8th Nordic Conference on Construction Economics and Organization

Generalising via the case studies and adapting the oil and gas industry's project execution concepts to the construction industry

Øystein Mejlænder-Larsen*

Norwegian University of Science and Technology, 7491 Trondheim, Norway

Abstract

The aim of this paper is to explore whether it is possible to generalise findings on project execution in the oil and gas industry related to the use of project execution models and a 3D design environment, based on case study research. Besides, sufficient similarities between the two industries were assessed and the applicability of the findings from the cases in the oil and gas industry was assessed. The selected cases (the ongoing projects) have several principal similarities, but the extents of use differ. The project execution model (PEM) of the oil and gas industry is based on codified knowledge from project execution, which makes it easier to transfer such models to other industries. The use of 3D design environments or building information modeling (BIM) in the construction industry is similar to the use of PEMs in the oil and gas industry but BIM differs on model complexity and object information. The findings indicate that it may be possible to develop generalizable project execution concepts in the oil and gas industry by using the conceptual generalisation theory. Indeed, it is herein proposed that the high-similarity between the variables related to PEM and BIM enables the transfer and adaptability of PEM-based concepts to the construction industry.

Keywords: Building Information Modeling; Case selection; Case study; Generalisation; Project execution model

1. Introduction

The construction industry is a large and value-creating industry, but it suffers from too many building defects and often too high construction costs. Annual costs related to the repair of building damages in Norway, as a result of

* Corresponding author.
  E-mail address: oystein.mejlander-larsen@ntnu.no

defects during design and construction, probably represent 2-6 percent of the annual investment costs for new-build projects (Ingvaldsen, 2008). In recent years, the construction industry has seen an increase in larger and more complex building projects. Larger projects, higher complexity and increased risk in these projects imply that both building owners and contractors should focus on the professional management of projects, increased interaction between actors in value chains and the increased utilisation of available and innovative technology. However, the construction industry is one of the least R&D intensive industries in Norway (Reve & Sasson, 2012). According to Bygballe and Ingemansson (2011), poor technological and economic developments may partly be due to the state's low and fragmented involvement, i.e. several ministries share responsibility for the construction industry, in contrast to only one ministry being responsible for the oil and gas industry. In part, the low level of the public and private funding of construction-related research has its limiting consequences.

In turn, the oil and gas industry has managed large and complex projects and invested heavily in the development of new technology over the past 40 years. The Norwegian oil and gas industry has gained the international recognition for project leadership, PM and technology utilisation.

It is herein foreseen that the construction industry would benefit from gathering knowledge and learning new lessons from other industries with relevant experience in executing large and complex projects. The case in point involves many similarities in project execution between the construction industry and the oil and gas industry in terms of project phases, actors, management principles and technology use. Overall, the author's PhD study involves the exploration on the successful management of major oil and gas projects by one of Norway's largest engineering, procurement and construction (EPC) contractors, Kvaerner, based on the use of a project execution model (PEM[A]), combined with the utilisation of the 3D design environment[B], corresponding to building information modeling (BIM[C]) in the construction industry. Success is measured in terms of right quality, as planned and on time. The objective of a PEM is to secure predictability in project execution by using a standard methodology well known to each project team. Multidisciplinary understanding and common goals through management and execution processes are the prerequisites to avoid rework and instead deliver "correct the first time" (Kvaerner, 2012b). The utilisation of the 3D design environment is crucial for successful implementation of PEM in a project, combined with structured (object related) information, planning, change management and document management.

Nomenclature

A   A project execution model (PEM) reflects a logic sequence in critical project activities where progress and quality requirements are aligned at significant milestones to ensure predictable project execution (Kvaerner, 2012b). It is mainly based on the Project Integration Management knowledge area defined in PMBOK Guide (PMI, 2013).

B   A 3D design environment refers to a multi-discipline and object based 3D design software integrated with a number of information systems that serves as the main source of information for engineering and construction. The main purpose is to improve the coordination and consistency between the disciplines responsible for the design in the project (Kvaerner, 2012a).

