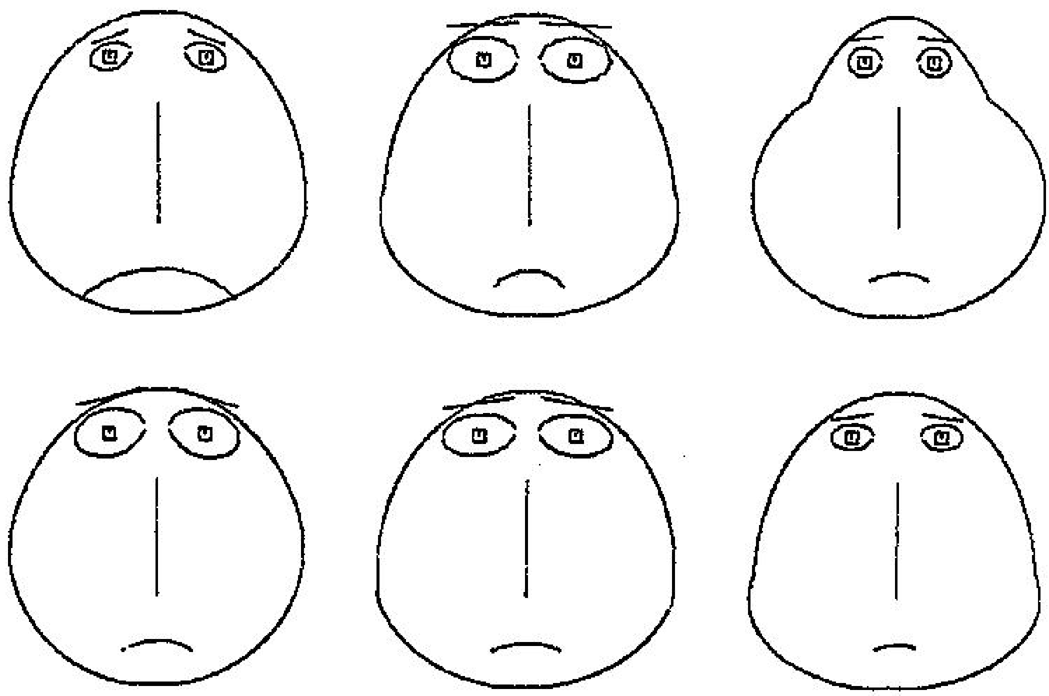

Figure 4-11: Multivariate Data Visualization with Faces (Source: Chernoff, 1971, p. 5)

Although this technique has not been discussed in the context of PPM literature, it has proved to be useful in other applications of multivariate data analysis and decision support (Everitt and Nicholls, 1975). Chernoff faces can be a meaningful tool to overcome cognitive limitations in the analysis of multivariate numerical data, provided that metrics and criteria are carefully selected.

The use of decision trees constitutes another popular strategic planning approach, as discussed (Dye and Pennypacker, 1999; Cooper et al., 2001a) and can be applied for calculating decision-relevant metrics, such as expected commercial value (ECV). ECV considers the future stream of earnings from the projects and the possibilities of both commercial and technical successes along with commercialization and execution costs. As mentioned above, the first stage of consideration is the project execution stage, where the probability of success is P_{es}. The second stage is the project launch, where the probability of commercial success is P_{cs}. The example is illustrated in Figure 4-12:

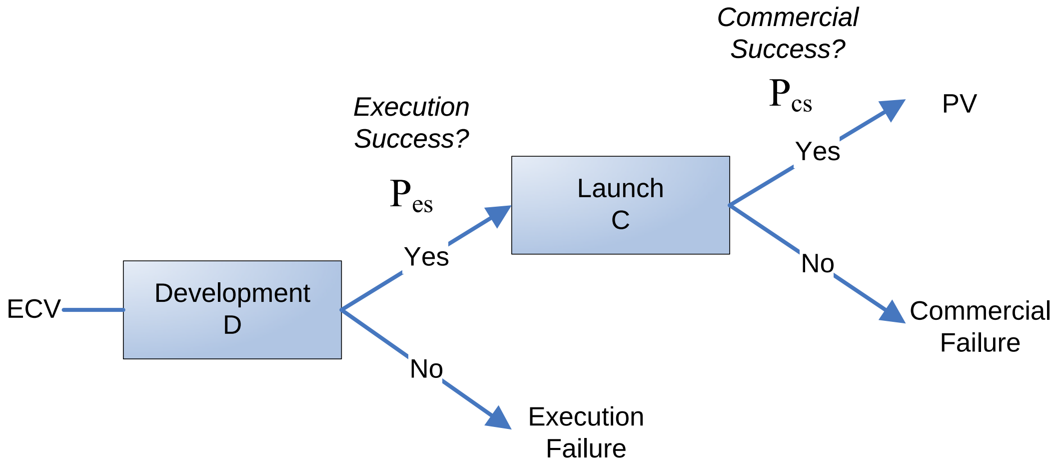

Figure 4-12: Determining the ECV (Cooper et al., 2001a, p. 35)

If D is the development (or project execution) cost, C is the cost of the commercial launch, and PV is the present value of future earnings assuming a commercially successful project, then:

$$\mathbf{ECV} = \left[(\mathbf{PV} \times \mathbf{P_{cs}} - \mathbf{C}) \times \mathbf{P_{es}} \right] - \mathbf{D}$$

Binominal tree models such as NPV can become complex, and the challenge of predicting the paths for success or failure remains one of the key estimating challenges of project and portfolio management.

4.2.2.6 Marketing Research

Market research, mostly performed by the marketing function of a business, typically provides estimates for market demand for products or services, expected price points and price sensitivities and other related data. Archer and Ghasemzadeh (1996) summarize examples of marketing research methods, such as focus groups, customer panels and perceptual maps. These methods should be considered supplementary, as they provide additional data points, while typically falling short of providing a comprehensive picture of project alternatives, including cost, risks and other decision parameters.

4.3 Proposition 1 – Systematic Choice of Project Selection Methods

After reviewing a large spectrum of approaches to portfolio selection and different types of methods and techniques, the question to be answered—left open by current literature and frequently asked by practitioners—is what method or methods should be used in a particular organization. As numerous authors conclude (see discussion in Chapter 2 and Section 3.1), there is no consensus for what portfolio selection methods are to be used by an organization, and many competing methods have their justification, depending on application scenarios, organizational culture and maturity. Hence, the question remains how to go about developing or choosing the "right" portfolio selection methodology, consisting of the most suitable methods and techniques. This question is explored in this chapter.

Proposition 1 – Systematic choice of project selection methods
A structured process for the choice of all methods and techniques, which constitute the portfolio selection methodology, carefully selects from available options and recognizes the influence of organizational culture, maturity and information availability.

4.3.1 Model Introduction

Section 2.4 defined the achieving of strategic alignment, maintaining of portfolio balance and maximizing of portfolio benefit as the three primary goals of PPM. [38] Following the notion of management by objectives, portfolio management should address these goals, and each of the chosen selection methods should contribute to the goal achievement. Archer and Ghasemzadeh (1999b) mapped an inventory of methods and techniques against stages and phases of the PPM process, which is displayed in the following table. This inventory can be used in the assembly of a portfolio management methodology based on the specific needs and boundary conditions of the organization.

Table 4-2: Selection Activities and Methodologies (Archer and Ghasemzadeh, 1999b)

Process Stage	Phase	Activity	Potential Methods
Pre-process	Strategy development, methodology selection, development of strategic focus, resource constraints, choice of model techniques	Strategic mapping, portfolio matrices, cluster analysis, etc.	
Portfolio Selection Process	Pre-screening	Rejection of projects which do not meet portfolio criteria	Manually applied criteria, strategic focus, champion, feasibility study available
	Individual project analysis	Calculation of common parameters for each project	Decision trees, uncertainty estimate, resource requirements estimate, etc.
	Screening	Rejection of non-viable projects	Ad-hoc techniques (e.g. profiles)
	Portfolio selection	Integrated consideration of project attributes, resource constraints, interactions	AHP, constrained optimization, scoring models, constrained optimization
	Portfolio Adjustment	User-directed adjustment	Matrix displays, sensitivity analysis
Post-process	Final Portfolio	Project development	Project management techniques, data collection

[38] The fourth goal, continuous process improvement, shall be ignored for now, as it is not directly relevant for the *selection* of the portfolio selection method. It will be reviewed in conjunction with Proposition 2.

For each phase in the selection stage, the following process is to be applied, following a uniform approach that consists of five steps.

As depicted in Figure 4-13, each phase commences with the validation of entry criteria, which serves the purpose of assuring clarity of objectives for the respective activity and availability of required information in order to deliver the desired outcome of the phase. As the second step, the environmental analysis is performed as to what method or method are available, acceptable and supported by sufficient data. As a result of this analysis, the method for the respective phase is selected and applied, and lastly, the achievement of the outcome of the phase is validated in a reflection step. This method for systematic selection is an extension of current portfolio selection frameworks and builds upon the framework introduced in Table 4-2.

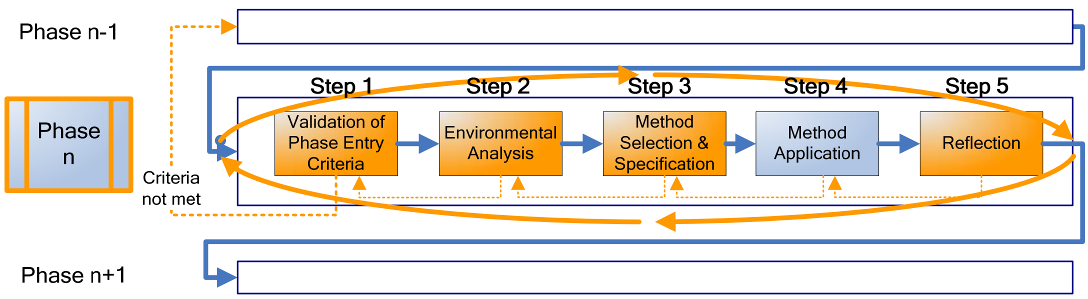

Figure 4-13: Systematic Choice of Methods

The five steps shall be discussed in the following sections of this chapter and are followed by examples for several phases of the portfolio life cycle.

4.3.1.1 Step 1– Validation of Phase Entry Criteria

This first step serves the purpose of a gate, following the notion of the stage-gate process for portfolio management that was developed in the new product development context (see for example Cooper, 2005). This gate ensures that all prerequisites for further pursuit of steps 2 through 5 are in place. If this is not the case and criteria for beginning a phase are not met, it is suggested to return to the prior phase or phases and establish the required prerequisites. The proposed gate criteria are as follows:

1. Are objectives of the phase clearly articulated and understood?
2. Are pre-screening criteria defined?
3. Are thresholds quantified for each criterion?
4. Does the data quality meet the requirements for decision making?
5. Are suitable methods identified to achieve the objective(s) of the pre-screening phase?

In case of positive answers to the above questions, it is recommended to proceed with the next step. However, based on his reflective learning experience, the author suggests that portfolio managers often operate under imperfect conditions; for example, data quality may not meet the requirements for decision making. In this case, requirements may need to be revisited and the question if requirements are realistic and truly mandatory in nature for decision making needs to be answered. If even absolute minimum requirements cannot be satisfied, the portfolio manager may still proceed to the next step but should document assumptions and the lack of fulfillment of requirements and evaluate the consequences.

4.3.1.2 Step 3 – Environmental Analysis

This step addresses organizational enablers and boundary conditions to allow for an evaluation of what methods are not only applicable from a theoretical point of view but can be successfully implemented in the context of the organizational environment. Especially in the context of establishing new PPM processes, the change management challenge cannot be underestimated. As Kotter points out, anchoring new approaches in the organizational culture is key to success, and it requires a realistic assessment of what can be achieved at a given point in time (Kotter, 1996, pp. 145-158). In the context of the environmental analysis, several parameters are useful for the assessment of what methods and techniques may be both effective and efficient in a given organizational environment:

- *Legacy approaches* – What has previously worked and is accepted in the organization?
- *Decision culture* – Is the organization driven by strong decision making at the top or in certain functions, or does the organization subscribe to a consensus culture?

- Current maturity – Will a certain approach be understood and embraced, given the state of maturity of the organization in respect to PPM in general or a specific method or technique?
- Available of data – Are data required for using certain methods available or attainable with reasonable effort and in the required quality?

4.3.1.3 Step 3 – Method Selection and Specification

At the core of this third step is the definition, customization or refinement of methods and techniques, based on available methods and techniques previously discussed in Section 4.2.2, specific goals (as per Step 1) and the outcome of the environmental analysis (Step 2). If methods or techniques are not available, custom methods may be developed, suitable for the organizational context.

For the reasons previously discussed, the author does not subscribe to or recommend any particular methods or techniques to be universally applicable and to fit all application scenarios, but rather suggests following the step-wise approach in order to assure that methods and techniques, which are currently applied or chosen for future application, are not only recommended as a result of positive research or practitioner experience, but also are suitable for the organization.

The specification or refinement of methods may be required, for example scoring models may exhibit different factors, weights and thresholds for different organizations and require adjustment over time.

4.3.1.4 Step 4 – Methods Application

In Step 4, methods and techniques are being executed as they have been selected and specified in the previous step. Following the notion of any standard process, using given inputs, methods and techniques are applied, and outputs are produced.

4.3.1.5 Step 5 – Reflection

In addition to the generated outputs, the opportunity to reflect on the effectiveness and efficiency of methods and techniques applied should not be missed. In this context, the achievement of phase objectives (as per Step 1) and the readiness for the subsequent step (validation of phase exit criteria) should be validated. Furthermore, an evaluation of success from a process perspective is meaningful, that is, whether methods were not only effective in delivering the expected outcomes but also were efficient in terms of efforts and time needed.

4.3.2 Application of the Five-Step Approach

Section 4.3.1 introduced the proposed five-step approach for choosing the portfolio selection method, which is applied to the selection stage of the PPM life cycle. This section demonstrates the practical application of the approach for one of the phases of the lifecycle, the pre-screening phase (see Section 2.5.1 for reference). The five-step approach has been translated into a tabular format, which has been applied by the author in the project and case study validation, as discussed in Section 7.3. The example in the table details the process flow for each step, as explained in the prior section.

Table 4-3: Choosing the Selection Method for the Pre-Screening Phase

	Step	*Example*
I	**Validation of Phase Entry Criteria**	**1. Is the objective of the phase understood?** Elimination of those projects that do not meet the pre-screening criteria **2. Are pre-screening criteria and corresponding thresholds defined?** *Examples for criteria:* *a) Projects to be labeled mandatory ("must-do" projects)* *b) Projects to be rejected ("can't-do" projects)* *c) Projects that do not align with strategy* *d) Projects that do not have sufficient support* *Examples for thresholds:* *a) Projects for which an approved business case exists that makes a credible case of a regulatory requirement (e.g., federal mandate for reporting) or business necessity (e.g., protection of vital business property from damage/theft, competitive necessity)* *b) Example: Projects, which require in excess of $x million in funding, or projects that do not provide benefits information or credibly demonstrate a positive NPV* *c) Non-mandatory projects that do not align with any of the strategic themes* *d) Projects that do not obtain a certain minimum number of votes in the*

		initial voting round by the portfolio selection committee **3. Does the data quality meet the requirements for decision making?** Is the purpose of the step clearly articulated? *Examples:* • Projects are submitted with approved by a designated line manager • All projects provide risk, cost and benefits information • Validate interdependencies to avoid elimination of those projects, that are connected to projects, which are decided to undergo further analysis in the next phase. • Earmark or bundle projects as programs, where program criteria apply **4. Are suitable methods identified to achieve the objective(s) of the pre-screening phase?** *Examples:* • Criteria-based project pre-screening, or/and • Portfolio committee voting rules and • Interdependency analysis
II	**Environmental Analysis**	**1. What methods are likely to be organizationally accepted?** Cultural acceptance and compatibility with decision culture. *Example:* Elimination of projects based on NPV threshold in an organization that does not have a ROI/NPV mindset. **2. What methods are adequate at the current maturity stage?** Will the method(s) be understood and is it adequate in respect to the current degree of sophistication of decision making?
III	**Method Selection & Specification**	**Decision based on Steps I and II to select method.** *Example:* Selection of Methods (1) and (3), using the criteria and thresholds specified in Step 1, in light of a financially result-driven culture and recognition of complexity, which is due to frequent oversight of project interdependencies.
IV	**Method Application**	**Execute phase, as specified in Step III and specified in Step I and II.**
V	**Reflection**	**1. Validate achievement of objective as stated in I.1** Have projects been eliminated that do not meet thresholds for pursuit? Have mandatory projects been earmarked as such? Are project interdependencies identified and inventoried? If not, does the step need to be repeated or does the method need to be changed? **2. Validate process success** Did the selected method(s) prove to be adequate, as analyzed in Step II? Is there a need for repeating the phase?

4.3.3 Assembling the Portfolio Methodology

As mentioned in 3.6, individual methods and techniques contribute to the methodology for the entire PPM life cycle, and constitute a “portfolio” of methods. As part of establishing or refining a governance process for PPM, a consistency test for the methodology may be meaningful. Such test may evaluate the “balance” of maturity or sophistication of the methods used, the efficient use of data applied across the phases, as well as the agility and speed of the entire process.

4.3.4 Summary

Rather than adding to the body of knowledge of prescriptive methods and techniques for portfolio selection, Proposition 1 has provided a how-to approach for the selection or development of a PPM methodology, consisting of methods and techniques applicable throughout the PPM life cycle. The five steps, from the validation of entry criteria through environmental analysis, method selection and specification, method application to the reflection, describe the recommended process for selecting or defining the appropriate methods and techniques. Lastly, a portfolio methodology is the superset of these methods and techniques across the phases of the selection process, and shall be consistent and efficient. A suitable PPM methodology ultimately caters to the portfolio management goals of achieving strategic alignment, portfolio balance and maximum portfolio benefit, and it entails an ongoing reflection component to drive continuous process improvements.

The methodology selection explained in the underlying life cycle model (see Figure 2-6) is expanded by using the five-step model introduced in Section 4.3.1 and illustrated by Figure 4-13. The resulting model extension is depicted in Figure 4-14.

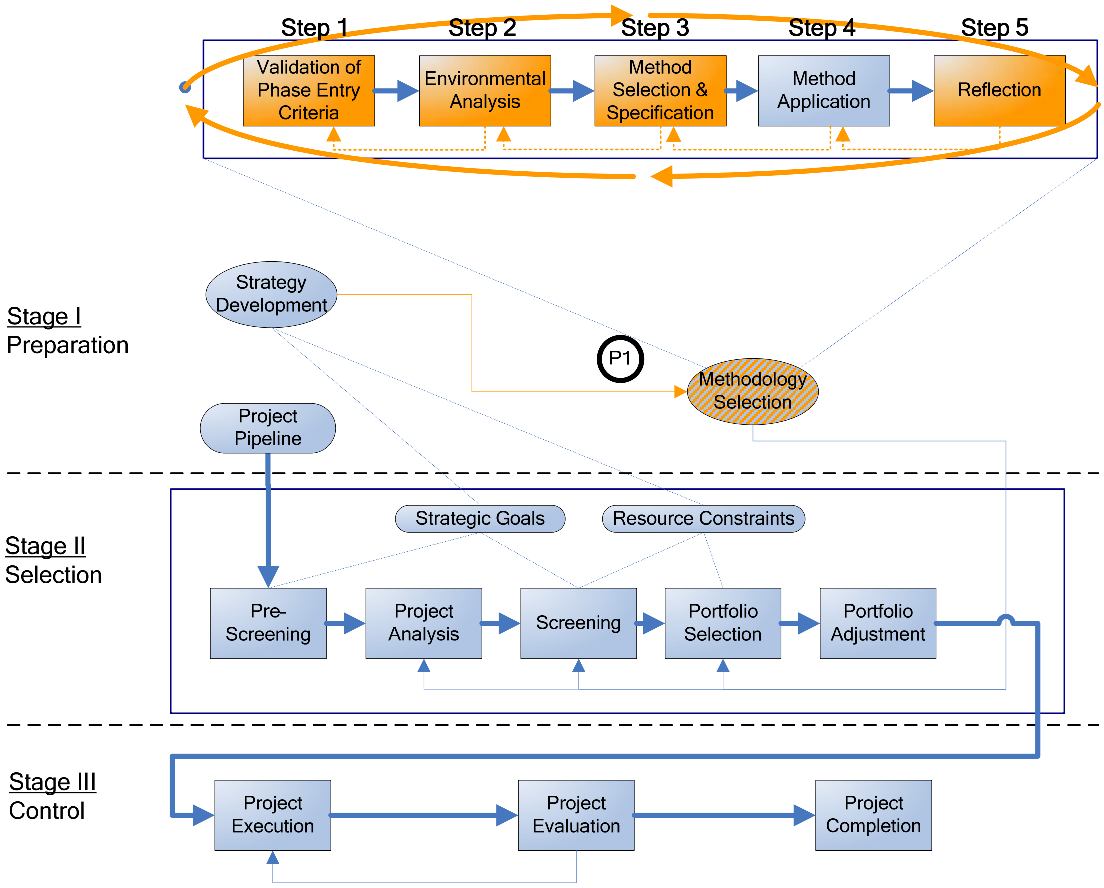

Figure 4-14: Model Extension for Proposition 1

4.4 Proposition 2 – Systematic Analysis of Portfolio Interdependencies

Project interdependencies are a key aspect of the complexity of project portfolio management, and more specifically project selection, as explained in Section 4.2. Proposition 2 addresses the aspect of project interdependencies, and allows coherent portfolio decisions rather than a project-by-project selection approach.

Proposition 2 - Emphasis on portfolio-centric vs. project-centric selection activities
Understanding the dimensions and characteristics of interdependencies between projects in a portfolio and further qualifying and quantifying them, will lead to improved outcomes in the selection of portfolios and ultimately greater project portfolio management maturity.

Five types of interdependencies are addressed by the proposed portfolio analysis. They are discussed conceptually and illustrated for a sample portfolio:

1. **Benefit (utility) interdependencies** – The execution of two projects leads to greater (or lesser) benefits than the sum of their benefits, if performed individually.
2. **Risk interdependencies –** A positive or negative correlation of risks exists leading to risk diversification or amplification effects
3. **Outcome interdependencies** – The achievement of an outcome, that is, a finished product of a project is dependent on achieving an outcome of another project. Technical dependencies could be considered a special case of outcome dependencies, whereas a certain technical prerequisite, which could be an outcome of a project, will be required to accomplish the outcome of another project.
4. **Schedule interdependencies** – Projects are schedule-dependent, similar to task dependencies within projects, for example, a project can start only after another project is completed (finish-to-start interdependency).
5. **Resources** – Projects are dependent on the same exact resources.

Schmidt (1993) first proposes benefit, outcome and resource "interactions." Eilat, Bolany and Shtub (2005) use Schmidt's concept to include interdependencies into a mathematical portfolio selection model. Another suggested interdependency category found in literature focuses on learning effects, as the learning on a project may constitute an input for another project (Killen, Krumbeck, Kjaer and Durant-Law, 2009). However, it is the author's opinion that such learning interdependencies would be captured by outcome interdependencies, as far as explicit knowledge is concerned, which could be considered an output (or outcome) of a project, as well as resource interdependencies, which would cover the necessary transfer of tacit knowledge.

To further explain and illustrate the concept, a sample portfolio of a software development department of a company is provided (see Table 4-4). The diverse portfolio, consisting of ten projects, entails development and other activities.

Table 4-4: Sample Portfolio for Interdependency Analysis

ID	Project Name	Description
1	Development Accelerator	Acquire and implement a Computer-Aided Software Design tool to accelerated development.
2	eOrder Application Development	Development of a Web-based order entry application for complex orders of engineering products.
3	eInventory Application Development	Development of a Web-based order entry application for complex orders of engineering products.
4	ePayment Application Development	Development of a Web-based payment processing application for complex orders and terms and conditions.
5	Data Loader Development	Tool necessary to allow for data conversion for legacy customers who want to migrate to e-Application suite.
6	System Integration	Integration of eOrder, eInventory, ePayment into one integrated solution.
7	Pilot Implementation	Test implementation of the integrated Web-based applications (Projects 2, 3, 4 ,5) with one new customer.
8	Marketing Campaign	Advertize new Web-based application suite to target customers.
9	Agile Development Method & Training	Implement the "Agile" development methodology to accelerate development of software packages.
10	Office Renovation	Complete renovation of the building.

4.4.1 Benefit (or Utility) Interdependency

Portfolio benefit or utility (U) from executing two projects A and B jointly may exceed the sum of the benefits of each individual project: $U(A+B) > U(A) + U(B)$. This scenario can be illustrated with projects #1 and project #2, where the delivery of the development accelerator (project #1), which is of use for the effective and efficient development of an electronic order application, will accelerate the application development and deliver a higher quality application at lower cost. This benefits achievement sets the stage for a clear increase in benefits from project #2. In the given example, the same logic would apply for benefits interdependencies between project #1 and the other application development efforts for inventory and billing systems, labeled as projects #3 and #4.

A different type of synergies from a benefits point of view can also be illustrated with projects #2, #3 and #4: If the development of all three applications realizes the respective individual benefits from their business cases, that is, creating the functionality meeting the respective market demand, then a comprehensive product suite may attract new buyers seeking an integrated solution, rather than just singular applications.[39]

Projects may also exhibit the opposite from synergies[40]: This is the case when the portfolio benefit from executing both projects together is less than the sum of the benefits from the individual projects: $U(A+B) < U(A) + U(B)$. Example for such a scenario would be redundant[41] projects, projects with overlapping benefits (partial redundancy) or projects, which deliver conflicting outcomes (for example, the construction of an environmentally damaging manufacturing site, while running a large-scale green image campaign).

Lastly, two projects A and B are independent in respect to delivering benefits or utility, if the sums of the benefits delivered from both projects individually equals the sum of the utility of both projects: $U(A+B) = U(A) + U(B)$. For the sample portfolio, the case can be made that projects #1 and #10 are independent, in respect to benefits delivery. It is unlikely that the achievement of benefits from a software tool development will have a positive or negative impact on the achieving of the benefit from the headquarters renovation or vice versa.

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[39] As the Enterprise Resource Planning and Customer Relationship Management software markets have demonstrated during the past few decades, such synergies are significant and have created entire markets for packaged software.

[40] Although the terms antergy and dissynergy exist, there is no generally accepted antonym for synergy.

[41] While redundancy shall not be further discussed here, three redundancy types should be considered in the analysis: (1) intentionally redundancy, such as a result of desired internal competition of product development efforts; (2) unavoidable redundancy (two project entail redundant components that cannot be broken out); or (3) accidental redundancy as a result of process defect/ information asymmetry.

4.4.2 Risk Interdependencies

As stated in Section 2.2.5.3, MPT has significantly influenced project portfolio management theory and practice. In the financial services industry, risk management has become a sophisticated discipline that has evolved over decades and has developed highly sophisticated models and instruments for measuring and managing covering market, credit, and operational risks, despite its recent challenges.

Project risk management has been a maturing discipline and is becoming increasingly recognized among project management practitioners, as PMI's "Risk Management Professional" certification suggests.[42]

Risk management on the portfolio level has first been analyzed by McFarlan in the early 1980s, who advocated a risk-based approach to selecting project portfolios (McFarlan, 1981). Despite the recognition by several authors that risk management for portfolios must exceed the managing of risk across all projects, even recent publications by academics and practitioners illustrate that portfolio risk management is a virtually untapped research area (De Reyck, Grushka-Cockayne, Lockett, Calderini, Moura and Sloper, 2005; Kendrick, 2009). Although the topic of portfolio level risk is outside of the scope of this work, it shall be pointed out that a proper treatment of portfolio risk could become rather complex.

Figure 4-15, illustrates a simplified risk breakdown structure for four projects of the sample portfolio introduced earlier; a well-specified example for a risk breakdown structure applicable to IT portfolios can be found in Maizlish and Handler (2005). As depicted in Figure 4-15, interdependencies on a portfolio level could become rather complex. For example, the technical feasibility of project #1 (technical risk) could severely impact the timely completion of projects #2 and #3, as the development accelerator is used for the development effort. Furthermore, a delay in the development

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[42] PMI's certification focuses on skills in assessing, identifying and managing project risks. See www.pmi.org/CareerDevelopment/Pages/AboutCredentialsPMI-RMP.aspx

accelerator development will delay the application development (assuming that project #1 is part of the critical path for the delivery of projects #2 and #3). Also, if no consistent tooling is used, and the agile development approach (project #9) is not culturally accepted, projects #2 and #3 are more likely to experience quality issues.

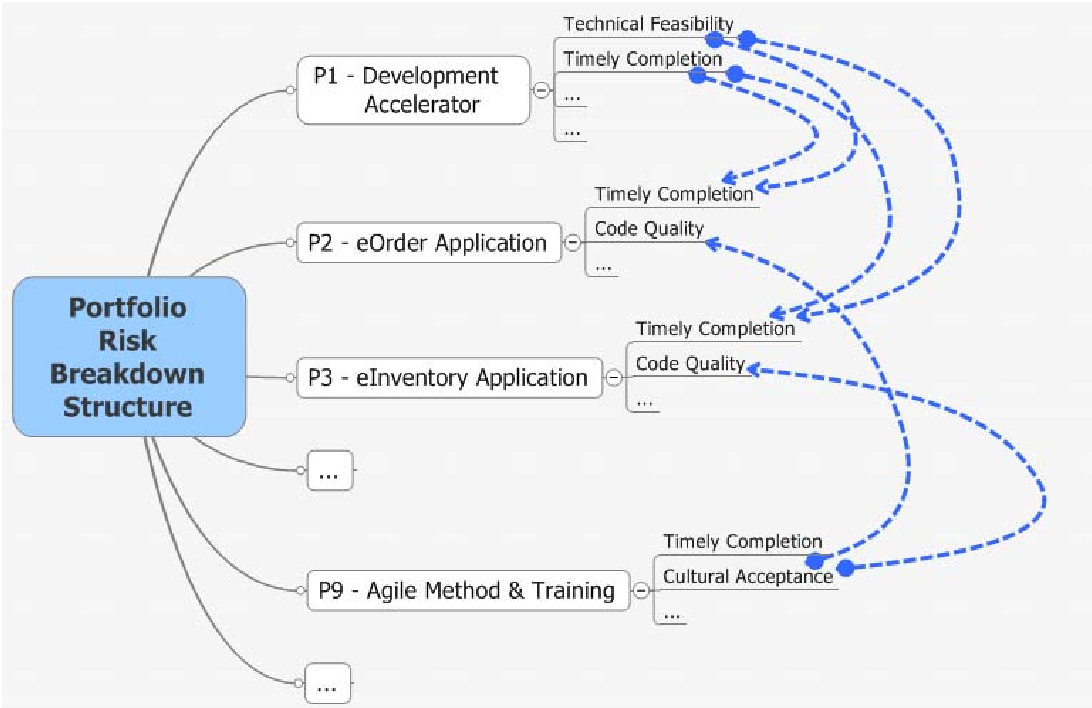

Figure 4-15: Portfolio Risk Breakdown Structure (RBS) and Interdependencies

Some parallels to financial risk management, as per MPT become immediately apparent. The number of risk interdependencies between projects in a portfolio can quickly become rather large, and it would be extremely complicated to aggregate risk across the portfolio, which is due to different risk types and lacking knowledge of sensitivity. For example, the question of how partial acceptance of a systems development life cycle would affect code quality risk for the development projects would be difficult to estimate.

Lastly risk of the same type for two projects (for example, the risk of timely completion, R_T) may not be additive: $R_T(A) + R(B) <> R_T(A+B)$.

A risk of timely completion of one project may amplify the timely completion risk for another project, but conversely, there may also be diversification effects across a portfolio. For example, the deviation from budget leads to risk reduction on the portfolio level, as some projects are budgeted too low whereas others have been over-budgeted.

4.4.3 Outcome Interdependencies

Project outcomes may be interdependent. In the above example, project #6, the systems integration of all applications requires that the applications are actually developed. Outcome interdependencies—unlike benefits interdependencies—focus on the achievement of project deliverables rather than the benefits. For example, if the work scope of projects #2, #3 and #4 is not delivered, then the outcome of project #6 cannot be realized.

Technology interdependencies are an example for outcome interdependencies. Groenveld (1997) provides an approach to the depiction of such interdependencies in roadmaps and explains road mapping as “a process that contributes to the integration of business and technology and to the definition of technology strategy by displaying the interaction between products and technologies over time, taking into account both short- and long-term product and technology aspects” (Groenveld, 1997, p. 49). Figure 4-16 translates the notion of the roadmap to the sample portfolio for interdependency analysis, which was introduced at the beginning of this section (see Table 4-4 on page 133). Depending on certain path decisions, or in other words depending on what projects are selected and implemented, certain path-dependent outcomes are achieved. Outcomes, such as the “integrated Web-based product suite” in the illustration below, depend on the successful achieving of the outcome from the development of three applications. This is particularly important, if an end-node of such a causal chain of outcome interdependencies constitutes a mandatory project. In that case, all preceding projects become mandatory as well.

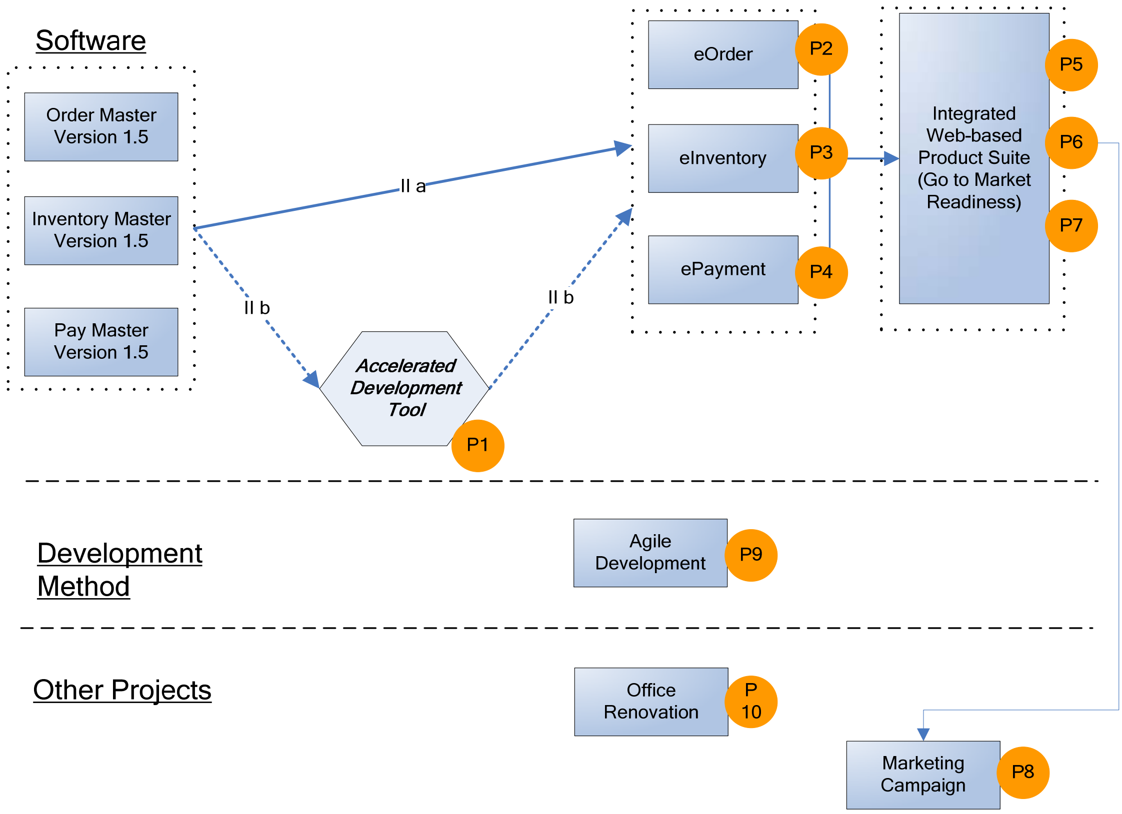

Figure 4-16: Outcome Interdependencies in Roadmap Format

4.4.4 Schedule Interdependencies

Similar to interdependencies between tasks, projects within a portfolio may depend on each other, in regard to timing. The four types of time interdependencies, which are used to define task interdependencies in the management of project management (finish-to-start, finish-to-finish, start-to-start and start-to-finish), can be applied to the portfolio level. To illustrate, two simple examples are the time interdependencies between projects: The systems integration project (#6) can only commence if all application development projects (#2, #3 and #4) are completed. The start of a pilot implementation (project #7) is dependent on the completion of at least one of the three development projects (#2 or #3 or #4).

