ÓBUDAI EGYETEM
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Thesis Booklet

Optimized Tailoring of Agile Project Management Frameworks

From Combining Scrum and PMI towards Multivariate Optimization for Project Process Relevance Factors

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1 Background, Novelty, and Application Scenario

1.1 Background

Managing projects involves versatile approaches and related skillsets. Although every project is said to be different and unique, project management frameworks like the project management body of knowledge (PMBOK) [1], ICB4 of the International Project Management Association [2], or PRINCE2 framework of Axelos [3] push toward a standardized project management approach by providing certifications and guidelines on how to act as a responsible project manager. Comparing the three mentioned frameworks, PMBOK is with its 890.000 issued certificates [4], on the one hand, one of the most widespread and used frameworks right now and, on the other hand, the most defined and structured in regards to providing guidance about what to do, when to do it and how to do it. These well-established project management frameworks have been confronted with the trend of agile methods and cultures since the birth of the agile manifesto [5] in 2001, demanding changing requirements before following a plan, frequent deliveries and running code before comprehensive documentation. Nowadays, agile and iterative methods are used in 70% of IT projects [6].

An ambivalence between the flexibility of agile cultures and approaches and the rigidity of project management frameworks can provide freedom for experienced project managers; it can make decisions harder for inexperienced project managers [7], especially in agile-managed IT projects [8].

The problem statement of this research and Ph.D. Thesis stems from the field of tension between flexible agile methods, combined with the rigidity of project management frameworks, the uniqueness of projects and the individuality of project managers executing their project work. By investigating these topics from different angles in the form of three individual hypotheses, this research can not only improve the practice of project management but also the way management-related processes are handled.

Additionally, a generically applicable model for process-based management approaches is provided, and the subjective nature of project management based on a data-driven approach is reduced.

1.2 Application Scenario

Application of the research results can be applied from two separate viewpoints as detailed in figure 1:

- From a project management-related viewpoint, solutions of critical project processes reduce the gap of compatibility between PMBOK processes and agile methods. Further, project management practitioners can follow the developed optimization approach to optimize their work, hence directly improving the health and resulting success of their projects.
- From a higher viewpoint, an abstract generic model for the optimization of process-oriented management models can be applied in many different management scenarios. This can prove that multivariate optimization can be used to provide a data-driven and thus less subjective tool to improve the way of process-oriented working. Possible fields of application may be as small and defined as a single sprint in agile software development or as complex as a large-scale financial audit process.

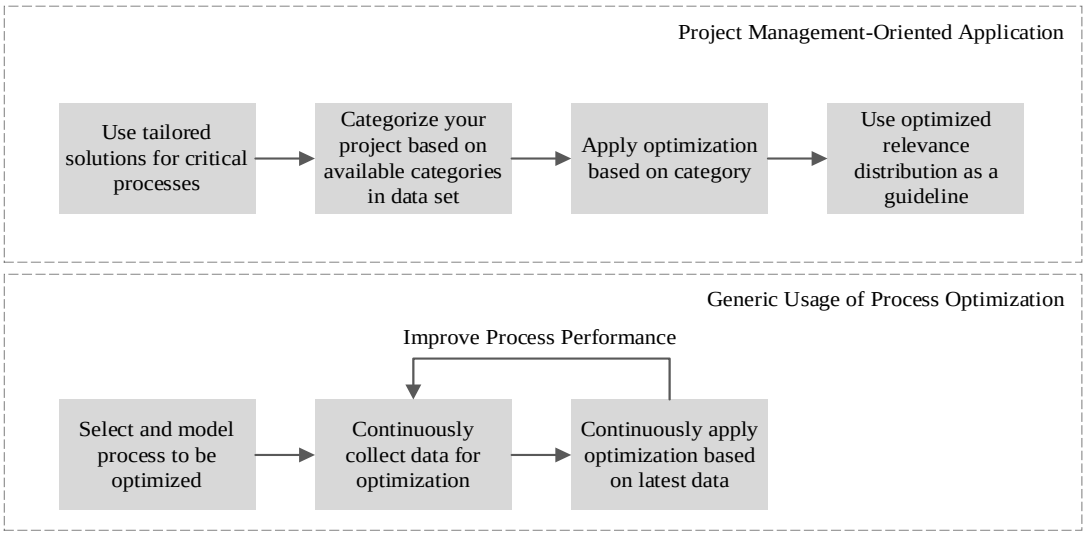

Figure 1: Application Scenarios

1.3 Novelty

This section shows that currently, no approach exists to tailor project processes of the PMBOK version 6 towards the needs of agile frameworks like Scrum. Different stage-gate-oriented approaches suggest the improvement and optimization of agile-developed IT projects [9,10], however, they do not build on the PMBOK project management framework as such. Several other publications investigate certain parts of projects, like risk management [11] or organizational requirements [12]. Often, published articles provide insight into lessons learned from a certain kind of project category or industry [10] without providing a commonly valid and understandable approach to close the gap

between agile development practices and traditional project management. Tailoring as such is often applied from an organizational point of view [13] and not so much from a framework point of view. Answering such related questions as described in thesis 1 of this research can provide novel insights into the profession of agile-developed IT projects.

The second part of this research, summarized in thesis 2, investigates multivariate optimization as a tool to optimize the success and health of projects. Based on detailed literature research it can be concluded that multivariate analysis as such is a well-established tool to analyze projects and gain an understanding of many different aspects. However, the approach of using multivariate regression and optimization to provide practitioners with a proposal about how much different tasks need to be done, in other words presenting them with optimized project process relevance factor distributions, is not presented in scientific literature. Consequently, the novelty of this approach can be assumed.