C   Building Information Modeling (BIM) can be defined as a digital representation of physical and functional characteristics of a facility. It is a shared knowledge resource for information about a facility and forms a reliable basis for decisions during its life cycle – from concept to demolition (NBIMS, 2007).

Via many case projects, the PhD study aims at identifying solutions and practices within process and technology areas that could be adapted to the construction industry and, thus, contribute to higher effectiveness in building processes. In turn, the aim of this paper is to re-use the same case projects as a reference to explore the theoretical basis for generalising based on such case studies and to assess whether it is possible to generalise findings on project execution and the use of PEM and the 3D design environment in the oil and gas industry. Furthermore, the sufficiency of similarities in project execution between the two industries is investigated and the adaptability of such findings to the construction industry is assessed. The working hypothesis is that case-based findings on project

execution in the oil and gas industry can be generalised and that findings related to the use of PEM and the 3D design environment (BIM) can be adapted to the construction industry.

2. Case study research

The choice of an applicable research method is important when doing social science research. Herein, the possibility to generalise based on case study research is assessed. The choice of the case studies is based on Yin's (2009) framework and therein the three conditions for distinguishing different research methods, i.e. the form of the research question, the extent of control a researcher has over actual behavioural events and the degree of focus on contemporary events. The first condition is to classify the type of research question being asked. "How" and "why" questions are explanatory, dealing with conditions followed over time, instead of incidents. The research questions for the PhD study as a whole are "How can the construction industry learn from the oil and gas industry in terms of executing projects more efficient, with the use of project execution models?" and "How does the use of the 3D design environment (BIM) support this?" The research question starts with "How", because case projects are followed over time. This condition will favour the use of experiments, case studies and histories as research methods. The next condition is the extent of control over and access to actual relevant behavioural events, i.e. case projects. In turn, the author is only observing case projects over time, without any formal role and manipulation. These two conditions still favour the use of case studies and histories as research methods. The last condition is based on the focus on contemporary events as opposed to historical events. The focus of the author is on examining contemporary events and the follow-up of the selected ongoing projects within the two industries, through various phases, which makes case study a preferred option. Together, these three conditions only favour case studies to be relied upon.

3. Case selection

Flyvbjerg (2006) states that generalizability relates to the question of case selection and that the right strategic selection of cases can increase the generalizability of case studies. According to Seawright and Gerring (2008), there are two objectives in case selection in case study research. That is to find a representative sample and to aim for variation on the dimensions of theoretical interest, within a relevant population. Among the seven case study types, "most similar" cases provide the strongest basis for generalisation. "Most similar" cases must consist of at least two cases. The chosen cases should be broadly representative for the population of interest, and ideally, similar on all measured variables except the variables of interest. In turn, the case projects in the overall study have several principal similarities, but the extents of the use of the PEM and the 3D design environment (BIM) in project execution differ between the oil and gas industry and the construction industry.

In the oil and gas industry the contract is mainly EPC where only one, two or all three areas can be subcontracted. The author has access to the three ongoing projects at Kvaerner as the cases in the oil and gas industry. Kvaerner has initially selected the two cases, i.e. the delivery of the topsides for the two production platforms in the North Sea, both executed as the EPC contract and one with engineering on the subcontract. The last case involves the modifications and the projects on the onshore gas facility on the west coast of Norway, executed as the EPC contract, with engineering on the subcontract.

An EPC contract in the oil and gas industry corresponds to a design-build contract in the construction industry where the engineering and construction services are contracted by a single builder or contractor. Design-build and design-bid-build, where engineering and construction are contracted separately, are the most common contracts in the construction industry. The author has access to up to three case projects in the construction industry, related to the research project "Collaboration in the building process - with BIM as a catalyst" (Forskningradet, 2014), funded by the Research Council of Norway. The industry partners have selected the cases, i.e. the commercial buildings and the ongoing projects located in and around Oslo, via the design-build contract and the design-bid-build contract.

Principally, project phases and sequences in project execution can be grouped according to the phases in construction projects, defined in ISO 22263:2008 (ISO, 2008), which starts with a pre-project phase, followed by a

pre-construction phase, a construction phase and finally a post-construction phase. Within these principal groups of phases, the number of phases and the name of these differ for the two industries. Despite these differences, the sequence and structure of the project phases in the cases in the both industries are similar, operating with the delivery milestones connected to each phase.

