

Challenges of Cost Management in Complex Projects

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Abstract

Contingency approaches for understanding complexity in projects are intended to help academics and practitioners make distinctions between different types of projects to better understand the relationship between practices and outcomes when applying different project management processes. In this paper, we build on existing research on complex products and systems (CoPS) to address the challenges of managing costs in projects of varying complexity. Based on a qualitative case study, we identify several challenges in performing various cost management functions related to cost estimation, cost control and monitoring, revenue recognition, profitability analysis and margin calculation. The cost management functions are impacted by the large size, complexity, uncertainty and uniqueness of those projects.

Keywords: complex projects, complex product systems, cost management, contingency theory

1. Introduction

Numerous tools, techniques, guidelines and methodologies have been developed over the years to help manage projects and programs. However, major projects and programs across a range of sectors such as IT, defense, financial services and construction continue to be dogged by poor performance and failure to deliver the promised benefits (Economist, 2005; House of Commons, 2004a, 2004b; Ministry of Defence [MOD], 2004). The literature has drawn attention to how increasing complexity may be a significant factor in the success and failure of projects (Flyvbjerg, Bruzelius, & Rothengatter, 2003; Meier, 2008; Miller & Lessard, 2001; Morris & Hough, 1987; Williams, 2005; Brady & Davies, 2014). A better understanding of project complexity could to help both academics and practitioners make distinctions between different types of projects to better understand the relationship between practices and outcomes in project-based processes (Williams 1999; Gerald, Maylor, & Williams, 2011). However, there is little empirical research on how these complexity characteristics affect specific management processes. It is this gap that this paper seeks to address by examining the challenges of managing costs in projects of varying complexity. We try to answer the research question: How is cost management in projects affected by the project's level of complexity?

Theoretically we draw from contingency theory, which suggests that there is no optimal strategy for managing projects and organizations and that managerial approaches have to be tailored to account for the specific context (Lawrence & Lorch, 1967; Shenhar, 2001). We analyze cost management functions of project with varying degree complexity to identify which type of challenges increasing project complexity creates for project cost estimation, budgeting and cost control.

1.1 Characteristics of Complex Projects

In the literature, large projects with a wide scope and complex deliveries are also called integrated projects (Hobday, Davies, & Prencipe, 2005), complex projects (Barlow, 2000), Complex Product Systems (Hobday, 1998), turnkey projects (Davies, Brady, & Hobday, 2006) and simply large projects (Miller & Lessard, 2001). These projects involve integrating a wide scope of products and services into a total solution to meet the customer's complex and unique needs. To understand how complex projects differ from more standardized projects, Hobday et al. (2005) suggest that they should be classified according to the project's breadth of the scope and technological uncertainty. Recent studies based on comprehensive systematic literature reviews (Bosch-Rekvelde, Jongkind, Mooi, Bakker, & Verbraeck, 2011; Gerald et al., 2011) have extended our understanding of complex project. The characteristics of complex projects are related to size of a project, interconnectedness of various elements of a

project, uncertainty and project uniqueness.

A distinctive characteristic of complex projects is size of a project, which can be measured by number of activities or project technical scope (Bubshait, 1998; Hobday et al., 2005). Other measures of project size include the total project cost, the number of employees involved and duration of a project (Tukel & Rom, 1998). In addition, the size of the project can be considered using two principally different approaches: 1) the actual size of the project and 2) the relative size of the project, which is the significance of the project to the company and the industry Kujala et al. (2008). The relative size of the project is related to number of projects performed each year and how large a share of company resources must be used to execute the project. The interconnectedness of various elements of project such as technical parts or organizational units increases project complexity (Bubshait & Selen, 1992; Baccarini, 1996; Vidal & Marle, 2008).