Matters become further complicated, on the portfolio level, as interdependencies can occur at a more granular level. For example, it may be decided that the marketing campaign will only start if the integration testing phase of one development effort, rather than the entire project, is successfully completed. To easily comprehend and make portfolio decisions without ignoring schedule interdependencies, a proven project management tool can be applied: Figure 4-17 provides an example for a portfolio Gantt chart.

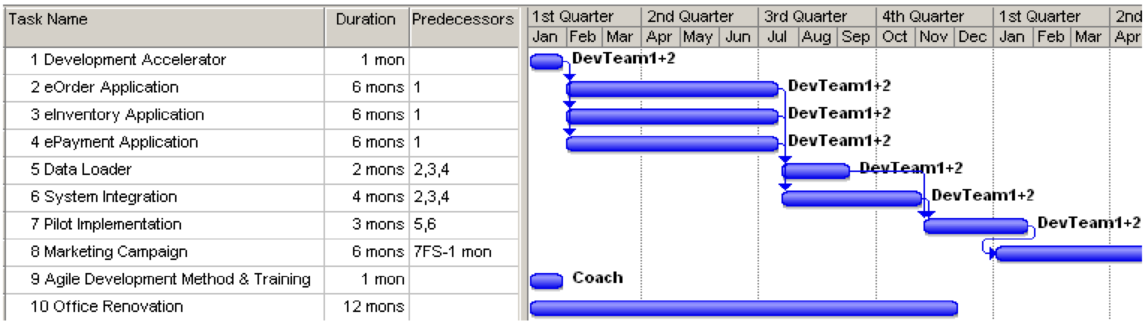

Figure 4-17: Gantt Chart Representation of Schedule Interdependencies

4.4.5 Resource Interdependencies

Resource interdependencies are one of the most significant practical challenges. Figure 4-17 provided a visualization of resource needs through a Gantt chart; however, in reality, resource management at the portfolio level is far more complex than at the project level. In theory, portfolio resource management appears as a multi-dimensional problem, as the allocation of resources is managed for multiple resources of certain skill sets across multiple projects and over time. Although resource interdependencies have been recognized as a significant challenge (Engwall and Jerbrant, 2003) and viable mathematical optimization models for this basic context do exist (Laslo, 2009), the management of resource interdependencies remains complex, beyond the three-dimensionality of portfolio resource management:

- Meaningfully granular taxonomies for skill sets are difficult to define, and skills are asymmetric across individuals (for example, there is no one unique skill set of a "Senior SQL Database Administrator," and resource requirements maybe more specific, whereas resource data may not be)

- Skill sets of individuals are dynamic, and teams change constantly. For example, learning effects from consecutive projects need to be considered; resources used on one development project, which have acquired a certain specialized skill set, will also be required to be deployed on another similar or follow-up project.
- Soft skills aspects and organizational politics can hardly be captured in resource management systems but play an important role in reality (that is, in the interest of avoiding of dysfunctional project teams).

PPM reality suggests that resource interdependencies constitute a significant project portfolio management challenge (Irving, 1995; Blichfeldt and Eskerod, 2008). The survey conducted by the author, and discussed in Section 2.7, reported a 73% rate of resource allocation issues, namely resource conflicts between projects and chronic resource overload. Understanding of the complexity of resource management and resource interdependencies in particular, is a first step toward addressing resource allocation challenges.

The implication of identifying such resource interdependency may lead to the discovery of other interdependencies that were not previously visible. A resource capacity shortage (for example, the necessity that the same development team, tasked with project #2 must also work on projects #3 and #4) could lead to a time interdependency.

4.4.6 Tooling for the Management of Interdependencies – Further Considerations

Several visualization tools for project interdependencies have been introduced in Section 4.4.5, which serve the purpose to address cognitive limitations of portfolio managers in respect to indentifying qualifying interdependencies. Additional tools could be applied, such as graph theory.[43]

Another aspect, not discussed previously would be interdependencies with complex feedback mechanisms and intertemporal choice aspects, in line with the discussions in Section 2.2.5.6. Such comprehensive approach would need to seek out advanced tooling, system dynamics (Warren, 2002).

Lastly, for purposes of qualifying and quantifying interdependencies, matrices, similar to their application in the quantification of correlations in financial portfolios, could be considered for the mathematical modeling of portfolio interdependencies (Anderson, 1958). Such application to PPM is demonstrated by Eilat, Bolany and Shtub (2005), based on the framework of Verma and Sinha (2002). Portfolio matrices, as displayed in Figure 4-18, can contain either qualitative information, depicting whether interdependencies exist ("1" or "0") or can capture the degree of interdependency (that is, a multiplier for the impacted variable, for example, benefit), which can be further used in a mathematical optimization model (Eilat et al., 2005). A practical application of the approach for small projects has been found and analyzed at Boeing (Dickinson, 1999).

	P1	P2	P3	P4
P1		1	0	1
P2	1		0	0
P3	1	0		1
P4	1	0	0	

	P1	P2	P3	P4
P1		1.2	0	0.25
P2	1.2		0	0
P3	0.3	0		1
P4	1.5	0	0	

Figure 4-18: Interdependency Matrices (Example)

[43] Researchers at the University of Sydney have been investigating the topic of "visual project mapping." However, no official publications had been available to the author at the time this thesis work was completed.

Although mathematically straightforward, the practical application of the approach, especially for large portfolios, requires significant effort, and the quantification of interdependencies (correlations) is a challenge that would reach far beyond the scope of discussion for this thesis.

4.4.7 Summary

The following table summarized the interdependency types discussed in this Section, as part of Proposition 2.

Table 4-5: Interdependency Types (Summary)

Dimension	Explanation	Interdependency Characteristic
Benefit (Utility)	Synergy	The benefit from doing two projects together exceeds the sum of their benefits, if performed individually U(A+B) > U(A) + U(B)
	Opposite from synergy/negative benefits impact	The benefit from doing two projects together delivers less than the sum of their benefits, if performed individually U(A+B) < U(A) + U(B)
	Independence/no synergy	The projects are independent, from a benefits point of view. No synergies or negative benefits impacts exist: U(A+B) = U(A) + U(B)
Risk	Positive Correlation (Diversification Effect) Negative Correlation (Amplification Effect) No correlation (risk independence)	R(A+B) < R(A) + R(B) R(A+B) > R(A) + R(B) R(A) + R(B) = R(A+B)
Outcome	Project A requires B Project A requires B and C	B → A (B+C) → A
Schedule	Projects A and B are to start simultaneously B can only start, when A finishes	SS (A, B) FS (A, B)
Resources	Same resources as in A must work on B Same resources as in A cannot work on B	HR(A+B) HR(A<>B)

In addition to addressing the interdependency dimensions, three types of decisions can be made, after determining interdependencies as described. For strong interdependencies, dependent projects can be clustered into sub-portfolios or programs, as they meet the criteria and definition of a program (see Section 2.2.2). In the event that the pre-screening process reveals strong cross-interdependencies but a clustering into a program may not be appropriate, interdependencies should be annotated in the portfolio inventory to be adequately reflected in later portfolio selection steps. For some weaker interdependencies, portfolio management may decide to ignore or earmark for minor adjustment to the business case in the subsequent project evaluation phase. As a result of the interdependency analysis, interdependency information for all projects should be added to the portfolio inventory. Qualification and quantification of interdependencies can leverage several tools and techniques, as observed in the literature and tested by the author in his role as a practitioner, as well as in the context of the validation efforts for Proposition 2 of this thesis (see Chapter 7):

- Portfolio-Gantt Chart showing time interdependencies between projects or work packages within projects (see Section 4.4.6),
- Portfolio roadmaps to depict outcome interdependencies (see Section 4.4.3),
- Interdependency matrices, that is, for risk interdependencies (see Section 4.4.6), and
- Verbal interdependency information in the context of the portfolio inventory, as an additional attribute or remark.

As a result of the discussion in this chapter, portfolio interdependency analysis adds an important aspect to the life cycle model. It initially occurs in the pre-screening phase, but also impacts other phases of Stage II, as the identified interdependencies are considered when portfolio decisions are made. The process addition is illustrated in Figure 4-19:

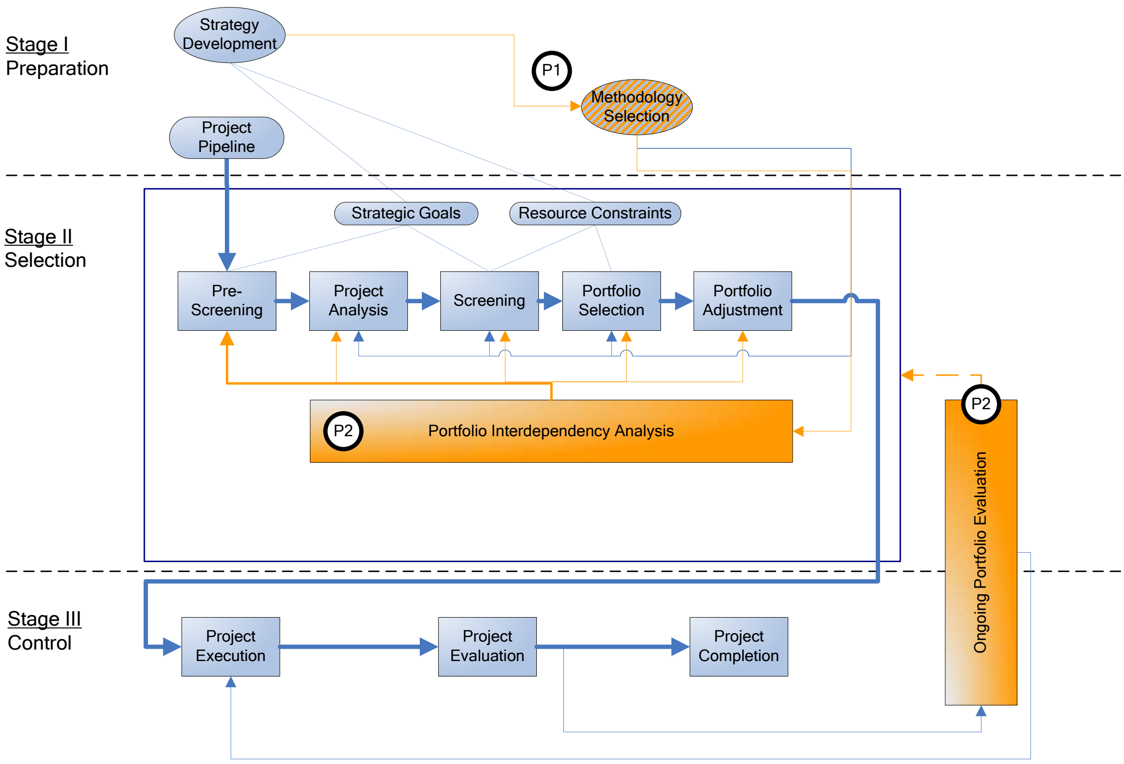

Figure 4-19: Portfolio Life Cycle with Proposition 1 and 2 Enhancements

4.5 Chapter Summary

Section 4.2 provided an immersion into portfolio selection methods and techniques, as a baseline for the discussion of Propositions 1 and 2 in Sections 4.3 and 4.4. Proposition 1 provided a methodology enhancement from a process point of view that allows the selection or definition of portfolio management methods and techniques and their assembly into a comprehensive and consistent methodology. The five-step process, which underlies the method selection in Proposition 1, is subsequently validated in the case study in Section 7.3.

Secondly, in the context of the critical complexity factor of PPM, the interdependencies between projects in a portfolio were analyzed, five interdependency types have been defined, their characteristics discussed and tools have been provided for their identification. Proposition 2 is validated through experimentation in Section 7.2.

5. METRICS SELECTION

5.1 Chapter Introduction and Objective

This chapter focuses on the selection of metrics for the evaluation of portfolio management outcomes and the portfolio management process. Similar to the structure of the prior chapter, Section 5.2 will provide the contextual basis of measurement theory and describe the process of measurement and metrics implementation. As the PPM literature delivers little input on metrics definition and measurement approaches, other related disciplines, such as software engineering and decision science are leveraged. Subsequent to the literature immersion, Propositions 3 and 4 are developed. Although the project and portfolio management literature is rather descriptive when it comes to measurement, which is similar to the positive approach on methodologies, the author takes a process approach toward defining measurements rather than prescribing specific metrics. One of the challenges, the comparison of projects based on metrics, is discussed in Section 5.5. The chapter concludes with a summary.

5.2 Immersion – Measurement and Metrics

Practitioners and academics frequently state that "what gets measured gets managed." Despite some reservations regarding the axiomatic use of such a statement (Emiliani, 2000), performance measurement is recognized as an essential factor to actually achieving intended performance. Also, it must be recognized that metrics do not just observe, but actually drive behavior (Hauser and Katz, 1998). However, the identification of success factors and the selection of metrics are frequently performed by managers in a rather ad hoc fashion, and metrics represent data that are either easy to measure or that have been historically used. Furthermore, the economics around metrics are not well understood, and not just the lack of metrics but their incorrect use can lead to erroneous conclusions and potentially wrong decisions. Interestingly, the research on metrics and measurement reveals that the intersection between metrology, the science of measurement, management science, and project management in particular, is rather unexplored. Although much has been written about metrics in project management and to a very limited degree in project portfolio management, a structured and systematic approach to the development of metrics and design of a consistent measurement framework could not be found in the project and portfolio management literature.

5.2.1 Definitions

5.2.1.1 The Concept of Measurement

Measurement can be understood as a process that deals with "the assignment of numbers to objects in order to represent their properties, not any property but only those specific properties called magnitudes or quantities" (Díez, 1997, p. 168). Others provide analogous definitions but add as a distinction that a measurement process should follow clearly defined rules (Fenton and Pfleeger, 1996) and should be derived from a model or theory (Kaner and Bond, 2004; Dekkers and McQuaid, 2005).

Practitioners often confuse measurement with "observing values," for example, with the help of some measurement device.[44] This fact deserves some further attention, as the aforementioned assignment of meaningful numbers to objects does not imply any assumptions on confidence levels of the measurement. This is particularly relevant in the project portfolio management context: As the case was made, portfolio outcomes are stochastic in nature, which is due to the uncertainty of outcomes, one of the complexity aspects of PPM that has been previously discussed in Section 1.4.[45] Hubbard further points toward measurement as "observations that reduce uncertainty, where the result is expressed as a quantity" (Hubbard, 2007, p. 21).

Measurement theory further delivers on several premises, which make measurement meaningful and possible. The first premise is the comparability of

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[44] The author had frequent opportunities to poll clients on their understanding of the term "measurement" and typically received answers related to "observing values" or "calculating numbers" that ignore the attribute of uncertainty of outcomes.

[45] See discussion about the complexity of portfolio selection, more specifically the management aspect of complexity in Section 1.4

metrics.[46] Another axiom of measurement theory is the requirement for consistency and transitivity of a metric for two objects (for example, if A, based on the same characteristics of evaluation, is preferred to B and B is preferred to C, then A is to be preferred to C); these premises are deeply rooted in the rationality assumption, which is the premise of traditional economic and business theory and has been widely adopted by the project management literature. When reviewing portfolio selection concepts in the literature, little discussion on such fundamental assumptions can be found, with a few exceptions (for example Cicmil and Hodgson, 2006). However, decision models, such as the Analytical Hierarchy Process, discussed in Chapter 4, have accepted and embraced the reality of inconsistent choices (intransitivity) and even reveal and address the degree of inconsistency of choices (Foreman and Selly, 2002).

A *measurement scale* provides a frame of reference, which ultimately allows the ability to contextualize a metric. Stevens introduced four types of measurement scales: nominal, ordinal, interval and ratio scales (Stevens, 1946). Stevens' taxonomy has been enhanced by two more types: typological and absolute scale measurement. *Nominal* scales are a form of semantic expression and deliver referential values (for example, the assignment of a risk ID number for the project issue). A classification of a risk by root cause, such as "supplier-related delay," would constitute a *typological* scale measure, as it would classify a metric based on a pre-defined taxonomy. Unlike nominal and typological scale measures, an *ordinal* scale would allow for a meaningful comparison of objects, as for example severity of schedule delays as high, medium or low would be determined. *Numerical* scale measurement can be performed using interval, ratio or absolute scales. *Interval* scales use arbitrary increments or ranges (1 to 10 days, 11 to 20 days, etc.); they can be used for comparing data, but not for any numerical processing, such as averaging, adding etc. One special form of interval scales is logarithmic scales, which allow for the transformation of non-linear measures into a linear metric. *Ratio* scales (for example, a schedule performance index, measured in percent), and *absolute*

[46] This axiom is rooted in the concept of "Gleichheit", literally translated "alikeness", based on Helmholtz's 1887 paper "Zählen und Messen erkennthistheoretisch betrachtet."

scales (for example, expected loss, measured in dollars) are the most common representations of metrics and allow for more effective comparison and numerical processing.

Numeric scale is the most valuable and meaningful and least ambiguous of the measurements (Pandian, 2003, p. 9), and only interval, ratio and absolute scale measures allow for mathematical operations. Table 5-1 summarizes and illustrates the taxonomy of measurement scales.

Table 5-1: Examples for the Application of Stevens' (1946) Measurement Scale

	Measurement Scale	*Example: Object of Measurement*	*Example: Assigned Value or Number*
Linguistic Scales	Nominal Scale	Risk ID	001
	Typological Scale	Risk type	"Supplier risk"
	Ordinal Scale	Probability of occurrence	"High"
Numeric Scales	Interval Scale	Probability of occurrence	Between 7 and 9 in 10
	Ratio Scale	Probability of occurrence	75%
	Absolute Scale	Expected loss	$500,000

5.2.1.2 Metrics and Key Performance Indicators

The process of measurement produces metrics and key performance indicators; and definitions for both shall be discussed here. Dinsmore and Cooke-Davies define *metrics*[47] as "a form of measure for communicating information in a compact and meaningful way (Dinsmore and Cooke-Davies, 2006, p. 186). Rose's definition points toward the use of metrics as "a means of measurement for determining the degree of conformance to specifications" (Rose, 2005, p. 54). Lastly, *The Standard for Portfolio Management* (Second Edition) states that metrics "measure quantitative or qualitative information aggregated from the portfolio components" (PMI, 2008c, p. 18) and lists several examples, which are provided in Section 5.2.4.

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[47] The literature review revealed that instead of 'metrics', the terms 'measures' and 'performance measures' are often used as synonyms.

Ambler, Kokkinaki and Puntoni (2004) provide a thorough theoretical analysis of metrics in the context of management science, which yields several criteria for the defining of metrics. From the viewpoint of *control theory*, metrics are a tool to validate that planned activities deliver their intended outcomes. Furthermore, observing outcomes provides feedback on effectiveness of the metrics selection itself, which leads to the discussion of process metrics, as covered by Proposition 4. From the viewpoint of *agency theory,* executive management (the principal) delegates work to a project management office (PMO) or to a portfolio manager (the agent) and have the ability to assess performance and behavior through metrics. Lastly, *institutional theory* suggests that metrics are set in the context of organizational culture and history, as well as customary circumstances of the market or environment in which the organization operates. In this context, executives and managers often refer to rather subjective performance indicators, which, however, are customary among industry peers, even if alternative metrics appear more meaningful from an independent, that is, academic perspective (Ambler et al., 2004, pp. 477-479).

Key performance indicators (KPIs) constitute a subset of metrics "focusing on those aspects of organizational performance that are most critical for the current and future success of the organization" (Parmenter, 2007, p. 3). Some of Parmenter's recommended characteristics from extensive surveying are that KPIs should be measured frequently, acted on by management, transparent in their meaning to the entire organization and tied to individual or team responsibilities (Parmenter, 2007, p. 5).

5.2.1.3 Critical Success Factors and Early Warning Signals

The concept of critical success factors (CSFs) was first defined by Rockart as a select set of areas where result achievement ensures strategic success, in the sense of mandatory success criteria, which deserve continuous management attention (Rockart, 1979). CSFs have been widely discussed in the project management literature and related disciplines. In the most in-depth analysis of project management literature to date, 27 different project CSFs have been distilled from 63 relevant sources of surveys, case studies and theoretical work (Fortune and White, 2006). Although the number of CSFs alone indicates little consensus across authors, Fortune and White discovered that disagreement even exists on the most important CSFs, as only 17% of the authors agree on the top three critical success factors.

Table 5-2: Project CSFs (Source: Fortune and White, 2006)

CSF	Citation count	CSF	Citation count
Support from senior management	39	Project sponsor/champion	12
Clear realistic objectives	31	Effective monitoring/control	12
Strong/detailed plan kept up to date	29	Adequate budget	11
Good communication/ feedback	27	Organizational adaptation/culture/structure	10
User/client involvement	24	Good performance by suppliers contractors/consultants	10
Skilled/suitably qualified/sufficient staff/team	20	Planned close-down/review/acceptance of possible failure	9
Effective change management	19	Training provision	7
Competent project manager	19	Political stability	6
Strong business case/sound basis for project	16	Correct choice/past experience of project management methodology/tools	6
Sufficient/well-allocated resources	16	Environmental influences	6
Good leadership	15	Past experience	5
Proven/familiar technology	14	Project size/level of complexity/number of people involved/duration	4
Realistic schedule	14	Different viewpoints (appreciating)	3
Risks addressed/assessed/managed	13		

Table 5-2 illustrates the range of opinions on what is critical to the success of projects. Although there may be many root causes for the disparity, it is evident that there is no universally applicable set of CSFs.

Other authors have approached CSFs from a different point of view. For example, Balachandra (1989) defined 14 early warning signals to watch for potential R&D project failure, which have been validated by a later empirical study (Sanchez and Perez, 2004):

Table 5-3: Early Warning Signals for Project Failure (Source: Balachandra, 1989)

Early Warning Signal	
Achievement of Technological Goals	Government Regulations
Personnel Commitment	Lack of Talented People

Communication Between Departments	Project Matching to Company's Strategy
Client Interface	Number of Projects in Portfolio
Cost and Time Deviations	Pressure on Project Leader
Quality of Documents	Project Champion
Number of Expected End Uses	Top Management Support

5.2.1.4 Metrics, CSFs and KPIs in Context

Although the identification of CSFs and early warning signals are extremely valuable from both a project and portfolio management perspective, CSFs only constitute a starting point toward management action, as concrete metrics must be identified for each concrete PPM application scenario.

The previously discussed large number of CSFs and the low level of consensus on which success factors are really critical, furthermore explain the significant number of metrics found in the project management literature. As Pandian states, “the final choice of metrics has to be organization specific. Instead of fitting management systems to perceived metrics list, we better turn the table and look for fitting metrics choices... [T]here is no universal metrics system that can be plugged into the project environment” (Pandian, 2003, p. 19).

In addition to identifying critical success factors (or indicators for potential failure) and deriving relevant metrics or KPIs, it needs to be determined at what threshold should project or portfolio managers take action and what type of action is required when a threshold is reached. This discussion is resumed in the context of Proposition 3 in Section 5.3.

5.2.2 Metrics Classification and Characteristics

Metrics can be obtained through plain adaptation also known as “fundamental measurement” (Díez, 1997, p. 168) or “derived measurement” through comparison and calculation of ratios or more complex operations (Pandian, 2003). *Plain adaptation* or the observing of an actual value (for example, actual cost at completion) is the simplest form of measurement, because no further calculations are required to obtaining the metric, as what is observed constitutes the metrics itself. *Comparison metrics,* typically defined in the form of a delta or a ratio between two values, require the measurement of two variables that will yield a metric. For example, a cost variance for a project would be the difference between actual and planned costs. Similarly, ratios provide measures as a quotient of two observed or measured values; return on investment is one of the most prominent metrics of this type. More *complex (composite) metrics* are the result of calculation beyond subtraction or division of values; Net Present Value and Internal Rate of Return are two examples (Pandian, 2003, pp. 16-18).

The project management literature provides few classifications of metrics. Levin and Rad introduced a nomenclature of "things," "people" and "enterprise" metrics (Rad and Levin, 2004; Levin and Rad, 2006). Four types of enterprise metrics, which entail portfolio metrics, are discussed in Section 5.2.4.

Metrics can exhibit further characteristics in regard to the time horizon of the observed objects: Leading indicators may signal likely future outcomes or events, whereas lagging indicators provide current and retrospective views of past outcomes and performance (Kaplan and Norton, 1992). The notion of leading and lagging indicators has been widely discussed and applied in economics; however, the academic literature on project and project portfolio management does not put particular emphasis on this distinction. In line with the traditional focus on metrics that measure the aspects of the triple constraint, many metrics are lagging indicators, such as metrics describing actual resource usage per a certain date (staff hours, materials, capital, etc. spent to date) and cost and schedule performance, typically measured as cost variance and schedule variance or as the respective indices in percent (cost performance index and schedule performance index). Earned value analysis provides leading indicators, such as Estimate at Completion (EAC), which projects the total project cost at the completion of the project.

Applied research provides some interesting additional insights into the topic of leading and lagging indicators. For example, Gartner Research surveyed 130 clients on metrics to evaluate project success and concluded that the "tried and true" metrics of on-time and on-budget project delivery are failing to correlate with what the clients' executives considered the true success criteria of projects: alignment with strategy (27.7%), revenue growth (23.8%) and ROI (16.2%) were named as the top criteria for project success (Tracy, Guevara and Stegman, 2009).

It must be recognized, however, that project benefits are often realized over time and, in many cases, over years beyond the project completion. Figure 5-1 illustrates the project and portfolio measurement dilemma: most of what is measured and what project managers are accountable for is related to the project execution. Metrics that measure aspects of the triple constraint are typically lagging, but even leading indicators, such as earned value metrics like EAC do not provide insight toward the achievement of a business benefit.

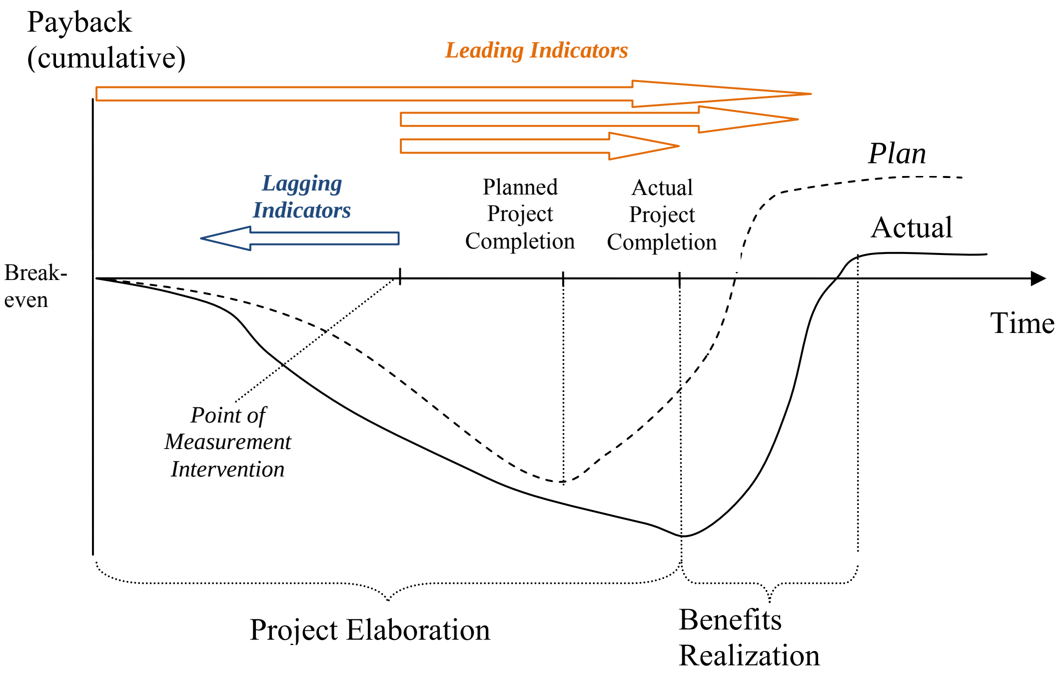

Figure 5-1: PPM Measurement Dilemma

The aforementioned Expected Commercial Value (see Section 4.2) points in the direction of leading indicators: the understanding of contributing factors and sensitivities allows for ECV predictions. Other techniques are used to provide leading indicators for projects, such as user acceptance testing, which can generate data to predict customer satisfaction and acceptance of a solution under development for either one or multiple customers of product development project.

5.2.3 Measurement Process and Approaches to Metrics Selection

5.2.3.1 Measurement Process and Implementation

Data yield information, which can be translated into knowledge. The ultimate purpose of measurement and metrics is the enabling of informed decisions. Management literature provides countless examples of how a poor-quality decision process is more likely to yield undesirable outcomes than a high-quality process (Janis, 1989) so that the perfection of metrics are only the penultimate goal.

As recognized before, the process of measurement goes beyond the mere assignment of numbers to objects or events, which constitutes just one step within the measurement process, as per the definition in measurement in a more narrow sense. Although traditional measurement theory focuses on such observation and judgment, a more comprehensive and phased measurement process shall be considered going forward.

From the perspective of measurement theory, three phases of measurement coexist and influence each other. *Cognitive measurement* can be considered a mental process that is founded on the human ability to perceive and to judge based on subjective criteria. *Semantic measurement* uses expressions to label observations, as explained previously in the discussion of nominal scale measures; much of this is applied in project and portfolio status reporting, where risks are defined as high, medium or low, and project health status is represented by traffic light symbols as red, yellow or green based on defined rules. Lastly, *quantitative measurement* delivers the aforementioned numeric scale measures (Pandian, 2003, pp. 5-6). To illustrate the notion of the three measurement phases, a risk management process could start with the cognitive and semantic phases as risks are identified and qualified (for example, high-risk projects may be defined based on certain project complexity criteria), and the quantitative stage may entail the determining of impact and probability of occurrence as interval, ratio or absolute scale measures. However these three phases are not necessarily sequential[48], as for example, judgment and the use of intuition (cognitive measurement) could be applied throughout the measurement process.

Hubbard provides a detailed process, consisting of three phases. As a first step, the actual decision problem and the parameters of the decision model are articulated. A second step of "preliminary measurement" covers the identification of the value of information in order to determine the appropriate level of measurement, as the measurement effort is not to exceed the benefits from measurement and the determination or design of the measurement method. As a third step, metrics design would conclude the process, as appropriate metrics are selected and applied (Hubbard, 2007, pp. 244-248).

In order to gear measurement efforts toward those areas that are relevant to strategic and execution success, selecting the right metrics becomes an important activity. Naturally, there is an infinite number of metrics that could be collected. However, "only a few key variables merit deliberate measurement efforts. The rest of the variables have an information value at or near zero" (Hubbard, 2007, p. 33). Hubbard further concludes from a series of cases a measurement inversion, whereas the most valuable information is often collected the least and vice versa (Hubbard, 2007, p. 96-97).

Implementing a measurement process requires a projectized approach and is best managed as an iterative and reflective process, as proposed by Bourne (Bourne, Mills, Wilcox, Neely and Platts, 2000) and as illustrated in Figure 5-2.

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[48] The notion of "phases" is in the context of cognitive, semantic and quantitative measurement, which may mislead, because they are not necessarily sequential but rather coexistent throughout a measurement process, which will be discussed in this chapter.

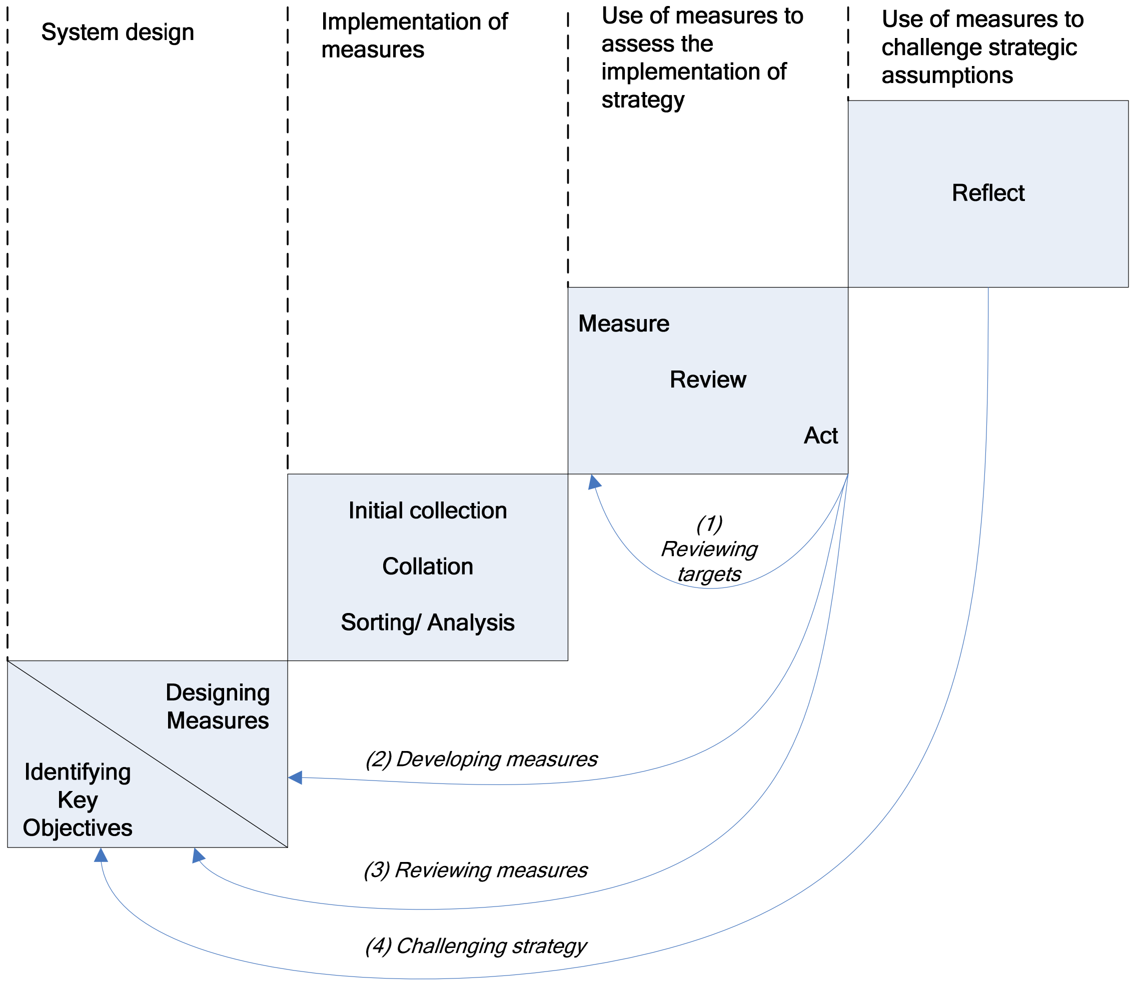

Figure 5-2: Implementation of a Measurement Process (Bourne et al., 2000)

The importance of a conscious and diligent implementation of a new measurement process cannot be stressed enough. In the context of the discussion around implementations of balanced scorecard measurement frameworks, Neely at al. (1997) stated a 70% failure rate, attributable to poor choices of what to measure and the implementation process.

