Economic Risk-Based Management in Software Engineering: The HERMES Initiative

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Abstract

Developing software of high quality is both socially and economically critical. Nevertheless software projects are often managed badly without considering economic potential and constraints. The decision making process is often performed in an ad-hoc manner and approaches from business administration or operations research are rarely adopted. In Austria, we have recently been developing a research agenda that addresses these issues in an interdisciplinary research plan. This paper introduces and motivates this joint research initiative and identifies important issues needing attention.

1. Introduction

The pervasive impact of software on life in our society makes the capability to develop high-quality software a socially and economically relevant issue. However, approaches to the management of software engineering (SE) projects are often based on surprisingly simplistic assumptions, often just rules of thumb and lessons learned. While there are many projects documented that run well, there are also many reports on late, over-budget, and sometimes spectacularly disastrous projects. While (empirical) SE is good at generating knowledge on a technical level that has a clear use and is less dependent on context assumptions, the improvement on the management level lags behind, possibly due to more complex dependencies of this knowledge on project context. What is missing so far, is a profound exchange of knowledge and collaboration of SE with related research fields, namely business administration and operations research, in order to attack SE management problems in a more comprehensive way.

We have recently been developing a new research initiative in Austria. The proposed Joint Research Project (JRP) "Integrated Economic Risk-based Management in Software Engineering" (IERMSE, further called "Hermes") aims at addressing some of these issues. Therefore, Hermes combines approaches from the disciplines software engineering, business administration, and operations research to tackle the key challenge of project management (PM) and quality management (QM), i.e., to help develop high-quality software in an economically efficient way. The key issues of the JRP are represented in the title: (a) 'risk-based' refers to project uncertainty and variability, which is often connected with mainly negative aspects of defects and loss, and will be completed with the positive side of risk: opportunities in SE projects and an orientation towards the added value of SE projects, processes and products; (b) 'economic' refers to the integration of economic points of views with the typical technical focus in SE; (c) 'management in SE' includes the full range of management from detail management of project activities to the large-scale management of multiple projects in a business unit. Hermes focuses on strategic proactive management (in contrast to reactive management for local short-term optimization) of multiple software projects in an uncertain and dynamic business environment.

The Hermes JRP is motivated by recent international initiatives, such as the workshop "Economics-Driven SE Research" (EDSER) or the workshop on "SE Decision Support" (SEDECS) at the International Conference on SE and Knowledge Engineering both stating the need for the systematic integration of scientific economic approaches into SE.

2. Research Areas

Figure 1 presents an overview on the JRP research areas in three groups: (A) general concepts and methodologies for valuation and decision support; (B) management approaches for SE projects and processes; and (C) management support infrastructure.

Research areas A1 und A2 will provide a solid methodological foundation from management science as they develop advanced methods (A1) for the valuation of SE projects and (A2) for making key decisions (regarding

uncertainty, risk, multiple target criteria, and different preferences among stakeholders) in SE management for the framework process model steps of the projects in group B.