The last part of the research generates a generic model to make the multivariate optimization of project management frameworks applicable for all kinds of different process-based management models and frameworks. The used process flow chart modeling method introduced by Frank B. Gilberth in 1921 [14], is a well-established tool in the creation of process models. Also, the concept of continuous improvement by crosschecking the success and validity, following William Deming's PDCA approach [15] is well-known in scientific and managerial practice. Hence, the approach of process modeling does not contain any form of novelty as such. However, if the approach of Thesis 2 can be seen as novel, an abstraction of such a novel approach using well-established methods will be novel as well.

2 Research Strategy

This research follows a clearly defined three-phase strategy summarized in three hypotheses, which were transformed into specific theses based on results derived empirically.

Firstly, summarized in Hypothesis 1, literature reviews of agile approaches and the PMBOK project management framework reveal critical areas and gaps of compatibility, indicating a need for improvement and tailoring. This basic problem statement is investigated even deeper by analyzing and counting scientific literature to extract a matrix of initial project process relevance factors highlighting critical project processes from an additional point of view. Based on identified critical project processes, solutions are proposed. Their effectiveness is proven by a large-scale quantitative survey and detailed statistical analysis.

Hypothesis 2 approaches the objective of data-driven optimization of the project management framework. A custom-developed data collection application provides a numerical basis for regression and optimization. Then, different regression methods are introduced, followed by an investigation of their applicability to the collected data set. To finalize the second Thesis, the selected regression approach is used to successfully optimize project health for data collected with the application.

Hypothesis 3 abstracts and even improves the steps of data-driven optimization in Thesis 2 into a generic model applicable to optimizing all kinds of process-oriented management frameworks. An exemplary application of different subcategories of the collected data set acts as a first step toward proving the applicability of the generic model.

Figure 2 illustrates the research strategy, building upon the described three individual theses.

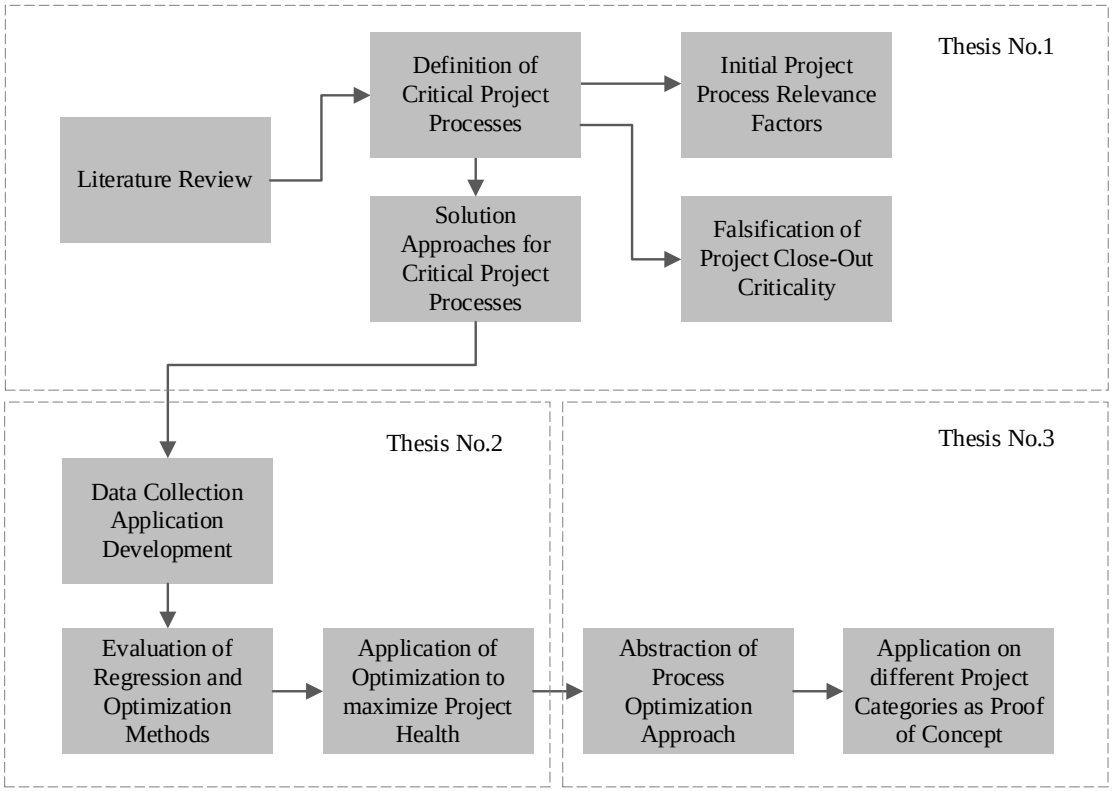

Figure 2: Research Strategy

3 Research Questions and Methods

Following the clarification of the fundamental research approach, the specific research questions and suggested Hypotheses of the three research categories are defined in detail.

3.1 Compatibility of Agile Frameworks and PMBOK Project Processes

3.1.1 Research Questions

The purpose of this research category is to develop a clear understanding of whether agile frameworks like Scrum and the PMBOK version 6 project management framework consisting of 49 project processes are compatible and which project processes seem to be especially critical. Such challenging environments for project managers can manifest if the project manager is keen to strictly follow the project management framework and development teams in the project are keen to strictly follow a Scrum approach. In case of gaps in compatibility, the most critical processes shall be highlighted and described. Solutions shall be proposed to close the gaps in compatibility. The effectiveness of the proposed solutions shall be proven.