The complexity of a project has three kinds of elements: technical/technological, organizational and environmental (Bosch-Rekvelde et al., 2011). These elements can be further divided into two basic dimensions: differentiation and interdependence (Baccarini, 1996). Differentiation describes the number of interrelated parts or elements related to the execution of the project, and interdependence (also called connectivity) describes the degree of interrelatedness between those elements. For example, the level for organizational complexity can be described as the number of organizational units involved in the project and the connection between those units (Bubshait & Selen, 1992). Similarly, technological/technical complexity encompasses elements such as the clarity of the technical specifications related to the output of the project, the wideness and uncertainty of a project's scope, the newness of the technology, uncertainty in methods and the interrelations between technical processes (Bosch-Rekvelde et al., 2011). A simple definition for environmental complexity is the number of stakeholders (relationships) the project must cope with (Vidal & Marle, 2008).

Uncertainty is knowledge related to project goals or means of achieving those goals (Williams, 1999). One of the most obvious areas of project uncertainty is the uncertainty and variability associated with estimates of project's objectives such as the cost, quality and time related to different subprojects and activities (Atkinson, Crawford, & Ward, 2006; Ward & Chapman 2003). The estimates are typically based on the project parties' subjective judgments and could be affected by numerous kinds of biases. They are related to lack of knowledge or previous experience about the design, production and logistics of the project deliverables. Also the role of project parties and their relationships are important sources of uncertainty. Atkinson et al. (2003) emphasize the role of the parties' performance level, objectives and motivation while Ward and Chapman (2006) concentrate on the relationships between the parties and assert that ambiguity related to the parties' relationships should be systemically addressed in every project, not only in the projects that involve contracts between organizations.

Projects by definition are unique: "*A project is a unique entity formed of complex and interrelated activities*" (Artto, Martinsuo, & Kujala, 2011). The uniqueness of a project is often associated with the customization of products and processes (Engwall, 2003; Geraldi & Adlbrecht, 2007; Hobday, 1998). Uniqueness is also related to external factors such as previous experience working with projects or an unfamiliar societal context (Bosch-Rekvelde et al., 2011; Orr & Scott, 2008). Project novelty is mainly used in relation to R&D projects to describe the technological challenge in creating new products (Shenhar, 2001). Technological novelty can be divided into two dimensions: product technology novelty, which includes the novelty related to product architecture, parts and modules needed to deliver the resulting product of the project, and process technology novelty, which includes novelty related to manufacturing flows, manufacturing tools or process stages of the project (Tatikonda & Rosenthal, 2000).

1.2 Project Cost Management

The task for the cost management function is to produce information for internal users who need accurate, detailed and frequent economic information for making decisions (Belkanoui, 1993). Specifically, cost management "identifies, collects, measures, classifies, and reports information that is useful to managers for determining the costs of products, customers, and suppliers, and other relevant objects and for planning, controlling, making continuous improvements, and decision making" (Hansen & Mowen, 2006). Project cost management includes three major functions called cost estimating, budgeting and cost control (Project Management Institute [PMI], 2004). The goal of these functions is to "*ensure that the project is executed in a cost efficient, profitable manner, according to business principles and from the perspective of the entire company*" (Artto et al., 2011). These three major functions and sub-functions covering the entire PLC as presented in figure 1.