5.2.3.2 Metrics Definition and Selection Techniques

Inasmuch as no universal set of metrics that would fit all circumstances and application scenarios exists, the question that remains to be answered is how to go about identifying the "right" metrics.

Research in the field of software engineering provides a widely accepted and applied framework that facilitates the goal-oriented measurement and metrics selection. The Goal Question Metric (GQM) approach, introduced by Basili and Weiss (Basili and Weiss, 1984) and often attributed to Basili, Caldiera and Rombach (Basili, Caldiera and Rombach, 1994) follows the Management by Objectives paradigm: a meaningful metric requires the prior definition of an organizational goal (G), followed by the phrasing of a question (Q) that corresponds to these goals and ultimately helps define a metric (M) that will allow answering the stated question G. Table 5-4 provides an example for the application of GQM:

Table 5-4: GQM Example (Arlt, 2009a)

Goal:	*Purpose* *Issue* *Object* *Viewpoint*	***Add*** ***new revenue stream through offering*** ***multi-year service contracts*** ***for extended warranty repairs***
Question		How much additional revenue and profit can be attained?
Metric		Service revenue (in $) Gross profit from service contracts (in $), (in %)

Although various modifications to the GQM approach have been introduced in the literature, the method has been studied and applied extensively for software projects and beyond (Boyd, 2005). The steps of GQM in its extended form are depicted in the following table:

Table 5-5: Enhanced GQM Approach (Briand, Differding and Rombach, 1997)

	Six Steps of Goal Question Metric Approach
1	Characterize the environment. Identify the characteristics of the organization and project or projects to be measured.
2	Identify measurement goals and develop measurement plans. Define measurement goals based on the information in step 1.
3	Define data collection procedures. Define data collection procedures for all measures defined in step 2.
4	Collect, analyze and interpret data.
5	Perform post-mortem analysis and interpret data. Compare data collected in step 4 with organizational baseline.
6	Package experience. Structure results into reusable form to be used in the future.

The discussion around concept introduced in this section is extended and applied in the context of Propositions 3 and 4.

5.2.4 Project Management and Project Portfolio Management Metrics

The Standard for Portfolio Management (Second Edition) suggests the selection or development of strategically relevant metrics, as well as the review and replacement of those metrics that are no longer relevant. Furthermore, *The Standard* provides examples of quantitative and qualitative metrics, illustrated in following table:

Table 5-6: Metrics in The Standard for Portfolio Management (PMI, 2008c, p. 19)

Quantitative Metrics
• Increase in revenue attributable to the portfolio • Development of new markets and expansion of customer base as a result of the portfolio • Cost reduction attributable to the portfolio • Change in net present value of the portfolio • Return on investment from the portfolio • Internal rate of return of the portfolio • Degree to which portfolio and business risks have been reduced by undertaking the portfolio components • Availability of resources needed to support the portfolio components, both as planned and in execution • Percentage by which cycle times are reduced due to the portfolio, and • Change in quality improvement score attributable to the portfolio
Qualitative benefits
• Degree of strategic alignment, and • Recognition of legal and regulatory compliance

Although the PMI recognizes the differences between project, program and portfolio metrics, it emphasizes that portfolio metrics must "focus more on the progress toward achieving an organization's financial, customer satisfaction, efficiency, risk and diversification goals." It is also interesting to note that the first edition of *OPM3* articulated a best practice recommendation #6140 "Provide metrics repository" further specifying that organizations should maintain a central repository for metrics to be applied for all projects (PMI, 2003), whereas the second edition of the *OPM3* standard has withdrawn this recommendation.[49]

[49] A knowledge repository is mentioned in the second edition of *OPM3*; however, *it is* not specified whether this knowledge repository is to entail metrics.

As mentioned in Section 5.2.2, Rad and Levin (2006) have provided the most comprehensive discussion on metrics in project management to date, and their taxonomy of things, people and enterprise metrics shall be reviewed briefly. Whereas things metrics capture the traditional measurement of quantitative aspects underlying projects that are, for example, related to the triple constraint of scope, time and cost, people metrics focus on aspects, such as leadership, team work conflict management and communication that are typically considered intangible and have only recently obtained greater attention in the literature. Lastly, enterprise metrics take a more holistic view of the organization as a whole and include among others, strategic and organizational process metrics, and are closely related to what would be measured on the portfolio level (Rad and Levin, 2004; Levin and Rad, 2006).

The authors' equal weighting of people and enterprise metrics versus thing metrics illustrates the shift away from a tactical measurement approach in the project and portfolio management disciplines. Rad and Levin (2006) specifically suggest four types of metrics (in the authors' nomenclature "indices"), which are displayed in the following two tables.

Table 5-7: Project Selection Indices (Source: Rad and Levine, 2006, pp. 305–306)

Project Selection: *Organizational Indices*	Project Selection: *Project Indices*
Quantitative • Benefit-cost ratio • Payback period • Average rate of return • Net present value Qualitative • High-level mandate • Operational necessity • Competitive necessity • Product line extension • Market share	• Delivery date in relation to needed date • Resource availability • Conceptual estimate of cost and duration • Updates estimate of cost and duration • Original scope and quality • Updated scope and quality • Probability of project success • Variances in the deliverable (scope, quality, cost duration)

Table 5-8: Organizational Indices (Source: Rad and Levine, 2006, pp. 305-306)

Organizational Indices: Financial	Organizational Indices: *Strategic*
• Total expected value of the portfolio • Discounted cash flow of income from the deliverable • Internal rate of return • Net present value of earnings resulting from the project • Expected commercialization value of the deliverable • Time to break even • Total cost as a percentage of the total available funds	• Probability of success of the deliverable • Validity of the project vision • Utility of the project deliverable • Strategic importance • Attractiveness of the deliverable • Impact of the deliverable on the enterprise • Benefits of the deliverable to the enterprise • Duration of projects as compared to the urgency of the need for the deliverable

5.3 Proposition 3 – Choice of Effective Metrics

In line with the previous discussion on gaps in the prevalent project and portfolio management literature and benefits from an effective and efficient approach to portfolio metrics and measurement, Proposition 3 is developed in this chapter:

Proposition 3 – Choice of effective metrics on strategic, portfolio and project levels
A process guideline to help selecting and defining metrics systematically, in line with organizational goals and cognizant of organizational maturity, increases the focus on achieving the portfolio management goals.

5.3.1 Requirements Toward Meaningful Portfolio Metrics

A review of the management science literature on metrics and measurement leads to the critique on current approaches. Although the literature provides a large amount of discussions around metrics and measurement, an increasing amount of criticism can be found that challenges the overemphasis of measurement and the conventional wisdom that what gets measured will also get managed (Emiliani, 2000).

Furthermore, measurement itself drives behavior (in social sciences referred to as the Hawthorne effect), and it can yield both positive and negative impact. If metrics reward the wrong behavior, thresholds are unattainable or yield conflicting objectives, then those negative impacts may occur (Buytendijk, 2007). Also, measurement is often confused with its actual purpose: rather than replace decision making by providing a discrete value, which defines adequate action, measurement reduces uncertainty and, as a result, may enable the making of big, risky decisions (Hubbard, 2007, pp. 21-24). Measuring what is relevant in a quality that instills confidence in metrics, as a foundation for quality decisions, as well as a viable balance between information from measurement and measurement efforts, are discussed as requirements toward meaningful metrics. These three factors are illustrated in Figure 4-4 and are discussed in the subsequent sections of this chapter.

Figure 5-3: Metrics Requirements

5.3.1.1 Relevance

Relevant metrics must support decision making in the sense of the definition of measurement that was provided in Section 5.2.1. The criterion of relevance is met, if metrics are:

(a) Timely,
(b) Contextually aligned with the nature of the business,
(c) Retrospective or predictive,
(d) Aligned with decision needs of the organization, and
(e) Appropriate for the maturity of the organization.

The need for *timely information* should be straightforward: the provision of information at the time required for decision making, at regular decision points along the process of selecting and controlling the portfolio, is an obvious prerequisite for quality decisions. *Contextual alignment* with the nature of the business would suggest that not all organizations should put emphasis on financial metrics, such as ROI or NPV; for example, R&D labs, think tanks, corporate angels and incubators, though serving the purpose of generating viable opportunities, would run the risk of stifling innovation if every early-stage project should provide and substantiate such metrics. Both *retrospective and predictive* metrics are of value to portfolio management; however, depending on the information need and purpose, a conscious choice of either one is more than desirable. The *alignment of metrics with decision needs* to accomplish organizational goals can be ensured by applying a goal-based approach to metrics selection, such as GQM, as discussed in Section 5.2.3. The previous discussion of critical success factors and potential failure points comes into play here, as metrics should be tested for their correlation with success or risks of failure. Furthermore, as information needs and availability for low- versus high-maturity organizations vary, metrics should be selected *corresponding to the maturity* of the organization. The literature recognizes that gathering data, such as goal-related information to perform proper measurement in the context of applying goal-oriented measurement, can be difficult in low maturity organizations (Boyd, 2005); and some information, though highly desirable, may not be attainable at all. Instead of sophisticated quantitative metrics, other more qualitative metrics could take precedence on the measurement agenda. What will become more important is to attain a common denominator of measures across projects in a portfolio to allow for a consistent evaluation and project comparison based on uniform data across the portfolio. In this context, obtaining comprehensive data for some, while relying on less or no data for other projects, will make the portfolio selection difficult and inconsistent.

5.3.1.2 Quality

Management decisions hinge on the quality of information obtained for the selected metrics, as measurement errors may lead to inaccurate conclusions. Pandian provides a concise definition for the aspects of measurement errors (Pandian, 2003, p. 10):

- Accuracy – proximity of the measured value to the actual value
- Precision – repeatability of an outcome for the same measurement
- Noise – distortion of value through external influences[50]
- Sensitivity of the measure or the individual – that is, less mature managers would be less attuned to "detect" a signal
- Calibration – error reduction through measurement process improvement
- Traceability and clarity – a metric is easy to understand and translate into action for all relevant stakeholders with little or no ambiguity (Crawford, 2008)

Even a mature and high-quality decision process can yield negative outcomes if judgment is based on information of poor quality. Conversely, it has been observed, that proper metrics can improve the rate of goal achievement, identify trends and improve outcomes, that is, project performance against the triple constraint (Rad and Levin, 2006).

5.3.1.3 Viability

Neely and Bourne (2000) discuss reasons for design and implementation pitfalls of measurement initiatives and identify two primary challenges toward measurement success. First, the collection of metrics must be less expensive than the merit that can be achieved from the data. Demonstrating such "Metric ROI" is critical to obtain buy-in from rational decision makers, and especially those individuals or managers who will be assigned the measurement task. Second, in relation to the human aspect of portfolio management, metrics must be organizationally accepted and politically viable.

For a low-maturity organization, for example, establishing a PPM processes will require gathering a minimum set of simple, easy-to-obtain and easy-to-understand metrics in the highest quality possible for all candidate and all ongoing projects.

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[50] One example for the challenge of noise in measurement is the discussion around ROI from project management excellence, initiated by Ibbs (PM-ROI) and recently resumed by the Project Management Institute in their "Value of Project Management" research effort. The quantification of ROI from project management has been very difficult, in part due to many factors that influence organizational performance that could not be isolated (Ibbs and Kwak, 1997).

Obtaining such quality data for an entire organization will take time, and though efforts are made toward establishing minimum standards across the organization, much of the desired quantitative information may not be obtained. Also, as with any change, considerable resistance toward measurement efforts and an increase in transparency can be anticipated from at least some stakeholders.

5.3.2 Proposed Metrics Taxonomy

Section 2.4 stated and elaborated the four goals of project portfolio management. Following the paradigm of goal-aligned metrics, PPM goals should reflect the goals of strategic alignment, portfolio balance, maximization of portfolio benefits and continuous improvement of PPM processes. Inasmuch as a comprehensive PPM process controls all phases from review of a candidate project through portfolio selection to project execution and closure, it is important that measurement occurs at more than one level (see Figure 5-4).

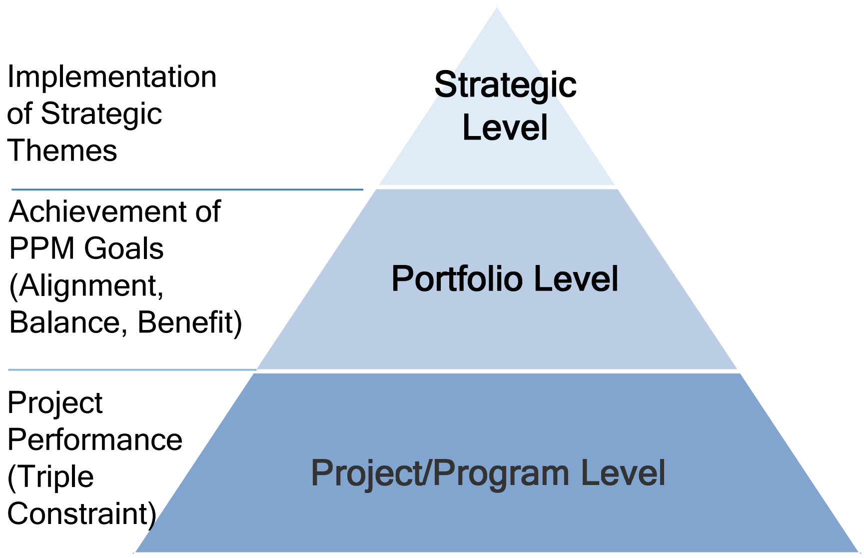

Figure 5-4: Three-Tier Metrics Model for Portfolio Management

A measurement system should consist of metrics that provide information at all three levels, and metrics should reconcile in both directions. For example, if one strategic theme is to "deliver $20 million profit from a new geographic market," "profit from new market" would constitute the strategic metric. Consequently, as this objective would be implemented through a portfolio of projects, portfolio management should be tasked with the achievement of a certain benefit, for example, achievement of $100 million revenue through deploying branch offices (Project A), regional marketing campaign (Project B), setup of a multi-lingual call center (Project C), with business cases that cumulatively deliver the targeted strategic benefit at a cost that is not to exceed available funds (portfolio optimization constraint). The respective portfolio-level metrics in this simple example would be "revenue as a result from market expansion" and "project implementation cost." Lastly, project metrics would relate to the attainment of a given scope that would deliver the planned benefits and within budgeted cost.

Metrics should correspond to one of the three levels, meet the requirements discussed in Section 4.2.1 and should be defined to a degree that maximizes the chance of measurement success. Such format may follow metrics characteristics as those below, proposed by Neely (1997) or the ISM3 Consortium[51] (Aceituno, 2007):

Table 5-9: Metric Parameters After Neely (1997) and Aceituno (2007):

Metric	*Metric*
Purpose	Name and description
Relates to	Measurement procedure, describing how measurement is performed
Target	Measurement frequency
Formula	Thresholds or triggers for action
Frequency	Target value, describing the best possible value of the metric
Who measures	Units of measurement
Source of data	
Who acts on data	
What do they do	
Notes and comments	

Both approaches illustrated in Table 5-9 entail characteristics for a consistent capture of measures. The author selected the application of Neely's approach toward the definition of both strategic portfolio and project metrics, but also for process metrics discussed in the context of Proposition 4. Expanding on Bourne's measurement model,

[51] ISM3 is the Information Security Management Maturity Model, an extension of ISO9001 to information security management.

introduced in Section 5.2.3, the author proposes a five-phase approach for PPM metrics development and deployment of the following measurement approach:

1. Design three-tiers of metrics, following the GQM approach to achieve alignment of goals on all levels
2. Validate metrics requirements against relevance, quality and viability criteria, as introduced in Section 5.3.1
3. Implement metrics
4. Apply metrics and evaluate achievement of goals
5. Reflect on strategy and measurement process

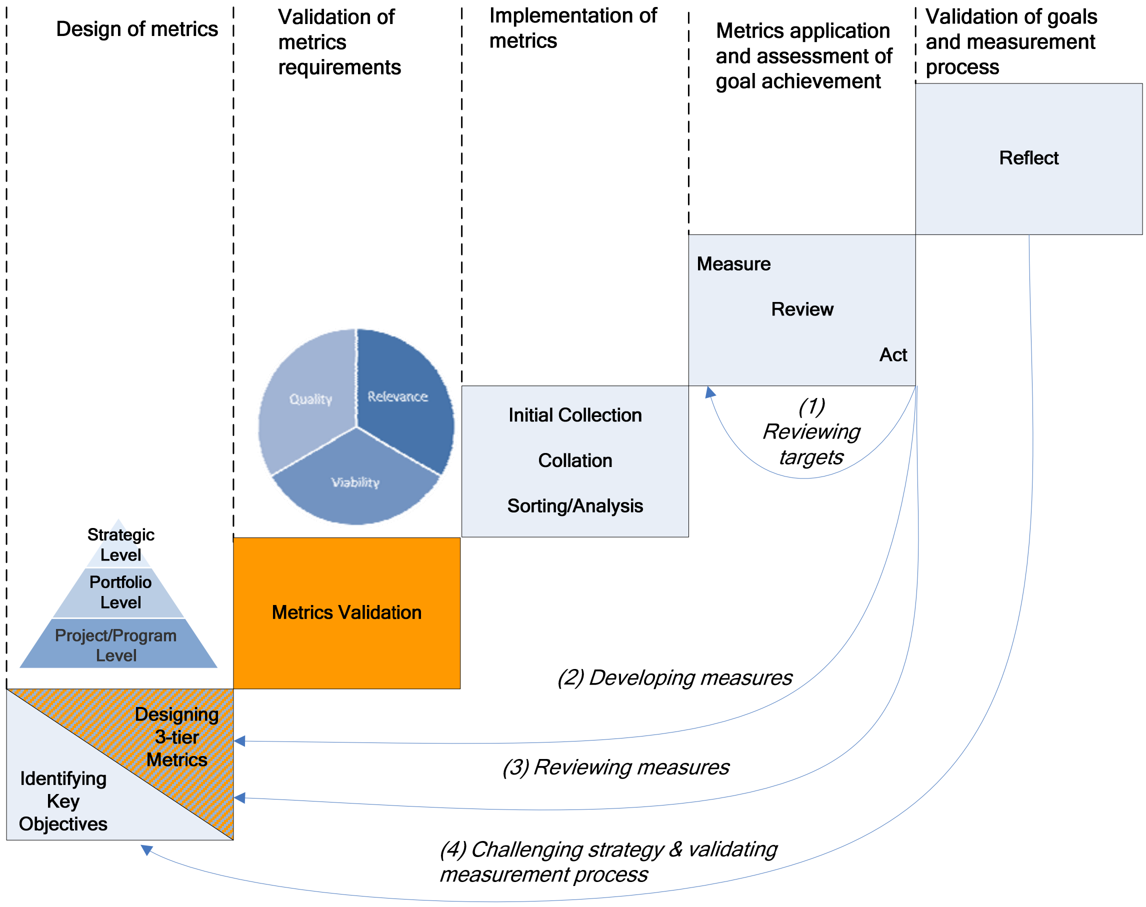

Figure 5-5: Enhanced Measurement Model

The proposed model illustrated in Figure 5-5, is subsequently applied and validated in Chapter 6 in the context of both a case study and, to a degree, the experiment conducted by the author. The application itself in the case study discussed serves as an example. For the reasons previously discussed, the author does not see merit in a prescriptive model for portfolio metrics, yet while recognizing the value of a metrics compendium for practitioners (i.e. Rad and Levin, 2006) as a valuable source for strategic, portfolio and project/program-level metrics.

5.4 Proposition 4 – Use of Process Metrics to Determine and Drive PPM Maturity

Proposition 4 – Use of Process metrics to determine and drive PPM maturity
A set of metrics is established to monitor process and continuous process improvement, as well as the fulfillment of the "business case" for performing project portfolio management, in order to achieve and sustain buy-in from the organization and their executives.

Proposition 4 constitutes an extension to Proposition 3, as the author suggests to apply the same principles and process discussed in Section 5.3 to process metrics with two objectives:

1) *Evaluate process quality* – Is the introduced process effective and efficient?
2) *Drive process improvement* – What steps should be taken next in regard to improving processes, and what improvements with respect to the three primary PPM goals can be expected as a result?

Process measurement can relate to all three tiers introduced in the context of Proposition 3, which is illustrated in Figure 5-6.

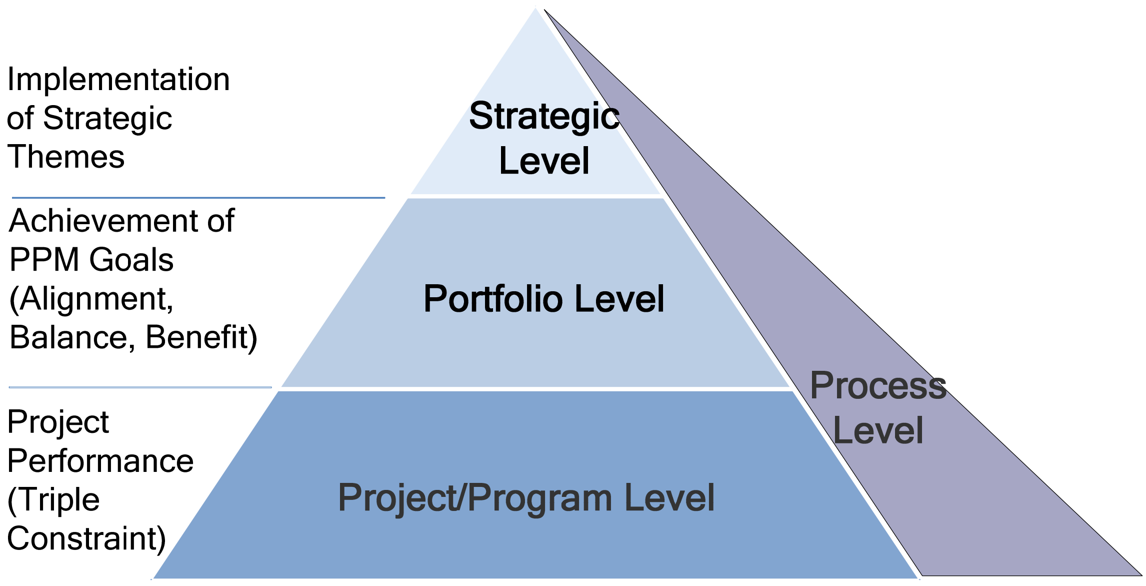

Figure 5-6: Addition of Process Measurement

For purposes of illustration, some examples for such process metrics are provided:

- Process adherence
  - Number of projects not captured in the portfolio inventory
  - Number or percentage of project approvals that bypass the standard approval process
- Process quality and PPM excellence
  - Reliability of business cases (that is, accuracy of estimates)
  - Use of contingency margins
- Agility
  - Response time from project idea, identified as high strategic priority to portfolio decision
  - Response time to project event (that is, indication of imminent failure, delay, scope creep, etc.)
- Response time to strategy change (time elapsed from communication of strategic change until portfolio is reshuffled)
- Efficiency
  - Effort spent on portfolio management activities

- Consistency of choice in the project selection (for example, based on the consistency index of the AHP model, discussed in Chapter 3)
- Improvement in funds and resource allocation over time

As with strategic, portfolio and project metrics, a diligent choice of metrics, based on solid metrics requirements and a systematic process is required in order to have effective and efficient metrics in place.

5.5 Metrics Comparison and Aggregation

In practice, three options for comparing a project based on multiple metrics exist. First, it could be decided to use only one of the metrics as the key criterion for the selection decision. Although this is rare in practice, some organizations have such a singular (that is, financial) focus that this approach is viable and metrics like NPV or ROI constitute the single criterion for the selection. Second, as introduced in Section 4.2.2, ranking methods typically use weighted averages to calculate composite metrics, which provide one "common currency" for the comparison of projects. Lastly, the AHP delivers an alternative approach toward metrics aggregation. Anbari, Cioffi and Foreman (2010) proposed to use AHP to build a composite metric, based on the pair-wise comparison of portfolio metrics.

5.6 Chapter Summary

This chapter introduced the concept of measurement from the perspective of theory and challenges in practice and discussed metrics classification, measurement process, as well as the existing measurement-related references in the PPM literature. Two closely aligned propositions for the measurement of outcomes of PPM and process were introduced. The author provided a procedural approach toward the development of metrics, including tools for the development and specification of metrics. Furthermore, an implementation approach for a measurement framework with application to PPM has been developed that entails a three-tiered perspective and validates the developed metrics based on relevance, quality and viability criteria.

The following graph puts the model extensions of Propositions 3 and 4 into the context of the base model as well as previously introduced Propositions 1 and 2.

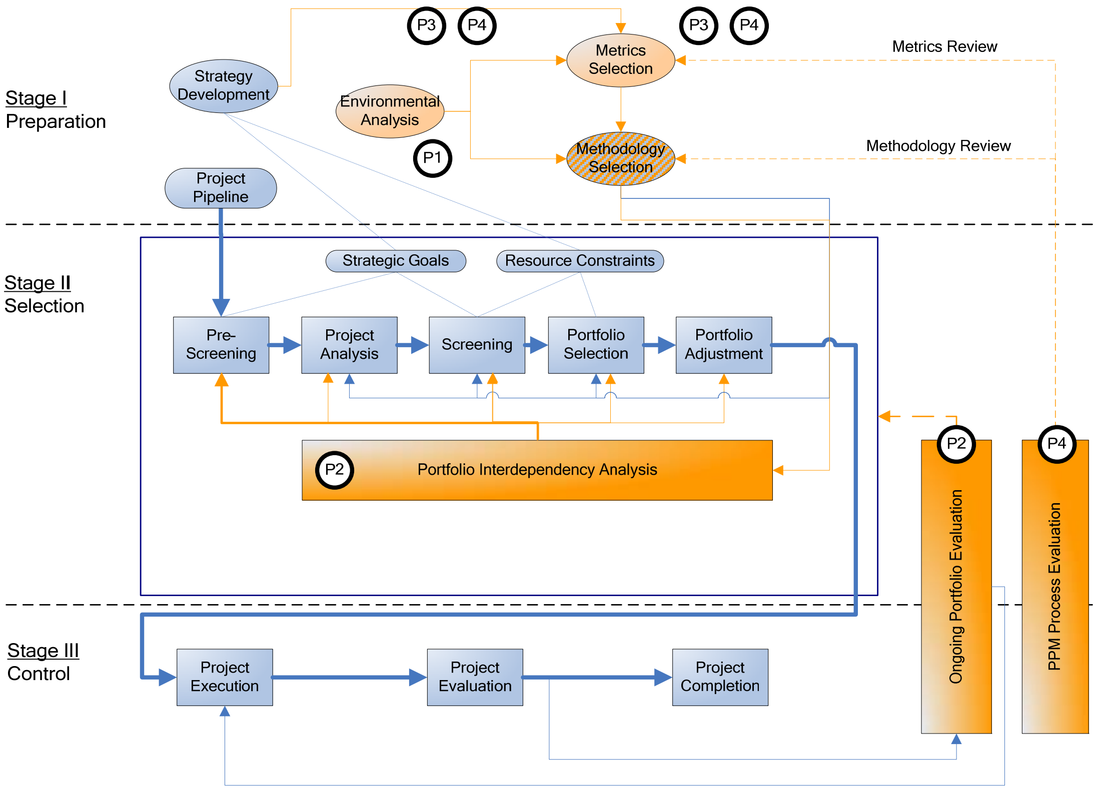

Figure 5-7: Portfolio Life Cycle with Propositions 3 and 4 Enhancements

6. Tight Integration of PPM and Strategic Planning

6.1 Chapter Introduction and Objective

This chapter discusses another key aspect of portfolio management, the achievement of alignment between strategy and portfolio, and expands the common definition of alignment, which is focused on strategic fit. After the immersion on strategy and strategic alignment in Section 6.2, Proposition 5—the reconciling of potential misalignments between strategy and portfolio, or portfolio gap analysis—is discussed in Section 6.3 and the terms of strategy gap and project gap introduced and demonstrated. Chapter 6 concludes with a brief discussion on implementation issues in the alignment of strategic planning and PPM, as well as an integrated picture of the propositions.

6.2 Immersion – Strategy Definition and Alignment Through PPM

Management science provides a wealth of literature on the topic of organizational strategy. It is not the objective of this chapter to discuss the full breadth of the literature but rather to provide a brief outline of trends and to focus on strategy in the alignment context of project portfolio management.

Norrie (2006, p. 25) provides a detailed overview of the literature on organizational strategy and notable contributors to strategy literature, such as Mintzberg (1987) and Porter (1980). Although most of the pertinent literature discusses how to develop strategy, it is increasingly recognized that its implementation is an even greater challenge and requires a combination of skill sets of both strategy formulation and execution (Breene et al., 2007). However, in practice there is very often an “organizational divide” between strategy departments and operations or project management organizations. Bower and Gilbert (2007) discuss various root causes for mismatch of strategy and action: Organizational structures lead to dispersion of knowledge and power, as well as different perspectives, which result from organizational roles of individual decision makers, also referred to as Miles' Law[52] (Miles, 1978). Furthermore, top-down strategy execution implies top-down control, which in reality is often limited. Strategy formulation and execution are more dynamic than the top-down notion would suggest: "[A]t the same time that corporate staff is beginning to plan for and roll out initiatives, operating managers invariably are already acting in ways that either undercut or enhance them." (Bower and Gilbert, 2007, pp. 75-76).

One approach to address the issue from a PPM perspective, especially for multi-level hierarchical organizations, is to delegate some of the authority for strategy and portfolio from the top to lower organizational nodes in the organization. This approach, leads to cascading portfolios, which allow the articulating of a corporate strategy and deriving of some enterprise-wide corporate initiatives controlled at the top corporate level, whereas other mandates cascade down into the organization and are operationalized where managed best (Bourne, 2008). Kaplan and Norton provide several case studies for the cascading of strategy and refer to it as a hybrid approach between centralized, top-down management of strategy and decentralized approaches (Kaplan and Norton, 2006, pp. 169-192).

Figure 6-1 illustrates the notion of cascading for an organization consisting of three major hierarchical levels: Whereas corporate strategy cascades down to divisions and both corporate and divisional projects cascade further to the departmental level, project portfolios are managed at the corresponding levels. This "largest common denominator approach" allows the autonomy of a department to manage those activities from strategy to execution with little or no externalities beyond the departmental level. If however, a project serves the greater good of the division or business unit, their management is more appropriate as part of a portfolio at the higher organizational level.

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[52] Miles' Law, a term from the behavioral science literature, can be shortly described as "Where you stand is where you sit" and summarizes the common observation of role-based perspective of decision makers.

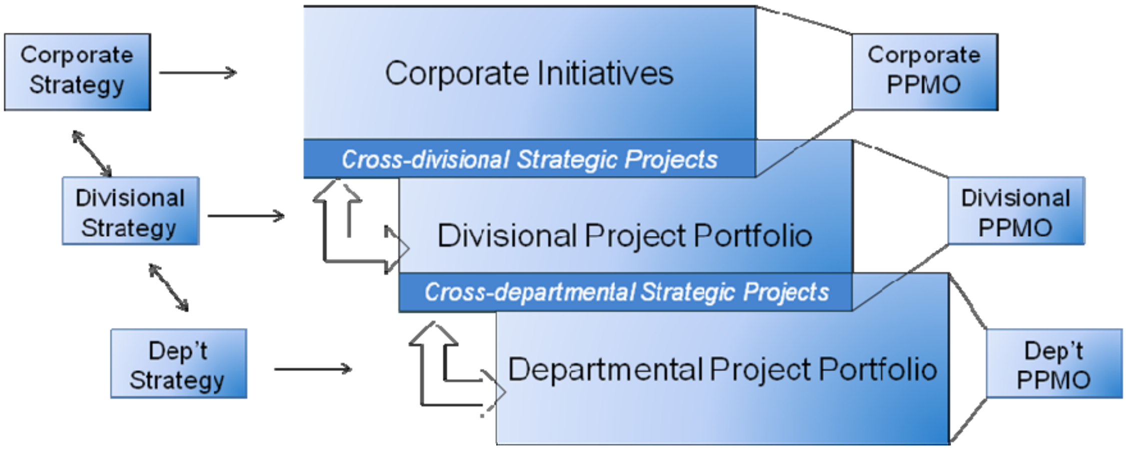

Figure 6-1: Multi-Level Cascading Portfolios (Arlt, 2009a)

6.2.1 Strategy

According to Mintzberg, strategy is a plan that consciously guides action. It can be viewed as a ploy to outmaneuver competitors and exhibits patterns of consistent and repeated action. Furthermore, strategy is a position of an organization in its environment and lastly provides a perspective shared collectively by members of an organization about the organization itself (Mintzberg, 1987). Mintzberg further analyzed and categorized ten strategy schools for defining strategy that have emerged over the past 50 years (Mintzberg, Lampel and Ahlstrand, 2005). Walker, Arlt and Norrie discussed the application of the ten schools in the context of project management and describe how different approaches toward the articulating strategy influence project and portfolio management (Walker et al., 2008).

The strategy literature typically discusses organizational vision, mission and (core) values as inputs to the strategy formulation and uses additional techniques to perform an environmental scan before articulating a strategy. Such techniques include PEST (Turner, 2002) and SWOT (Freisner, 2008),[53] as well as Porter's five forces (Porter, 1980),

[53] PEST abbreviates the macro factor-oriented analysis of Political, Economic, Social, and Technological factors. SWOT elaborates Strengths, Weaknesses, Opportunities and Threats within the organization. Both methods have evolved from a series of sources and are not credited to specific individual contributors.

serving the purpose of developing strategies that are meaningful in the organizational (micro environment) and external context (macro environment).

Kaplan and Norton (2000) discuss the aforementioned challenge of strategy execution and describe five critical success factors, as illustrated in the following table:

Table 6-1: Success Factors of Strategy Execution (Kaplan and Norton, 2006, p. 3)

Success Factor	Explanation
Mobilization	Change through executive leadership
Organizational Alignment	Alignment of corporate functions, boards, business units, support units and external partners with strategy
Strategy translation	Defining Strategy Maps, Balanced Scorecards and Initiatives
Employee Motivation	Education, communication, goal setting, incentive compensation and staff training
Governance	Integration of strategy into planning, budgeting, reporting and management reviews

Two success factors are highlighted due to their relevance to PPM. Following the notion of Kaplan and Norton, project selection as discussed in this work relates to strategy translation as "initiatives" can be equated to projects. Organizational alignment (as it is defined in a broader sense) includes the notion of strategic alignment, as discussed in PPM and is further discussed in the following chapter.

6.2.2 The Concept of Strategic Alignment

Papp (1998) presents a strategic alignment model, generalizing industry models of two prior decades that emphasizes multiple alignment dimensions. Papp's IT-oriented model, which connects the four aspects of business strategy, IT strategy, organizational and IT infrastructure, analyzes alignment in the sense of linkages between these four aspects, such as strategy execution. Kaplan and Norton provide a more generalized alignment framework, the Balanced Scorecard, which they developed in the 1990s (Kaplan and Norton, 1992; Kaplan and Norton, 1996; Kaplan and Norton, 2000) and have continuously extended since (Kaplan and Norton, 2006), which suggest a number of "alignment checkpoints" in the organization.

6.2.2.1 Strategic Fit

Porter (1996) first introduces the concept of strategic fit as the internal consistency of those activities that implement strategy. One of the cornerstone papers on strategic fit validates the importance of synchronizing strategy, organizational setup and managerial activities and distinguishes between minimal fit, tight fit, early and future fit (Miles and Snow, 1984). Whereas a "minimal fit" of organizational activities with the defined strategy is a prerequisite for survival, a "tight fit" of strategy with environmental factors, the inherent consistency of the strategy or strategies of an organization, as well as the fit of strategy with organizational structure and managerial and operational activities ensures corporate excellence. Achieving an early and future fit or in other words, the forward-looking alignment of strategy, organizational setup, and activities, distinguishes those organizations that ultimately outperform their peers significantly or create entirely new business models and markets. In the context of project portfolio management, strategic fit validates the alignment of projects and programs with organizational strategy and objectives, as highlighted in Figure 6-2.