The following questions shall be answered:

(Q.1.1) Where do methods, tools, values and processes of Scrum and PMBOK version 6 lack compatibility, and which solutions could fill these critical areas?

(Q.1.2) Which processes seem to be in general especially critical based on scientific literature?

3.1.2 Process and Methods to Answer Research Questions

To answer research question Q.1.1, all 49 project processes of PMBOK version 6 are analyzed and their content is compared with values, tools, and methods of the Scrum development framework, highlighting project processes that seem to be less compatible and describing the reasons for the gap in compatibility in the form of a comparison table. To propose a solution for identified gaps, deep literature research in all large scientific databases is carried out to select and describe a solution proposal for the critical processes. To verify the effectiveness and applicability of the solutions in improving the practice of agile developed projects, these solutions are introduced to project management practitioners via an online survey. Detailed statistical analysis is carried out using the software SPSS version 21 [16] to prove their effectiveness.

If project processes are not obvious in their criticality and lack of compatibility, their criticality is specifically investigated utilizing an online survey and statistical analysis.

To answer research questions Q.1.2, scientific literature is collected to solve project management-related issues. These publications are assigned to PMBOK processes based on the assumption that a majority of problem-solving literature may point towards particularly critical processes.

3.2 Towards Multivariate Optimization of Project Management Frameworks

3.2.1 Research Questions

The purpose of this research category is to verify if an optimization approach using multivariate optimization techniques is feasible to improve the success of project management practitioners by delivering an optimized data-based distribution of project process relevance.

The following questions shall be answered:

(Q.2.1) How can information about success and the way project management practitioners do their work be transformed into usable data for optimization and how can this data get optimized with mathematical methods?

(Q.2.2) How do optimized project process relevance distributions look depending on defined conditions and boundaries? How can these results be interpreted?

3.2.2 Process and Methods to Answer Research Questions

To answer question Q.2.1 of this research category, an online data collection application capable of capturing distributions of project process relevance is developed. The aim is to form an input parameter for this specific optimization approach. Project health acts as a success performance indicator and forms the output parameter. Besides capturing this information, the application will also capture demographic data of survey participants and categorical information of described projects to answer future research questions and create project categories that are applied in the third research category. Further, different parametric and non-parametric multivariate regression approaches are evaluated concerning applicability and validity. The most suitable optimization approach is selected and an optimized distribution using MATLAB R2018b [17] is created. To answer question Q.2.2, different results depending on boundaries and conditions for optimization regarding validity and usefulness for project management practitioners are interpreted and discussed.

3.3 Development of a Generic Optimization Model for Process-based Management Frameworks

3.3.1 Research Questions

The purpose of this research category is to create a generic model for optimizing different kinds of process-based management frameworks. This model shall be based on the optimization result of Hypothesis 2 and contain additional improvements providing a foundation to advance the work of manifold industries by broadening the scope of the optimization approach.

The following questions shall be answered:

(Q.3.1) Can the optimization approach described in Hypothesis 2 be abstracted and enriched in the form of a process model to be usable in other applications?

(Q.3.2) Does this created generic model also work using sub-categories of the collected data?

3.3.2 Process and Methods to Answer Research Questions

To answer the questions of this research category, the steps of Hypothesis 2 are abstracted into a procedural model, facilitating the process flow chart methodology and this existing approach is enriched with additional beneficial process steps. This created model is then applied using categorically filtered data from the collected data set. Finally, different optimization results of differently filtered data sets are compared. As a proof of concept, the outcome as such is interpreted as well as lessons learned when applying the generic model.

4 Scientific Results

In the following, the new scientific results for each research category are presented in the form of hypotheses and related theses.

4.1 Compatibility of Agile Frameworks and PMBOK Project Processes

A comparison of all 49 PMBOK project processes with the Scrum framework, highlighting gaps in compatibility forms the basis and problem statement for this research. 6 processes have been selected as critical and one process as questionably critical regarding the compatibility of PMBOK and Scrum. The comparison shows that most of the PMBOK processes are not negatively affected by agile development or by agile culture and values. Very often, agile practices provide a valuable contribution to the goals of PMBOK processes. Challenges for agile project managers are identified in the 6 processes of:

- Manage Execution
- Develop Project Structure Plan
- Develop Project Schedule
- Estimate and Define Costs based on Requirements
- Manage Team
- Develop Team

Further, a potentially critical process is identified in: “Closing Project or Phase”

These results provide the first part of the answer to the research question Q.1.1 “Where do methods, tools, values, and processes of Scrum and PMBOK version 6 lack compatibility, and which solutions could fill these critical areas?”

As the next step, solutions for these critical process areas are developed And shown below, as well as the criticality of the process “Close Project or Phase” falsified by a quantitative survey.

- Proposed Solution 1: Strike system for the process “Manage Project Execution”
- Proposed Solution 2: Adapted strike system for the processes “Develop Team” and “Manage Team”
- Proposed Solution 3: Macro- and micro-planning for the process “Develop Project Structure Plan”
- Proposed Solution 4: Macro- and micro-planning for the process “Develop Project Schedule”
- Proposed Solution 5: Hybrid approach MVP and velocity planning for the process “Estimate and Define Costs based on Requirements”

The results of the quantitative survey analyzing the proposed solutions show that a large number of participants do not know about the PSs for critical processes but still tend to give good ratings regarding usability and applicability. This finding proves the usefulness of postulated PSs. However, even if participants know about the PSs and indicate their usefulness, these still do not seem to be widely used. A reason for this lack of usage could be the missing integration into established project management frameworks, which provide certainty for project management practitioners and strengthen the need and overall research goal to tailor and adapt traditional, established project management frameworks to be used in agile developed IT projects.