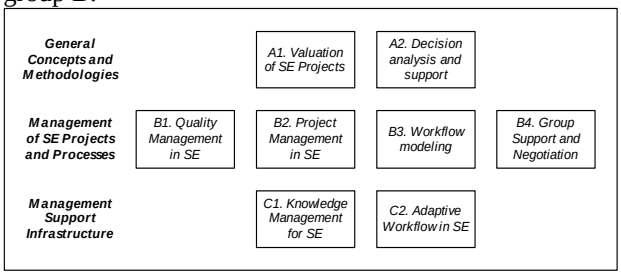

Figure 1. Hermes Research Areas

The research areas in group B form the center of the research initiative as they focus on key application aspects of SE management: (B1) quality management, (B2) project management, (B3) workflow modeling, (B4) group support and negotiation for team building – each with a specific framework process model that can describe the suitability of a range of methods for a particular SE project: from simple methods used in current practice to sophisticated scientific methods to be developed. The four framework process models in projects B1 to B4 allow defining capability levels for all models and methods used for a process step: (a) to assess the capability of models and methods used in current practice, (b) to rank candidates for 'best practice' approaches, and (c) to determine the need for scientific research in these areas. The framework process models also facilitate the empirical evaluation of new scientific methods and the dissemination of suitable methods into practice. Such a framework process model has to be compatible with commonly used SE process models, such as the V-model, the spiral model, or recent agile approaches. The assessment part of the frameworks should be compatible to wide-spread approaches, such as CMM(I) or SPICE: (a) to define capability/maturity levels for key process areas and (b) to allow gap analysis in specific project environments. Experience with existing assessment frameworks documents good results for improvement on technical aspects, but also a need for management support for SE projects, especially for multiple projects. We regard the approach of framework process models with several maturity levels for each step in the model as an excellent opportunity to achieve method development and application that is rooted in practice, supports a strong management vision, and allows stable growth on a clear path to scientific sound methods at a suitable pace for a business partner in practice.

The projects in group C develop advanced management support infrastructure techniques/tools for key areas needed in the processes of the projects in group B: (C1) knowledge management repository and (C2) adaptive workflow tool support.

3. Research Method

In the SE community the importance of empirical research to evaluate technical processes has been growing considerably. This is for example documented in the Empirical Software Engineering journal and an increasing number of empirical papers in top SE journals and conferences. The general research approach in the JRP is empirical validation of hypotheses generated from theory and practice according to the Quality Improvement Paradigm [1] as SE processes with effects that depend on project context cannot be evaluated solely with a theoretical argumentation but must be empirically evaluated.

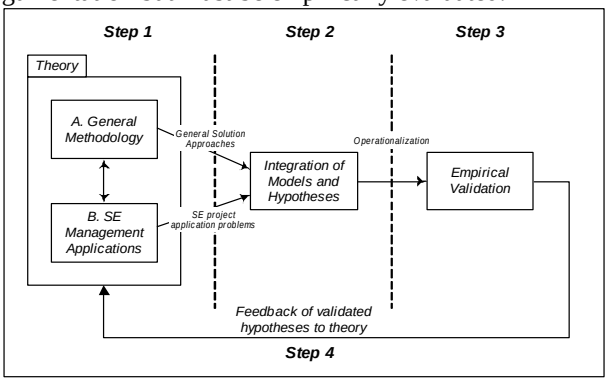

Figure 2. Research Approach

Figure 2 shows the four steps in the research approach: 1. initial theory foundation based on existing research; 2. operationalization of models and hypotheses – application of the initial theory foundation for modeling and simulation studies that prepare the design and project plans for empirical studies (e.g., simulation with prototypes, calibration with empirical data; feasibility studies); 3. conduct of empirical studies (validation of theory and simulation studies with empirical data); and 4. feedback of results from simulation and empirical studies to build an advanced SE theory.

In the initiative we will first focus on developing a detailed theoretical foundation for the applied methods (e.g., stable frameworks for reference processes) and identify solution packages for SE application problems. These solution packages are not necessarily integrated and get evaluated in environments with low risk and a reasonable return on investment (e.g., prototypes and feasibility studies).

Subsequently, we want to validate, refine, and integrate these solution approaches (processes and tools) using empirical and simulation techniques: e.g., evaluation of usability in large field studies. A major focus is also on the dissemination of proven solutions into practice and to spark applied research in industry.

The JRP goals rely on the one hand on advanced knowledge on economic valuation and economic/statistical decision theory and on the other hand on

knowledge on SE processes, negotiation, and SE project management: (a) one cannot take existing approaches in business administration or operations research and simply apply them to SE problems as SE problems differ significantly from traditional situations in Business Administration and Operations Research. Researchers in business administration and economics typically see a software development project as a R&D project, which is untypical and risky, and thus not routinely investigated. (b) SE research usually has a technical and practical focus and is less based on scientifically founded management methods. (c) Project managers usually have a focus on getting things done, rather than on science in general and particularly in SE.

To attain the goals of the proposed JRP there is a need for a critical mass of scientists with deep knowledge in a variety of research areas that would be unlikely to come together in unrelated individual small research projects. Also, to tackle these tasks the project needs researchers with a multi-science background to coordinate the different projects and translate between the research cultures. This joint JRP will enable the collaboration of established research groups, working so far on different aspects of the theory and application of the JRP research areas, in one organized cooperating group. It should also intensify international contacts and collaboration.

