# Connections between type of contract and software project outcome

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**Abstract**

This paper reports two empirical studies on how the use of different contract types affects 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 [1]. 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 [2].
* Very few, if any, software specifications and contracts are complete. For example, it is hardly possible to give an 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 [3].
* The clients’ understanding of what will benefit their organization may change during the execution of software projects. As suggested by the findings reported in [4], 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 [5-7]. 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 behavior [8] and good alignment between client and provider goals [9].

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.

The remaining part of this paper is organized as follows. Section 2 briefly summarizes previous empirical studies on contracts in software development contexts. Section 3 reports on the effect of contract type on risk of project failure based on an analysis of a large international dataset of small-scale, outsourced software projects. Section 4 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. Section 5 discusses the results and their limitations, and 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 [10-14].
* *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 [15]. Typical findings are that the use of FP contracts tends to decrease with increased project uncertainty and increased complexity in specifying and measuring requirements [13, 16], with less frequent interaction between client and provider [11, 13], lower provider reputation [12], and decreased project size or project complexity [13, 17]. 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 [18]. A review of the rather consistent results on contract selection factors in software development contexts can be found in [15].
* *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 [19], a decrease in provider profit in [20], and no difference in provider profit in [21]. The use of FP contracts was connected with an increase in cost overrun in [12] and a decrease in cost overrun in [22]. The use of FP contracts was connected with less rework in [23], higher proportion of administrative work in [14], and no effect on client cost in [20]. The use of FP contracts was connected with lower delivery quality in [19] and with higher delivery quality in [20]. The use of FP contracts was connected with an increased proportion of project failure, as measured by client satisfaction or client benefit in [4, 24].

There is not much evidence on the *mechanisms* connecting the choice of contract type and differences in project outcomes or on the effect of the *context* of the effect of contract type on project outcomes. This is especially unfortunate given the lack of result robustness on the connections between contract type and project outcome. A notable exception is the study reported in [19], which reports that (Indian) software providers tended to allocate their best developers on FP types of contract projects. This allocation resulted, according to the authors, in higher delivery quality and higher provider profit with the use of FP contracts, which suggest that the connection between choice of contract and outcome is dependent on the resource management strategies. Results on the importance of understanding the context are reported in [25]. That study found that more *reliable* clients, with reliability measured as to what degree the clients applied standardized contracting and project execution processes and managed to communicate project goals, were more successful in using the FP type of contract. These two studies demonstrate the importance of understanding the underlying mechanisms and the context to properly interpret the results on the connection between contract use and software project outcome.

# 3. Contract use in small, offshoring software projects

## 3.1 Research question and hypothesis

The research question addressed in this section is how the choice of contract type is connected with project outcome.Our hypothesis, motivated by the findings in [4, 24], is as follows:

*There is an increase in the risk of software development failure when a project uses an FP rather than a T&M type of contract, even after adjusting for differences in project, client, and provider characteristics.*

## The dataset

The dataset used to test the hypothesis consists of small-scale, outsourced software projects from an international marketplace connecting clients and providers. The providers are single software developers and smaller outsourcing companies located in low-cost countries. The services offered by the marketplace include, amongst others, evaluations of provider and client performances on previously completed projects, skill evaluations of the providers, search facilities for finding and inviting providers with appropriate skills, and support for FP and T&M types of contracts.

Characteristics of the dataset used in the analysis include the following:

* Project data registered: May 2001–October 2012
* Number of projects: 407,815
* Proportion of failed projects, defined as started projects that were either cancelled or received a client satisfaction rating of *poor* or worse: 11.8%
* Number of projects that used FP and T&M types of contracts: 404,348 and 3,467, respectively
* Price range of projects: 1–30,000 USD, with a mean of 146 USD

Two characteristics potentially problematic for our model building, discussed below, are: i) the low proportion of T&M contracts, less than 1%, leading to a strong imbalance in values, and ii) the very small size of most of the projects, which may be considered as tasks rather than projects.

The effect of the *imbalance* in variables for our type of analysis is examined in [26]. The authors report that this type imbalance seems to be unproblematic for the model validity, especially when using a binary logistic regression model, as we do. The authors recommend the use of *all* observations and argue that there is no need to try to create more balanced datasets.[[2]](#footnote-2) Notice that although the *proportion* of T&M contract projects is low, the *number* of such projects is high (3,467). The low proportion of the use of T&M contracts may, however, make the results more vulnerable to systematic differences in what the typical clients, project types, or amount of previous collaboration between clients and providers are for T&M and FP types of contracts. It may, for example, be that only the most competent clients or providers use T&M contracts. It is therefore essential to include variables representing client, project, and collaboration characteristics in the explanatory model, which we attempt to do.

It may be that any contract effects found in this study are mainly relevant for *very small projects and tasks*. To analyse how much the existence of mainly very small projects in the data set could reduce the value of our analysis, we separated the dataset into four equally large-size categories. We found that the effect of the contract type was approximately the same for all size categories. Admittedly, even the largest size category includes only relatively small projects, and there is consequently a need to be careful about generalizing the results to larger software projects.