The investigation of project closeout criticality with a quantitative survey concludes that project closeout processes are not highly critical in agile-developed IT projects.

As the last step of this the first part of the thesis, initial process relevance factors are defined based on identified scientific literature listing critical, relevant, and troubling areas in IT projects. Summarizing the outcome of this analysis four areas of project processes are especially relevant for project success. The result of this initial relevance factor development answers the research question Q.1.2 “Which processes seem to be in general especially critical based on scientific literature?”

In the following, the two parts of Hypothesis 1 are discussed as a basis for Thesis 1:

(H.1.1) Some areas of the processes of PMBOK version 6 framework show criticality in compatibility with Scrum development. This criticality can be detailed by highlighting differences in the form of a comparison table and by developing a matrix of relevance factors based on literature research.

A comparison table detailed all PMBOK processes, compared them to Scrum methods and agile approaches, and identified 6 critical project processes and one potentially critical process. A matrix of relevance factors based on deep literature research showed high relevance in several project processes. These two results and their interpretation confirm Hypothesis H.1.1.

(H.1.2) In the case of a confirmed Hypothesis H.1.1 by identified critical processes, solution approaches for identified gaps in compatibility can be proposed and their effectiveness is proven.

Solutions for 6 critical processes have been selected based on literature research, their application, and their effectiveness investigated and proven by the use of quantitative statistical analysis. The criticality of one potentially critical project process has been falsified by the use of quantitative statistical analysis. Hypothesis H.1.2 can be confirmed.

Hence, the two parts of Hypothesis 1 are verified and can be summarized in Thesis 1.

Thesis 1: Compatibility of Agile Frameworks and PMBOK Project Processes

I conducted a comparative analysis on PMBOK and SCRUM methodologies, based on which I developed a comparison table detailing PMBOK project processes, putting them in contrast to Scrum methods and approaches and identifying 6 critical processes and one potentially critical process regarding

compatibility. I supported this problem statement of incompatibility with the creation of an initial project relevance factor matrix, highlighting processes of high criticality in the project management practice. I falsified the criticality of the potentially critical process and proposed applicable and effective solutions for all other critical processes. These combined results improve and tailor the PMBOK version 6 framework for handling agile methods.

My own publications supporting Thesis 1 are [18–22].

4.2 Towards Multivariate Optimization of Project Management Frameworks

The second part of the research covers an approach to improving project health from a "how to work" as a project manager rather than from an agility perspective. The goal is to research objectively where successful project managers put their focus and if the mathematical approach of multivariate optimization can be applied to define an optimized project process relevance factor distribution.

Trying to answer such a question and defining one single optimized solution may be seen as critical because projects and project managers are highly individual and subjective and therefore not suitable for comparison. Such individuality is justified and allowed in the following approach of Hypothesis 2. It is not a goal of this research phase to define how much focus project managers should put on different project processes. However, the goal is to provide a data-based indication of where successful project managers do put their focus. Which processes execute successful project managers a lot and which barely? And provide proof that multivariate optimization is an applicable method to achieve such results.

The first step in this research phase is to collect data about projects from project management practitioners in the form of project process relevance factor distributions as input variables and project health indicators as output variables. As adjusting these distributions can be challenging for survey participants, a custom-developed data collection application is developed. Based on this collected data and an initial data cleaning and analysis, different regression and optimization methods are evaluated for applicability. As the last step toward a proof-of-concept result for optimization, boundaries, and conditions are defined.

Since many of the survey participants are currently working on a specific project, the execution phase, which can have quite a long duration comprising the bulk of the project work, was selected for this research. The execution phase contains 10 processes, 8 of which are continuous and act as the scope of the optimization approach.

After the successful collection of data, the most suitable multivariate regression and optimization approach for the data and its conditions is selected. After evaluating the different regression methods, stepwise regression was selected as the most applicable for the collected data, and additional constraints were chosen to identify a suitable maximum of combined project health factors in relation to the best distribution of project process relevance factors.

As an overall result of the optimization phase, it can be concluded that the best distribution of project process relevance factors for the defined scope and boundaries based on the currently collected data looks as shown in table 1:

Project Process	Optimized Project Process Relevance in %
P1: Direct and Manage Project Work	9.0
P2: Manage Project Knowledge	8.8
P3: Manage Quality	21.1
P4: Develop Team	5.0
P5: Manage Team	5.0
P6: Manage Communications	24.8
P7: Implement Risk Responses	5.0
P8: Manage Stakeholder Engagement	21.3

Table 1: Result of Optimization

The result of this research phase is a proof of concept, showing the potential of an optimization approach and the challenges involved in using constraints to adapt unrealistic results, if needed. It answers the research questions Q.2.1 and Q.2.2:

(Q.2.1) How can information about success and the way project management practitioners do their work be transformed into data usable for optimization and optimized with mathematical methods?

The use of a custom-developed survey application proved successful in collecting project process relevance factor distributions and project health factors, which are later merged into one single output factor for multivariate optimization.