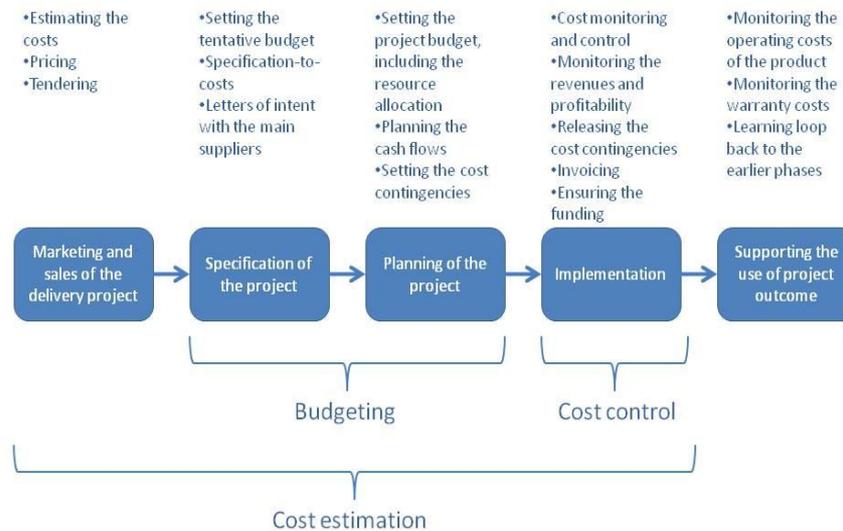


Figure 1. Cost management through the project lifecycle

Managing a project's costs starts early during the marketing and sales phase of the project when tentative cost estimates are created. During this phase, estimates are iteratively specified to provide accurate and reliable information to be used in tendering and pricing the delivery project. During the project specification phase, a tentative project budget is set, a specification-to-cost approach is exploited to ensure cost-effective specifications and, typically, the letters of intent with the main suppliers are signed. Before the implementation phase, the project budget is created based on the latest cost estimates. In the project planning phase, the resources for the work tasks are allocated, cash flows are planned and typically cost contingencies are set. During the planning and implementation phases, the actual costs of the project are monitored. In addition, cost estimates and forecasts are constantly updated and then compared with the project budget. In the implementation phase, the project revenues are monitored, invoicing is performed and cost contingencies are released. In some projects, funding is also ensured during the implementation phase. After system delivery, the operating costs of the delivered system are monitored in co-operation with the customer, warranty costs are monitored and a learning loop back to the earlier phases should be created.

2. The Empirical Research

A case study method was chosen to gain in-depth understanding of the challenges related to cost management in projects. The case company is a global power solution provider for the marine and energy markets with more than €4.5 billion in annual revenue. For the purpose of this paper we shall call it Power Co. Power Co has more than 15,000 employees in more than 70 countries around the world and is divided into three business units. Cases were selected based on theoretical sampling (Curtis, Gesler, Smith, & Washburn, 2000). In this analysis, the focus is the marine power solutions business unit. The projects studied included two standard delivery projects with low complexity and two projects with high complexity. The selection of the projects enabled us to identify management challenges that are specifically related to complexity of the project as they were implemented in the similar context.

The empirical data was collected by reviewing the cost management performance reports for the four projects and gathering further information through eight interviews with key persons involved in the projects. The cost management performance reports were reviewed three times during different phases of the project. Interviewees included a general manager of project management, three project managers, two project engineers, one project controller and the director of business control and administration. All had worked on the case projects, and the project managers and engineers had a deep understanding of the specific case project in which they were involved. In contrast, the general manager, project controller and business control and administration director had wide knowledge of all the case projects and provided valuable information when we compared the characteristics of different projects.

3. Description of the Empirical Case Projects

Two of the case projects were equipment deliveries with limited scope. Power Co was very familiar with this

type of delivery, and their management accounting systems were tailored to meet the requirements of this type of project. To analyze the special challenges related to complex projects, two projects with a large scope, new combinations of products, high complexity and high uncertainty were chosen. The analysis process can be considered inductive in nature and case comparison was done only to increase our understanding about which challenges related to cost management were caused by complexity of the project. The empirical data was gathered by reviewing the cost management performance reports of the case projects three times during the project and through eight interviews with key employees at the case company. In table 1 characteristics of case projects are described.

Table 1. Characteristics of empirical case projects

Characteristics	Project 1	Project 2	Project 3	Project 4
Economic value and length of the project	Medium €, 20 months	Very high €, 24 months	Small €, 6 months	Medium €, 16 months
Scope of the project	Restricted scope with only main equipment and auxiliary equipment	Full scope with main equipment, propulsion and electrical automation (Also some additional sub-scopes)	Restricted scope with only main equipment and auxiliary equipment	Full scope with main equipment, propulsion and electrical automation
Uniqueness or novelty of the solutions	standard product	Totally novel solution type for the company	standard product	Unique solution
Integration of different disciplines and subproject from several business units	No	Yes	No	Yes
Are there several subprojects	No	Yes	No	Yes
Project classification according to the case company system	Challenging with medium uncertainty	Very challenging with high uncertainty	Simple project with low uncertainty	Very challenging with high uncertainty