## 3.3 The model

We use a binary logistic regression model for our analysis. The main reason for this choice of model is the, relatively speaking, simpler interpretation of odds ratios compared to model parameters of alternative, such as regression-based, models. For all but one of the variables, project size, we transfer the ratio or ordinal scale values into category-based values. We do this to ease the analyses and the interpretation of the odds ratios and to enable the inclusion of the category value “no value”. Notice that “no value” in the dataset is not the same as missing or unknown values but instead indicates whether or not a client or provider has received satisfaction scores, started any projects, and completed skill tests. We consider the use of broad variable categories useful in our situation where smaller changes in the variable values, such as satisfaction scores, do not necessarily reflect important changes in the underlying phenomenon we want to model. We use the median value of a ratio or ordinal scale variable as the threshold value for the separation into a “low” or “high” category value to include an equal number of observations in each category. The contract type and other variables explaining the project outcome—that is, failure (1) or no failure (0)—are described in Table 1.

**Table 1: The model variables**

|  |  |  |
| --- | --- | --- |
| **Variable** | **Description** | **Values used in model** |
| **Dependent variable** | | |
| Project Failure | The outcome (failure or no failure) of the project | Failure: Project cancelled or completed with very low (“poor” or worse) client satisfaction  No failure: Otherwise |
| **Independent variables** | | |
| **Contract type** | | |
| Contract Type | The contract type selected by the client | FP: The client pays a fixed price for the specified work  T&M: The client pays the provider for the amount of work and other expenses |
| **Provider selection** | | |
| Evaluation Strategy | The client’s strategy for the selection of a provider | Traditional: Evaluation based on CVs, references, interviews, price, and/or quality of proposal  Trial-sourcing: Evaluation of a provider by trying out one or more providers on, typically, a smaller piece of the project |
| Focus on Low Price | The focus on low price when selecting a provider | Low: Selection of a provider with a price that is higher or the same as the mean bid (mean fixed price or hourly price offered)  High: Selection of a provider with a price lower than the mean bid |
| **Project size** | | |
| Project Size | Log-transformed price paid by the client (cost of project) | [0,->) |
| **Provider skill** | | |
| Failure Rate of Provider | Proportion of failed previous projects by the project provider | Low: Best 50% of all providers  High: Worst 50% of all providers  No value: No previous projects |
| Satisfaction Score of Provider | Mean client satisfaction score of the provider’s work in previous projects | Low: Worst 50% of all providers  High: Best 50% of all providers  No value: No previous projects |
| Skill Test Score of Provider | Mean skill test score of the provider | Low: Worst 50% of all providers  High: Best 50% of all providers  No value: No skill tests taken |
| **Client skill** | | |
| Failure Rate of Client | Proportion of failed previous projects by the project client | Low: Best 50% of all clients  High: Worst 50% of all clients  No value: No previous projects |
| Satisfaction Score of Client | Mean provider satisfaction score of the client’s support in previous projects | Low: Worst 50% of all clients  High: Best 50% all clients  No value: No previous projects |
| **Collaboration** | | |
| Previous Collaboration | Previous projects completed with the same client and provider | Yes: At least one previous project with the same client and provider  No: Otherwise |
| Same Geographical Region | Same or different geographical region. The regions used were Africa, East Asia, Eastern Europe, Latin America, the Middle East, North America, Oceania, South Asia, and Western Europe | Same: Client and provider located in the same region  Other: Otherwise |
| Failure Rate of Provider Region | The failure rate of the region of the selected provider | High: Provider belongs to region with unusually high provider failure rate (the regions Africa and South Asia)  Low: Other provider regions |
| Failure Rate of Client Region | The failure rate of the region of the client | High: Client belongs to region with unusually high client failure rate (the regions East Asia, the Middle East and South Asia)  Low: Other client regions. |

## 3.4 Results

The fit of the developed binary logistic regression model is indicated by the calibration data in Table 2. As can be seen, a higher model calculated risk of project failure follows the observed proportion of failure quite well—that is, the model fit is reasonably good. The adjusted R2 is moderate (22%), which is not surprising given the, to a large extent, probabilistic nature of project failure.

**Table 2: Calibration data**

|  |  |
| --- | --- |
| Model calculated risk value in (probability) interval | Observed proportion of project failures |
| (0%; 0.5%) | 0% |
| (0.5%; 0.8%) | 0% |
| (0.8%; 1.2%) | 1% |
| (1.1%; 2.1%) | 2% |
| (2.1%; 7.1%) | 5% |
| (7.1%; 12.1%) | 10% |
| (12.1%; 17%) | 15% |
| (17%; 23%) | 20% |
| (23%; 31%) | 26% |
| (31%; 83%) | 39% |

The odds ratios, which represent the effect sizes, are presented in Table 3 and show the increase and decrease in risk of project failure for one unit of increase in a variable when the variable is continuous and for one variable value relative to another when the variable is category-based. An odds ratio of, for example, 3.0 between variable values A and B means that the failure risk for projects with value B instead of A for a variable, given the same values on all other variables, is three times higher. An odds ratio of one means that whether a project has the value A or B for that variable does not affect the project failure risk. For ease of reading, we present the comparison of the values so that the odds ratios are always equal to or larger than one.