(Q.2.2) How do optimized project process relevance distributions look depending on defined conditions and boundaries? How can these results be interpreted?

Using stepwise regression proved to be a successful method to optimize the collected data, resulting in project process relevance factor distributions as shown in table 1.

In the following, Hypothesis 2 is discussed.

(H.2) Optimizing project process relevance factor distributions with suitable multivariate regression and optimization methods is achievable with data collected from project management practitioners. However, the multivariate nature may need a large amount of input data to achieve robust results.

Facilitating the cloud service Heroku [23], a data collection application is developed to record project-specific data of the survey participants. To reduce complexity, only continuous processes of the project execution phase are selected as proof of concept for multivariate optimization. The data showed nonparametric characteristics and the method of stepwise regression as a usable process. However, the result does not seem to be robust, because the optimization results drastically change with only a few additional data-sets.

Hence, Hypothesis 2 is confirmed and can be summarized in Thesis 2.

Thesis 2: Towards Multivariate Optimization of Project Management Frameworks

I analyzed with mathematical-statistical methods project process relevance factor distributions of continuous processes in the project execution phase and project health indicator factors from project management practitioners to serve as a basis for multivariate optimization. The evaluation of various parametric and non-parametric regression methods proved stepwise regression as most applicable. A defined selection of boundaries and conditions for optimization thus creating an optimization result suitable to serve as proof of concept that multivariate optimization is applicable as a novel approach to optimize the project process relevance factor distributions.

Publications supporting Thesis 2: [24,25]

4.3 Development of a Generic Tailoring and Optimization Model for Process-based Management Frameworks

In this third research phase, the steps of optimization are converted into a generic process model, which is based on steps defined in Thesis 2, and additional steps to increase the applicability and effectiveness of the generic model are added. These development steps are applied to 6 practical applications.

Based on phase descriptions and their allocated tasks, the following generic process model can be abstracted as shown in figure 3.

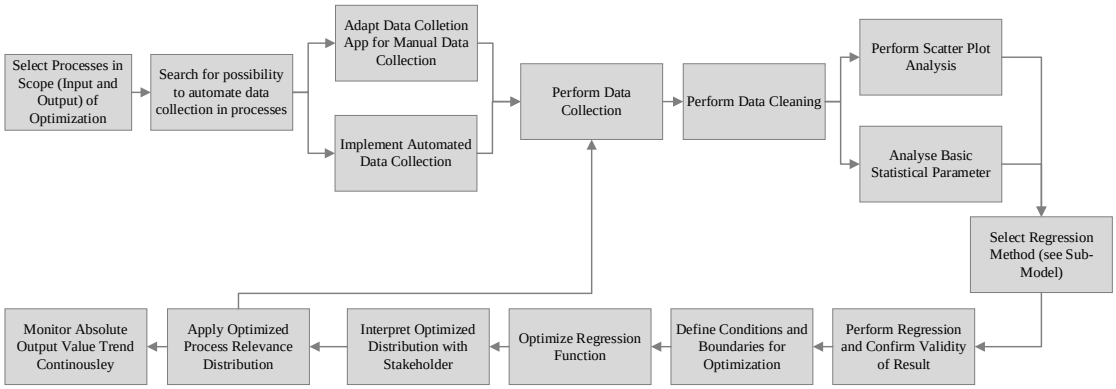

Figure 3: Generic Optimization Model

The described optimization model consists of 15 individual steps and tasks. Most of these tasks are simplified short descriptions of the steps taken in Thesis 2. Nonetheless, special attention is needed for the abstracted processes of “Data Collection”. In the first research phase, data collection was performed by using an online survey tool, which simply collected possibly subjective evaluations of survey participants. This lack of objectivity is also mentioned as a limitation of the research. Based on this critical statement, the generic process model implements an automated data collection step. This automation can be seen as another novelty of the model. Besides merely asking practitioners what and how much effort and focus they put into certain tasks, the generic

model proposes to implement automated inputs for data collection, which improves the subjective nature of manual survey participation. As an example of such an automated collection, a traditional Sprint iteration in Scrum-based development is portrayed. During each sprint, survey participants may lock in their operating systems to attend Daily Scrum standup meetings and block these times in their individual Outlook calendars. Such information embedded in Software like Outlook or Logfiles of operating systems could be used as a source of automated data collection, adding parameters to a specific process step like “Scrum Meeting Attendance” for example. Also, the time used by a product owner describing and maintaining user stories in modern backlog systems like Jira [26] could be facilitated as an objective and automated data source.

Another aspect of the model that is worth mentioning is the feedback loop from “Apply Optimized Process Relevance Distribution”, back to “Perform Data Collection”. This process step is not yet a part of the optimization described in Thesis 2. It enables the model to be seen as ongoing and dynamic. It can be assumed that using the model will lead to process improvement, resulting in improved and new data-set elements, which can and should be used in future optimization attempts with the model. This simple element of feedback ensures that optimization is not a tool to be used once, but repeatedly and continuously.