Table 1. Summary of Research Projects

Project	*Problem Description*	*Research Goals*
A1: Valuation of SE Projects	Strategic decision-making is often focused on cost and risk instead of value creation.	Apply valuation techniques from corporate finance to SE projects.
A2: Decision Analysis and Support	Characteristics of decisions in SE involve uncertainty, multiple criteria, different incentives of stakeholders, and dynamic environments. Current techniques to support decisions with these characteristics are not adapted to the specific requirements of SE and need to be modified.	Apply and extend multi-criteria, dynamic, and stochastic decision models; apply negotiation and auction techniques to deal with information asymmetries, incentive incompatibility and strategic behavior of stakeholders.
B1: Quality Management in SE	There is little information on the value and risks for different Quality Assurance (QA) techniques and their combination with respect to project context in a company or organization.	Extend and investigate existing QA techniques from a technical perspective with respect to project context; use methods from A1 and A2 to better evaluate and plan QA in different realistic project scenarios.
B2: Project Management in SE	Project management, including several coupled projects in a company, is based on rules of thumb rather than well-studied methods.	Extend project management techniques for a multi-project environment; apply results from A1, A2, and B3 to support key project management decisions.
B3: Workflow Modeling	Project plans for single projects are often unrealistic and expensive to maintain. PERT and GERT techniques provide only limited considerations for cost effectiveness under uncertainty.	Project plans that capture uncertainty in a realistic way for analysis and that are worthwhile to maintain. Activity modeling, resource management with stochastic processes; white-box view on project level based on results from A2.
B4: Group Support and Negotiation in SE	Software is developed in teams; existing research often focuses on individual engineers thus neglecting team issues and collaboration.	Develop methods and tools supporting software development teams; apply negotiation methods as proposed in A2 to support group decision making and allow mutually satisfactory solutions among stakeholders.
C1: Knowledge Management	Different characteristics of SE process models lead often to inefficient knowledge management.	Tools for knowledge management for supporting SE process models in projects B1to B4.
C2: Adaptive Workflow Management in SE	Uncertainty in SE processes demands for flexible work flow management system support, ad-hoc communication and recommendation facilities and a proper balance between pre-modeled workflows on the one hand and incremental planning and ad-hoc reactions on the other hand.	Provide comprehensive WFMS support for SE based on B3, particularly addressing the issues of adaptivity of SE processes, reuse and synthesis of SE process knowledge and ad-hoc collaboration and recommendation facilities.

4. Project Overview

This Section gives an overview of the projects of the proposed JRP Hermes. For each project we present key problems targeted in the JRP and the key research goals of each project. Table 1 gives an overview.

A1. Valuation of SE projects: Current state-of-the-practice and state-of-the-art in software engineering focuses often exclusively on cost issues for decision-making. The main advantage of costs is that they are, at least partly, easier to measure than benefits. However, if we study valuation concepts in business administration, we observe that the goal of all methods is to appropriately quantify the value of a project. Therefore we want to establish a value-oriented valuation approach in software engineering. Based on this value-oriented concept we aim at developing a more complete approach towards project risk management. [4][7][8][12]

A2. Decision analysis and support: Decision problems in software engineering have special characteristics, which distinguish them from traditional decisions problems dealt with in operations research. Therefore an important goal of this research project is to analyze decisions in SE in order to identify feasible optimization methods. As far as different methods are concerned our main focus lies on multi-criteria decision making. Another important dimension of SE decisions is that they usually influence very different stakeholders. Therefore an important part of decision support is to extend existing preference elicitation techniques. Further goals include theoretical support of group decisions and the development of negotiation methods for SE problems. [13][19]

B1. Quality management (QM): QM methods for risk reduction are an integral part of risk management and address mostly product and process risks. Currently there is a large number of quality assurance techniques, but little pragmatic guidance founded on sound theory on when to use which technique. Based on a framework process model, which allows to assess the QM capability of a project organization, we propose to investigate defect reduction techniques – such as formal technical review and testing approaches – as well as tool support options for these techniques in different application contexts to gather data for improved value-oriented QM planning considering not only the technical but also the economic point of view. [2][9][11][16]