Case Project 1

Case Project 1 included generating sets and auxiliary equipment for a ship. The scope of the project also included the project management and site start-up services, but propulsion or electrical automation equipment are not included, thus the scope could be considered restricted. The value of the contract was considered medium-sized and the scheduled length from the order intake to the handover was about twenty months. About eighty percent of the project's total costs were caused by the main purchases which are done mostly with fixed prices from other legal entities and from the case company suppliers. That is why cost control during the project has only a restricted ability to affect to the total costs of the project. About 150 similar projects have been delivered by the case company using their current cost management system, meaning that only a limited amount of modifications and manual work were needed for cost control of the project. The main challenges of case project 1 were related to customer interface management, because the customer was very interested in the quality of the product and required assurances that the contracted quality level was achieved. The documentation for the project was very challenging, because the customer binds detailed documents which are formulated according to their policies.

Case Project 2

The value of the project contract was exceptionally large. The length of the project from order intake to handing over was about twenty four months, so the duration was longer than the other case business segment projects. The project included power modules for marine energy production use. The production and start-up of those modules was totally the case company's responsibility, so the main equipment, electrical automation and multiple additional sub-scopes needed to be designed as an integrated solution to generate electricity properly.

Six months of maintenance service and the option for two-years of additional maintenance service were included in the contract. The main equipment was delivered by PowerCo's joint venture and represented about 40% of the project's total costs. Steel modules to house the equipment were delivered from the local supplier in Asia and the value of the supply contract was about one sixth of the total costs. There were also multiple other scopes to the project that are produced by different legal entities than the contracting one. Due to the extended duration and high value of the project, accrued revenue recognition was enforced in the revenue calculation of the project. Because case project 2 includes multiple special sub-scopes, a high level of modifications and manual work were needed when creating the project structure for the cost management system.

Case Project 3

The third case project was the delivery of main and auxiliary equipment of the vessel located in customer segment B. The project also included the start up support and management of the project, but no propulsion or electrical automation were included and the amount of engineering needed was restricted. The value of the contract could be considered small and the length of the project from the order intake to the handing over was about six months. All in all, case project 3 was a quite conventional delivery project, which Power Co has long and solid experience with. From a technical point of view, the multi fuel solution, equipment using two different fuel types was one of the project's major challenges. The use of external suppliers can cause some challenges for the project management but from a cost managerial approach, the costs related to external suppliers were quite small so also the risks were limited.

Case Project 4

Case project four was a full scope power solution for a vessel. The project included the main equipment and auxiliary systems, a wide scope of propulsion equipment, electrical automation, project management and start up support to offer a total power source solution to the customer. The value of the project contract can be considered medium-sized and the estimated length from the order intake to the handover was about sixteen months. The different scopes of the project were delivered from entities in Europe and Asia so the project can be considered a truly global project and that caused multiple challenges. Purchasing from legal entities other than the contracting entity required the use of intra group purchase and sales orders which caused special challenges for project coordination. The wide scope of the project, meant that commissioning and site start up support required a significant amount of person-days and a site manager was also needed, which resulted in significant risks for the handover of the project. The project contract also included three optional ship sets, which made the project a valuable reference for the future business.

4. Findings

The following cost management functions or sub-functions were identified as the most interesting: updating the project cost estimates, monitoring the costs of the project, controlling the project costs, updating contingency plans, releasing specific contingencies, calculating margins and analyzing profitability.