The subsets of the data set of thesis 2 are used as a basis for six additional optimization approaches The definition of conditions and boundaries is also reused from Thesis 2, resulting in a final optimization model as shown in figure 4:

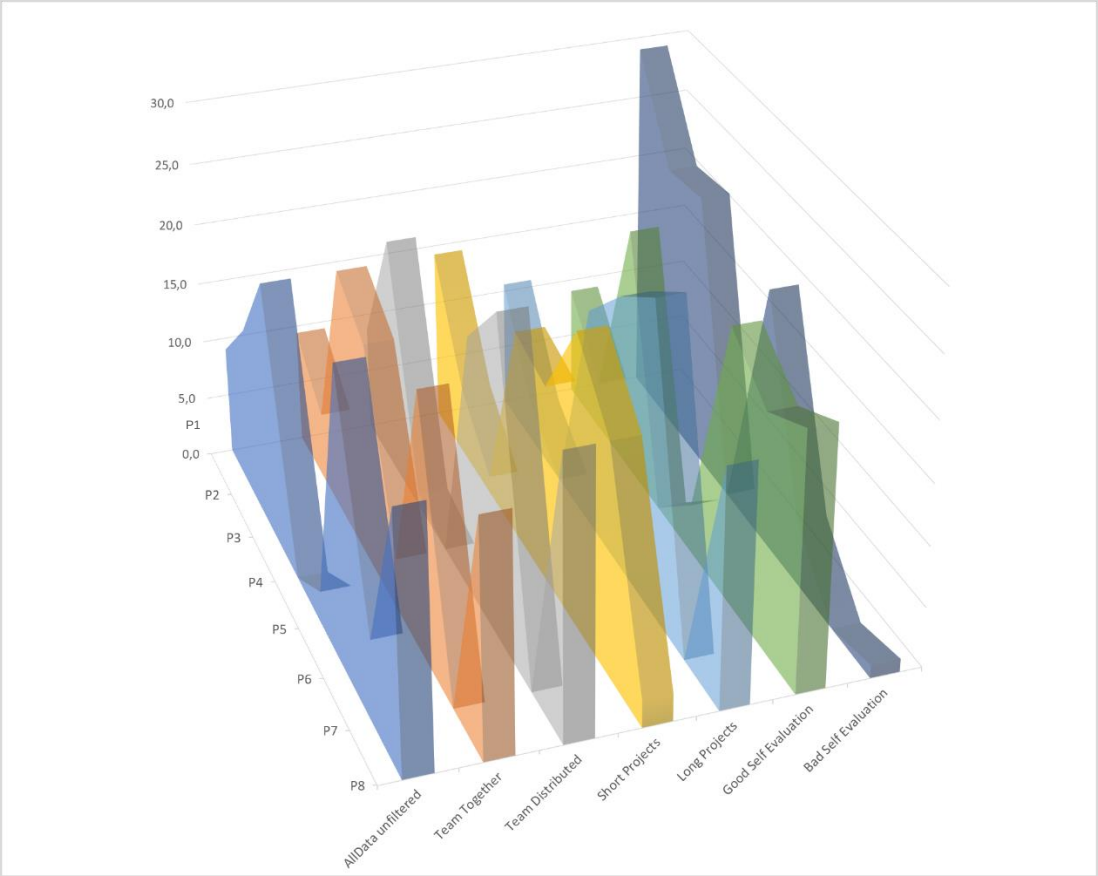

Figure 3: Optimized Case Study Process Relevance Distributions

To a certain degree, the distributions look related with similar factors of high relevance in the processes of Managing Communication (P6), Manage Stakeholder Engagement (P8), and low relevance in Direct and Manage Project Work (P1). Strangely, there seems to be one outlier. Project managers with bad self-evaluation generated a completely different optimization result. In this group, the best project health is supposed to be created when focusing on Directing and Managing Project Work (P1). Processes tending to be of high relevance in other groups like Manage Stakeholder Engagement and Manage Communications show low relevance in this group. Interpreting the other project groups as similar in the way the distributions present themselves, it can be concluded that the way projects need to be managed might not differ too much in different kinds of projects.

These interpretations and conclusions must be considered under the circumstances of unsatisfying p-values during regression. This reduces the reliability and meaningfulness of the results. However, interpreting the applicability of the generic process model leads to the conclusion that all undertaken process steps have been quite easy to perform for all 6 different optimization attempts.

In the following, Hypothesis 3 is discussed.

(H.3) As the PMBOK project management framework is merely one kind of process-oriented management framework, the multivariate optimization approach can be abstracted to a novel process model usable in various fields and applications.

Figure 3 presents the abstracted model of a generic optimization model for process-oriented management frameworks. The model is based on steps taken in Thesis 2 and enriched with additional steps like ongoing optimization through feedback loops and automated collection attempts to improve applicability and effectiveness. Figure 4 displays the outcome of optimizing 6 categorical subsets of the collected data using the optimization model. However, Hypothesis H.3 can only be partly confirmed, since newly-integrated process steps of the generic optimization model have not been applied due to restrictions on using subsets of the already collected data. Further, the statistical values of the 6 additional optimizations are unsatisfactory, most likely caused by the low amount of data sets.

As Hypothesis 3 is partly confirmed, Thesis 3 can be summarized as follows.

Thesis 3: Development of a Generic Optimization Model

Based on the optimization approach of Hypothesis 2 and enriched with improvement measures, I created a generic model to optimize all variants of process-based management frameworks. I applied this abstract model to different subsets of process relevance factor distributions to prove its applicability under the restrictions of low numbers of categorical data and some steps not being performed. This novel generic optimization model supports not only the profession of project management but also provides a practicable and usable approach for different industries and management applications to continuously improve the success and quality of their specific outcomes.

My own publication supporting Thesis 3: [27]

5 Summary of Theses and Contributions

5.1 Theses

Three parts of hypotheses were researched resulting in two complete and one partly confirmed theses.