Figure 6-2: Alignment (PMI, 2008c, p. 9)

The concept of strategic fit finds its application in the pertinent PPM literature both as a portfolio methodology (Koen et al., 2002) as well as a metric (Hauser and Katz, 1998). Although definition of strategic alignment in the sense of strategic fit is well covered in the PPM literature,[54] two other aspects of strategic alignment shall be discussed going forward: the determination of the degree of strategy implementation and the identification of strategy gaps.

6.2.2.2 Determining the Probability of Strategic Success

While strategic fit provides meaningful guidance toward selecting the "right" projects, PPM could deliver further insight toward the probability of strategic success. Artto et al. (2004) define both the alignment of projects with strategy and the evaluation of strategy achievement as the two elements leading to "effectiveness of strategy implementation." Hence, a prediction whether the execution of all projects in the selected portfolio will lead to the realization of the strategy is more than an interesting data point to measure. In the event that the selected portfolio is unlikely to be sufficient for the achievement of strategic success, two options are to be considered: The organization can either provide additional funds and resources for those projects, which were not initially considered for approval, due to funding and resource constraints; or the strategy requires revision as it cannot be realistically implemented. This aspect of alignment is not explicitly addressed in the portfolio management literature but is further discussed as part of Proposition 5.

6.2.2.3 Uncovering Strategic Opportunity

Lastly, the identification of gaps in the strategy constitutes a third aspect of alignment. As discussed earlier, asymmetric knowledge and different perspectives may lead to the articulation (and pursuit) of projects, which implies missed strategic opportunity. In this context, PPM yields significant potential to discover and address such missed opportunity by reviewing strategy from a bottom-up perspective. This is the second aspect of alignment that is not addressed by the PPM literature.

[54] Most authors in the PPM literature use strategic alignment synonymously with strategic fit and do not reflect on other aspects of strategic alignment.

Figure 6-3 summarized the three aspects of strategic alignment and highlights what is discussed in the context of Proposition 5 in the following chapter.

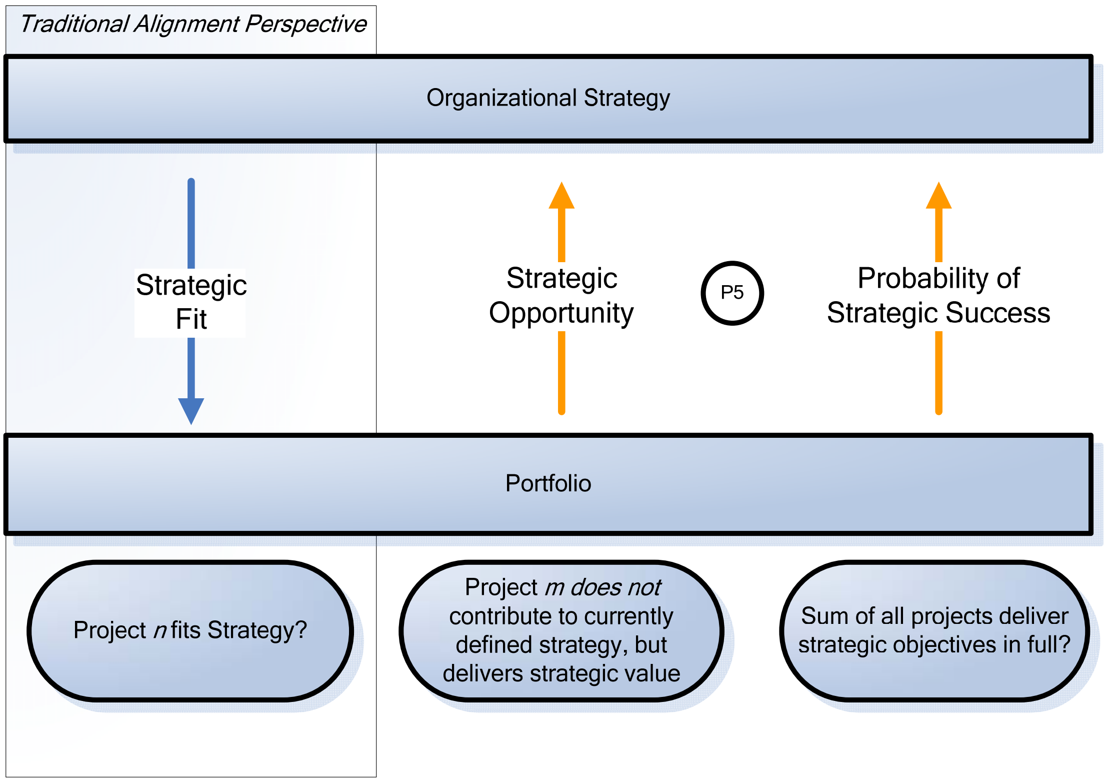

Figure 6-3: Alignment Dimensions – Traditional View and Extension

6.3 Proposition 5 – Reconciliation of Misalignments Between Strategy and Portfolio

As discussed in the immersion section of this chapter and articulated as one of the goals of project portfolio management, the alignment of projects with the strategic objectives of an organization is an essential activity of PPM. As documented in the literature and experienced in practice, the development of a concrete and actionable strategy has been a challenge for many organizations. Although many organizations can articulate a meaningful strategy, implementing this strategy effectively is still a considerable challenge for many. Breene et al. (2007, p. 84) cite a common theme for the disconnect between strategy and execution "…[W]hat we've been doing isn't in line with the company's strategy — and we need to fix that." Project portfolio management can reconcile between strategy and the portfolio of projects, and Proposition 5 attempts this reconciliation.

Proposition 5 – Reconciliation of misalignments between strategy and portfolio
An enhanced definition of portfolio alignment, including the degree of strategy implementation and the actual strategic contribution of projects, allows understanding the degree the strategy implementation that results from PPM and uncovering gaps in the strategy.

PPM creates an important link between strategy and organizational activities, as they are executed through projects. The alignment of the proposed projects with strategy is described in *The Standard for Portfolio Management* Second Edition (pp. 37–42). In this context, PPM organizations validate each portfolio component and assess its "strategic fit" or alignment. While this is important to assure that only those projects with a strategic benefit will be considered for funding and implementation, PPM can provide two more benefits to the strategy execution.

6.3.1 Addressing the Project Gap

Portfolio managers who operate based on a well-articulated strategy will perform a top-down alignment, where individual projects are evaluated based on their strategic merit. In addition, they will validate whether the cumulative benefit of all projects will lead to the accomplishment of a strategic theme. In other words, PPM can help answer the question whether enough is being done to translate strategy into reality. Figure 6-4 illustrates how a project portfolio falls $20 million short of achieving one of the strategic objectives. In this example, the PPM process reveals the project gap between the strategic goals of restoring cost competitiveness and the expected benefit from all projects and programs in the portfolio.

	Strategic Theme	Restore cost competitiveness	Improve product quality significantly	Expand into new geographic market
	Metric	Overhead cost reduction	Reduction of warranty claims	Emerging markets sales
	Goal	$50m	-200	$500m
Project/ Program	Project 1	$5m	0	0
	Project 2	$15m	0	0
	Project 3	0	0	0
	Project 4	0	0	0
	Program 1	$10m	0	$500m
	Program 2	0	-200	0
	Portfolio Total	$30m	-200	$500m
	Project Gap	**$20m**	**0**	**0**

Figure 6-4: Project Gap

As a result, executives must decide to either provide additional funding and resources to achieve the set strategic objectives of the organization—provided project opportunities exist that would close the project gap—or to curtail strategic ambitions. Either way, the portfolio manager can provide a reality check for executives by verifying strategic ambition with benefits that the project portfolio can deliver.

6.3.2 Identifying the Strategy Gap

PPM can provide further meaningful insight for strategic planners and executives. As projects are evaluated for their alignment with strategic objectives, organizations may identify projects that exhibit a solid business case yet do not contribute to any strategic theme. Three scenarios should be considered:

1. The respective project is not viable, as it constitutes a distraction from strategic objectives.

2. Although not in line with strategy, the project is a meaningful "one-off," which does not dilute the strategic focus and should be executed.
3. The project in itself establishes a meaningful addition to the current strategic themes and should be executed.

In the third scenario, a potential strategy gap is identified as a result of the screening of two projects (see Figure 6-5). Although it is not the objective of PPM to actively shape strategy, this bottom-up feedback provides critical input to strategic planning and executive management. In this example, a fourth strategic theme was added by executive management, which further increases portfolio value, and even more so the performance of the organization. This example demonstrates that alignment should be a bi-directional process as a strategy articulated from the top may be enhanced, based on PPM inputs.

	Strategic Theme	Restore cost competitiveness	Improve product quality significantly	Expand into new geographic market	Add a new revenue stream
	Metric	Overhead cost reduction	Reduction of warranty claims	Emerging markets sales	New revenue from service contracts
	Goal	$50m	-200	$500m	**$15m**
Project/ Program	Project 1	$5m	0	0	
	Project 2	$15m	0	0	
	Project 3	0	0	0	$5m
	Project 4	0	0	0	$10m
	Program 1	$10m	0	$500m	
	Program 2	0	-200	0	
	Portfolio Total	**$30m**	**-200**	**$500m**	**$15m**
	Project Gap	**$20m**	**0**	**0**	**0**

Figure 6-5: Strategy Gap

Addressing both project and strategy gap ultimately elevates the importance of PPM in the organization, as executives can better answer the following questions:

- Is the current strategy realistic and attainable?
- Do we need to explore additional opportunities to achieve strategic success?
- Is our strategy valid and complete? What ideas from within the organization should we take into strategic consideration? Are there any strategic trends that have not been visible to the executive level?

If properly executed, project portfolio management can provide relevant bottom-up input to business strategy and create significant motivation in the organization.

6.3.3 Organizational Integration of Strategic Planning and PPM

The elements of project and strategy gap analysis, which provide both a reality check for an articulated organizational strategy and potentially missed strategic opportunity, both drive and require a closer alignment of strategic planning and portfolio management. In this sense, the timing of strategic planning and portfolio management action should be synchronized, and there is mutual benefit in the continuous exchange between strategic planners and portfolio managers, to ensure that strategy is properly understood (top-down alignment) and realistic and cognizant of all opportunities.

6.4 Chapter Summary

This chapter discussed and addressed the portfolio management goal of achieving strategic alignment, which was introduced in Section 2.4, and expanded on the aspect of strategic fit, the traditional top-down perspective in the portfolio management process. Proposition 5, the reconciling of potential misalignments between strategy and portfolio, or portfolio gap analysis introduced the notion of closing both project gaps and strategy gaps. If properly executed, portfolio analysis can elevate portfolio management to an even more valuable partner of strategy execution. As a conclusion of this chapter, Figure 6-6 contextualizes Proposition 5 in the context of the expanded portfolio management framework with all other propositions introduced in this thesis work.

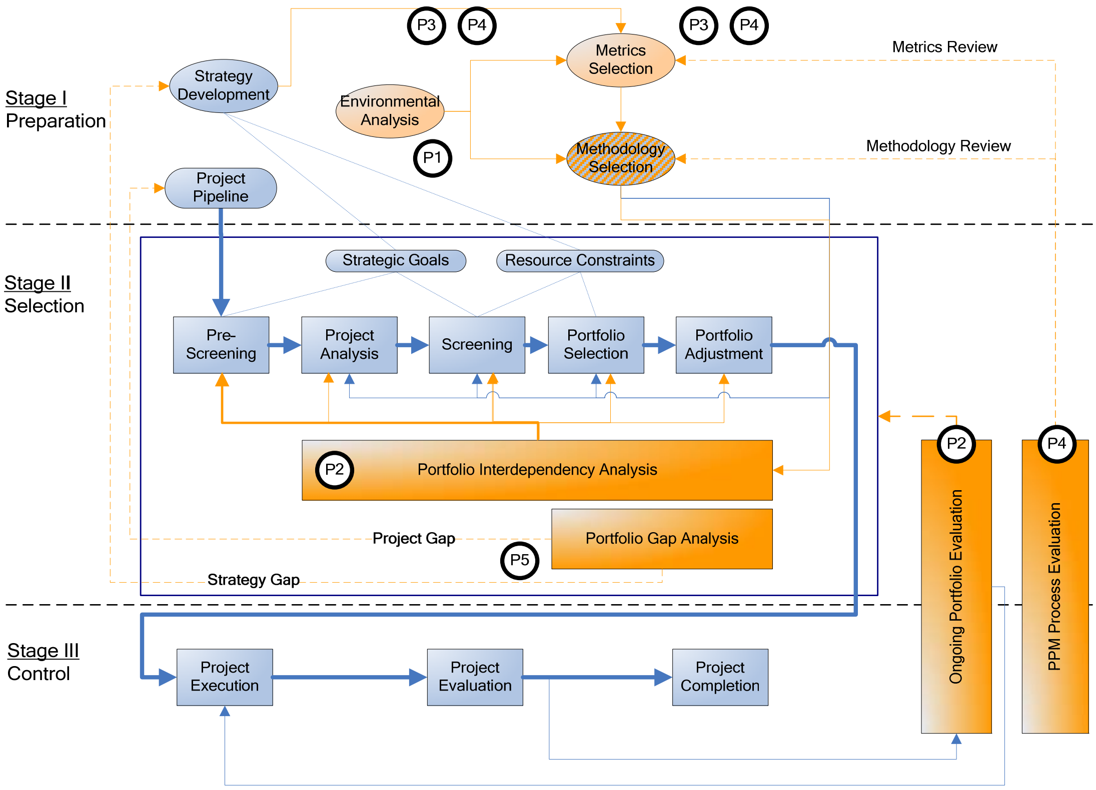

Figure 6-6: PPM Life Cycle with Proposition 5 Enhancements

7. VALIDATION OF PROPOSITIONS

7.1 Chapter Introduction and Objective

This chapter serves the purpose of validating the five propositions introduced in Chapters 1 and 2 and developed in Chapters 3, 4 and 5. Experiment and case study, the two research methodologies used, are explained in detail and findings are discussed in the context of each proposition. The chapter concludes with a summary of the findings.

7.2 Portfolio Selection Experiment

7.2.1 Introduction to the Experimental Validation of Propositions 2, 3 and 5

As elaborated in Section 1.6, the author chose experimentation for the validation of Propositions 2, 3 and 5. Figure 7-1 provides the work breakdown structure of the experiment, including planning + design, testing, experimentation and analysis phases over the course of approximately 3 ½ months. The work breakdown structure elements are further explained in the subsequent chapter.

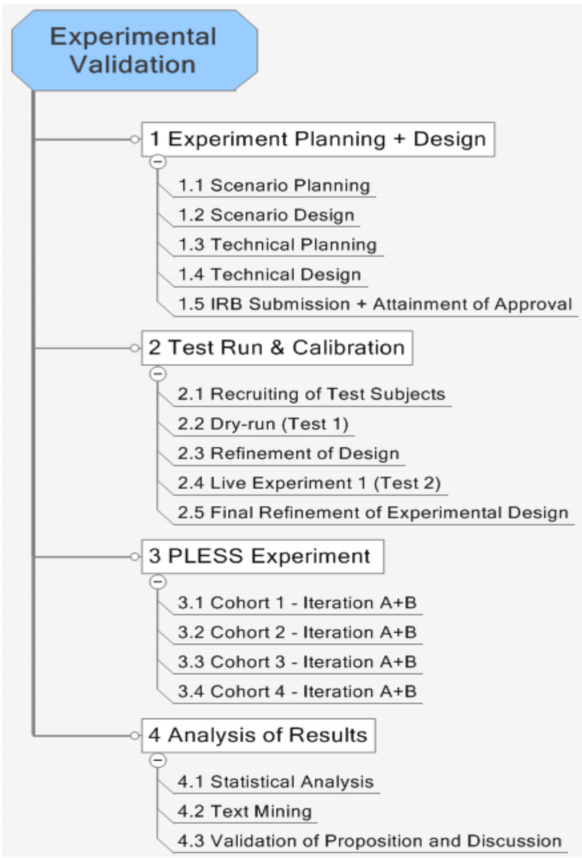

Figure 7-1: WBS for Experimental Validation

The experiment was conducted in the Princeton Laboratory for Experimental Social Science (PLESS) at Princeton University[55], a facility that

[55] I would like to express my gratitude to Dr. Jens Grossklags, Postdoctoral Research Associate, Center for Information Technology Policy at Princeton University and Prof. Adam Finkelstein, Professor, Computer Science, Princeton University for their support of this experiment.

supports research studies in Experimental Economics, Political Science, Experimental Game Theory, and Decision Science. Experiments conducted at PLESS range across many topics of research, including bargaining behavior, voting, and other social science phenomena. The PLESS provides a controlled environment for such experimentation and access to students of Princeton University as test subjects. The students, who predominantly represent computer science and social sciences schools at Princeton University, voluntarily participate and receive small cash rewards for the participation in such experiments. Reward payments were based on the current standards at Princeton University: students received a $20 reward for the participation in the 1-hour experiment, without additional performance reward component.

7.2.2 Experimental Planning and Design

In the planning and design phase, the author decided to use an experimental approach toward proposition validation. The approach had several advantages. A validation would be possible with a large enough audience that would lead to results with statistical significance. Also, all study subjects would face the same problem statement and would have the same boundary conditions for decision making, as to information, tools and time available. In addition, it can be assumed that the maturity of the portfolio decision makers in such an experimental setup would be close to the prevalent “initial” PPM maturity, as discussed in Section 2.7. Furthermore, the recruited participants at Princeton University would most likely exhibit a consistent and high level of intelligence and the cognitive ability to solve decision problems, as long as the candidate portfolio was carefully selected and therefore, decisions would not require in-depth technical or business expertise. Lastly, an experiment would allow gathering results in a relatively short period of time, while a significantly longer time frame would be required for observing an end-to-end portfolio life cycle of one or multiple organizations in practice. For the reasons stated above, the experimental setup required a careful balance between reflecting the real-world complexity of portfolio decision making and cognitive, tool and knowledge limitations.

7.2.2.1 *Scenario Planning & Design*

Iterations A and B were set up to essentially accomplish the same tasks: screening a given portfolio to eliminate three projects and subsequently conducting the selection of the "optimal" portfolio under given constraints. It is important to notice that no information was withheld in Iteration A that would be provided in Iteration B, and no information was changed between the iterations. Because it is self-evident that more information or greater accuracy of information is likely to produce better portfolio selection results, both Iterations "A" had to be given the same quality of information, as discussed in the context of data quality in Section 5.3.1. The author abandoned the initially considered scenario of providing less information content and quality to one of the participant groups (that is, to avoid conveying interdependency information). This, however, would evidently lead to inferior portfolio decisions, and would constitute a self-fulfilling prophecy, even if multiple deterministic scenarios were used. From an experimental perspective, this approach would only be credible if a large number of portfolios would be generated randomly—a scenario that did not deliver any merit beyond proving that a solution becomes more accurate with greater availability of data. Inasmuch as such outcome would not provide any epistemological merit, the approach was abandoned. However, participants were provided with more detailed instructions and additional tooling in Iteration B, in line with the methodology enhancements proposed in Chapters 3, 4, and 5. In the context of the propositions, the scenario planning and design led to four portfolio management tasks to be performed by the participants: (1) portfolio screening, (2) portfolio selection, (3) strategy analysis and (4) reflection on their decision process. These tasks where applied to answer the following questions and provide validation for considered propositions, as displayed in Table 7-1:

Table 7-1: Validation Approach

Proposition and related question	Validation	through Task #
1. Systematic analysis of interdependencies (Proposition 2)		1 and 4
a. Are interdependencies better understood following a process of interdependency analysis?	Measurable convergence of participants towards elimination of the "right projects", as inter-dependencies are better understood.	
b. Does the proposed tooling for	Post-experimental polling results	

	interdependency analysis yield better portfolio decisions?	support the notion of better understanding of interdependencies by the participants of the experiment.	
2.	**Choice of effective metrics (Proposition 3)**		2 and 4
	a. Does a metrics selection process allow participants to make better choices of what metrics to consider and assign the appropriate weight metrics in the decision process?	Measurable convergence towards the metrics that are best aligned with the strategic goals and assignment of appropriate weighting factors for those metrics.	
	b. Will decision outcomes converge toward the optimal portfolio as a result?	Measurable convergence towards a more optimal portfolio selection.	
3.	**Reconciliation of misalignments between strategy and project portfolio (Proposition 5)**		3 and 4
	a. Does the proposed strategy analysis increase the attainability of the portfolio strategy?	Post-experimental polling results for improved understanding of attainability of the strategy	
	b. Will the reconciliation process yield meaningful feedback for executive management and strategic planning?	Recognition of clarity and consistency of the strategy. Recognition of strategy gaps and missed strategic opportunities.	

Implementing the notion of balancing complexity with experimental limitations, the scenario was designed to keep the underlying portfolio easy to understand, but also to avoid oversimplification and decision with outcomes that cause themselves to become true (self-fulfilling prophecies). The portfolio was limited to a manageable choice set of 16 projects. For each project, 15 attributes and metrics were provided, including long-term benefits and cost; short-term benefits, cost and resource needs; project duration; and several additional metrics, relevant to the portfolio decision. These metrics include both short- and long-term ROI, confidence of success, the degree of innovation and the degree of support articulated in committee votes.[56] In addition, Iteration A contained a detailed introduction to the experiment, including problem statement, context and strategy, as well as a concise overview for all projects, including project descriptions, explanation of benefits and additional, and decision-relevant information (see Appendix B).

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[56] Detailed definitions of all business case attributes and metrics are provided in Appendix B, in the context of the participant instructions, and shall not be repeated here.

For purposes of introduction of the experimental design, the underlying case of the experiment, as stated in Appendix B shall be summarized:

- A (hypothetical) company, BMSI, is a software vendor facing two major challenges:
    - Sharp decline in earnings and significant loss in 2009, and no cash reserves
    - Competitive disadvantage due to outdated (software) product
- Consensus-oriented culture, which means projects with only one sponsor have no chance of success
- CEO's strategy consists of three elements: *"First and foremost, restore short-term financial success, secondly, return to developing state-of-the-art solutions and lastly, put the focus back on the customer."*
- 16 candidate projects and limited financial and human resources to implement
- The portfolio management team interpreted and further operationalized the strategy:
    - Achieve at least 10% increase in customer satisfaction rating
    - Scrutinize projects without positive ROI

The portfolio of candidate projects mirrors the sample portfolio introduced in Section 4.4, with the addition of six further items, projects 11 through 16:

Table 7-2: Sample Portfolio with Extensions

ID	Project Name	Description
1	Development Accelerator	Acquire and implement a Computer-Aided Software Design tool to accelerated development.
2	eOrder Application Development	Development of a Web-based order entry application for complex orders of engineering products.
3	eInventory Application Development	Development of a Web-based order entry application for complex orders of engineering products.
4	ePayment Application Development	Development of a Web-based payment processing application for complex orders and terms and conditions.
5	Data Loader Development	Tool necessary to allow for data conversion for legacy customers who want to migrate to e-Application suite.
6	System Integration	Integration of eOrder, eInventory, ePayment into one integrated solution
7	Pilot Implementation	Test implementation of the integrated Web-based applications (Projects 2, 3, 4, 5) with one new customer.
8	Marketing Campaign	Advertize new Web-based application suite to target customers.
9	Agile Development Method & Training	Implement the "Agile" development methodology to accelerate development of software packages.
10	Office Renovation	Complete renovation of the building.
11	Server Update (MANDATORY)	Buy and install new hardware and migrate existing applications.

12	Data Conversion Tool (MANDATORY)	Build additional software "adapters" to allow access to customer data.
13	Fix of current software	Fix errors in existing software product.
14	Enhancement of current software	Enhance existing software to allow for basic Web-based access.
15	Improved software testing method	Implement new software testing tool for early detection of software errors.
16	Engineering Product Exchange	B2B marketplace for engineered product orders: the "eBay for complex engineering products."

The projects were added to construct two investment alternatives for a short-term fix of an existing software product with a more strategic investment into new technology. Multiple projects were required to implement either of the alternative paths, and individuals were confronted with investment trade-offs, such as short-term ROI on the one hand, and degree of innovativeness and long-term ROI on the other. Also, the portfolio was designed to allow only for a limited number of projects to be achieved as a result of both human resource and funding constraints.

7.2.2.2 Technical Planning and Design

The author decided to develop an easy-to-use selection tool that would provide decision-relevant information on the computer standard screens, used in the PLESS, which would allow participants to immediately see the impact of their selection decisions on resource and funds use as well as benefits when selecting or deselecting projects from the portfolio. The author further decided to provide paper-based instructions and response forms to allow the participants to simultaneously read instructions, supporting documentation and decision aides and to make portfolio screening and selection decisions without switching between screens or applications.[57] The portfolio selection tool is exhibited in Figure 7-2 and contains the following major elements:

1. Project name, benefits, cost, resource, time information and other decision-relevant metrics, as previously explained

[57] The tool design was performed with particular attention to ease of use and simplicity, reflecting on the experience of the author with the impact of user interface design on experimental outcomes while collaborating with Siemens Corporate Research’s User Interface Design Center.

2. Selection column (SELECT YES/NO), which triggers the inclusion or exclusion from the portfolio and leads to the calculation of summary values on the bottom of the screen.
3. Rules codified in formulas within the spreadsheet, reflecting on interdependency information provided to the individuals as part of the experimental instructions.[58]
4. Summary values for the currently selected portfolio for both benefits and constraints, highlighting (in red) if constraints were exceeded as a result of the selections made.

General information		Long-term (FY 2011-2015) Benefit and Cost		Short-term (FY 2011) Benefits, Cost and Resource Needs						Minimum Project Duration	Return on investment (ROI)		Confidence of success	Innovation Content	Committee Votes	SELECT YES/NO
ID	Project Name	Return ($)	Total Est. Cost ($)	Return ($)	Cost in FY 2011	Increase in Customer Satisfaction (Score)	Senior Developer	Junior Developer	Services Staff	(Months)	FY 2011 ROI	5-year ROI	Confidence Level	Degree of Innovation	(out of 12)	0=No 1=Yes
1	Development Accelerator	385,000	200,000	320,000	100,000	5%	0.5	1.5	0.0	1	320%	193%	100%	High	3	1
2	eOrder Application Development	5,000,000	2,500,000	250,000	2,000,000	0%	1.0	4.0	0.0	6	13%	200%	60%	High	6	1
3	eInventory Application Development	1,500,000	750,000	75,000	700,000	0%	1.0	3.0	0.0	6	11%	200%	60%	High	6	1
4	ePayment Application Development	1,500,000	600,000	75,000	500,000	0%	1.5	3.0	0.0	6	15%	250%	60%	High	6	1
5	Data Loader Development	300,000	50,000	0	50,000	0%	0.0	2.0	0.0	2	0%	600%	60%	Medium	6	0 1
6	System Integration	0	150,000	0	150,000	0%	0.5	4.5	0.0	4	0%	0%	60%	Medium	6	0
7	Pilot Implementation	0	300,000	0	300,000	0%	1.0	2.0	5.0	3	0%	0%	90%	N/A	4	0
8	Marketing Campaign	0	500,000	0	500,000	0%	0.0	0.0	0.0	6	0%	0%	50%	N/A	12	0
9	Agile Development Method & Training	100,000	150,000	20,000	150,000	0%	1.0	0.0	2.0	1	13%	67%	50%	High	3	0
10	Office Renovation	0	5,000,000	0	1,000,000	0%	0.0	0.0	0.0	18	0%	0%	100%	Low	11	0
11	Server Update (MANDATORY Project)	0	250,000	0	250,000	0%	0.0	0.0	2.0	3	0%	0%	100%	N/A	8	1
12	Data Conversion Tool (MANDATORY Project)	0	100,000	0	100,000	0%	1.0	2.0	0.0	3	0%	0%	100%	N/A	8	1
13	Fix of current software	1,500,000	1,000,000	300,000	1,000,000	15%	2.0	10.0	1.0	6	30%	150%	95%	Low	6	1
14	Enhancement of current software	2,800,000	3,000,000	560,000	3,000,000	0%	3.0	8.0	1.0	6	19%	93%	95%	Low	6	0
15	Improved software testing method	50,000	100,000	0	100,000	5%	1.0	1.0	0.0	2	0%	50%	90%	High	3	0
16	Engineering Product Exchange	10,000,000	500,000	0	500,000	5%	1.0	3.0	2.0	12	0%	2000%	80%	High	1	1
	Constraints				4,500,000		8.0	25.0	10.0							
	Sum	19,500,000		1,020,000	5,150,000		8.0	26.5	5.0							

Figure 7-2: Portfolio Selection Tool [59]

[58] Although the formulas were not visible in the tool itself, all information was shared with the participants in the instructions and no information was withheld.

[59] This figure serves the purpose of illustrating the tool. A more legible version of the content can be found in Appendix B, Exhibit 1.

7.2.2.3 IRB Submission and Attainment of Approval

The ethics-related aspects concerning this experiment have been discussed in Section 3.5. Ethics application and the required certificates can be found in Appendix C.

7.2.2.4 Test Run and Calibration

Two test runs were performed in order to correct potential errors in the tooling and instructions, provide additional explanations and clarification where needed and refine the user interface of the tool. Two test subjects tested Version 1 and provided both initial data and feedback on experimental setup and the materials provided, which led to a refined Version 2. After the validation of Version 1 was completed, individuals were recruited with the help of the PLESS Online Scheduler for a total of five experimental sessions, in order to allow gathering data points from 70 participants. The first of these five sessions ran the experiment based on Version 2 at the PLESS with a smaller initial group of 12 students, followed by an interim analysis of data and minor final refinements to both tooling and instructions, which led to the final Version 3 for the remainder of the participants.[60]

7.2.2.5 PLESS Experiment

The experiment was conducted as previously explained and the supporting detail in Appendices B and C with four cohorts of participants, providing a total of 65 sets of data at the conclusion of the experiment, as a result of the elimination of five invalid data sets. Data analysis and discussion of findings can be found in Sections 7.2.3, 7.2.4 and 7.2.5.

7.2.2.6 Statistical Analysis

The analysis phase of the experiment consisted of statistical analysis, mining of the textual comments provided by the participants and the interpretation of the results in light

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[60] For example, the consequences of exceeding available constraints were highlighted in both tool and instructions, because five participants made portfolio selections, which exceeded the available funds and resources. The data sets from these five individuals were discarded, as they would not be comparable with the other data. As none of the key data or instructions was changed, the data from 7 of the 12 individuals of the first cohort could be used.

of the propositions and questions elaborated in Section 7.2.2. The following Section will discuss analysis steps, findings and conclusions in detail.

7.2.3 Analysis of Experimental Outcomes – Screening

Several statistical analyses are used to validate whether and to what degree the systematic analysis of portfolio interdependencies improved the understanding of portfolio complexity and improved portfolio decisions. For this purpose, a first look shall be taken at the results from the screening exercise in both iterations. Based on the problem statement (see Appendix B), individuals had to exclude three projects in the screening step, which would not be considered for further inclusion in the portfolio. Figure 7-3 visualizes what projects (projects #1 through #16 displayed on the X axis) were eliminated in the screening step and how often (number of individuals on Y axis). For example, project #8 was eliminated by 13 individuals in Iteration A and 58 in B.

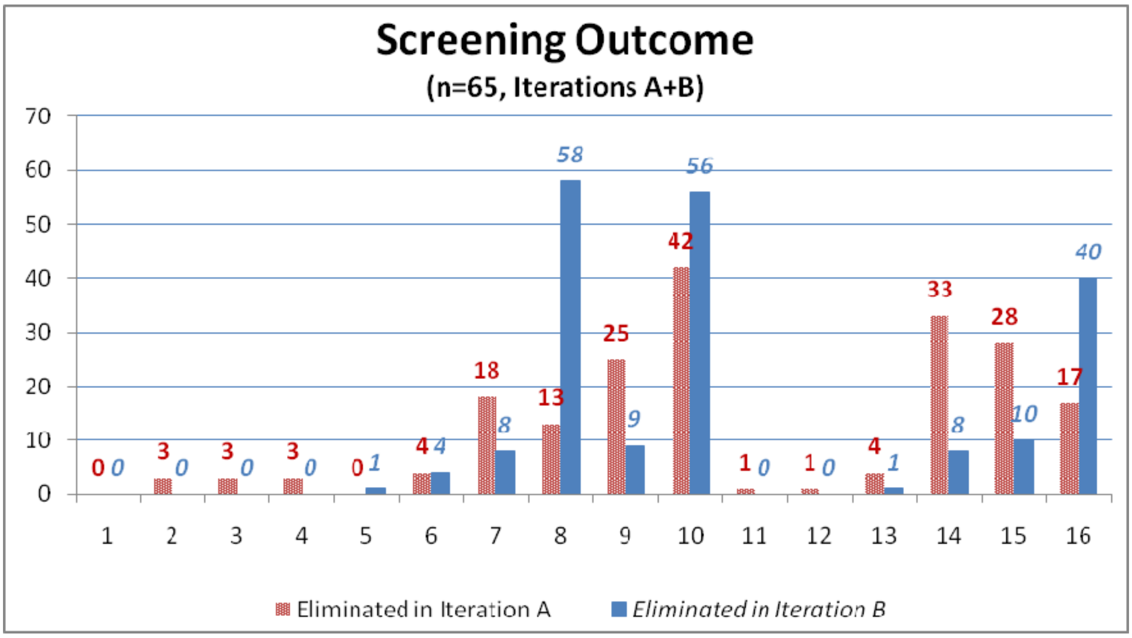

Figure 7-3: Screening Results for Iterations A and B

It becomes apparent that individuals significantly changed their decisions of what projects to exclude from Iteration A to Iteration B and the following can be observed:

Finding #1: Improved accuracy, by recognizing non-critical and not feasible projects

- In Iteration B, 89% of individuals (20% in Iteration A) eliminated project 8 (marketing campaign), which is not feasible in the described timeframe
- 86% of individuals eliminate project 10 (office renovation) in Iteration B (65% in Iteration A), as it is recognized as a non-critical project.
- In Iteration B, 62% of individuals (26% in Iteration A) eliminated project 16 (engineering exchange) for several reasons (see comments under Finding #4).

Finding #2: Greater logical consistency of choices, due to recognition of dependencies

- Projects 2, 3, 4, 5, and 13 were recognized as precursors for the two alternatives to either continue the pursuit of the legacy software development or to embark on the development of a new product generation. As a result, these projects where eliminated by much fewer individuals.

Finding #3: Structured process reduces errors

- Few individuals eliminated projects 2, 3, 4, 5 and 13 after the execution of the interdependency analysis in Iteration B, with solely two exceptions (as illustrated in the above figure, one individual excluded project 5 and one other individual excluded project 13).
- The one individual who selected to eliminate Projects 11 and 12 in Iteration A did not eliminate these projects in Iteration B and stated in the commentary section, "I noticed my mistake from Iteration A after following step-by-step instructions in this iteration."

A closer look at the dispersion of outcomes, as discussed before, already indicates a much greater consensus among individuals on what projects to eliminate after Iteration B. A second validation of what triplets [p_1, p_2, p_3] of projects have been eliminated confirms this observation: Out of 364 possible combinations[61], individuals made 32 choices of projects [p_1, p_2, p_3] in Iteration A and 19 choice sets in Iterations B for elimination, converging toward the expected outcome that projects 8 and 10 as well as projects 16 or 9 or 15 would be eliminated. As explained before, more than one choice set was feasible and rational, and individuals made their conscious choice based on a set of metrics as well as their individual reasoning, as both their choices and comments revealed. As illustrated in Figure 7-4, a convergence toward the choice set [8, 10, 16], which represents the least desirable projects, could be observed (**Finding #4**), as 26 individuals commented on project 16 as resource-intensive while not contributing the short-term

[61] For 14 projects (n=14) that are potential candidates for the elimination – discounting the two mandatory projects 11 and 12, which should not be eliminated – three projects (k=3) are to be eliminated, which leads to C $\binom{n}{k}$ 364 combinations that are theoretically possible.

revenue objective. Thirteen individuals pointed out that that they eliminated project 16, due to the fact that only one committee member voted for the project and the problem statement emphasized that due to the consensus culture "single-sponsor projects never succeed."