**Table 3: Odd ratios (effect sizes) of the logistic regression model**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Predictor variable** | **Variable value A** | **Variable value B** | **Odds ratio** | **95% odds ratio confidence interval** |
| **Contract** | | | | |
| Contract type | FP | T&M | 16.4 | (12.0; 22.5) |
| **Provider selection strategy** | | | | |
| Evaluation strategy | Traditional | Trialsourcing | 7.7 | (1.92; 33.3) |
| Focus on low price | High | Low | 1.22 | (1.19; 1.25) |
| **Project size** | | | | |
| Project size | Ratio variable | Ratio variable | 2.11 | (2.0; 2.1) |
| **Provider skill** | | | | |
| Failure rate provider | High | Low | 1.92 | (1.89; 2.0) |
| High | No value | 1.43 | (1.32; 1.54) |
| No value | Low | 1.35 | (1.25; 1.47) |
| Satisfaction score provider | Low | High | 1.38 | (1.34; 1.42) |
| No value | High | 2.45 | (2.27; 2.65) |
| No value | Low | 1.78 | (1.65; 1.92) |
| Test score provider | Low | High | 1.18 | (1.14; 1.23) |
| No value | High | 1.70 | (1.65; 1.76) |
| No value | Low | 1.44 | (1.40; 1.48) |
| **Client skill** | | | | |
| Failure rate client | High | Low | 1.75 | (1.72; 1.82) |
| High | No value | 1.79 | (1.69; 1.85) |
| No value | Low | 1.01 | (0.94; 1.06) |
| Satisfaction score client | Low | High | 1.16 | (1.13; 1.19) |
| No value | High | 1.24 | (1.18; 1.30) |
| No value | Low | 1.07 | (1.02; 1.12) |
| **Collaboration** | | | | |
| Previous collaboration | No | Yes | 16.7 | (14.5; 16.9) |
| Same geographical region | No | Yes | 1.01 | (0.97; 1.02) |
| Failure rate provider region | High | Low | 1.32 | (1.29; 1.35) |
| Failure rate client region | High | Low | 1.49 | (1.43; 1.54) |

1: Should be interpreted as indicating that a 10-times larger project had a 2.1-times higher risk of project failure.

As can be seen from Table 3, the model suggests that the risk of project failure was as much as 16.4 times higher for projects using FP compared to using T&M contracts. Only the variable related to whether the client and the provider had previously collaborated had a slightly stronger effect on risk of project failure, with an odds ratio of 16.7. Notice that the model gives the effect of contract type, adjusting for possible systematic differences in client, provider, and project characteristics, as represented by the variables of the model. The results consequently provide strong support for the hypothesis stated in Section 3.1.

The results do not state that the choice of an FP contract is the *direct* *cause* of a higher risk of project failure. There may be missing variables, and we may not have succeeded in modelling all the relationships properly. The results, nevertheless, give us reason to suspect that there are interesting connections between the use of contract type and the risk of project failures. This is further examined in the next study.

# 4. Contract use in Norwegian software projects with a public client

## 4.1 Research goal and proposed connections

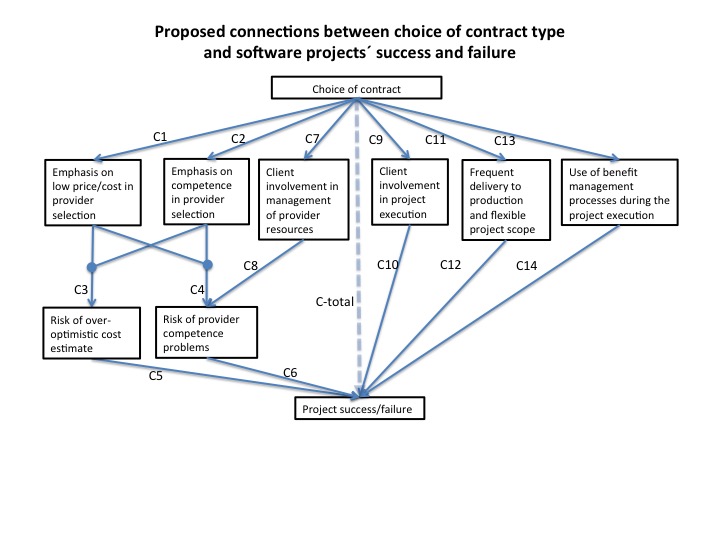
The main research goal of the second study is to better understand how the contract type and project outcome are connected. In addition, we wanted to examine to what extent the previous negative connection between use of FP contracts and risk of project problems would be replicated in a context with much larger software projects.

The proposed connections (our hypotheses) are described and motivated in Table 4 and are visualized in Figure 1. Some of the connections are, to a large extent, common sense and included to make the connections between contract and project outcome complete. The measurement of the variables is described in Section 4.2, and the results from empirically testing the connections are reported in Section 4.3.

