The Role of Valuation in Value-Based Software Engineering

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Abstract

Current state-of-the-practice and state-of-the-art in software engineering (SE) typically focuses on cost issues and technical considerations for decision-making as costs are generally easier to measure than benefits. Value-based SE emphasizes the concept of 'value' in SE. However, so far the concept of value in SE is not well analyzed in its various dimensions. Furthermore, the process of measuring value, i.e. valuation, has mostly been discussed in the SE community from a mathematical perspective. In order to establish a comprehensive value-oriented valuation approach in SE we aim at applying valuation concepts from finance and economy, which try to appropriately quantify benefits, costs, and risks of a project or a project portfolio. We put a special focus on the value of information and individual preferences. We expect that such a value-oriented concept allows developing a more complete approach for project risk management.

1. Current Interests

The authors are researchers and lecturers in computer science and software engineering at Austrian universities in Vienna and Linz. In research we are specifically interested in the empirical investigation of the cost and benefits of methods for requirements engineering and quality assurance. Another research area is value-based software engineering management (Boehm and Huang, 2003).

2. Past Work

In the last couple of years we conducted a series of experiments to investigate the benefits of quality assurance methods and tools (Biffl, 2001a). In a series of papers we investigated the economic aspects of quality assurance and decision support for management (Biffl, 2001b; Port et al., 2002; Biffl et al., 2003).

3. Issue Statement

A basic concern of software management is to develop the right software in a cost-effective way. The "right software" regards what software is worthwhile to be developed for a given project context including, for example, stakeholders' needs, organizational and technical options. The "cost-effective way" regards how software is acquired, developed, reused and/or integrated. We want to address the following issues:

1. *Explicit consideration of upside (i.e., opportunities) and downside risks:* Risk is often associated only with negative courses of events and thus considered as something to be avoided. We aim for a more complete modeling and view of uncertainty, also taking into account unexpected developments that could lead to positive surprises. Consequently, both dimensions need to be appropriately valued and taken into account in decision processes.
2. *Quality definition, measurement, and valuation*: Quality is a consequence of quality-focused engineering and management and requires investments. To make appropriate investment decisions it is important to determine the value added through an increase in quality. Prominent application areas are (a) software security and (b) SE models that communicate quality goals between engineers and other stakeholders in a project.
3. *Involvement and collaboration of success-critical stakeholders.* Value-based SE relies on involving important stakeholders at all levels because their individual needs and preferences determine project success and value. Rather than focusing on individual needs stakeholder involvement should support finding and negotiating more complete solution packages. In fact, value is a 'subjective concept' in software engineering because the value of a project or product can be very different for different stakeholders.
4. *Context awareness:* The project's environment has great influence on the conduct of a project. The

context comprises all relevant influencing factors on a project increasing the uncertainty of the project occurring for different reasons and stemming from multiple sources. Consequently, an SE project should not be regarded isolated but embedded within its context.

Valuation techniques are required to address and resolve all of these issues. However, current valuation know-how in the software engineering community is not sufficient for this purpose. Therefore we propose the following long-term approach to define and create valuation techniques for value-based software engineering.

4. Proposed Approach

The focus of our research is to apply well-known techniques from finance and economics to value SE projects under uncertainty and to support software project managers. This application of existing techniques is difficult and requires some integrated research effort, as the SE context differs considerably from the standard financial and economic applications. So far, there is no universal definition of success in the area of SE. Currently, people regard software projects which are over budget or late as failure. But that is often more a failure of the cost estimation rather than a failure of creating project value. The success of a software project should thus be defined in terms of value creation: a project should be deemed successful if it delivers a value greater than the cost of the resources put into the project.

Valuation in financial markets succeeds in determining fair prices, which directly lead to decisions and are independent of individual risk preferences. In the area of software development this is not possible. Therefore, the value of products, processes, and specific decisions will always depend on subjective preferences of the stakeholder. In more detail we propose to address the issue of valuation in value-based software engineering step-by-step. The following individual challenges have to be appropriately dealt with:

Value Drivers and Value Creation: The basic goal of software development is to create software, which satisfies needs and therefore represents value. However, comprehensive definitions of individual value drivers (i.e., a performance variable that supports decision-making and prioritization) and process frameworks for value creation (Porter, 1985) are missing so far in SE. Current project management strategies and SE economics are cost-oriented and focus on reducing a set of defined risks on project-level (Boehm, 1984; Boehm, 1991; Boehm et al., 2000). The goal of this research area is to develop a broader model of value creation in SE.