4.1 Cost Estimation

Cost estimation starts during the sales phase of the project when estimates provide significant information for tendering and contract calculation. In complex projects, the wide project scope sets challenges for the sales engineers who are responsible for compiling the contract calculations. This is demonstrated by the project manager of case project 2, who stated, "When we are delivering products and services which have not been delivered ever before, cost estimation gets harder." Complex projects are unique and complicated, so historical information for estimating costs is not available and the amount of technical expertise required to understand the project is huge. Thus, in complex projects, estimating the designing, engineering, project management and commissioning costs is much more challenging than in a project with more restricted scope. "The larger the project is, the larger is the amount of engineering work related to it and also the effect of the engineering costs to the total costs of the project is more significant" (project controller). A Project manager typically has specific technical expertise and a deep understanding of that particular technical sector, whereas his technical competence related to other technical sectors is more restricted. In the execution phase, the uncertainty of complex projects causes problems in procuring resources from suppliers without long-term contracts that outline prices. The uncertainty and uniqueness of the purchase prevent the responsible person from estimating the cost of the purchased product. Thus, he or she does not enter an estimate of the costs into the ERP system. As a result, the cost estimate for the entire project is no longer reliable, and cost overruns occur when the costs of the purchase are actualized. These situations are far more likely to occur in complex projects than in standard projects where typically only standard products and well-known suppliers are used. Because of the wide scope of the project, it is very challenging for the project controller to recognize such situations.

4.2 Cost Monitoring and Controlling

In complex projects, with wide scopes tailored to meet customers' needs, compiling and calculating the tender is much more time-consuming and costly than in non-complex projects. Typically, complex projects are larger than standard projects, meaning a smaller number of complex projects, compared to standard projects, can be executed with the same resources. That is why a smaller number of tenders are typically needed. A second challenge related to the cost control of complex projects is the use of new and unknown suppliers. Suppliers from developing countries in particular often have problems delivering the expected quality with the contracted price, so cost overruns are likely to occur. When the value of the project is high, the capital costs caused by the schedule overruns are also significant. "The wider the scope and the higher the costs of the project, the more significant the costs if the project gets stuck with the work in progress status" (general manager). Problem solving related to the wide scope is typically costly, and the case company is responsible for all of the costs, so customer complaints can lead to significant cost overruns. Projects with a wide scope require intra-group deliveries from different legal entities all over the world. The wide scope also requires numerous WBS elements. All of these reasons mean that most project managers and project engineers do not completely understand the overall cost structure of the complex project, which causes cost-related confusion and cost overruns.

Several interviewees also observed that due to the challenging and complex technical scope of the project, updating the project plan is challenging in complex projects and a lack of technical expertise increases the risk of purchasing mistakes. Complex projects are more closely monitored by the general project management and by project/business control. The BC&A Director also stated, "Because cost management of the projects is not as actively performed by project employees, the business control function have taken a more significant role in cost management." In practice, the project controller usually follows up the actual costs of the project. If significant cost overruns are observed, he discusses the overrun and reasons with project management. Unfortunately, according to the project controller, the wide scope of a complex project has created challenges in observing and understanding likely reasons for cost overruns. In particular, more attention has been paid to cost controlling in the most challenging phases of the projects: commissioning, design and engineering and logistics. For example, commissioning employees are specified experts in their respective technical sector, but they cannot speed up commissioning related to other technical sectors. In complex projects, technical scopes are closely related to each other, which increases the complexity of the commissioning and increases the total cost and consequences of schedule delays.

4.3 Revenue Recognition, Profitability Analysis and Margin Calculation

Controlling project margins is one of the most important functions to ensure profitability. Margin control is done by project employees who are mainly interested in the total margin of the project and business segment. For them, margin control is one way to control the cost performance of the project. However, they play a vital role in ensuring the high quality of cost and margin-related data. This is clearly demonstrated by a comment by the general manager: "Because we work in a global organization, instead of local margins, we are interested in the global project and segment margins." However, general management is more interested in following up the profitability of the different products, customers and legal entities. The margins of local companies in particular should be properly calculated to ensure that accounting is done according to accounting laws and principles and to ensure appropriate taxation. The role of intra-group transactions is particularly emphasized in complex projects where there are numerous sub-scopes and products are supplied from globally located legal entities. It is vital for the reliability and accuracy of the margin calculations to ensure that purchase order requisitions, purchase orders, sales orders and other intra-group transactions are performed correctly. Because the case company still faces significant challenges related to the intra-group transactions and project plan updates, the business control tries to make sure that transactions get done properly to ensure the reliability of the data needed in the margin calculations. These challenges are emphasized when multiple scope changes occur in the project as they often require recalculation of transfer prices and intra-group transactions between the legal entities need to be modified accordingly. Ideally, these types of changes should be avoided, but due to uncertainty in the project definition phase, they are often unavoidable. Also customers' change orders typically have a higher margin than the original project and should be seen as opportunities to increase profitability.