Kvaerner manages large and complex onshore and offshore EPC projects in the 6 to 10 billion NOK range. If Kvaerner is going to compete in a global market, they are highly dependent on using a PEM. The extent of the use of Kvaerner's PEM depends on the types of projects as well as the composition, preferences and competences of the project team. Case projects differ from each other in these respects. In addition, the use of the PEM depends on the use of subcontractors and to the extents that they use their own PEMs, respectively. The more similar the latter are to Kvaerner's PEM, the more streamlined the process becomes in terms of detailed deliveries and milestones. In the two cases, Kvaerner has subcontracted the engineering to Aker Solutions. In the last case, Aker Solutions supplements the engineering resources to Kvaerner. Namely, the two companies were separated in 2011, but they use more or less the same PEM (and Aker Solutions is focusing on the engineering and procurement part).

The 3D design environment is used in Kvaerner in all the cases and towards some of the subcontractors. By project, the use and outcomes depends on the scope of subcontracted engineering and the extents to which the respective subcontractors are actually using it. This often depends on experience and the client's contractual requirements. From the systems perspective, the size and complexity of the 3D model and information related to each object are much greater in the oil and gas industry than in the construction industry. This results in a large number of connected support systems in order to process the large amount of information. The 3D model itself therefore contains less information about each object, because most of the information is defined in the corresponding support systems – connected to each object with unique tag numbers. In the construction industry, all relevant information is contained within each object in the BIM. In the cases, the use of the BIM differs between the traditional approach to BIM where there are few requirements in the contract and the ambitious requirements within the engineering team and towards the contractor. In the both industries, a client can have specific requirements related to the delivery, quality and structure of the 3D design environment or the BIM, in addition to requirements towards traditional drawings. Clients with their BIM requirements give incentives for the extended use of the BIM in projects.

Despite some variance, the case projects are similar along many of the main project dimensions, except the use of the PEM and the utilisation of the 3D design environment or the BIM. This fulfils the basic requirements for "most similar" cases, which is a viable starting point for being able to generalise. Having cases with the different utilisation of these dimensions opens the possibility to analyse the impacts that the PEM and the 3D design environment or the BIM have on project execution.

4. Generalisation in case study research

It is stated that the generalisation of findings of qualitative research in general, and especially those of case studies, is restricted. Data collection, such as participant observations and interviews with a small number of individuals, makes it impossible to know how findings can be generalised to other settings (Bryman, 2012). This is also known as the challenge with "external validity" (Yin, 2009) of research findings and the problem of knowing if the research findings are generalizable beyond the case study researched. This has historically been a barrier for doing case studies, especially the single-case ones. Many of the critics come from the natural sciences, where case studies (qualitative research) have been compared with surveys (quantitative research). In the natural sciences, statistical generalisation is the basis for most generalisations and also the basis for generalising in survey research (Yin, 2009). According to Bryman (2012), there are two kinds of generalisations in qualitative studies; analytic generalisation and moderatum generalisation.

Yin (2009) states that analytic generalisation is the basis for generalisations in case study research where the goal is to generalise results to a broader theory. A previously developed theory is used as a template to compare the empirical findings in the case study research. In the most basic form, replication can be claimed if two or more cases support the same previously developed theory. Analytic generalisation can be used whether the case study involves

one case or several cases. According to Tjora (2012), the goal with qualitative research is to develop knowledge to a phenomenon, which can be tested through concept/theory development. The author introduces herein conceptual generalisation, which is a variant of analytic generalisation and closely related to grounded theory. The goal is to develop concepts (typologies or models) that capture the central characteristics of observations and findings, and that have relevance to other cases than only those being studied. The results from the research can be related to other research and a relevant theory to support a greater validity and generalizability. In most cases, theory development by generalising results to a broader theory is not an absolute criterion. The theoretical discussion and development of concepts are often sufficient to achieve conceptual generalisation (Tjora, 2012).