Different models exist for the analysis of value creation in economic theory. The most prominent is the model of Porter, based on value chain analysis. The core idea behind this model is the definition of value as "the amount buyers are willing to pay for what a supplier provides them". Application of this model in the context of SE projects would include, for example, the following four steps: (a) definition of the strategic goal of the project, (b) identification of critical activities, (c) definition of the properties of the product, and (d) definition of the values of the activities.

Cost Benefit Analysis: The valuation of software products and processes depends on a detailed analysis of underlying costs and benefits. Measuring the value of software and related activities/products is difficult and so far nearly unexplored in the SE context (for initial application-oriented research see (Favaro and Favaro, 1996; Favaro et al., 1998; Favaro and Favaro, 1999; Biffl and Halling, 2001; Port et al., 2002; Favaro, 2002). A special focus of this project is put on the valuation of intangible or soft benefits, the influence of time on the value of these benefits and costs, and the consideration of uncertainty. Comparable situations can be found in the valuation of public goods and social investments (see Layard and Glaister, 1994).

Existing economic project management techniques in SE do not include intangible benefits (e.g., increased flexibility; information gain). For example, modern development processes focus on agility but current project management practice does not have techniques to appropriately value this gain in flexibility. Existing cost and risk-oriented techniques (Boehm, 1984; Boehm, 1991) include only tangible benefits (e.g., the saving of working hours) but largely ignore intangible benefits. In order to capture the value of an increase in development flexibility (one possible intangible benefit), real option theory represents a promising approach (Erdogmus and Favaro, 2002).

Valuation of individual projects and project portfolios: For the valuation dimension we aim at tailoring existing corporate finance valuation techniques, for example the discounted cash-flow method and real option theory (Trigeorgis, 1996). As far as the application of option theory to software development is concerned, some preliminary research exists in the area of Extreme Programming, which represents a very special software development process (Erdogmus and Favaro, 2002) and software design decisions (Sullivan et al., 1999). In this research project we want to build on these threads of research and provide a well-founded methodological valuation framework, which is applicable, in general, to valuation problems in software engineering.

Elicitation of subjective preferences: In decision analysis, different methods have been developed to support the consistent elicitation of subjective judgments (Keeney/Raiffa, 1976; von Winterfeldt/Edwards, 1986). These methods also allow for the consistent assignment of cardinal utilities to outcomes defined only on an ordinal scale. These features are important for the selection of SE development projects, where for example technical risks can only be described by different levels of familiarity with the technology involved in a project.

However, empirical research in this area has shown that theoretically equivalent methods often lead to different results based on the specific context of the decision problem to be solved (Schoemaker/Waid, 1982; von Winterfeldt/Edwards, 1986).

Two characteristics of SE decision processes are inadequately addressed by current preference elicitation methods:

Firstly, these methods usually require the decision makers to provide precise information, for example on attribute levels which would make them indifferent between two alternatives. However, decision makers are often not able to provide such precise information. This is to be expected in the problem domain of SE, where decision makers are experts in project management or software development, but are not explicitly trained in decision analysis. Therefore decision makers in this field will probably only be willing to provide incomplete information. While several methods exist to process such incomplete information (for example weight intervals) in choosing alternatives (Weber, 1987; Vetschera, 2003; Vetschera, 2004), they are not well integrated with preference elicitation methods.

Secondly, existing approaches to decision analysis assume that both the preferences of the decision maker and the decision situation, i.e., the set of alternatives which are available and the attributes used to evaluate these alternatives, are stable over time. During the lifetime of an SE project, this assumption is not fulfilled. New stakeholders become relevant during the project, which leads to the formulation of new attributes, or new sets of alternatives can emerge. These phenomena cannot be handled adequately in existing approaches.

Incentives and asymmetric information in SE project management: There is a considerable amount of asymmetric information in SE projects. For example, developers can much better estimate the true effort associated with requirement changes and their ability to perform changes than their customers; vendors of components have better information on the true performance of their components and the effort required to adapt components to a specific environment.

This private information of different parties is crucial in many decisions to be made during an SE project. In selecting projects or portfolios of projects, costs and benefits of projects must be estimated as closely as possible, in the selection of COTS components, true performance data is crucial. But since the outcome of those decisions directly affects those stakeholders who should provide the required information, there are considerable incentives to distort information and behave strategically during such decision processes.

5. Open Issues

We would like to discuss the following issues specifically at the workshop:

- What are most important value drivers in SE (including products and processes)?
- How can we make intangible benefits more tangible by determining their value? What are important intangible benefits?
- How can we value information? What is the impact of asymmetric and incomplete information on value-based SE?
- How important are individual preferences for value-based SE? Can we generalize valuation techniques like real option theory to account for subjective preferences?

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