**Table 4: Proposed connections between contract type and project outcome**

|  |  |
| --- | --- |
| **Proposed connections** | **Motivation** |
| *C-total*: Projects using FP contracts are more likely to become problematic than those using T&M contracts. | Corresponds with previous results; see sections 2 and 3. |
| *C1*: Clients in projects using FP contracts are more likely to focus on low price/cost when selecting providers compared to those using T&M contracts. | FP contracts are based on paying a provider a price for a *delivery*, while T&M contracts are based on paying for competent execution of *work-hours*. It may follow that the focus on low price/cost of the project will tend to be higher in FP contract contexts. Notice that the use of T&M contracts does not exclude a focus on low price. The clients may, for example, focus on low hourly price or low estimated cost when selecting providers. |
| *C2*: Clients in projects using FP contracts have a less thorough evaluation of provider competence when selecting providers compared to those using T&M contracts. | If the focus on low price is higher, see argumentation above, it may follow that the focus on evaluating competence is lower when using FP contracts. |
| *C3*: A stronger focus on low price *and* less thorough evaluation of provider competence when selecting a provider is connected with a higher risk of selecting a provider with a price based on over-optimistic cost estimates. | Corresponds with the results in [27, 28]. |
| *C4*: A stronger client focus on low price *and* less thorough evaluation of provider competence when selecting a provider is connected with higher risk of the project experiencing problems with provider competence. | Corresponds with the results in [29]. |
| *C5*: Projects with price/budgets based on over-optimistic cost estimates are more likely to become problematic. | Corresponds with the results in [24]. |
| *C6*: Projects experiencing provider competence problems are more likely to become problematic. | Lack of provider competence is likely to be a key project failure factor, see, for example, [30]. |
| *C7*: Clients in projects using FP contracts are likely to be less involved in the management (selection, monitoring) of the provider resources compared to those using T&M contracts. | When the client selects an FP type of contract, it mainly buys a delivery, not work-hours. This may make it more difficult to put requirements on *who* is going to do the work. |
| *C8*: Projects with clients less involved in the resource management of the projects are more likely to experience problems with provider competence. | There is a large variation in competence among software professionals, see, for example, [31]. It may follow that clients who are more selective about who is working on their projects will experience fewer competence problems. |
| *C9*: Clients in projects using FP contracts are less involved in the project management and execution compared to those using T&M contracts. | Buying a specified product from a provider with a fixed price means that it may be harder to be much involved in the management and execution of the work, as this may make it less clear to what extent the provider is responsible for the, potentially too low, quality of the final delivery. |
| *C10*: Projects with clients less involved in project management and execution are more likely to become problematic. | Corresponds with the results in [32] |
| *C11*: Projects using FP contracts are less likely to have a flexible scope *and* frequent delivery to production than those using T&M contracts. | Corresponds with the results in [4, 23]. |
| *C12*: Projects without flexible scope *and* frequent delivery to productions are more likely to become problematic. | Corresponds with the results in [4]. |
| *C13*: Projects using FP contracts are less likely to implement benefit management during project execution than those using T&M contracts. | Choosing an FP contract may be connected with clients thinking of the deliveries as more fixed. It may follow that clients in such contexts are more likely to think of the benefit management as conducted only in the early phase, developing the business case, and when taking the system in use, to realize the benefit, and not very much during the project execution. |
| *C14*: Projects not implementing benefit management during project execution are more likely to experience project problems. | Corresponds with the results in [4]. |

**Figure 1: Proposed connections**



## 4.2 Information collection

We collected information on 35 software projects with clients from nine different governmental agencies and two municipalities in Norway. The data collection was based on interviews with software professionals representing the roles of the project owner, project management, and the user organization. Whenever available, we collected information from written project documentation, such as planning documents, project summaries, and experience reports. Typically, the projects included management and technical personnel from both the provider and the client sides, while the domain experts were mainly from the client side.

We aimed at collecting information about the *four* *last* software projects of each of the participating organizations. An emphasis on the last projects was introduced to avoid a self-selection bias, such as a bias toward the most successful projects. While this strategy worked for most of the participating organizations, a few of the organizations were found not to have used only the last projects but also selected recent projects they considered good examples of successful and not-so-successful projects. This means that the average project performance of the projects we observed may not be a perfect representation of the last projects of the included organizations. Not all organizations were able to provide four projects, but all contributed with at least two projects. The deviations from the originally planned selection process may affect the representativeness of our sample but are less likely to significantly affect our analysis of *how* the contract type influences the project outcome.

Each interview lasted 30–60 minutes. The interviews were semi-structured and contained the same set of questions for each person in the same role, but had follow-up questions that could differ from project to project. In total, 107 interviews were conducted, typically three per project.

The semi-structured interviews covered aspects of the project related to the following:

* Project purpose and type
* Client process of selecting the provider and/or individual software professionals
* Client process of managing internal and external human resources
* Type of contract regulating work and deliveries, including how the contract was used in practice
* Project management and development processes, including the use of agile practices, quality assurance, and project delivery plan
* Benefit management processes, from the creation of business case to the realization of benefits
* Project outcome in terms of client benefits, cost control, time control, and technical quality. This information was collected in absolute terms, such as the actual benefits compared to the planned benefits and the actual cost compared to the budgeted cost. The project outcome was also collected using more subjective input, i.e., the level of success related to the above dimensions as perceived by the different project stakeholders.
* Perceived success factors, experienced problems, and lessons learned from the project

We typically collected information from all project roles at the same meeting. This enabled people in other roles than the one we were interviewing to fill in with information from the perspective of their role. The great majority of the interviewees were from the client side. It is possible that some of the project outcome evaluations would have been different had we interviewed a larger proportion of people from the provider side, such as externally hired software developers. The main observation was, however, that there were no large differences in how successful the projects were perceived to be from the perspectives of the clients and the external providers. On the rare occasions of differences in judgment, we emphasized the judgment that best fit the other documentation and observations of the project outcome and the judgment of the person in the most relevant role for the question asked. This similarity in judgment of the project outcome among clients and providers is consistent with that found in other, similar contexts; see [4, 24]. As a further evaluation of the role dependency of the responses, we went through the answers with people from the provider side, not previously interviewed, who had held project management or quality assurance jobs in 10 of the 35 projects. In general, this evaluation confirmed the validity of the collected responses. The identified differences were mainly related to how the successes and failures were explained, in particular to what extent the provider or the clients were to blame for project problems.