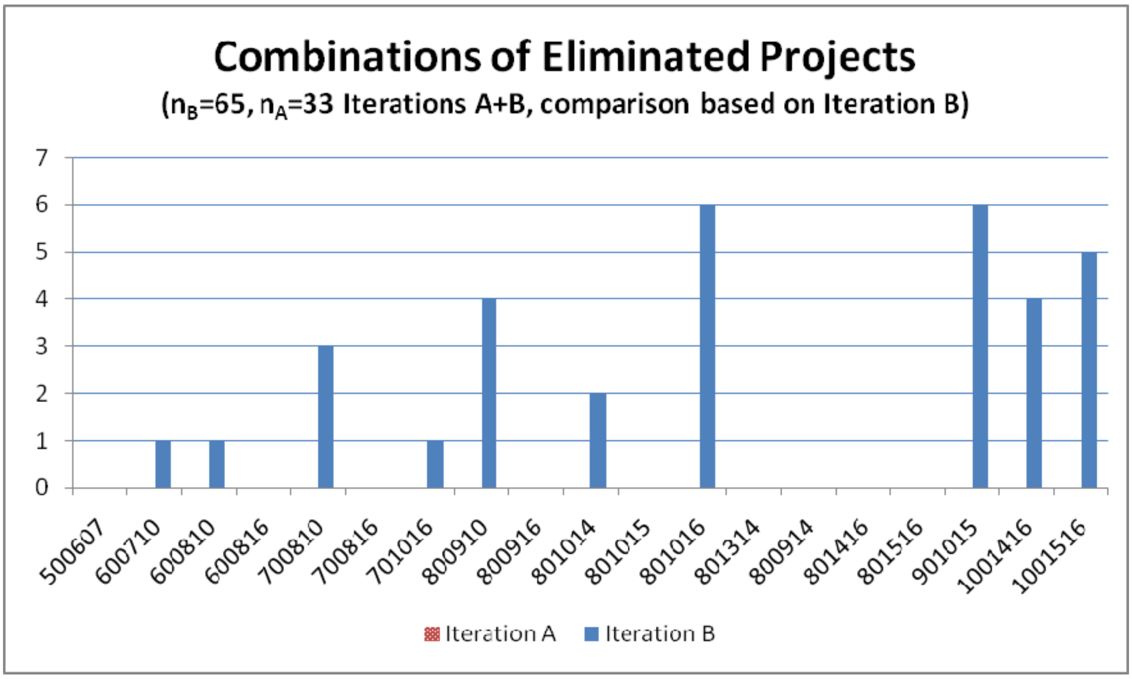

Figure 7-4: Screening Outcome – Combination of Eliminated Projects

In addition to the evidence discussed before, the reflection section of the experiments provides insight into the perception by individuals to what degree the model extension for systematic interdependency analysis impacts decisions and outcomes. As participants of the experiment were asked to perform a post-mortem comparison of the screening exercise in both iterations, and especially the effectiveness of the interdependency analysis, Figure 7-5 visualizes that the vast majority of the participants agrees or somewhat agrees (63%) with the notion that the interdependency analysis helped understanding the time, benefits and outcome interdependencies and, as a result, led to greater confidence in eliminating the "right" projects (53%) (**Finding #5**).

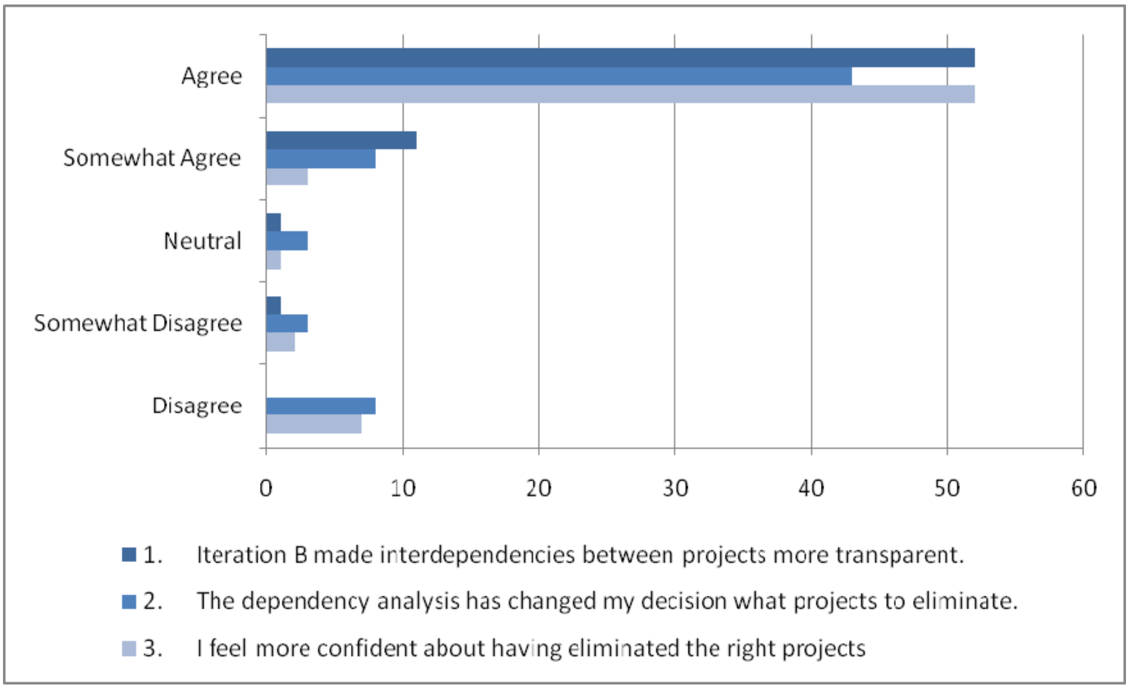

Figure 7-5: Reflection on Interdependency Analysis

A closer look at the small number of participants who disagreed with the effectiveness of the interdependency analysis revealed that these individuals mostly did not change their screening choices from Iteration A to Iteration B, as they already gained an adequate understanding of interdependencies from the textual description. Although the degree of complexity was sufficient to experience cognitive challenges in Iteration A for most participants, some individuals fully grasped the interdependencies in the first iteration, which can be explained with familiarity with similar optimization problems, that is, in economics or above-average cognitive capabilities.[62]

[62] While the author did not keep a full record of completion time for all individuals, it was observed that some individuals completed the experiment in approximately 35 minutes with optimal portfolio outcomes, whereas the median participant required used slightly more than 50 minutes to complete the experiment with less than optimal outcomes. These "outlier" in the distribution of participants were to be expected and can be explained with variance in experience and cognitive abilities. Given the audience of Princeton University students, exceptionally capable individuals were to be expected.

The above findings #1 through 5, and especially the convergence of screening decisions toward the expected and rationally founded outcomes in Iteration B and the reflective feedback by the participants strongly support the validity of Proposition 2.

7.2.4 Analysis of Experimental Outcomes – Selection

The second proposition to be validated through the experiment, the choice of effective metrics and its impact on portfolio decisions, was supported by Task 2 of the experiment. Individuals were asked to walk through a multi-step process, to select and prioritize metrics consciously and subsequently to make their portfolio selections. The experimental step once again looked at what metrics were chosen and how they were weighted by the individuals and what portfolios were selected, based on the selected metrics and assigned weights. Lastly, individuals were asked to reflect on the experience, similar to Task 1. The outcome of the task is summarized in the following table, that provides arithmetic means ($\bar{x}$), standard deviation (σ) and rank of the metrics choice set (R) for each iteration. The ordinal rankings for the metrics were translated into numerical ranks in order to compute basic descriptive statistics for the datasets.[63]

Table 7-3: Metrics Prioritization

	Iteration A		**Iteration B**				
	$\bar{x}$	σ	$\bar{x}$	σ	**R (A)**		**R (B)**
Confidence	**1.86**	0.81	**1.32**	0.92	**3**	⇒	6
5yr ROI	**2.43**	0.81	**1.66**	1.05	**1**	⇒	4
Votes	**1.37**	0.94	**1.42**	1.00	5	⇒	5
1yr ROI	**2.25**	0.83	**2.72**	0.60	**2**	⇒	**1**
Innovation	**1.31**	0.95	**1.98**	0.94	6	⇒	**2**
Customer	**1.53**	0.89	**1.75**	0.98	4	⇒	**3**

Two observations become apparent. First, ranks and weights changed significantly between iterations, as can be seen in Table 7-3. Second, the outcome after Iteration B is

[63] The following conversion factors were used: high = 3, medium = 2, low = 1, none = 0

in line with the expectations of the design of the experiment: 1-year ROI ranks highest, followed by innovation and customer satisfaction (**Finding #6**). However, the data showed—except for the relatively close band for 1-year ROI data—a rather large standard deviation for all other metrics, as visualized in Figure 7-6.

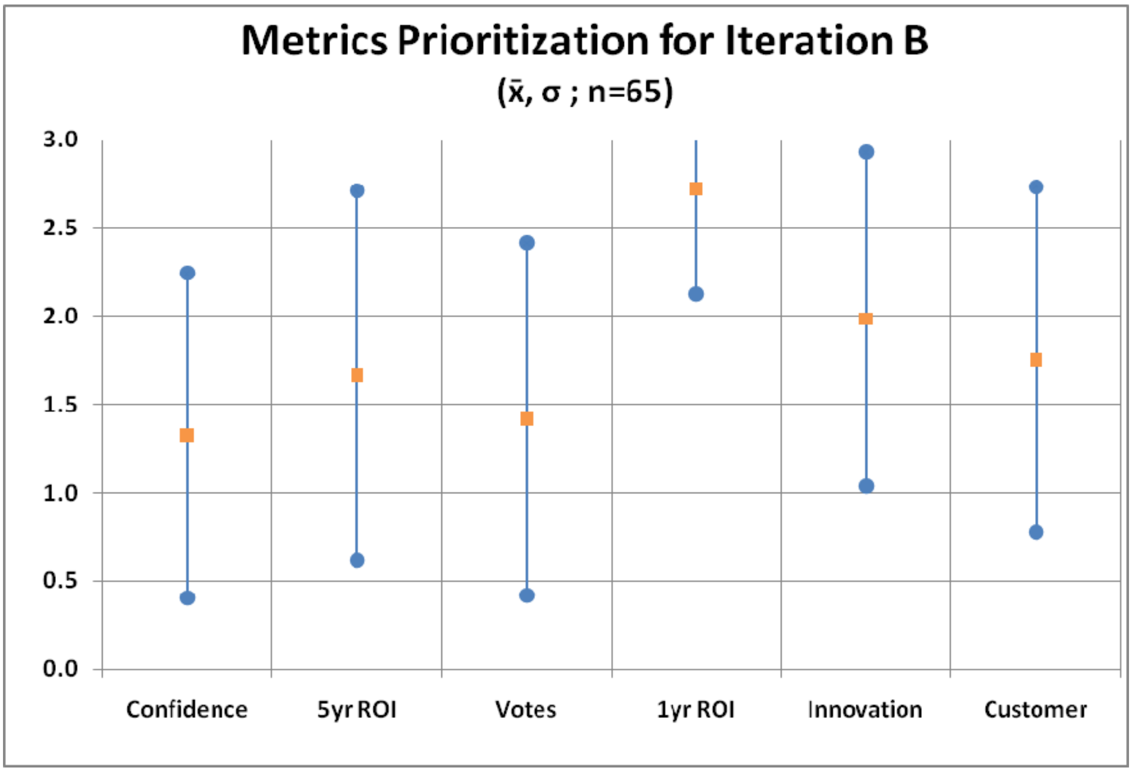

Figure 7-6: Prioritized Metrics for Iteration B

One explanation for this variance of opinions can be found in the experimental setup, which could have been improved by requesting the individuals to rank the metrics by weight in the decision rather than using ordinal metrics. In retrospective, more guidance could have been provided here and the originally envisioned pair-wise comparison ranking of metrics weights would have likely yielded better results, but was dropped due to time boundaries for the experiment and complexity concerns. The fact remains, however, that there was a clear shift toward strategic priorities in the second iteration, which can be attributed to the systematic metrics selection.

This shift toward strategic priorities is consequently translated into choices of portfolios, which are more closely aligned with strategic priorities. As figures Figure 7-7 and Figure 7-8 illustrate, between Iterations A and B results converged toward higher 1-year ROI, with the average 1-year portfolio ROI changing from $731,538 to $831,077, a 13.6% increase. The greater dispersion of results for Iteration A could be expected after reviewing the previously discussed metrics prioritization.

Figure 7-7 confirms another interesting aspect of portfolio decisions, that is, the notion of unintended consequences. Although the participants of the experiment gave innovation the lowest priority in their comparison of metrics in Iteration A, a cluster of high-innovation portfolios could be observed at the same time. Whereas seven individuals already had assigned the innovation score as a “high” weight in their portfolio selection decision, an even larger number ended up in the top quadrants for innovation, simply by accident.

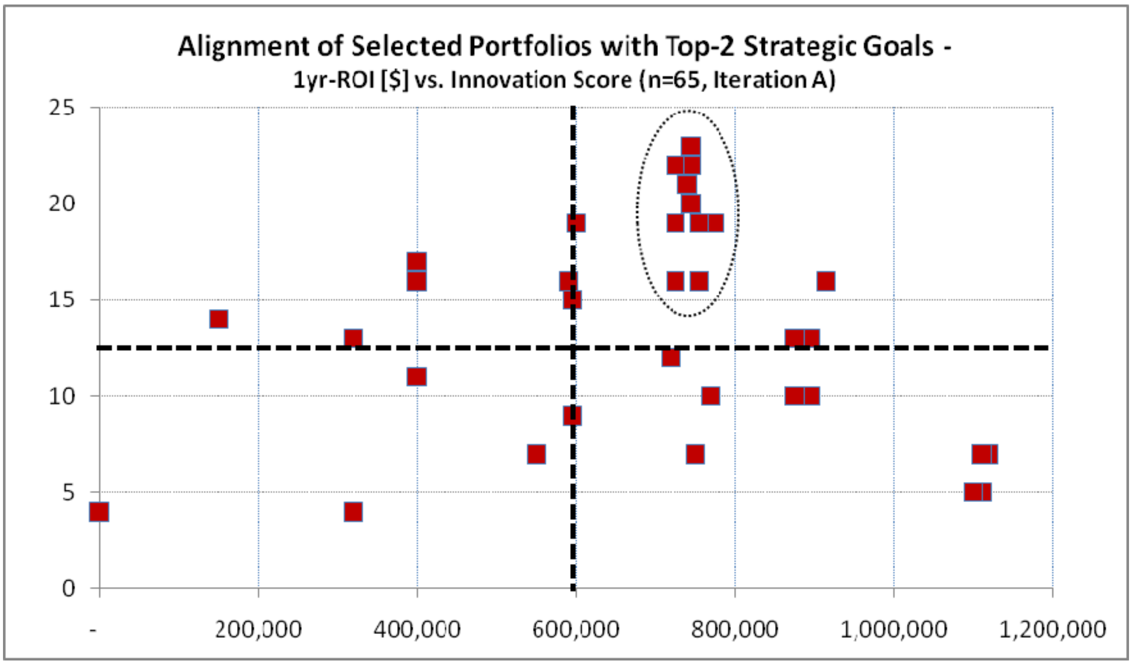

Figure 7-7: Alignment of Selection Outcomes with Strategic Goals – Iteration A

Figure 7-8 makes a strong case for a systematic and conscious metrics selection (even in this much abbreviated format used in the experiment), as a clear convergence towards strategically aligned portfolios with high 1-year ROI’s and innovative character can be observed (**Finding #7**).

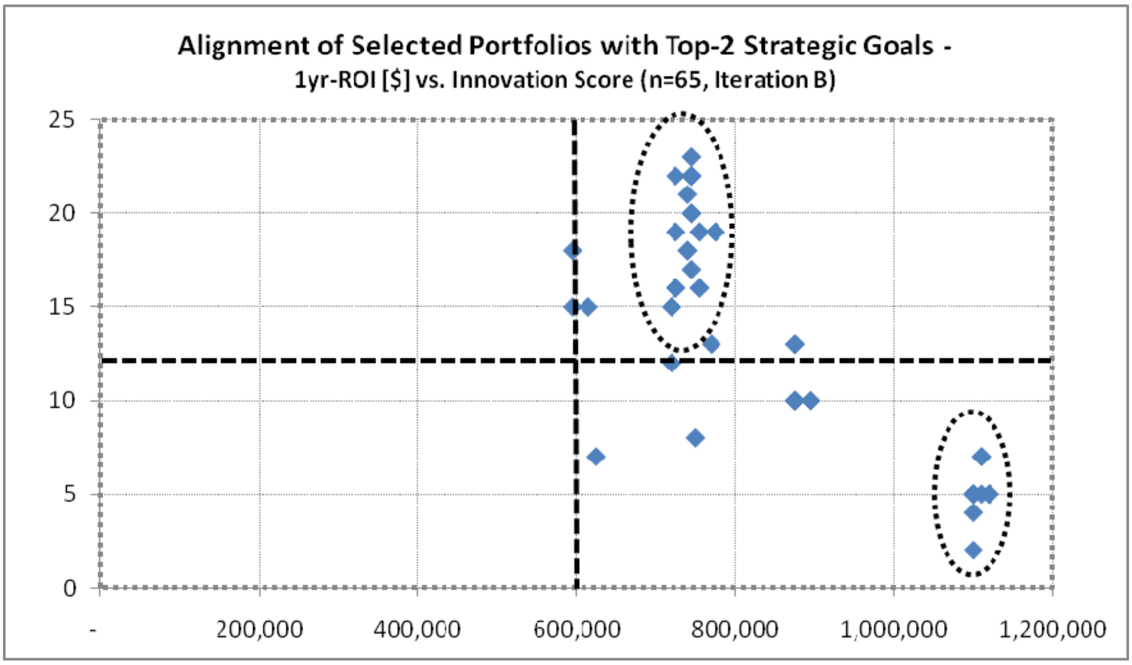

Figure 7-8: Alignment of Selection Outcomes with Strategic Goals – Iteration B

Also, the reflection questions confirmed that the refined approach increased participant confidence about the choice of metrics and the portfolio (see Figure 7-9; **Finding #8**).

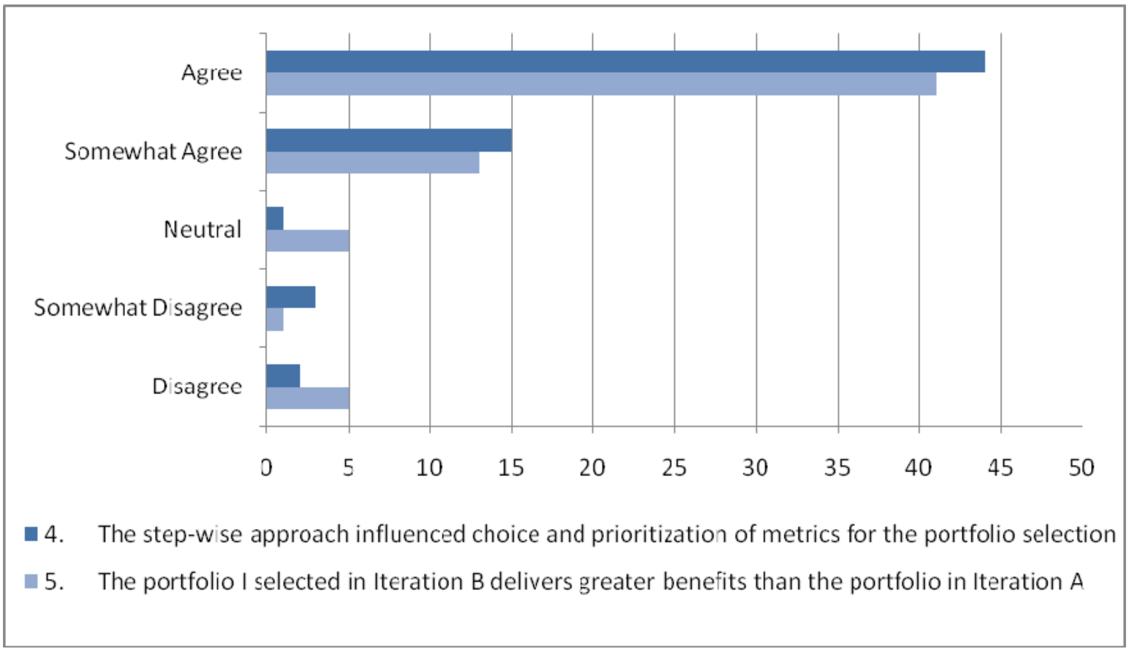

Figure 7-9: Reflection on Metrics Choice and Portfolio Selection

Findings #6 though 8, and namely the improved consistency, alignment of metrics choices and the resulting improved portfolio selection, as well as the reflective feedback from the participants, provide ample support for Proposition 3.

7.2.5 Analysis of Experimental Outcomes – Strategy Reconciliation

The final task, performed in Iteration B, related to strategic judgment and feedback. Some quantitative feedback shall be provided, followed by the text analysis and interpretation.

First, most of the participants were asked about the clarity of the strategy. Data points in this regard are difficult to judge, given the varying frame of reference of the individuals and that it is fair to make the assumption that most of the participants of the experiment have had limited exposure to corporate strategy. More than two-thirds of the participants considered the strategy to be clear, whereas the author would have suggested otherwise. Although strategic objectives and their priorities were articulated, targets were not set for all strategic aspects, which would have improved the odds for identifying project gaps in the context of the portfolio selection process.

Table 7-4: Strategy Analysis

	Agree	**Disagree**	**Not sure**
The strategy is clearly articulated.	46	14	5
The strategy is consistent in its objectives.	21	31	13
Achieving 1-yr. return of $1.2M is feasible with given resources.	0	41	24

It is interesting to notice that less than one-third of the participants considered the strategy consistent. Numerous text comments pointed in the direction of the inconsistencies: 14 participants recognized a trade-off between the focus on short-term ROI and innovation; and 4 participants also “challenged” the CEO to help make those projects successful that do not have the required committee votes.

Most participants also recognized that a return of $1.2 million in year 1 would not be feasible, a meaningful feedback, and commented that additional funds would need to be provided in order to achieve that level.

When taking a look at the attainability of the strategy, Iteration B led to a different picture than Iteration A: after the more structured analysis of Iteration B, more participants disagreed than agreed with the statement "the strategy appears to be attainable"—an important reality check to be conveyed to the CEO (**Finding #9**).

Table 7-5: Attainability of Strategy

The strategy appears to be attainable	Agree	Disagree	Not sure
Iteration A	37	9	19
Iteration B	19	26	20

The final question in Task 3 required the participants to share which additional project or projects they would have pursued if constraints were less stringent. The following five projects gained significant support:

Table 7-6: Wish List for Additional Projects

ID	Project	Number of picks
16	Engineering Product Exchange	22
13	Fix of current software	21
8	Marketing Campaign	15
10	Office Renovation	11
3	eInventory Application Development	10

The frequent selection of Project 16 can be interpreted as an explicit strategy gap (**Finding #10**). One individual wrote as feedback to the CEO to "make project 16 part of your strategy and provide extra money." Most other choices were motivated by greater ROI or innovation through the provision of additional funds and resources (projects13, 8 and 3). However, project 10, the office renovation, unexpectedly made the list, and participants annotated an increase in employee morale as their motive—completely decoupled from the organizational situation and strategic statement. Project 10 delivers a great example for the bounded rationality discussed in the context of decision theory.

Lastly, in response to the final reflection question, 78.5% of individuals recognized an improved alignment of their portfolios with the articulated strategy[64] (**Finding #11**).

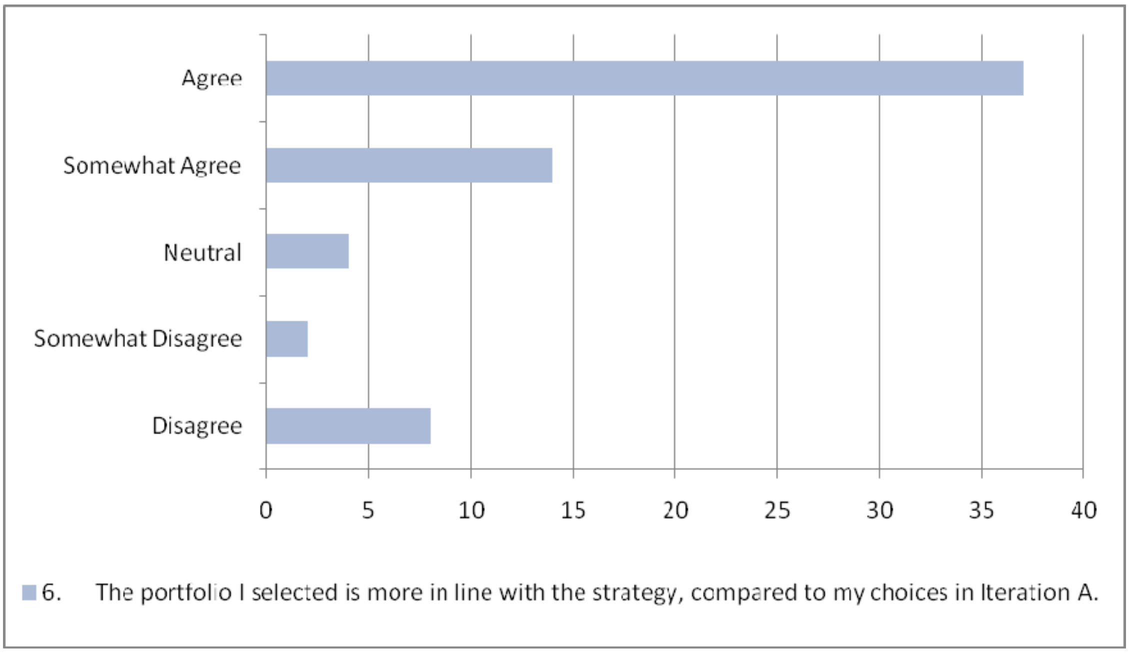

Figure 7-10: Reflection on Strategy Implementation

From an epistemological point of view, the quantitative and qualitative evidence from the experiment appears to substantiate Proposition 5 as being reasonable and likely to be true, as supported by Findings #9 through 11.

7.3 Client Case Study

This case study focuses on a subset of the broader efforts of the organization and is focused on the choice of method selection (Proposition 1), as well as the selection and application of process metrics (Proposition 4). The case study is first introduced and explained and is followed by the interpretation of results and discussion.

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[64] When data of the eight respondents who disagreed with that statement was reviewed, this small group of participants already had exhibited portfolios with high 1-year return and a high degree of innovation in Iteration A and only marginally adjusted and improved outcomes.

7.3.1 Case Study Introduction

As outlined in Section 1.6, the author decided to validate Propositions 1 and 4 through a case study, resulting from significant work with a client in 2009 and 2010. The subject of the case study, one of the largest retailers in North America, decided in 2008 to establish a formal project portfolio management process for all business projects with significant information technology (IT) content. Most of 2009 was used for the necessary preparatory activities: establishing the required governance, defining the portfolio management life cycle and preparing PPM stakeholders to execute it, as well as capturing all required data, beginning with a formal business case process for all candidate projects. To properly manage business projects with significant IT content, the company decided to establish a portfolio board, representing all business units and Corporate IT and tasked to champion the end-to-end PPM life cycle. In recognition of the low PPM maturity of the organization, it was decided to focus on activities that would lead to a standardized[65] process.

The author had been serving the organization as an advisor and had been providing inputs and recommendations toward establishing the governance process, specifics of the selection methodology and metrics to be used for the project selection, adopting both generally accepted PPM practices, as well as new and enhanced concepts, which have been brought forward in the proposition of this thesis.

One of the initial efforts to consciously drive organizational portfolio management was to articulate clear objectives and rules of engagements for PPM in the organization. For this very purpose, a charter was drafted, discussed through a number of iterations and agreed upon by critical stakeholders of the PPM process.

The following constitutes an abstract from the charter and provides the context of the discussion of methodology and metrics selection.

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[65] The term "standardized" refers to the aspiration of the first attainable maturity stage for the organization, as per the nomenclature of the *Organizational Project Management Maturity Model* discussed in Chapter 2.

Table 7-7: Portfolio Board Mission and Guiding Principles

The mission of the Portfolio Board is to:

- *Improve the decision making process for business technology projects and to approve and fund those projects which best enable the strategic business objectives of the company.*
- *Monitor and control the business technology project portfolio to ensure a high success rate in realizing the scope of the projects on time and within budget.*

The Board has been established to champion the project portfolio management process, including business case review, project prioritization and selection of business technology projects in the context of the annual fiscal year project planning cycle and throughout the Fiscal Year. In this context, the Board performs the following tasks:

- *Recommend top strategic projects to the Executive Level for approval and funding,*
- *Determine what planned and unplanned business technology projects get approved throughout the fiscal year,*
- *Provide leadership and counsel to IT for business technology project priorities for the entire company,*
- *Monitor and manage the project portfolio performance. Review and react to results from project reviews and the impact of plan deviations on the project portfolio throughout the Fiscal Year,*
- *Obtain and maintain knowledge and educate others about business strategic needs and the required information technology to meet the Company's strategic goals and objectives.*

The guiding principles for the charter of the Board are:

- *Decisions are made based on well-defined criteria and backed by business cases with credible financial and non-financial metrics and a linkage to strategic objectives.*
- *Each project is objectively decided upon based on its own merits and contribution to the overall business.*
- *Needs for directional and/or funding changes are detected early in the control process and decisions to initiate, accelerate, defer, redirect or cancel projects are made faster.*

From the perspective of an advisor and coach to the organization, three important change management objectives were identified and needed to be addressed to implement the charter successfully:

- **Achieve portfolio transparency** and oversight of *all p*rojects in scope, from the proposal stage through execution and close-out,
- **Drive toward consistency** in the handling of candidate projects, and ultimately the selection of the portfolio,
- **Set realistic expectations** in light of the current organizational environment, recognizing existing capabilities, tools, organizational buy-in (and resistance to greater transparency, as well as change in approach), and data availability and quality, which would not permit the immediate pursuit of the "best practice" solution from a theoretical point of view.

The case study is developed further in 7.3.2 and 7.3.3, with the ultimate purpose of discussing and substantiating Proposition 1, the systematic choice of project selection methods, and Proposition 3, the use of process metrics to determine and drive PPM maturity.

7.3.2 Systematic Choice of Project Selection Methods

In the context of this case study, the systematic method selection shall be validated for project screening, prioritization and selection phases. In light of the stated mission to "improve the decision process for business technology projects," significant efforts were made in defining the portfolio selection methods, suitable for the current maturity and environmental context of the organization. The following sections provide the systematic steps for establishing the appropriate methods for portfolio screening, prioritization and selection[66], in line with the five-step process flow proposed in Section 4.3.1. These steps cover (I) Validation of Phase Entry Criteria, (II) Environmental Analysis, (III) Method Selection & Specification, (IV) Method Application and (V) Reflection. In the application of these five steps performed for the aforementioned life cycle phases, particular emphasis is given to Step (V) Reflection: findings documented in the reflection step resulted from both observations throughout the PPM implementation efforts and post-mortem interviews conducted with the portfolio manager.

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[66] A pre-screening step is being performed, at least for now, within the business units and can be described as somewhat heuristic; clear criteria and uniform thresholds have not been established yet.

7.3.2.1 Screening

As part of the screening process, the number of projects to be considered for the later selection needed to be significantly reduced in order to arrive at a manageable choice set. In addition, mandatory projects needed to be identified as such; and interdependencies that were revealed in the business cases needed be revisited and updated, from a portfolio perspective. The following illustrates the considerations and decisions made, in the context of the decision process established in Chapter 3.

<u>Step I – Validation of Phase Entry Criteria</u>

1. Are the objectives of the phase clearly articulated and understood?

The purpose of the phase was to eliminate those projects that do not meet the screening criteria for the submission of project proposals, as explained below. Furthermore, projects that are mandatory were to be earmarked as such. The screening phase also served the purpose of quality assurance for the plausibility and consistency of business case data used for further consideration in the portfolio selection.

2. Are criteria and corresponding thresholds defined?

At this initial stage, the organization decided to establish three screening criteria:

(1) Exclude candidate projects with incomplete information.
Threshold: Projects that do not deliver a completed Quick Business Case and that have been formally approved

(2) Earmark mandatory projects
Thresholds:
1 - Projects that implement regulatory mandates
2 - Projects that are submitted by the executive management as “strategic initiatives”

(3) Annotate interdependencies between projects

3. Does the data quality meet the requirements for decision making?

The organization had established a format for the Quick Business Case to assure completeness and plausibility of data. Business cases were to be completed by assigned business analysts in the business units, with support of central IT and reviewed by an assigned business unit executive. Furthermore, a validation and sign-off by a business unit manager was required for the proceeding to the next phase.

4. Are suitable methods identified to achieve the phase objectives?

Four methods were identified to achieve the phase objective, as stated in I.1:

1. Quick business case template, mandatory for all submitted candidate projects
2. Quick business case sign-off by business unit executive
3. Initial quality assurance review by portfolio manager
4. Capture of cross-project interdependencies, as interpreted from the business cases and validated by the members of the portfolio board.

<u>Step II – Environmental Analysis</u>

1. What methods are likely to be organizationally accepted?

Cultural acceptance and compatibility with decision culture was given significant consideration. This applied both to the choice of the selection methods and the selection of metrics, which are part of the selection methods. A “balanced” and focused set of decision-relevant metrics was defined, taking into account the trade-off between comprehensiveness of information and the anticipated resistance of the business units to change. Such resistance was expected, as the request for compliance with this new process required unprecedented commitments, disclosure of information and the dedication of time and effort toward completing business cases.

In this context, it was decided to avoid requesting complex multi-period financial metrics, such as NPV and IRR that would reach beyond the “initial” maturity of the organization and had not been customary in use in the organization. Although this omission would inevitably lead to sub-optimal portfolio allocations from a theoretical perspective, the disadvantages of enforcing the collection of multi-period financial metrics would have exceeded the benefits from doing so: Most likely few analysts would have provided the requested data, even less in the required time frame and quality; and lastly it was recognized that more comprehensive requirements could have jeopardized the overarching goal of organizational adoption of the new business case process.

2. What methods are adequate at the current maturity stage?

Business case composition and review, with limitation in the context of a "Quick" Business Case and plausibility check.

Step III – Method Selection and Specification

1. Quick Business Case

An annual process for capturing business cases for all proposed projects that contained the following attributes was put in place:

- General project request information – clearly articulated description of the nature of project, expected results, time frame, and processes/functions impacted
- Consequence of non-action – impact on the business, if a project request is not implemented, providing opportunity cost and revealing mandatory projects as such)
- Detailed benefits description, as tangible or intangible, for pre-defined benefits types
- Alignment with strategy, as a qualitative statement (alignment with one or multiple strategic themes)
- Quantitative and qualitative metrics
    - Benefits type (for example, cost avoidance), amount (captured as cumulative benefit for the lifespan of the project rather than broken out by fiscal year, calculation)
    - Cost (labor, infrastructure and other cost to the organization, at this point captured as cumulative cost for the lifespan of the project rather than broken out by fiscal year)
    - Benefits Score, based on pre-defined thresholds and criteria
    - Risk Score, based on pre-defined thresholds and criteria
    - Strategic Alignment Score, based on pre-defined thresholds and criteria

2. **Multi-step Review of the Quick Business Case by—**
   - Assigned manager in the business unit, to perform initial validation of proposal, including the associated qualitative attributes and quantitative metrics
   - Portfolio Manager, to verify and validate completeness of business case information
   - Portfolio Board members, to provide validity from the perspective of a cross-organizational context.

