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Direct and indirect connections between type of contract and software project outcome

Magne Jørgensen *, Parastoo Mohagheghi, Stein Grimstad

Simula Research Laboratory, Fornebu, Norway

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Abstract

This paper reports two empirical studies on how the use of different contract types affects, directly and indirectly, the outcomes of software projects. The first study evaluates the effect of contract type on project failure using information from a large international dataset of small-scale, outsourced software projects and tasks. The second study proposes and tests how the use of contracts is connected with project outcome using information about Norwegian software projects with a public client. Both studies find that the use of fixed price contracts is connected with a higher risk of project failure compared to time and materials types of contracts. The results from the second study suggest that different project outcomes with different contract types is explained by differences in how the provider is selected, how the client is involved in the project, the use of agile practices and the use of benefit management during project execution.

Keywords: Software projects; Contracts; Fixed price; Time and materials; Success; Failure

1. Introduction

The use of contracts to regulate work processes and output is several thousand years old (Johns, 1904). A variety of contract types have been developed and used, but there are two contract types that have dominated and still dominate most work domains: fixed price (FP) and time and materials (T&M) types of contracts. An FP type of contract is where the client agrees to pay the provider a certain price for a specified delivery. A T&M type of contract, on the other hand, is where the client agrees to pay for the effort spent by the provider, usually based on an agreed price per work-hours for different types of skills and for other expenses required to deliver the desired product or service.

At first glance, the better choice of these two contract types from the perspective of a software client may seem obvious. Specify the requirements of the deliveries, let the providers compete in offering low prices and good competence for the delivery, and select the one with satisfactory competence and the lowest price. This way the client will know how much to pay, the provider has the financial risk in case of over-optimistic cost estimates, and the provider will not have the unfortunate incentive of increasing its profit by working slowly or spending more hours than really needed, as one may fear might happen with T&M contracts. There are, however, several considerations that make it less obvious that FP contracts are the better choice:

- The providers offering the fixed price are likely to be aware of the risk of cost estimates that are too low, especially when the uncertainty in required work effort is high. This risk may lead the provider to increase the price to ensure they do not accrue a loss, which in turn will make the software project more expensive. This type of provider behaviour is documented in several project bidding contexts, see for example (Hong and Shum, 2002).
- Very few, if any, software specifications and contracts are complete. For example, it is hardly possible to give an

* Corresponding author at: Simula Research Laboratory, P.O.Box 134, 1325 Lysaker, Norway.
E-mail address: magnej@simula.no (M. Jørgensen).

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operational and complete specification of software maintainability and user friendliness requirements. When there is a fixed price for a delivery that is only partially specified—that is, a fixed price for non-fixed content, the work on the incompletely specified requirements may receive low provider priority. This may, amongst others, create problems with the quality and the client benefits of the software deliveries. This type of provider behaviour, often termed *opportunistic behaviour* or *moral hazard*, may particularly be a problem if the selected provider has underestimated the cost so much that it risks a substantial financial loss (Kern et al., 2002).

- The clients' understanding of what will benefit their organization may change during the execution of software projects. As suggested by the findings reported in (Jørgensen, 2016), requirement changes do not only frequently happen but are sometimes essential to ensure successful software projects with respect to client benefits. If a fixed price for a specified content leads to less flexibility in requirements during project execution, and consequently to projects less successful in delivering client benefits, the use of more flexible T&M types of contracts may be a better choice.
- Seemingly around 10% of all started software projects are aborted or cancelled without delivering any client benefits (Sauer et al., 2007; Tichy and Bascom, 2008; El Emam and Koru, 2008). If the use of an FP contract to some extent contributes to the risk of project failures or projects delivering very few client benefits this would be a strong argument against the use of it.

The selection of contract type that reduces risk of failure is consequently not as simple as selecting between who should have the financial risk related to cost overrun and the advantage of knowing the price before the project starts. Many other considerations and factors are potentially important, including incentives for desired provider and client behaviour (Suprapto et al., 2016) and good alignment between client and provider goals (Turner and Simister, 2001).

While there are many studies on factors affecting clients' *choice* of contract type in the software industry (see Section 2), there are very few studies on how, and even fewer on why, the choice of contract type affects the likelihood of *success* or *failure* of software projects. This is especially the case when measuring success in terms of delivered client benefits. This paper aims to contribute to fill this gap in knowledge, with an emphasis on how FP and T&M contracts affect the success and failure rate of software projects, as viewed from a client perspective. We do this by including two studies of software projects in different contexts. The first study is based on an analysis of a large international dataset of small-scale, outsourced software projects. The second study provides an interview and project documentation-based analysis of possible connections between the use of contract type and the success and failure of software projects. The observation of similar connections between contract types and software project outcome in these two, quite different, contexts would suggest that the connections are robust and valid in several software development contexts.

The remaining part of this paper is organized as follows. Section 2 briefly summarizes previous empirical studies on contracts in software development contexts. Sections 3 and 4 report from the first and second study, respectively. Section 5 discusses the results and their limitations. Section 6 concludes.

2. Related work

Our identification of empirical research papers on contracts in software development contexts started with a search using the terms *software* AND *contract* AND ("*fixed price*" OR "*time and material*" OR "hourly"). The most cited relevant papers were used as a starting point for the examination of papers referencing or being referred to by these papers. The additional papers found this way were in turn subject to the same procedure (forward and backwards snowballing). Representative results from the identified papers, with key references includes the following:

- *Frequency of use*: Typically, between 40 and 70% of software projects use FP and between 15 and 50% T&M types of contracts (Adler and Scherer, 2011; Fink et al., 2013; Banerjee and Duflo, 2000; Kalnins and Mayer, 2004; Ahonen et al., 2015).
- *Selection factors*: The factors determining the selection of contracts have been much studied, often in the context of transaction cost economy theory, control theory, and contingency theory (Fink and Lichtenstein, 2014). Typical findings are that the use of FP contracts tends to decrease with increased project uncertainty and increased complexity in specifying and measuring requirements (Kalnins and Mayer, 2004; Gopal and Koka, 2012), with less frequent interaction between client and provider (Fink et al., 2013; Kalnins and Mayer, 2004), lower provider reputation (Banerjee and Duflo, 2000), and decreased project size or project complexity (Kalnins and Mayer, 2004; Gopal et al., 2003). The explanatory strength of the selection factors varies between contexts and over time. A meta-analysis reports that the strength of the connection between project uncertainty and choice of contract type has decreased over the years and is close to zero in recent years (Schermann et al., 2016). A review of the rather consistent results on contract selection factors in software development contexts can be found in (Fink and Lichtenstein, 2014).
- *Outcome*: The results on how contract choice affects the outcome of software projects are mixed. The use of FP contracts was connected with an increase in provider profit in Gopal and Koka (2010), a decrease in provider profit in Jain and Khurana (2015), and no difference in provider profit in Hoermann et al. (2015). The use of FP contracts was connected with an increase in cost overrun in Banerjee and Duflo (2000) and a decrease in cost overrun in Moløkken-Østvold and Furulund (2007). The use of FP contracts was connected with less rework in Gopal et al. (2002), higher proportion of administrative work in Ahonen et al. (2015), and no effect on client cost in Jain and Khurana