Thesis 1: Compatibility of Agile Frameworks and PMBOK Project Processes

I conducted a comparative analysis on PMBOK and SCRUM methodologies, based on which I developed a comparison table detailing PMBOK project processes, putting them in contrast to Scrum methods and approaches and identifying 6 critical processes and one potentially critical process regarding compatibility. I supported this problem statement of incompatibility with the creation of an initial project relevance factor matrix, highlighting processes of high criticality in the project management practice. I falsified the criticality of the potentially critical process and proposed applicable and effective solutions for all other critical processes. These combined results improve and tailor the PMBOK version 6 framework for handling agile methods.

Deep literature research was applied to identify and collect scientific publications highlighting critical areas of project management and serving as a basis for the assignment of initial project process relevance factors to PMBOK project processes in 6 different agile and traditional project categories.

The solutions proposed for identified incompatible processes were investigated for applicability and effectiveness using a large-scale quantitative survey and detailed statistical analysis.

Thesis 2: Towards Multivariate Optimization of Project Management Frameworks

I analyzed with mathematical-statistical methods project process relevance factor distributions of continuous processes in the project execution phase and project health indicator factors from project management practitioners to serve as a basis for multivariate optimization. The evaluation of various parametric and non-parametric regression methods proved stepwise regression as most applicable. A defined selection of boundaries and conditions for optimization thus creating an optimization result suitable to serve as proof of concept that multivariate optimization is applicable as a novel approach to optimize the project process relevance factor distributions.

Facilitating the cloud service Heroku [23], I developed a data collection application to collect demographic and project-specific data of survey participants. To reduce the complexity caused by too many input variables for optimization, only continuous processes of the project execution phase were selected for the proof of concept of multivariate optimization.

Eight different optimization approaches were evaluated based on different regression methods. These cover parametric and non-parametric approaches. Stepwise regression was selected as the most applicable regression method and boundaries and conditions for the optimization step were defined to create a result that is realistic for everyday use.

The optimization results of the constrained and unconstrained optimization are shown and the results, which act as a proof of concept of the applicability of the optimization attempt, were compared and interpreted. These results are supported by additional statistical validation of the data set.

Thesis 3: Development of a generic optimization model

Based on the optimization approach of Hypothesis 2 and enriched with improvement measures, I created a generic model to optimize all variants of process-based management frameworks. I applied this abstract model to different subsets of process relevance factor distributions to prove its applicability under the restrictions of low numbers of categorical data and some steps not being performed. This novel generic optimization model supports not only the profession of project management but also provides a practicable and usable approach for different industries and management applications to continuously improve the success and quality of their specific outcomes.

Abstracted process steps were described to perform a multivariate regression and optimization approach generically based on the steps taken in Hypothesis 2. These were enriched with additional steps like ongoing optimization through feedback loops and automated data collection attempts.

Six different subsets of data serve as the basis for case study applications for the optimization model resulting in 6 different distribution results. Although the process itself can be followed during this application, this part of the Hypothesis can only be partly confirmed since proposed process steps, like automated data collection, are not included in the case study and some of the optimization results show unsatisfying statistical parameters, resulting in low trustworthiness of the actual optimization values.

5.2 Contributions

Below, the contributions to the 3 different theses described in the preceding chapters are collected, followed by a list of publications that resulted during this research project.

Thesis 1

I reviewed literature in the field of the PMI project management framework PMBOK and the agile development framework Scrum.

The compatibility of both approaches was compared and critical project processes of PMBOK version 6 were highlighted when confronted with agile development approaches. This resulted in the presentation of 6 specific challenging processes, which were described in detail.

Literature was reviewed for solutions to close the identified gaps. An online survey was developed to prove the effectiveness of the proposed solutions with statistical analysis to tailor the PMBOK project management framework to agile needs. Furthermore, I falsified the potential criticality of the project closeout process with an online survey and statistical analysis.

Based on scientific literature research, publications were collected highlighting critical processes in project management. They were assigned to project categories to form a table of initial project process relevance factors.

Own publications related to this research phase summarized in Thesis 1 are: [20,18,22,21,19]

Thesis 2:

I defined a multivariate optimization goal and developed a data collection application to collect needed data for the optimization as well as demographic and project-categorical data of the survey participants.

Different parametric and non-parametric optimization methods were evaluated, which was followed by a selection of the most suitable ones.

Boundaries and conditions for the optimization were defined to facilitate realistic results and their interpretation. The optimization results and conditions were supported with additional statistical analysis.

Own publications related to this research phase summarized in Thesis 2 are: [24,25]

Thesis 3:

I described abstracted process steps to perform a multivariate regression and an optimization model usable for different process-based management frameworks based on the approach successfully used in Thesis 2.

The approach of Thesis 2 was enriched and improved with additional steps like a feedback loop for continuous improvement and automated data collection.

The generic model was applied to 6 different subsets of the collected data set resulting in 6 unique optimization results.