Characteristics of the included 35 projects are as follows:

* Type of project: new system (17), extension of existing system (6), off-the-shelf software (7), combination of new system and extension of existing system (5)
* Motivation of project (more than one motivation possible): modernization or improvement of existing services (27), change of functionality to adhere to new government regulations (12), new products (3)
* Budget size: large (13), medium (9), small (13), where large is defined as having a budget of more than 100 million NOK (about 10 million Euro), medium having a budget between 10 and 100 million NOK (between 1 and 10 million Euro), and small having a budget less than 10 million NOK (about 1 million Euro)
* Software development model: waterfall model (2), incremental development (6), agile development (27)

The *project success categories* used in our analyses are mainly based on what the interviewees perceived to be the level of success and problems with respect to the success dimensions of client benefits, cost control, time control, and technical quality. We introduced three levels of success for each of the dimensions: successful, problematic, very problematic/failure. The *project as a whole* was categorized as *successful* if it was perceived as successful on *all* success dimensions. Projects considered to be very problematic on at least one success dimension, or being cancelled before completion, were categorized as *very problematic/failure*. If not successful on all dimensions, but not very problematic/failure on any dimensions, the project was categorized as *problematic*.

We collected, as described earlier, the actual cost overrun, the time overrun, and scope completeness but found the experienced level of success and failure to better reflect the project outcome in terms of success from the clients’ perspective. In particular, we found this type of measurement to better reflect what was actually was a success or a problem. As an illustration, sometimes a bit lower user benefits than planned or some cost overrun caused no problems for the project or the client. In other contexts, a similar amount of benefit reduction or cost overrun was much more harmful.

The above success categorization resulted in 25 projects being experienced as successful, five as problematic, and five as very problematic of failures. Separated according to individual success dimensions, the projects’ degrees of success were distributed as follows:

* Client benefit: successful (29), problematic (4), very problematic/failure (2)
* Cost control: successful (26), problematic (7), very problematic/failure (2)
* Time control: successful (30), problematic (3), very problematic/failure (2)
* Technical quality: successful (29), problematic (4), very problematic/failure (2)

The proportion of successful projects in our sample (25 of 35; i.e., 71%) is high in comparison with the proportions reported in other studies of software projects—see for example the study on public software projects reported in [33]. The high proportion of successful projects may partly be caused by how we defined success, but it may also be caused by our sample not being representative of software projects with a public client. For the robustness of our main analysis, the representativeness of the sample is not crucial, as long as the analysed connections are preserved. The relatively low proportion of problematic or very problematic/failure projects had the consequence that we decided to combine the categories of problematic and very problematic/failure for the purpose of the statistical analyses, resulting in 25 *successful* and 10 *problematic* projects.

Our analyses focus on the differences between FP and T&M types of contracts. We expected, based on previous experience with Norwegian public software development projects, that many of the projects would use so-called *target price* contracts—in other words, contracts based on an agreed (target) price with mechanisms enabling sharing the pain/gain in case the provider-related cost becomes higher or lower than the agreed price. We argue, consistent with the findings in [24], that the type of risk sharing mechanism implemented in target price types of contracts to a large extent determines whether target price contracts should be considered to be close to an FP or a T&M type of contract. The essential difference, at least related to project behaviour, seems to be whether the provider is paid for *all* completed work-hours, as in T&M contracts, or risks taking a *financial loss* in situations with high cost overrun, as in FP contracts. In the context of target price contracts, this causes us to categorize target price contracts with risk sharing and payment, regardless of size of cost overrun, i.e., without upper limit for risk sharing, as T&M types of contracts, and target price where there is an upper limit for risk sharing, and consequently a risk of the provider not getting paid for all the work, as FP types of contracts.

The use of FP and T&M contracts in the observed projects is, using this above categorization, distributed as follows:

* FP contracts: 13 projects (including eight target price contracts with an upper limit for risk sharing, where the provider typically would not be paid when the cost overrun exceeded 20–30%).
* T&M contracts: 18 (including eight target price contracts without an upper limit for risk sharing, where the provider typically would be paid at least 50% of the hourly payment when the number of work-hours exceeded that used as input for the target price, regardless of the size of cost overrun).
* Performance-based contracts: 2 projects. The payment here was to a large extent based on the amount of use of the developed software.
* No contract (close to purely internal projects): 2 projects.

For the contract analysis in this paper, focusing on FP and T&M types of contracts, we exclude the two projects with performance-based contracts and the two projects not having any contract, leaving 31 software projects to be analysed.

The categorization and measurement of the remaining variable values are described in Table 5.