An alternative to analytic generalisation is moderatum generalisation. Payne and Williams (2005) claim that qualitative research methods can produce limited generalisations where the scope of what is claimed is moderate and open to change. These can be testable propositions that can be confirmed or rejected through further evidence and, thus, lead to generalisations that have a more hypothetical character. The goal is to create externally valid and explicit generalisations, even in a moderated form. Generalisations can be moderated in five ways. The first is whether the findings of a study are limited to certain types of phenomena, which defines how widely applicable the findings are. The second is about the limitations of time periods where findings related to current conditions are likely to be more valid than a claim about future conditions. The third is about how detailed the study has characterised the topic and how it defines the level of precision from very precise to more approximate. The fourth is about limiting claims to basic patterns or tendencies so that similar studies produce closely related but not identical findings. The fifth is about how the condition for generalisation is related to the ontological status of the phenomena that are researched, where there are stronger claims about some phenomena (like social structures) than others (like cultural features).

The conceptual generalisation is herein chosen. It gives the most applicable tools to generalise from the ongoing case study research, based on the collection and analysis of the qualitative data from the case projects. The stepwise-deductive-inductive (SDI) method (Tjora, 2012) is being used. The principle of this method is to work stepwise from data to concepts or theories (inductive) and verify these theoretical outcomes to the more empirical ones (deductive). The collected data are transcribed and the computer assisted qualitative data analysis software (CAQDAS) is used to develop the "empiric-close" coding that reflects the contents of the text. The codes are grouped into the categories and used as a basis to finally develop concepts. This is similar to what Halkier (2011) has described as "category zooming", as one of three ways to generalise qualitative data. In turn, the author describes a three-step process, from coding and categorizing, through the tracing of systematic relationships between categories and finally aiming for a tightly connected synthesis by conceptualizing. The collected data from the case projects at Kvaerner are analysed. Insight is gained on how the projects are designed and executed using the PEM and the 3D design environment (BIM), how these two areas are related to each other and what the effects the 3D design environment or the BIM has on project execution. By analysing the data using the SDI method, the purpose is to identify concepts within defined themes related to project execution with the use of the PEM and the 3D design environment or the BIM. Relating the concepts to a relevant theory and research as well as discussing these will fulfil the principles in conceptual generalisation.

The author also aims at fulfilling several aspects of moderatum generalisation. The findings of a case study are limited to certain types of phenomena. This relates to what George and Bennett (2005) have identified as "building block", one of six types of theory-building research objectives, which study types or subtypes of a phenomenon. The phenomenon researched is the project execution at Kvaerner, with a focus on the PEM and the 3D design environment as the subtypes. The generalisation is likely to take place more easily through the working with the subtypes with the smaller and well-defined scope in comparison with the larger types and a broader scope. It seems that the working with a subtype of a phenomenon is also an effective strategy for potential theory development, because the development of a (sub)theory for a subtype is more manageable in comparison with the development of a general theory for the entire phenomenon. The author is focusing on the findings related to the current conditions because the cases involve the ongoing projects. The research on ongoing projects corresponds to what Payne and Williams (2005) define as "social structures", having a high ontological status. This can make it easier to make stronger claims about findings. When it comes to the level of detail in the research, the aim is external validity,

which depends on what is called "thick description". This refers to the richness of the data collected and the detailed description on how it is collected (Payne & Williams, 2005). This author is collecting a large number of data from many different sources, mainly from the oil and gas industry. The primary source of the data collection is the documentation and the interviews. The necessary background information and the detailed descriptions are accessed through the relevant company and project documentation. The interviews with the resources in the key positions are conducted both within the company and inside the cases so that any variance between the theory and the practice in the projects can be identified. By interviewing more than one resource on each main theme, the quality of the gathered data increases and competing explanations are pinpointed for further investigation. The secondary source of the data collection involves the observations. Through the observations at the project meetings and on site, the author is comparing his own observations with the explanations from the documentation and the interviews.