An own publication related to this research phase summarized in Thesis 3 is: [27]

5.2.1 List of Own Publications

The list below contains all the publications related to this research project, sorted by time and starting with the most recent publication:

- P. Rosenberger and A. Tick: "A Generic Approach for Multivariate Process Optimization" in the conference proceedings of IEEE 20th Jubilee World Symposium on Applied Machine Intelligence and Informatics (SAMI 2022) in Slovakia, March 2022
    - Introducing the generic regression and optimization model
    - Proving applicability with 2 case study applications of the model on 2 data-subsets
- P. Rosenberger and J. Tick: "Multivariate Optimization of PMBOK, Version 6 Project Process Relevance" in Acta Polytechnica Hungarica, 18 (11), December 2021 [24]
    - Defining the optimization goal
    - Introducing the developed data collection application
    - Selecting a non-parametric optimization method
    - Interpreting the optimization results.
- P. Rosenberger and J. Tick: "Agile Enhancement of Critical PMBOK Project Processes" in the Journal of Modern Project Management, Issue 9 (1). August 2021 [19]
    - Proposing solutions for 5 critical PMBOK project processes
    - Describing a quantitative online survey to explore the applicability and current state of use of the proposed solutions
    - Analyzing the survey statistically.
- P. Rosenberger and J. Tick: "Applicability of Traditional Project Closeout Approaches in Agile Developed IT Projects", published by Springer in the proceedings book of the 4th International Conference on Design, Simulation, and Manufacturing: The Innovation Exchange (DSMIE-2021), Ukraine, June 2021 [22]
    - Falsifying the Hypothesis of the criticality of the project process of project closing.
- P. Rosenberger and J. Tick: "Applicability of Multivariant Linear Optimization for Project Process Relevance Modeling" in the conference proceedings of Sixth International Scientific Conference on Project Management in the Baltic Countries, Latvia, April 2020 [25]
    - Dismissing unconstrained parametric least square regression as suitable for the optimization approach.
- P. Rosenberger and J. Tick: "Relevance of PMBOK v6 Processes for Tailored Agile Project Categories" in the conference proceedings of IEEE 13th International Symposium on Applied Computational Intelligence and Informatics (SACI 2019) in Romania, May 2019 [21]
    - Developing initial relevance factors based on a literature review for 6 selected project categories.
- P. Rosenberger and J. Tick: "Adaptation of selected PMBOK processes to fit Scrum developments" in the conference proceedings of the Fifth International Scientific Conference on Project Management in the Baltic Countries, Latvia, April 2019 [18]
    - Proposing Solutions for critical PMBOK processes.

- P. Rosenberger and J. Tick: “Suitability of PMBOK 6th edition for agile developed IT Projects” in the conference proceedings of 18th IEEE International Symposium on Computational Intelligence and Informatics (CINTI 2018), Budapest, November 2018 [20]
    - Comparing PMBOK version 6 project processes with the Scrum agile development framework
    - Identifying 5 critical process areas regarding compatibility.

6 Conclusion

In this Doctoral Thesis, I present three major parts of developing optimized tailoring of agile project management frameworks in form of three theses building on each other.

Based on an initial introduction of PMBOK version 6 and Scrum, a comparison table was developed which highlights these 6 project processes with critical compatibility and one process with potential critical compatibility:

Critical processes:

- Manage Execution
- Develop Project Structure Plan
- Develop Project Schedule
- Estimate and Define Costs based on Requirements
- Manage Team
- Develop Team

Potentially critical process:

- Closing Project or Phase

Based on this initial result, also acting as a problem statement, I falsified the assumption of the criticality of project closeouts and defined these solutions:

- Strike system for the process “Manage Project Execution“
- Adapted strike system for the processes “Develop Team” and “Manage Team“
- Macro- and micro-planning for the process “Develop Project Structure Plan“
- Macro- and micro-planning for the process “Develop Project Schedule“
- Hybrid approach MVP and velocity planning for the process "Estimate and Define Costs based on Requirements”

A large-scale online survey proves the solutions to be applicable and useful for project management practitioners.

Based on substantial literature research, publications were collected highlighting critical areas of project management. They were assigned to PMBOK project processes in 6 different project categories forming a table of initial project process relevance factors. This result as such provides an additional possibility for project management practitioners to evaluate process relevance factors for different project categories.

The described results together form Thesis 1 of the research project, providing a tailored project management framework to be applied for agile developed IT projects.

After improving the project management practice of “what to do” when managing agilely developed projects, I developed an approach to indicate “how much” to execute

project management processes to increase project health and success. To serve as proof of concept, I chose a data-driven approach collecting data from practitioners with a self-developed cloud-based survey application. For data collection, continuous processes of the project execution phase were chosen. The defined processes formed the input parameter of the optimization approach and a summarized project health indicator as the output parameter being optimized.

Different optimization approaches were evaluated based on parametric and nonparametric regression methods. Stepwise regression was selected as the most applicable regression method and boundaries were defined to create a realistic optimization result.

Chosen constraints and boundaries proved to have a large influence on the optimization result, which necessitated a comparison of restrained and unrestrained optimization. These results were supported by additional statistical validation of the data set.

This proof of concept for a successful multivariate optimization formed Thesis 2 of this research project.

Lastly, and summarized in Thesis 3, I abstracted the process steps of Thesis 2 into a generic optimization model and enriched these steps with additional steps like ongoing optimization through feedback loops and automated data collection attempts to be applicable for all possible process-based management frameworks.

Six different subsets of data serve as input for case study applications for the optimization model resulting in six different distribution results. Although the generic model itself could be followed during this application, Hypothesis 3 could only be partly confirmed as proposed process steps, like automated data collection, have not been included in the case study and some of the optimization results show unsatisfying statistical parameters, resulting in low trustworthiness of the actual optimization values.

It can be concluded that this overall research project and its results not only improve the compatibility between traditional project management according to PMBOK version 6 and agile development but also applies a novel approach to facilitating multivariate regression and constrained optimization. Thereby practitioners are provided with more than project management, i.e., a process-oriented management framework with a model to improve the way of doing management tasks in everyday work.

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