In the projects with completed contract or partial delivery revenue recognition, the main challenges caused by the wide scope of the project are the specific delivery dates of the separate sub-scopes. In projects with a percentage of completion (POC)-based revenue recognition, major problems are related to inaccurate estimates or entered costs. If the estimates or entered costs are inaccurate, the recognized revenue for the year (or quarter or month) could be unrealistic, which causes undesirable fluctuations in the recognized revenues and profits or losses. That impedes forecasting of the company's profits or losses, which causes problems for financial decision-making within the

company and could substantially mislead investors.

4.4 Setting and Releasing Cost Contingencies

Contingency management is one of the most important cost management functions in the case company. "In every project, some amount of contingencies are included in the project and the management of contingencies includes risk management, risk minimization and cost contingencies releasing functions" (BC&A director). To ensure appropriate risk management of the project, the case company has implemented an ABC risk categorization tool. Projects with A status are the most challenging, and projects with C status are standard ones with minor risk. Bigger contingencies are included in the A category complex projects: "In full scope projects, we often take unique and new actions, so all of the circumstantial factors are not known in advance. That is why more money is allocated to the contingencies to cover possible cost increases" (project manager). The same project manager also stated that coordinating a full scope project is much more complex than coordinating a standard project, so it is quite natural that larger contingencies are set. Additionally, releasing cost contingencies is also challenge in complex project due to the POC-based revenue recognition method. To properly recognize revenues according to the POC method, cost contingencies must be released during the project.

5. Summary of the Empirical Findings

The most important cost management functions and sub-functions related to the execution phase of complex projects are updating the project cost estimates, monitoring the costs of the project, controlling the project costs, calculating and releasing specific contingencies, calculating the margins and analyzing profitability. The most important challenges based on our empirical study are the following:

- Due to uniqueness of each project there is no accurate information for pricing and setting up appropriate contingencies in the sales phase. For example, cost of purchasing unique services is difficult to estimate.
- Prices of resources can vary during a long project, which causes problems for estimating costs.
- In complex projects, there are more project management and integration engineering costs, which are more difficult to calculate that product costs.
- Numerous legal entities require their own margin calculation.
- Profitability of the project is difficult to calculate and requires well-designed transfer pricing when project is implemented in several independent business units.
- If the project size is large as compared to parent organization, cost overruns may results financial challenges to parent organization.
- High uncertainty leads to large contingencies. Multiple contingencies are related to the different WBSs, so perceiving the total value of the contingencies is challenging.
- Long-term and high-value projects require the use of the percentage of completion (POC)-method. This requires the use of the recognition of accrued revenue, which leads to contingencies having to be released during the project.

6. Discussion

This research brings up challenges related to cost management in complex projects, which were characterized by the following attributes: large size, complexity, uncertainty and uniqueness. These types of projects require their own specific management emphasis and methods (Jolivet & Navarre, 1996). Executing complex projects efficiently sets up new challenges related to employees' competence, organizational form and project management (Kovács & Paganelli). The increasing and underestimated complexity of projects is suggested as a major reason for cost overruns (Neleman, 2006; Williams, 2005). Our research clearly demonstrates that increasing complexity of a project leads to special challenges for the cost management function as many of the existing cost estimation methods are inadequate to cope with the complex and uncertain nature of modern large-scale projects.