Step IV – Application

The method described in Step III, was executed following the PPM implementation plan, as follows:

1. Initial compilation of business cases, and coaching of business analysts by the PMO and Portfolio Manager in the use of the new Quick Business Case format and related requirements (August 2009)
2. Quick Business Case review and approval by designated business unit manager (September 2009)
3. Follow-up review by the Portfolio Manager and feedback to business analyst, resulting in adjustments and corrections, as needed (September 2009)
4. Individual business case review by each Board member and Board workshop (including training session) to address concerns and questions raised for projects within the portfolio (September-October 2009)
5. Process step complete (October 2009)

Step V – Reflection

Step I: The approach taken has helped to reduce the choice set for the selection, as originally intended. In retrospective, it is evident that too many business cases are accepted (an indication for a greater focus on pre-screening activities) and still too many projects "survive" the screening phase. Thresholds for elimination, which did not exist beyond business case completeness, will be revisited.

Post-process reviews (after the screening process, as well as later in the PPM process) have led to the conclusion that several projects that were labeled “mandatory” did not meet the respective criteria for mandatory projects or mandates could have been implemented in different (that is, more cost-effective) ways. Although the identified methods have proved to be effective and efficient, thresholds require further refinement and calibration. The key objectives of comprehensive business case data in vastly improved quality were achieved, despite the remaining room for improvement.

Step II: Assumptions made in the environmental analysis were widely accurate. Although significant attention was given to communication and training as a result of the identified needs, it became evident that even greater efforts in this regard would have been needed. Some of the metrics identified, especially alignment information, though greatly desired, could not be effectively gathered due to lacking buy-in and the ability to execute on the accurate determination of strategic alignment.

Steps III and IV: The choice set of information for business case data has proved to be widely suitable for the purpose and the organizational context. However, some metrics will be eliminated from the business case and others will not be rolled up for further decision making in the subsequent PPM phases. As management has decided to give much greater emphasis to benefits, cost and resource constraints, corresponding metrics will be refined.

Although the business case quality has significantly improved, it is still not deemed adequate, and investments in estimating training and process to increase accuracy are now being made. Certain business case elements, such as the “risk of not doing the project” were neither properly understood nor populated correctly. Improvement needs for the data quality around financial metrics, including total cost, benefits and funding sources, for both estimates and actual have become apparent, as significant cost overruns are occurring and consuming the contingency margin early in the execution life cycle. Additional clarification and training is provided to the business analysts and project managers who are chartered to compile the business cases.

Although the interdependency analysis has been performed rather ad hoc, awareness for the issue of project interdependencies and the need for a thorough analysis prior to project selection has been established; there will be subsequent improvements in this regard.

However, one key objective has been achieved: Organizational resistance toward business case submission has significantly decreased, and there is an appreciation for the economics of compiling business cases.

7.3.2.2 Portfolio Prioritization

As the foundation of consistent and more reliable data was established, the discussion around criteria and weights moved to the center of the debate. Both financial and non-financial criteria from the business case, as well as the judgment by the Portfolio Board members were taken into consideration.

Step I – Validation of Entry Criteria

1. Is the objective of the phase understood?

It was understood in principle, that those projects that deliver the greatest utility to the entire organization should be prioritized.

2. Are criteria and corresponding thresholds defined?

In this first pursuit of a consistent project prioritization, the seeking of criteria and weights was performed as an iterative process, whereby criteria and weights were gradually defined and calibrated, while the outcome of the scoring and evaluating the validity of criteria and weights were observed, based on group opinion about the corresponding outcomes:

1) Prioritization: What projects ended up being prioritized compared to the group judgment of perceived top priorities?
2) Threshold: How many projects would be feasible under application of financial and resource constraints?

Although by definition no selection decision would be made at this point, the prioritization with applicable constraints provided a preview of what projects may end up as a feasible choice set in the subsequent selection phase.

3. Does the data quality meet the requirements for decision making?

Although no nominal judgment can be made about the quality of criteria, the reflective learning process throughout the iterations led to an improvement of the criteria and threshold values. For example, the Board decided to apply a contingency margin for the funding of unexpected intra-year projects, which led to the ability to better respond to intra-year requests compared to the approach followed in the past.

4. Are suitable methods identified to achieve phase objectives?

Both AHP and multi-criteria scoring models were considered as methods for prioritizing projects. Adjustments to the rank order, based on heuristics were considered. Lastly, voting on projects was part of the choice set of methods.

Step II – Environmental Analysis

1. What methods are likely to be accepted organizationally?

Simple and easy to understand methods are the most likely to be accepted at this stage. Also, given the organizational desire to achieve maximum consensus, voting would need to play a role.

2. What methods are adequate at the current maturity stage?

After initial consideration of AHP and weighted factor ranking models, AHP was dismissed due to the expected lack of acceptance and the size of the portfolio as the two main reasons. Given the intent to manage the entire business IT portfolio as one, weighted factor ranking was selected as the mechanism for portfolio prioritization. Due to the lack of organizational experience and historical data, prioritization criteria and weighting factors were defined through multiple iterations and their calibration was consciously driven as an ongoing learning process.

Step III – Method Selection and Specification

Based on Steps I and II, the following decision for the prioritization method was made:

1. Initial Multi-factor Scoring

As previously mentioned, the prioritization of projects in the portfolio, especially at this maturity stage, was performed as an iterative process:

1st iteration: Identify high-level prioritization criteria

a) Degree of strategic alignment
b) Project benefit
c) Risk of not doing the project
d) Risk of project failure
e) Compliance requirement (flag for executive/regulatory mandates)

2nd iteration: Refinement of criteria, that is, for the strategic themes

3rd iteration: Assignment of weights and validation with executive management:

The tool suggested for this process was AHP; however, it was decided against using pair-wise comparison methods and to use group judgment for the factor weighting. In this context the executives determined what weights were to be assigned to strategic themes

4th iteration: Ranking of all projects that passed pre-screening and project analysis based on identified criteria and defined weights

Further iterations: Calibration of weighting factors and observation of impact to the rank order to fine-tune the model.

As part of this step, the two thresholds applied were the primary constraints subject to which the portfolio would be selected:

1) Funding constraint (primary threshold)
2) Human resource constraint (secondary threshold)

2. Online Voting on Project Support by All Board Members

Based on the ranking order from the initial multi-factor scoring exercise, the Portfolio Board members were asked to cast their votes for their top 25 projects in order to obtain a view of what projects would be supported by a sufficient number of Board members.

This online voting exercise was used as an input for the subsequent selection phase.

Step IV – Method Application

Initial multi-factor scoring and online voting on project support were conducted in sequence, as elaborated in Step III. Although the scoring was prepared by the Portfolio Manager and presented for discussion and review by the Portfolio Board, the voting was conducted individually with the help of an online polling tool.

Step V – Reflection

Although the multi-factor scoring approach widely follows what is described as common practice in the literature and supported the objective stated in Step I, the breakthrough in respect to achieving buy-in and consensus by the Board as a whole resulted undoubtedly from the voting approach.

As a result, the initial scoring step will likely be simplified and greater emphasis may be given to the voting exercise, which will be further refined (that is, transparency of voting to all board members replaces the "secret ballot" approach).

For the multi-factor scoring, financial factors are likely to be rated higher, whereas other factors may be de-prioritized.

7.3.2.3 Portfolio Selection

Following the notion of the portfolio prioritization, the portfolio selection step was again set up with an emphasis on building consensus across the Portfolio Board.

Step I – Validation of Entry Criteria

1. Is the objective of the phase understood?

A portfolio of projects is to be selected to achieve the greatest benefit and receive the maximum implementation support from the Portfolio Board members.

2. Are criteria and corresponding thresholds defined?

Projects receive the most support from the Portfolio Board, as a result of scoring-based ranks, iterative decision rounds and voting process. Financial constraints are clearly defined, as well as resource constraint on an aggregated level.

3. Does the data quality meet the requirements for decision making?

Although no nominal judgment can be made about the quality of criteria, the reflective learning process throughout the iterations led to an improvement of the criteria and the threshold value. For example, the portfolio manager applied a contingency margin for the funding of unexpected intra-year projects, which increased the funding threshold.

4. Are suitable methods identified to achieve phase objectives?

In order to select the portfolio that maximizes portfolio benefits and receives maximum implementation support, criteria and weighting factors were initially defined and refined iteratively throughout the selection process. The calibration of criteria and factors against the achievement of the aforementioned objectives was an ongoing organizational learning process.

Step II – Environmental Analysis

1. What methods are likely to be organizationally accepted?

Simple financial metrics, a qualitative approach to risk and a qualitative ranking of strategic contribution, were chosen in light of the initial maturity and the legacy thinking.

2. What methods are adequate at the current maturity stage?

Through a series of Board meetings, it was validated that the applied methods were adequate for achieving the intended goal and had received the required buy-in from the Board.

Step III – Method Selection and Specification

The following method was defined:

1. Voting Iterations

1st iteration: Bucketing of projects, based on the degree of Board support and the elimination of projects that did not obtain minimum support of at least five votes.

2nd iteration: Board review and discussion of voting results; and establishes project buckets, based on degree of executive support

3rd iteration: Pair-wise comparison of projects within the established buckets and averaging of scores across Board members.

4th iteration: Validation and final adjustment to the results.

2. Preliminary Selection of the Portfolio

As the final part of the selection workshop, the funding constraint (available funds minus contingency margin) was applied to evaluate what projects are being selected based on the funds available.

3. Finalization of the Portfolio

Lastly, resource constraints were analyzed and applied after the workshop to validate the feasibility of the portfolio from a staffing perspective.

Step IV – Method Application

The method, as specified in Step III, was applied in the context of a two-day selection workshop, where the four voting iterations and the preliminary portfolio selection were performed. The finalization of the portfolio, resulting from the application of resourcing constraints was completed subsequently due to the lack of the appropriate PPM software tool that would allow for an immediate application of resource constraints to the portfolio.

As recognized early in the process, even with such a tool in place the goal of immediately determining the feasibility of the portfolio from a resource perspective could not be achieved due to the lack of adequate data. Resource supply data exist only at a very aggregated level, which is insufficient for organizational resource leveling, and resource demand data were not granular enough in the Quick Business Cases to allow for resource optimization.

Step V– Reflection

Although the emphasis on building Board consensus will remain at the center of the selection process, quantitative—especially financial—criteria will carry increasing weight in the portfolio selection process.

The use of a proper PPM tool, which will enable constrained optimization and allow for easy and fast simulations (what-if scenarios), will help accelerate and significantly improve the portfolio selection phase in the next portfolio selection cycle. Adequate tool enablement will lead to even greater transparency of project and portfolio information across the organization, as candidate and approved projects will be made visible to a broader audience in the organization for the first time.

Significant efforts will need to be dedicated to resource management, and training will be necessary for business analysts to provide the required resource needs data as part of the Quick Business Case process.

7.3.3 Process Metrics Determining PPM Success and Driving Maturity

In addition to the ongoing reflective learning throughout the process of establishing PPM in the organization, several metrics were selected to measure PPM process success, with the intent to drive and validate the improvement of PPM maturity over time. These measures, which were initially included in the charter of the portfolio governance body, targeted the following portfolio management objectives and are anchored in the portfolio management board charter:

Table 7-8: Process Metrics Overview

1. **Improved decision-making process for top strategic projects** – All proposed business technology projects are substantiated with a complete and high-quality business case. 2. **Complete and high-quality inventory** – Inventory of all relevant business technology projects with a solid rationale for all projects, their respective prioritization, and alignment with the Strategic Plan of the business. 3. **Empowerment of portfolio management and avoidance of politically motivated exceptions –** Achieve high Executive Steering Committee approval rate of Portfolio Board decisions. 4. **Integration with other key managerial processes –** Timely integration with accounting, finance, and funding approval process. 5. **Managerial Commitment** – Active participation of all Board members in the decision process.

It was the objective to choose a small set of metrics, which would allow monitoring process quality and the maturing of the process over time. All metrics are discussed below and the Performance Measure Record Sheet is used to provide a uniform structure, quality and alignment for all five selected metrics:

1. Business Case Quality for the Portfolio
2. Portfolio Inventory Quality and Completeness
3. Portfolio Management Board Empowerment
4. Process Alignment
5. Management Commitment

Metric 1	*Business Case Quality for the Portfolio*
Purpose	*Ensure that portfolio screening and selection decisions are made based on high-quality data*
Relates to (objective)	1. **Improved decision-making process for top strategic projects** – All proposed business technology projects are substantiated with a complete and high-quality business case.
Target	*100% by October 2009*
Formula	*Number of projects considered for selection (pipeline) divided by number of projects with complete and approved business case*
Frequency	*Once per year in FY09; quarterly for intra-year submissions*
Who measures	*Portfolio Manager*
Source of data	*Submitted business cases*
Who acts on data	*Portfolio Manager/business analysts*
What do they do	*Portfolio Manager facilitates quality review, provides coaching to business analysts and project managers in the compiling of business cases and rejects those business cases that do not meet minimum requirement for completeness and quality.*

Metric 2	*Portfolio Inventory Quality and Completeness*
Purpose	*Consistently fund those projects that best reflect strategic objectives of the company and its businesses*
Relates to (objective)	2. **Complete and high quality inventory** – Inventory *all* relevant business technology projects with solid rationale for all projects, their respective prioritization, and alignment with Strategic Plan of the business.
Target	*100%*
Formula	*Number of projects considered for selection (pipeline) divided by number of projects with data on rationale, prioritization and alignment*
Frequency	*Quarterly*
Who measures	*Portfolio Manager*
Source of data	*Portfolio inventory and underlying submitted business cases*
Who acts on data	*Portfolio Manager/Board*
What do they do	*Portfolio Manager—in concert with the board—ensures that all projects requesting funds and resources from the organization are part of the inventory and submitted through the business case process.*

Metric 3	*Portfolio Management Board Empowerment*
Purpose	*Funnel all projects through Board and minimize "bypass" approval through individual executives without following the PPM selection process (with the exception of emergency funding).*
Relates to (objective)	3. **Empowerment of portfolio management and avoidance of politically motivated exceptions** – Achieve high Executive Steering Committee approval rate of Portfolio Board decisions
Target	*95%*
Formula	*Number of projects approved by Portfolio Board divided by number of projects pursued*
Frequency	*Quarterly*
Who measures	*Portfolio Manager/Board Co-chairmen*
Source of data	*Portfolio inventory and submitted business cases*
Who acts on data	*Board Co-chairmen*
What do they do	*Board Co-chairmen intervene with Board members or executive management if the portfolio management process is bypassed.*

Metric 4	*Process Alignment*
Purpose	*Optimal alignment of PPM with annual strategic planning and budgetary cycle to use up-to-date strategic guidelines for alignment and tie-in with funding/capital allocation process*
Relates to (objective)	4. **Integration with other key managerial processes** – Timely integration with accounting, finance, and funding approval process.
Target	*Alignment of schedule with budgetary cycle*
Formula	*Number of projects considered for selection (pipeline) divided by number of projects with data on rationale, prioritization, and alignment*
Frequency	*Quarterly*
Who measures	*Portfolio Manager*
Source of data	*PPM milestone plan, including timelines for PPM life cycle, in alignment with activities and deadlines for strategic planning and budgetary cycle.*
Who acts on data	*Portfolio Manager*
What do they do	*Adequate time management of due dates/deliverables*

Metric 5	*Management Commitment*
Purpose	*Achieve and sustain buy-in from all lines of business and executive team members*
Relates to (objective)	5. **Managerial Commitment** – Active participation of all Board members in the decision process
Target	*High satisfaction, "meeting expectations" of the co-chairmen of the Portfolio Board*
Formula	*N/A*
Frequency	*Quarterly*
Who measures	*Portfolio Manager and Co-chairmen*
Source of data	*Survey*
Who acts on data	*Portfolio Manager and/or Co-chairmen*
What do they do	*Establish and implement action plan, depending on survey outcome*

For all five metrics, the respective criteria for relevance, quality and viability (see Section 5.3.1) were validated in discussions with the portfolio manager.

7.3.4 Findings

The case study provided the expected validation for Propositions 1 and 4 and additional indication for the validity for Proposition 3, thereby filling in some of the gaps of what was not possible to accomplish in the context of the experiment. Findings #12 through 15 describe the conclusions from the case study, as described in the previous sections.

Finding #12: Effectiveness of the 5-step Approach

The five-step approach used for the definition of the methodology selection proved both efficient and effective in the progressive development of the portfolio management methodology and the respective methods and techniques. The positive feedback of the portfolio manager and the portfolio board was particularly focused on Step I (Validation of Phase Entry Criteria) and Step V (Reflection) and the repeat loops, which contributed to the learning effect on the Board and a significant jump in maturity in this Year-1 iteration. Although Step II (Environmental Analysis) was not necessarily visible to all Board members, one of the executives appreciated the "ambitious, yet realistic and organizationally compatible" approach toward the implementation effort.

Although ample focus was given to the actual methodology selection, the rigorous application of all five steps was a guarantor of implementation success. One example was the desire to adopt AHP as the method for selection, but it was decided that both effort and complexity would overwhelm the participants, who would need to buy into the necessity and merit of PPM and could be moved to greater sophistication at a later point in time.

Finding #13: Attainability and importance of relevant, viable and quality metrics

Significant success was achieved in articulating relevant, viable and qualitative metrics. Although the specific criteria for these three requirements were tested, post-mortem analysis revealed that this validation of requirements fulfillment is a learning process as well; and though the five process metrics have held up and will continue to be used as originally defined, some of the project metrics captured in the business cases will be abandoned. This insight is not a result of the failure of the process itself, but rather it stems from optimistic judgment about the level of organizational buy-in and the required efforts to capture the respective data in the desired quality.

Finding #14: Use of an effective format for capturing measurement information

The format for the capture of the process metrics has proved to be highly effective for several reasons. First, articulating a purpose created clarity among the decision makers and led to the elimination of several ideas for metrics that, while emulating metrics in other organizations, showed no merit for the specific case of this organization. Second, clarity around targets (where applicable) supported the notion of “management by objectives” for the measurement approach. Lastly, the most important and appreciated part of the metrics definition related to “who acts on data” and “what do they do,”—a seemingly trivial yet eye-opening exercise that triggered managerial action in the execution.

Finding #15: Limitations of (solely) process-driven approach

After the 2010 improvement iteration, the organization reached a state where further process improvement is possible, but the management of the PPM complexity factors, especially in regard to the mathematical aspect, will require a stronger tool focus in order to significantly improve. At this stage human resource data constituted one of the greatest management challenges; and given the size of the portfolio and organization, cognitive limitations of managing resources for the entire portfolio without proper tooling had been more than reached.

7.4 Summary of Findings

In summary of the experimental results discussed in Chapters 7.2.3, 7.2.4 and 7.2.5 Table 7-9 provides an overview of the validation for Propositions 2, 3 and 5:

Table 7-9: Summary of Results - Experimental Validation

Proposition and related question	Validation through Finding #
1. Systematic analysis of interdependencies (Proposition 2)	
a. Are interdependencies better understood following a process of interdependency analysis?	**#1**: Improved accuracy, by recognizing non-critical and not feasible projects **#2:** Greater logical consistency of choices, due to recognition of dependencies
b. Does the proposed tooling for interdependency analysis yield better portfolio decisions?	**#3**: Structured process reduces errors **#4:** Convergence towards the optimal choice set for projects to be eliminated **#5:** Increased transparency of dependencies and participant confidence
2. Choice of effective metrics (Proposition 3)	
a. Does a metrics selection process allow participants to make better choices of what metrics to consider and assign the appropriate weight metrics in the decision process?	**#6:** Metrics prioritization represents strategic priorities **#7**: Convergence towards strategically aligned portfolios
b. Will decision outcomes converge toward the optimal portfolio as a result?	**#8**: Step-wise approach influenced prioritization and selection and led to superior portfolios
3. Reconciliation of misalignments between strategy and project portfolio (Proposition 5)	
a. Does the proposed strategy analysis increase the attainability of the portfolio strategy?	**#9**: The strategy analysis can provide a reality check on the attainability of the strategy
b. Will the reconciliation process yield meaningful feedback for executive management and strategic planning?	**#10**: The strategy analysis can reveal strategy gaps. **#11**: Improved Strategic alignment is the result of the strategy analysis.

Table 7-10 further summarizes the findings from the case study:

Table 7-10: Summary of Results – Case Study

#	Finding
12	Effectiveness of the 5-step Approach
13	Attainability and importance of relevant, viable and quality metrics
14	Use of an effective format for capturing measurement information
15	Limitations of a (solely) process-driven approach

Interviews and observations during the case study confirmed the validity of the propositions but also showed potential limitations to a purely process-centric approach, as explained by Finding #15.

7.5 Chapter Summary

This chapter provided detailed explanations of the validation through experimentation for all five propositions. Although the case study was mainly focused on validating the how-to approach, the experiment delivered quantitative evidence for the merit of proposed improvements in regard to improved portfolio outcomes.

8. CONCLUSIONS

8.1 Chapter Introduction and Objective

"Das schönste Glück des denkenden Menschen ist, das Erforschliche erforscht zu haben und das Unerforschliche zu verehren." (Johann Wolfgang von Goethe, 1749–1832) translates as "The greatest joy of the thinking man is to have explored what can be explored and to appreciate what cannot be explored." Following Goethe's saying, the author has at the same time both completed and begun a journey of exploration of project portfolio management, an area that still holds great opportunity for research contributions.

This chapter summarizes findings from this research effort and provides conclusions from this research effort. Furthermore, the research approach is revisited and several areas that would warrant further research are laid out, as they were discovered by the author in the context of his research effort.

8.2 Research Question

The central research question of this thesis was to evaluate how improvements to PPM maturity, and ultimately portfolio management outcomes, could be achieved. In this context, three themes were pursued in order to investigate improvement potentials from refinements regarding the portfolio selection methodology, measurement and process integration.

These themes have been further substantiated by five propositions that align with the aforementioned themes. Figure 8-1 recaps the logical construct of this thesis, including overall objective, themes and propositions.

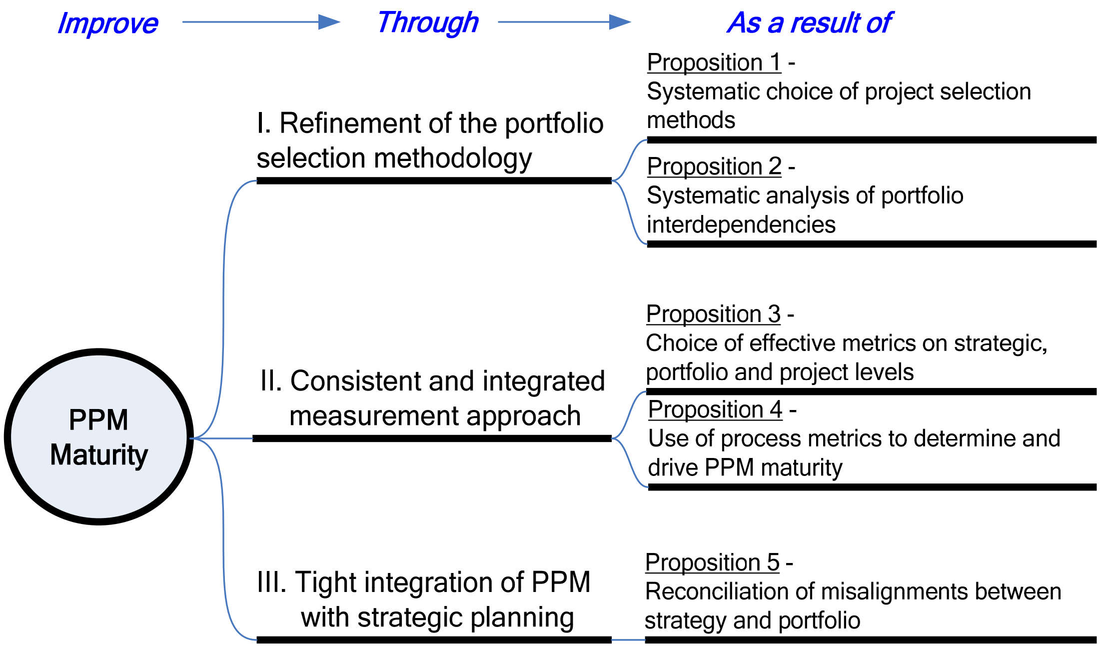

Figure 8-1: Research Themes and Propositions

8.3 Original Contributions and Conclusions

This thesis work constitutes the end point of a series of efforts undertaken by the author, contributing in five different dimensions:

1. Contribution to the PPM body of knowledge
2. Application of an interdisciplinary approach to the PPM field
3. Use of experimental research in project portfolio management
4. Publications and contribution to PPM standards
5. Support of real-world PPM improvements and self-learning

These aspects will be detailed in the following sections.

8.3.1 Contribution to the PPM Body of Knowledge

As the primary contribution of this doctoral thesis, the five propositions have been developed, substantiated and discussed, and two validation approaches have been used to establish a case for their usefulness and validity.

The elaboration of the five propositions and their validation have led to a number of findings, as outlined below.

A five-step approach has been developed in support of identifying proper selection methods for each phase of the PPM life cycle:

I. Validation of Phase Entry Criteria
II. Environmental Analysis
III. Method Selection & Specification
IV. Method Application
V. Reflection

The approach proved effective and efficient for development of the methodology of the case study client and received overwhelmingly positive feedback from the portfolio manager and the board chartered to oversee the PPM process of the large organization. Especially the size and complexity of the organization made the approach very suitable, and particularly the environmental analysis and reflection yielded measureable improvements, as multiple iterations where performed.

The analysis of five interdependency types, namely benefit, risk, outcome, schedule and resources interdependencies proved meaningful and both the approach toward interdependency analysis and the introduced tooling showed improvements in portfolio outcomes in the behavioral experiments.

A multi-tiered taxonomy for metrics has been introduced, consisting of strategic, portfolio and project metrics. The author did not attempt to prescribe specific metrics, but rather provided a concept for the development and validation of metrics. The measurement approach and validation criteria for metrics were tested with the help of the case study, which was exemplified with the analysis of process metrics and also partially validated through experimentation.

Lastly the topic of strategic alignment was explored, and the top-down view of strategic alignment, in the sense of strategic fit as found in the literature, was supplemented with the bottom-up perspective of PPM toward the executive level, thereby providing validation for strategic objectives and helping to identify strategy gaps. The concept of strategy gap and project gap were elaborated and tested in the context of the experiment.

8.3.2 Application of an Interdisciplinary Approach to the PPM Field

The author further took to take a broad view and interdisciplinary approach to the PPM topic, specifically including insights from decision science as well as behavioral science and its application in behavioral economics. The understanding of mathematical, managerial, process and behavioral aspects that constitute the complexity of PPM established the foundation for discussing and addressing some of these factors through the propositions of this thesis. In the context of framing the problem and the literature review, other complexity parameters were defined and further elaborated throughout this thesis to capture a full picture of PPM complexity, all of which significantly impact the decision-making quality. Mathematical, managerial, process and behavioral aspects of complexity have been discussed and addressed throughout this thesis work. Although the mathematical aspects of PPM appeared to be reasonably covered in the researched literature, this thesis has focused on the process aspects, specifically the iterative nature and the need for a more refined process sequence for both the execution of portfolio selection and the alignment of portfolios with strategy. In addition, the managerial aspect is covered in regard to the interdependency analysis, and the behavioral aspect was briefly examined on numerous occasions.

8.3.3 Use of Experimental Research in Project Portfolio Management

One of the most interesting aspects of this thesis was the opportunity to validate several propositions with the help of experimental validation. The successful application of techniques from the field of behavioral economics have led both to a confirmation of the validity of the propositions, but even more so, to having opened the opportunity for reapplication of the technique to other problems (see Section 8.5 Further Research).

8.3.4 Publications and Contribution to PPM Standards

Several publications and contributions to standard work (see Publications and Presentations, p. xv) have influenced and contributed to the research presented here. The early literature review and applied research efforts leading up to this thesis research effort also supported the authors contributions to *The Standard for Portfolio Management* of the Project Management Institute in its first and second editions (PMI, 2006;2008c) and several other publications, as listed.

8.3.5 Support of Real-World PPM Improvements and Self-Learning

Last but not least, the opportunity for the author to increase the breadth and depth of his knowledge through a combination of research, while simultaneously teaching, coaching, practicing and consulting in the PPM field, has iteratively driven the learning process that has contributed to and benefited from this thesis.

The case study work deserves particular mentioning in this context, as it was the end point of a consulting and iterative, reflective learning process with a client that the author had the privilege to serve for an extended period of time. In the opinion of the author, this part of the effort allowed the combined application of positivist and realist, and to some degree interpretivist, research philosophies, and it was particularly gratifying as the client experienced and recognized substantial PPM process improvements.

Figure 8-2 provides a summary for the five contributions recognized by the author.

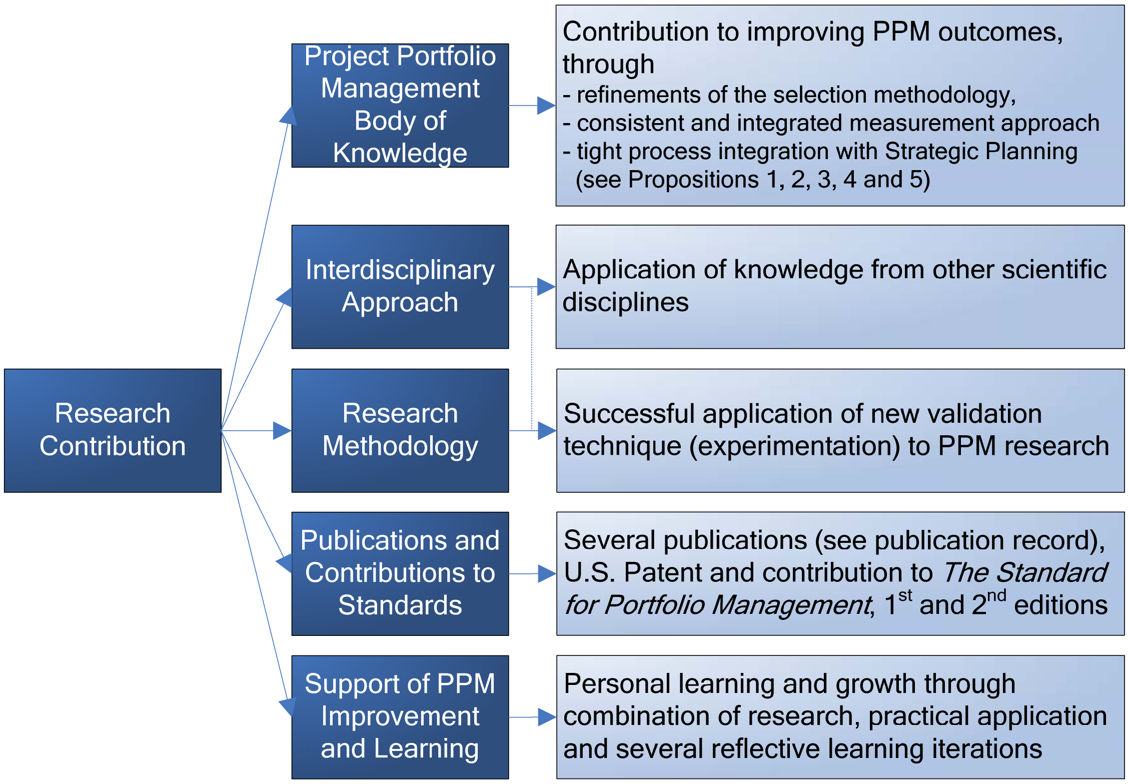

Figure 8-2: Overview of Contributions

8.4 Critical Reflection on the Research Process

This research process introduced several innovations, as is expected of a doctoral thesis. To the author's best knowledge, human subject experimentation, as conducted here, has not been used in the project management field and the approach was designed to purposefully use a demographic that the author felt fitted the context of the research question and would hold up in the reality of project portfolio management practice. Despite the empirical evidence for the validity of the approach (see discussion on the experimental research approach in Section 3.2.3), the approach contains an element of subjectivity on the part of the author. If any weakness in the author's rationale exists, then it remains for further research to improve upon this new approach.

The author also leveraged a considerably broad spectrum of cross-disciplinary material, a result of a clearly perceived need for an interdisciplinary approach for addressing challenges in PPM, plus the author's professional and academic background, specifically in the field of economics and finance. This is worth noting, as the DPM degree is geared toward practitioners researching project management practice, based upon their practice—as has been prescribed by Winter et al. (2006). Two aspects come to mind with regard to this facet.

First, it is only natural that the author's view of project management practice is colored by his personal experience as practitioner and academic, and therefore the thesis artifact does provide an ethnographic value in that it sheds light in part on real-world experience as a project manager. Thus, the research provides a historical context that may be of value to researchers in the future, as it helps readers to understand the Zeitgeist, or particular context of the time. This contextual revelation is important for the author as a reflective practitioner and may be of value to others who take interest in various project management career trajectories of others. (Section 1-3 helps to shed some light on the context of the author.)

Second, as a practicing project manager undertaking a doctoral thesis, it is worth reflecting on views in hindsight of the journey. The author has come to the conclusion that both the DPM program and the thesis have constituted a learning journey through the absorption of literature and coursework components and from my being compelled to re-frame ideas, adopt them into practice and refine them. Additionally, the sheer effort to explain and justify assertions made, the research paradigm and approach, as well as the findings, have advanced the author's critical thinking about PPM to a higher level. The author's potential for operating at that stated level was most likely present at the outset of the DPM, but it was fine-tuned and honed during the process, especially at the later composition stage. The author's thesis supervisor and others have emphasized that the finishing of a comprehensive research work at the highest quality sets the bar for the completion of a doctorate. The required routine and "brute force" effort, which is perhaps not the most enjoyable part for an individual with a creative mindset, is, however, a necessary part of the task. Committing to a doctorate somewhat contradicts today's focus on quick results, as it requires a long time for ideas to develop and mature from the original seed of a thesis topic to this final version presented for examination through many iterations. Therefore, the process of undertaking a doctorate is one of maturation in a set of skills and attributes that is even more appreciated at the conclusion of such an endeavor.

8.5 Future Research

Upon exploring a broad range of aspects to improve project portfolio management, a number of areas for further research have become apparent. First, it is the conviction of the author that future research in PPM needs to be more holistic, thus placing less emphasis on techniques and focusing more on the integration of knowledge from decision science and behavioral science. The recognition that PPM is first and foremost a complex decision problem rather than a matter of constrained optimization should shift the discussion into the appropriate direction. In this respect, research and reapplication of complexity theory and operations research could be of significant value. Moreover, the visualization of complex decision problems with the intent to achieve greater decision quality should be investigated.

Second, several specific areas that have been covered in this research effort deserve a deeper immersion. For example, the area of risk interdependencies, part of Proposition 2, should yield interesting opportunities for further research due to the lack of previous discussion and the complexity and relevance of the matter. Understanding portfolio risk as a function of interdependencies among the entire portfolio and the ability to make probabilistic statements for the expected portfolio success would be a significant strategic tool for portfolio managers. In addition, time interdependencies could be examined from the perspective of intertemporal choice by modeling scenarios of timing and by sequencing of activities and their intended and unintended consequences on portfolio outcomes. Although such models should become rather complex and challenging from a cognitive perspective, there is significant benefit from mastering them.

Inasmuch as benefits from a more structured management process for interdependencies have been demonstrated by this thesis, it would be meaningful to further formalize the interdependency analysis process and provide a consistent approach to the identification, qualification and quantification of interdependencies, illustrated in Figure 8-3, and to define requirements for the ongoing management of interdependencies in a portfolio in the monitoring and control stage.