5. Generalisation between industries

A possibility to generalise from the oil and gas industry to the construction industry depends on the similarities between the two industries. The oil and gas industry, with its large projects competing in a global market with global competitors, is somewhat different from the construction industry, with small to medium projects and competing in a local market with mainly local competitors. Nevertheless, the variances between the key project execution characteristics in the oil and gas industry and those in the construction industry turned out to be relatively small. The both industries are project-based with less control of its environment, compared to other industries. The primary outputs involve unique projects. Major projects involve several stakeholders, including a client, an end-customer (user), a main contractor, sub-contractors, specialist suppliers and advisors/consultants, which form temporarily coalitions during the duration of the project. Relationships between these stakeholders vary, depending on project types and contract types (Barlow, 2000).

Successful project execution depends on a project team that has relevant competences and can collaborate in order to solve problems inherent in large and complex projects. This is mainly based on what Lampel (2001) calls "core competencies", which means the ability to assemble a pool of resources according to the demands of each particular project. There are at least two essential core competences, i.e. engineering know-how and technical competence. Engineering know-how includes programmable activities that are broken down, analysed and described in detail, such as the use of a PEM. It also includes tacit activities, such as identifying crucial knowledge and applying it to where it is needed, learning from own experience and innovating solutions for problems that occur. A key aspect of a PEM is that resources with variable competences in a project team are able to execute their work in a predefined sequence and quality. In turn, technical competence is related to the use of technological assets such as the 3D design environment or the BIM and other support systems (Lampel, 2001). There is one (different) project team for each case project, but the desired composition of all the teams and the aggregated competences are somewhat similar. As a minimum, a project manager and/or a PM team should have necessary experience and a competence to utilise resources and find solutions to challenges that occur. There is also a goal in both industries to have project teams that consist of resources that use best practices from earlier projects and relevant software systems for managing and executing projects.

Table 1. Characteristics inherent in the case project execution in the oil and gas and construction industries.

Characteristics	Oil and gas industry	Construction industry	Degree of similarity
Market	Global	National/local	Low
Project size	Large projects	Small to medium projects	Low-medium
Execution	Project based	Project based	High
Stakeholders	Clients, end-users, contractors, suppliers, consultants	Clients, end-users, contractors, suppliers, architects, consultants	High
Project team composition	Engineering know-how and technical competence	Engineering know-how and technical competence	High

It is herein hypothesised that the more similar the industries are related to project execution and more specifically on the variables related to the PEM and the 3D design environment or the BIM, the more relevant the findings from the oil and gas industry are towards the construction industry. Knowledge transfer between organisations depends on the degree of complexity and whether the knowledge can be codified. Codified knowledge is structured according to a set of easily communicated identifiable rules. Knowledge that is relatively easily codified is easier transferred than knowledge that is embedded in the culture and work principles of an organisation (Barlow, 2000). The development of the PEM as a methodology is based on the codified knowledge through the experience and the best practices in the project execution. It has been developed over several decades based on the experience of delivering the major offshore and onshore facilities. The PEM focuses on predictability in project execution and operations with defined management and execution work processes, deliverables, decision gates and interfaces so that project goals on quality and cost efficiency can be achieved (Kvaerner, 2012b). It is herein assessed that the principles in this methodology and the process description could be highly relevant for the construction industry. Typically, 3D design environments integrate product information with process information from enterprise-wide information systems. Recently, similar BIM based systems have been implemented in the construction industry. These tools enable visualisations of process and product status in order to deliver information to workers in construction environments (Sacks et al., 2010).

6. Discussion and conclusion

The starting point for this paper was the verification of the author's PhD study as the case study research, by relying on Yin's (2009) framework. Cases and their characteristics are essential for being able to generalise (Flyvbjerg, 2006; Seawright & Gerring, 2008). In this study, the chosen cases should be a "most similar" case study type, and thereby similar to the main variables except those related to the PEM and the 3D design environment or the BIM. The key characteristics of the case projects have been reported upon including the comparative use of these two variables along the key dimensions in the two industries. In most cases in the both industries, engineering was subcontracted, by either the contractor (EPC and design-build) or the owner (design-bid-build). The sequence and structure of the project phases and the related milestones are similar. The PEM was used in all the case projects in the oil and gas industry and the 3D design environments contained less information on each object, and most of the information was defined in the support systems. In the cases in the construction industry, all the relevant information was contained within the BIM. Despite being cases in the two industries, the project execution was similar along the main dimensions except the use of the PEM and the utilisation of the 3D design environment and the BIM, respectively, which makes it more relevant to generalise on the results.