Because complex projects provide customized solutions to cover the customer's problem the resulting solution often differs significantly from the solutions of earlier projects. A lack of experience with similar projects and restricted availability of the historical data causes inaccuracy in the estimates (Doloi, 2011). Without earlier experience from similar projects, the managers and controllers of a project cannot anticipate when and where project cost overruns are likely to occur. Those challenges were also recognized by Kovács and Paganelli (2003), who stated that the activities of complex projects are usually geographically distributed and activities are performed in unprepared or even hostile environments. Those "unprepared or hostile environments" in combination with the technically large scope create challenges for commissioning – which was also recognized as

the most challenging project phase in the Power Co's complex projects. According to most interviewees, the technically large scope also sets challenges for estimating and controlling the design and engineering costs. The difficulties of estimating costs in projects with a technically large scope are also recognized by Haidar and Ellis (2010).

In large projects the coordination of large number of different internal and external stakeholder is a major challenge for cost management. Increasing the number of suppliers creates challenges for managing and estimating supplier costs (Iyer & Jha, 2005). In the complex case projects, in which wide and varying scopes are delivered, multiple specialized equipment and technical experts are needed. Since producing the equipment and managing specialized competence in house is not cost-efficient, the case company uses multiple suppliers and consultants in complex projects. The suppliers vary significantly across different projects, which increases the uniqueness of the project. From the cost management point of view, this uniqueness causes cost overruns related to the suppliers and external engineering. This is emphasized especially in novel and unique projects, in which there are challenges to estimate and control level of performance and quality that will be achieved with the new suppliers (Atkinson et al., 2006). Internal suppliers may also create special challenges as they have their own objectives and employ their own margin calculation and profitability follow-up processes.

Because the different legal entities are specialized to deliver their own sub-scopes and equipment, the organizational structure of complex projects varies according to the scope of the project. A complex and distributed project organization increases the complexity of the cost structure, which causes challenges in detecting potential or actual cost overruns (Kovács & Paganelli, 2003). Intra-organizational transactions also required more delicate margin calculation and a wider cost control. In large organizations each legal entity may have its own procedures and country context that set some specific rules for cost management and transfer pricing. Thus in a large and complex project it may be very difficult to understand and monitor the overall profitability of the project. If the relative size of the project is significant, the consequences of large cost overruns can also significantly affect the company's profits or even endanger its financial position.

As integrated projects are typically long-term and large in value, companies are liable to recognise the revenues of those projects with degree of completion such as POC or some other accrued revenue recognition method. The objective of the percentage of completion method is to enhance the comparability of separate accounting periods' financial statements (Wüstemann & Kierzek, 2005). The method requires that (1) cost calculation and the financial statements provide the proper information for the reliable calculation of the project's cost, and (2) the percentage of completion of the project can be reliably quantified in the financial statement. Both these requirements are quite challenging to meet in complex projects involving multiple organizational units. High uncertainty and related contingencies complicate the issue as recognizing accrued revenue requires that cost contingencies are released during the project.

7. Conclusion

Project companies are moving in the value chain to provide integrated solutions that combine multiple customized products and services to their customers. These large and complex delivery projects require their own specific management emphasis and methods. In this research, we adopted a contingency research perspective and aimed to identify characteristics that are relevant to take account when designing efficient organizational structures and management approaches for cost management. Based on a qualitative case study, we identified several challenges to the accuracy and performance of various cost management functions related to the large size, complexity, uncertainty and uniqueness of the projects. However, as a qualitative case study within one firm and four projects, these results have mainly developed theory. We propose further research, based on a larger sample size of multiple firms and projects and quantitative analyses, is needed to validate our results.

Increasing complexity and underestimating complexity are major reasons for cost overruns and time delays in projects. Thus, understanding and dealing with complexity are important knowledge areas in project management. Regardless, managing extremely complex projects is very challenging, and special management methods are needed to execute complex projects successfully, which requires the project manager to have specialized competencies. This research increases our understanding how cost management should be applied in the context of complex projects.

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