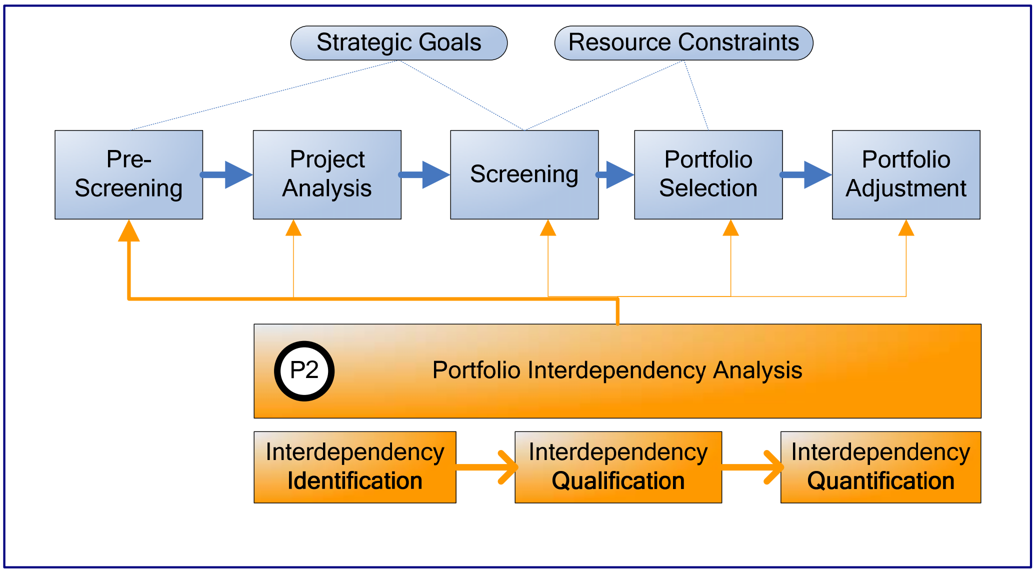

Figure 8-3: Structured Process for Interdependency Analysis

In the context of consistent measurement approaches, empirical research analyzing what metrics organizations use at strategic, portfolio, project and process levels would have merit for both academics and practitioners. An actual empirical research on portfolio metrics used and a metrics library would offer valuable insights for both academics and practitioners. Lastly, the area of organizational integration of strategic planning and PPM functions constitutes a research area with relevance for those organizations that have already progressed on the PPM maturity path. The closer alignment of strategic planning and further evolution of the concepts of project and strategy gap could and should be investigated.

8.6 Chapter Summary

The chapter summarized the main findings from this thesis. Lastly the chapter reviewed the contributions of this research work to the body of knowledge and suggested potential directions for further research in the area of PPM from the perspective of the author.

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Project Portfolio Management Survey Results - US Commercial

Q1. From my perspective, our organizational Project Portfolio Management process appears to be—

Answer Options	Response Count
Mostly ad-hoc and informal	52
Somewhat formalized, using a repeatable process for project evaluation, selection and approval	86
Standardized and tool-supported	43
Optimized, managing the project portfolio as a workflow and responding quickly to change.	6
Total responses	**187**

Q2. Evaluation of candidate projects, project selection and approval cycles are performed—

Answer Options	Response Count
Ad hoc (i.e., no set schedule)	48
As part of the annual budgeting cycle	38
Semi-annual, quarterly or monthly	62
When significant changes in project needs or project outcomes occur.	26
Don't know	13
Total responses	**202**

Q3. Project reviews are performed—

Answer Options	Response Count
On a regular basis (e.g., stage gate reviews or monthly/quarterly	129
After project completion	26
Reviews are not performed	32
Total responses	**187**

Q4. As a result of the project review—

Answer Options	Response Count
Funds and resource allocations are reviewed	67
Corrective action is taken quickly	61
Nothing happens	59
Total responses	**187**

Q5. The Project Portfolio Management process is supported by—

Answer Options	Response Count
Limited tools and templates (i.e., spreadsheets)	111
A software-based PPM solution	55
No readily identified tool or process of any kind	21
Total responses	**187**

Q6. Overall I would rate our level of maturity in the Project Portfolio Management process as—

Answer Options	Response Count
Very mature	5
Mature	37
Somewhat mature	88
Immature	57
Total responses	**187**

Q7. In our organization, we observe the following:

Answer Options	Agree	Disagree	No Opinion	Total Responses
Senior management appears satisfied with benefits from projects and the pace of benefits achievement.	106	45	17	**168**
There is a complete portfolio inventory, containing all projects.	97	59	12	**168**
Projects are not unilaterally approved by senior executives, but systematically selected and approved.	97	51	20	**168**
There are no redundancies and conflicts in project priorities.	27	129	12	**168**

A consistent approach for screening, prioritizing, selecting and approving projects is both defined and applied.	66	85	16	**167**
Dependencies between projects are clearly articulated and well-understood.	56	101	10	**167**
Priorities are consistent over time and do not change frequently.	37	121	9	**167**
There are few or no resource conflicts and work overload for critical resources is the exception.	17	143	7	**167**

Q8. As a result of the global recession, the following challenges have emerged:

Answer Options	Agree	Disagree	N/A	Total Responses
We are increasing the focus on Project Portfolio Management, as project funding decisions are more difficult.	102	42	16	**160**
The gap between available funds and the demand for project outcomes is increasing.	121	26	13	**160**
Resourcing projects is increasingly difficult and less predictable.	117	30	13	**160**
Direction and strategy change more frequently.	99	48	13	**160**
The funding approval process has become more complicated and time-consuming.	89	52	19	**160**
Strategic projects obtain significantly less funding than tactical projects, compared to previous years.	61	57	41	**159**
Project outcomes and delivery quality are suffering, as critical staff could not be retained, trained and developed adequately.	68	75	17	**160**
We struggle with our Project Portfolio Management process due to a lack of experience, tools or processes.	87	57	16	**160**

Q9. Which of the following best describes your job title?

Answer Options	Response Count
Executive/Line of Business Head	2
Line of Business Director/Manager/VP	8
PMO Head	11
Program Manager	25
Project Manager	112
Total responses	**163**

Q10. What is your company's annual revenue?

Answer Options	Response Count
<$10M	18
$10M to $100M	23
$100M to$1B	35
$1B to $10B	38
>$10B	44
Total responses	**158**

Q11. At what level is your project portfolio defined and managed? (Check all that apply)

Answer Options	Response Count
Corporate	73
Business Unit	69
Department	51
Division	47
Don't know	11
Total responses	**251**

Q12. How many projects are contained in the project portfolio in a given year?

Answer Options	Response Count
<10	8
10 to 100	65
101 to 1,000	51
>1,000	8
Don't know	26
Total responses	**158**

Q13. Which of the following best describes your role in the Project Portfolio Management process? (Check all that apply)

Answer Options	Response Count
Provide project proposals or business case	74
Participate in decision process to prioritize and select projects	44

Approve final portfolio, appropriate funding	15
Allocate/manage resources	69
Manage PPM tool and/or process	84
Total responses	**303**

Q14. The Project Portfolio Management process is managed by—

Answer Options	Response Count
The head of the organization (e.g., CEO, Business Unit head, etc.)	24
The head of the finance organization (e.g., CFO, Business Unit Controller, etc.)	11
The head of the Project Management Office (PMO)	58
A steering committee or portfolio governance board	39
No particular individual	26
Total responses	**161**

Project Portfolio Management Survey Results – Europe, Middle-East, Africa

Q1. From my perspective, our organizational Project Portfolio Management process appears to be—

Answer Options	Response Count
Mostly ad-hoc and informal	48
Somewhat formalized, using a repeatable process for project evaluation, selection and approval	79
Standardized and tool-supported	55
Optimized, managing the project portfolio as a workflow and responding quickly to change.	16
Total responses	**198**

Q2. Evaluation of candidate projects, project selection and approval cycles are performed—

Answer Options	Response Count

Ad hoc (i.e., no set schedule)	34
As part of the annual budgeting cycle	50
Semi-annually, quarterly or monthly	64
When significant changes in project needs or project outcomes occur.	42
Do not know	8
Total responses	**201**

Q3. Project reviews are performed—

Answer Options	**Response Count**
On a regular basis (e.g., stage gate reviews or monthly/quarterly)	133
After project completion	39
Reviews are not performed	26
Total responses	**198**

Q4. As a result of the project review—

Answer Options	**Response Count**
Funds and resource allocations are reviewed	66
Corrective action is taken quickly	89
Nothing happens	43
Total responses	**198**

Q5. The Project Portfolio Management process is supported by—

Answer Options	**Response Count**
Limited tools and templates (i.e., spreadsheets)	112
A software-based PPM solution	51
No readily identified tool or process of any kind	35
Total responses	**198**

Q6. Overall I would rate our level of maturity in the Project Portfolio Management process as—

Answer Options	Response Count
Very mature	8
Mature	61
Somewhat mature	83
Immature	46
Total responses	**198**

Q7. In our organization, we observe the following:

Answer Options	Agree	Disagree	No Opinion	Total Responses
Senior management appears satisfied with benefits from projects and the pace of benefits achievement.	98	53	27	178
There is a complete portfolio inventory, containing all projects.	95	72	12	179
Projects are not unilaterally approved by senior executives, but systematically selected and approved.	99	59	21	179
There are no redundancies and conflicts in project priorities.	38	125	15	178
A consistent approach for screening, prioritizing, selecting and approving projects is both defined and applied.	87	82	9	178
Dependencies between projects are clearly articulated and well-understood.	75	88	15	178
Priorities are consistent over time and do not change frequently.	68	98	12	178
There are few or no resource conflicts and work overload for critical resources is the exception.	40	120	17	177

Q8. As a result of the global recession, the following challenges have emerged:

Answer Options	Agree	Disagree	N/A	Total Responses
We are increasing the focus on Project Portfolio Management, as project funding decisions are more difficult.	104	46	15	**165**
The gap between available funds and the demand for project outcomes is increasing.	109	40	16	**165**
Resourcing projects is increasingly difficult and less predictable.	103	46	15	**164**
Direction and strategy change more frequently.	79	67	18	**164**

The funding approval process has become more complicated and time-consuming.	98	56	11	**165**
Strategic projects obtain significantly less funding than tactical projects, compared to previous years.	58	73	33	**164**
Project outcomes and delivery quality are suffering, as critical staff could not be retained, trained and developed adequately.	76	70	17	**163**
We struggle with our Project Portfolio Management process due to a lack of experience, tools or processes.	82	66	15	**163**

Q9. Which of the following best describes your job title?

Answer Options	**Response Count**
Executive/Line of Business Head	10
Line of Business Director/Manager/VP	21
PMO Head	22
Program Manager	35
Project Manager	68
Total responses	**175**

Q10. What is your company's annual revenue?

Answer Options	**Response Count**
<$10M USD	25
$10M to $100M USD	38
$100M to$1B USD	39
$1B to $10B USD	29
>$10B USD	25
Total responses	**156**

Q11. At what level is your project portfolio defined and managed? (Check all that apply)

Answer Options	**Response Count**
Corporate	68
Business Unit	80

Department	54
Division	28
Do not know	11
Total responses	**241**

Q12. How many projects are contained in the project portfolio in a given year?

Answer Options	**Response Count**
<10	35
10 to 100	75
101 to 1,000	34
>1,000	6
Do not know	6
Total responses	**156**

Q13. Which of the following best describes your role in the Project Portfolio Management process? (Check all that apply)

Answer Options	**Response Count**
Provide project proposals or business case	77
Participate in decision process to priorities and select projects	72
Approve final portfolio, appropriate funding	26
Allocate/manage resources	67
Manage PPM tool and/or process	65
Total responses	**313**

Q14. The Project Portfolio Management process is managed by

Answer Options	**Response Count**
The head of the organization (e.g., CEO, Business Unit head, etc.)	42
The head of the finance organization (e.g., CFO, Business Unit Controller, etc.)	7
The head of the Project Management Office (PMO)	62
A steering committee or portfolio governance board	29
No particular individual	16
Total responses	**162**

Project Portfolio Management Survey Results – Asia (except for India)

Q1. From my perspective, our organizational Project Portfolio Management process appears to be—

Answer Options	Response Count
Mostly ad-hoc and informal	15
Somewhat formalized, using a repeatable process for project evaluation, selection and approval	21
Standardized and tool-supported	14
Optimized, managing the project portfolio as a workflow and responding quickly to change	10
Total responses	**60**

Q2. Evaluation of candidate projects, project selection and approval cycles are performed—

Answer Options	Response Count
Ad hoc (i.e., no set schedule)	13
As part of the annual budgeting cycle	13
Semi-annually, quarterly or monthly	17
When significant changes in project needs or project outcomes occur	11
Do not know	6
Total responses	**60**

Q3. Project reviews are performed—

Answer Options	Response Count
On a regular basis (e.g., stage gate reviews or monthly/quarterly)	45
After project completion	9
Reviews are not performed	6
Total responses	**60**

Q4. As a result of the project review—

Answer Options	Response Count

Funds and resource allocations are reviewed	26
Corrective action is taken quickly	26
Nothing happens	8
Total responses	**60**

Q5. The Project Portfolio Management process is supported by—

Answer Options	Response Count
Limited tools and templates (i.e., spreadsheets)	27
A software-based PPM solution	18
No readily identified tool or process of any kind	15
Total responses	**60**

Q6. Overall I would rate our level of maturity in the Project Portfolio Management process as—

Answer Options	Response Count
Very mature	3
Mature	19
Somewhat mature	28
Immature	10
Total responses	**60**

Q7. In our organization, we observe the following:

Answer Options	Agree	Disagree	No Opinion	Total Responses
Senior management appears satisfied with benefits from projects and the pace of benefits achievement.	32	8	15	**55**
There is a complete portfolio inventory, containing all projects.	29	19	7	**55**
Projects are not unilaterally approved by senior executives, but systematically selected and approved.	29	16	10	**55**
There are no redundancies and conflicts in project priorities.	19	29	7	**55**
A consistent approach for screening, prioritizing, selecting and approving projects is both defined and applied.	35	18	2	**55**
Dependencies between projects are clearly articulated and well-understood.	28	21	6	**55**

Priorities are consistent over time and do not change frequently.	25	22	8	**55**
There are few or no resource conflicts and work overload for critical resources is the exception.	19	28	8	**55**

Q8. As a result of the global recession, the following challenges have emerged:

Answer Options	**Agree**	**Disagree**	**N/A**	**Total Responses**
We are increasing the focus on Project Portfolio Management, as project funding decisions are more difficult.	27	13	11	**51**
The gap between available funds and the demand for project outcomes is increasing.	32	9	10	**51**
Resourcing projects is increasingly difficult and less predictable.	37	6	8	**51**
Direction and strategy change more frequently.	35	12	3	**50**
The funding approval process has become more complicated and time-consuming.	36	8	7	**51**
Strategic projects obtain significantly less funding than tactical projects, compared to previous years.	30	9	12	**51**
Project outcomes and delivery quality are suffering, as critical staff could not be retained, trained and developed adequately.	32	9	9	**50**
We struggle with our Project Portfolio Management process due to a lack of experience, tools or processes.	20	22	9	**51**

Q9. Which of the following best describes your job title?

Answer Options	**Response Count**
Executive/Line of Business Head	7
Line of Business Director/Manager/VP	10
PMO Head	1
Program Manager	13
Project Manager	17
Total responses	**53**

Q10. What is your company's annual revenue?

Answer Options	Response Count
<$10M USD	6
$10M to $100M USD	13
$100M to$1B USD	11
$1B to $10B USD	14
>$10B USD	4
Total responses	**48**

Q11. At what level is your project portfolio defined and managed? (Check all that apply)

Answer Options	Response Count
Corporate	13
Business Unit	27
Department	14
Division	8
Do not know	2
Total responses	**64**

Q12. How many projects are contained in the project portfolio in a given year?

Answer Options	Response Count
<10	6
10 to 100	29
101 to 1,000	4
>1,000	3
Do not know	6
Total responses	**48**

Q13. Which of the following best describes your role in the Project Portfolio Management process? (Check all that apply)

Answer Options	Response Count
Provide project proposals or business case	28
Participate in decision process to priorities and select projects	26
Approve final portfolio, appropriate funding	9
Allocate/manage resources	21
Manage PPM tool and/or process	17
total responses	**103**

Q14. The Project Portfolio Management process is managed by

Answer Options	Response Count
The head of the organization (e.g., CEO, Business Unit head, etc.)	12
The head of the finance organization (e.g., CFO, Business Unit Controller, etc.)	1
The head of the Project Management Office (PMO)	17
A steering committee or portfolio governance board	10
No particular individual	8
Total responses	**49**

Project Portfolio Management Survey Results – India

Q1. From my perspective, our organizational Project Portfolio Management process appears to be—

Answer Options	Response Count
Mostly ad-hoc and informal	11
Somewhat formalized, using a repeatable process for project evaluation, selection and approval	18
Standardized and tool-supported	9
Optimized, managing the project portfolio as a workflow and responding quickly to change.	15
Total responses	**53**

Q2. Evaluation of candidate projects, project selection and approval cycles are performed—

Answer Options	Response Count
Ad hoc (i.e., no set schedule)	11
As part of the annual budgeting cycle	11
Semi-annually, quarterly or monthly	15
When significant changes in project needs or project outcomes occur.	11
Do not know	5
Total responses	**55**

Q3. Project reviews are performed—

Answer Options	Response Count
On a regular basis (e.g., stage gate reviews or monthly/quarterly)	44
After project completion	3
Reviews are not performed	6
Total responses	**53**

Q4. As a result of the project review—

Answer Options	Response Count
Funds and resource allocations are reviewed	20
Corrective action is taken quickly	26
Nothing happens	7
Total responses	**53**

Q5. The Project Portfolio Management process is supported by—

Answer Options	Response Count
Limited tools and templates (i.e., spreadsheets)	22
A software-based PPM solution	21
No readily identified tool or process of any kind	10
Total responses	**53**

Q6. Overall I would rate our level of maturity in the Project Portfolio Management process as—

Answer Options	Response Count
Very mature	9
Mature	16
Somewhat mature	19
Immature	9
Total responses	**53**

Q7. In our organization we observe the following:

Answer Options	Agree	Disagree	No Opinion	Total Responses

Senior management appears satisfied with benefits from projects and the pace of benefits achievement.	31	8	8	**47**
There is a complete portfolio inventory, containing all projects.	25	14	7	**46**
Projects are not unilaterally approved by senior executives, but systematically selected and approved.	30	7	10	**47**
There are no redundancies and conflicts in project priorities.	15	19	12	**46**
A consistent approach for screening, prioritizing, selecting and approving projects is both defined and applied.	27	13	7	**47**
Dependencies between projects are clearly articulated and well-understood.	20	18	8	**46**
Priorities are consistent over time and do not change frequently.	15	27	5	**47**
There are few or no resource conflicts and work overload for critical resources is the exception.	20	19	7	**46**

Q8. As a result of the global recession, the following challenges have emerged:

Answer Options	**Agree**	**Disagree**	**N/A**	**Total Responses**
We are increasing the focus on Project Portfolio Management, as project funding decisions are more difficult.	26	9	8	**43**
The gap between available funds and the demand for project outcomes is increasing.	26	7	9	**42**
Resourcing projects is increasingly difficult and less predictable.	27	10	6	**43**
Direction and strategy change more frequently.	23	15	5	**43**
The funding approval process has become more complicated and time-consuming.	24	9	10	**43**
Strategic projects obtain significantly less funding than tactical projects, compared to previous years.	22	11	10	**43**
Project outcomes and delivery quality are suffering, as critical staff could not be retained, trained and developed adequately.	22	14	7	**43**
We struggle with our Project Portfolio Management process due to a lack of experience, tools or processes.	18	17	8	**43**

Q9. Which of the following best describes your job title?

Answer Options	Response Count
Executive/Line of Business Head	6
Line of Business Director/Manager/VP	8
PMO Head	4
Program Manager	6
Project Manager	18
Total responses	**54**

Q10. What is your company's annual revenue?

Answer Options	Response Count
< INR 100M	10
INR 100M to INR 1,000M	11
INR 1,000M to INR 5,000M	8
INR 5,000M to INR 10,000M	3
> INR 10,000M	10
Total responses	**42**

Q11. At what level is your project portfolio defined and managed? (Check all that apply)

Answer Options	Response Count
Corporate	22
Business Unit	25
Department	8
Division	5
Do not know	1
Total responses	**61**

Q12. How many projects are contained in the project portfolio in a given year?

Answer Options	Response Count
<10	12
10 to 100	20
101 to 1,000	2
>1,000	0
Do not know	8
Total responses	**42**

Q13. Which of the following best describes your role in the Project Portfolio Management process? (Check all that apply)

Answer Options	Response Count
Provide project proposals or business case	14
Participate in decision process to priorities and select projects	17
Approve final portfolio, appropriate funding	7
Allocate/manage resources	18
Manage PPM tool and/or process	19
Total responses	**79**

Q14. The Project Portfolio Management process is managed by—

Answer Options	Response Count
The head of the organization (e.g., CEO, Business Unit head, etc.)	15
The head of the finance organization (e.g., CFO, Business Unit Controller, etc.)	2
The head of the Project Management Office (PMO)	10
A steering committee or portfolio governance board	9
No particular individual	6
Total responses	**45**

Project Portfolio Management Survey Results – U.S. Public Sector

Q1. From my perspective, our organizational Project Portfolio Management process appears to be—

Answer Options	Response Count
Mostly ad-hoc and informal	12
Repeatable capital planning and investment control (CPIC) process for project business case evaluation, selection and approval, aligned with the federal fiscal year process	5

Standardized and tool-supported with the ability to select candidate projects under resource and financial constraints	3
Optimized, managing the project portfolio as a workflow and responding quickly to changes in project status or budget	2
Total responses	**22**

Q2. Evaluation of candidate projects, project selection and approval cycles are performed—

Answer Options	**Response Count**
Ad hoc (i.e., no set schedule)	4
As part of the annual budgeting cycle	7
Semi-annual, quarterly or monthly	5
When significant changes in project needs or project outcomes occur	3
Don't know	3
Total responses	**22**

Q3. Project reviews are performed—

Answer Options	**Response Count**
On a regular basis (e.g., semi-annually, quarterly or monthly)	13
After project completion	4
Reviews are not performed	5
Total responses	**22**

Q4. As a result of the project review—

Answer Options	**Response Count**
Funds and resource allocations are reviewed	5
Corrective action is taken quickly	6
Nothing happens	11
Total responses	**22**

Q5. The Project Portfolio Management process is supported by—

Answer Options	**Response Count**
Limited tools and templates (i.e., spreadsheets)	14

A software-based PPM solution	2
No readily identified tool or process of any kind	3
A clearly defined governance structure and decision-making process	3
Total responses	**22**

Q6. Overall I would rate our level of maturity in the Project Portfolio Management process as—

Answer Options	Response Count
Very mature	2
Mature	1
Somewhat mature	6
Immature	13
Total responses	**22**

Q7. In our organization, we observe the following:

Answer Options	Agree	Disagree	No Opinion	Total Responses
Senior management appears satisfied with benefits from projects and the pace of benefits achievement.	9	5	5	**19**
There is a complete portfolio inventory, containing all projects.	11	6	2	**19**
Projects are not unilaterally approved by senior executives, but systematically selected and approved.	6	9	4	**19**
There are no redundancies and conflicts in project priorities.	1	16	2	**19**
A consistent approach for screening, prioritizing, selecting and approving projects is both defined and applied.	6	12	2	**20**
Dependencies between projects are clearly articulated and well-understood.	3	14	3	**20**
Priorities are consistent over time and do not change frequently.	4	14	1	**19**
There are few or no resource conflicts and work overload for critical resources is the exception.	2	15	2	**19**

Q8. In the current environment, the following challenges have emerged:

Answer Options	Agree	Disagree	N/A	Total Responses
We are increasing the focus on Project Portfolio Management, as project funding decisions are more difficult.	15	2	2	**19**

The gap between available funds and the demand for project outcomes is increasing.	16	1	1	**18**
Government staff shortages make resourcing increasingly difficult and less predictable.	18	0	0	**18**
Direction and strategy change more frequently.	15	2	0	**17**
The funding approval process has become more complicated and time-consuming.	15	4	0	**19**
Strategic projects obtain significantly less funding than tactical projects, compared to previous years.	12	3	2	**17**
Project outcomes and delivery quality are suffering, as critical staff could not be retained, trained and developed adequately.	13	4	1	**18**
We struggle with our Project Portfolio Management process due to a lack of experience, tools or processes.	15	2	1	**18**

Q9. Which of the following best describes your job title?

Answer Options	**Response Count**
Director (GS15)	4
PMO Manager	3
Program Manager	3
Project Manager	8
Total responses	**19**

Q10. What is the approximate budgeted value of the project portfolio on an annual basis from the agency Exhibit 53?

Answer Options	**Response Count**
<$10M	6
$10M to $100M	4
$100M to $1B	5
$1B to $10B	1
>$10B	2
Total responses	**18**

Q11. How many major projects/programs requiring an OMB Exhibit 300 are typically contained in the project portfolio in a given year?

Answer Options	**Response Count**
<10	4

10 to 20	1
21 to 50	2
>50	4
Don't know	7
Total responses	**18**

Q12. Which of the following best describes your role in the Project Portfolio Management process? (Check all that apply)

Answer Options	**Response Count**
Provide project proposals or business case	10
Participate in decision process to prioritize and select projects	5
Approve final portfolio, appropriate funding	2
Allocate/manage resources	10
Manage PPM tool and/or process	7
Total responses	**34**

Q13. The Project Portfolio Management process is managed by—

Answer Options	**Response Count**
A dedicated portfolio management or CPIC office using a structured governance model	5
The head of the organization (e.g., CIO, Sub-agency head, etc.)	3
The head of the finance organization (e.g., CFO, Sub-agency head, Controller, etc.)	3
The head of the Project Management Office (PMO)	3
No particular individual	4
Total responses	**18**

APPENDIX B – PLESS EXPERIMENT - PARTICIPANT INSTRUCTIONS

PORTFOLIO DECISION MAKING

ITERATION A

You are provided with full information and limited guidance.

Please execute the following two tasks:

1. Screening of projects portfolio,
2. Portfolio selection and

Please fill in your responses in this document and return it when you are finished. Thank you.

You may return to Iteration A for reference purposes.

HOWEVER, PLEASE DO NOT GO BACK INTO ITERATION A TO MAKE CHANGES!

Introduction

BuyMoreStuff, Inc. (BMSI) sells software to engineering companies. BMSI's software enables their customers to market highly customized industrial engineering products. The functionality of the software covers order entry, payment and inventory management.

For the first time in its history, BMSI is experiencing a sharp decline in earnings, as its software has fallen behind in the competition for state-of-the art software in their market and needs to decide whether to fix and enhance the current software products or to embark on developing a new product generation. To make things worse, the large cash reserves of the firm are nearly depleted, as a result of a staggering loss in 2009, and further losses are expected in 2010, which is the greatest challenge for the company.

As part of the annual approval process for projects in the new Fiscal Year 2011 (FY2011), 16 project proposals have been brought forward from within the organization. As available funds and personnel resources do not allow the pursuit of all projects, only the "best" of them can be selected and executed in FY2011. In this study, you play the role of the executive, who decides, which projects will be pursued and which will be rejected. Please note that your decisions are focused on a one-year investment time frame. As a result of your selection, funds and resources for FY2011 will be allocated.

BMSI's culture is rather consensus-oriented: projects with a high degree of executive support typically have the highest chance of success (single-sponsor projects never succeed). BMSI management has maintained its pioneer spirit: it is willing to assume calculated risks.

BMSI's CEO communicated the following strategy: First and foremost, restore short-term financial success; secondly, return to developing state-of-the-art solutions; and lastly, put the focus back on the customer.

Your management team has been discussing the strategy and decided to aim at raising the customer satisfaction score by at least 10%. You also agreed that those projects that don't deliver *any* return on investment will experience exceptional scrutiny in the decision process.

Please read through the **project overview** for all projects that have been proposed at this decision point and are the basis for your selection (EXHIBIT 1).

Also, familiarize yourself with the **business case data** in the Excel Spreadsheet. All long-term and short-term benefits, cost and resource data are estimates, provided by the managers, who have submitted business cases for their respective proposals. The following provides some further explanation of what you find in the columns of the Excel Spreadsheet:

- Long-term Benefit and Cost (FY2011-2015, 5-year time frame)
  - Return (estimate, attributable to the project)
  - Total Estimated Cost (total cost of the project)
- Short-term Benefits, Cost and Resource Needs (FY2011, 1-year time frame)
  - Return (Estimate for realized return in 2011, attributable to the project)
  - Customer Satisfaction Score (measure of satisfaction based on annual survey)
  - Cost (project cost incurred in FY2011)
  - Resources (Number of senior developers, junior developers and services staff, required for the duration of the project)
- Minimum. Project Duration (time it will take at a minimum to finish project)
- Other decision-relevant variables
  - Return on investment (ROI) 2011 – ratio of 2011 return divided by 2011 cost
  - 5-year return on investment – ratio of 5-year return divided by cost over 5 years
  - Confidence of success – confidence level of the manager who approved the project proposal, that the project will succeed
  - Innovation content – degree of innovativeness or technical sophistication, as evaluated by your head of Research & Development
  - Committee votes – votes of your 12 executive committee members in favor of pursuing the project

Task 1: Screening of projects

To simplify the decision of which projects to pursue and which to reject, you are asked to eliminate three projects in a first decision round.

Before you reject any projects, you should consider the following interdependencies, which may have an impact on your decision:

I. Projects Number 11 and 12 are mandatory and cannot be eliminated.
II. Projects 2, 3, and 4 highly benefit from the prior completion of project 1.
III. Starting Project 5 requires the prior completion of Projects 2, 3 and 4.
IV. Starting Project 6 requires the prior completion of Projects 2, 3, 4 and 5.
V. Starting Project 7 requires the prior completion of Project 5 and 6.
VI. Project 8 can only start one month before the completion of Project 7.
VII. Starting Project 14 requires the prior completion of Project 13.
VIII. The benefit of Project 1, a 10% reduction of development cost, is variable and depends on what and how many development projects (P2, P3, P4 and/or P5) are pursued.
IX. The benefits of Project 7 will only be achieved, if Projects 5 and 6 are successfully accomplished.
X. Benefits of Project 14 will be reduced by 30%, if both Project 14 and Projects 2, 3 and 4 are pursued (this means that 30% of customers are estimated to choose the new software over the enhanced current software).

Based on the objectives described in the introduction and the information provided above, which three projects would you eliminate from further consideration?

*Please check (**X**) the three projects, which you decide to eliminate:*

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**

Which criterion or criteria influenced your decision? Please describe.

____

____

____

Task 2: Portfolio Selection

Use the Microsoft Excel Table to choose those projects that you suggest to execute, subject to funding and resource constraints. By changing the SELECT Yes/No attribute to "0," you will de-select projects and can see the impact on the use of budget and staffing resources.

You are assigned a 2011 budget of $4.5 million and you have 8 Senior Developers, 25 Junior Developers and 25 Services Staff at your disposal (see constraint line near the bottom of the spreadsheet. These constraints cannot be exceeded! When total project cost and resources for the projects you selected exceed the above constraints, you must eliminate projects until the constraints are met. (As long as your "sum" values are highlighted "Red" and not "Green," you are not finished!)

Please mark projects you selected to pursue ("1") and those you decided to reject ("0"):

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**

What metrics did you use to support your decision for projects to be pursued or rejected? What weights did you give the respective metric(s)?Please check (***X*** *)*

Metric (listing is in no particular order)	**Weight in your decision**			
	High	**Medium**	**Low**	**None**
Confidence of success				
5-year return on investment				
Number of votes				
1-year return on investment				
Degree of innovation				
Customer satisfaction				
Other? ______________________________				

What's your feedback to the CEO?

	Agree	**Disagree**	**Not sure**
The strategy appears to be attainable			
Other feedback:			

EXHIBIT 1: Project Overview

ID	Project Name	Description	Benefits	Additional information
1	Development Accelerator	Acquire and implement a Computer-Aided Software Design tool to accelerated development.	Yields 10% cost savings on new development projects (#2, 3, 4 and 5) and helps reduce errors.	CIO has a strong desire to quickly complete this as an accelerator to the development efforts.
2	eOrder Application Development	Development of a Web-based order entry application for complex orders of engineering products	This new product will allow attracting customers, due to features and enormous flexibility. The solution is highly innovative.	Close integration with eInventory and ePayment application has greatest merit for customer
3	eInventory Application Development	Development of a Web-based order entry application for complex orders of engineering products	Same as eOrder application	Close integration with eOrder and ePayment application has greatest merit for customer
4	ePayment Application Development	Development of a Web-based payment processing application for complex orders and terms and conditions	Same as eOrder application	Close integration with eOrder and eInventory application has greatest merit for customer
5	Data Loader Development	Tool necessary to allow for data conversion for legacy customers who want to migrate to e-Application suite	Allows conversion of existing data, which is expected to be a mandatory requirement of existing customers	This tool must be built if at least one of Web-based applications is deployed.
6	System Integration	Integration of eOrder, eInventory, ePayment into one integrated solution	Major selling point to new customers of the Web-based application.	.
7	Pilot Implementation	Test implementation of the integrated Web-based applications (Projects 2, 3, 4 ,5) with one new customer	Final validation of Web-based applications and their implementation with live customer.	The pilot is a first trial of the new software. The marketing campaign will only start, if the pilot implementation is successful.
8	Marketing Campaign	Advertize new Web-based application suite to target customers.	Customer awareness	.
9	Agile Development Method & Training	Implement the "Agile" development methodology to accelerate development of software packages	Improved efficiency of development teams and shorter timelines	Agile will only be used for the non-critical software development, which limits risks, but also benefits.
10	Office Renovation	Complete renovation of the building.	Boost employee morale and improve appearance of the property. All exec's will modern offices with windows.	This idea was brought to the table by the CEO, who had committed to an activity that would boost morale of the staff.
11	Server Update (MANDATORY)	Buy and install new hardware and migrate existing applications.	Increase of Server Capacity to enable Software as a Service application hosting	This is critical to have apps running and store client data. Project must be done in order to run Web-based products.
12	Data Conversion Tool (MANDATORY)	Build additional software "adapters" to allow access to customer data.	Allow selling to large enterprise customers, who will need to interface with many data sources.	Necessary additional activity to make software work with most clients.
13	Fix of current software	Fix errors in existing software product.	Addresses bugs reported by customers and significantly improve customer satisfaction with existing tool.	This project should be considered whether the new Web-based product suite is developed or not.
14	Enhancement of current software	Enhance existing software to allow for basic Web-based access.	Implement some of the functionality, requested by existing and desired by target clients in the existing software.	Cheaper alternative to Web-based applications, but smaller target market.
15	Improved software testing method	Implement new software testing tool for early detection of software errors	Error reduction.	Usable for all development efforts.
16	Engineering Product Exchange	B2B market place for engineered product orders - the "eBay for complex engineering products"	New source of income for BMS Inc., leveraging the large customer base and functionality of the existing product suite	This proposal came from a young Sales Engineer and is supported by his manager.

PORTFOLIO DECISION MAKING

ITERATION B

You are provided with the same case as in Iteration A, but with additional guidance and visual aids.

Please repeat the execution of the following three tasks:

1. Screening of projects portfolio,
2. Portfolio selection and
3. Strategy validation

Please fill in your responses in this document and return it when you are finished.
Thank you.

You may return to Iteration A for reference purposes.
HOWEVER, PLEASE DO NOT GO BACK INTO ITERATION A TO MAKE CHANGES!

Task 1: Screening of projects

To simplify the decision, which projects to pursue and which to reject, you are asked to eliminate three projects in a first decision round. You are guided through a six-step decision approach.