In the paper, conceptual generalisation (Tjora, 2012) is initially adopted as a way of generalizing in qualitative research in general and case study research in particular. In addition, the aim is to fulfil several requirements in moderatum generalisation (Payne & Williams, 2005) in order to have a broader foundation for generalisation. The study is limited to the subtypes of the focal phenomenon and the focus is on the current conditions through the ongoing projects. All this corresponds with "social structures", which has a high ontological status.

So can we generalise the findings on the oil and gas industry to the construction industry? The working hypothesis still is that the more similar the project execution characteristics of the two industries with the variables inherent in the PEM, the 3D design environment/the BIM are, the more likely a possibility is to generalise and transfer findings between these project-based industries. So far, many similarities have been detected. The PEM is based on codified knowledge about project execution, which makes it more transferable to other organisations and across certain industries. Principally, the use of the 3D design environment versus the BIM is similar, except on model complexity and object information. Thus, it is herein argued that these necessary similarities create a basis for generalisation of findings on project execution between the two industries.

Acknowledgements

References

Barlow, J., 2000. Innovation and Learning in Complex Offshore Construction Projects. Research Policy 29(7), 973-989.

Bryman, A., 2012. Social Research Methods. Oxford University Press: Oxford.

Bygballe, L. E., Ingemansson, M., 2011. Public Policy and Industry Views on Innovation in Construction. IMP Journal 5(3), 157-171.

Flyvbjerg, B., 2006. Five Misunderstandings about Case-Study Research. Qualitative Inquiry 12(2), 219-245.

Forskningsradet, 2014. Samhandling i byggprosesser, med BIM som katalysator. Avaibale at https://www.forskningsradet.no/ prosjektbanken_beta/#/project/219270/en (Accessed on 13 February 2015).

George, A. L., Bennett, A., 2005. Case Studies and Theory Development in the Social Sciences. MIT Press: Cambridge, MA.

Halkier, B., 2011. Methodological Practicalities in Analytical Generalization. Qualitative Inquiry 17(9), 787-797.

Ingvaldsen, T., 2008. Byggskadeomfanget i Norge 2006: en vurdering basert på et tidligere arbeid og nye data. SINTEF byggforsk: Oslo, Norway.

ISO, 2008. ISO 22263: 2008 Organization of Information about Construction Works -- Framework for Management of Project Information. ISO

Kvaerner, 2012a. Application Factsheets.

Kvaerner, 2012b. Kvaerner PEM Method Statement.

Lampel, J., 2001. The Core Competencies of Effective Project Execution: the Challenge of Diversity. International Journal of Project Management 19(8), 471-483.

NBIMS National Building Information Modeling Standard, 2007. National Institute of Building Sciences of the USA.

Payne, G., Williams, M., 2005. Generalization in Qualitative Research. Sociology 39(2), 295-314.

PMI Project Management Institute, 2013. A Guide to the Project Management Body of Knowledge (PMBOK Guide), Fifth Edition. Project Management Institute.

Reve, T., Sasson, A., 2012. Et kunnskapsbasert Norge. Universitetsforlaget: Oslo.

Sacks, R., Koskela, L., Dave, B. A., Owen, R., 2010. Interaction of Lean and Building Information Modeling in Construction. Journal of Construction Engineering and Management 136(9), 968-980.

Seawright, J., Gerring, J., 2008. Case Selection Techniques in Case Study Research A Menu of Qualitative and Quantitative Options. Political Research Quarterly 61(2), 294-308.

Tjora, A. H., 2012. Kvalitative forskningsmetoder i praksis. Gyldendal akademisk: Oslo.

Yin, R. K., 2009. Case Study Research: Design and Methods. Sage: Thousand Oaks, CA.