**Table 5: Variables connecting contract type and project outcome**

|  |  |
| --- | --- |
| **Variable** | **Measurement** |
| Focus on low price in selection of providers | Categorized as “strong” or “weak”  The categorization is based on the project owner’s response to our question about how strongly a low price (bid, hourly price, or cost estimate) had been emphasized in the selection of providers. |
| Process for the evaluation of competence in selection of provider | Categorized as “extensive” or “not extensive”  The competence evaluation process is categorised as “extensive” if it extends the traditional evaluation process, understood as evaluation based on the project proposal, *cv*-s of key personnel, and references given by the providers themselves. Examples of processes that extended the traditional process are skill-testing, requests for proof of concepts, collection of independent references, and extensive evaluation of previous deliveries by the providers. |
| Realism of provider’s cost estimate used as basis for price or budget | Categorized as “strongly over-optimistic” or “not strongly over-optimistic”  To be categorized as strongly over-optimistic, the initial estimate had to be perceived as strongly over-optimistic by the project stakeholders. Usually this corresponded with at least 30–50% cost overrun. |
| Provider competence | Categorized as “problematic” or “not problematic”  The categorization is based on, from the client perspective, whether or not insufficient provider competence had been experienced at some stage. |
| Client involvement in management of the provider resources | Categorized as “strong/medium” or “weak”  To be characterized as “medium” the client had been involved, on a regular basis, in deciding on individual provider resource usage. Clients with “strong” involvement more or less controlled the selection of individual provider resources. |
| Flexible scope *and* frequent delivery to production | Categorized as “yes” or “no”  A project is categorized as having flexible scope if scope changes were treated as an integrated part of the project execution. A project is categorized as having frequent deliveries to production if there were at least four deliveries per year, and some of these deliveries were to “production”, i.e., in actual use by real users and enabling feedback during the project execution. |
| Benefit management during project execution | Categorized as “yes” or “no”  To be categorized as “yes” the project had at least implemented a prioritization process, typically based on a list of user stories, epics, or requirements, where functionality was regularly prioritized, managed, and, if needed, changed with the goal of delivering client benefit. |
| Client involvement in project management and execution | Categorized as “strong” or “weak”  To be categorized as “strong”, more than 30% of total project effort had to be completed by resources on the client side. This threshold is consistent with the results on minimum client involvement reported in [32]. |

## 4.2 Results

Table 6 summarizes the tests of the proposed connection using a quantitative, categorical analysis. The statistical tests of differences are based on a one-tailed, Z score calculation for two population proportions.

**Table 6: Results on the connections between contract type and project problem/success**

|  |  |
| --- | --- |
| **Proposed connections** | **Results** |
| C-total | *Problematic projects when using:*   * FP contract: 62% (8 of 13) * T&M contract: 17% (2 of 18)   Test of difference in proportions gives p < 0.01 |
| C1 | *Strong focus on low price/cost when selecting providers in:*   * FP contract projects: 54% (7 of 13) * T&M contract projects: 11% (2 of 18)   Test of difference in proportions gives p < 0.01 |
| C2 | *Lack of extensive process for evaluation of provider competence in:*   * FP contract projects: 69% (9 of 13) * T&M contract projects: 39% (7 of 18)   Test of difference in proportions gives p = 0.047 |
| C3 | *Providers with strongly over-optimistic estimates in:*   * projects with strong focus on low price/cost when selecting providers *and* no extensive provider evaluation process: 75% (6 of 8) * other projects: 22% (5 of 23)   Test of difference in proportions: p < 0.01 |
| C4 | *Provider competence problems in:*   * projects with a strong focus on low price/cost when selecting providers *and* no extensive provider evaluation process: 80% (8 of 10) * other projects: 10% (2 of 21)   Test of difference in proportions: p < 0.01 |
| C5 | *Problematic projects when:*   * providers had strongly over-optimistic cost estimates: 82% (9 of 11) * otherwise: 5% (1 of 20)   Test of difference in proportions: p < 0.01 |
| C6 | *Problematic projects when experiencing:*   * provider competence problems: 82% (9 of 10) * otherwise: 5% (1 of 21)   Test of difference in proportions: p < 0.01 |
| C7 | *Weak client involvement in resource management of provider resources in:*   * FP contract projects: 77% (10 of 13) * T&M contract projects: 28% (5 of 18)   Test of difference in proportions: p < 0.01 |
| C8 | *Provider competence problems in:*   * projects with weak client involvement in resource management of provider resources: 53% (8 of 15) * other projects: 13% (2 of 16)   Test of difference in proportions: p < 0.01 |
| C9 | *Weak client involvement in project management and execution in:*   * FP contract projects: 39% (5 of 13) * T&M contract projects: 11% (2 of 18)   Test of difference in proportions: p = 0.036 |
| C10 | *Problematic projects with:*   * weak client involvement in project management and execution 57% (4 of 7) * strong/medium client involvement in project management and execution: 25% (6 of 24)   Test of difference in proportion: p = 0.055 |
| C11 | *Lack of frequent deliveries to production or lack of flexible scope in:*   * FP contract projects: 85% (11 of 13) * T&M contract projects: 36% (10 of 18)   Test of difference in proportion: p = 0.044 |
| C12 | *Problematic projects:*   * without frequent deliveries to production *and* flexible scope: 43% (9 of 21) * with frequent deliveries to production *and* flexible scope: 10% (1 of 10)   Test of difference in proportions: p = 0.034 |
| C13 | *Lack of benefit management in the project execution in:*   * FP contract projects: 62% (8 of 13) * T&M contract projects: 33% (6 of 18)   Test of difference in proportions: p = 0.059 |
| C14 | *Problematic projects when:*   * not implementing benefit management in the project execution: 50% (7 of 14) * implementing benefit management in the project execution: 18% (3 of 17)   Test of difference in proportions: p = 0.027 |