Step 1: Understand the objectives of the exercise

- Earmark projects, which cannot be eliminated under any circumstances.
- Eliminate projects, which do not meet certain screening criteria

Step 2: Understand Screening criteria and thresholds elimination

- Keep non-negotiable projects.
  Threshold: Projects that are labeled as "MANDATORY"

- Eliminate projects that are not feasible
  Threshold 1: Projects that by themselves (!) exceed total budget or resource constraints (such project may or may not exist) or
  Threshold 2: Projects that are recognized as not feasible, as a result of the interdependencies analysis (see below)

- Eliminate Projects that do not meet minimum pass criteria:
  Threshold : Projects that do not yield a 5-year ROI >0
  Threshold: Projects with one vote or less (insufficient support, as per introduction)

Step 3: Define Methods to use

Here is what you will do in the "Execute" Step

- Analysis of interdependencies to avoid elimination of interrelated projects
- Application of screening criteria (as spelled out in Step 2), with regard to interdependencies

Step 4: Execute

- *Perform Interdependency Analysis*

EXHIBITS 2, 3 and EXHIBIT 4 help you understand the interdependencies between projects, which you should take into account when selecting or deselecting projects.

- *Eliminate three projects, based on your screening criteria and thresholds*

Please check ☒ the <u>three</u> projects that you decide to eliminate:
What criterion or criteria influenced your decision? Please describe.

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**

____

____

Task 2: Portfolio Selection

Before you proceed to the project selection, it is advisable to define what metrics to use for the decision. As you have multiple metrics at your disposal to support your decision, you must choose which ones are most aligned with the objectives of the organization.

Step 1: Revisit and prioritize organizational goals and map best-fit metric to each goal

The choice set of metrics includes:

- Confidence of success
- 5-year return on investment
- Number of votes
- 1-year return on investment
- Degree of innovation
- Customer satisfaction

Goal (See CEO's Strategy in Introduction)	**Corresponding Metric**	**Threshold** (minimum value to be selected – this may be N/A)	**Priority (H/M/L)**
1.			
2.			
3.			

Step 2: Project Selection

Use the Microsoft Excel Table to choose those projects that best meet the goals and priorities that you have identified above. The selected projects are subject to:

- Funding and resource constraints
- Interdependencies, as identified in Task 1

By changing the SELECT YES/NO attribute to "0," you will de-select projects and can see the impact on the use of budget and staffing resources.

You are assigned a 2011 budget of $4.5 million and you have 8 Senior Developers, 25 Junior Developers and 25 Services Staff at your disposal (see constraint line near the bottom of the spreadsheet. These constraints cannot be exceeded! When total project cost and resources for the projects you selected exceed the above constraints, you must eliminate projects until the constraints are met. (As long as your "sum" values are highlighted "Red" and not "Green," you are not finished!)

Please mark the projects you selected ("1") and did not select ("0"):

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**

What criteria did you apply? What was your rationale for the selection? Please check: ☒

Metric (listing is in no particular order)	**Relevance**			
	High	**Medium**	**Low**	**Not**
Confidence of success				
5-year return on investment				
Number of votes				
1-year return on investment				
Degree of innovation				
Customer satisfaction				
Other? ______________________________________				

Task 3- Strategy Analysis

The introduction provided the following strategy statement by the CEO:

"BMSI's CEO communicated the following strategy: Restore short-term financial success, return to innovation and put the focus back on the customer. Customer satisfaction, which is surveyed annually, shall return to previous levels. The goal is to increase customer satisfaction score in FY2011 by at least 15%."

Please validate the following statements (☒) and provide your rationale:

	Agree	**Dis-agre e**	**Not sure**	**Comment/ Rationale**
The strategy is clearly articulated				
The strategy is consistent in its objectives				
As a result of the portfolio selection exercise, the strategy appears to be attainable				

The CEO adds to his strategy statement the objective to earn a FY2011 return of at least $1.2 million as a result for the selected projects.

Please validate the following statements (☒):

	Agree	**Disagree**	**Not sure**
Feasible without further resources and funds			

With your understanding of the company's situation and if constraints were less stringent, which project or projects would you have pursued that you did not include in you selection?

Project(s)	**Rationale**

Reflection

Please reflect on the choices you made in Iteration B, versus Iteration A:

Statement	**Disagree**	**Somewhat disagree**	**Neutral**	**Somewhat Agree**	**Agree**
1. Iteration B made interdependencies between projects more transparent.					
2. The interdependency analysis has changed my decision what projects to eliminate.					
I feel more confident about having eliminated the right projects.					
3. The step-wise approach has influenced my prioritization of metrics used for the portfolio selection.					
4. I sense that the portfolio I selected delivers greater benefits than the portfolio I selected in Iteration A.					
5. The portfolio I selected is more in line with the strategy, compared to my choices in Iteration A.					

What would be your feedback to the CEO, toward consistency of his strategy?

Do you think the strategy can be successfully implemented?

EXHIBIT 2: Technical Interdependencies Between Projects

Example: Project 6 requires completion of Projects 2, 3, and 4. Project 14 requires completion of Project 13.

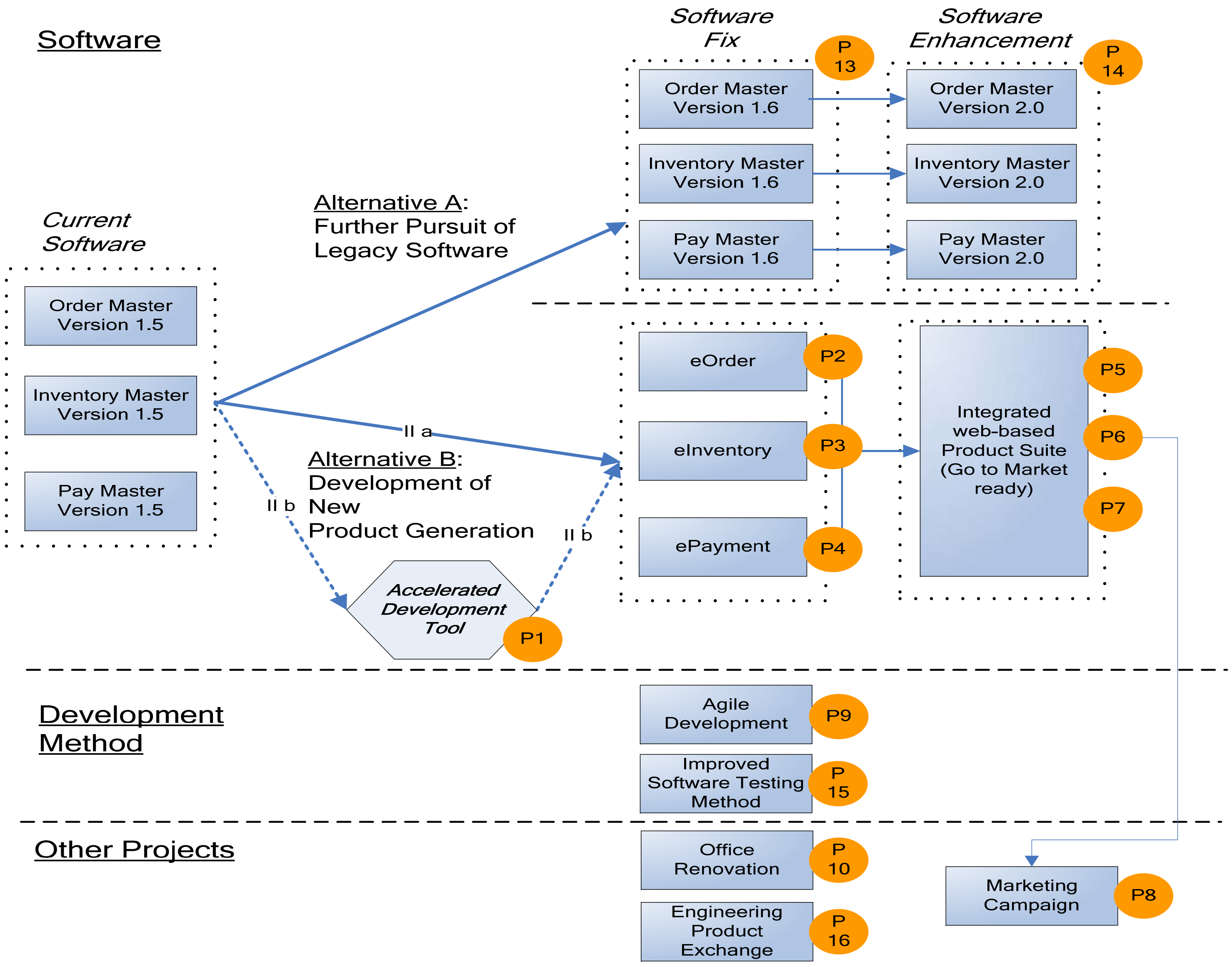


EXHIBIT 3: Time Interdependencies of Projects

Interdependencies II through VI are illustrated with in this exhibit (see page 4). The beginning of the bar in the chart indicates <u>*earliest possible start*</u>*. The chart indicates which projects are feasible within FY2011 and which can be excluded as not feasible.*

Task Name	Duration	Predecessors
1 Development Accelerator	1 mon	
2 eOrder Application	6 mons	1
3 eInventory Application	6 mons	1
4 ePayment Application	6 mons	1
5 Data Loader	2 mons	2,3,4
6 System Integration	4 mons	2,3,4
7 Pilot Implementation	2 mons	5,6
8 Marketing Campaign	6 mons	7
9 Agile Development Method & Training	1 mon	
10 Office Renovation	12 mons	
11 Server Update	3 mons	
12 Data Conversion Tool	3 mons	
13 Fix of current software	6 mons	
14 Enhancement of current software	6 mons	13
15 New software testing method	2 mons	
16 Engineering Product Exchange	12 mons	

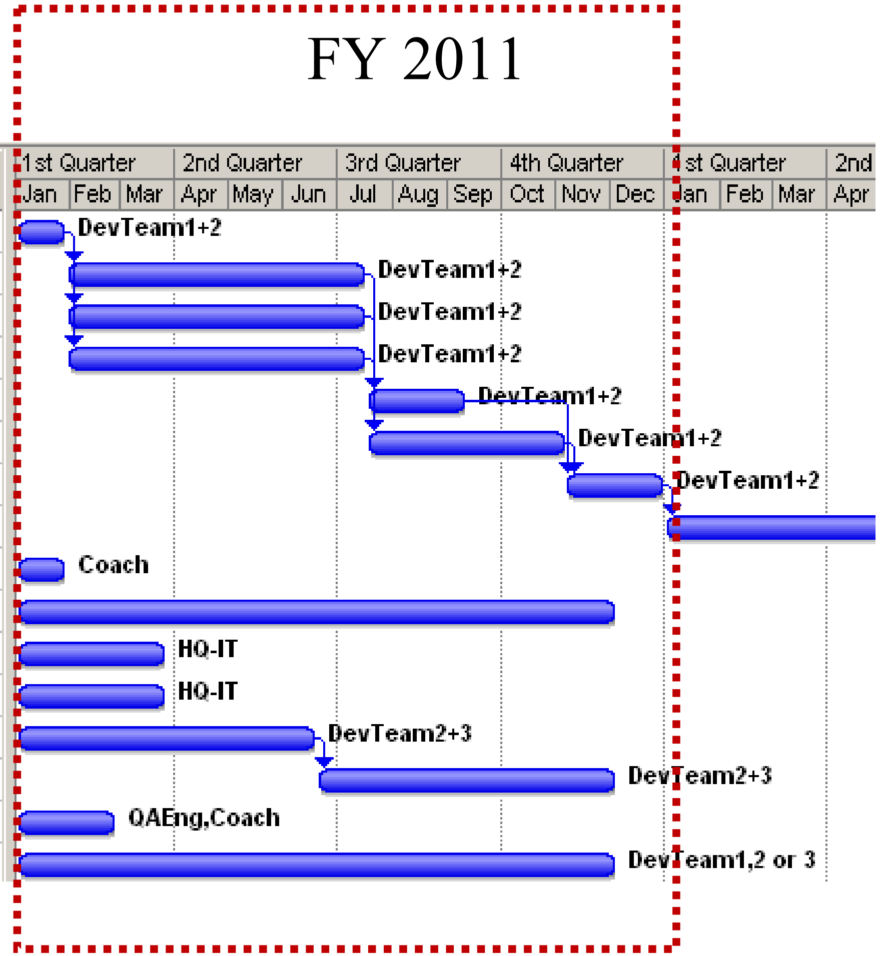
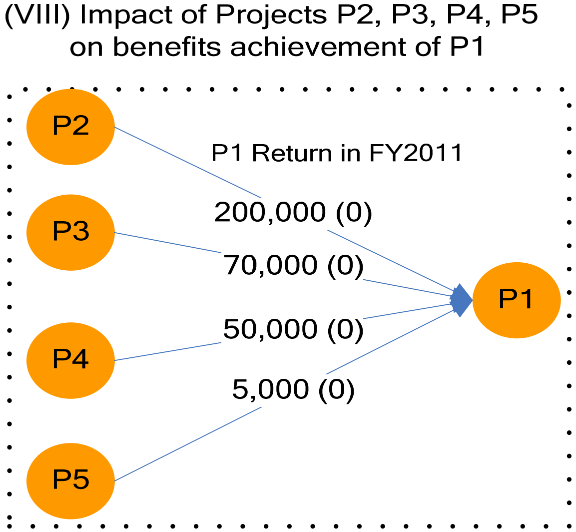
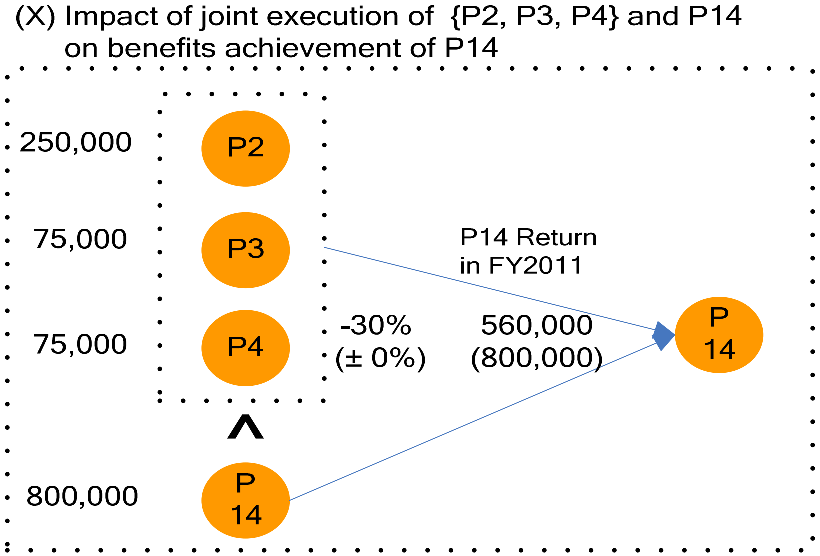


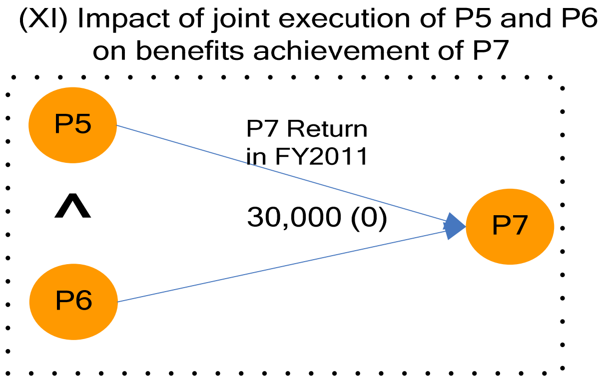
EXHIBIT 4: Benefits Interdependencies Between Projects

This is <u>for your information</u>, as certain benefits numbers (return in $) will automatically change in the Excel Spreadsheet, when you de-select or select interdependent projects.

The interdependency diagrams symbolize what happens to a project (right side of each graph). If a certain project is realized and achieves (or does not achieve) its benefits, then what's the impact on another project







Roman Numerals correspond to benefits interdependencies numbers listed under Iteration A, Task 1.

APPENDIX C – PLESS EXPERIMENT – REVIEW BOARD APPLICATION

Princeton University

Institutional Review Board for Human Subjects

Questionnaire B 2009-2010

PROTECTED SUBJECTS POPULATION

CRITERIA FOR EXEMPTION FROM REVIEW

BY THE INSTITUTIONAL REVIEW BOARD FOR HUMAN SUBJECTS

1. Are the data you propose to collect from or about any of the following protected populations: **prisoners**; **pregnant women**; **fetuses**; **or institutionalized mentally disabled** (individuals residing as patients in an institution who are mentally ill or retarded; emotionally disturbed; psychotic; or senile)?

   If Yes, then you <u>may not</u> apply for exemption review and <u>must</u> submit a Questionnaire A to the IRB for regular review.

***No**. We do not aim to collect data from prisoners; pregnant women; fetuses; or institutionalized mentally disabled. Since we are conducting an online experiment we cannot categorically exclude individuals from all protected populations, however, no part of our research addresses specific risks related to these groups, or advertises our experiment in a way that protected groups are targeted.*

2. Are the data you propose to collect from or about **minors**?

If Yes, will the research involve a survey, an interview, or observations in which the investigator participates in the activities being observed?

If Yes to this last question, then you may not apply under exemption review criteria and must submit a Questionnaire A to the IRB for regular review.

No. *We do not aim to collect data from minors. The terms of service of the research site prohibit the participation of minors. We have no additional means to guarantee the exclusion of minors. Our experiment does not increase any risk factors additional to what a user would generally experience on the research site.*

If your answers to questions 1 and 2 are No, you might be able to submit a Questionnaire B to the IRB for Human Subjects for review. See exemption criteria at the end of this form.

1.a. State the title of the proposed research.

Validation of propositions to improve outcomes from IT portfolio selection

1.b. If applicable, please *list the agencies* (University or other) that are funding or have been asked to fund this research.

The research will be funded by Princeton University. Additional resources will be provided from private funds of Mr. Mario Arlt, if needed. These funds are no provided by other agencies with conflicts of interest.

2. State approximate dates for starting and ending this research project. **(Note: The project may not start until it has been approved by the Board.)**

This effort is to commence as early as possible, and intend to collect data during a 1-2 week timeframe to accommodate a May 15 deadline for the latest starting point of the data analysis.

3.a State the name of the Investigator(s), departmental address(es), e-mail address(es), fax number(s), and campus phone number(s). All applicants other than professors must list the name, departmental address, e-mail address of a faculty advisor. Use the abbreviations listed on the cover page to identify all names listed.

AD: Adam Finkelstein, Associate Professor, Department of Computer Science, 35 Olden Street, Princeton University, Princeton, NJ 08540;
Voice: (609) 258-5756; Fax: (609) 258-1771; Email: af@cs.princeton.edu

AD/Postdoc: Jens Grossklags, Postdoctoral Research Associate, Center for Information Technology Policy (CITP), Sherrerd Hall, Third Floor (Room 318), Princeton, NJ 08544, Voice: (609) 258-2278, Fax: (609) 964-1855; Email: jensg@princeton.edu

PI/Doctoral Student: Mario Arlt, School of Property, Construction and Project Management, RMIT University, PO Box 2476V, Level 8, 368 Swanston St, Vic 3001, Melbourne, Australia
Voice: (609) 916-0101; Fax: (208) 730-7825; s3114759@student.rmit.edu.au

3.b Is this a student project? If yes, please check the appropriate box:

☐Junior Project ☒Senior Thesis

This is a joint research project between Dr. Grossklags and Mr. Arlt

4. Provide a detailed description of the research including a characterization of the nature and context of research interaction with subjects, respondents or informants. If applicable, include a sample of your survey. If you are claiming exemption under category 4, the study of existing data or specimens, please provide the source and type of the research material, and describe your research objectives and methodology.

Goals of the research:

We propose to undertake an experiment to better understand the impact of methodology refinements and the provision of additional portfolio-related data on selected project portfolios and the resulting benefit from their execution. The tasks will be performed in a

Web-based application, which both guides the individual through the decision process and provides information to improve the quality of decisions between iterations.

<u>The task:</u>

In prior research the investigator (Mario Arlt) developed four propositions for the improvement of project portfolio selection, a complex task typically performed by IT managers and executives. The investigator conducted an initial survey, which confirmed the relatively low degree of maturity of decision quality, attributable to—at least in part—bounded rationality of the decision makers.

It is the objective of the study to introduce both information and decision aides and validate the outcome of the selection process pre- and post- model and information improvements.

Exhibit 1 illustrates the portfolio matrix provided to the participants, which will be modified and enriched with data throughout the study.

EXHIBIT 1: SAMPLE PORTFOLIO MAP FOR PROPOSITION VALIDATION

General information		Long-term (FY 2011-2015) Benefit and Cost		Short-term (FY 2011) Benefits, Cost and Resource Needs						Minimum Project Duration	Return on investment (ROI)		Confidence of success	Innovation Content	Committee Votes	SELECT YES/NO
ID	Project Name	Return ($)	Total Est. Cost ($)	Return ($)	Cost in FY 2011	Increase in Customer Satisfaction (Score)	Senior Developer	Junior Developer	Services Staff	(Months)	FY 2011 ROI	5-year ROI	Confidence Level	Degree of Innovation	(out of 12)	0=No 1=Yes
1	Development Accelerator	385,000	200,000	320,000	100,000	5%	0.5	1.5	0.0	1	320%	**193%**	**100%**	High	**3**	0
2	eOrder Application Development	5,000,000	2,500,000	250,000	2,000,000	0%	1.0	4.0	0.0	6	13%	**200%**	**60%**	High	**6**	1
3	eInventory Application Development	1,500,000	750,000	75,000	700,000	0%	1.0	3.0	0.0	6	11%	**200%**	**60%**	High	**6**	1
4	ePayment Application Development	1,500,000	600,000	75,000	500,000	0%	1.5	3.0	0.0	6	15%	**250%**	**60%**	High	**6**	1
5	Data Loader Development	300,000	50,000	0	50,000	0%	0.0	2.0	0.0	2	0%	**600%**	**60%**	Medium	**6**	0
6	System Integration	0	150,000	0	150,000	0%	0.5	4.5	0.0	4	0%	**0%**	**60%**	Medium	**6**	0
7	Pilot Implementation	0	300,000	0	300,000	0%	1.0	2.0	5.0	3	0%	**0%**	**90%**	N/A	**4**	1
8	Marketing Campaign	1,000,000	500,000	0	500,000	0%	0.0	0.0	0.0	6	0%	**200%**	**50%**	N/A	**12**	1
9	Agile Development Method & Training	100,000	150,000	20,000	150,000	0%	1.0	0.0	2.0	1	13%	**67%**	**50%**	High	**3**	1
10	Office Renovation	0	5,000,000	0	1,000,000	0%	0.0	0.0	0.0	18	0%	0%	**100%**	Low	**11**	0
11	Server Update (MANDATORY Project)	0	250,000	0	250,000	0%	0.0	0.0	2.0	3	0%	**0%**	**100%**	N/A	**8**	1
12	Data Conversion Tool (MANDATORY Project)	0	100,000	0	100,000	0%	1.0	2.0	0.0	3	0%	**0%**	**100%**	N/A	**8**	1
13	Fix of current software	1,500,000	1,000,000	300,000	1,000,000	15%	2.0	10.0	1.0	6	30%	**150%**	**95%**	Low	**6**	0
14	Enhancement of current software	0	3,000,000	0	3,000,000	0%	3.0	8.0	1.0	6	0%	**0%**	**95%**	Low	**6**	0
15	Improved software testing method	50,000	100,000	0	100,000	5%	1.0	1.0	0.0	2	0%	**50%**	**90%**	High	**3**	0
16	Engineering Product Exchange	10,000,000	500,000	0	500,000	5%	1.0	3.0	2.0	12	0%	**2000%**	**80%**	High	**1**	0
	Constraints				**4,500,000**		**8.0**	**25.0**	**10.0**							
	Sum	9,100,000		420,000	4,500,000		6.5	14.0	9.0							

Experimental design parameters:

We intend to capture the choices participants make, measure the speed of decision making and will survey the self-perceived confidence level with the decisions made.

Description of experimental protocol:

We will design, deploy and host the experiment on a Princeton University server. After completion of the programming we specify the payment and bonus (for successful portfolio selection) that individuals will receive after completion. We will orient the payments on the current standards for other similar experiments conducted by Princeton Computer Science Researchers studies.

We will then design a standardized "flyer" that will be provided to the students. The message will include a brief description including:

- *Title message and payment (and potentially bonus)*
- *Brief description of the task*
- *Potential discussion of payment conditions*
- *Potential framing (e.g., to encourage helping)*

When individuals select our task they will see our experiment within a Microsoft Excel spreadsheet.

Individuals will also receive task instructions and feedback forms. The experiment will be repeated several times for a number of tasks.

At the end of experiment participants are requested to respond to a brief questionnaire to receive individual's feedback about the task.

We are meeting exemption criteria:

Like a typical task available in such experiments: Our task is similar to others studies performed. Such tasks include the testing of user interfaces, evaluation of pictures, and quiz-like surveys.

No coercion: Potential participants can sort the task according to different criteria.

Leave the experiment at any time: Participants that select our task can abort the task at any time during the experiment. They will then not receive payment for participation.

Rules are clearly communicated: We clearly explain the payment rules to the participants, and what the task entails. We do not explain to them the entire framework of *our complete experiment, that is, that we are contrasting and comparing different portfolio selection and analysis methodologies.*

Anonymity: Participants have a user ID that will be communicated to us when they are accepting and completing the task. We have no means to associate the user ID with actual personally identifying data.

Physical, legal, psychological, or social jeopardy: We do not expect that individuals will be harmed in any form. Individuals might be slightly disappointed with our task because they might find it boring or difficult. There is a minor risk that a technical glitch (for example, disconnection from our research Website) would prevent payment. But we will thoroughly test our setup to prevent such outcomes.

No deception: We do not hide any essential experiment characteristics from potential participants.

5. Does the research proposed meet all criteria for protected subject population exemption review (see list at end and check the appropriate box): ☒ Yes ☐ No.

6. Check the appropriate exemption claim category. Read carefully the Criteria for Exemptions located at the end of this document before completing.

   [ ] 1. Educational based research (results not incorporated into students' grades).

   [X] 2. Educational tests, observation of public behavior, interview or survey procedures (non-sensitive material, anonymity guaranteed).

   [ ] 3. Educational tests, observation of public behavior, interview or survey procedures that are not exempt under Category 2, but may be exempt if the human subjects are elected or appointed public officials or candidates for public office (non-sensitive material, but anonymity is not required because the subjects are in the public arena).

   [ ] 4. Collection or study of existing data, pathological or diagnostic specimens (anonymity guaranteed).

   [ ] 5. Public benefit or service programs.

   [ ] 6. Taste testing.

7. Training and Certification. All University personnel who interact with human subjects or with identifiable subject data as part of this research project must complete the University's training program and be so certified prior to initiating contact with subjects or identifiable subject data. Furthermore, all third party contractors or subcontractors or collaborating institutions whose personnel will interact with human subjects or with identifiable subject data as part of this research project must certify to the IRB that their personnel have undergone appropriate internal training as well.

Please respond to the following questions:

a. Have all investigators identified above completed the University's training program (please check appropriate box): ☒ Yes ☐ No.

b. Are there any current or anticipated future employees or students working on this project who will interact with human subjects or with identifiable subject data?
☐ Yes ☒ No.

c. Are there or will there be any third party contractors or subcontractors or collaborating institutions working on this project whose personnel will interact with human subjects or with identifiable subject data? ☒ Yes ☐ No.

Mr. Arlt is not affiliated with Princeton University. He is a Doctoral Student at the School of Property, Construction and Project Management, RMIT University, PO Box 2476V, Level 8, 368 Swanston St, Vic 3001, Melbourne, Australia.

The raw data will be exclusively maintained in the United States. Only results of the data analysis will be used for external publication.

Please note that the IRB **will not approve** this study unless all proper training is completed or certifications are received.

8. Include the signature of the Investigator(s) and the date. Also include the advisor's signature, if applicable.

For student projects:

Faculty Advisor Assurance:

I am the faculty advisor for the student submitting this protocol. By my signature, I certify that I have reviewed the protocol and believe that it is scientifically and ethically sound. Furthermore, I believe that the student has the necessary training, experience and knowledge to conduct the research in a manner consistent with the regulations governing human subject research and sound research principles. I agree to:

- Oversee and monitor the conduct of this research by communicating regularly with the student investigator;
- Assist with the resolution of any problems or concerns encountered during the research;
- Assure that the Princeton IRB is notified in the event of an adverse event or protocol deviation.

I understand that as faculty advisor I am responsible for the conduct of this research.

Mario Arlt (sig)

____

Student Investigator (Mario Arlt)

Date: 4/15/2010

Adam Finkelstein (sig)

____

Faculty Advisor (Prof. Adam Finkelstein, PhD)

Date: 4/15/2010

Jens Grossklags (sig)

____

Postdoctoral Advisor (Jens Grossklags, PhD)

Date: 4/15/2010

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Mario Arlt** successfully completed the NIH Web-based training course “Protecting Human Research Participants”.

Date of completion: 04/09/2010

Certification Number: 430637

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Adam Finkelstein** successfully completed the NIH Web-based training course “Protecting Human Research Participants”.

Date of completion: 12/03/2009

Certification Number: 281311

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Jens Grossklags** successfully completed the NIH Web-based training course “Protecting Human Research Participants”.

Date of completion: 12/02/2009

Certification Number: 346652

CRITERIA FOR EXEMPTION FROM REVIEW
BY THE INSTITUTIONAL REVIEW BOARD FOR HUMAN SUBJECTS

To protect the ultimate interests of all human subjects, the University asks that each investigator obtaining information from human subjects, respondents or informants send a statement characterizing each research study to the IRB. Normally, this statement will take the form of answers to QUESTIONNAIRE A, submitted for review by the IRB for Human Subjects. Certain categories of research listed below are EXEMPT from this review process. If the investigator (or in the case of a student, his/her advisor or supervisor) believes his/her research clearly qualifies as EXEMPT for one of the listed reasons, he/she may signify this by indicating the exemption category on the attached form (QUESTIONNAIRE B). Copies are available from the IRB website, the URL is: http://www.princeton.edu/orpa/irb.htm. Completed QUESTIONNAIRES (either A or B) should be returned to ORPA, where they will provide an ongoing record of research involving human subjects, respondents, or informants conducted at Princeton University or by Princeton personnel.

In general, EXEMPT research should have each of the following **characteristics**:

- Participation by human subjects, respondents, or informants can in no way put them in physical, legal, psychological, or social jeopardy.
- The purpose and sponsorship of research is clearly and accurately stated to the subjects, respondents, or informants.
- No coercion is involved in eliciting participation and subjects, respondents, or informants are made clearly aware that they may withdraw from participation at any time.

Bearing these considerations in mind, the following **categories** of research are EXEMPT from full review by the IRB on Human Subjects:

(1) **Education-based research**

Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as research on regular and special education instructional strategies, or research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

(2) **Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior may be exempt, unless:**

a. Information obtained is recorded in such manner that human subjects can be identified, directly or through identifiers linked to the subjects; and
b. Any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

(3) **Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, that is not exempt under category (2) of this section, may be exempt if:**

a. The human subjects are elected or appointed public officials or candidates for public office; or
b. Federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

(4) **Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, may be exempt if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.**

(5) **Research and demonstration projects may be exempt if they are conducted by or subject to the approval of department or agency heads, and they are designed to study, evaluate, or otherwise examine:**

a. Public benefit or service programs;

b. Procedures for obtaining benefits or services under those programs;

c. Possible changes in or alternatives to those programs or procedures; or

d. Possible changes in methods or levels of payment for benefits or services under those programs.

(6) **Taste and food quality evaluation and consumer acceptance studies may be exempt:**

a. If wholesome foods without additives are consumed; or

b. If a food is consumed that contains a food ingredient at or below the level and for a use at or below the level found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the US Department of Agriculture.

We emphasize that the above categories refer only to research that is routinely EXEMPT from full IRB review. RESEARCH THAT DOES NOT CLEARLY FALL INTO ONE OF THE SIX EXEMPTION CATEGORIES MUST BE REVIEWED BY THE FULL IRB FOR PROTECTION OF HUMAN SUBJECTS THROUGH SUBMISSION OF A QUESTIONNAIRE A AND IT WILL BE APPROVED, IF IN THE JUDGMENT OF BOARD MEMBERS, THE INTERESTS OF HUMAN SUBJECTS ARE ADEQUATELY PROTECTED.

IRB
Institutional Review Board
For Human Subjects

Princeton University
Office of Research and Project Administration
Fourth Floor, New South Building
Post Office Box 36
Princeton, NJ 08544-0036
609-258-3105

NOTICE OF EXEMPTION

From: Alex Todorov
Chair, IRB
Date: April 23, 2010

RE: Protocol #: 0000004817

Protocol Title: Validation of propositions to improve outcomes from IT portfolio selection

The above named protocol and following information (if applicable) has been reviewed and found to qualify for Exemption according to paragraph #2 of 45 CFR 46.101(b) of the Code of Federal Regulations of the Department of Health and Human Services.

This Notice of Exemption does not replace, or serve in place of, any departmental or other approvals that may be required
.

- If you wish to have your protocol approved for continuation, please submit a completed Continuation Form at least one month before the expiration date. It may take up to four weeks from the time of submission to the time of approval to process your continuation request.

- **Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol on the expiration date. Information collected following suspension is unapproved research and can never be reported or published as research data.**

- If you do not wish continued approval, please notify the IRB when the study is terminated.

- Once the protocol has been completed, please notify the IRB.

- The IRB has the responsibility to ensure that this research continues to meet the eligibility requirements for exempt status. Therefore, all changes or amendments to your protocol or consent form require review and approval by the IRB **BEFORE** implementation.

APPENDIX E – APPROVAL TO USE CLIENT CASE STUDY INFORMATION

The following email exchange documents the permission to use case study data for the purpose of this thesis.

From: [redacted]
Sent: Wednesday, May 19, 2010 10:17
To: Arlt, Mario
Subject: FW: Case study for doctoral thesis work

Hi Mario,

I've got the approval for your case study.
Thanks,
[redacted]

From: [redacted]
Sent: Wednesday, May 19, 2010 10:04 AM
To: [redacted]
Subject: RE: Case study for doctoral thesis work

Hi [redacted] – This looks fine – thanks for sharing.

Many thanks,

[redacted] *– Corporate Affairs Department*
[redacted]

From: [redacted]
Sent: Tuesday, May 18, 2010 2:52 PM
To: [redacted]
Subject: Case study for doctoral thesis work

Hi [redacted],

As a follow up to the voicemail I just left you, attached is a case study for one of our consultant's doctoral thesis work for your review and approval. He is working on getting his PhD in Portfolio Management. We worked together on the efforts he has referenced in the case study (Corp IT Portfolio Review Board). The case study has been highly sanitized and there are no references to [redacted].

Please let me know if you have any questions and/or if there is anything else I need to do.

Thanks in advance for your assistance.
[redacted]

From: Arlt, Mario [mailto:MArlt@esi-intl.com]

Sent: Tuesday, May 18, 2010 2:00 PM

To: [redacted]

Subject: Case Study v5.docx

APPENDIX F – APPROVAL TO USE SURVEY INFORMATION

ESI
INTERNATIONAL
an informa business

ESI International
901 North Glebe Road • Suite 200
Arlington, VA 22203

ESI International authorizes Mr. Mario Arlt, Vice President of Client Engagements to use data from the 2009 Survey

"View from the Ground:
The Project Manager Perspective on Project Portfolio Management Effectiveness"

for the purpose of his doctoral thesis.

Arlington, August 15, 2010

Mary Simpkins / VP-Mktg + Communicat

Name/ Title