B2. Project management: Current project planning in practice suffers from simplistic approaches (a) that lack practical support for modeling uncertainty and project interdependencies to help a project manager decide among several project options and (b) that are easy to maintain over the course of a project. We aim at project plan models that are based on information the project manager can provide, that are maintainable to project change in real project situations, and that support managers in applying methods developed in research areas A1 and A2. From such a value- and risk-oriented approach we expect more realistic plans that can be used for more effective project control and better decision-making. [6][17]

B3. Workflow modeling: This project focuses on modeling activities under variability and uncertainty to investigate the interrelationships of many work packages in a SE project for improved project control under uncertainty in day-to-day activities. Using UML and Petri Nets as modeling frameworks, we will study simulation and optimization techniques. Knowing that there is always a trade-off in modeling between the expressiveness of the model (i.e., the modeling power) and the model complexity (affecting the time to solve the problems) we are looking for efficient evaluation approaches. To achieve this goal, we have to identify problem classes and the appropriate choice of models and parameters in the solution methods. [18]

B4. Group support and negotiation in SE: Software development requires team work and collaboration of different experts belonging to the development team and external project partners. This research project aims at evaluating the dynamics of this team work and at providing tool support using the methods developed in projects A1 andA2. One specific and important aspect of this group support is negotiation because it enables project teams to discuss open issues, develop a shared vision of the project, and create a Win-Win situation for all team members. Therefore we propose to extend existing group support processes and tools for negotiation to other negotiation situations in a SE project, such as project planning, project controlling, risk monitoring, and post-mortem reviews for process improvement. Improving the quality of meetings and teamwork promises to effectively lower the overall project risk. [5][10][14][15]

C1. Knowledge management for SE: Knowledge management (KM) in SE focuses on managing and modeling resources of the software development process to provide useful feedback information or knowledge for the concerned actors (software engineers, end users, and project management). KM can be used for (a) significantly exert a strong influence on decreasing development costs, time to production, and increase software quality as well as (b) helping to deploy knowledge across distributed teams to compress development time frames.

C2. Adaptive workflow management in SE: Workflow management systems (WFMSs) are more and more used to make SE processes explicit and to enable their enactment by workflow engines, thus facilitating standardization and reuse and increasing productivity and efficiency. To cope with the varying degree of uncertainty inherent in every SE project, workflow management systems should not only be able to provide pre-modeled and potentially

automated workflows but should also be adaptive allowing incremental planning and ad-hoc reactions to changing situations which is not fully supported by existing approaches. The emphasize of this project is on a comprehensive WFMS support for SE, particularly addressing the issues of adaptivity of SE processes, reuse and synthesis of SE process knowledge and ad-hoc collaboration and recommendation facilities.

5. Issues

We decided to present this research proposal at the EDSER workshop in order to discuss the following issues with the workshop participants:

1. Is the proposed research agenda complex enough? Or, did we miss any important field that should be represented in the project structure? For example, what about psychology in order to understand and motivate team members of software development teams appropriately.

2. Is the proposed research agenda too complex? Should we remove some fields/projects because they are not required for developing better solutions? Will software engineering maintain its ad-hoc and intuitive characteristic because it simply is rather an art than a craft?

3. Is it worth investing effort into developing better software? Will the market appropriately value high/appropriate quality, or will other approaches towards software engineering like open source projects solve the problem of quality? The proposed projects will result in well-founded methods/process to optimize decision-making. However this will take some time and increase development effort and time. Will their be an incentive for software development companies to use "better" processes?

4. Why are SE management techniques still mainly based on simplistic assumptions and intuition

5. What are the reasons for the lack of methodological foundation in the area of SE, in particular SE economics? For comparable areas like for example corporate valuation (i.e., where the value of entire corporations is modeled) and credit risk estimation (i.e., where the risk of bankruptcy is estimated for a company) a large body of theory exists. However, little effort has so far been invested in well-defined theory in the area of software engineering.

6. How can we best transfer economic methods and tools into SE? What are the pitfalls?

7. Do you know about related research projects that may provide valuable input to this research?

6. Conclusions

In this paper we have briefly reported on a new research initiative that aims at integrating economic theories and approaches into SE to improve decision-making in real-world situations. This initiative is a first step to spark and integrate international research. We invite the EDSER community to share their ideas, suggestions, and concerns.

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