As shown in Table 6, we find support for the direction of all the proposed connections. Although all differences are in the proposed direction, two of them (C10 and C13) are not statistically significant at p < 0.05 (but at p < 0.1). This may be a result of the low statistical power for smaller differences of our study, but may also indicate that there are no differences in the proposed direction for these two connections.

Table 7 includes representative qualitative experience-based evidence from the interviews based on the responses on what was considered to be important experiences from the projects, and, at the same time, related to the connections evaluated in this paper. None of the collected responses contained experiences, as we interpreted it, in conflict with the proposed connections, but not all connections were reported as reasons for problems or successes, either.

**Table 7: Experienced project problems**

|  |  |
| --- | --- |
| **Connection** | **Experiences from the projects** |
| Effect of strongly over-optimistic cost estimates in connection with use of FP contracts on experienced provider competence and project problems (C3, C4, C5, C6) | * *The provider, trying to reduce losses, put less qualified people on the project.* [FP contract] * *The collaboration climate between the provider and us got more and more formal the more it got clear that the provider would lose money on the project.* [FP contract] * *The provider, when pressured on their profit on the project, got more focused on the wording in the requirement, not what gave us as client benefits.* [FP contract] |
| Effect of client’s involvement in resource management and project execution on project outcome (C6, C8, C10) | * *Based on previous experience, we changed from selecting resources from one provider to selecting individual resources from several providers.* [experienced as a success factor, T&M contract] * *We did not have a sufficiently good check of the competence of the provider. It turned out that the provider lacked good domain competence.* [FP contract] * *We did not have enough competence as a client to be involved and understand consequences of the choices made in the project.* [FP contract] |
| Flexible scope and frequent deliveries to production (C12) | * *We learned much during the project. Combined with flexible scope* *this was essential for the project’s ability to deliver.* [T&M contract] * *The project had continuous deliveries with feedback from the users and automated testing processes to enable this.* [experienced as a success factor, T&M contract] * *The project had problems in involving important users and other stakeholders.* [FP contract] |
| Benefit management (C14) | * *We thought about how to realize the benefits too late.* [FP contract] * *We should have had more focus on benefits and needs and less on writing requirement.* [FP contract] * *The real users on the client side should have been involved earlier to better understand their needs.* [FP contract] |

Not many of the reported experiences were directly related to the choice of contract type, that is, related to the connections C1, C2, C7, C9, C11, and C13. One reason for this may be that people tend to report only what they perceive as *direct* reasons for project success or problems and not so much indirect and contributing reasons; see [34]. Contract type may be considered to only indirectly affect the successes and problems of projects and, consequently, seldom be reported. Alternatively, or in combination, awareness about how choice of contract type is related project success and failure may have been low.

# 5. Discussion of results and threats to validity

The two studies reported in this paper replicate the previous findings on a connection between the use of FP types of contracts and increased risk of problematic software projects. They also demonstrate that it is hardly a simple, deterministic and direct connection between the use of FP contracts and project problems but rather a context-dependent, probabilistic and indirect relationship.

The second study, perhaps being the first of its kind in software development contexts, examined *how* the choice of contract type was connected with project outcome, as seen from the client perspective. The results include, amongst others:

* Clients using FP contracts tended to have a stronger focus on low price/cost and a lower focus on evaluating provider competence when selecting providers than clients using T&M contracts. A stronger focus on low price, partly from statistical reasons related to selection bias/”the winner’s curse” [35], increases the risk of selecting providers with over-optimistic cost estimates, which in the context of FP contracts means a higher risk of selecting a provider who experiences a financial loss on the project [35]. This, in turn, means a higher risk of providers with opportunistic behaviour and experiencing project problems; see also [24]. The type of behaviour in projects using FP contracts, as experienced by the clients and supported by the data, may make it meaningful to talk about the *fixed price behaviour of the providers*. The risk of taking a financial loss in FP contract contexts tends to make providers behave less flexibly and more opportunistically, leading to a higher risk of low client benefits. Interestingly, we also observed that the *clients* tended to behave differently, including being less flexible, in projects with an FP type of contract. One of the providers in our second study, for example, stated that the clients tended to require the delivery of all specified functionality even when some of it was not really needed. More examples of the *fixed price behaviour of clients* are given below.
* Clients using FP contracts tended to be less involved in the resource selection and monitoring of provider resources than clients using T&M contracts. This may be a natural consequence of buying a delivery rather than paying for work-hours. As one of the clients in our second study stated: “*We cannot both set a fixed price for the delivery and decide on how the provider is supposed to use his resources to enable the delivery*”. We found a strong relationship between clients being involved in the selection and monitoring of provider resources and the rate of successful projects.
* Clients using FP contracts tended to be less involved in the project management and execution than clients using T&M contracts, which in turn seems to be connected with a higher risk of problematic projects. The reason may be that less involved clients are less competent and for this reason have a higher risk of project failure. It may also be that FP contracts tend to make the client think of the delivery as the responsibility of the provider and that more involvement on their part would make the responsibility of the provider less clear.
* Projects with FP contracts are less likely to have flexible scope and use frequent delivery to production (enabling feedback from users)—that is, to use agile practices reported to be connected with more successful projects [4]—than projects with T&M contracts. A possible reason for this is that it is difficult to implement flexible scope and frequent deliveries with learning feedback in contexts with FP contracts, which assumes a fixed price for a specified (fixed) delivery.
* Projects with FP contracts are less likely to implement benefit management during the project execution, which is also a practice connected with more successful projects [4], than projects using T&M contracts. Benefit management during the project execution may, as argued above, be hindered in projects using an FP type of contract by more complex project implementation of flexible scope and feedback from users.

The main *limitations* of the results of the two studies reported in this paper, not already discussed in relation to the study designs, are, in our opinion, as follows:

* The effect of the use of a contract type on the success or failure of a project is complex and context-dependent. We have tried to document the essential aspects of the context but may nevertheless not have understood our contexts sufficiently well to properly interpret and present the results. The lack of a full understanding of the context means, for example, that there may be contexts different from ours where the use of FP contracts reduces rather than increases the risk of project problems. This may, for example, explain the more positive results from the use of the FP type of contracts in Indian software offshoring contexts and reported in [20]. Our studies are from two different contexts—small, international offshoring software projects and larger Norwegian software projects with a public client. Clearly, there are other contexts, and more research is needed to better understand in which contexts different types of contracts give the best support for successful software projects.
* Our evaluation of project success is, in both studies, dominated by success viewed from the clients’ perspective. We believe, however, that a client’s evaluation of the success or failure of a project is essential and more in accordance with what is reasonable to consider as software project success or failure than, for example, the profit of the provider, which has been the focus of most of the previous studies. In addition, most of the information used in the analysis of the connections between contract type and project outcome in the second study is supported by factual project and process information, and is not likely to be dominated by the situation that the information is from the clients’ perspective.
* The connections we report may to a large extent be correlational. If this is the case, and there is no effect stemming from the choice of contract type, it may not help the client much if it changes its use of contracts from an FP to a T&M type of contract. While we do not believe this to be the case, given the correspondence in results from different contexts, there is still a need for further studies to extend and evaluate the network of connections with emphasis on better understanding the causal relationships—the underlying mechanisms—between contract type and project outcome.

# 6. Conclusion

It is hardly defensible to make strong and general conclusions about the effect of contract choice on software project outcome based on previous evidence and that from our two studies. A few moderately well supported conclusions and recommendations, with warnings about their context dependencies, are perhaps the best we can do. We believe that the evidence supports the following:

* Projects using FP contracts seem, in general, to be more problematic compared to projects using T&M contracts.
* The increase in risk of problematic projects from the use of an FP contract seem to be connected through the following client tendencies increasing project problem risks:
* More focus on low price in the selection of providers and, as a consequence, a higher risk of selecting providers with over-optimistic cost estimates causing opportunistic behaviour.
* Less focus on competence in the selection of providers and, as a consequence, a higher risk of experiencing problems with provider competence.
* Less involvement in the management and monitoring of provider resources during the project execution and, as a consequence, a higher risk of problems with provider competence.
* Less involvement in project management and execution.
* Less use of the flexible delivery scope and frequent delivery to production.
* Less focus on benefit management during project execution.

It may be possible to use FP contracts and still avoid the above tendencies. The available evidence suggests, however, that it is easier to succeed in doing so when using T&M contracts. We believe, consequently, that clients should be careful about using FP contracts in software development projects. The main client reason for using FP contracts may be to avoid the financial risk related to large cost overruns. If, however, the risk of low client benefits and more problematic or failed projects substantially increase when using FP contracts, as indicated in our studies, the financial risk argument in favour of FP contracts becomes much weaker.[[3]](#footnote-3)

The selection of a T&M contract is clearly not enough in itself to succeed with software projects. The observed reduced risk of problematic software projects when using T&M contracts is more likely a consequence of the use of it tending to increase the likelihood that a project has a thorough evaluation of provider competence; that the clients are more involved in selecting and monitoring individual provider resources; that the clients are more involved in the execution of the project; that the project uses the agile practices, flexible scope, and frequent delivery to production, and that the project implement benefit management during the project execution. The use of T&M contracts seems to ease the implementation of all these practices, which in turn tends to increase the likelihood of successful software projects. In short, the use of FP types of contracts tends to complicate good practices, and the use of T&M types of contracts tend to ease the use of such practices, thus decreasing the risk of project failure.

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2. Nevertheless, we tested the effect of the contract type on more balanced datasets. We divided all the fixed price projects, randomly, into 10 equally large sub-sets, included all T&M projects in each of them, and repeated the model building using the 10 more balanced datasets. The effect of the contract type on risk of project failure was about the same in all 10 models. [↑](#footnote-ref-2)
3. As documented in [12], the client tended to pay part of the cost overrun even when using an FP contract—that is, not even the financial risk tended to be transferred to the provider with a fixed price. [↑](#footnote-ref-3)